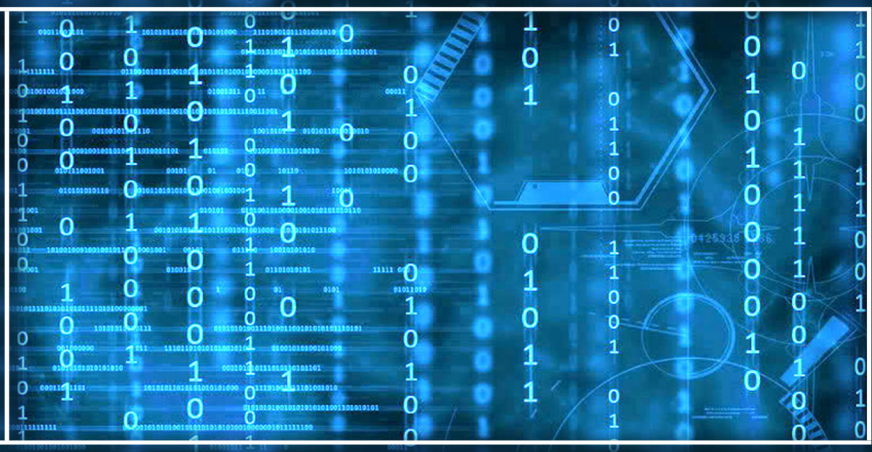
IJACSA
WHERE WISDOM SHARES
International Journal of Advanced Computer Science and Applications

Volume 10 Issue 10

October 2019



ISSN 2156-5570(Online)
ISSN 2158-107X(Print)

www.ijacsa.thesai.org

Editorial Preface

From the Desk of Managing Editor…

It may be difficult to imagine that almost half a century ago we used computers far less sophisticated than current home desktop computers to put a man on the moon. In that 50 year span, the field of computer science has exploded.

Computer science has opened new avenues for thought and experimentation. What began as a way to simplify the calculation process has given birth to technology once only imagined by the human mind. The ability to communicate and share ideas even though collaborators are half a world away and exploration of not just the stars above but the internal workings of the human genome are some of the ways that this field has moved at an exponential pace.

At the International Journal of Advanced Computer Science and Applications it is our mission to provide an outlet for quality research. We want to promote universal access and opportunities for the international scientific community to share and disseminate scientific and technical information.

We believe in spreading knowledge of computer science and its applications to all classes of audiences. That is why we deliver up-to-date, authoritative coverage and offer open access of all our articles. Our archives have served as a place to provoke philosophical, theoretical, and empirical ideas from some of the finest minds in the field.

We utilize the talents and experience of editor and reviewers working at Universities and Institutions from around the world. We would like to express our gratitude to all authors, whose research results have been published in our journal, as well as our referees for their in-depth evaluations. Our high standards are maintained through a double blind review process.

We hope that this edition of IJACSA inspires and entices you to submit your own contributions in upcoming issues. Thank you for sharing wisdom.

Thank you for Sharing Wisdom!

Managing Editor
IJACSA
Volume 10 Issue 10 October 2019
ISSN 2156-5570 (Online)
ISSN 2158-107X (Print)

Editorial Board

CONTENTS

Detecting Public Sentiment of Medicine by Mining Twitter Data

Daisuke Kuroshima[1], Tina Tian[2]
Department of Computer Science, Manhattan College, New York, USA

***Abstract*—The paper presents a computational method that mines, processes and analyzes Twitter data for detecting public sentiment of medicine. Self-reported patient data are collected over a period of three months by mining the Twitter feed, resulting in more than 10,000 tweets used in the study. Machine learning algorithms are used for an automatic classification of the public sentiment on selected drugs. Various learning models are compared in the study. This work demonstrates a practical case of utilizing social media in identifying customer opinions and building a drug effectiveness detection system. Our model has been validated on a tweet dataset with a precision of 70.7%. In addition, the study examines the correlation between patient symptoms and their choices for medication.**

Keywords*—*Twitter; social media; data mining; public health

I. Introduction

Twitter, a microblogging service, has gained rapid popularity over the decade [1]. Massive quantities of real-time, fine grained microblog messages (also known as tweets) are available on Twitter. It is estimated that the social network attracts 321 million monthly active users worldwide, posting more than 500 million tweets everyday [2]. Published tweets can be accessed through Twitter's web portal or extracted programmatically using its Application Program Interface (API) [3].

Due to its rapid growth and the accessibility of the massive quantities of tweets, Twitter has become a valuable information resource for various applications. For example, enterprises have studied the usefulness of Twitter in organizational communication and information gathering [4]. Researchers have monitored real-time activities on Twitter to detect earthquakes [5]. Furthermore, Twitter has been used in studying political campaigns [6].

One particularly interesting research field is to apply social network data in the medical domain. Past research suggested that social media serve as valuable tools to involve patients more in their care and promote more effective communications between physicians and patients [7]. Currently, Twitter is the most popular platform of social media used for healthcare communications [8].

In this paper, we present a computational approach that collects, processes and analyzes Twitter data for detecting public sentiment of medicine. Machine learning models are used for an automatic classification, which is able to examine tweets that show positive or negative sentiment. The results from the supervised classification study demonstrate how Twitter can be utilized to identify patterns of customer opinions.

The rest of the paper is organized as follows. Section II reviews the related work. In Section III, we describe the data set used in the experiment and explain the methods and algorithms adapted in analyzing the data. Section IV presents the results of the study and Section V concludes the paper and proposes future directions.

II. Related Work

Social media, particularly Twitter, has gained increasing attention in medicine [9]. This is mainly due to the broad reach of Twitter users; anyone with a Twitter account is able to publish public tweets of up to 140 characters [10]. Compared to the traditional approach of evaluating drug efficacy where information comes from limited surveillance resources, Twitter greatly increases the number of people who can contribute to the discussion. Therefore, larger scale data can be leveraged for studying the effectiveness of medication.

Tweets can provide critical opinions and first-hand reviews on drugs based on patient experience. Communications on Twitter come from diverse backgrounds, making it a unique source of information gathering from the general population. Moreover, Twitter provides real time and direct surveillance. For example, Lee et al. used Twitter data for real-time disease surveillance on flu and cancer [11]. Gesualdo monitored tweets for allergic disease surveillance [12].

Past research has shown the predictive power of Twitter for health care. Tweets have been used to collect evidence about post-market pharmacovigilance [13] [14]. Aramaki et al. have used Twitter to detect influenza epidemics [15]. Baumgartner et al. utilized Twitter for discovering emergent online communities of cannabis users [16]. Recently, Twitter data were used as an information source to detect drug abuse in real time [17]. In addition, the study of Twitter updates successfully tracked the spread of cholera in Haiti [18]. Overall, Twitter has been proven to be a valuable knowledge source in tracking natural disasters, infectious disease outbreaks and drug use.

In this paper, we describe a computational method that identifies the public sentiment of over-the-counter (OTC) drugs using Twitter. Specifically, common pain relievers are targeted in the experiment. Self-reported patient data are collected by mining the Twitter feed. Moreover, the study shows the uses of the selected drugs among Twitter users, presenting a different perspective compared to the drug facts provided by pharmaceutical companies.

III. Data Set and Methodology

The system performs a sentiment analysis on a Twitter tweet corpus regarding drugs collected from January 2019 to April 2019. In this section, we discuss the data set used in the study and how we processed the tweets in order to determine their sentiment.

A. Data Set

In this work, a list of four OTC painkillers is examined. They are Advil, Aleve, Motrin and Tylenol. We name it List A. Brand names are chosen over names of the substances, as they are more frequently mentioned by Twitter users. Both Advil and Motrin contain ibuprofen. Aleve's main substance is naproxen while Tylenol majorly contains aspirin.

It is possible to collect a subset of Twitter feed by running a keyword search using Twitter's Search API. In order to extract more relevant tweets for learning the sentiment, we apply a second list of keywords, which includes symptoms of the patients taking drugs in List A, reported by pharmaceutical companies. Table I shows a sample of keywords included in the new list, named List B. This approach also enables us to study uses of the drugs from the general public.

Synonyms of the keywords are included in List B. For example, "throw up" and "puke" are added to the list as synonyms of "vomit". Different tenses are taken into account as well. For instance, besides "puke", the list also contains "puked" and "puking". Twitter is known for its informal language style [19]. Therefore, List B has included several casual words and phrases, such as "tummy", which is an informal way to describe the stomach.

Both List A and List B are passed to the Twitter Search API for extracting the dataset. A tweet is only selected if it contains at least one drug from List A and one keyword from List B. In this study, we target tweets that are written in English and published in the United States. During the three months of data collection, more than 10,000 tweets were extracted. Duplicated tweets, such as retweets, were removed. The remaining 6,447 distinct tweets form the final dataset for the study.

TABLE. I. Sample of Keywords in List B

stomach	cough	fever
headache	vomit	bloat
nausea	swelling	blood
itching	rash	sore throat
running nose	stuffy nose	sneezing
pain	belching	stiff
irritated eyes	lower back	difficulty sleeping
cry	swallow	muscle

TABLE. II. Breakdown of the Dataset

Drug	**Number of tweets**
Advil	2,162
Aleve	455
Motrin	502
Tylenol	3,680

Table II reveals a breakdown of the dataset concerning each specific drug. The total number of tweets in the table slightly exceeds the size of the dataset, as some tweets include more than one drug in List A. As one can see, Advil and Tylenol are more popular choices among Twitter users, while Tylenol being the most frequently mentioned drug in the experiment.

B. Data Pre-Processing

Before we deliver the dataset to machine learning methods for sentiment detection, it is necessary to pre-process the raw data. As seen in Fig. 1, the process includes data manipulations, such as data cleaning, data splitting and text vectorization to properly prepare the training set. The training data are then labeled with sentiment tags and passed to machine learning algorithms for further studying the test dataset. The rest of this section elaborates the processing procedure.

The first stage of data pre-processing is text cleaning. Extracted tweets are converted to all lowercase letters. URLs in tweets are removed, as they do not contribute to sentiment detection. Tweets with selected user mentions are eliminated from the study. One example is the user mention @Advil, which appears in our dataset as Advil is one of the search keywords. However, username @Advil belongs to a personal Twitter account, who has no relation with Advil the drug.

Next, we split the dataset into training set and test set to be used with machine learning algorithms. Among all the tweets, 259 of them are randomly selected to form the training set. The test set consists of the remaining 6,188 tweets. Each tweet in the training set is manually classified as positive sentiment or negative sentiment. They are labeled P or N respectively. A tweet is evaluated as positive if the Twitter user (patient) published a positive experience with the drug. On the other hand, a tweet is labeled negative if the user reported the drug being ineffective. As a result, 133 tweets in the training set are classified as positive and the remaining 126 tweets are labeled negative.

The training dataset and the sentiment labels are stored in an .arff file in order to be processed by machine learning tools. Fig. 2 shows a sample of the training data file. As one can see, two attributes are included in the relation. One attribute is the tweet, which is a string type, and the other is its classification, which comes from set {P, N}. The rest of the file consists of the data section, in which each line contains an example with the two attributes separated by a comma.

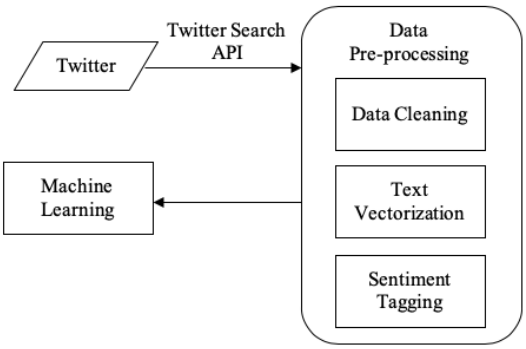


Fig. 1. System Architectural Overview.

@relation 'training.arff'

@attribute tweet string
@attribute classification {P, N}

@data
"i'd be sick because i'm allergic to advil", N
"when i say i was on a million meds, i mean it. i was taking a steroid pack to help me heal, melatonin to sleep, advil to help my pain and i had anti nausea meds like i was taking easily like 10 pills a day for a good month oop", P
"@sar_free well take some tylenol so that fever can go away", P
"i have such a headache i took tylenol to stop this exact thing", N

Fig. 2. Sample of Training Data.

In order for our machine learning models to learn the correlation between a tweet and its sentiment classification, text vectorization is used to parse the data. In the process, tweet strings are converted to word vectors, as known as bag of words. Tweets are tokenized by applying pre-defined delimiters, such as blank spaces and punctuation signs. For example, tweet "i'd be sick because i'm allergic to advil" is converted to vector [i, d, be, sick, because, i, m, allergic, to, advil]. A list of stop words is applied to eliminate neutral and nonsemantic terms in a vector, such as the, in, of, etc. Additionally, stemming is used to words with the same root. For example, cat, cats, catlike and catty are considered the same term.

Overfitting is a common issue in machine learning. To tackle the problem, we select the top 100 most frequent words from each classification. That is, 100 terms from the positive tweet corpus and 100 terms from tweets with the negative annotation. Together they form the vocabulary of this study. In this work, the most frequent words are determined by calculating their term frequency-inverse document frequency (tf-idf). The following formulas describe how tf-idf of a term is computed.

Let *t* be a term and *d* be the tweet that contains term *t*. The term frequency of *t*, denoted as *tf(t,d)*, can be calculated as

$$tf(t,d) = \frac{f_{t,d}}{\sum_{t' \in d} f_{t',d}} \quad (1)$$

where $f_{t,d}$ stands for the number of appearances of term *t* in the tweet and $\sum_{t' \in d} f_{t',d}$ represents the total number of occurrences of all words in tweet *d*. Let *D* be the entire document, specifically, the collection of tweets in our experiment. The inverse document frequency of term *t*, symbolized as *idf(t,D)*, can be computed using the following formula.

$$idf(t,D) = log \frac{N}{|\{t' \in D : t \in d\}|} \quad (2)$$

where *N* stands for the total number of tweets in the dataset. $\{t' \in D : t \in d\}$ represents the set of tweets in our data collection that contain term *t*. For example, there are 6,447 tweets in the dataset and the word sick appears in 189 of them. Thus, the inverse document frequency of term sick is computed as log(6447/189), which approximates 5.1. The final term frequency-inverse document frequency of term *t* is the product of the two previously calculated frequencies, as shown in the formula below.

$$tfidf(t,d,D) = tf(t,d) \cdot idf(t,D) \quad (3)$$

Term frequency-inverse document frequency is used as the measure to select the most popular terms to be studied by machine learning models. As a result, a combined list of 141 top words from both the positive and the negative classifications constructs the vocabulary. The total size is less than 100 times 2, as some words overlap in the two classes.

IV. Results

As mentioned in Section III, our dataset consists of 6,447 distinct tweets that contain keywords from both a list of medicines and a list of symptoms. The coverage of symptoms in the user-reported data enables us to further study the uses of the drugs. Overall in our experiment, headache is the most common cause to seek over-the-counter pain relievers. Other frequently mentioned symptoms are ear pain and back pain.

Fig. 3 shows a bar chart of the top five most common uses for each medicine. A bar in the graph represents the percentage of a particular symptom reported for a drug. Common symptoms include headache, fever, ear pain, back pain, etc. The term general pain is used to represent unspecified pain reported by the patients. For example, our study shows that the main uses of Advil are headache, general pain and back pain. Among them, headache is the dominant cause of Advil consumption, reported by 33% of the Advil users.

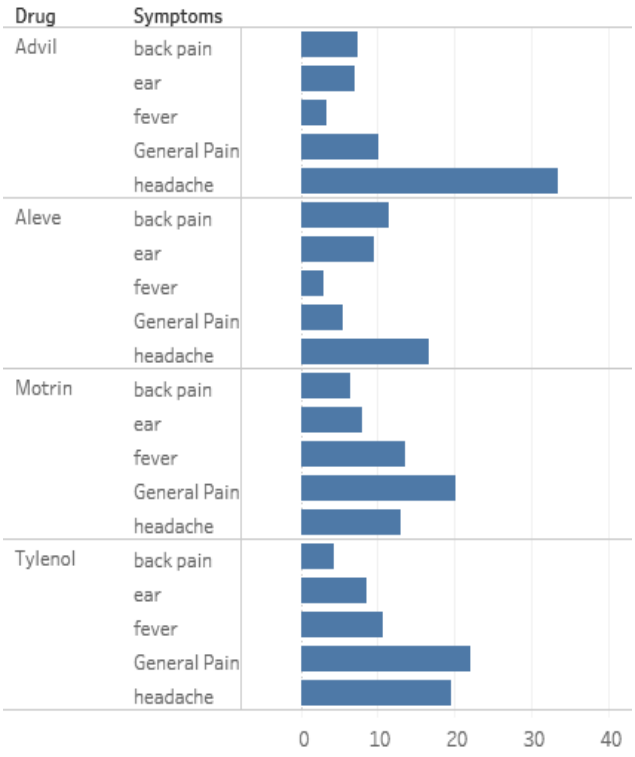


Fig. 3. Use of Each Drug in Percentage.

Fig. 4 reveals the co-occurrence patterns between drugs in our study and their reported uses. Circles are color coded in order to distinguish among different drugs. For example, Motrin consumption is symbolized with color red and patient cases of Advil are annotated with blue circles in the figure. Each circle represents the tweets in our dataset that reported a particular use of a drug. For example, circle "Advil headache" in the figure symbolizes the set of tweets that contain both keywords advil and headache. The size of a circle is in proportion to the number of tweets it represents. Thus, large circles are a sign of frequent co-occurrences between a drug and its reported use.

As seen in Fig. 4, patients with headache tend to seek Advil. In our study, it is found that people with the symptom of fever prefer Tylenol and Motrin over others. An interesting observation is that a large portion of Aleve consumers use it for ear pain. The dataset also suggests that Tylenol is a popular choice for other specific pain, such as hip pain, backache, muscle cramp and chronic pain. Moreover, 50% of the patients who reported to show symptoms of sore throat and swelling chose Aleve over other pain relievers in the study.

In order to render the most accurate result in examining the sentiment of tweets, several machine learning models are applied in this work. They are decision tree learning, random forest, support vector machine, naïve Bayes and k-nearest neighbors. The study compares their accuracy and selects the algorithm with the highest precision for automatic sentiment classification. As mentioned in Section III, the training set consists of 259 randomly selected tweets in the dataset. Each tweet is labeled with a sentiment of positive or negative. In order to compare different machine learning algorithms, the training data are divided into two sets. One set contains 90% of the training data, which is used to train the different machine learning models. The remaining 10% of the training data construct the second set, which is used to validate the classification results. In this work, 10-fold cross validation is applied to achieve better precision.

Every machine learning model generates its predicted result regarding each tweet in the validation set. The prediction is a classification of positive or negative sentiment. If a tweet in the validation set is labeled positive and the learning model successfully predicts it, we mark it as a case of True Positive (TP). On the other hand, if the model delivers a positive classification while the tweet is annotated negative, we record the instance as False Positive (FP). Similarly, a tweet is considered True Negative (TN), if the learning algorithm correctly reports a negative sentiment. Otherwise, if the model fails to predict a positive label, the case is noted as False Negative (FN). The four categories summarize all possible scenarios from the validation process. An example of each category is shown in Table III.

To evaluate the accuracy of each machine learning model, three measures are considered in this study. They are precision, recall and F-measure. All the three parameters can be computed using the number of instances included in the four categories viewed in Table III. The following formulas show the calculation of the three accuracy measures, where TP, FP, TN and FN represent the number of tweets belonged to each scenario.

$$Precision = \frac{TP}{TP+FP} \quad (4)$$

$$Recall = \frac{TP}{TP+FN} \quad (5)$$

$$F\text{-}measure = \frac{Presision \cdot Recall}{Precision+Recall} \quad (6)$$

Table IV reveals the precision, recall and f-measure from validating selected machine learning models. Each model is associated with two sets of accuracy measures. One set is based on the positive classification and the other is built on the negative classification. Finally, their weighted average is calculated, which shows in bold in the table.

As seen in Table IV, among all the learning models, naïve Bayes provides the highest average precision, recall and f-measure. Therefore, it is chosen as the algorithm to determine the sentiment classifications of the test data. As a result, 3,068 tweets in the test set are categorized with positive sentiment and the rest 3,377 tweets are classified as negative.

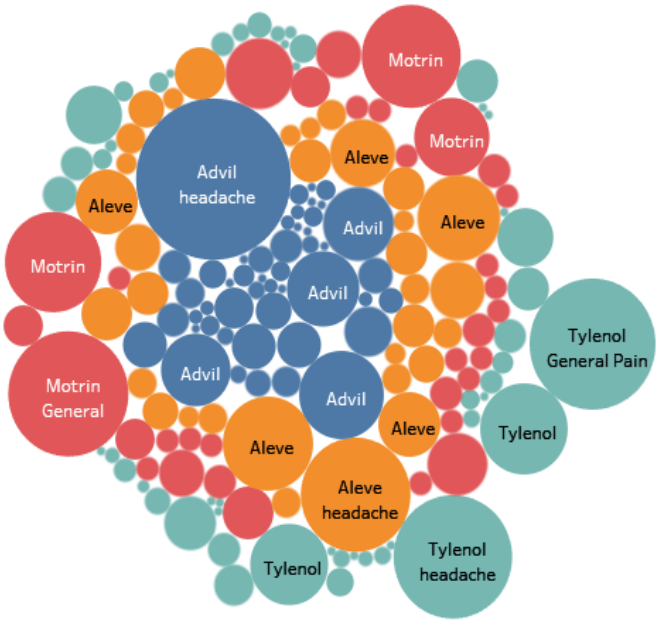


Fig. 4. Co-Occurrence Patterns between Drugs and their uses.

TABLE. III. EXAMPLES OF CLASSIFICATION RESULTS

Category	Example
TP	Mix salt in warm water and wash around your mouth. It alleviates the pain a little. Advil liquid gels do work too lol
FP	Unfortunately I DO have stomach issues, after playing that game for about ten years. :(I used to use extra-strength advil AND extra-strength Tylenol to knock the pain out, but it caught up to me this year.
TN	The IUD is gone and the tylenol is taken and STILL THE PAIN.
FN	I have a headache today... should take an Advil

TABLE. IV. PRECISION, RECALL AND F-MEASURE

Learning Model	Classification	Precision	Recall	F-Measure
Decision Tree	Positive	57.8%	65.5%	61.4%
	Negative	64.9%	57.1%	60.8%
	Weighted Average	**61.5%**	**61.1%**	**61.1%**
Random Forest	Positive	64.3%	55.8%	59.7%
	Negative	64.5%	72.2%	68.2%
	Weighted Average	**64.4%**	**64.4%**	**64.2%**
Support Vector Machine	Positive	69.9%	57.5%	63.1%
	Negative	67.1%	77.8%	72.1%
	Weighted Average	**68.4%**	**68.2%**	**67.8%**
K-Nearest Neighbors	Positive	62.6%	68.1%	65.3%
	Negative	69.0%	63.5%	66.1%
	Weighted Average	**66.0%**	**65.7%**	**65.7%**
Naïve Bayes	Positive	69.7%	67.3%	68.5%
	Negative	71.5%	73.8%	72.7%
	Weighted Average	**70.7%**	**70.7%**	**70.7%**

V. CONCLUSIONS AND FUTURE WORK

In this work, we built a drug sentiment classification system based on Twitter data. The system is able to automatically identify patients' opinions on selected drugs. The study demonstrated that public sentiment of medicine can be detected using data on social media, such as tweets. Our model has been validated on a real-world dataset with a precision of 70.7%. Additionally, the study investigated the correlation between patient symptoms and their choices for medication.

In the future, it is planned to apply the same methodology on prescription drugs and newly released medications. Learning public sentiment of new drugs can be particularly crucial, providing valuable feedback for patients and healthcare providers. Moreover, future work involves expanding the dataset, which will include a larger pool of tweets for training the learning models. It is possible for the system to achieve a higher precision rate with an expanded set of training data.

Currently, this work only considers binary classifications. Thus, the sentiment of a tweet is labeled as either positive or negative. However, it is observed that some tweets do not indicate an identifiable opinion regarding the drugs in the study. In other words, they have a neutral sentiment. These tweets have been eliminated from the training set. Nevertheless, it is possible that the test data may contain a subset of neutral tweets that were mislabeled as positive or negative by our learning model. In the future, it is planned to adapt the one-vs-all classification method to tackle neutral sentiment.

REFERENCES

[1] C. C. Aggarwal, Social Network Data Analytics. Springer, 2011.

[2] Twitter, http://twitter.com, retrieved 09/01/2019.

[3] Twitter Search API, https://developer.twitter.com/en/docs/tweets/search/api-reference/get-search-tweets.html, retrieved 09/01/2019.

[4] A. Archambault and J. Grudin, "A longitudinal study of Facebook, LinkedIn, & Twitter use," Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 2741-2750, 2012.

[5] T. Sakaki, M. Okazaki, and Y. Matsuo, "Earthquake shakes Twitter users: real-time event detection by social sensors," Proceedings of the 19th International Conference on World Wide Web, pp. 851-860, 2010.

[6] I. Vegas, T. Tian, and W. Xiong, "Charactering the 2016 U.S. presidential campaign using Twitter data,", Journal of Advanced Computer Science and Applications, vol. 7, no. 10, 2016.

[7] H. Cayton, "The alienating language of health care," Journal of Royal Society of Medicine, vol. 99, no. 10, pp. 484 -484, 2006.

[8] W. Raghupathi and V, Raghupathi, "Big data analytics in healthcare: promise and potential," Health Information Science and Systems, vol. 2, no. 1, 2014.

[9] K. Chretien, J. Azar, and T. Kind, "Physicians on Twitter," Journal of the American Medical Association, vol. 305, no. 6, pp.566 -568, 2011.

[10] Twitter,https://developer.twitter.com/en/docs/basics/counting-characters.html, retrieved 09/01/2019.

[11] K. Lee, A.A. Agrawal, and A. Choudhary, "Real-time disease surveillance using Twitter data: demonstration on flu and cancer," Proceedings of the 19th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, pp. 1474 – 1477, 2013.

[12] F. Gesualdo, G. Stilo, A. D'Ambrosio, E. Carioni, E. Pandolfi, P. Velardi, A. Fiocchi, and A.E. Tozzi, "Can Twitter be a source of information on allergy? correlation of pollen counts with tweets reporting symptoms of allergic rhino conjunctivitis and names of antihistamine drugs," PLoS One, vol. 10, no. 7, 2015.

[13] N. Alvaro, M. Conway, S. Doan, C. Lofi, J. Overington, and N. Collier, "Crowdsourcing Twitter annotations to identify first-hand experiences of prescription drug use," Journal of Biomedical Informatics, vol. 58, pp. 280 - 287, December 2015.

[14] A. MacKinlay, H. Aamer, and A. Yepes, "Detection of adverse drug reactions using medical named entities on Twitter," Annual Symposium Proceedings, AMIA Symposium, pp. 1215 - 1224, 2017.

[15] E. Aramaki, S. Maskawa, and M. Morita, "Twitter catches the flu: detecting influenza epidemics using Twitter," Proceedings of the Conference on Empirical Methods in Natural Language Processing, pp. 1568 – 1576, 2011.

[16] P. Baumgartner and N. Peiper, "Utilizing big data and Twitter to discover emergent online communities of cannabis users," Substance Abuse: Research and Treatment, vol. 11, 2017.

[17] N. Phan, S. A. Chun, M. Bhole, and J. Geller, "Enabling real-time drug abuse detection in tweets," Proceedings of the 33rd International Conference on Data Engineering, 2017.

[18] R. Chunara, J.R. Andrews, and J.S. Brownstein, "Social and news media enable estimation of epidemiological patterns early in the 2010 Haitian cholera outbreak," The American Journal of Tropical Medicine and Hygiene, vol. 86, issue 1, pp. 39 - 45, 2012.

[19] K.L. Liu, W.J. Li and M. Guo, "Emoticon smoothed language models for Twitter sentiment analysis," Proceedings of the 26th AAAI Conference on Artificial Intelligence, pp. 1678-1684. 2012.

Interpolation of Single Beam Echo Sounder Data for 3D Bathymetric Model

Claudio Parente[1], Andrea Vallario[2]
Department of Sciences and Technologies
University of Naples "Parthenope"
Naples, Italy

***Abstract*—Transmitting sound waves into water, and measuring time interval between emission and return of a pulse, single beam echo sounder determines the depth of the sea. To obtain a bathymetric model representing sea-floor continuously, interpolation is necessary to process irregular spaced measured points resulting from echo sounder acquisition and calculate the depths in unsampled areas. Several interpolation methods are available in literature and the choice of the most suitable of them cannot be made a priori, but requires to be evaluated each time. This paper aims to compare different interpolation methods to process single beam echo sounder data of the Gulf of Pozzuoli (Italy) for 3D model achievement. The experiments are carried out in GIS (Geographic Information System) environment (Software: ArcGIS 10.3 and its extension Geostatistical Analyst by ESRI). The choice of the most accurate digital depth model is made using automatic cross validation. Radial basis function and kriging prove to be the best interpolation methods for the considered dataset.**

Keywords*—Interpolation; bathymetric model; 3D model; digital depth model; kriging; radial basis function; Geographic Information System (GIS)

I. Introduction

As reported in literature, interpolation is a process of using a discrete set of known data points to construct new data points [1, 2, 3, 4]. Data points resulting from experimentations and measurements represent the values of a function for a limited number of values of the independent variable. Interpolation permits to estimate the values of that function for intermediate values of the independent variable [5, 6].

The concept of spatial interpolation is related to the digital terrain model (DTM): introduced by Miller & Laflamme [7] at the Photogrammetry Laboratory of the Massachusetts Technology Institute, DTM can be defined as a three – dimensional representation of a terrain surface consisting of X, Y, Z coordinates stored in digital form. This representation can be obtained as a vector-based triangulated irregular network (TIN) as well as a grid, both displayable in 3D.

DTM represents the bare ground surface without any objects belonging to the built (power lines, buildings and towers) and natural (trees and other types of vegetation) [8]. When the earth's surface is represented including all objects on it, the model is called digital surface model (DSM). Digital elevation model (DEM) is often used as a generic term for DSM and DTM [9]. In this study, we use DEM as synonymous of DTM.

Data for DEM can be acquired using different techniques, i.e. photogrammetry, land surveying, lidar, etc. [10].

DEMs are basic in land analysis and management as they are directly usable in GIS environment [11]. They are fundamental for many applications, i.e. 3D thematic model construction [12], assessment of potential groundwater vulnerability to pollution [13], assessment of potential dam sites [14], landslide hazard [15,16], satellite images ortho-rectification for useful applications in coastal area studies [17], etc.

Interpolation methods that support DEM generation can be used for seabed model. This can be indicated as Digital Depth Model (DDM) because describes the variability of the distance between the sea surface and sea bottom. In other terms, interpolation methods permit to realize a bathymetric model that can be defined, according to International Hydrographic Organization (IHO), as ''a digital representation of the topography (bathymetry) of the seafloor by coordinates and depths'' [18]. Depth data to be processed can be obtained with different techniques, i.e. bathymetric survey, nautical map, lidar. Similarly to DEM, DDM can be generated using different interpolation methods and the choice of the one able to supply the most performed model is not banal.

For this purpose, this study aims to realize a review of some existing interpolation methods usable for DDM construction. The paper supplies suitable information to select the method for DDM generation. Firstly, the single beam echo sounder technique to acquire depth data necessary to shape seafloor is introduced. Following this, a brief description is given for some existing DEM generation methods that can be used also for DDM production. Next, the performance of each method is evaluated considering a case study concerning the Gulf of Pozzuoli (Italy): single beam echo sounder data are processed and the accuracy of each method is referred to the closeness of interpolated values to measured values. To compare the different approaches adopted in this study, cross validation is carried out for each model. Finally, we remark the importance of the work and suggest the potential applications and extensions for future studies.

II. Source of Data

A. Single Beam Echo Sounder

Single beam echo sounder permits to determine the depth of water by diffusing sound waves into water. The amount of time it takes for the sound to travel through the water, spring

back the seafloor, and return to the sounder, permits to determine the depth of water. Fundamental for this purpose is the exact knowledge of the speed of sound in water that is variable and dependent on pressure (depth), density, temperature and salinity [19,20,21]. For example, the speed of sound in water ranges from 1450 to 1498 meters per second in distilled water and 1531 m/s in sea water at 20-25 °C [22].

International Hydrographic Organization (IHO) has fixed the requirements for bathymetric survey, so the necessary precision and accuracy of the hydrographic echo sounder are defined in IHO special publication S-44 [18].

Hydrographic echo sounders are usually dual frequency: a low frequency pulse (normally around 24 kHz) can be transmitted simultaneously with a high frequency pulse (normally around 200 kHz). Because these frequencies are discrete, there is not interference between the two return signals. Dual frequency echo sounding produces positive effects, such as the facility to recognize a sea grass (Posidonia Oceanica) layer. The high frequencies are appropriate in shallow water [23]. The lower frequencies are suitable in deeper water because less susceptible to attenuation in the water column [24].

Most hydrographic operations use a 200 kHz transducer, which is suitable for inshore work up to 100 meters in depth. Deeper water requires a lower frequency transducer as the acoustic signal of lower frequencies is less susceptible to attenuation in the water column. Commonly used frequencies for deep water sounding are 33 kHz and 24 kHz.

The beam width of the transducer determines the resolution of the data, so a fine one is preferable. This aspect is fundamental for hydrographic survey in deep water, because the resultant footprint of the acoustic pulse can become too much great once it reaches a far object.

Single beam echo sounder must be calibrated by a bar check for correct determination of the speed of sound in the water column [25]. The bar check consists of immersing a flat plate below the echo sounder transducer, measuring the depths at points of known depths below the surface and comparing the actual and measured depths. The sound velocity in the echo sounder is modified until the measured depth is equal the known depth [26]. Finally, the echo sounder is fixed with the average sound velocity over the water column.

A bar check should be conducted at least daily, and whenever there is a change of survey area during the day, to ensure consistent data quality [27]. Likewise, the use of bar check is necessary when any SBES components are modified or replaced on the vessel.

B. Study Area and Pre-Elaboration of Depth Data

For this study, 2023 depth points resulting from single beam echo sounder survey of the Gulf of Pozzuoli, are used for 3D bathymetric models construction. Depth measurement data are kindly provided by the Italian Hydrographic Office (Istituto Idrografico della Marina) and present decimeter accuracy. The interested area is reported in Fig. 1. It extends within the following UTM/WGS84 plane coordinates - 33T zone: E_1 = 423,630 m, E_2 = 428,320 m, N_1 = 4,513,461 m, N_2 = 4,518,761 m. Depth values range between -9.7 m and -118.1 m.

Because the sample points are fairly evenly distributed along the ship routes and these are not very far each from others, the distribution of depth values is quite uniform, as it is shown in Fig. 2.

Depth data are available in txt format and converted in vector file (shp) using the ESRI software ArcGIS 10.3 [28]. The extension named “Geostatistical analyst” and available within the above mentioned program, is used to generate bathymetric models of the study area.

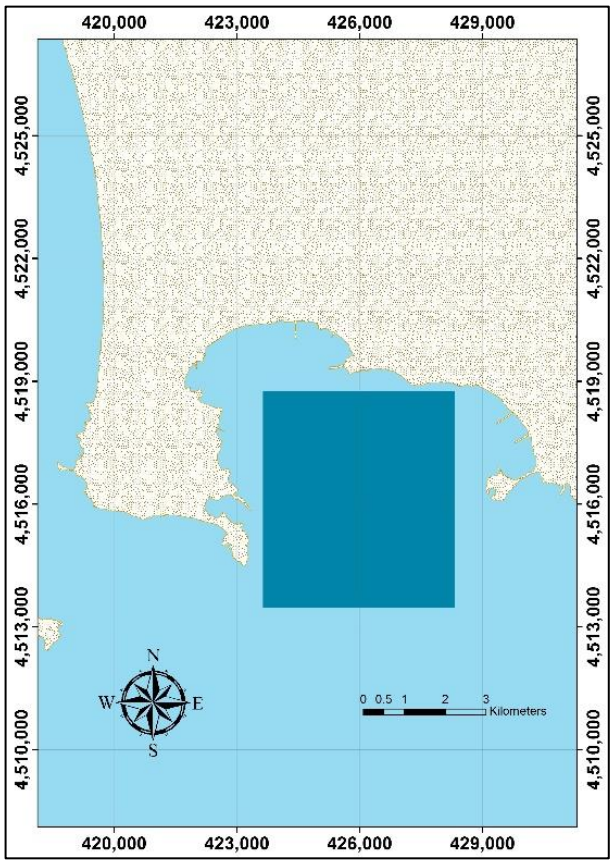


Fig. 1. The Gulf of Pozzuoli: in Blue the Area Covered by Single Beam Echo Sounder Data.

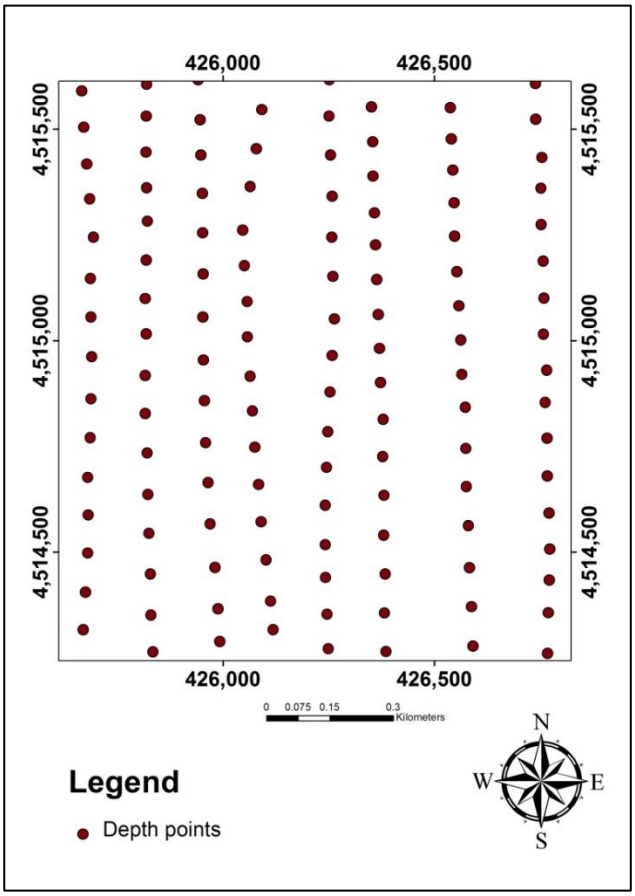


Fig. 2. Particular of the Distribution of the Depth Points.

III. Interpolation Methods

In literature different interpolation methods are available and their application to the same data can produce different results. Therefore, it is necessary to compare these methods and choice the most performed one.

The interpolation methods are founded on the principle of spatial autocorrelation, which is well represented by Tobler's first law of geography: "Everything is related to everything else, but near things are more related than distant things" [29, 30].

Methods of interpolation are generally classified into two categories: local and global methods. In the local methods, the interpolated value is affected only by the values at nearby points from the initial data set, while in the global methods, each interpolated value is affected by all of the data [31]. For local methods, a specified number of points, or all points within a specified radius, are used to determine the output value of each location. In Fig. 3, the research of the neighbouring measured points using a specified radius is shown.

Another way to classify interpolation methods is to distinguish them as either exact or approximate methods, according to their characteristic of preserving or not preserving the original sample point values on the inferred surface [32].

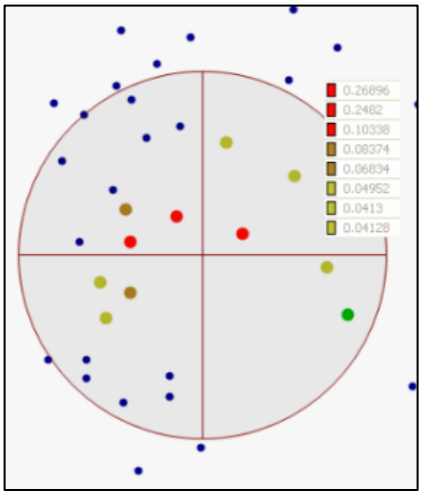


Fig. 3. The Research of the Neighbouring Measured Points (Source: ArcGIS Pro Help).

This section briefly presents the different interpolation methods used in this study. For all local interpolators, to determine the output value for each location, four sectors are used, with maximum number of points equal to 15 neighbours, and minimum equal to 10 for each sector.

A. The IDW method

Inverse Distance Weighting (IDW) is a deterministic interpolation method, so the resulting surface must pass through each measured sample value. This method is based on the assumption that closer values are more related than further values. It uses measured values surrounding an unmeasured location to predict its value [32].

Interpolated points are estimated based on their distance from known values: for consequence, points that are adjacent to known values are more influenced than points that are distant [33]. In other terms, the values of the neighbouring measured points are weighted by the inverse of the distance at the calculated [34]. As a result, as the distance increases, the weights decrease rapidly [35].

The interpolation function is represented by the following formula:

$$z_{x,y} = \frac{\sum_{k=1}^{N} \frac{z_k}{d_k^p}}{\frac{1}{d_k^p}} \quad (1)$$

Where

$Z_{x,y}$ = estimated value at the position (x,y) of the grid,

z_k = a neighbouring data point value,

N = the number of neighbouring points,

d_k = the distance between the data point and the point being interpolated,

P = a positive-power parameter.

In this study, IDW with power equal to 2 is applied.

B. Radial Basis Function (RBF)

Radial basis functions (RBFs) are a series of exact interpolation techniques, so the surface passes through the data values.

There are different basis functions, such as: completely regularized spline (RBF-CRS), spline with tension (RBF-SwT), thin-plate spline (RBF-TPS), multiquadric function (RBF-MF), inverse multiquadric function (RBF-IMF). Each basis function produces a different interpolation surface [36].

A RBF is conceptually similar to an elastic membrane that fits on the measured sample values and minimizes the total curvature of the surface; the selection of the basis function determines how the rubber membrane fits between the values [37,38].

In this study, all the above five mentioned RBFs are applied.

C. Global Polynomial Interpolation

Global polynomial interpolation (GPI) is an approximate method that fits a smooth surface defined by a mathematical function (a polynomial) to the input sample points [39].

The user can choice the order of the polynomial that ranges from a first-order to higher order. The interpolation function can be written as:

$$z = \sum_{i=0}^{m_1} \sum_{j=0}^{m_2} a_{i,j}\, x^i y^j \quad (2)$$

If n is the order of the equation, the following relations are valid:

$$0 \le m_1 \le n \quad (3)$$

$$0 \le m_2 \le n \quad (4)$$

$$m_1 + m_2 \le n \quad (5)$$

The values of the coefficients $a_{i,j}$ are determined using the known elevation values in the sample points.

The predictive surface is typically generated by using a least-square regression fit that minimizes the squared differences between the surface and measured points [40]. The estimation of the coefficients permits to determine the value of the polynomial function at any point within the map area [41].

The polynomial can be expanded to any desired degree, although there are computational limits because of rounding error. In this study, the orders 1, 2 and 3 are considered. As we all know, a first order polynomial (linear) corresponds to a flat plan (no bend). A second-order polynomial (quadratic) allows for one bend, a third-order (cubic) for two bends [39].

D. Local Polynomial Interpolation

Local polynomial interpolation (LPI) is similar to GPI, except that it uses a local subset defined by a window rather than using the entire dataset [42]. The window is shifted across the map area and the surface value at the centre of the window is estimated. The size of this window must be large enough to include a reasonable number of data point [43]. For example, a second order polynomial requires at least six points, a third order ten points, and so on.

LPI is more flexible than GPI, but requires to define more parameters [42], i.e. the neighborhood shape, maximum and minimum number of points, sector configuration [44].

E. Kriging

Kriging originated in the field of mining geology as is named after Danie Gerhardus Krige, a mining engineer born in Bothaville, Free State, South Africa, in 1919 [45].

Similarly to IDW, Kriging weights the surrounding measured values to estimate the value at an unknown point. Unlike IDW and other methods, Kriging uses the spatial correlation between sampled points to estimate the value at an unknown point: the spatial arrangement among the measured points, rather than a presumed model of spatial distribution, is used for interpolation; in addition to that, it supplies estimates of the uncertainty surrounding each interpolated value [46].

In other terms, in Kriging, the weights are founded not only on the distance between the measured points and the estimate location, but also on the overall spatial organization of the empirical observations; this can be introduced using the spatial autocorrelation [47].

The spatial correlation between the measurement points can be computed by means of the semi-variance function. It is half the variance of the differences between all possible points spaced a constant distance apart:

$$\gamma = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [Z(u_i) - Z(u_i + h)]^2 \quad (6)$$

Where

N(h) is the number of pairs of measurement points with distance h apart;

$z(u_i)$ is the value at location u_i,

$z(u_i+h)$ is the value at location u_i+h

As points are compared to increasingly distant points, the semivariance increases; in case of strong spatial dependence, points that are closer together will present a smaller semivariance [48].

A variogram is introduced as a graphical representation of the covariance calculated between each pair of points in the sampled data and plotted against the distance. Because half the variance is plotted, the resulting graphical representation is sometimes called “semivariogram”.

Usually, to speed up the procedure, the pairs are gathered into lag bins. For example, the average semivariance is calculated for all pairs of points that present distance between 20 meters and 30 meters.

The empirical semivariogram plotting the observed values is substituted with an acceptable semivariogram model that best fits the data. In this way, the kriging algorithm can access to semivariogram values for lag distances other than those used in the empirical semivariogram [49].

There are several Variogram models available to fit the data [50,51], i.e. linear, gaussian, exponential, stable, etc.

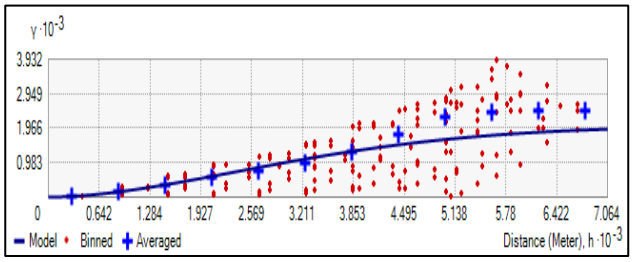


Fig. 4. The Semi-Variogrm Obtained with Ordinary Kriging Application to Bathymetric Data.

Different types of kriging are present in literature, and interested readers could refer to several papers for detailed description of them, e.g. [52, 53]. In this study ordinary kriging (OK), simple kriging (SK) and universal kriging (UK) are considered, using in all cases stable variogram model because it produces the best results. The resulting semi-variogram obtained with ordinary kriging, is shown in Fig. 4.

IV. Comparison of Methods

The accuracy of an interpolation method is usually tested analyzing the closeness of interpolated values to accepted values. In the case of DDM, measured depths can be considered the accepted values. However, the analysis should be carried out on Check Points (CPs) that are not listed in the dataset used for interpolation, and thus the amount of information to be used for DDM generation would be depleted. In other terms, the lack of knowledge about the depth in some points used as CPs would limit the accuracy of the resulting model in these points.

For this reason, the best approach to evaluate the accuracy of DDM is to use Cross Validation (CV). Different methods are available in literature for CV application [54].

One of the possible approach for CV is the leave-one-out method: each sampling point is removed from the dataset and the other points are used to interpolate the depth value at its location; the residual is calculated between measured and interpolated values before moving to the next point [55,56,57]. Rather than removing all the points, once at time, a subset of the initial database can be removed in turn [58]. For this study, the leave-one-out method is applied. The overall performance of the interpolation methods can be avaluated using statistical terms of the differences between the original and interpolated points, such as mean, minimum, maximum, mean absolute, Root Mean Square Error (RMSE), and other factors [59]. RMSE is expressed as:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}\left(Z_i(x,y)-Z_i'(x,y)\right)^2}{N}} \quad (7)$$

Where:

N is the number of the depth points;

Zi (x,y) is the measured depth at the location i(x,y);

$Z_i'(x,y)$ is the interpolated depth at the same location i(x,y).

In this study, fifteen interpolation methods are applied. In Table I, minum, maximum, mean and RMSE of the residuals calculated by CV for each method is reported.

By comparing the interpolation methods applied in this study, it is possible to note some significant differences as well as analogies in the output results for each statistic parameter. The range of minimum values (in m) goes from –44.304 (GPI-1) to −8.991 (SK), while the range of maximum values (in m) goes from 5.054 (RBF) to 22.352 (GPI-1). The range of mean values (in m) goes from -0.038 (IDW) to 0.536 (SK), while the range of RMSE goes from 13.682 to 0.608 (RBF-SwT and RBF-TPS). According to all indicators, four methods tend to be equal in terms of better performance: RBF-SwT, RBF-TPS, OK and UK.

Generally, RBF interpolation methods tend to produce good results for gently varying surface: they are inappropriate when large changes in the depth values occur within short distances and/or when the sample data are affected by considerable measurement error or uncertainty [36]. The area considered in this study is free of wide variations in the morphology and the depth measurements are sufficiently accurate, so RBF methods produce excellent results.

The appropriateness of Kriging approach for bathymetry representation and its better performance that other methods such as IDW [60] are confirmed in this study.

As is to be expected, GPIs give the worst outcomes. As evidenced by other performing methods, the study area presents a morphology that is unlike plane or second or third order surface, so the results of GPIs cannot be satisfactory.

One of the most performed model, resulting from ordinary kriging application, is shown in Fig. 5 (2D visualization) and Fig. 6 (3D visualization).

TABLE. I. Statistical Terms of the Residuals Supplied by Cross Validation

Interpolation method	**Statistical terms of the residuals**			
	Min (m)	***Max (m)***	***Mean (m)***	***RMSE (m)***
IDW	-12.982	6.251	-0.038	1.517
RBF - CRS	-14.707	9.538	-0.010	1.201
RBF - SwT	-9.313	5.054	0.004	0.608
RBF - TPS	-9.313	5.054	-0.003	0.608
RBF - MF	-9.381	7.372	-0.009	0.801
RBF - IMF	-9.449	7.934	-0.007	0.876
GPI-1	-44.304	22.352	0.006	13.682
GPI-2	-35.367	17.129	0.002	5.840
GPI-3	-30.502	12.297	-0.001	4.350
LPI-1	-9.347	5.198	0.058	0.735
LPI-2	-9.272	5.809	0.006	0.757
LPI-3	-9.197	5.667	-0.006	0.748
OK	-9.335	5.272	0.027	0.724
SK	-8.991	8.006	0.536	1.649
UK	-9.332	5.272	0	0.717

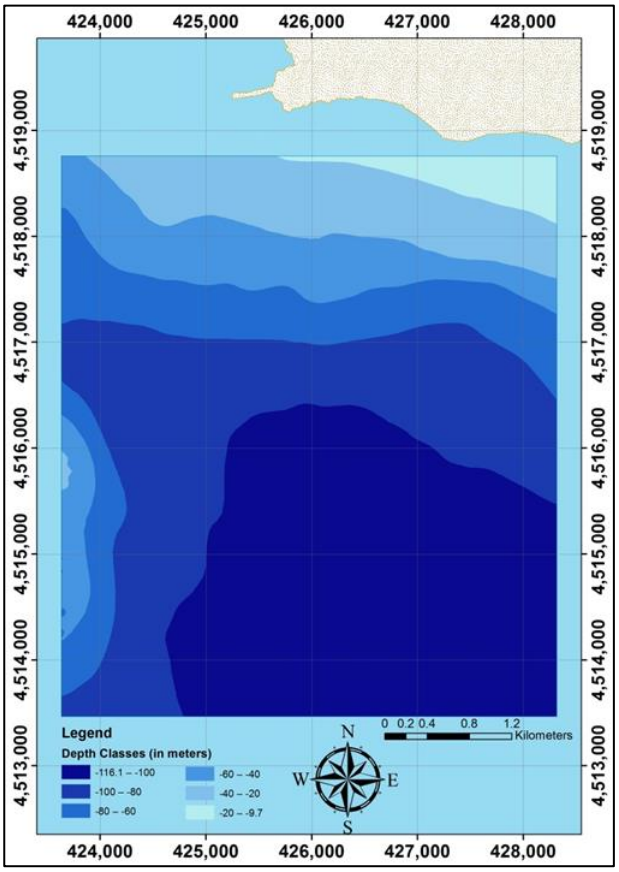


Fig. 5. One of the Most Performed Model (Resulting from Ordinary Kriging Application) in 2d Visualization.

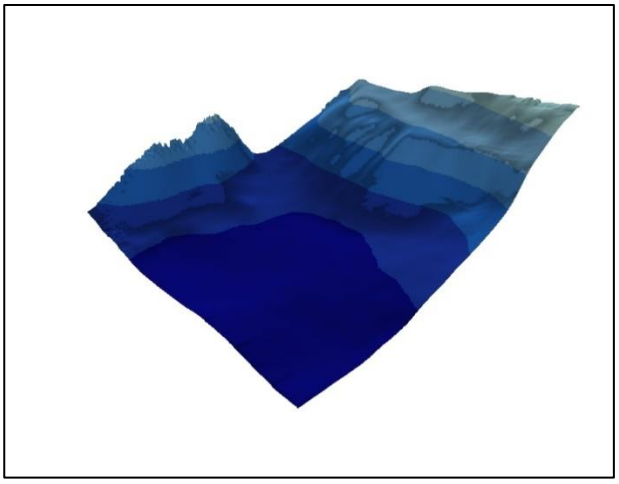


Fig. 6. 3D Visualization of the Model Shown in Fig. 5.

V. Conclusion

The analysis presented here illustrates the performance of spatial interpolation methods for bathymetry modelling. Because every method gives a different output representation, the main challenge is to produce the most accurate model based on the available data. This goal can be achieved by comparing different methods. In this study, 15 methods are tested on 2023 depth points resulting from single beam echo sounder survey of the Gulf of Pozzuoli. CV leave-one-out is used to analyze the performance of each interpolation methods: statistical terms of the differences between measured and interpolated points permit to compare the considered methods.

RBF-SwT, RBF-TPS, OK and UK present the better performance, GPI-1, GPI-2 and GPI-3 the worst. The positive results of some interpolation methods find easy explanations: they are due to the quite regular distribution and sufficiently accurate measurement of the initial points for the RBF methods, and to the greater interpretative capacity of the stochastic approach for kriging methods.

The results obtained in this study remark that the quality of a DDM is related to the choice of an appropriate interpolation method in order to fit the dataset, according to other studies on those aspects [11,34,42]. However, single beam echo sounder survey permits the availability of data that are not completely random: depth points are quite regularly distributed along the ship routes and that eases the interpolation process. Nevertheless, some factors such as the distance between two nearby ship routes and seabed morphology have an important influence on the accuracy of the chosen method.

Concerning the future developments of this work, further studies will be focused on the possibility to integrate data from different bathymetry survey in order to increase the number of available depth values and to evaluate the relationship between point density and model accuracy. In addition, we will be mainly focused on the relationship between interpolation methods and seabed morphology.

Acknowledgment

The research is supported by University of Naples “Parthenope”. We wish to thank the Italian Hydrographic Office (Istituto Idrografico della Marina) for providing the data. We also like to thank the technical staff of our Department for their contribution to this project; particularly, special thanks should be given to Mr. Mariano Rovito (Laboratory of Topography and Photogrammetry) and Ferdinando Sposito (Laboratory of Geomatica, Remote sensing and GIS), for their valuable technical support to this project.

References

[1] Z. Zhan, Y. Fu, R. J. Yang, Z. Xi, Z., and L. Shi, “A Bayesian inference based model interpolation and extrapolation,” SAE International journal of materials and manufacturing, 5(2), pp. 357-364, 2012.

[2] K. Wang, “A study of cubic spline interpolation,” InSight: Rivier Academic Journal, 9(2), 2013.

[3] P. P. Shingare, and M, S. S, Kale, “Review on digital elevation model,” International Journal of Modern Engineering Research (IJMER), 3(4), pp. 2412-2418, 2013.

[4] A. Barac, Automatic conversion of scanned sea charts into 3D models (Master's thesis), 2012.

[5] J. Stoer, and R. Bulirsch, Introduction to numerical analysis, Vol. 12, Springer Science & Business Media, 2013.

[6] S. D. Conte, and C. De Boor, Elementary numerical analysis: an algorithmic approach, SIAM, Philadelphia (USA), 2017.

[7] C. L. Miller, and R. A. Laflamme, “The digital terrain model theory and application,” Photogrammetric Engineering, Vol. 24 (Issue 3), pp- 433–442, 1958.

[8] Stilla, U., and Soergel, U. “Reconstruction of buildings in SAR imagery of urban areas,” in Urban remote sensing (pp. 47-67). Taylor & Francis, 2014.

[9] C. Hirt, "Digital terrain models," in Encyclopedia of Geodesy, 1-6, DOI 10.1007/978-3-319-02370-0_31-1, Springer International Publishing, Switzerland, 2014.

[10] Z. Li, Q. Zhu, and C. Gold, Digital terrain modeling: principles and methodology, CRC Press, Boca Raton, FL, 2005.

[11] G. Garnero, and D.Godone, "Comparisons between different interpolation techniques," in International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 5, W3, 2013.

[12] P. Maglione, C. Parente, R. Santamaria, and A. Vallario, "3D thematic models of land cover from DTM and high-resolution remote sensing images WorldView-2," Rendiconti Online della Società Geologica Italiana, Vol. 30:33-40, 2014.

[13] N. A. Gesim, N. A., and T. Okazaki, "Assessment of Groundwater Vulnerability to Pollution using DRASTIC Model and Fuzzy Logic in Herat City, Afghanistan," IJACSA - International Journal of Advanced Computer Science and Applications, 9(10), pp. 181-188, 2018.

[14] A. Rasooli, and D. Kang, "Assessment of potential dam sites in the Kabul River Basin using GIS," IJACSA - International Journal of Advanced Computer Science and Applications, Vol. 6, No. 2, 2015.

[15] M. C. Spreafico, L. Perotti, F. Cervi, M. Bacenetti, G. Bitelli, V. A. Girelli, E. Mandanici, M. A. Tini, and L. Borgatti, "Terrestrial Remote Sensing techniques to complement conventional geomechanical surveys for the assessment of landslide hazard: The San Leo case study (Italy)," European Journal of Remote Sensing, 48(1), pp. 639-66., 2015.

[16] K. Freeborough, C. Dashwood, D. D. Doce, G. Jessamy, S. Brooks, H. Reeves, and S. Abbott, "A national assessment of landslide hazard from Outside Party Slopes to the rail network of Great Britain," Quarterly Journal of Engineering Geology and Hydrogeology, qjegh2018-029, 2018.

[17] P. Maglione, C. Parente, and A. Vallario, "High resolution satellite images to reconstruct recent evolution of domitian coastline," American Journal of Applied Sciences, 12(7), pp. 506-515, 2015.

[18] International Hydrographic Organization (IHO), IHO Standards for Hydrographic Surveys. 5th edition, International Hydrographic Bureau, Monaco, Special Publication No: 44, 2008.

[19] C.T. Chen, and F. J Millero, "Speed of sound in seawater at high pressures," The Journal of the Acoustical Society of America, vol. 62, no. 5, pp. 1129-1135, 1977.

[20] R. Urick, Principles of Underwater Sound, McGraw-Hill, 1983.

[21] F. J. L. Ribeiro, A. C. P. Pedroza, and L. H. M. K. Costa, "Deepwater monitoring system using logistic-support vessels in underwater sensor networks," in The 21st International Offshore (Ocean) and Polar Engineering Conference-ISOPE , Vol. 2, pp. 327-333, 2011.

[22] Nichy Du, "Speed of Sound in Water," in The Physics Factbook – Hypertextbook,2000,https://hypertextbook.com/facts/2000/NickyDu.shtml.

[23] F. Giordano, G. Mattei, C. Parente, C., F. Peluso, and R. Santamaria, "Integrating sensors into a marine drone for bathymetric 3D surveys in shallow waters". Sensors, 16(1), 41, 2016.

[24] P Barr, F. J., and Sanders, J. I. "Attenuation of water-column reverberations using pressure and velocity detectors in a water-bottom cable," in SEG Technical Program Expanded Abstracts 1989 (pp. 653-656). Society of Exploration Geophysicists, 1989.

[25] The International Federation of Surveyors (FIG), Publication 56 - Guidelines for the Planning, Execution and Management of Hydrographic Surveys in Ports and Harbours, Copenhagen, Denmark, 2010

[26] Ferreira, H., Almeida, C., Martins, A., Almeida, J., Dias, N., Dias, A., and Silva, E. "Autonomous bathymetry for risk assessment with ROAZ robotic surface vehicle," in Oceans 2009-Europe (pp. 1-6). Ieee.

[27] Canadian Hydrographic Service, Hydrographic survey management guidelines, June 2013, Edition 2, 2009.

[28] Esri, ArcGIS 10.3, Redlands, CA, USA, 2015.

[29] W. R. Tobler, "A computer movie simulating urban growth in the Detroit region," Economic Geography, Vol. 46, pp. 234–40, 1970.

[30] H. J. Miller, "Tobler's first law and spatial analysis," Annals of the Association of American Geographers, 94(2), pp. 284-289, 2004.

[31] C. Özkan, "Surface interpolation by adaptive neuro-fuzzy inference system based local ordinary kriging," in Asian Conference on Computer Vision, pp. 196-205, Springer, Berlin, Heidelberg, January 2006,

[32] N. S. N. Lam, "Spatial interpolation methods: a review," The American Cartographer, 10(2), pp. 129-150, 1983.

[33] Bartier, P. M., and Keller, C. P.. Multivariate interpolation to incorporate thematic surface data using inverse distance weighting (IDW). *Computers & Geosciences*, *22*(7), 795-799, 1996.

[34] Alcaras, E., Parente, C. and Vallario, "A Comparison of different interpolation methods for DEM production," International Journal of Advanced Trends in Computer Science and Engineering. Vol. 6: 1654-1659, 2019.

[35] ESRI, "How inverse distance weighted interpolation works," in ArcGIS Pro help, ESRI, Redlands, CA, USA.

[36] ESRI, "How radial basis functions work," in ArcGIS Pro help, ESRI, Redlands, CA, USA.

[37] G.F. Lin, and L.H. Chen, "A spatial interpolation method based on radial basis function networks incorporating a semivariogram model,". J. Hydrol 288(3–4), pp.288–298, 2004, doi:10.1016/j.jhydrol.2003.10.008

[38] H. Apaydin, F. K. Sonmez, and Y. E. Yildirim, "Spatial interpolation techniques for climate data in the GAP region in Turkey," Climate Research, 28(1), pp. 31-40, 2004.

[39] ESRI, "How global polynomial interpolation works," in ArcGIS Pro help, ESRI, Redlands, CA, USA,

[40] S. Eberly, J. Swall, D. Holland, B. Cox, and E.Baldridge, ,"Developing spatially interpolated surfaces and estimating uncertainty," United States Environmental Protection Agency, pp. 28-40, 2004.

[41] W. Wang, W. Qi, N. Chen, P. Wang, and J. Chen, J. "Research on determining the weights of urban land grading evaluation factors based on Spearman rank correlation analysis," in International Symposium on Spatial Analysis, Spatial-Temporal Data Modeling, and Data Mining, Vol. 7492, p. 74921U, International Society for Optics and Photonics, October 2009.

[42] W. Luo, M. C. Taylor, and S. R. Parker, "A comparison of spatial interpolation methods to estimate continuous wind speed surfaces using irregularly distributed data from England and Wales," International Journal of Climatology: A Journal of the Royal Meteorological Society, 28(7), 947-959, 2008.

[43] M. J. De Smith, M. F. Goodchild, and P. Longley, Geospatial analysis: a comprehensive guide to principles, techniques and software tools. Troubador publishing ltd, Leichester (UK), 2007.

[44] J. Seyedmohammadi, L. Esmaeelnejad, M. Shabanpour, "Spatial variation modelling of groundwater electrical conductivity using geostatistics and GIS," Modeling earth systems and environment, 2(4), pp. 1-10, 2016.

[45] Assibey-Bonsu, W., "Professor Danie Krige's First Memorial Lecture: The Basic Tenets of Evaluating the Mineral Resource Assets of Mining Companies, as Observed in Professor Danie Krige's Pioneering Work Over Half a Century," in Geostatistics Valencia 2016 (pp. 3-25). Springer, Cham, 2017.

[46] Columbia University Mailman School of Public Health, Kriging, Columbia University, 722 West 168th St. NY, NY 10032, https://www.mailman.columbia.edu/research/population-health-methods/kriging

[47] ESRI, "How kriging works", in ArcGIS Pro help, ESRI, Redlands, CA, USA,

[48] L. H. Peters, Spatial Autocorrelation: Covariance and Semivariance, GEOG 593, 2009.

[49] **G.** Bohling, G., "Introduction to geostatistics and variogram analysis," Kansas geological survey, 1, pp. 1-20.

[50] M. Armstrong, Basic linear geostatistics. Springer Science & Business Media, 1998.

[51] D. Chen, Advances in data, methods, models and their applications in Geoscience. BoD–Books on Demand, 2011.

[52] M Meul, and M. Van Meirvenne, "Kriging soil texture under different types of nonstationarity," Geoderma, 112(3-4), pp. 217-233, 2003.

[53] P. Singh, and P. Verna, "A Comparative Study of Spatial Interpolation Technique (IDW and Kriging) for Determining Groundwater Quality," in Venkatramanan, S., Viswanathan, P. M., & Chung, S. Y. (Eds.). GIS and Geostatistical Techniques for Groundwater Science, Elsevier, 2019.

[54] K. C. Lam, R. G. Bryant, and J. Wainright, "Application of spatial interpolation method for estimating the spatial variability of rainfall in Semiarid New Mexico, USA," Mediterranean Journal of Social Sciences, 6(4), S3, 2015.

[55] P. A. Burrough, and R.A. McDonnell, Principles of Geographical Information Systems, Oxford: Oxford University Press, 1998.

[56] R. S. Bivand, E.J. Pebesma, and V. Gomez-Rubio, Applied Spatial Data Analysis with R, Springer, 2008.

[57] G. E.Fasshauer, and J. G. Zhang, "On choosing "optimal" shape parameters for RBF approximation," Numerical Algorithms, 45(1-4),pp. 345-368, 2007.

[58] U. Falchi, C. Parente, and G. Prezioso, "Global geoid adjustment on local area for GIS applications using GNSS permanent station coordinates," Geodesy and Cartography, 44(3), pp. 80-88, 2018.

[59] A. I. EL-Hattab, "Single beam bathymetric data modelling techniques for accurate maintenance dredging," The Egyptian Journal of Remote Sensing and Space Science, 17(2), 189-195, 2014.

[60] I. O. Ferreira, D. D. Rodrigues, G. R. D. Santos, and L. M. F. Rosa, "In bathymetric surfaces: idw or kriging?," Boletim de Ciências Geodésicas, 23(3), pp. 493-508, 2017.

Study of Cross-Platform Technologies for Data Delivery in Regional Web Surveys in the Education

Evgeny Nikulchev[1], Dmitry Ilin[2]
Vladimir Belov[3], Pavel Pushkin[4]
MIREA–Russian Technological University, Russia

Pavel Kolyasnikov[5]
Russian Academy of Education
Russia

Sergey Malykh[6]
Psychological Institute of Russian Academy of Education
Russia

***Abstract*—Web-surveys are a popular form of collecting primary data from various studies. However, mass regional polls have their own characteristics, including the following: it is necessary to take into account various platforms and browsers, as well as the speed of networks, if rural areas remote from large centers are involved in the polls. Ensuring guaranteed data delivery in these conditions should be the right choice of technology for the implementation of surveys. The paper presents the analysis results of the technologies sustainability to various regional conditions for web survey conducted within one week at schools throughout the Russian Federation. The survey involved 20 000 real educators. The paper describes the technologies used and provides information about browsers and operation systems used by respondents. The absence of failures in data delivery confirms the effectiveness of the solutions.**

Keywords*—Web-surveys; mass regional polls; various platforms and browsers; cross-platform technologies

I. Introduction

An adequate choice of information technology ensures a guaranteed quality of primary data delivery and user convenience in mass regional surveys.

The research was conducted using the digital platform [1] for large-scale psychological research DegitilPsyTool.ru [2], developed by the Russian Academy of Education. The platform is designed to collect large amounts of data using web technologies [3], meets the requirements of the legislation of the Russian Federation for the functioning of information systems.

The digital platform is a tool for collecting and storing research data, which are the basis for the formation of methods, analytical materials, guidelines, at the territorial, regional and federal levels.

Primary data collection is carried out using web interfaces [4] of the described platform. Database is being formed based on surveys at schools [5]. These data are going to be available for analysis by multidisciplinary research teams. The methods used to conduct research are integrated into the digital platform after careful study and become available for expert analysis. Long-term data storage is provided in conjunction with the methods used in the Data Center of Russian Academy of Education. This will allow to track the dynamics of changes in indicators, their characteristics, to make selective analysis according to regional characteristics, to consider factors influencing factors on the value of indicators, as well as their change over time.

Digital Psychological Tools platform is developed as an ever-evolving information environment with a set of tools for conducting research at all levels, consolidating diverse research groups and ensuring interaction between them.

Data collection tools are aimed at followings: data collecting in educational institutions and samples of any size; collecting population research data; collecting longitudinal research data; collecting research data on experimental techniques. Tools were created for formatting new techniques and use the capabilities of the existing base of proven, reliable methods of psychological research.

The platform tools allow conducting a simultaneous survey of a large number of schools, including through the use of technology for simultaneous work both online and offline, followed by the transfer of results.

The platform is developed to comply with the requirements of the legislation of the Russian Federation for data storing and processing.

Big data storage tools meet today's technological challenges. Based on new information technologies and data structuring for processing large amounts of data, the followings have been formed: a multi-level data storage system that provides quick access to frequently used data, a poorly structured storage form that allows you to store data along with the methods used; a virtualization system for computing resources, which allows for simultaneous development and operation of the platform; a backup system that ensures the integrity and safety of data, as well as a system of customizable switching network interaction with databases, to ensure the operational interaction of applications and analytical-information systems with databases.

The paper consists of 2 parts. The first part presents the results of the analysis of the sustainability of technologies to various regional conditions in conducting a web survey completed within one week throughout the Russian Federation at schools. The survey involved 20,000 real educators. The first part discusses the issues of creating a cross-platform interface and presents the results on the use of browsers in conducting mass research in the education system on the territory of the Russian Federation. The second part describes the solution for collecting data in a browser and then packing it into an archive,

which ensures independence from the communication channel during the survey completing.

II. Cross-Platform Research

For web-based software implementation of the test survey, an internal standard for the presentation of the test in a structured form has been developed. It allows using a special algorithmic structure to create a psychological test interface based on elements that have been developed and tested on various devices and OS. The presence of the standard makes it possible to develop an interactive designer of quiz tests to automate the creation of new tests.

Based on the analysis of functional requirements and limitations related to the survey, it was found that the most effective form of intra-platform presentation is the use of JSON (JavaScript Object Notation) format [6, 7]. To control the structure of JSON documents [8, 9], JSON Schema tools are used.

In the platform, each research methodology consists of automatically generated surveys (for school principals and psychologists). The software implementation of each survey is a web interface for interviewing respondents. At the same time, an important feature is the need for cross-platform functioning of interfaces [10], which makes it possible to conduct polls on a wide range of devices, popular browsers and operation systems like Windows, Linux, MacOS, iOS, Android. The used intra-platform standard for describing survey elements will allow the automatic generation of an interface [11] in various software environments.

Generated on the basis of the survey description standard [12], the web interface has been tested on various devices, operation systems and browsers. The approach used is cross-browser [13] and allows the interface to work and to display in all popular browsers with a certain adaptation in real time. A schematic example of the display of the user interface for various types of devices is shown in Fig. 1.

Fig. 1. An Example of Adapting an Interface for Various Types of Devices.

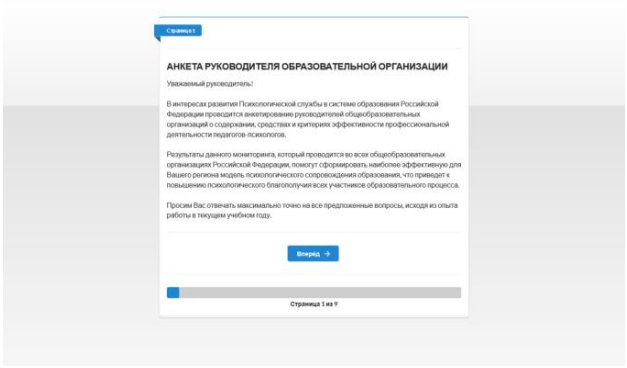


Fig. 2. The Initial Page of the School Head's Surveys.

Fig. 2 to 4 show screenshots of the school heads surveys.

Fig. 5 to 7 shows screenshots of the survey pages.

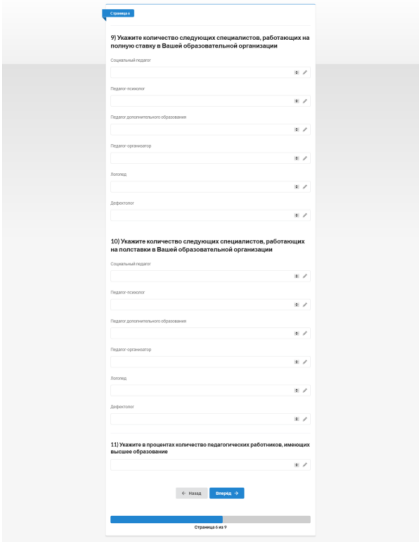


Fig. 3. An Example of the School Head's Survey Interface.

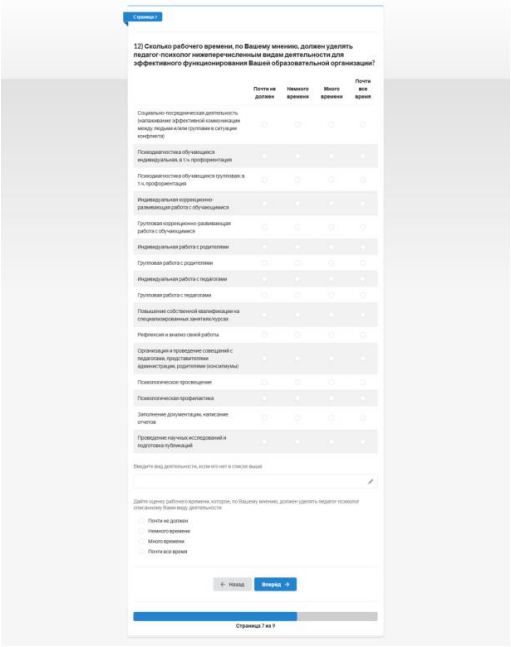


Fig. 4. An Example of the Interface for School Heads.

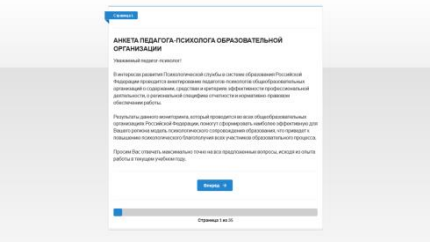


Fig. 5. The Initial Page of the Psychologist Profile.

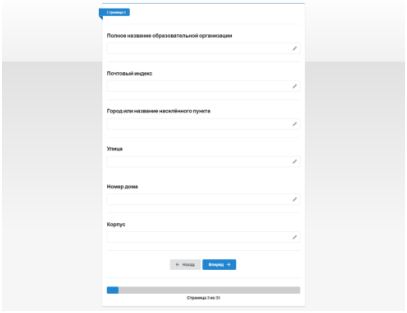


Fig. 6. An Example of the Profile Interface for the Psychologist.

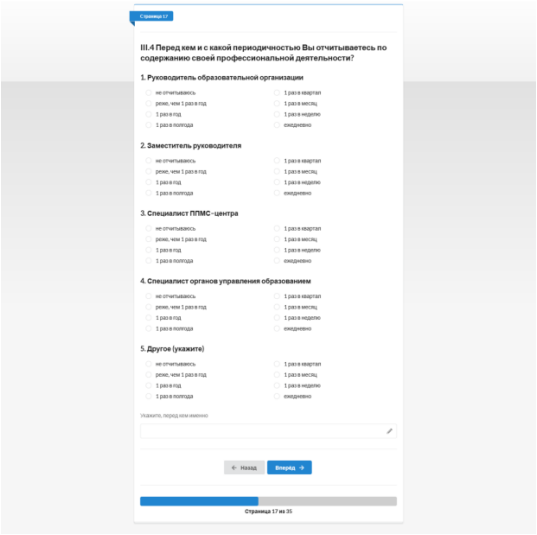


Fig. 7. An Example of the Profile Interface for the Psychologist.

As a monitoring result, information was obtained on the operation systems and browsers types used for survey. The results obtained indicate the effectiveness of the selected technologies, since all surveys were successfully completed without distortion of the images from the respondents. Fig. 8 shows the main operation systems, in Fig. 9 shows browsers used to fill out surveys at schools during a mass survey across Russian Federation.

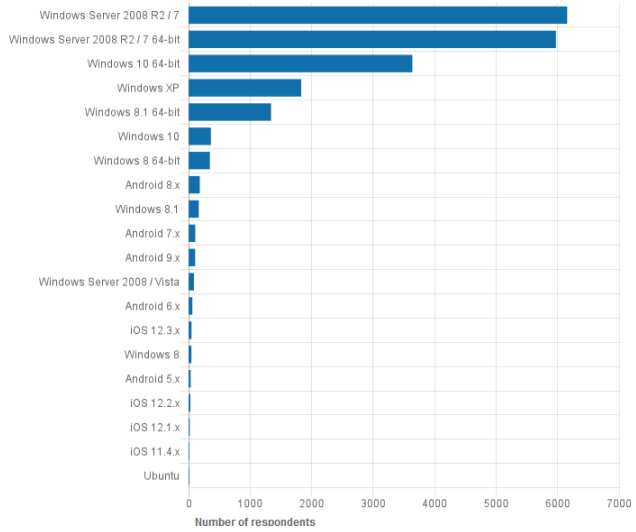


Fig. 8. Operation Systems used to Fill out Survey.

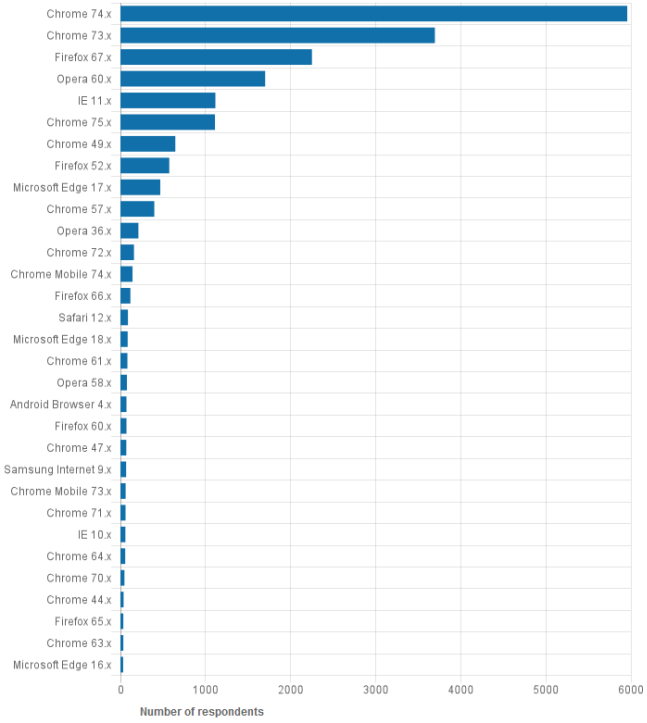


Fig. 9. Browsers used to Fill out Survey.

III. The Use of the Archiving for Ensuring Guaranteed Data Delivery

One of the monitoring tasks is to ensure functioning, independent of the quality of the communication channel. This problem is solved due to the following logic. Firstly, the archive, which contains necessary files (such as images) and the survey structure based on the JSON schema, is being loaded onto the client side. Then, the sever receives not archived JSON file with the survey results (it contains the numbers of questions and entered data).

It is assumed that the archive is a complete package that is transmitted to the client browser along with the survey format and other data necessary for data collection. All system data must be downloaded before the test starts and its integrity check is carried out (checksum). To ensure control, it is more convenient to transfer data to the browser in the form of an archive, since it will be necessary to download only one file and check only its checksum. If you use the standard approach and upload multiple files separately, you will have to verify the checksums for each of them separately, and on the server side you will need to organize additional storage.

Using client-side archives changes the standard approach for working with files. In the standard approach, the address of the actual location of the requested resource is indicated in HTML, for example, an image that will be downloaded by HTTP request and displayed automatically by the browser. In the case of using archives, all actions will need to be done programmatically: download it in its entirety, unpack it and only then use it in HTML. In addition, the browser may require more computing resources and computer RAM to work with the archive, since it will not be able to directly optimize the loading, saving and caching downloaded images and files.

As an archive, the preferred option is using the zip format, which is supported by a large number of operation systems and programs. This will allow to pack and unpack the contents of the survey without the need for additional software. In this regard, it will be most appropriate to use the JSZip library [14], which has an API for working with zip archives.

JSZip is a JavaScript library for reading, creating and editing zip files and is distributed on the basis of two licenses - MIT or GPLv3. According to the documentation [15], JSZip is guaranteed to support files up to 10 MB in size, does not support data encryption and multi volumes, uses only UTF-8. The library works in all modern browsers, such as Firefox, Google Chrome, Opera, Internet Explorer 10+ and Edge. In Internet Explorer 9 and below, JSZip does not work well and may crash when working with large files, as these browser versions do not support typed arrays and the compression algorithm will use regular arrays.

A number of tests were performed to evaluate the capabilities of the JSZip library.

Testing Cyrillic characters. Archives that were created on Mac OS are read normally, while archives that were created on Windows have incorrectly encoded file names. Due to the fact that on Mac OS, the encoding is UTF-8, and on Windows, most likely, cp1251. The compression level does not affect the ability to read archives; only the unpacking time and CPU load may change, but only slightly. Encrypted archives are not supported by the library and cannot be opened. Supported compression method Deflate, other methods work will not be read, due to the use of the pako library.

Testing bulk archives. Various computers and smartphones were taken to test the JSZip library. According to the measurements, it is clear that the time of unpacking a large archive is not critical even on a mobile device.

The finished survey for the psychological platform is a complete ZIP archive. For preparing a test in the specified format, ZIP archiving should be used without compression and without setting a password.

The archive should contain the *index.json* file. This file should be executed strictly in accordance with the specification below. For a typical case, the following archive structure is proposed:

```
index.json
resources/
    question_1/
        image_1.jpg
        image_2.jpg
        ...
    question_2/
        image_1.jpg
        image_2.jpg
        ...
```

In addition to the mandatory presence of the *index.json* file, there are the following limitations of the psychological test downloaded to the archive platform:

- archive size: no more than 10 megabytes;

- archive format: ZIP;

- compression: absent;

- password: none;

- file names: case sensitive.

Due to the ever-increasing complexity of tools and technologies in web development, the task arises of preparing the client part of the project for its proper operation and display in the user's browser. For its implementation, assembly systems are used that automate the process of preparing code and resources of the client part of the web application. The main objective of automation systems for assembling client web applications is to combine the same type of modules and automate routine tasks.

The main tasks implemented by the assembly systems can be distinguished:

- web language compilation (CoffeeScript, TypeScript, Babel) [16, 17];
- compilation of CSS preprocessor (LESS, SASS, Stylus) and postprocessors (PostCSS, Rework) [18, 19];
- modular system implementation JavaScript (AMD, CommonJS) [20];
- code minification and obfuscation;
- preparing web resources (image compression, deleting meta data, creating sprites, preparing fonts, etc.);
- checking the code for quality, i.e. code linting (ESLint, JSLint, JSCS, JSHint) [21–23].

As a solution for building the client part of the web application, Webpack was used [24], which is a modern solution that provides high speed and relevant tools for the developer. Webpack, unlike the Gulp and Grunt counterparts, offers much more features by default and covers most of the required build tasks. However, it is worth noting that Gulp and Grunt are task managers for Node.js, and not a complete build system like Webpack. To create a build process on Gulp and Grunt, it is needed to write manual build tasks.

To implement the functionality that is not available in the standard Webpack package, the following extensions were applied:

- ExtractTextPlugin. It is used to extract the text of the processed module and save to an external file. Required when processing style sheets.
- OptimizeCssAssetsPlugin. It implements the functionality to minimize the resulting CSS markup code.
- CopyWebpackPlugin. It implements the functionality of copying individual files or structural units.

- HotModuleReplacement. It implements a quick module replacement mechanism. This mechanism significantly increases development speed and is used when tracking changes to apply them.
- ProvidePlugin. It imports dependencies common to the entire project.
- UglifyJsPlugin. It implements the functionality for minimizing JavaScript code.
- ConfigWebpackPlugin. It combines environment and internal configuration.
- Optimize.CommonChunk. It separates code sections, which are common for several modules, into a separate file.

In addition to extensions, the project also involved external loaders that process the input data, since the functionality, they implement, cannot be implemented using standard Webpack tools:

- file-loader. Arbitrary input file processing.
- babel-loader. Compilation of JavaScript ES6 code in compatible with most browsers ECMAScript 5;
- css-loader. CSS code processing;
- sass-loader. Convert SCSS and SASS code to CSS;
- ng-cache-loader. Provides support for HTML templates;
- image-webpack-loader. Image processing and compression.

The results of monitoring at schools in Russia demonstrated the effectiveness of the selected methods and information technologies. Fig. 10 shows the distribution of the rendering time of the survey on the client device, which confirms the advisability in using the developed technology for transmitting data in the form of an archive.

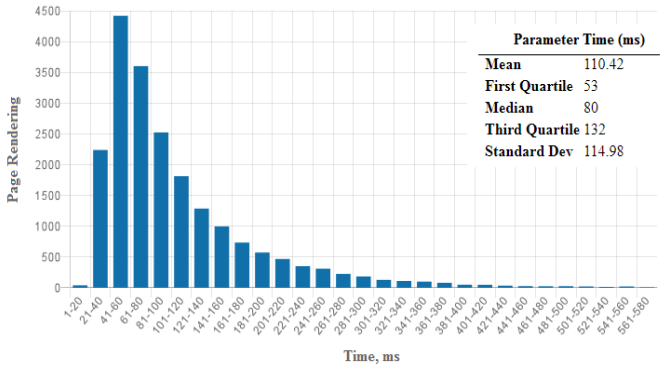


Fig. 10. Distribution Characterizing the Time of Rendering Survey Pages.

IV. Conclusion

The survey involved 20,000 real school heads from municipal and village schools throughout the country. The absence of failures in data delivery using various operation systems and browsers confirms the effectiveness of the solutions.

Thus, the selected web-based survey tools based on the Digital Platform for Interdisciplinary Psychological Research, as a result of monitoring, have demonstrated their effectiveness and prospects for conducting federal-level research at schools.

Acknowledgments

The study was performed as part of the state task of the Ministry of science and height education of Russian Federation, project 25.13253.2018 / 12.1 “Development of the technological concept of the Data Center for Interdisciplinary Research in Education”.

References

[1] R. D. Hays, H. Liu, & A. Kapteyn, “Use of Internet panels to conduct surveys,” Behavior research methods, vol. 47, no. 3, pp. 685-690, 2015.

[2] I. Zakharov, E. Nikulchev, D. Ilin, V. Ismatullina, & A. Fenin, “Web-based platform for psychology research,” ITM Web of Conferences, vol. 10, p. 04006, 2017.

[3] E. Nikulchev, D. Ilin, P. Kolyasnikov, I. Zakharov, & S. Malykh, “Programming technologies for the development of web-based platform for digital psychological tools,” International Journal of Advanced Computer Science and Applications, vol. 9, no. 8, pp. 34-45, 2018.

[4] F. Keusch, “Why do people participate in Web surveys? Applying survey participation theory to Internet survey data collection,” Management review quarterly, vol. 65, no. 3, pp. 183-216, 2015.

[5] M. Das, P. Ester, & L. Kaczmirek (ed.), “Social and behavioral research and the internet: Advances in applied methods and research strategies,” Routledge, 2018.

[6] J. Xin, C. Afrasiabi, S. Lelong, …, & C. Wu, “Cross-linking BioThings APIs through JSON-LD to facilitate knowledge exploration,” BMC bioinformatics, vol. 19, no. 1, p. 30, 2018.

[7] S. Brahmia, Z. Brahmia, F. Grandi, & R. Bouaziz, “A Disciplined Approach to Temporal Evolution and Versioning Support in JSON Data Stores,” In Emerging Technologies and Applications in Data Processing and Management, IGI Global, 2019, pp. 114-133.

[8] A. Agocs, & J. M. Le Goff, “A web service based on RESTful API and JSON Schema/JSON Meta Schema to construct knowledge graphs,” In 2018 International Conference on Computer, Information and Telecommunication Systems (CITS), IEEE, 2018, pp. 1-5.

[9] J. L. C. Izquierdo, & J. Cabot, “JSONDiscoverer: Visualizing the schema lurking behind JSON documents,” Knowledge-Based Systems, vol. 103, pp. 52-55, 2016.

[10] M. Jasim, “Building cross-platform desktop applications with electron,” Packt Publishing Ltd, 2017.

[11] E. Nikulchev, D. Ilin, P. Kolyasnikov, and A. Kosenkov, “E-learning Tools on the Healthcare Professional Social Networks,” International Journal of Advanced Computer Science and Applications, vol. 10, no. 4, p. 29-34, 2019.

[12] V.K. Grigoriev, A.S. Ilyushechkin, &M.A. Ovchinnikov, “Quality assessment of a user interface based on the mental time of performing the user tasks of the subject area,” Russian Technological Journal, vol. 7, no. 1, pp. 38-47, 2019.

[13] E. Yigitbas, A. Anjorin, I. Jovanovikj, …, & G. Engels, "Usability Evaluation of Model-Driven Cross-Device Web User Interfaces," In International Conference on Human-Centred Software Engineering, 2018, pp. 231-247.

[14] J. V. de Figueiredo Leite, J. M. X. N. Teixeira, & V. Teichrieb, "Optimizing 3D object visualization on the web," International Conference on Virtual, Augmented and Mixed Reality, 2016, pp. 287-298.

[15] S. Knightley, D. Duponchel, F. Buchinger, & A. Afonso, "JSZip," Oracle, 2016 (https://docs.oracle.com/cd/E80480_01/English/licensing_information/helpmain.htm?toc.htm?103589.htm).

[16] T. Burnham, "Coffeescript: accelerated Javascript development," Pragmatic Bookshelf, 2015.

[17] Y. Fain, & A. Moiseev, "Angular 2 Development with TypeScript," Manning Publications Co., 2016.

[18] F. Marani, "Adding CSS/JavaScript to Our Django Project," In Practical Django 2 and Channels 2. Apress, Berkeley, CA, 2019, pp. 179-203.

[19] Libby A. Mastering PostCSS for Web Design. – Packt Publishing Ltd, 2016.

[20] U. Campos, G. Smethurst, J. P. Moraes, R. Bonifácio, &, G. Pinto, "Mining rule violations in JavaScript code snippets," In Proceedings of the 16th International Conference on Mining Software Repositories, 2019, pp. 195-199.

[21] K. F. Tómasdóttir, M. Aniche, & A. Van Deursen, "The adoption of javascript linters in practice: A case study on eslint," IEEE Transactions on Software Engineering, 2018.

[22] D. Crockford, "Jslint: The javascript code quality tool," 2011 (http://www.jslint.com).

[23] A. Mardan, "Getting Node. js Apps Production Ready," Practical Node.js. Apress, Berkeley, CA, 2018, pp. 331-364.

[24] T. Koppers, "Webpack: Module bundler," 2016.

Method for Texture Mapping of In-Vehicle Camera Image in 3D Map Creation

Kohei Arai[1]
Department of Information Science, Saga University, Saga City, Japan

***Abstract*—Method for texture mapping of in-vehicle camera image in 3D map creation is proposed. Top view of ground cover targets can be mapped easily. For instance, aerial photos, high spatial resolution of satellite imagery data allows creation of top view of ground cover targets and also map creation. It can be used for pedestrian navigations. On the other hand, side view of ground cover targets is not so easy to obtain. In this paper, two methods are proposed. One is to use acquired photos with cameras mounted on the dedicated cars. The other one is to use high spatial resolution of satellite imagery data, such as IKONOS, Orbview, etc. Through experiments with the aforementioned two methods, it is found that texture mapping for the ground cover targets can be done with the two proposed methods in an efficient manner.**

Keywords*—Texture mapping; high spatial resolution of satellite imagery data; 3D map

I. Introduction

It is aimed at visually representing a three-dimensional map easy to understand for people who cannot read a two-dimensional map. "How fast can you map?" is the question. In particular for the texture mapping1 of the side wall of the buildings, the followings are problems,

- The number of buildings is innumerable.
- It cannot spend time on one building.

Therefore, the followings are getting much important,

Create a tool and make it workable.

(Win32 API[2], OpenCV[3], OpenGL[4]) These are candidates for the texture mapping. In this connection, there are the following three questions,

1) How to take a picture?

- Because the way of shooting varies depending on the person, it is diverse, so that the following conditions have to be set in this research.

- Shoot directly in front.

- Take it from an angle.

(It is assumed that 4 corners of the building are contained in one picture)

2) How to map the acquired pictures:

- Photos taken from just in front are easy to map.

- If a picture is taken from an angle, rotate it about the height direction as if it were to be taken from the front as if it were taken. Therefore, three dimensional information required.

3) Mapping models:

Extract three-dimensional information from multiple pictures. Then, Affine Approximate Projection Model[5] can be used with the following model,

(Representative: Para perspective Projection Model[6])

Factorization method[7]

Pedestrian navigation using three-dimensional map

It became easy to understand its position and the direction heading to the destination. Issues in 3D map creation is the followings,

One year to create three-dimensional map around the major 5300 intersections of government-designated cities in Japan. Therefore, 3D map has to be created in an efficient manner considering the followings.

Difficulty in collecting images around the intersection

It takes time to capture, map the image to a 3-dimensional map.

In this paper, two methods are proposed. One is to use acquired photos with cameras mounted on the dedicated cars. The other one is to use high spatial resolution of satellite imagery data, such as IKONOS[8], Orbview[9], etc. Through experiments based on the aforementioned two methods, it is found that texture mapping for the ground cover targets can be done with the two proposed methods in an efficient manner.

The next section describes research background and the proposed method. Then, some experiments are described followed by conclusion with some discussions. After that some future research works are described.

[1] https://en.wikipedia.org/wiki/Texture_mapping
[2] https://ja.wikipedia.org/wiki/Windows_API
[3] https://opencv.org/
[4] https://ja.wikipedia.org/wiki/OpenGL
[5] http://www.isprs.org/proceedings/XXXVII/congress/4_pdf/231.pdf
[6] https://www.cse.unr.edu/~bebis/CS791E/Notes/PerspectiveProjection.pdf
[7] https://en.wikipedia.org/wiki/Factorization
[8] https://www.satimagingcorp.com/satellite-sensors/ikonos/
[9] https://lta.cr.usgs.gov/satellite_orbview3

II. Research Background and the Proposed Method

A. Research Background and the Related Research

Mashups by orchestration and widget-based personal environments: key challenges, solution strategies, and an application is proposed [1]. Meanwhile, semantic mashups. intelligent reuse of Web resources is well described [2]. On the other hand, “What is Web 2.0. Design Patterns and Business Models for the Next Generation of Software” is well reported [3]. Also, "Services Mashups: The New Generation of Web Applications" is proposed [4]. In the meantime, "As Bing Takes Over Yahoo Search, SearchMonkey Dies, BOSS Is No Longer Free, But Site Explorer Still Works". is well reported [5].

Mashup based content search engine for mobile devices is proposed and introduced [6] together with module based content adaptation of composite e-learning content for delivering to mobile learners [7]. Also, efficiency improvements of e-learning document search engine for mobile browser is proposed [8] while efficiency improvement of e-learning document search engine for mobile browser is discussed [9]. Video searching optimization with supplemental semantic keyword for e-learning video searching, is proposed [10] already. 3D Interactive visualization for inter-cell dependencies of spreadsheets is proposed [11] while "IANA Considerations" of the application/json media type for JavaScript Object Notation (JSON) is well reported [12].

Meanwhile, e-learning system utilizing learners' characteristics recognized through learning process with Open Simulator is proposed [13] together with avatar utilized Q/A system of e-learning content designed with Open Simulator [14]. These are related research works to the proposed Method for texture mapping of in-vehicle camera image in 3D map creation. Hvidsten, Mike [15] introducing the OpenGL texture mapping guide in his homepages.gac.edu. (Retrieved 22 March 2018).

B. Conventional Method

Take GoogleSketchUp [10] of 3D software provided by Google for free. Using this, texture mapping can be done. This is a matter of the number of processes and the length of processing time.

Firstly, side view of photo of the building in concern is acquired. Four corners of the building can be extracted easily as shown in Fig. 1. Then, mapped it using the photograph from the front (no rotation). Thus, the side view of the building wall can be mapped with texture.

C. Proposed Method

As described in the previous section, one of the serious problems of the conventional method is the number of processes and too long processing time. In the proposed method, at least two photos are acquired in advance to the texture mapping process. Namely, manually select the four corners of the building taken in the photograph, apply projective transformation as a feature point, and map to the side. This simulation is repeated for five times to measure the average required time. The basic process flow of the proposed texture mapping method is illustrated in Fig. 2.

There are two different image sources, car mounted camera and high spatial resolution camera or radiometer onboard satellite. From the car mounted camera, side view of texture from an aspect of image is acquired while top view of texture and a small portion of side view texture image are acquired from the high spatial resolution radiometer onboard satellite. Occluded side view texture can be assumed from the portion of satellite image. Fig. 2 shows, also, the relation among the coordinate systems of sun illumination, object building or houses, car mounted camera in the world coordinate system. Although the coordinate systems of sun illumination, and the object are fixed, the car mounted camera coordinate system can be moved and vibrated. By using acquired image by the camera, it is possible to estimate the movement as well as vibration in the world coordinate system. Meanwhile, the height of the object can be estimated with the satellite image as shown in the later section.

Fig. 3 shows the process flow of the proposed texture mapping method. Proposal on a method for efficient mapping using pictures taken from onboard camera

It is premised that 3-dimensional information of the building is acquired in advance by Zenrin Co., Ltd.[11] etc. Then, ortho images (images after orthogonal projection conversion) can be created. Fig. 4 shows an example of the texture mapping processed image.

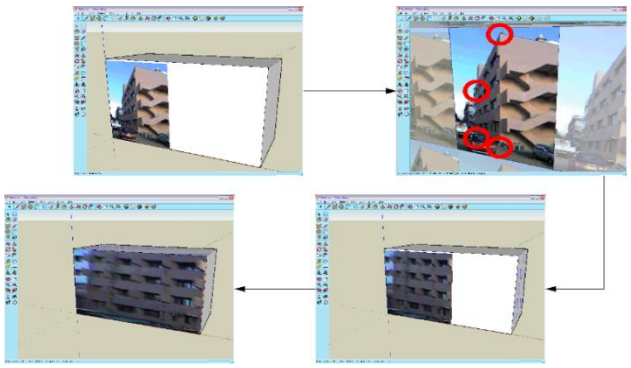


Fig. 1. Side View Texture Mapping with GoogleSketchUp.

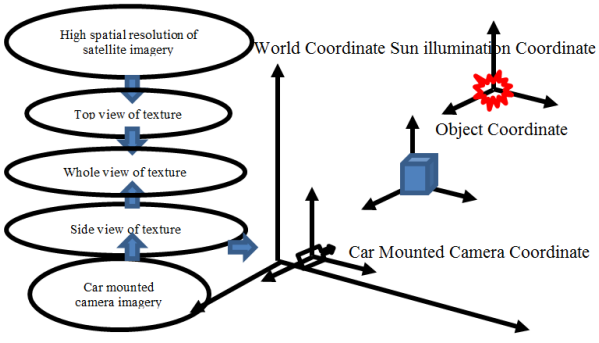


Fig. 2. Basic Process Flow of the Proposed Texture Mapping Method.

[10] https://www.sketchup.com/, https://google-sketchup.jp.uptodown.com/windows

[11] https://www.zenrin.co.jp/english/index.html

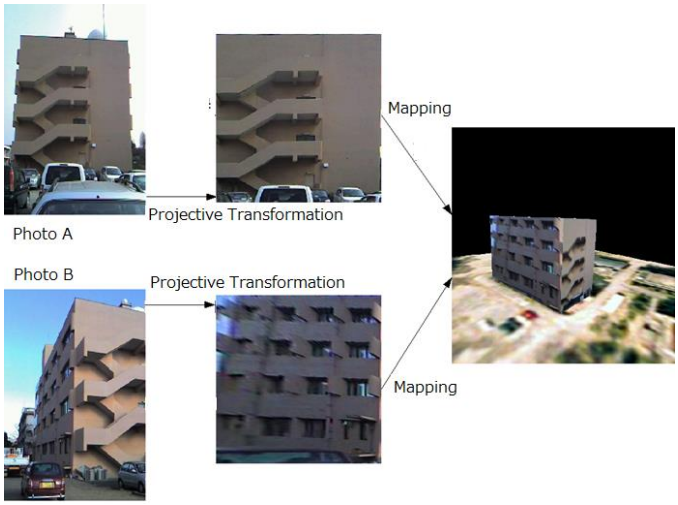


Fig. 3. Process Flow of the Proposed Texture Mapping Method.

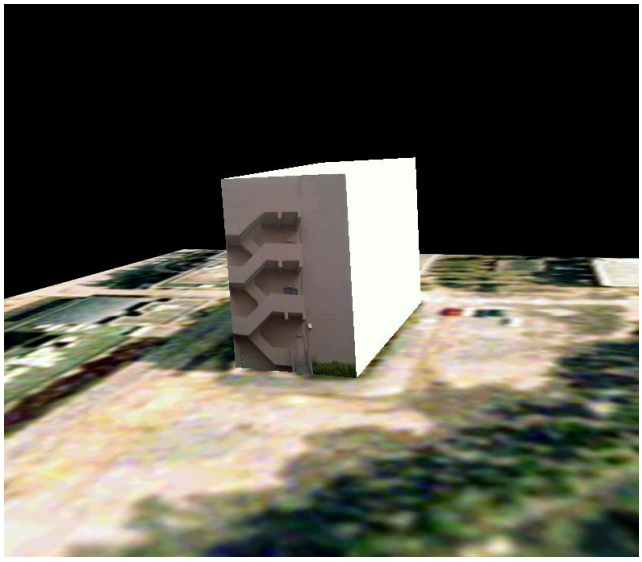


Fig. 4. Example of the Texture Mapping Processed Image.

D. *Texture Mapping with High Spatial Resolution of Satellite Images*

More than two of off-nadir view of high spatial resolution of satellite images are assumed to be acquired. From the images, the following processes are going to be done,

1) Estimation of 3-D building height
2) IKONOS image segmentation
3) Texture Mapping

Fig. 5 shows an example of high spatial resolution of IKONOS satellite images. IKONOS satellite sensor characteristics are as follows,

1) Launch Date: 24 September 1999 at Vandenberg Air Force Base, California, USA
2) Operational Life: Over 7 years
3) Orbit: 98.1 degree, sun synchronous
4) Speed on Orbit: 7.5 kilometers per second
5) Speed Over the Ground: 6.8 kilometers per second
6) Revolutions Around the Earth: 14.7, every 24 hours
7) Altitude: 681 kilometers
8) Resolution at Nadir: 0.82 meters panchromatic; 3.28 meters multispectral
9) Resolution 26° Off-Nadir: 1.0 meter panchromatic; 4.0 meters multispectral
10) Image Swath: 11.3 kilometers at nadir; 13.8 kilometers at 26° off-nadir
11) Equator Crossing Time: Nominally 10:30 AM solar time
12) Revisit Time: Approximately 3 days at 40° latitude
13) Dynamic Range: 11-bits per pixel
14) Image Bands: Panchromatic, blue, green, red, near IR.

Estimate the height of the building using the shadow of the building from the image. If θ can be estimated, h' is obtained as shown in Fig. 6.

Therefore, building height in concern can be estimated by using the calculated length of the shadow.

Fig. 5. Example of High Spatial Resolution of IKONOS Satellite Images.

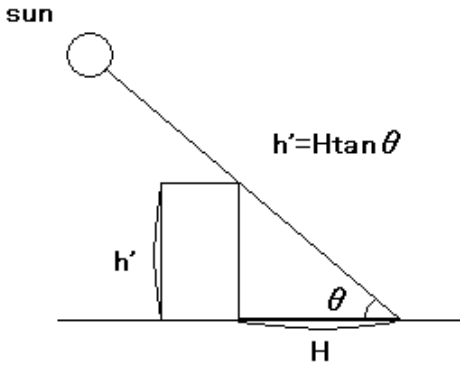


Fig. 6. Method for Estimation of Building Height in Concern.

III. EXPERIMENT

A. Preliminary Experiment

Looking at the IKONOS image cut out for the texture, the difference in resolution appears depending on the place to use for the 3D map. It is necessary to correct pixels and create images to be used for texture. Due to the appearance problem, there is a possibility that the resolution has to be improved.

Fig. 7(a) and (b) show the one side of the extracted building derived from the IKONOS image and the other side of the extracted building derived from the IKONOS image, respectively.

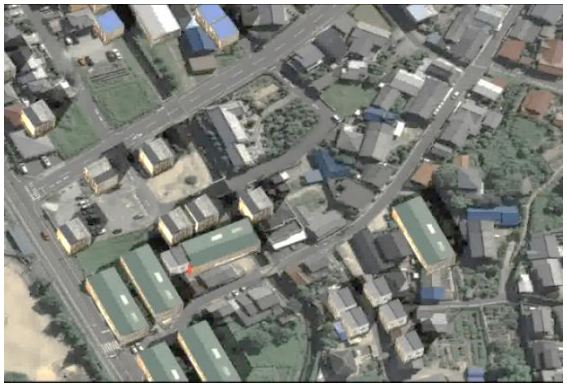
As shown in Fig. 8, occluded side of the texture cannot be mapped obviously. That is way, at least two satellite images which are acquired from the different look angles are required.

Consider an efficient method of obtaining texture from a strabismus image. It also solves the problem of resolution when extracting IKONOS images.

(a) One Side.

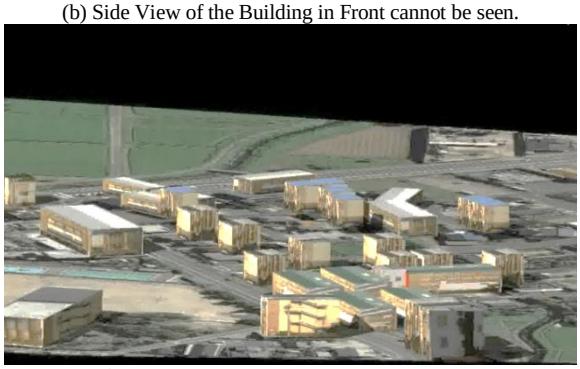
(b) Other Side.

Fig. 7. One Side and the other side of the Extracted Building Derived from the IKONOS Image.

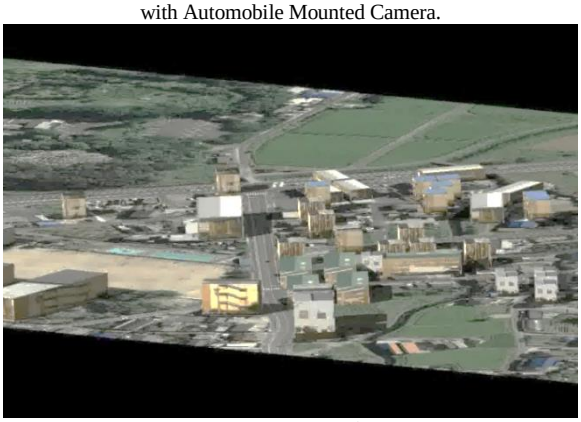


(a) IKONOS Image.

(b) Side View of the Building in Front cannot be seen.



(c) Side View of the Building in Front can be seen with the Image Acquired with Automobile Mounted Camera.



(d) Clear Side View Texture Mapping is Done for All the Ground Cover Target.

Fig. 8. Side View Texture Mapping with the Proposed Method.

B. Effectiveness of the Proposed Method

The proposed additional method for 3D map creation is to use both high spatial resolution of satellite imagery data and

the cameras mounted on automobile. Although the proposed fundamental method for 3D map creation is to use high spatial resolution of satellite imagery data, it is not always to obtain more than two high spatial resolution of satellite imagery data from the different aspect. Therefore, if the more than two of high spatial resolution of satellite imagery data from the different aspect cannot be obtained and enough off-nadir view of high spatial resolution of satellite imagery data are not acquired, then the automobile mounted camera images are used only for the occluded ground cover targets for texture mapping.

Fig. 8 shows examples. Fig. 8(a) shows IKONOS image of Saga, Japan. Side wall of some of the houses and the building can be seen. It, however, is not for all the ground cover targets. Therefore, the side view of the building in front of Fig. 8(b) cannot be seen. Side view of the building in front can be seen with the image acquired with automobile mounted camera as shown in Fig. 8(c). It, however, can be done with the proposed method. Clear side view texture mapping is done for all the ground cover target as shown in Fig. 8(d).

IV. Conclusion

Method for texture mapping of in-vehicle camera image in 3D map creation is proposed. Top view of ground cover targets can be mapped easily. For instance, aerial photos, highly spatial resolution of satellite imagery data allows creation of top view of ground cover targets and also map creation. It can be used for pedestrian navigations. On the other hand, side view of ground cover targets are not so easy to obtain. In this paper, two methods are proposed. One is to use acquired photos with cameras mounted on the dedicated cars. The other one is to use high spatial resolution of satellite imagery data, such as IKONOS, Orbview, etc. Through experiments with the aforementioned two methods, it is found that texture mapping for the ground cover targets can be done with the two proposed methods in an efficient manner.

The examples shows the effectiveness of the proposed method. In the IKONOS image of Saga, Japan., side wall of some of the houses and the building can be seen. It, however, is not for all the ground cover targets. Therefore, the side view of the building in front cannot be seen. Side view of the building in front can be seen with the image acquired with automobile mounted camera. It, however, can be done with the proposed method. Clear side view texture mapping is done for all the ground cover target.

V. Future Research

Further study is required for further examples. The proposed method has to be attempted for more different target sites such as buildings are overlapped from the viewing angles, and so on. Also, it would better to apply the proposed method in the different environmental conditions, motion vibrations, night time observation, a bad weather conditions, and so on. Then limitation of the proposed method will be clarified.

Acknowledgment

The author would like to tank Mr. Kazunori Kinoshita, Mr. Tessei Yamaguchi of former students of the Saga University Japan for his effort to conduct the experiments.

References

[1] Ahmet Soylu, Felix Mödritscher, Fridolin Wild, Patrick De Causmaecker, Piet Desmet.. “Mashups by Orchestration and Widget-based Personal Environments: Key Challenges, Solution Strategies, and an Application.” Program: Electronic Library and Information Systems 46 (4): 383–428. 2012.

[2] Endres-Niggemeyer, Brigitte ed.. Semantic Mashups. Intelligent Reuse of Web Resources. Springer. ISBN 978-3-642-36402-0 2013.

[3] O’Reilly, T., What is Web 2.0. Design Patterns and Business Models for the Next Generation of Software, p. 30 2005.

[4] Benslimane, D.; Dustdar, S.; Sheth, A.. "Services Mashups: The New Generation of Web Applications". IEEE Internet Computing 10 (5): 13–15. doi:10.1109/MIC.2008.110 2008.

[5] Tuesday, August 17th,. "As Bing Takes Over Yahoo Search, SearchMonkey Dies, BOSS Is No Longer Free, But Site Explorer Still Works". TechCrunch. Retrieved 2012-09-18. 2010 (2010-08-17).

[6] Kohei Arai, Mash-up based content search engine for mobile devices, International Journal of Advanced Research in Artificial Intelligence, 2, 5, 39-43, 2013.

[7] Kohei Arai and Tolle Herman, Module based content adaptation of composite e-learning content for delivering to mobile learners, International Journal of Computer Theory and Engineering, 3, 3, 382387, 2011.

[8] Kohei Arai, Herman Tolle, Efficiency improvements of e-learning document search engine for mobile browser, International Journal of Research and Reviews on Computer Science, 2, 6, 1287-1291, 2011.

[9] K.Arai, T.Herman, Efficiency improvement of e-learning document search engine for mobile browser, International Journal of Research and review on Computer Science, 2, 6, 1287-1291, 2012.

[10] K.Arai, T.Herman, Video searching optimization with supplemental semantic keyword for e-learning video searching, International Journal of Research and Review on Computer Science, 3, 3, 1640-1644, 2012.

[11] H. Shiozawa, K. Okada, Y. Matsushita: 3D Interactive Visualization for Inter-Cell Dependencies of Spreadsheets, Proc. IEEE InfoVis '99, pp. 79-82, Oct. 1999.

[12] Douglas Crockford (July 2006). "IANA Considerations". The application/json Media Type for JavaScript Object Notation (JSON). IETF. sec. 6. RFC 4627. https://tools.ietf.org/html/rfc4627#section-6. Retrieved October 21, 2009.

[13] Kohei Arai, Anik Nur Handayani, E-learning system utilizing learners' characteristics recognized through learning process with Open Simulator, International Journal of Advanced Research in Artificial Intelligence, 2, 4, 8-12, 2013.

[14] Kohei Arai, A.N.Hardiyani, Avatar utilized Q/A system of e-learning content designed with Open Simulator, Proceedings of the International Conference on Convergence Content 2012, 149-150, 2012.

[15] Hvidsten, Mike (Spring 2004). "The OpenGL Texture Mapping Guide". homepages.gac.edu. Retrieved 22 March 2018.

Author’s Profile

Kohei Arai, He received BS, MS and PhD degrees in 1972, 1974 and 1982, respectively. He was with The Institute for Industrial Science and Technology of the University of Tokyo from April 1974 to December 1978 also was with National Space Development Agency of Japan from January, 1979 to March, 1990. During from 1985 to 1987, he was with Canada Centre for Remote Sensing as a Post Doctoral Fellow of National Science and Engineering Research Council of Canada. He moved to Saga University as a Professor in Department of Information Science on April 1990. He was a councilor for the Aeronautics and Space related to the Technology Committee of the Ministry of Science and Technology during from 1998 to 2000. He was a councilor of Saga University for 2002 and 2003. He also was an executive councilor for the Remote Sensing Society of Japan for 2003 to 2005. He is an Adjunct Professor of University of Arizona, USA since 1998. He also is Vice Chairman of the Science Commission “A” of ICSU/COSPAR since 2008 then he is now award committee member of ICSU/COSPAR. He wrote 37 books and published 570 journal papers. He received 30 of awards including ICSU/COSPAR Vikram Sarabhai Medal in 2016, and Science award of Ministry of Mister of Education of Japan in 2015. He is now Editor-in-Chief of IJACSA and IJISA. http://teagis.ip.is.saga-u.ac.jp/index.html

Development Trends of Online-based Aural Rehabilitation Programs for Children with Cochlear Implant Coping with the Fourth Industrial Revolution and Implication in Speech-Language Pathology

Haewon Byeon
Department of Speech Language Pathology
Honam University, Gwangju, Republic of Korea

***Abstract*—The Korea Research Foundation selected the miniaturization and development of home care devices as the future promising technologies in the biotechnology (BT) area along with the Fourth Industrial Revolution. Accordingly, it is believed that there will be innovative changes in the rehabilitation field, including the development of smart diagnostics and treatment devices. Moreover, rehabilitation equipped with individualization, precision, miniaturization, portability, and accessibility is expected to draw attention. It has been continuously reported in the past decade that hearing-impaired toddlers who became able to hear speech through cochlear implantation and hearing rehabilitation before the age of 3, which is a critical period of language development, show a language development pattern similar to that of healthy toddlers. As a result, the need for developing language rehabilitation programs customized for patients wearing artificial cochlea has emerged. In other words, since the improved hearing ability owing to cochlear implant does not guarantee to promote speech perception and language development, intensive rehabilitation and education are needed for patients to recognize the heard speech as a meaningful language for communication. Nevertheless, a literature search on domestic and foreign cases revealed that there are insufficient language rehabilitation programs for cochlear implant patients as well as customized programs for them in the clinical coalface. This study examined the trend and marketability of online-based aural rehabilitation programs for patients wearing artificial cochlea and described the implications for language rehabilitation. This study suggested the following implications for developing a customized aural rehabilitation program. It is needed to secure and develop contents that can implement "a hand-held hospital" by using medical devices and mobile devices owned by consumers that transcend time and space. Also, it is necessary to develop a cochlear implant hearing rehabilitation training program suitable for native Korean speakers.**

Keywords*—Cochlear implant; future promising technologies; smart diagnostics; Online-based aural rehabilitation

I. INTRODUCTION

The number of people suffering from hearing loss is continuously increasing in South Korea. The Health Insurance Review & Assessment Service (2018) reported that the number of patients who visited medical clinics due to hearing loss increased by 18.7% in five years, from 746,499 in 2012 to 886,091 in 2016. It is believed that the number of patients with potential hearing loss is higher than recorded because many people with hearing problems do not visit medical clinics. According to the Korea Centers for Disease Control and Prevention (2016), one of two patients with hearing loss did not visit a medical clinic until they had a major obstacle in their daily life and only 12.6 percent of them used assisting devices such as a hearing aid, even though they were diagnosed with hearing loss. It is projected the number of patients with hearing loss will increase steadily because the noise environment is getting more severe due to continuing industrialization.

The artificial cochlea is a device that delivers sound to the inner ear's auditory nerve through artificial electrical stimulation [1]. The cochlear implant has been mainly applied to children with the highest degree hearing impairment who gain little by wearing hearing aids. Since cochlear implantation was approved by the Food and Drug Administration (FDA) in 1990, the number of cochlear implant patients has increased drastically worldwide. The cochlear implant surgery has been covered by health insurance since 2005 in South Korea, and patients just need to bear 20% of the cost from examination to surgery. Therefore, it is expected that the market size will be expanded rapidly. Additionally, it is projected that the future of artificial cochlea related rehabilitation business is bright because the medical expense of South Korean patients with hearing loss has increased by 12.6% in the past five years and the number of patients with hearing loss in their 20s is increasing every year.

In particular, the number of patients with presbyacusia is increasing in South Korea due to aging. It is hard to diagnose and treat presbyacusia because the elderly do not recognize that their hearing has been deteriorated over a considerable period of time and their cochleae have been damaged gradually. Lin et al. (2011) [2] reported that people with presbyacusia were more likely to suffer from Alzheimer's dementia because the sound stimulation to the brain would be decreased since they could not hear spoken words clearly for a long time and it ultimately deteriorated cognitive ability and memory power.

Consequently, it is expected that the cochlear implant surgery will be expanded to the elderly population due to the increased population with presbyacusia [3]. Furthermore, the Korea Research Foundation (2017) [4] elected the miniaturization and development of home care devices as the future promising technologies in the biotechnology (BT) area along with the Fourth Industrial Revolution. Accordingly, it is believed that there will be innovative changes in the rehabilitation field, including the development of smart diagnostics and treatment devices. Moreover, rehabilitation equipped with individualization, precision, miniaturization, portability, and accessibility is expected to draw attention.

It has been continuously reported in the past decade that hearing-impaired toddlers who became able to hear speech through cochlear implantation and hearing rehabilitation before the age of 3, which is a critical period of language development, show a language development pattern similar to that of healthy toddlers [5, 6, 7, 8, 9, 10, 11, 12]. As a result, the need for developing language rehabilitation programs customized for patients wearing artificial cochlea has emerged [13]. In other words, since the improved hearing ability owing to cochlear implant does not guarantee to promote speech perception and language development, intensive rehabilitation and education are needed for patients to recognize the heard speech as a meaningful language for communication [14]. Nevertheless, a literature search on domestic and foreign cases revealed that there are insufficient language rehabilitation programs for cochlear implant patients as well as customized programs for them in the clinical coalface. This study examined the trend and marketability of online-based aural rehabilitation programs for patients wearing artificial cochlea and described the implications for language rehabilitation.

II. Cochlear Implant and Communication Skills

Accurately listening and generating speech are essential skills in communication but, in the case of sensorineural hearing loss, which occurs when a part or all of the auditory nerve is damaged, it is difficult to restore general communication abilities only by prescribing a hearing aid. Particularly, since these patients hear many consonants in the high-frequency range distortedly in a spoken language condition (Fig. 1), they are generally recommended to have a cochlear implant (Fig. 2).

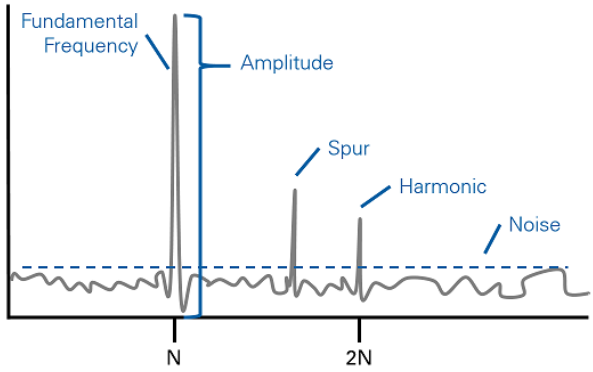


Fig. 1. Fourier Transform for Frequency Domain Visualization.

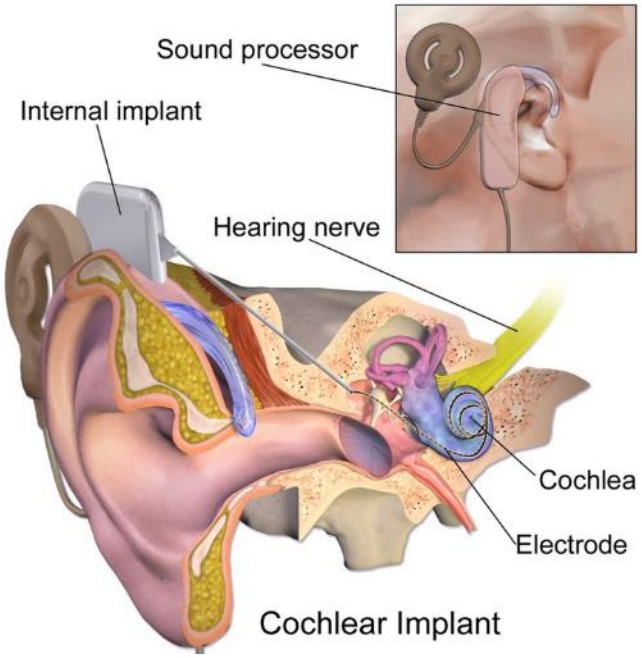


Fig. 2. Structure and Concept of Cochlear Implant, Source: American Speech-Language-Hearing Association (2004).

Cochlear implantation is an electrode insertion surgery that implants the electrode, which converts an incoming sound into a voice signal to stimulate the auditory nerve and transmits the delivered electrical stimulation to the brain, into the cochlea. The artificial cochlea directly stimulates the spiral ganglion cells or peripheral auditory nerves that remain in the cochlea to help the auditory center recognize the sound. It is possible to confirm that the audible threshold for each frequency increases after having a cochlear implant (Fig. 3). Especially, it was found that the threshold in the low-frequency range (left (red) of Fig. 3) and that in the high-frequency range (right (blue) of Fig. 3) increased.

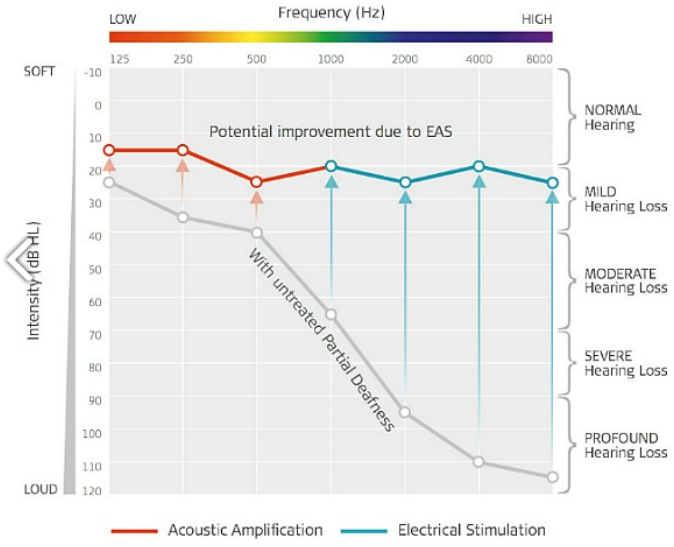


Fig. 3. Efficacy of Hearing Elevation after Cochlear Implantation.

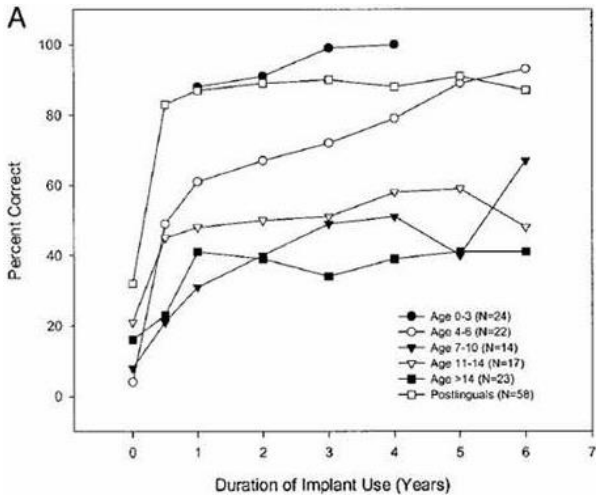


Fig. 4. Effect of Cochlear Implantation According to Rehabilitation Period, Source: Dunn, et al. (2008) [16].

Cochlear implantation for children with hearing impairment shows revolutionary results in the aspect that it improves the hearing ability of children. The improvement of speaking and language ability after cochlear implantation varies by various factors such as the age of hearing loss initiation, cause of hearing loss, duration of hearing loss, the residual hearing before an operation, and communication methods. American Speech-Language-Hearing Association (2004) [15] reported that hearing ability improved when the duration of hearing rehabilitation and artificial cochlea usage is lengthened. Dunn et al. (2008) [16] showed that, although it varied by the age of a patient, when patients underwent hearing rehabilitation steadily after cochlear implantation, they could distinguish common sounds, such as ambient sounds approximately one year after the surgery, 70-80% of children could understand everyday words approximately 2 years after the surgery, and 70% of children could have a conversation without using lip reading after 4 years (Fig. 4).

III. The Necessity of Customized Aural Rehabilitation Programs for Children with Cochlear Implants

Patients cannot recognize all sounds immediately after cochlear implantation. Unlike the general public who hears the amplified sound, the cochlear implant patients hear by converting sounds into electrical signals. Therefore, they need additional adaptive training after surgery. Tye-Murray (2016) [17] reported that the degree of communication improvement depended on by children's learning style, skills of professionals, task presentation method, and task performance ability. In particular, unlike ambient noise, speech is composed of sounds using various frequency ranges and capricious sounds. Therefore, customized aural rehabilitation is essential. According to Tye-Murray (2019) [14], speech perception is made in the phoneme unit that causes semantic differences (e.g., row vs. low) and is related to the sense development of children.

Therefore, the speech perception program of cochlear implant subjects should consider the semantic development characteristics of the subjects as well as the phoneme characteristics of Korean consonants. Hearing-impaired people have a relatively hard time recognizing words based on consonants compared to those based on vowels in speech perception. Therefore, consonant discrimination and identification are factors that take a long time in hearing rehabilitation of cochlear implant subjects. It is necessary to develop customized aural rehabilitation programs considering the characteristics of Korean phonemes (universal characteristics) and those of semantic development (individual characteristics).

IV. Convergence of Information and Communication Technology (ICT) and Healthcare

The Fourth Industrial Revolution, which combines ICT and rehabilitation science, is expected to break down the boundaries between industries, brings about various forms of convergence and competition, and causes new changes. Among them, it is believed that the healthcare industry has a huge growth potential owing to the convergence of new ICT technologies because the efficiency of the industry is very low, although it is already quite large.

The market size of the global digital healthcare industry continues to grow due to the aging of the world's population and the increase in patients with chronic diseases (Fig. 5). The market size has already reached $96 billion in 2016 and will be $206 billion by 2020 by growing by 21.1% annually. More specifically, mobile health will become the main trend in digital healthcare for a while.

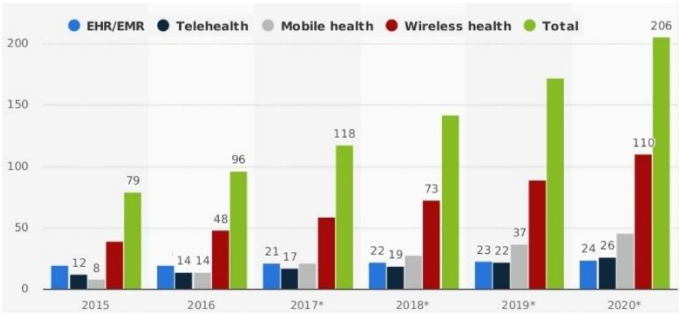


Fig. 5. Prospect of the Global Digital Healthcare Industry.

V. The Need for a Customized Smart Auditory Rehabilitation System

Most cochlear implant patients receive aural rehabilitation at the ENT Hearing Loss Center of a University Hospital or a Speech Therapy Center specialized for hearing rehabilitation. However, aural rehabilitation has spatial and temporal limitations and costs a lot of time and money because it is performed by 1:1 individualized therapy. Moreover, it is difficult to obtain a rehabilitation opportunity because there are only a few hearing rehabilitation centers. Aural rehabilitation training requires the rehabilitation treatment of professional and trained therapists, but subjects are treated in general centers or hospitals without considering their characteristics because there are not enough local aural rehabilitation centers. In other words, it is necessary to develop a smart aural rehabilitation system that is not limited to spatially and temporally, based on expertise, and customized for the level of subjects.

VI. Necessity of Developing an Industry-Academic-Institute Collaboration Model

Various studies on wellness personalized management technologies have been actively conducted in leading countries such as the United States and Japan. In the United States, the National Sanitation Foundation has invested $330 million in 756 projects from 2013 to 2015 (three years) to develop personalized healthcare-related technologies [18]. Europe has also invested €580 million in 247 projects on wellness personalized healthcare-related technologies from 2013 to 2015. It is required for South Korea to analyze major factors in the cochlear implant-related market and actively develop industry-academic-institute collaboration models. Especially, it is needed to secure and develop contents that can implement "a hand-held hospital" by using medical devices and mobile devices owned by consumers.

VII. Growth of the Mobile Healthcare Market

Mobile healthcare refers to a system where patients and doctors can give or receive medical services without being constrained by time and space. It is defined as checking and managing own health status by using a smartphone and medical applications. The market size of the global mobile healthcare industry is approximately $2.4 billion and is believed to grow to $8 billion by 2018. Lee (2017) [19] showed that interest in mobile healthcare is greatly increasing worldwide including South Korea (Fig. 6).

The healthcare paradigm is shifting from institution-oriented service to consumer-oriented service. Technavio (2014)[20] argued that the market size of cochlear implant is $1,590 million as of 2014 and will grow 13.6% annually and become $2.8 billion in 2020. Lee (2017) [21] reported that the market size of cochlear implant in South Korea is $34.6 billion in 2014 and is increasing. Lee (2017) [21] also projected that the market size will be approximately $68.5 by 2018 owing to an 18.6% annual grow (Fig. 7). It is believed that the growth rate of the South Korean market (18.6%) is higher than that of the global market (13.6%) because of the application of medical insurance, the increase of the elderly and population with hearing loss, and the improvement of income level.

The cochlear implantation was first conducted in 1989 in South Korea and it is now being performed in a number of hospitals. The operation targets and medical institutions conducting it are gradually expanding. The cost of cochlear implantation is more than ₩20 million in South Korea. However, it has been covered by medical insurance since 2005, and a patient needs to pay ₩4 million from examination to surgery. Therefore, it is expected that the market size will grow further.

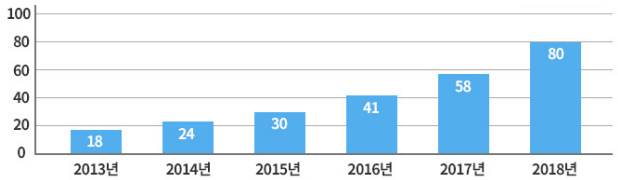


Fig. 6. The Size of the Global Mobile Healthcare Market, Source: Lee (2017) [19].

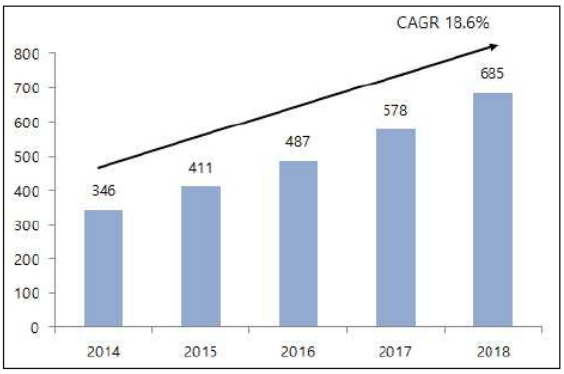


Fig. 7. Market Size of Cochlear Implant in Korea.

The Korea Centers for Disease Control and Prevention (2016) [22] reported that the number of patients with hearing loss increased from 266,348 people in 2010 to 280,460 people in 2014, 5.3% annual growth. In terms of age group, people in 70's accounted for 54,066 people (19.2%), the largest group, followed by people in 60's (50369 people; 18%) and people in 50's (47,485 people; 16.9%). Among all hearing-impaired people, 61.8% were using hearing aids and 3.4% of them underwent cochlear implantation that transform sound stimuli into auditory stimuli and deliver it to the brain. Recently, the range of patients requiring cochlear implants is gradually increasing: even patients with losing the hearing of only one ear have a cochlear implant.

VIII. Development Status and Trend of Online Aural Rehabilitation Programs

Auditory Training-Spice for Life (Fig. 8) and Angel Sound (Fig. 9) have been developed and marketed in the US for ICT-based aural training [23, 24]. However, they focus on enhancing the aural memory mainly using ambient sounds, not speech and do not support Korean, which are limitations [23, 24]. Therefore, it is necessary to develop a cochlear implant hearing rehabilitation training program suitable for native Korean speakers.

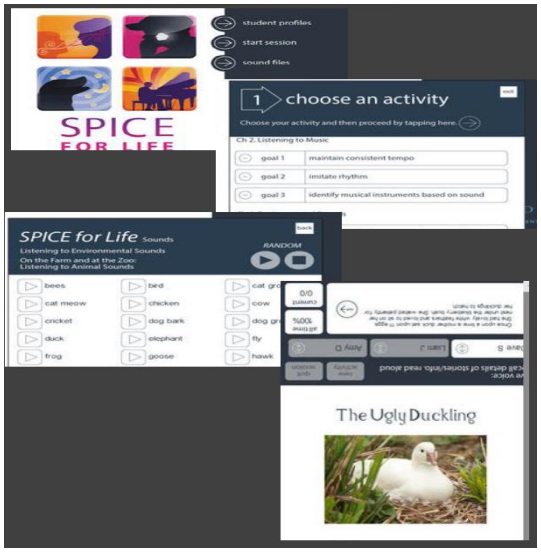


Fig. 8. Auditory Training-Spice for Life.

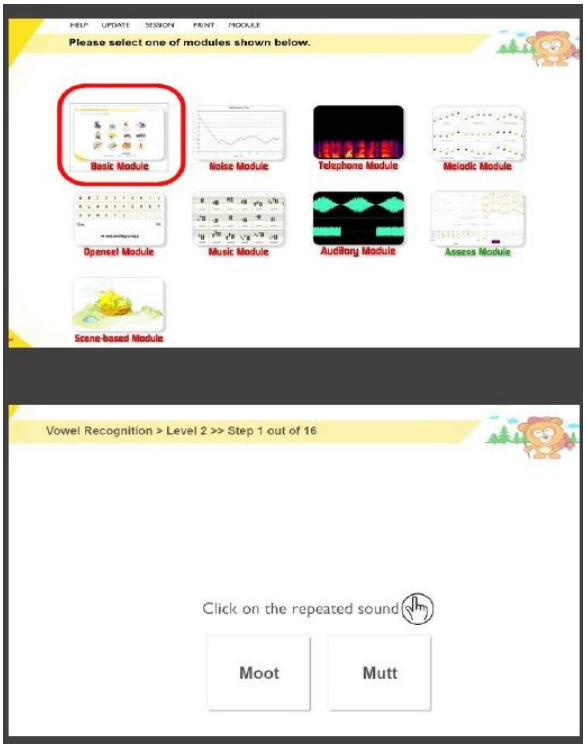


Fig. 9. Angel Sound.

Although it is needed to develop a robust ICT-based aural rehabilitation program for children and adults who need aural rehabilitation without being constrained by time and space after cochlear implantation in South Korea, programs developed by South Korean companies yet just focus on articulation training and augmentative and alternative communication. Ling 6 Sound Test App released in 2013 is the only program developed in South Korea for patients with cochlear implant. Table I shows the status of studies or intellectual property rights associated with the aural rehabilitation programs for people with cochlear implant in South Korea.

Although it is needed to develop a robust ICT-based aural rehabilitation program for children and adults who need aural rehabilitation without being constrained by time and space after cochlear implantation in South Korea, programs developed by South Korean companies yet just focus on articulation training and augmentative and alternative communication. Ling 6 Sound Test App released in 2013 is the only program developed in South Korea for patients with cochlear implant. Table I shows the status of studies or intellectual property rights associated with the aural rehabilitation programs for people with cochlear implant in South Korea.

App Annie's report (2016) [25] examined the expenditure of digital content compared to the population of seven countries (South Korea, Japan, the US, the United Kingdom, Germany, France, and Russia). The report revealed that the digital contents market of South Korea, Japan, the US, and the United Kingdom exceeded the mean of the seven countries, indicating that the South Korean market was a main market for digital content (Fig. 10).

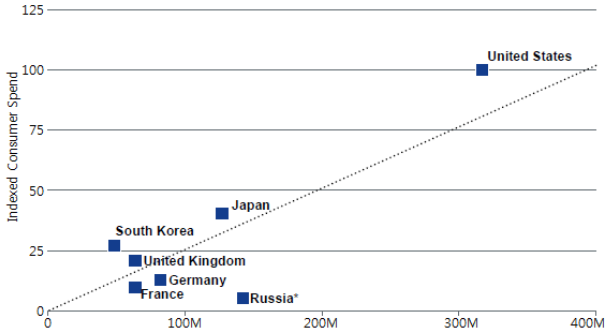


Fig. 10. Digital Content Spending Costs by Country 2016.

IX. Trends in the Digital Content Market

Particularly, South Korea showed the largest consumption and highest growth rate in digital content usage per device and confirmed that the South Korean market has the strongest consumption power in the world [25]. In addition, the South Korean market leads the profit of mobile apps in the smart contents market. In terms of the market size, the South Korean market was the third largest in the world after the US and Japan [25]. App Annie (2016) [25] reported that the South Korean mobile app market grew 2.3 times compared to the previous year. Although it is not yet known for the rehabilitation contents market due to lacking statistical data, it is expected that the size of the market will grow rapidly, considering the overall trend of the market.

TABLE. I. List of Research or Intellectual Property

Type	Title	Institution	Registration date
Paper & Report	Case study of speech perception enhancement in hearing-impaired adult by auditory training program of mobile device	Korean Academy of Audiology	2014
	Development of a speech recognition threshold application using voice recognition technology: pilot study	Journal of Speech-Language & Hearing Disorders	2015
	A study on mobile application ux/ui design of communication for the hearing & language impaired	Journal of the Korean Society of Design Culture	2015.06
	Developing a mobile application to learn korean for children with hearing impairment - human-centered design approach	AAC Research & Practice	2016.06
Intellectual property	Smart glass system for hearing-impaired communication (No. 1018309080000)	Hyunjoo Park	2018.02.13
	Auditory sense training apparatus (No. 1018178340000)	Yunsik Choi	2018.01.05
	System for aidding communication of deaf person (No. 1016057960000)	Korea University of Social Welfare	2016.03.17
	Infants" vocal development evaluation device, and system and method of auditory rehabilitation for infants (No. 1020150102447)	Hallym University	2015.07.20

In Korea, most ICT-based rehabilitation programs remain in articulation training or augmentative and alternative communication. The only Korean program developed for cochlear implants is the Ling 6 Sound Test App. Table I shows the status of research or intellectual property rights (patent registration) of the cochlear implant rehabilitation program developed in Korea.

X. Conclusions

It is necessary to develop ICT-based rehabilitation program to improve the ability of children with cochlear implant to listen to the speech sound. Since speech perception is greatly affected by the phoneme characteristics of a specific language, it is impossible to apply the results of foreign studies or use a program developed in a foreign country. Consequently, a speech perception program considering the phoneme characteristics of Korean should be developed. It is also required to develop an aural rehabilitation program that takes into account the universal language development characteristics (e.g. consonant/vowel-phonemes correspondence rules) and the normal aspects of an individual language (e.g., sense development). This study suggested the following implications for developing a customized aural rehabilitation program.

First, it is necessary to develop an aural rehabilitation training program based on smart devices. In order to promote the language development of children with cochlear implant, we must have a rehabilitation training program that can introduce verbal stimuli using sound and a systematic program for them to continuous listen and comprehend sound. It will be necessary to develop and commercialize an ICT-based program that can be applied at rehabilitation practically to provide listening training for children with cochlear implant.

Second, it is needed to develop ICT-based rehabilitation programs in order to establish the foundation for introducing new health rehabilitation technologies for the Fourth Industrial Revolution and accumulating future technologies (e.g., IoT). We shall apply for the rights and patents associated with online aural rehabilitation training programs for people with cochlear implant. Moreover, an industry-academia consortium must protect the right of new technologies by jointly applying for intellectual property rights and commercialize their technologies.

Third, it is needed to develop aural training programs customized for each hearing level. For example, we may develop an ICT-based aural rehabilitation training program by reorganizing intervention contents according to the characteristics of the Korean and the language level of a target age based on the auditory skills level determined by the Auditory Skills Program [26]. I hope that various customized aural rehabilitation programs will be developed for the hearing impaired by applying rapidly advancing ICT technologies.

Acknowledgment

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF- 2018R1D1A1B07041091 and NRF-2019S1A5A8034211).

References

[1] G. Feng, E. M. Ingvalson, T. M. Grieco-Calub, M. Y. Roberts, M. E. Ryan, P., Birmingham, D. Burrowes, N, M. Young, and P. C. Wong, Neural preservation underlies speech improvement from auditory deprivation in young cochlear implant recipients. Proceedings of the National Academy of Sciences, vol. 115, no. 5, pp. E1022-E1031, 2018.

[2] F. R. Lin, L. Ferrucci, E. J. Metter, Y. An, A. B. Zonderman, and S. M. Resnick, Hearing loss and cognition in the Baltimore longitudinal study of aging. Neuropsychology, vol. 25, no. 6, pp. 763-770, 2011.

[3] H. Olze, S. Gräbel, U. Förster, N. Zirke, L. E. Huhnd, H. Haupt, and B. Mazurek, Elderly patients benefit from cochlear implantation regarding auditory rehabilitation, quality of life, tinnitus, and stress. The Laryngoscope, vol. 122, no. 1, pp. 196-203, 2012.

[4] Korea Research Foundation. 12 future technical reports. Korea Research Foundation, Daejeon, 2017.

[5] D. J. Ertmer, Speech intelligibility in young cochlear implant recipients: gains during year three. Volta Review, vol. 107, no. 2, pp. 85-99, 2007.

[6] A. E. Geers, J. G. Nicholas, A. L. Sedey, Language skills of children with early cochlear implantation. Ear and hearing, vol. 24, no 1, 46S-58S, 2003.

[7] J. G. Nicholas, and A. E. Geers, Will they catch up? the role of age at cochlear implantation in the spoken language development of children with severe to profound hearing loss. Journal of Speech, Language, and Hearing Research, vol. 50, no. 4, pp. 1048-1062, 2007.

[8] J. N. Li, S. Chen, L. Zhai, D. Y. Han, A. A. Eshraghi, Y. Feng, S. M. Yang and X. Z. Liu, The Advances in Hearing Rehabilitation and Cochlear Implants in China. Ear and hearing, vo. 38, no. 6, pp. 647-652, 2017.

[9] G. W. Hwang, and H. J. So, Developing a mobile application to learn Korean for children with hearing impairment: human-centered design approach. AAC Research & Practice, vol. 4, no. 1, pp. 101-123, 2016.

[10] A. Laplante-Lévesque, M. Kathleen Pichora-Fuller, and J. P. Gagné, Providing an internet-based audiological counselling programme to new hearing aid users: a qualitative study: Provisión de un programa de consejería audiológica por Internet para nuevos usuarios de auxiliares auditivos: un estudio cualitativo. International Journal of Audiology, vol. 45, no. 12, pp. 697-706, 2006.

[11] S. G. Lee, and Y. Lee, The effects of auditory intervention using smartphone application on auditory memory in children with cochlear implants. The 30th Korean Academy of Speech-Language Pathology and Audiology Conference, pp. 307-309, 2016.

[12] J. Yu, H., Chun, C. G. Song, and W. Han, Case study of speech perception enhancement in hearing-impaired adult by auditory training program of mobile device. Audiology and Speech Research, vol. 10, no. 2, pp. 158-168, 2014.

[13] J. Lim, and E. Park, Development and research trends of application as the smart education media for ASD. Journal of the Korean Association for Persons with Autism, vol. 12, no. 1, pp. 93-117, 2012.

[14] N. Tye-Murray, Foundations of aural rehabilitation: Children, adults, and their family members. Plural Publishing, San Diego, 2019.

[15] American Speech-Language-Hearing Association. Technical Report: Cochlear Implants, ASHA Supplement 24, e-pub, 2004. doi:10.1044/policy.TR2004-00041.

[16] C. C. Dunn, R. S. Tyler, S. Oakley, B. J. Gantz, and W. Noble, Comparison of speech recognition and localization performance in bilateral and unilateral cochlear implant users matched on duration of deafness and age at implantation. Ear and Hearing, vol. 29, no, 3, pp. 352-359, 2008.

[17] N. Tye-Murray, B. Spehar, M. Sommers, and J. Barcroft, Auditory training with frequent communication partners. Journal of Speech, Language, and Hearing Research, vol. 59, no. 4, pp. 871-875, 2016.

[18] F. R. Vogenberg, and J. Santilli, Healthcare trends for 2018. American Health & Drug Benefits, vol. 11, no. 1, pp. 48-54, 2018.

[19] Y. Lee, Mobile application development for improving auditory memory skills of children with hearing impairment. Audiology and Speech Research, vol. 13, no. 1, pp. 50-61, 2017.

[20] TechNavio. Global Biorefinery Market 2015-2019. Infiniti Research Limited, Toronto, 2014.

[21] T. Lee, ICT Convergence Healthcare Services Status and Future * Strategies. Asia-pacific Journal of Multimedia Services Convergent with Art, Humanities, and Sociology, vol. 7, no. 10, pp. 865-878, 2017.

[22] The Korea Centers for Disease Control and Prevention. Korea National Health and Nutrition Examination Survey 2016. Centers for Disease Control, Osong, 2016.

[23] J. Barcroft, B. Spehar, N. Tye-Murray, and M. Sommers, Task-and talker-specific gains in auditory training. Journal of Speech, Language, and Hearing Research, vol. 59, no. 4, pp. 862-870, 2016.

[24] C. Bexelius, L. Honeth, A. Ekman, M. Eriksson, S. Sandin, D. Bagger-Sjöbäck, and J. E. Litton. Evaluation of an internet-based hearing test—comparison with established methods for detection of hearing loss. Journal of Medical Internet Research, vol. 10, no. 4, pp. e32, 2008.

[25] App Annie. App Annie mobile app forecast: The path to $100 billion. App Annie, New York, 2016.

[26] S. Romanik, Auditory skills program. University of Melbourne, Melbourne, 2008.

Effective Methods to Improve the Educational Process of Medicine in Bulgaria

Galya N. Georgieva-Tsaneva
Institute of Robotics
Bulgarian Academy of Sciences
Sofia, Bulgaria

***Abstract*—The introduction of modern technologies into the educational process of medical students is a challenge of the new era in education, which can increase the success of students and give them confidence in their capabilities. The paper considers the use of physiological clinical record databases as an effective means of gaining prior experience from students that will be of use to them in their professional work. The paper describes the entering of serious educational games into the learning process of students in Bulgaria. The serious games and the pedagogical methods applied therein are an innovative technological means of developing individual, social and cognitive qualities on which the individual's professional realization depends. The paper presents the results of a survey conducted at the universities of medical education in Bulgaria. Respondents' opinion of their desire to use serious games in their training and how games affect them has been studied and shown.**

Keywords*—Serious educational games; learning process; gaming training; pedagogical methods; innovative technological means; medical education

I. Introduction

Modern medical student education approaches and methods include information and communication technology as an innovative, effective, and next-generation student-centered tool.

One of the methods for improving the education of medical students is to create and use databases of real physiological data of patients, through which students can get acquainted with the real data of patients obtained through clinical research. The creation of logbooks containing data to track the development of the disease enables future physicians to monitor the results of the assigned treatment. The analysis of clinical data through appropriate mathematical technologies for the processing and analysis of physiological data is an effective tool for improving the education of medical students.

Another effective method of entering medical training is serious educational games. Today, technologies are complementary to traditional teaching methods [1] and are good practice for raising students' attention [2]. Over the years, serious games have become interactive software systems that can offer educational information and attractively generate specialized skills. Serious educational games in medicine can be an essential and valuable element of students' theoretical and practical training. In this way, serious games have the potential to integrate into the learning process and to help improve students' educational outcomes.

This paper considers serious educational games as a modern innovative tool for creating knowledge, skills, and habits among medical students by integrating medicine, computer technology and the attractive form of teaching methods of game situations. Entering confident medical training can make serious games an indispensable part of that training.

Over the last decades, Serious Educational Games (SEGs) are increasingly entering the education process in schools around the world [3], and recent years in Bulgaria. The aim of the Serious Educational Games is to support, supplement and upgrade traditional learning and the aim is different from ordinary fun games. Serious games enable their users to practice what they learn, test themselves, evaluate and increase their knowledge in an engaging, motivating and modern technological environment. SEGs use state-of-the-art visualization and simulation technologies [4] and they can be used both in the school environment and at home, at any time and everywhere, challenging learners to explore strange processes and phenomena, and putting them in a stimulating, competitive but a safe learning environment. SEGs enable the application of the principle of adaptability to the particular player and thus become maximally useful for each of their users, while the knowledge given in the form of a game enables the processing of high-difficulty learning content and the achievement of good absorption of a larger quantity of material; this method will contribute in the long run to improving students' abilities and for higher educational outcomes.

The report aims to show the main pedagogical characteristics of the SEGs and the impact of serious games on the learning outcomes.

The report presents the results of a study done among students in Bulgaria on the use of SEGs in the learning process, about the interest of the students in the inclusion of Serious Educational Games in their training and to study the impact of SEGs on the learning process in Bulgaria.

The importance of this research stems from the use of real physiological data to conduct mathematical medical analyzes and the achievement of educational goals in medical education (raising students' interest and creating an initial experience in working with medical data). The survey about serious games has specific objectives and is limited to the use of serious games in medical education in higher education.

The rest of the paper is summarized as follows: Literature survey is shown in Section II. In Section III are presented modern methods for application in the educational process. Section IV presents the results of a mathematical analysis of Holter data and Section V presents the results of a study among medical students in Bulgaria. Conclusions are described in Section VI.

II. Research Background

Today, the classical model of learning through passive perception is not efficient for the new generation of students [5], often even boring. Today's modern education must, therefore, comply with the requirements of the new innovative technological age.

Modern technologies today offer a variety of tools that can be implemented in the educational process, helping to increase its effectiveness. Internet technologies are a prerequisite for the creation and use of large volumes of physiological data that once created can be used at any time, from anywhere in the world. In the field of medicine, effective databases have been created that are used by the scientific research community and are a valuable resource for the development of research [6].

In the field of cardiology, there is a wide range of publicly available physiological databases. Most of the records in them are obtained through Holter monitoring and are sorted according to some classification features. The most popular and with the most physiological records database is PhysioBank, which contains 75 freely downloadable databases. The records are for patients with various cardiac disorders: heart failure, sudden cardiac death, sleep apnea, and more. The MIT-BIH databases (containing records of cardiac arrhythmias suitable for cardiac dynamics testing) [7] [8]; the AHA (American Heart Association) database (containing two-channel three-hour Holter records, parts of which are manually annotated); European ST-T Database (annotated, containing excerpts from ambulatory electrocardiographic records) [9]; ECG-ViEW II (containing digital parameters of the electrocardiogram) are also publicly available. Information from all these publicly available databases can be retrieved, analyzed with mathematical technology through software systems [10], and used as an additional training tool by medical students.

Other innovative educational tools today are serious educational games. Game-based education can be implemented in the following two ways: through the instructional model: students play serious games developed by a teacher or other developer and constructivist model: learners learn by designing and playing games created by themselves.

SEGs help the learning process by making and creating the author's things, engaging learners actively in the process of learning [11]. The use of serious educational games in student education is a challenge and is placed on the agenda for teacher and learner surveys [12]. The positive impact of games on the learning process has been explored by many authors. Boeker, Andel, Vach, & Frankenschmidt [13] present the results of a study conducted among students divided into two groups: one group in the training included SEGs and the other one did not. The results show higher learning success in games including games. The authors Pettit, McCoy, Kinney, & Schwartz in [14] conduct a study among students, which shows an increase in the efficiency of the training during inclusion in the training hours of the SEGs.

The main features of serious games were studied and presented in 2017 by the authors Bigdeli, & Kaufman [12], adding the pedagogical aspect of the impact of games in the learning process:

- Single player or multiple player's participation;
- Conflicts creating;
- Clearly defined rules;
- The predetermined goal of the game;
- Artificial nature of games;
- The pedagogical nature of the serious game.

III. Application of Innovative Methods in the Learning Process

A. Benefits of Serious Games

The training in all areas of knowledge can be effectively helped by the creation of innovative, serious learning games. The student training through serious education games has the potential, thanks to the following benefits it gives:

- Breaking the traditional concepts of learning related to a particular place of learning and certain hours during which it is happening, by offering free choice of place and learning time;
- Opportunities to customize the user interface of the serious educational game with the individual speed and individual learning characteristics of each particular user;
- Developing the ability to solve tasks assigned by the teacher in University independently;
- Opportunities for joint training of a group of users and development of teamwork skills.

Benefits of Incorporating Innovative Serious Games in the Higher Education Training Process:

- Providing computer-aided training;
- Creating an interactive virtual reality;
- Making timely feedback by offering different forms of encouragement to achieve progress and success that have a stimulating impact on learners;
- Creating opportunities for the learner to learn from his / her experience;
- Supporting the educational learning process by experimenting, researching, generating and verifying hypotheses;
- Raising the motivation for training through the racing character of the serious game;

- Ability to raise the level of difficulty for the game, which assists in the acquisition of knowledge at a higher level; increasing time spent in SEGs, leading to higher education learning outcomes and raising the level of skills and competencies of learners;
- Serious educational games offer a comprehensive view of new information through a variety of tools: using graphical, acoustic and other signaling tools to enhance learning outcomes.

Serious educational games can be seen as interactive visual systems that combine the benefits of traditional learning and the attractiveness, dynamics, and impact of computer games. Serious learning games engage students of all ages in a fun, unobtrusive and non-standard way, integrating into a whole fun, learning, and skill-building experience.

In serious educational games, there are the following benefits to the educational process [15]:

- cognitive element: develop creativity and create skills to solve real problems;
- motivational element: create a sense of conviction in their abilities, develop perseverance in achieving their goals;
- emotional element: create a sense of conviction in their abilities, develop perseverance in achieving their goals;
- social element: contribute to the socialization of participants.

In this way, the benefits of serious educational games develop many useful social, cognitive and individual qualities in the students who use them. Fig. 1 shows the main types of qualities in these three groups that develop the using of serious games in the learning process. The figure shows how many useful qualities are developed through serious games; these are qualities that are valuable to medical students; for example, the qualities of motivation and the ability to achieve the goal, combined with the attainment of excellent medical skills, can lead to the successful end of the treatment of patients with risk diseases.

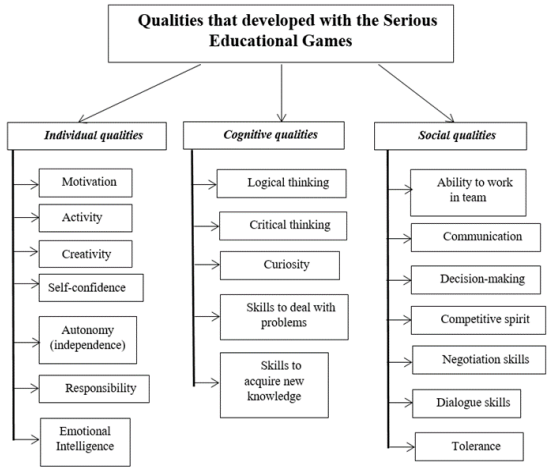


Fig. 1. The main Types of Qualities that Develop Serious Educational Games.

Serious games with their interactive way of conducting action are prerequisites for creating online socialization, new ways of interacting learners through online collaboration, an online based social environment, using verbal, computer-based ways of communicating and learning.

Fig. 2 shows the following major differences in characteristics between serious games (SG) and games that are played for fun (FG) (according to Isabela Granic et al [15]).

B. The Pedagogical Capabilities of Serious Educational Games in the Learning Process

According to Kolb [16], knowledge is best gained and strengthened by personal experience. SEGs are an excellent way to learn by building experiences, exploring and manipulating objects, building skills that are needed in teamwork and co-workers. An important feature of the good learning of teaching material in the learning process through serious educational games is the briefing: implementation of initial guidelines, briefly introduced by the lecturer, which puts right the foundations on which students can build their knowledge [17]. The following feature described by Rowe, Shores, Mott, & Lester in [18] must also be considered: students with higher achievements have higher efficiency in solving new problems, they have a greater interest in collecting and organizing information. At the same time, however, students with higher achievements usually use traditional ways to solve the task, and lower-learning students prefer to use computer-based methods. In this way, SEGs can be used as a means to improve the learning educational results of students with a lower degree of learning.

C. Methods to Achieve Educational Goals in Serious Games

One of the leading methods for achieving educational goals through the use of serious games is the guiding principle of the teacher: to lay the foundations of new knowledge, guide, direct and correct, so that training through serious educational games can be truly effective, meaningful and not admitted the learner wasting time or moving in a different direction from a useful learning of the material.

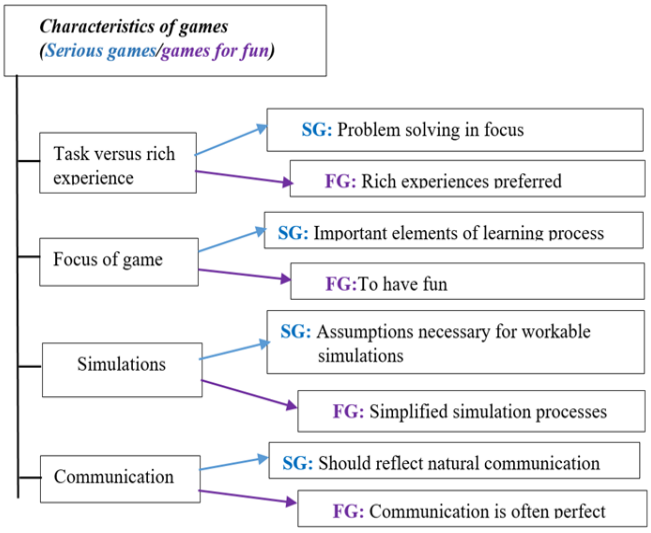


Fig. 2. Characteristics of Serious Games end Games for Fun.

One of the important tasks of a game is to have the opportunity to adapt the game to the current knowledge, skills, and experience of the particular learner. In order to achieve the pedagogical goals of the training, the teacher needs to maintain a continuous dialogue with his / her pupils in order to keep track of their progress, the difficulties they encounter (to provide adequate help), analyze the information they receive about the student's achievements, to give advice, to support and correct the learning process.

In the scientific literature, eight component elements have been identified, identified and used to create a successful gameplay model (GameFlow): concentration, challenge, skills, control, clear goals, feedback, immersion, and social interaction [19]. For the optimal achievement of the educational goals of the games, it is good that all these principles are well established in them. Almost all games count on a clear goal and feedback. It is also necessary to strike a balance between the challenge of the game and the potential ability of the learner (according to his age, previous knowledge, and skills) to cope with it. Solving this task creates the learner's sense of satisfaction and builds confidence in his / her skills, which is one of the pedagogical tasks of teaching. An important task in creating serious educational games is to provide an opportunity to assess the player's progress and provide timely feedback.

D. Current Contemporary World Trends and Innovative Technologies in the Field of Semantic Knowledge

At the base of the Semantic Web (the concept is first used by the World Wide Web Consortium (W3C) Director) is the idea that innovative technologies can process data and interpret knowledge. The use of ontologies to present semantically based knowledge is a contemporary current global trend. Ontology is a means of creating a system of formally presented knowledge based on some accepted conceptualization - a description of a multitude of objects, notions, facts, knowledge and their interrelations. Ontology is a conceptual information model in a given area of knowledge in a formal way. Ontologies are very useful in creating search engines and information retrieval and are useful base in developing serious educational games in a given subject area of knowledge. One of the main goals of SEGs is to teach learners structured knowledge.

E. Serious Games as a Method of Transferring Knowledge

Serious educational games are increasingly becoming an alternative way of transferring knowledge in the area of knowledge they are targeting. SEGs are a method of conveying new, up-to-date knowledge that scientists, professionals, and explorers have reached, and by incorporating them into serious games, that knowledge can quickly and effectively reach the learners. Classical methods of transferring knowledge, such as specialized literature, learning through teaching, require a long time to master the educational material. In setting up SEGs it is useful to develop a design framework through which knowledge transfer is realized. It is a good idea to create a strategy for the dissemination of knowledge by designing algorithms to support decision-making.

F. Exploring Consumer Opinion about Serious Educational Games

The SEGs positive impact on education stems from an increase in the efficiency of the learning process, the possibility of additional self-learning of the learning material, consolidation of the acquired knowledge, support of unscheduled learning, effortless learning, increasing the interest in the studied subject and activation the participation of learners. At the same time, the entry of SEGs into Bulgarian education has been running for more than 10 years, and it is becoming increasingly popular among teachers who are beginning to assess their potential. Nowadays there are factors that support the use of games in educational schools and universities: provision of modern equipment in the renewed study rooms, increase of the number of SEGs set up in Bulgaria for the purpose of training students of different age groups and different subjects, provision of fast and quality Internet (especially in schools in larger settlements). For the comprehensive entry of the games into the learning process in Bulgaria, it is also necessary to conduct appropriate courses for teachers who want to modernize their teaching methods.

Serious educational games are suitable for assessing acquired knowledge, for extra-extra-curricular training, for home preparation, they can be an incentive for learning, they are appropriate for exercising the acquired knowledge, for achieving specific learning objectives, for building up the learning material.

From the respondents' answers, it is clear that they are willing to use serious educational games in the schooling process and for additional homework. It is also clear that innovative technologies in general and, in particular, serious educational games are not often used in the learning process. One of the main obstacles to the use of serious educational games in school is the lack of state-of-the-art technological equipment and the lack of appropriate SEGs that match the material studied, can be used in the limited time of the class, and the teachers have the appropriate technical competence to use of the Serious educational games. During the investigation, some of the teachers became interested, and they created serious games (textual to evaluate the material studied) and offered the pupils' games; games were received with interest.

G. Use of Mathematical Technologies for Physiological Data Analysis in the Medical Education Process

An effective technological method of analyzing physiological data is wavelet analysis. Used as an alternative to traditional Fourier analysis, Wavelet analysis is now widely used in various areas of real life and is a commonly used tool in scientific research. Wavelet analysis provides information on signal behavior simultaneously in the time and frequency domain and is suitable for use of non-stationary, dynamic signals such as cardiac signals.

The spectral analysis of cardiac data in the present study was performed using the wavelet-based method (continuous wavelet transform, wavelet basis of Morlet). Used interpolation of input data (resampled at 4 Hz) through cubic spline wavelet. The results obtained are presented in digital and graphic form.

The ratio (low frequencies / high frequencies) LF / HF obtained in the spectral analysis of the study series was investigated. this parameter is an indicator of sympathetic balance in the nervous regulation of the human body. According to the heart rate variability standard [20], values corresponding to a healthy organism are between 1.5 and 2.0.

IV. Results of a Holter Data Study by Mathematical Tolls

A mathematical analysis of the cardiac data of a patient with atrial fibrillation was performed; the data were obtained through Holter monitoring conducted for 24 hours. The patient was admitted to a medical institution (Multiprofile Regional Hospital for Active Treatment MOBAL "Dr. Stefan Cherkezov", Cardiology ward, Veliko Tarnovo, Bulgaria). The Holter monitor device was installed (start time: 10.00 in the morning), after which the patient left the hospital, continuing throughout his 24-hour study to perform his normal daily activities.

The created software module (by the author) for analysis of cardiac data using Wavelet analysis was made and compiled in the MATLAB programming environment.

The cardiology series obtained after preprocessing input data (denoising, detection of peaks with maximum amplitude (R peak), etc.) obtaining the intervals between these peaks (RR intervals) is shown in Fig. 3.

Fig. 4 presents the distribution of frequencies depending on time (spectrogram of the investigated cardiac series, Atrial fibrillation) obtained using wavelet technology. The predominant blue areas in the low frequency (LF: 0.04-0.15 Hz) and high frequency (HF: 0.15-0.4 Hz) regions are an indicator of low signal power in the cardiology series studied, which is an indicator of serious health problems [21].

Fig. 5 presents the spectral components obtained in the analysis of the cardiac series tested (Very LF (0.0 – 0.04 Hz), LF and HF). Spectral components are calculated by applying three mathematical methods: the Burg method, the Lomb-Scargle method, and the Wavelet method. The calculated LF / HF ratio by these three methods is obtained outside the range of normal values for a healthy individual (< 1.5). The results obtained are an indicator of the presence of cardiac problems in the investigate subject.

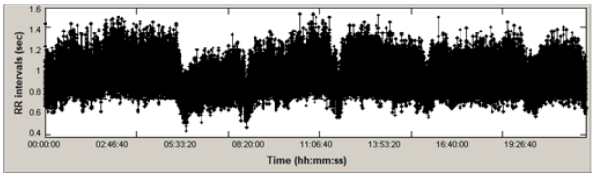


Fig. 3. The RR Intervals of the Studied Cardiology Sequence.

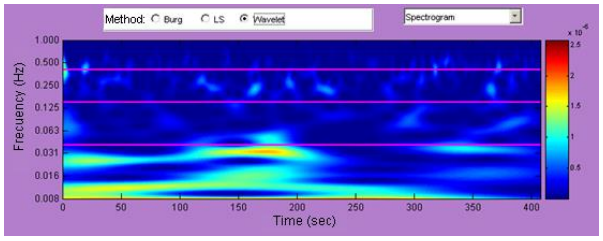


Fig. 4. Atrial Fibrillation Spectrogram.

Frecuency band	Peak (Hz)	Power (ms^2)	Power (%)	Power (n.u.)	LF/HF(ratio) n.u.1.5-2.0
Burg					
VLF	0.04	257.9	14.2		
LF	0.04	528.7	29.0	0.338	0.510
HF	0.22	1035.8	56.8	0.662	
Lomb-Scargle					
VLF	0.04	16.0	11.3		
LF	0.08	42.6	29.9	0.337	0.509
HF	0.21	83.7	58.8	0.663	
Wavelet					
VLF	0.01	1612.8	28.5		
LF	0.05	1328.2	23.5	0.328	0.488
HF	0.23	2721.4	48.1	0.672	

Fig. 5. Wavelet Analysis Results.

V. Results of a Survey Conducted Among Bulgarian Students

A study was conducted on the use of serious educational games by students in connection with their education in the country's higher universities. 162 students from the universities in Bulgaria, responded to the survey voluntarily. The study was conducted in April and May 2019, and participants were randomly selected. The survey aims to study the use of SEGs in the educational process in Bulgaria and to establish does it has to interest in the implementation of serious educational games in the classroom.

On the question "Do You play serious games related to your training" 42 students of all 162 responded with "Yes" (Fig. 6). This is a very small number of students and shows that the use of serious educational games in training in these universities is not well advocated.

On the question: “Do You think the serious games help to your training?” 134 of the respondents answered positively (Fig. 7), showing a high interest among students in the use of serious educational games for training and their positive attitude towards serious games.

Fig. 6. The use of Serious Educational Games in the Educational Process in Bulgaria.

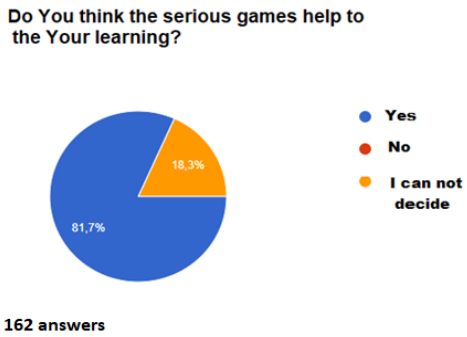


Fig. 7. Studying Learners Attitudes Towards Serious Games.

Of all 162 respondents, 142 students (86.6%) believe that serious games will help raise learners' interest in the learning process (Fig. 8). Only 2 respondents have answered “No”, and 12.2% said: "I cannot decide".

126 (0.78%) of all respondents believe that the inclusion of serious games in learning will increase their motivation to learn (Fig. 9). Six participants of the survey have answered “No”, and 18.3% said: "I cannot decide".

The results of the conducted survey among students in Bulgaria show a positive attitude of students towards the inclusion of serious educational games in the learning process, willingness to use them and expect from the use of serious games to increase their interest in learning and motivation to achieve high educational results. At the same time, the study shows that today in Bulgarian universities the use of social security systems is not well advocated.

The conducted research on the means that students prefer to use in addition to traditional training tools in their medical education is summarized in Table I (Questions in questionnaire: “Do You want to use (Do use) these tools your university learning process”). The results show that students prefer to take advantage of modern technology in their training.

Table II presents the qualities that are developed through SEGs according to the respondents of the study (Question in the questionnaire: "Do serious games develop these qualities?"). The qualities that are developed through the use of SEGs are individual, collective and can enhance the educational outcomes of students.

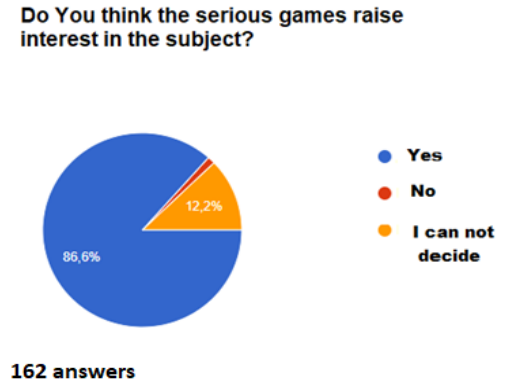


Fig. 8. Answers to the Issue of Enhancing Motivation in Learning.

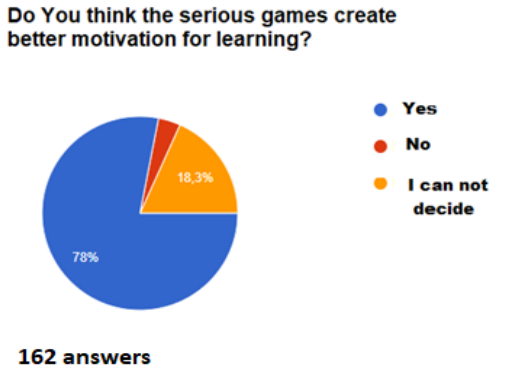


Fig. 9. Answers to the Issue of Enhancing Motivation in Learning.

A. Discussion on the use of SEGs in Training in Bulgaria

Serious educational games today take advantage of new technologies and are becoming more challenging, intriguing and in line with the goals of the learning process. The set budget for a serious educational game has a great influence on the complexity, type of the game and the interesting and dynamic elements in the game. Today, gaming funds in the education sector (worldwide) are several times smaller than the funds spent on fun games creating. This leads to a lag in the technological and modernity of serious games in the education process.

Today, augmented and mixed reality technologies [22], effective graphical imaging tools (creating realistic controls for transparency, reflection, and refraction), content generation techniques are new challenges for improving serious games [23]. Open software platforms have been created to quickly create and easily personalize serious games that are beginning to be used by teachers in Bulgaria who want to stimulate their students' creativity and improve their skills and knowledge. Thus, the main problems, which will be decisive for the entry, development and use of serious games in higher education in Bulgaria and, respectively, in medical education at universities in the country, are the issue of financing serious games and the question of the desire of teachers to accept the challenge of game-based learning.

TABLE. I. MODERN TRAINING TOOLS

Tools	„I want to use (I use) in the learning process“	„I do not want to use in the learning process“	“I cannot decide”
Educational games site	74.69%	2.47%	22.84%
Interactive online tests	88.27%	8.02%	3.7%
Online video training materials	77.78%	1.85%	20.37%
Virtual and mixed reality games	51.23%	20.99%	27.78%
Databases with real clinical data and results	85.8%	7.4%	6.79%
Software training systems	78.39%	11.11%	10.49
Using graphics tablets	59.88%	10.49%	29.63%

TABLE. II. DEVELOPED QUALITIES

Qualities	„Yes”	„No”	“I cannot decide”
Communication skills	74.69%	17.9%	7.4%
Ability to work in a team	69.75%	16.05%	14.2%
A quick thought	95.68%	1.23%	3.08%
Skills for coping with difficulties	88.89%	4.94%	6.17%
Orientation and adaptation in extreme situations	84.58%	7.4%	8.02%
Developing tactics and strategies for achievement of success	79.63%	9.88%	10.49%

VI. Conclusion

The paper presents two effective methods that can increase the motivation of medical students to learn and contribute to improving the quality of students' preparation: the use of mathematical technologies to analyze physiological data and the use of serious games in the educational process of medicine.

The paper examines the issues related to the use of Serious Educational Games, focusing on the pedagogical aspects of their use in the learning process.

Serious educational games aim to support traditional training by using the latest information and communication technologies developments and modern innovative methods.

The study conducted among students in Bulgaria shows a high interest in SEGs and their inclusion in the learning process. The majority of respondents believe that SEGs will contribute to improving their education, create student aspirations to build up the learning material, increase motivation for learning and professional development. As a result of the research, it can be concluded that students in Bulgaria will readily accept the use of serious educational games in their training and this will lead to the improvement of their knowledge, skills, and experience and will contribute to building them as excellent specialists in their area of professional interests.

Acknowledgment

This work was supported by NSF of Bulgaria under the Research project № DM 12/36/20.12.2017, "Investigation of Mathematical Techniques of Analysis of Physiological Data with Functionality for People with a Visual Deficit" and the Bulgarian Ministry of Education and Science under the National Research Programme "Young scientists and postdoctoral students" approved by DCM # 577 / 17.08.2018.

References

[1] A. Noorhidawati, S. Ghalebandi, R. Siti Hajar, "How Do Young Children Engage with Mobile Apps? Cognitive, Psychomotor, and Affective Perspective," Journal of Convergence Information Technology, Vol. 87, pp. 385-395, 2015.

[2] M. Prensky, Digital game-based learning, ACM Computers in Entertainment, 2003, Vol. 1, No 1, Book Two.

[3] J. Colbert, D. Chokshi, "Technology in Medical Education—Osler Meets Watson", Journal of General Internal Medicine, Vol. 29, No 12, pp. 1584-1585.

[4] P. Leger, P. Charland, H. Feldstein, J. Robert, G. Babin, D. Lyle, "Business Simulation Training in Information Technology Education: Guidelines for New Approaches in IT Training", Journal of Information Technology Education, Vol. 10, pp. 39-53, 2011.

[5] M. Larsen, "Advice for New and Student Lectures on Probability and Statistics", Journal of Statistics Education, Vol.14, No 1, pp. 1-13, 2006.

[6] G. Georgieva-Tsaneva, "Effective information methods for description and storage of data in health care", International Journal of Mechanical Engineering and Technology, Vol. 10, No 2, pp.708-715, 2019.

[7] G. B. Moody, R. G. Mark, "The impact of the MIT-BIH arrhythmia database", IEEE Engineering in Medicine and Biology Magazine, 2001, pp. 45-50.

[8] G. B. Moody, R. G. Mark, "The MIT-BIH arrhythmia database on CD-ROM and software for use with it", IEEE Computers in Cardiology, 1990, pp. 185-188.

[9] A. Taddei, A. Biagini, et al., The European ST - T database: Development, distribution and use, IEEE Computers in Cardiology, 1991, pp. 177-180.

[10] G. Georgieva-Tsaneva, "Wavelet based interval varying algorithm for optimal non-stationary signal denoising", Proceedings of the 20th International Conference on Computer Systems and Technologies, ACM International Conference Proceeding Series, New York, USA, pp.200-206, 2019.

[11] Z.L. Márkus, G. Kaposi, M. Veres, Z. Weisz, G. Szántó, T. Szkaliczki, D. Paneva-Marinova, R. Pavlov, D. Luchev, M. Goynov, L. Pavlova, Interactive Game Development to Assist Cultural Heritage. Digital Presentation and Preservation of Cultural and Scientific Heritage. Vol. 8, Sofia, Bulgaria: Institute of Mathematics and Informatics – BAS, 2018, pp. 71-82, ISSN 1314-4006 (Print), eISSN 2535-0366 (Online).

[12] S. Bigdeli, D. Kaufman, "Digital games in medical education: Key terms, concepts, and definitions", Medical Journal of the Islamic Republic of Iran, Vol.31, No 1, pp. 300-306, 2017.

[13] M. Boeker, P. Andel, W. Vach, A. Frankenschmidt, "Game-based e-learning is more effective than a conventional instructional method: A randomized controlled trial with third-year medical students", PloS one. Vol. 8; No 12: e82328, 2013. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3857775/.

[14] K. Pettit, L. McCoy, M. Kinney, F. Schwartz, "Student perceptions of gamified audience response system interactions in large group lectures and via lecture capture technology". BMC Med educat. Vol.15, No 92, pp. 1-15, 2015.

[15] I. Granic, A. Lobel, R. Engels, "The benefits of playing video games". American Psychologist, Vol. 69(1), pp.66-78, 2014.

[16] D. Kolb, Experiential Learning. Prentice Hall, New York, 1984.

[17] A. Gloria, F. Bellotti, R. Berta, E. Lavagnino, "Serious Games for education and training", International Journal of Serious Games, Vol. 1, No. 1, pp. 100-105, 2014.

[18] P. Rowe, L. Shores, B. Mott, J. Lester, "Individual Differences in Gameplay and Learning: A Narrative-Centered Learning Perspective". In Proceedings of the Fifth International Conference on the Foundations of Digital Games, Monterey, 2010.

[19] P. Sweetser, P. Wyeth, "GameFlow: A Model for Evaluating Player Enjoyment in Games", ACM Computers in Entertainment, Vol. 3, No. 3, pp. 1-24, 2005).

[20] M. Malik, "Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Heart rate variability: standards of measurement, physiological interpretation, and clinical use" Circulation, Vol. 93, 1996; pp. 1043-1065.

[21] C. Russoniello, Y.Zhirnov, V.Pougatchev, E.Gribkov, "HRV and Biological Age: Implications for Health and Gaming," Cyberpsych., Behav. Soc. Netw, Vol. 16, (4), 302-308,2013.

[22] M. Zyda, "From Visual Simulation to Virtual Reality to Games". IEEE Computer, Sept., Vol. 38 (9), pp. 25-32, 2005.

[23] G. N. Yannakakis, J. Togelius, "Experience-driven procedural content generation", IEEE, Transactions on Affective Computing, Vol. 2, No 3, pp.147-161, 2011.

Region-wise Ranking for One-Day International (ODI) Cricket Teams

Akbar Hussain[1], Yan Qiang*[,2], M. Abdul Qadoos Bilal[3], Kun Wu[4], Zijuan Zhao[5], Bilal Ahmed[6]
College of Information and Computer
Taiyuan University of Technology, Taiyuan, Shanxi, China

***Abstract*---In cricket, the region plays a significant role in ranking teams. The International Cricket Council (ICC) uses an ad-hoc points system to rank cricket teams, which entirely based on the number of wins and losses a match. The ICC ignores the strength and weaknesses of the team across the region. Even though the relative accuracy in the ad-hoc ranking is high, but they do not provide a clearly defined method of ranking. We proposed Region-wise Team Rank (RTR) and a Region-wise Weighted Team Rank (RWTR) to rank cricket teams. The intuition is to get more points to a team that wins a match from a stronger team as compared to a team that wins against a weaker team & vice versa. The proposed method considers not only the number of region-wise wins and losses but also incorporates the region-wise strength and weakness of a team while assigning them the ranking score. In conclusion, the ranking list of the teams compares to the ICC official ranking.**

***Keywords*---Batting; bowling and fielding strength; PageRank; region strength; team's strength**

I. Introduction

Ranking in sports is a significant measure for the performance and comparison between different teams. The International Cricket Council (ICC) is the governing body that ranks cricket players and teams based on their previous and current performances. Traditionally, the ICC uses an ad-hoc rating system to rank cricket teams. This Ad-hoc rating system is based on the number of wins or loses in a match to assign a rating score1. Authors criticized the current ICC rating system as being non-transparent, and providing a better ranking still needs proper investigation [1].

There are five region in the world in which cricket is played. These regions are classified as follows; Asia, Africa, the Americas, Europe, and Oceania Region[2]. In cricket, the region/venue plays an essential role in measuring players' and teams 'performance because every region has distinct playing conditions. Region-wise ranking classifies the team's strengths and weaknesses throughout the region/venue. The team's strength is the foundation of several parameters of a team, such as bowling, batting, and fielding strengths. The consistent performance of the players in these departments improves their team's strength. The teams with higher strength are usually considered higher in rank. Ahmed et al. proposed the modified NSGA-II procedure to find a set of high-performing teams having better bowling and batting performance [2].

The proposed methods are the extensions of the PageRank Algorithm [3]. PageRank is a ranking algorithm that models the searchable web pages as a directed graph, with each page acting as a node. Every webpage has several numbers of incoming and outgoing links or links directed to that webpage. These links are "citations" concerning web pages. The idea is that the more a team wins matches from stronger teams, the higher it is ranked. The Region-wise Team Rank (RTR) considers the strengths and weaknesses and as well as win and loss matches of the team while ignores the number of runs and wickets from which matches wins. Besides, the Region-wise Weighted Team Rank (RWTR), considered both the strength of the team and the number of runs and wickets through which matches wins. Finally, the region-wise score of all the regions of the RTR method combined and computed the Unified Region-based Team Rank (URTR). Similarly, the Region-wise Weighted Team Rank (RWTR) scores merged and computed the Unified Region-wise Weighted Team Rank (RWTR). In conclusion, both the URTR and RWTR scores are merged and compared with the ICC official ranking using Spearmans' rho.

II. Related Work

Research has identified a limited material set of references regarding region-wise and a unified team's strength; however, a comprehensive review revealed the following. The author developed a new performance measure to quantify the performance of the players [4]. A player scoring runs against a strong bowling lineup or taking wickets against the strong batting lineup deserves more credit. Batting, bowling, and fielding have always been the most critical aspects of the cricket game. But with the advent of T20 cricket, the combined batting and bowling rate quantify the performance of the player using multiple linear regressions [11]. The multiple linear regression model used [9] to predict the match outcome, while the match is in progress. Different variables are considered for training and testing the model, such as home ground advantage, region performance, the past and current form of the team to predict the match outcome. Logistic regression is applied to predict the best team after the knock-out phase in the ODI cricket series [6]. Fielding is also an essential aspect of the cricket game. Parag Shah [7] has developed to measure the aggregated fielding performance of each player in ODI and T20 cricket matches. The application of the Social Network Analysis (SNA) quantifies the quality of the player-versus-player score [5]. The application of

*Corresponding Authors

[1]https://www.sportsrec.com/calculate-followon-score-cricket-8088680.html

[2]https://www.icc-cricket.com/about/members

machine learning framework, the artificial neural network (ANN) is applied to predict the results of cricket sports [8]. The simulation method is applied for ODI cricket matches to predict the match outcome. Given that only a finite number of outcomes can occur, throwing each ball. A discrete generator on a finite set developed where the outcome probabilities estimated from historical data of the matches [10].

A team that wins a match through runs and wickets plays a significant role in the team's ranking. Similarly, weighting factors are also an essential parameter in ranking cricket teams. Daud et al. [12] proposed team rank and t-index to rank cricket teams, but they do not consider the strengths and weaknesses of the teams across the region. The International Cricket Council (ICC) ranks cricket teams without considering the strengths and weaknesses across the region. However, Daud et al. [13] proposed a Region-based Players Link fusion (RPLF) algorithm to rank cricket players by using a region-based intra-type and inter-type relation-based features to rank the players in cricket.

Page et al. develop PageRank for ranking web pages. Several researchers have attempted to improve the PageRank process [3]. Xing and Ghorbani proposed a weighted Pagerank (WPR) algorithm. The idea is to treat all links equally when rank scores calculated. The WPR algorithm takes into account the importance of both incoming and outgoing links and distributes rank scores among accessible web pages [14]. Many researchers in sports ranking used PageRank. The initial attempt was made by Mukherjee to apply the PageRank algorithm to identify the most excellent team and their captains [15]. Later on, the authors used PageRank for ranking cricket teams, but they ignored region-wise teams' strength and unified team strength, which is very important for the selection of the best team [12].

This research is probably the first generalized approach to rank ODI cricket teams across the region. The information retrieval technique is applied to build a model that can effectively measure the performance of a team across the region.

III. Ranking Cricket Teams

The International Cricket Council (ICC) official ratings system for One Day International Cricket Teams explained in this section.

A. ICC Rating System for ODI Cricket Teams

The International Cricket Council (ICC) is the governing body to represent cricket internationally. They award championship trophies to the teams with the highest rating in cricket matches. The ICC employs basic formulas for ODI cricket matches to calculate points and ratings to each team by winning, losing, or tying a match or a series of matches [1].

The ICC updates the ratings based on the recent score of the teams when two teams play a match or a series of matches. To determine the teams' new ratings after a particular match, first, calculate the points earned from the match.

- If the rating gap between two teams before the match is less than 40 points, then add 50 points more for a winning team than the opponent team's rating and assign 50 points fewer than the opponent's rating for losing a team. In case of a tie a match, each team assigns the opponent team's rating.
- If the gap between two teams' rating is greater than or equal to 40 points, then add 10 points more to a stronger team than its rating in case of winning a match or 90 points fewer than its rating by losing a match. Similarly, assign 90 points more to the total of a weaker team's rating for a win or 10 points fewer for a loss. In the case of a tie, the stronger team drops 40 points from its rating, and the weaker team improves 40 points over its original rating.
- Each team's rating is equal to its total points scored divided by the total matches played.
- Add the match points scored to the points already scored (in previous matches), add one to the number of matches played, and determine the new rating.
- Points earned by teams depend on the opponent's ratings. Therefore this system needed to assign base ratings to teams when it started started1.

B. PageRank Algorithm

Page et al. proposed a ranking algorithm named PageRank [3], which is used to rank web pages on the web. The PR of the pages should be high if they link to a more significant number of pages, and those pages are essential. PageRank based on the number of incoming and outgoing links of the pages (nodes) to determine their rank. Web pages with a higher number of incoming links are more important than pages with less number of incoming links. In general, the PageRank value for a web page determined by using the generalized equation as follows:

$$PR(A) = c \sum_{v \in B_A} \frac{PR(v)}{L(v)} \quad (1)$$

Where PR(A) is the value of PageRank of a page, A for each page **v** contained in the set B_A (the set containing all the pages linking to page A), divided by the number of out-links (***L(v)***) from page **v** and **c** is a normalization factor.

C. Cricket Formation and Terminologies

1) Team formation: In cricket team selection, the batsman, bowler, all-rounder, and wicketkeeper plays a significant role in a match. Batsman scoring runs with a bat while a bowler bowls to concede minimum run and get maximum wickets. All-rounder can be a bowler or/and batter, and wicketkeeper is a player who stands behind the wickets to stop the ball or take a catch of a batsman.

2) Ground: The ground is usually in a circle-shaped having radius 70 meters. Different grounds in the world have a size of 70 meters or more. There is a 22-meter pitch inside the ground having wickets on both sides. The bowler bowl and the batsmen try to hit a ball.

3) Over: An "over" is defined as a set of six consecutive balls bowled by a bowler.

4) Wicket: In cricket, the wicket is one of the two sets of three stumps at either side of the pitch. Wicket guarded a

batsman who, with his bat, attempts to prevent the ball from hitting the wicket by a bowler or fielder.

5) Runs Scored: In cricket sports, one team bat first and score as many runs as possible while the other team bowls. In case of the team batting first wins, it wins by runs while in case team batting second wins, it wins by wickets. In the ODI cricket match, five bowlers have permission to bowl a maximum of 10 overs. The bowler bowls while batsmen try to hit a ball and get runs. Only two batsmen are playing in a pitch at the same time, one at each side. There is a maximum of 6 runs or no runs on a ball hit by a batsman. When a batsman hits a ball, it crosses a boundary without touching a boundary line; it should be considered a 6 runs otherwise 4 runs. When a batsman hits a ball and reaches to the other side of the pitch, he/she completes his one run.

D. Proposed Method

1) Region-wise team 'strength: In cricket sports, ranking is essential to measure the performance and comparison between different teams. Bowling, batting, and fielding performances are the most critical parameters for the team's strength. Players showing consistent performance in each of the departments improve their team strength.

We created three datasets from the online website3 using scraping tools (parsehub and import.in) then created different features for each of the datasets of batting, bowling and fielding respectively. As a result, we combined the strengths of all the regions and find out the aggregated strength as shown in Fig. 1.

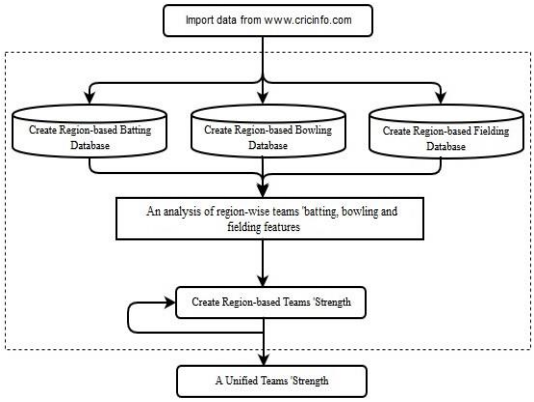


Fig. 1. A Graphical Representation of Region-based Teams' strength.

Equation (2) is applied to compute the region-wise teams 'strength.

$$\sum_{t,r=i}^{n} \boldsymbol{RT_{Strength}} = \sum_{t,r=i}^{n} \left(\frac{\boldsymbol{RT_{Batting_{Strength}}}}{\boldsymbol{RT_{bowling_{Strength}}}} * \boldsymbol{RT_{Fielding_{Strength}}} \right) \quad (2)$$

Where $\sum_{t,r=i}^{n} RT_{Strength}$ is the region-wise strength of a team t in region r, $RT_{Batting\_Strength}$ is the batting strength, $RT_{Bowling\_Strength}$ is the bowling strength and $RT_{Fielding\_Strength}$ is the region-wise fielding strength. The team's strength increases with the increases of batting features while the team's strength decreases with the increases of bowling features.

Batsmen always perform against the opponent team's fielding and bowling strengths. The Team_AvgRun (team average runs), Team_ER (team economy rate), Team_SR (team strike rate), and Team_WinLoss (team win/loss ratio) is considered to be the most important parameters for the teams 'batting strength. These features are ascertained as in (3).

$$\sum_{t,r=i}^{n} RT_{Batting_{Strength}} = \sum_{t,r=i}^{n} \left(\frac{(\mathrm{Team_{AvgRuns}} * \alpha) + (\mathrm{Team_{ER}} * \beta) + (\mathrm{Team_{SR}} * \gamma) + (Team\_WinLoss * \delta}{4} \right) \quad (3)$$

Where $\sum_{t,r=i}^{n} RT_{Batting\_Strength}$ is the region-wise batting strength of team t in region r., and$\alpha + \beta + \gamma + \delta = 1$, finding the optimum combination of these variables is difficult in the absence of gold standard benchmark rankings. Daud et al. assigned $\alpha, \beta, \gamma$and δ to different weights such as $\alpha = \beta = \gamma = 20\%$ and δ = 60%; however, we used $\alpha = \beta = \gamma = \delta = 25\%$ to each of the features [13], [12].

Many features affect the bowling strength of a team. The essential features are applied to compute the accurate bowling strength of a team in (4).

$$\sum_{t,r=i}^{n} RT_{Bowling_{Strength}} = \sum_{t,r=i}^{n} \left(\frac{(\mathrm{AvgRuns\_Conceded} * \alpha) + (\mathrm{ER\_Conceded} * \beta) + (\mathrm{SR\_Conceded} * \gamma) + (\mathrm{Team\_WLLoss} * \delta)}{4} \right) \quad (4)$$

Where $\sum_{t,r=i}^{n} RT_{Bowling\_Strength}$ is the region-wise bowling strength of team t in region r. AvgRuns_Conceded, ER_Conceded, SR_Conceded *and* $Team\_WinLoss$ are the region-wise team's bowling average runs conceded, bowling economy rate conceded, bowling strike rate conceded and teams 'win/loss ratio respectively.

Several features are affecting the fielding performance of the team. The essential features are formulated in (5) to compute the fielding strength of the teams across the region.

$$\sum_{t,r=i}^{n} RT_{Fielding\_Strength} = \sum_{t,r=i}^{n} \left(\frac{(\mathrm{RT_{run\_out}} * \alpha) + (\mathrm{RT_{wicket\_stmp}} * \beta) + (\mathrm{RT_{fielder\_cats}} * \gamma) + (\mathrm{RT_{wicket\_keeper\_cats}} * \delta)}{Total\ Number\ of\ Region\_based\ Innings\ Played} \right) \quad (5)$$

Where $\sum_{t,r=i}^{n} RT_{Fielding\_Strength}$ is the region-wise fielding strength of team t in region r, RT_{run_out}, RT_{wicket_stmp}, $RT_{fielder\_cats}$, and RT_{wkpr_cats} are the number of region-based run-out, wicketkeeper stumps, fielder catches and wicketkeeper catches of team t in region r respectively.

2) Region-wise TeamRank (RTR): The Region-wise TeamRank (RTR) is the extension of the PageRank algorithm. PageRank [3] is the most effective graph-based ranking algorithm on the web which based on the number of incoming and outgoing links to find their ranking. The RTR of team t is high if the team wins many matches against opposite teams that have a higher team strength and win-loss ratio. The RTR determined by using (6).

$$RTR\ (T) = \frac{1-d}{N} + d[\frac{RTR(Ti)}{\text{CTi}} * RT_{Strength}{}^{r}_{ti} + , \dots , + \frac{RTR(Tn)}{CTn} * RT_{Strength}{}^{r}_{tn}] \quad (6)$$

Where,

- $RTR(T)$ is the Region-wise TeamRank (RTR) of team T.
- RTR(T_i) is the region-wise team rank of Team T_i which links (lost matches) to team T.
- CT_i is the matches lost by team T_i.
- $(RT_{Strength}{}^{r}_{ti})$ is the region-wise team strength (calculated from equation 2) of Team T_i in region r.
- While d is a damping factor which is usually set between 0 and 1 (in our experiment we set d=0.85).
- And N is the total number of teams played in region r.

The in-links and out-links show won and lost matches by Team t_i in region r. The network of teams created in Fig. 2, which played head-to-head matches against each other. The nodes represent the teams, and edges between them are the matches played. If two teams t_i, and t_j, played a match in a specific region, and if team t_i wins from team t_j then, a directed edge is generated from team t_j to team t_i. Consequently, a directed graph is generated iteratively to rank the teams by considering the number of matches played and the team strengths across the region.

3) Region-wise Weighted Team Rank (RWTR): In the Region-wise Weighted Team Rank (RWTR), region-wise win/loss ratio of a team Ti and region-wise win and lost matches through runs and wickets considered. A team that wins matches from another team with less number of runs and wickets ranked lower as compared to a team that wins matches with more number of runs and wickets across the region.

TABLE I shows how two basic parameters (runs and wickets) influence the region-wise ranking of a team T? Assume team A and B have played 20 matches each in Asia region in which, both have won the same number of matches. If the sum of runs of the won matches of team A is 250, and the sum of wickets of the won matches is 50. And the sum of runs of the won matches of team B is 400 and the sum of wickets of the won matches is 30, then both teams, A and B, have different rank scores. In the above example, if we consider the win/loss ratio of each team then both teams have the same rank score. But when we consider runs and wickets through which a team won matches, then both teams have different rank scores 21.3 and 20.9, respectively as shown in TABLE II. Region-wise, WTR is calculated by using (7).

Where 10, 250 and 50 respectively are the number of matches, runs, and wickets through which Team A has won matches. TABLE III shows win and loss matches with runs and wickets.

$$\text{RWTR(T)} = \frac{1-d}{N} + \sum_{i=1}^{n} \frac{(RWTR(T_i)}{\text{CTi}} * RT_{Strength}{}^{r}_{ti} \quad (7)$$

Where RWTR(T) is the Region-wise Weighted Team Rank of Team T in region r. RWTR(T_i) is the Region-wise TeamRank of teams Ti which has lost matches to Team A.

WC(T_i) is the Region-wise out-links (lost matches) of Team T_i. $RT_{Strength}{}^{r}_{ti}$ (Calculated from (2)) is the Region-wise strength of team T_i in region r. Region-wise Weighted out-links (RWO) calculated by using weighted arithmetic mean in (8).

$$RWO = \frac{60(Region-wise-winloss) + 20(Runs) + 20(wickets)}{Region-wise-winloss+Runs+Wickets} \quad (8)$$

One can try different weights for the three features 33% w/l, 33% runs, 33% wickets or 40 % w/l, 30% runs, 30% wickets, but in our case, we used 60, 20 and 20 weights to each w/l, runs and wickets respectively.

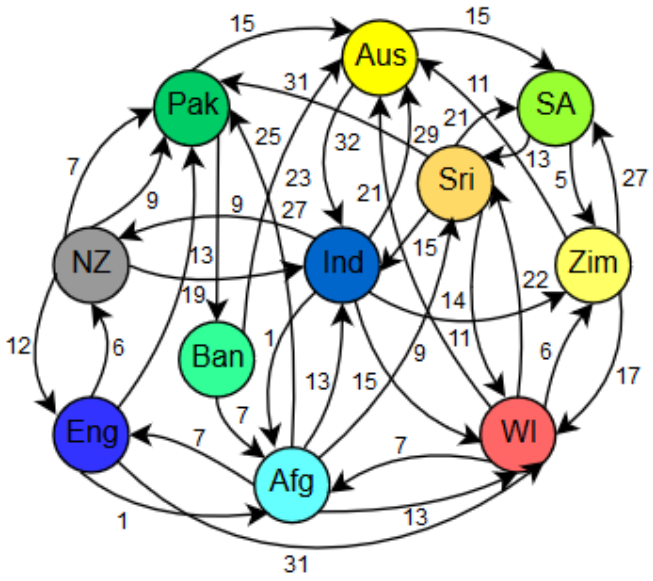


Fig. 2. A Graphical Representation of ODI Cricket Teams.

TABLE. I. RANK SCORES WHEN BOTH RUNS AND WICKETS ARE IGNORED

Teams	Win	Lost	W/L	Win by runs	Win by wicket
A	**10**	**10**	**1.0**	**250**	**50**
B	**10**	**10**	**1.0**	**400**	**30**

TABLE. II. RUNS AND WICKETS ARE CONSIDERED ALONG WITH W/L RATIOS

Team A	Team B
$\frac{60(10)+20(250)+20(50)}{(10+250+50)}$ = **21.3**	$\frac{60(10)+20(400)+20(30)}{(10+400+30)}$ = **20.9**

TABLE. III. WON AND LOST MATCH'S RUNS AND WICKETS ARE CONSIDERED

Team A	Team B
$\frac{60(10)+20(250)+20(50)}{(10+250+50)}$ / $\frac{60(10)+20(400)+20(30)}{(10+400+30)}$ = **1.018**	$\frac{60(10)+20(400)+20(30)}{(10+400+30)}$ / $\frac{60(10)+20(250)+20(50)}{(10+250+50)}$ = **0.0982**

IV. EXPERIMENTS

This section explains the dataset and performance evaluation in detail. It also provides a comparison of the ICC official teams ranking versus the region-wise ranking.

A. Dataset

The dataset is taken from the ESPNcricinfo website[3] of One Day International matches played between January 2001 and August 2019. The ICC grouped cricket teams into three categories i.e., full member countries, associate member countries, and affiliate member countries[2]. In our case, we considered only full member countries; they have the right to play Twenty20, One-Day, and Test cricket matches and follow the ICC rules. The authors considered only those teams in the domain of ranking which had played at least ten ODI matches across the region.

B. Results and Discussions

The proposed ranking determined the strengths and weaknesses of a team across the region. If a team visits to play a match against the opponent team, having a regional ranking enables a more equitable regional distribution. The captain, the coach, and the team's management should be aware of their teams' strength against the opposite team from the visiting region so that the selectors select a strong combination from his team.

There is no statistical test to say which ranking is better; however, Spearman's Rank Correlation can be used to assess the reliability and validity of the proposed ranking methods. The region-based ranking score of all the regions of RTR and RWTR, respectively, as shown in TABLE VII and computed the Unified Region-based Team Rank (URTR) and the Unified Region-based Weighted Team Rank (URWTR) respectively. Besides, the URTR and URWTR scores are merged and computed the UTR, as shown in TABLE VIII. Consequently, a non-parametric correlation (Spearman rho) is used to assess the validity and reliability of the proposed (URTR, URWTR, and UTR) ranking as in TABLE V, and TABLE VI respectively with the ICC official ranting system using Spearman rho which had a strong correlation with the proposed methods. The results and discussions prove that the proposed methods are highly correlated and very useful in terms of ranking cricket teams across the region. The ICC only presents a general ranking based on the most recent performance of the teams. However, an ODI rating system from the ICC is used as a baseline for comparing the region-wise and a unified team's ranking. In addition, the outcomes of the proposed methods are also compared subjectively with the existing ICC ranking.

[3]http://www.espncricinfo.com

TABLE. IV. ICC CURRENT RANKING FOR ODI CRICKET TEAMS

Teams	Matches	Points	Ratings	Rank
England	54	6,745	125	1
India	58	7,071	122	2
New Zealand	43	4,837	112	3
Australia	50	5,543	111	4
South Africa	47	5,193	110	5
Pakistan	49	4,756	97	6
Bangladesh	46	3,963	86	7
Sri Lanka	54	4,425	82	8
West Indies	49	3,740	76	9
Afghanistan	40	2,359	59	10
Zimbabwe	35	1,538	44	12

TABLE VII shows the ranking of the full member countries played ODI cricket matches across Asia, Africa, the Americas, Europe, and Oceania regions. The ICC team ranking is shown in TABLE IV, while the proposed ranking shown in TABLE VII. England, India, and New Zealand are the top 3 teams in the ICC ranking, while in the RTR ranking India, Pakistan, and Sri Lanka are the respective top three teams. Because of their more considerable team strengths and win-loss ratios compared to the other teams in the Asian region. Australia, Pakistan, and India are the respective top 3 teams in the RWTR method. Australian team ranks first because of winning matches with a higher number of runs and wickets.

In the ICC ranking TABLE IV, the top 3 teams are England, India and New Zealand while in the RTR ranking South Africa, Australia and Indian cricket teams are the first, second and third respectively because of their more considerable team strengths and win-loss ratios compared to the other teams in the Africa region. South Africa, Sri Lanka, and Australian cricket teams are the respective top 3 teams in the RWTR method. South African team ranks first because of winning matches with a higher number of runs and wickets. In the ICC ranking, the top 3 teams are England, India, and New Zealand while in the RTR ranking Australia, West Indies, and South African cricket teams are the first, 2nd and 3rd respectively because of their greater team strengths and win-loss ratios compared to the other teams in the America region. West Indies, South Africa, and Australian teams are the respective top 3 teams in the RWTR method. West Indies team ranks first because of winning matches with a greater number of runs and wickets.

England, India, and New Zealand cricket teams are the top-3 teams in the ICC ranking while first, fourth, and third in the RTR ranking. Because of their higher team strengths and win-loss ratios compared to the other teams in the Europe region.

England, Australia, and Indian cricket teams are the respective top-3 teams in the RWTR method. England team ranks first because of winning matches with a higher number of runs and wickets.

TABLE. V. CORRELATIONS OF THE ICC RANKING WITH URTR AND URWTR RANKING AND URTR WITH URWTR RANKING USING SPEARMAN'S RHO

Teams	ICC Rank	URTR Rank	URWTR Rank	Correlation between ICC and URTR	Correlation between ICC and URWTR	Correlation between URTR and URWTR
England	1	6	7	75.45%	61%	86.36%
India	2	3	2			
New Zealand	3	2	6			
Australia	4	1	1			
South Africa	5	4	3			
Pakistan	6	7	5			
Bangladesh	7	9	10			
Sri Lanka	8	5	4			
West Indies	9	8	8			
Afghanistan	10	11	9			
Zimbabwe	11	10	11			

TABLE. VI. CORRELATION OF ICC RANKING WITH UTR RANKING USING SPEARMAN'S RHO

Teams	ICC Rank	UTR Rank	Correlation between ICC and UTR Ranking
England	1	7	61%
India	2	2	
New Zealand	3	6	
Australia	4	1	
South Africa	5	3	
Pakistan	6	5	
Bangladesh	7	10	
Sri Lanka	8	4	
West Indies	9	8	
Afghanistan	10	9	
Zimbabwe	11	11	

TABLE. VII. REGION-WISE RANKING FOR ONE-DAY INTERNATIONAL (ODI) CRICKET TEAMS

Teams	Asia Region		Africa Region		America Region		Europe Region		Oceania Region	
	RTR	RWTR	RTR	RWTR	RTR	RWTR	RTR	RWTR	RTR	RWTR
Pakistan	0.033	0.74696	0.062	0.40362	0.0796	0.13616	0.060	0.17726	0.035	0.16214
India	0.034	0.72251	0.063	0.45770	0.0793	0.17120	0.061	0.25561	0.049	0.39800
Sri Lanka	0.032	0.71932	0.061	0.49659	0.0806	0.16141	0.058	0.15754	0.041	0.17313
Bangladesh	0.023	0.29832	0.038	0.04464	0.0759	0.10898	0.053	0.06956	0.029	0.07260
Australia	0.031	0.91622	0.064	0.48430	0.0872	0.27824	0.063	0.25479	0.063	0.70225
England	0.029	0.48493	0.056	0.32687	0.0789	0.12784	0.065	0.36283	0.042	0.17805
New Zealand	0.027	0.34328	0.060	0.35056	0.0794	0.12444	0.062	0.20638	0.062	0.56022
South Africa	0.028	0.43838	0.066	0.69583	0.0831	0.31941	0.057	0.16441	0.047	0.18375
West Indies	0.024	0.31721	0.047	0.12478	0.0839	0.45803	0.059	0.18169	0.046	0.20473
Zimbabwe	0.021	0.19635	0.041	0.12539	0.0732	0.01947	0.051	0.03639	0.020	0.05000
Afghanistan	0.026	0.51987	0.043	0.17877	N/A	N/A	0.031	0.02453	N/A	N/A

TABLE. VIII. A UNIFIED TEAMS RANKING FOR ODI CRICKET TEAMS

Teams	URTR Ranking	URWTR Ranking	UTR Ranking
Pakistan	0.05392	0.325228	0.189574
India	0.05726	0.401004	0.229132
Sri Lanka	0.05452	0.341598	0.198059
Bangladesh	0.04378	0.118820	0.081300
Australia	0.06164	0.527160	0.294400
England	0.05418	0.296104	0.175142
New Zealand	0.05808	0.316976	0.187528
South Africa	0.05622	0.360356	0.208288
West Indies	0.05198	0.257288	0.154634
Zimbabwe	0.04124	0.085520	0.063380
Afghanistan	0.03333	0.241057	0.137195

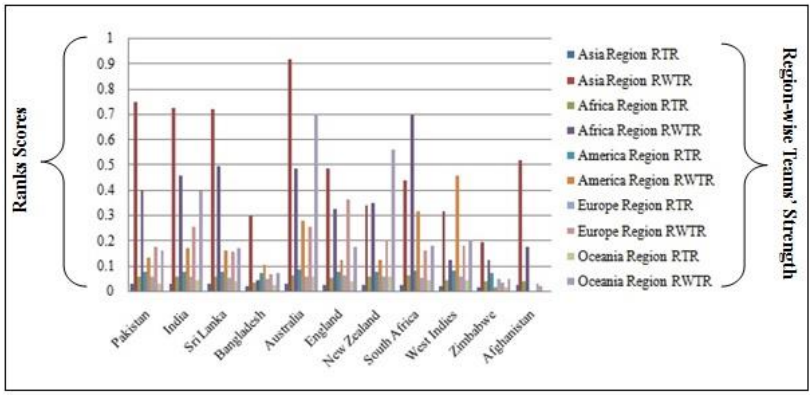


Fig. 3. Graphical Representation of Region-Wise Ranking for ODI Cricket Teams.

In the Oceania region, Australia, New Zealand, and India are the top-3 teams considering the RTR method while England, India, and New Zealand are the top-3 teams considering the ICC ranking as shown in TABLE IV. Because of their higher team strengths and win-loss ratios compared to the other teams across the region. Australia, New Zealand, and Indian teams are the respective top 3 teams in the RWTR method. Australian team ranks first because of winning matches with a higher number of runs and wickets. There are ups and downs between ODI cricket teams because of the teams 'strengths and weaknesses across the regions. Fig. 3 shows the graphical representation of region-wise teams' ranking for ODI cricket teams. It is clearly shown from the Fig. 3 that Australian cricket team is the highly ranked team in most of the regions.

The Unified Region-wise Team Rank (URTR) and the Unified Region-wise Weighted Team Rank (URWTR) are the weighted average scores of all the regions. Similarly, the Unified Team Rank (UTR) is the weighted average rank score of both the URTI and URTR methods. The Australian cricket team is ever first in the UTR while Indian and South African teams are second and third, respectively. The overall strength of the Australian team is higher as compared to the other teams. When the UTR results compared to the ICC rank, there is a strong correlation in the outcomes, as shown in TABLE VI.

The graphical representation of URTR, URWTR, and UTR ranking for ODI cricket teams is shown in Fig. 4. The Australian cricket team has overall better ranking in all the methods.

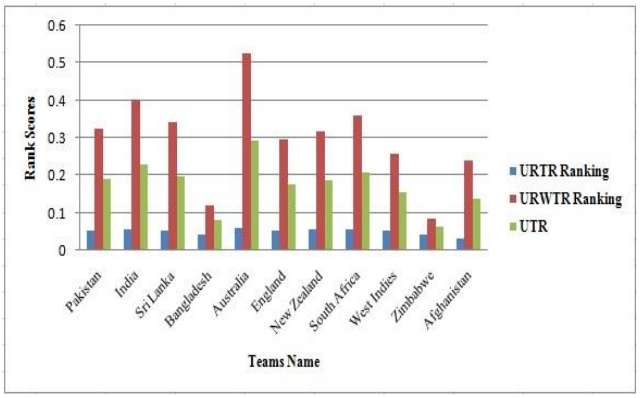


Fig. 4. Graphical Representation of a Unified Teams Ranking.

V. Conclusions and Future Work

We studied the ranking of ODI cricket teams across the region. We applied two methods; (1) Region-wise TeamRank (RTR) and (2) Region-wise Weighted TeamRank (RWTR). We investigated that the number of matches a team wins with the addition of team strength from the stronger team is very important by applying the TeamRank method. Furthermore, we concluded that the win/loss ratio and the number of runs and wickets through which a team wins from a team across the region also play an important role in cricket ranking. This paper is the first attempt to find out ranking cricket teams in ODI format to see the strength and weaknesses of each team across the region. In the future, we aim to build a deep model using Principal Component Analysis (PCA) for region-based teams' strengths and weaknesses to get better results and then compare the model with the traditional system.

Acknowledgment

This work was supported by the National Natural Science Foundation of China (61872261).

References

[1] Borooah and J. Mangan, "The Bradman Class": An Exploration of Some Issues in the Evaluation of Batsmen for Test Matches , 1877-2006," no. June 2014, 2010.

[2] F. Ahmed, K. Deb, and A. Jindal, "Evolutionary Multi-Objective Optimization and Decision Making Approaches to Cricket Team Selection," pp. 1–23.

[3] T. Pagerank, C. Ranking, and B. Order, "The PageRank Citation Ranking: Bringing Order to the Web," pp. 1–17, 1998.

[4] P. Shah, "New performance measure in Cricket," vol. 4, no. 3, pp. 28–30, 2017.

[5] S. Mukherjee, "Quantifying individual performance in Cricket − A network analysis of Batsmen and Bowlers," Phys. A Stat. Mech. its Appl., no. 393, pp. 624–637, 2014.

[6] P. Taylor and H. H. Lemmer, "Predicting the names of the best teams after the knock-out phase of a cricket series," Eur. J. Sport Sci., no. September, pp. 37–41, 2014.

[7] P. Shah, "Measuring Fielding Performance in Cricket," vol. 23, no. 2, pp. 113–114, 2016.

[8] R. P. Bunker and F. Thabtah, "Applied Computing and Informatics A machine learning framework for sport result prediction," Appl. Comput. Informatics, 2017.

[9] M. Bailey and S. R. Clarke, "Predicting the match outcome in one day international cricket matches, while the game is in progress.," J. Sports Sci. Med., vol. 5, no. 4, pp. 480–487, 2006.

[10] T. B. Swartz, P. S. Gill, and S. Muthukumarana, "Modelling and simulation for one-day cricket," vol. 37, no. 2, pp. 143–160, 2009.

[11] D. Bhattacharjee and D. G. Pahinkar, "Analysis of Performance of Bowlers using Combined Bowling Rate," vol. 06, no. 03, pp. 184–192, 2012.

[12] A. Daud, F. Muhammad, H. Dawood, and H. Dawood, "Ranking Cricket Teams," pp. 1–17, 1998.

[13] H. Daud, A., Hussain, A., Abbasi, R. A., Aljohani, N. R., Amjad, T., & Dawood, "Region-wise Ranking of Sports Players based on Link Fusion," in Companion of the web conference 2018, 2018, no. 1, pp. 259–266.

[14] W. Xing and A. Ghorbani, "Weighted PageRank Algorithm," in 2nd Annual Conference on Communication Networks and Services Research (CNSR 2004), 19-21 May 2004, Fredericton, N.B. Canada., 2004.

[15] S. Mukherjee and B. Engineering, "Identifying the greatest team and captain − A complex network approach to cricket matches," vol. 391, no. 23, 2012.

Land use Detection in Nusajaya using Higher-Order Modified Geodesic Active Contour Model

N. Alias[1]
Center for Sustainable Nanomaterials
Ibnu Sina Institute for Scientific and Industrial Research
Universiti Teknologi Malaysia, UTM, Skudai, Johor, Malaysia

M. N. Mustaffa[2], F. Mustapha[3]
Department of Mathematical Sciences
Universiti Teknologi Malaysia, UTM
Skudai, Johor, Malaysia

***Abstract*—Urban development is a global phenomenon. In Johor, especially Nusajaya is one of the most rapidly developing cities. This is due to the increase of land demand and population growth. Moreover, land-use changes are considered to be one of the major components of current environmental monitoring strategies. In this context, image segmentation and mathematical model offers essential tools that can be used to analyze land use detection. The image segmentation process is known as the most important and difficult task in image analysis. Nonlinear fourth-order models had shown to have a good achievement in recovering smooth regions. Therefore, these motivate us to propose a fourth-order modified geodesic active contour (GAC) model. In the proposed model, a modified signed pressure force (SPF) function has been defined to segment the inhomogeneous satellite images. The simulations of the fourth-order modified GAC model through some numerical methods based on the higher-order finite difference method (FDM) have been illustrated. Matlab R2015a software in Windows 7 Ultimate on Intel (R) Core (TM) i5-3230M @ 2.60GHz CPU with 8 GB RAM has been considered as a computational platform for the simulation. Qualitative and quantitative differences between modified SPF functions and other SPF functions have been shown as a comparison. Hence land use detection is very useful for local governments and urban planners to enhance the future sustainable development plans of Nusajaya.**

Keywords*—Higher-order geodesic active contour (GAC); segmentation; land use; finite difference method; numerical methods

I. Introduction

Nowadays, land-use changes, increasing due to increases in human activities which then give a big impact on the global environmental changes [1]. Consequently, most ecosystems and the surface of the earth are significantly being modified by different kinds of human activities [1], [2] especially in forestry and urban development. Several techniques were formulated, applied and evaluated in order to detect the land-use changes [3], [4]. Recently, image segmentation has been an area of active research in the detection of medical and satellite images. The well-known nonlinear PDE-based tool for image segmentation is known as the geodesic active contour (GAC) model.

The GAC model is also known as an edge-based model [5]–[8]. The GAC model creates an edge indicator that enforces the development contour to the object boundaries [9]–[11]. However, the GAC model has difficulty converging at the right boundaries when it works on images with extreme noise or weak edges. The weaknesses of the GAC model were improved by introducing the shrinkage force. Author in [12] also adopted an error term in the generalized geodesic active contour (GGAC) model in order to detect the multi-connected region of images. This method, however, often suffers from serious problems with boundary leaks in images with weak object boundaries and the contour must be located close to the desired target, or the evolution curve can pitch to a local minimum and converge to the incorrect solution [13].

To resolve the leakage issue, Chan and Vese suggested a particular case with an active contour approach in which the original image intensity is homogeneity [13]–[15]. The aim of the method proposed by Chan and Vese is to find a contour in the segmented image. If the image intensity is inhomogeneity within or outside the image, the constants are not accurate. The Chan-Vese (CV) model subsequently does not generally segment images with intensity inhomogeneity. Therefore, the local information of the given image should be considered to segment the inhomogeneity images [12], [13], [16]. Some researchers have proposed an essential model to extract local information from inhomogeneity images. The proposed model is known as an active contour model based on local image fitting [12], [13], [16]. The other proposed model that considered the local information from inhomogeneity images is known as the local signed pressure force (SPF) function which utilized the advantages from both GAC and CV model [11], [17], [18]. This model, however, very sensitive to the initial contour placement and if the given images have adjacent objects, then it may cause failure in local segmentation.

Then [19] came up with the idea to resolve this problem by replacing the stopping function with a new global SPF function to effectively stop contours on weak edges. This modification is based on a homogeneous assumption that used the average of the inner and outer intensity of the curve. Therefore, the global SPF function is capable of controlling the evolutionary direction. Although the global SPF function is more efficient and can overcome the high cost of re-initialization, it is limited to segment blurred and complicated images. From this limitation, it motivates us to propose a new modified SPF function that uses the good in local and global SPF function.

The GAC model was investigated as a helpful tool for image segmentation. In this paper, the fourth-order approximation has been implemented on the GAC model to enhance the accuracy of segmentation. The proposed fourth-order modified GAC model is based on the new modified SPF function that uses the edge and region information of the image. Therefore the aim of the proposed modified fourth-order GAC is to have achievement in recovering a smooth region and obtaining a better result in image segmentation. Furthermore, in the numerical part, the higher-order finite difference method (FDM) scheme has been utilized to develop the Penta-diagonal linear system of equation. Although this scheme is generally used in applied mathematics, only a few researchers have used this scheme to solve the image segmentation problem. Therefore, some numerical methods such as AGE, RBGS and JB methods will be used to solve the linear system of equation, which is a stable and easy method to implement.

In general, the purpose of this paper is to propose higher-order PDE-based segmentation to detect and monitor land-use changes in Nusajaya. Thus, the secondary objective is to improve the accuracy of land use segmentation. The rest of this paper is organized as follows. Section 2 is devoted to the descriptive study of the area. Related works on segmentation are presented in Section 3. Section 4 described the proposed segmentation model and some numerical methods. The proposed segmentation model was validated by several experiments and comparison results are presented in Section 5. A brief discussion based on the experiments is described in Section 6. Lastly is the conclusion of this paper as in Section 7.

II. Description of the Study

The study is located in the Nusajaya region of Johor as shown in Fig. 1. The new name of Nusajaya is known as Iskandar Puteri. This region has the fastest growing national economy. The Nusajaya region covers an area of 2217 km2 consisting of five local authorities. Furthermore, these five local authorities have five distinctive development points. Thus it guides its overall development. In 2010, Johor Baharu had 14.1kha of natural forest, extending over 38% of its land area. In 2017, it lost 572ha of natural forest.

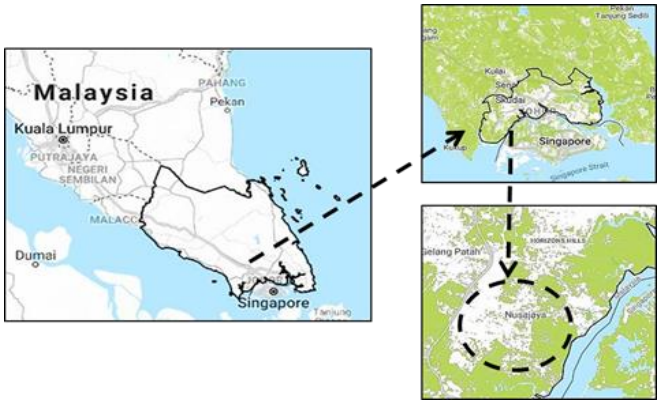


Fig. 1. Location of Study Area of Nusajaya, Johor Baharu, Malaysia. (https://www.globalforestwatch.org).

III. Related Work

A. The GAC Model

The energy functional of the snake model introduced by Kass et al. (1988) can be simplified as

$$E(\Gamma) = \int_0^1 E_{\text{int}}(\Gamma(q)) + E_{ext}(\Gamma(q))\,dq \tag{1}$$

Note that, $\Gamma : [0,1] \to \Re^2$ is a parametrized curve, E_{int} is the internal energy that controls the smoothness of the detected contours and E_{ext} is the external energy that is responsible for drawing contours towards the desired image features. Although (1) is successful due to its simplicity and efficiency, it is not intrinsic and has undesirable properties since it is dependent on the parameterization *q*, which is not related to the object boundary and it is also unable to change its topology. The active contour model is as follows [20]:

$$\frac{\partial u}{\partial t} = g(I)|\nabla u|\text{div}\left(\frac{\nabla u}{|\nabla u|}\right) + vg(I)|\nabla u|$$
$$= g(I)(v+\kappa)|\nabla u| \tag{2}$$

where *v* is a positive real constant and $g(I)$ as stopping functions for instance:

$$g = \frac{1}{1+\left|\nabla \hat{I}\right|^p} \tag{3}$$

This stopping function $g(I)$ is responsible for controlling and stopping the iterative when it arrives at the desired image features. As a result, the edge-based model works well for images with clear edge information, but when it is used for detecting images with high noise and weak or blurred edges, it fails to reach the desired image features.

B. CV Model

Chan and Vese proposed a specific case with an active contour approach in which the original image intensity is uniform [13]–[15], [21]–[23]. The aim is to find a contour, u in which the given image, I is segmented. The CV model is outlined in the following equation:

$$\frac{\partial u}{\partial t} = \delta(u)\left[\mu\text{div}\left(\frac{\nabla u}{|\nabla u|}\right) - \lambda_1(I(x)-c_1)^2 + \lambda_2(I(x)-c_2)^2\right] \tag{4}$$

where λ_1, λ_2 and μ are nonnegative constants. c_1 and c_2 represent the intensity averages for the inner or outer region.

The third term is the regularization length of the curve *u*. The following equations are defined for c_1 and c_2:

$$c_1(x) = \frac{\int_\Omega I(x)H(\phi(x))\text{dx}}{\int_\Omega H(\phi(x))\text{dx}} \tag{5}$$

$$c_2(x)=\frac{\int_\Omega I(x)(1-H(\phi(x)))\mathrm{dx}}{\int_\Omega (1-H(\phi(x)))\mathrm{dx}} \tag{6}$$

As in (5) and (6), c_1 and c_2 are referred to both the internal and the external contour global properties of the image contents. If the intensity within or outside contour is not uniform, the constants are not accurate.

C. The Local Region-based Model

The GAC model is easily affected by noise and needs a long execution time, while the CV model is inefficient with intensity inhomogeneity and produces unsatisfactory segmentation results. According to [24], they have suggested a new local region-based SPF function in order to resolve this problem by replacing the stopping function, $g(I)$ and effectively stop the contours even on weak edges. The local region- based SPF function benefits from two smooth constants approximating the image intensities locally inside and outside the contour [24]. The SPF function is defined as

$$spf_{LC}=\frac{G_\sigma(x)*I(x)-\frac{f_1+f_2}{2}}{\max\left(\left|G_\sigma(x)*I(x)-\frac{f_1+f_2}{2}\right|\right)}, \qquad x\in\Omega \tag{7}$$

where $I(x)$ is the image, Ω is the image domain, G_σ is the Gaussian kernel with standard deviation σ and * indicates the convolution operator. The denominator in (7) takes the maximum absolute value of the numerator. The SPF function is, therefore, will be derived within the range [-1, 1]. Therefore f_1 and f_2 are defined as follows:

$$f_1(x)=\frac{\int_\Omega G_\sigma * I(x)H_\varepsilon(\phi)\mathrm{d}\Omega}{\int_\Omega H_\varepsilon(\phi)\mathrm{d}\Omega}$$
$$f_2(x)=\frac{\int_\Omega G_\sigma * I(x)(1-H_\varepsilon(\phi))\mathrm{d}\Omega}{\int_\Omega (1-H_\varepsilon(\phi))\mathrm{d}\Omega} \tag{8}$$

The Heaviside function $H(\phi)$ in (8) was approximated by the smooth function H_ε defined as

$$H_\varepsilon=\frac{1}{2}\left[1+\frac{2}{\pi}\arctan\left(\frac{x}{\varepsilon}\right)\right] \tag{9}$$

where ε is a positive constant. f_1 and f_2 are the intensity averages for the inside and outside contour. Unfortunately, this local region-based SPF function can result in unsuccessful local segmentation when the images have adjacent objects. It is also easily affected by the initial contour placement [9], [11].

D. The Global Region-based Model

Consequently [19] proposed a new global SPF function to overcome the problem. Thus, by neglecting the term $\mathrm{div}\left(\frac{\nabla u}{|\nabla u|}\right)$, this model takes less time to converge and a fewer number of iterations to converge when compared with other models. The SPF function is defined as follows.

$$spf_{GL}=\frac{(c_1*c_2)*I(x)-\frac{c_1+c_2}{2}}{\max\left(\left|(c_1*c_2)*I(x)-\frac{c_1+c_2}{2}\right|\right)}, \qquad x\in\Omega \tag{10}$$

where c_1 and c_2 represent the intensity averages of regions inside (u) or outside (u).

$$c_1(x)=\frac{\int_\Omega I(x)H(\phi)\mathrm{d}\Omega}{\int_\Omega H(\phi)\mathrm{d}\Omega}$$
$$c_2(x)=\frac{\int_\Omega I(x)(1-H(\phi))\mathrm{d}\Omega}{\int_\Omega (1-H(\phi))\mathrm{d}\Omega} \tag{11}$$

As a result, this global SPF function cannot detect all boundaries. This is due to (10) only using the global intensity information.

IV. Proposed Model

A. A Novel of Higher-Order Modified GAC Model

This paper proposed a novel of higher-order modified GAC model that utilizes the advantages of the local region-based model and global region-based model by integrating the local and global intensity information to develop a modified SPF function. The proposed modified SPF function is defined as:

$$LCGL=(1-\omega_1)(spf_{LC}-spf_{GL})+\omega_1(spf_{GL}-spf_{LC}) \tag{12}$$

where $\omega_1=\mathrm{mean}(\mathrm{grad}(u))$ is the adaptive filter weight which helps to enhance the contrast of image. The main aim of modified GAC model is to detect the land-use changes in Nusajaya. The GAC approach allows the connection between the classical snake model (energy minimization) and the geometric active contour model (curve evolution theory). Therefore the GAC model allows stable boundary detection when the images have high gradients and gaps [20]. The main contribution of this paper is the new formulation of the fourth-order modified GAC model to enhance the capability for simulating and segmenting the land use on high-resolution satellite images of Nusajaya. Thus, the fourth-order modified GAC model is considered as follows:

$$\frac{\partial u}{\partial t}=|\nabla u|\phi\left(\left(\frac{1}{(\Delta x)^2}\frac{\partial^2 u}{\partial x^2}-\frac{(\Delta x)^2}{12}\frac{\partial^4 u}{\partial x^4}\right)+\left(\frac{1}{(\Delta y)^2}\frac{\partial^2 u}{\partial y^2}-\frac{(\Delta y)^2}{12}\frac{\partial^4 u}{\partial y^4}\right)\right)+(1-\omega_2)v\,spf_{LCGL}|\nabla u| \tag{13}$$

where $\phi = \frac{spf_{LCGL}}{|\nabla u|}$ and v is the balloon force that controls the contour expansion or shrinkage when the contour is inside or outside the object boundaries. Thus, spf_{LCGL} is the SPF function based on (12) and ω_2 as the adaptive weight function adopting from [25] which then helps to allocate the role of the local and global SPF function. The following equation illustrates the central difference approximation from second-order to the fourth-order spatial accuracy for the first term of (13). This can result in approximation in (14).

$$\frac{u_{i,j}^{n+1}-u_{i,j}^{n}}{\Delta t} = |\nabla u|_{i,j}^{n}\phi_{i,j}^{n}\left(\frac{-u_{i+2,j}^{n+1}+16u_{i+1,j}^{n+1}-30u_{i,j}^{n+1}+16u_{i-1,j}^{n+1}-u_{i-2,j}^{n+1}}{12(\Delta x)^4} + \frac{-u_{i,j+2}^{n+1}+16u_{i,j+1}^{n+1}-30u_{i,j}^{n+1}+16u_{i,j-1}^{n+1}-u_{i,j-2}^{n+1}}{12(\Delta y)^4}\right) + O(\Delta t)+O(\Delta x)^4+O(\Delta y)^4 \quad (14)$$

Equation (14) has five-point center space with spatial truncation error of the order, $O(\Delta x)^4$ and $O(\Delta y)^4$. The model in (13) is discretized using a fourth-order central difference formula. Thus, this paper considers developing algorithms of a higher order, in particular, those whose accuracies are enhanced based on higher-order FDM scheme. Therefore, to realize this application, it is important to know that the discretization generates the fourth-order GAC model into a Penta-diagonal, instead of a tri-diagonal system of equations. The smaller truncation error of the fourth-order modified GAC model will give a more accurate representation of the numerical methods. The proposed fourth-order numerical methods are the JB, RBGS, and AGE methods.

B. Fourth-Order Numerical Methods

1) AGE method: In this paper, with reference to the work done by [26], the AGE4-PENTA method has been used to solve the fourth-order GAC model. This method is unconditionally stable. AGE is a suitable method because it has low computational complexity [27]. Therefore, the AGE method can be expressed as in the following algorithm:

a) Evolution in x-direction Calculate

$$x^{\left(n+\frac{1}{2}\right)} = (G_1+rI)^{-1}\{(rI-G_2)x^{(n)}+f\}$$

$$x^{(n+1)} = (G_2+rI)^{-1}\left\{(rI-G_1)x^{\left(n+\frac{1}{2}\right)}+f\right\}$$

b) Evolution in y-direction Calculate

$$y^{\left(n+\frac{1}{2}\right)} = (G_1+rI)^{-1}\{(rI-G_2)y^{(n)}+f\}$$

$$y^{(n+1)} = (G_2+rI)^{-1}\left\{(rI-G_1)y^{\left(n+\frac{1}{2}\right)}+f\right\}$$

2) RBGS method: Referring to the general iterative formula for the RBGS method in [28], the fourth-order RBGS can be expressed as in the equations below:

a) Evolution in x-direction calculate

for $i = 3,\ldots,M-1$;

$$x_i^{n+1} = \frac{f_i + d_x x_{i-2}^n + a_x x_{i-1}^n + b_x x_{i+1}^n + e_x x_{i+2}^n}{(1+c_x)}$$

for $i = 2,4,\ldots,M$

$$x_i^{n+1} = \frac{f_i + d_x x_{i-2}^{n+1} + a_x x_{i-1}^{n+1} + b_x x_{i+1}^n + e_x x_{i+2}^n}{(1+c_x)}$$

b) Evolution in y-direction calculate

for $j = 3,\ldots,N-1$;

$$y_j^{n+1} = \frac{f_j + d_y y_{j-2}^n + a_y y_{j-1}^n + b_y y_{j+1}^n + e_y y_{j+2}^n}{(1+c_y)}$$

for $i = 2,4,\ldots,M$

$$y_j^{n+1} = \frac{f_j + d_y y_{j-2}^{n+1} + a_y y_{j-1}^{n+1} + b_y y_{j+1}^n + e_y y_{j+2}^n}{(1+c_y)}$$

3) JB Method: Based on the general iterative formula of the JB method in [28], the fourth-order JB method can be represented by:

a) Evolution in x-direction calculate

for $i = 2,\ldots,M-1$;

$$x_i^{n+1} = \frac{f_i + d_x x_{i-2}^n + a_x x_{i-1}^n + b_x x_{i+1}^n + e_x x_{i+2}^n}{(1+c_x)}$$

b) Evolution in y-direction calculate

for $j = 2,\ldots,N-1$;

$$y_j^{n+1} = \frac{f_j + d_y y_{j-2}^n + a_y y_{j-1}^n + b_y y_{j+1}^n + e_y y_{j+2}^n}{(1+c_y)}$$

C. Implementation

Several steps are involved in this experiment. The experiment starts with reading and converting the high-resolution satellite images of Nusajaya from signal to digital data. Then, the initial and boundary conditions of the proposed segmentation model are read and computed. The next step is employing and executing the numerical methods to solve the linear system of equation (LSE) of the fourth-order GAC model until convergence is achieved. Below is the algorithm for the proposed model.

V. Experimental Results

The proposed model is applied to the high-resolution satellite image of Nusajaya adopted from Google Earth. The range of intensities of the image is represented from 0 to 255, while the size in pixels (length × width) of the image is 200x200. The experiments developed by using Matlab R2015a software in Windows 7 Ultimate on Intel (R) Core (TM) i5-3230M @ 2.60GHz CPU with 8 GB RAM. In the proposed

model, the following parameters are used: $\tau = 1$, $\Delta x = \Delta y = 1$, $v = -3$, $\sigma = 1$ and $m = 200 \times 200$.

A. Comparison with Local Region-Based Model and Global Region-Based Model

In order to test the modified SPF function, the proposed model in (13) will be compared with the local region-based model and global region-based model. A visualization and quantitative analysis based comparison between the segmentation results of four different years of high-resolution satellite images of Nusajaya is obtained. The ground truth images and segmented images are used to calculate the false positive (FP), true positive (TP), false negative (FN), and true negative (TN) [11], [24].

Fig. 2 shows the comparison results of the global region-based model, local region-based model and the proposed fourth-order modified GAC model for high-resolution satellite images with weak boundaries and noise. From top to bottom, the images in the first row are the satellite images of Nusajaya in the year 2006, and this image is quite weak with intensity inhomogeneity; the second row and the third row are the satellite images in the year 2009 and 2012, respectively, with intensity inhomogeneity weak boundaries; then the fourth row is the satellite images year 2015, and this image has severe intensity inhomogeneity. The ground truth and the final contour of the proposed model, global region-based model, and the local region-based model are plotted as red contours, blue contours, green contours, and yellow contours, respectively. Fig. 2 reveals that the segmentation results of the global region-based model cannot obtain the correct boundaries for all images since the images have intensity inhomogeneity. Then, the local region-based model is unsatisfactory since this model only uses the local intensity information to classify the images. By integrating the global and local intensity information, the proposed model successfully detects the object boundaries with high accuracy, sensitivity, and specificity.

Table I shows a quantitative analysis based on the computed segmentation results from Fig. 2. As shown in Table I, the proposed modified SPF function provides high accuracy and slightly fewer numbers of iterations and execution time as compared to the methods of [24] and [19]. From the results in Table I, the robustness of the proposed model has been proved to segment the satellite images of Nusajaya with intensity inhomogeneity and weak boundaries and thus better than the other two models.

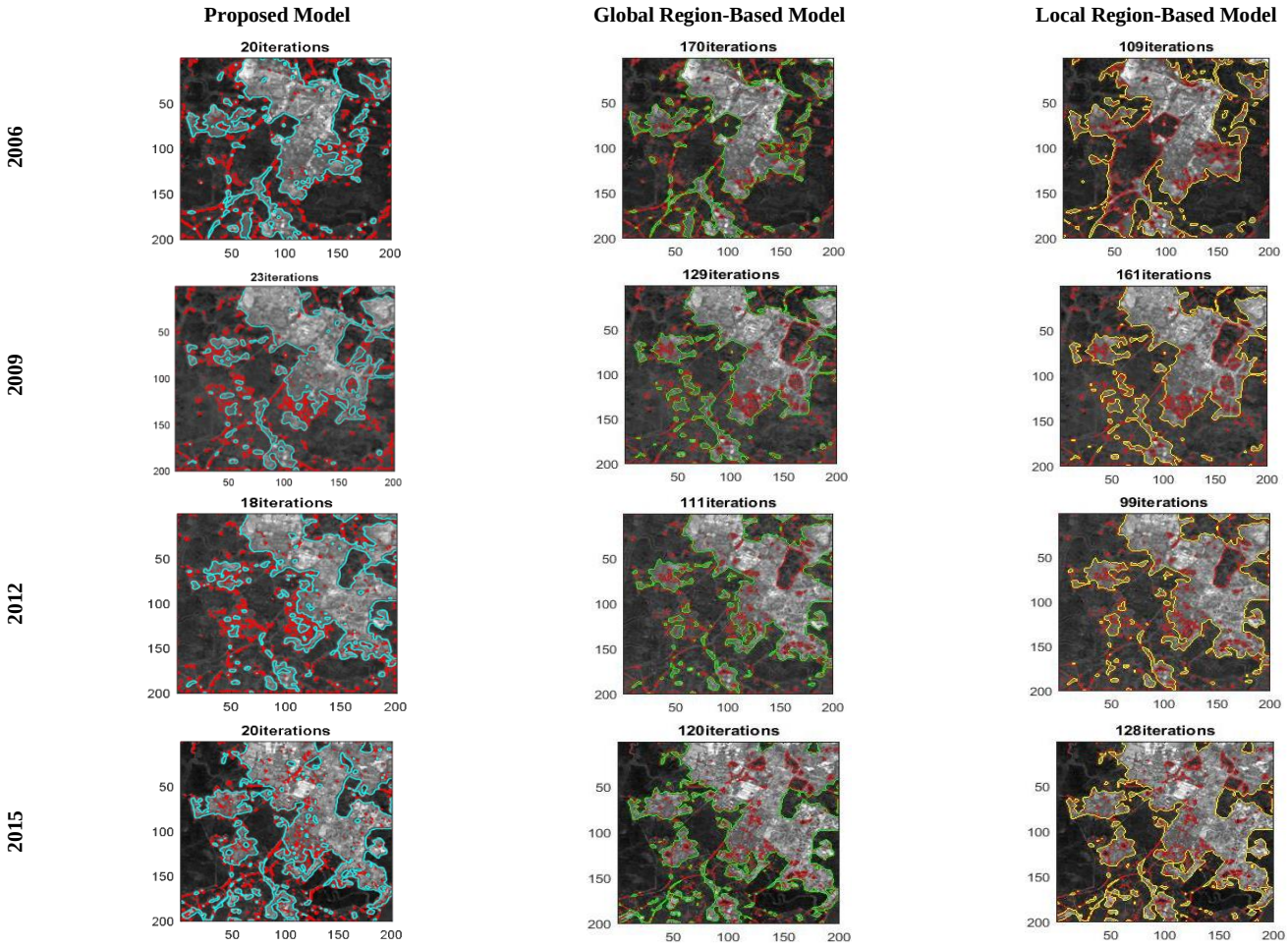


Fig. 2. Successful Edge-Region Segmentation from High-Resolution Satellite Images of Nusajaya in four different Years. The Ground Truth Contour is shown in Red, the Contour using the Proposed Model is shown in the Blue canyon, and the Contour using the Global Region-based Model and Local Region-based Model are Shown in Green and Yellow, Respectively.

TABLE. I. QUANTITATIVE ANALYSIS BASED ON FIG. 2

Model	Year	Accuracy	Specificity	Sensitivity	Execution Time	No. of Iterations
Proposed Model	2006	0.9401	0.9131	0.9555	24.6014	20
	2009	0.9269	0.8614	0.9642	29.0942	23
	2012	0.9731	0.9053	0.9563	22.0897	18
	2015	0.9355	0.9820	0.8943	10.2649	20
Global Region-Based Model	2006	0.9352	0.8880	0.9620	35.4278	172
	2009	0.9083	0.9268	0.8978	27.1598	129
	2012	0.9169	0.9418	0.9018	20.3581	111
	2015	0.9209	0.9786	0.8698	25.7558	120
Local Region-Based Model	2006	0.8341	0.9771	0.7529	32.4950	109
	2009	0.9066	0.9315	0.8924	60.6064	161
	2012	0.9129	0.9451	0.8933	32.0270	99
	2015	0.9209	0.9785	0.8687	48.8751	128

Based on the quantitative analysis results, the proposed model has better accuracy performance than the other two models. This is because the proposed model can separate well the background and foreground of the image and able to converge at the correct boundaries. The execution time and iterations of the segmentation are presented in Table I. The proposed model consumes less time with less number of iterations to obtain satisfactory results. By contrast, from Table I, the local region-based model consumes the longest execution time with the most number of iteration among all the consideration models. So overall, the proposed fourth-order modified GAC model was superior with respect to the accuracy, number of iterations and less execution time.

B. Comparison with a different value of σ

An experiment has been conducted with the satellite images in order to validate the robustness of the proposed fourth-order modified GAC model and its segmentation accuracy with a different value of σ.

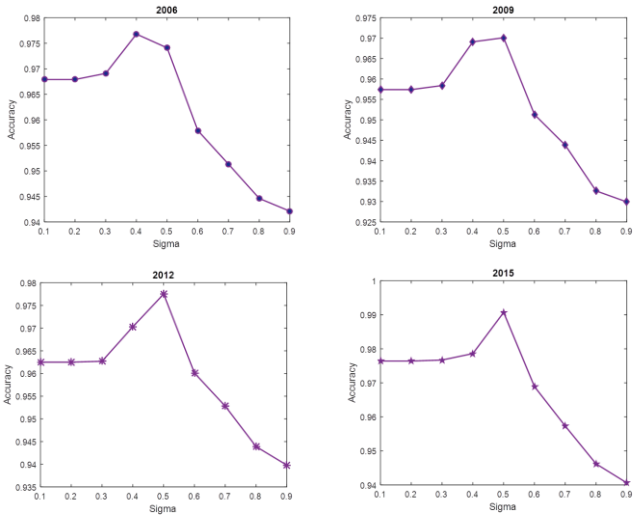


Fig. 3. Finding Optimum Accuracy with the difference Value of σ.

Fig. 3 shows the effect of the value of σ on the segmentation results of the proposed fourth-order modified GAC model. Fig. 3 reveals that when the value $\sigma = 0.4$, then the segmentation from satellite images year 2006 obtain high accuracy performance compared the other two tested values of σ. However, when setting the value of $\sigma = 0.5$ then the segmentation results for satellite images in years 2009, 2012 and 2015 obtain high accuracy performance compared to the other two tested values of σ. Therefore, this clearly validates that the optimum accuracy of the proposed model depends on the images and value of σ.

C. Comparison with different Numerical Method

This subsection focuses on the implementation of some numerical methods on the proposed fourth-order modified GAC model. This experiment has been conducted using the following parameters: $\tau = 1$, $\Delta x = \Delta y = 1$, $v = -3$, $\text{tol} = 1e^{-3}$ and $m = 200 \times 200$. In order to obtain a better segmentation with high accuracy, the value of σ for satellite images in the year 2006 is set as $\sigma = 0.4$ and the other three satellite images are set as $\sigma = 0.5$. Table II shows the numerical results for high-resolution satellite images of Nusajaya. As depicted in Table II, the AGE method gives an excellent segmentation performance with less number of iterations, consume less execution time and less error compared to RBGS and JB methods. This clearly validates the superiority of the AGE method in the proposed segmentation model.

VI. DISCUSSION

A. Discussion on the Value of σ

The value of σ plays an important role in the proposed model to segment the high-resolution satellite images of Nusajaya. If the value of σ is too small, the segmentation on land-use changes will not converge at the accurate boundaries. Otherwise, if the value of σ is too high, the results will give less accurate segmentation. In application, this paper suggests that the value of σ should be set in the range between 0.3 and 0.5 for most images. This can be seen in the graph plotted in Fig. 4 developed by using Matlab R2015a software.

TABLE. II. NUMERICAL ANALYSIS RESULT

Year	Method	Execution Time	No. of Iterations	Maximum Error	RMSE
2006	**AGE**	19.6139	3	5.2283e-04	2.6141e-06
	%	**74.75**	**96.51**	**46.16**	**74.38**
	RBGS	35.1314	30	7.9289 e-04	5.3551e-06
	%	**54.77**	**65.12**	**18.36**	**47.52**
	JB	77.6728	86	9.7117e-04	1.0205e-05
2009	**AGE**	15.8908	3	7.9277e-04	3.9638e-06
	%	**83.80**	**96.67**	**2.23**	**55.37**
	RBGS	45.4586	32	8.1261e-04	5.7283e-06
	%	**52.45**	**64.44**	**4.79**	**35.51**
	JB	95.6130	90	7.7545e-04	8.8819e-06
2012	**AGE**	13.8147	2	7.8261e-04	3.9130e-06
	%	**81.15**	**98.00**	**11.59**	**25.84**
	RBGS	28.5013	26	5.0318e-04	5.2762e-06
	%	**61.11**	**74.00**	**28.25**	**16.58**
	JB	73.2892	100	7.0132e-04	6.3249e-06
2015	**AGE**	16.5732	2	3.3148e-04	1.6574e-06
	%	**86.30**	**99.07**	**61.74**	**81.11**
	RBGS	31.4186	38	9.0516e-04	6.8728e-06
	%	**74.02**	**82.41**	**4.47**	**21.66**
	JB	120.9319	216	8.6642e-04	8.7728e-06

B. Discussion on Numerical Method Implementation

With regard to the rate of convergence, the achievements of the AGE method can be seen clearly from the results in Table II in terms of execution times and number of iterations. For all images, the AGE method is 74.75%-86.30% better than JB method in terms of execution times. AGE method is much better than the RBGS and JB. Even though the RBGS and JB methods are derived from fourth-order approximation of the GAC model, but they are lacking in terms of accuracy due to the rounding off errors that have been accumulated from the start of execution until the end. Amongst all the tested methods, the AGE method still maintains its greater accuracy in all satellite images of Nusajaya. In general, the proposed higher-order PDE-based segmentation employing fourth-order numerical methods provides a class of computationally efficient, convergent and highly accurate solutions for land use segmentation of high-resolution satellite images.

C. Discussion on Land-use Changes

Fig. 4 displays the segmentation visualization of land use in Nusajaya. White color is as land use and black color as the land cover. Thus, this can be seen that each year, the land uses become increasing and less land cover which might cause a negative effect on the earth's balance. It can be predicted the land cover in the Nusajaya area might decrease by around 0.87% every year. In the year 2006, the land cover of the Nusajaya area is only 63.17% and the rest is land use. Additionally, every three years, the land cover has been decreased to 62.98% for the year 2009, 60.01% for the year 2012 and 52.75% for the year 2015.

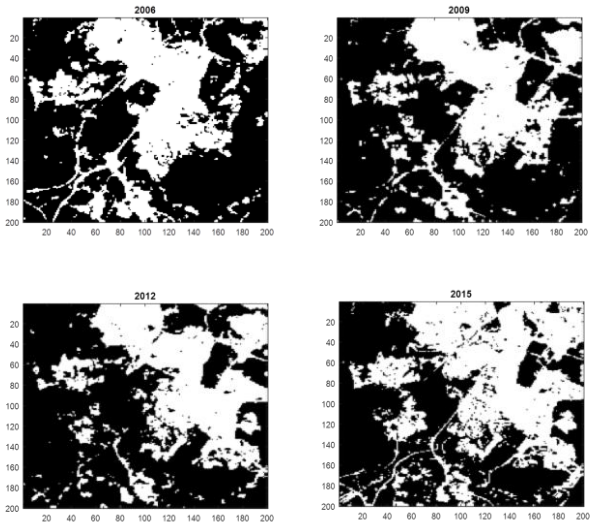


Fig. 4. Land use and Land Cover in Nusajaya in four different Years.

VII. CONCLUSION

In this paper, there are two contributions. First is the development of modified SPF function which integrates the local and global intensity information to detect land-use changes in Nusajaya. The second contribution is the construction of fourth-order modified GAC model to enhance the accuracy of segmentation. The local intensity information makes the model works well for images with intensity inhomogeneity. Then, the global intensity information helps the model to converge faster. Furthermore, the proposed segmentation model has been implemented with an adaptive filter weight on the SPF function able to smoothly and successfully segment the high-resolution satellite images of Nusajaya. Therefore, the adaptive filter weight helps the proposed segmentation model to avoid expensive computational regularization. Experiments show that the proposed higher-order modified GAC model can accurately segment satellite images with intensity inhomogeneity and weak boundaries. In addition, the implementation of the AGE method of the proposed model is more superior to the other numerical methods. However the value of σ needs to be well chosen depends on the image because the accuracy of segmentation may be affected. In the future, this work will be focused on reducing its computational complexity by implementing high-performance computing into the segmentation process.

ACKNOWLEDGMENT

This work was financially supported by the Universiti Teknologi Malaysia and Ministry of High Education (MOHE).

REFERENCES

[1] Giri, Remote sensing of land use and land cover: principles and applications. 2016.

[2] A. Alqurashi, L. K.-A. in R. Sensing, and undefined 2014, “Land use and land cover change detection in the Saudi Arabian desert cities of Makkah and Al-Taif using satellite data,” 139.59.98.9.

[3] P. Srivastava, D. Han, M. Rico-Ramirez, … M. B.-A. in S., and undefined 2012, “Selection of classification techniques for land use/land cover change investigation,” Elsevier.

[4] J. K. Thakur, P. K. Srivastava, S. K. Singh, and Z. Vekerdy, "Ecological monitoring of wetlands in semi-arid region of Konya closed Basin, Turkey," Reg. Environ. Chang., vol. 12, no. 1, pp. 133–144, Mar. 2012.

[5] S. Yuan, P. Monkam, S. Li, H. Song, and F. Zhang, "Active contour model via local and global intensity information for image segmentation," Chinese Control Conf. CCC, pp. 5618–5623, 2017.

[6] M. A. Shafiq, Z. Wang, and G. Alregib, "Seismic interpretation of migrated data using edge-based geodesic active contours," 2015 IEEE Glob. Conf. Signal Inf. Process. Glob. 2015, pp. 596–600, 2016.

[7] Y. Luo et al., "Myocardial iron loading assessment by automatic left ventricle segmentation with morphological operations and geodesic active contour on T2* images," nature.com.

[8] J. Sun, N. Ray, and H. Zhang, "VFCCV snake: A novel active contour model combining edge and regional information," 2014 IEEE Int. Conf. Image Process. ICIP 2014, pp. 927–931, 2014.

[9] F. Akram, J. H. Kim, and K. N. Choi, "Active contour method with locally computed signed pressure force function: An application to brain MR image segmentation," Proc. - 2013 7th Int. Conf. Image Graph. ICIG 2013, pp. 154–159, 2013.

[10] F. Akram, J. H. Kim, H. U. Lim, and K. N. Choi, "Segmentation of intensity inhomogeneous brain MR images using active contours," Comput. Math. Methods Med., vol. 2014, 2014.

[11] F. Akram, J. H. Kim, C. G. Lee, and K. N. Choi, "Segmentation of regions of interest using active contours with SPF function," Comput. Math. Methods Med., vol. 2015, 2015.

[12] J. Yuan, J. Wang, and L. Liu, "Active contours driven by local intensity and local gradient fitting energies," Int. J. Pattern Recognit. Artif. Intell., vol. 28, no. 3, 2014.

[13] L. Zhang, X. Peng, G. Li, and H. Li, "A novel active contour model for image segmentation using local and global region-based information," Mach. Vis. Appl., vol. 28, no. 1–2, pp. 75–89, Feb. 2017.

[14] V. C. Korfiatis, P. A. Asvestas, and G. K. Matsopoulos, "Automatic local parameterization of the Chan Vese active contour model's force coefficients using edge information," J. Vis. Commun. Image Represent., vol. 29, pp. 71–78, 2015.

[15] S. Mukherjee and S. T. Acton, "Region-based segmentation in presence of intensity inhomogeneity using legendre polynomials," IEEE Signal Process. Lett., vol. 22, no. 3, pp. 298–302, 2015.

[16] J. Shi, J. Wu, A. Paul, L. Jiao, and M. Gong, "A partition-based active contour model incorporating local information for image segmentation," Sci. World J., vol. 2014, 2014.

[17] J. Yu, H. Guo, C. Li, J. Lu, and C. Jiang, "A waterline extraction method from remote sensing image based on quad-tree and multiple active contour model," Cehui Xuebao/Acta Geod. Cartogr. Sin., vol. 45, no. 9, pp. 1104–1114, 2016.

[18] X. Li, D. Jiang, Y. Shi, and W. Li, "Segmentation of MR image using local and global region-based geodesic model," Biomed. Eng. Online, vol. 14, no. 1, pp. 1–16, 2015.

[19] Z. S. (2016) Reddy VL, "Active Contours With New Signed Pressure Force Function For Echocardiographic Image Segmentation," no. 4, pp. 3674–3678, 2016.

[20] Z. B. M. Zubaidin, "Alternating Group Explicit Method for Edge Detection on Brain and Breast Tumor Images.," Universiti Teknologi Malaysia, 2013.

[21] S. Liu and Y. Peng, "A local region-based ChanVese model for image segmentation," Pattern Recognit., vol. 45, no. 7, pp. 2769–2779, 2012.

[22] P. Getreuer, "Chan – Vese Segmentation Simplified Mumford – Shah Model Level Set Functions," vol. 2, pp. 1–11, 2012.

[23] P. Ahmadi, S. Sadri, R. Amirfattahi, and N. Gheissari, "Automatic aerial image segmentation based on a modified Chan-Vese algorithm," 2012 5th Int. Congr. Image Signal Process. CISP 2012, no. Cisp, pp. 643–647, 2012.

[24] H. Zhang, J. Liu, Z. Zhu, and H. Li, "An automated and simple method for brain MR image extraction," Biomed. Eng. Online, vol. 10, pp. 1–12, 2011.

[25] F. Dong, Z. Chen, and J. Wang, "A new level set method for inhomogeneous image segmentation," Image Vis. Comput., vol. 31, no. 10, pp. 809–822, 2013.

[26] E. S. Uzezi and G. Kparo, "Domain Decomposition of the Fourth-Order AGE Method on Heat Equation with MPI," Int. J. Comput. Appl., vol. 32, no. 10, pp. 25–38, 2011.

[27] N. Alias, H. F. S. Saipol, A. C. A. Ghani, and M. N. Mustaffa, "Parallel performance comparison of alternating group explicit method between parallel virtual machine and Matlab distributed computing for solving large sparse partial differential equations," Adv. Sci. Lett., vol. 20, no. 2, pp. 477–482, 2014.

[28] M. N. Mustaffa, N. Alias, and F. Mustapha, "Some numerical methods for solving geodesic active contour model on image segmentation process," Malaysian J. Fundam. Appl. Sci., vol. 13, no. 4–1, pp. 408–411, 2017.

Crypto-Steganographic LSB-based System for AES-Encrypted Data

Mwaffaq Abu-Alhaija[1]
Department of Networks and Information Security
Al-Ahliyya Amman University, AAU, Amman, Jordan

***Abstract*—The purpose of this work is to increase the level of concealment of information from unauthorized access by pre-encrypting and hiding it in multimedia files such as images. A crypto-steganographic information protection algorithm with LSB-method was implemented. The algorithm hides AES pre-encrypted confidential information in the form of text or images into target containing image files. This method uses the concept of data concealing in the least significant pixel bits of the target image files. The proposed method relies on the use of Diffie-Hellman public key exchange protocol for securely exchanging the stego-key used for LSB as well as the public key used for encrypting the secret information. The algorithm ensures that the visual quality of the image remains unchanged, with no distortions perceived by the human eye. The algorithm also complicates the detection of concealed information embedded in the target image with use of PRNG as an enhancement for LSB. The proposed system scheme achieved competitive results. On an average, the system achieved a Peak Signal-to-Noise Ratio (PSNR) of 96.3 dB and a Mean Square Error (MSE) of 0.00408. The results obtained demonstrate that the proposed system offers high payload capabilities with immunity against visual degradation of resultant stego images.**

Keywords*—Steganography; cryptography; cryptographic steganography; crypto-steganographic system; Least-Significant Bit Replacement (LSB-method); stego-key; public-key cryptography; Advanced Encryption System (AES); Diffie-Hellman protocol; key exchange; concealment of information; PRNG

I. Introduction

Due to modern technology, information plays a big role in a massive number of different fields. This information varies in its nature from personal, to economic, to technological, or even governmental. When storing, transmitting, or merely using information, there is an increasing necessity to sustain its confidentiality and integrity and guard it against the unauthorized access. The greater the significance of this information is, the more protection it needs. There is no absolutely 100% reliable method to encrypt information [1]. For many years Information Hiding has captured the imagination of researchers. Digital watermarking and steganography techniques are used to address digital rights management, protect information, and conceal secrets. While cryptography uses encryption to make the message incomprehensible, steganography conceals the traces of the information ever existing. The steganography can be employed on any medium such as text, audio, video and image while cryptography is implemented only on the text file thus making steganography superior to cryptography [1]. Any information, such as text, messages, images, multimedia files, etc., can be used as a data carrier. In the general case, it is advisable to use the word "message" because the message can be plaintext, cipher text, image, spreadsheet, audio or even video data [2]. Basically, any form of data that can be represented in a bitstream can be hidden through steganography [3, 4].

This proposed system will be more secure than cryptography or steganography techniques [digital steganography] alone and also as compared to steganography and cryptography combined systems. In this paper we propose an advanced cryptographic-steganography system that combines the features of cryptography and steganography. In the cryptographic steganography system, the message will first be converted into unreadable cipher and then this cipher will be embedded into an image file. Hence this type of system will provide more security by achieving both data encoding as well as data hiding.

The purpose of this work is to increase the level of concealment of information from unauthorized access by pre-encrypting and hiding it in multimedia files such as images. This method proposes a new approach to public-key steganography based on LSB method to hide the secret pre-encrypted information inside 24-bit image file. The proposed method relies on the use of a suitable public key exchange protocol (such as Diffie-Hellman) for exchanging the stego-key used for LSB as well as the public key used for encrypting the secret information.

II. Related Work

The development of global computer networks and multimedia tools has progressed dramatically over the past few years. Consequently, new methods of data-secured transmission through telecommunication channels are continuously being developed and are used for various purposes. These methods make it possible to hide messages in computer files (containers), due to the natural inaccuracies of the sampling devices and the redundancy of analog video or audio data. Advances in technology have allowed steganography (meaning hidden writing) to occupy a certain position in the field of information encoding and its concealment. Such a trend has emerged in the field of information security as computer steganography (the secret message is hidden in other than original media such as Text, Image, video and audio form) [1-4]. The general idea of hiding some information in digital content has a wider class of applications that go beyond Steganography. The techniques involved in such applications are collectively referred to as

information hiding. Methods that use image files are the most advantageous and promising, since their use is not limited by the amount of data transferred, for it all depends on the container selected. A special case of information hiding is digital watermarking. Digital watermarking is the process of embedding information into digital multimedia content such that the information (the watermark) can later be extracted or detected for a variety of purposes including copy prevention and control. Basically, it is advised to use the LSB approach [5] [7], which allows for a replacement that is not generally visible to the human eye; i.e. of less significance. Furthermore, many older output devices will not even be able to reflect such minor changes [8]. This approach allows replacing not only the two lower bits, but any number of bits. Although replacing more bits allows for more information to be hidden, however the greater the distortion will result in the original image [9].

Unlike information hiding and digital watermarking, the main goal of steganography is to communicate securely in a completely undetectable manner. A steganography task is to hide a certain message in another container file, so that the presence of the hidden message cannot be seen [2, 3]. As containers, digital images, audio and video files are commonly used [2, 5, 7]. As a result of embedding, steganography overcome the limitation of cryptography by hiding the fact that a transmission through the communication channel is taking place.

Both steganographic and cryptographic techniques are have proven to be powerful and robust. Alas, steganography and cryptography have been noted to be individually insufficient for complete information security. While steganography supports only Confidentiality and Authentication security principles, cryptography supports Confidentiality and Authentication security principles as well as Data integrity and Non-repudiation. Therefore, many researchers suggest a stronger and more reliable mechanism through combining both [16] [17], i.e. a crypto-steganographic system. Crypto-steganographic systems have great potential to increase information security.

III. The Basic Steganography Technique

There are special algorithms for hiding information in digital form using steganography [2, 4, 6]. Adding information to existing files (such as multimedia files) leads to distortions that are below the human sensitivity threshold, thus there is no noticeable change in the perception of the input files. The steganography technique involves a container (cover carrier), built-in secret message, and possibly stego key:

- Built-in (secret) message-a message embedded in a container.
- Container files - any file intended to conceal secret messages in. Empty containers, also known as cover files, are containers without a built-in message, whereas a filled container or stego object is a container that contains embedded information.
- A stego key or just a key is the secret key needed to control the stego process in selecting the actual image pixels to be used to conceal/extract information.

LSB (Least significant bit) replacement is the most common, yet simplest, method to embed information into container files [8]. The least significant bit the container file bytes is replaced by a bit of the secret message. LSB works best with 24-bit map images (BMP), in which each pixel is represented by 3 bytes (red, green, blue color components consecutively). Consequently, LSB allows to store 3 bits of information in one single pixel, replacing one bit of each color component. Thus, using a 256*256 image, LSB can store 196608 bits (i.e. 24576 bytes) of embedded data.

To demonstrate LSB replacement, the number 62 is to be embedded in a BMP image file. Converting 62 to binary yields 111110, requiring a grid for 2 pixels of a 24-bit image. An example grid of 2 pixels can be as follows in Table I.

Replacing 111110, the binary representation of 62, with the least significant bit of this part of the image results in the following grid of Table II.

Even though 62 was embedded into 2 bytes of the grid, only one single bit actually changed, depending on the embedded number. It has been found that on average only half the bits in a given image will need modification [7, 8, 10]. Given the fact that each primary color has 256 possible intensities, applying LSB results in small color intensity difference which is not perceived by the human eye.

In its simplest form, LSB makes use the lossless compression provided by BMP images. As shown above, consecutive bytes of the image data are used to embed the information, starting from the first image pixel for every byte of the message in successive order. Consequently, LSB in its most basic form is vulnerable and very easy to detect. As a remedy to achieve a more secure version of LSB, it is advised that the communication parties share a secret key. A stego-key refers to the secret key used to specify which pixels to target with LSB. Without prior knowledge of such a key, there would be no way of knowing which pixels actually contain embedded information. Fig. 1 below demonstrates the operation of stego-key enhanced LSB steganography.

An overview of the existing methods of solving the problem [2, 3, 5], showed that the most promising in terms of information capacity are containers in the form of image files in BMP format. Methods that use image files are the most advantageous and promising, since they practically do not limit the amount of data transferred, it all depends on the container selected. They also provide a high degree of protection. Therefore, they are better used in future implementations [7] [10]. For the steganographic algorithm proposed, it is advisable to use the LSB method and BMP image files as containers.

TABLE. I. An Example 2-Pixel Grid of a 24-Bit BMP

RED	GREEN	BLUE
00101101	11000100	01100011
00001101	00110011	10101010

TABLE. II. Adjusted Pixel Grid after Applying LSB

RED	GREEN	BLUE
0010110***1***	1100010***1***	0110001***1***
0000110***1***	0011001***1***	1010101***0***

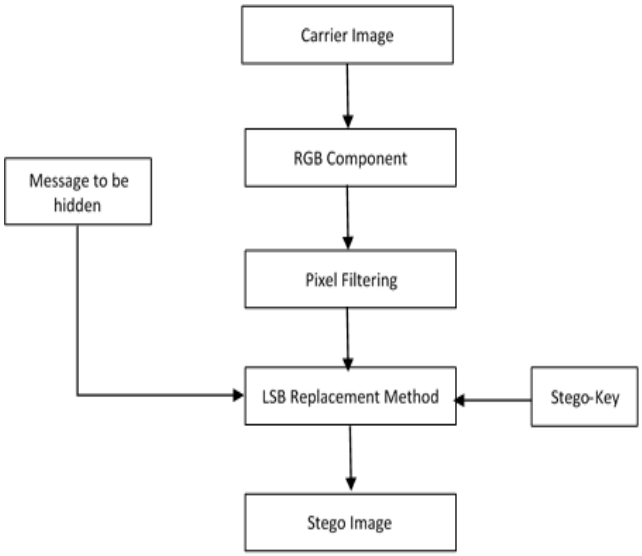


Fig. 1. Stego-Key Enhanced LSB Algorithm.

IV. Cryptographic Steganography

The basic steganography technique does not employ changes in the structure of the message in an attempt to achieve secure and undetectable communication. Nonetheless, a steganosystem could have the ability to embed a pre-encrypted message. The embedding process may depend on a secret stego-key. The stego-key is used to control the embedding process, such as the selection of pixels or coefficients carrying the message, etc. One or more stego-keys can be included in a steganosystem, depending on the number of security levels intended [12, 13, 16]. Similar to cryptographic systems, steganography can also be done using a private key (i.e. secret key steganosystem) or a public key (public key steganosystem). A secret key system uses a single key that must be defined either before the start of the secret message exchange or transmitted over a secure channel. This option is less effective because the attacker gains access to the data by intercepting the key. Public key steganosystems use different keys for embedding and retrieving messages, such that one key cannot be deduced from the calculations. Therefore, one key (public) can be freely transmitted over an unsecured communication channel. In addition, this scheme work well with mutual distrust of the sender and the recipient. Therefore, choosing such a key is more useful and provides a high level of security.

The system proposed by author adopts LSB method to replace the least significant bits in the container (image, audio, or video) with the bits of the hidden message. To increase the level of security of the proposed system the hidden message can be pre-encrypted using public-key encryption prior to embedding it into container file. The proposed system makes sure the difference between empty and filled containers is imperceptible to human senses, while maintaining the integrity of the embedded message without any data loss.

The flow chart of Fig. 2 gives the structure of the algorithm proposed by the author. The proposed method describes 2 phases for hiding the secret information by using the public steganography based on matching method in different regions of an image.

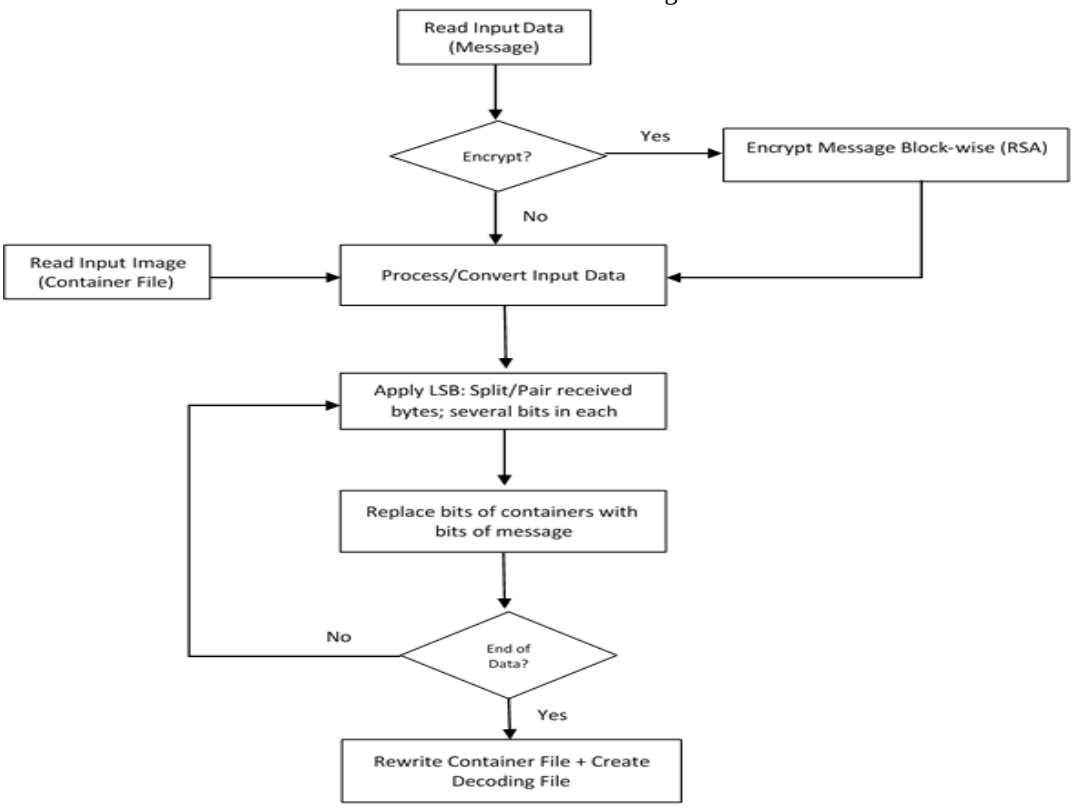


Fig. 2. Flowchart of Proposed Algorithm.

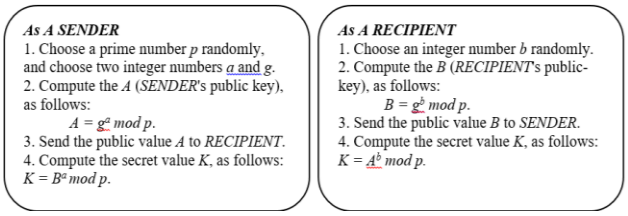


Fig. 3. Diffie-Hellman Key Exchange Protocol.

The first phase involves converting the Plain text message into cipher text using Public-key Encryption algorithm. The proposed algorithm performs AES block-wise encryption [18]. The two communication parties (SENDER & RECIPIENT) exchange the public keys over insecure networks by applying Diffie-Hellman Key exchange protocol [19]. Public key exchange cryptosystem like the Diffie-Hellman Key exchange protocol eliminates the key distribution problem by using two keys, a private and a public key. By exchanging the public keys, both parties can calculate a unique shared key, known only to both of them. Fig. 3 depicts the steps necessary for a successful Diffie-Hellman Key Exchange.

The AES encryption algorithm defines a number of transformations that are to be performed on data stored in an array [18]. The first step of the cipher is to put the data into an array; after which the cipher transformations are repeated over a number of encryption rounds. The number of rounds is determined by the key length, with 10 rounds for 128-bit keys, 12 rounds for 192-bit keys and 14 rounds for 256-bit keys. For the purpose of the proposed method, 10 rounds of transformation was adopted resulting in a 128-bit key.

The AES encryption cipher first undergoes a substitution of data using a substitution table; followed by shifting the data rows, then mixing of the columns, finally reaching the last transformation with a simple exclusive or (XOR) operation performed on each column using a different part of the encryption key. As AES is considered a symmetric data encryption technique, the same secret key can be used for both encrypting and decrypting.

The next phase is to find the shared stego-key between to be used for enhancing LSB. The authors in [10] and [11] studied the use of a Pseudo Random Number Generator (PRNG). Pseudorandom number generator acts as a black box, which takes one number (called the seed), and produces a sequence of numbers. The output generated is a random bit position from 7 most significant bits for each R, G and B values of each pixel of the image. Each of these bits will undergo an exclusively-OR operation with one bit of the message in successive order, then embedding the result in the least significant bit. The parameter controlling PRNG (i.e. the seed) ensures generating the same sequence of number in the same sequence. The author of this work proposed encrypting the PRNG parameter using AES with the key generated by applying the Diffie-Hellman Key exchange protocol, to finally send it over to recipient.

The detail of the second phase of the proposed algorithm is shown below in Fig. 4. The resultant stego image can be sent over unsecured communication channels to the intended recipient.

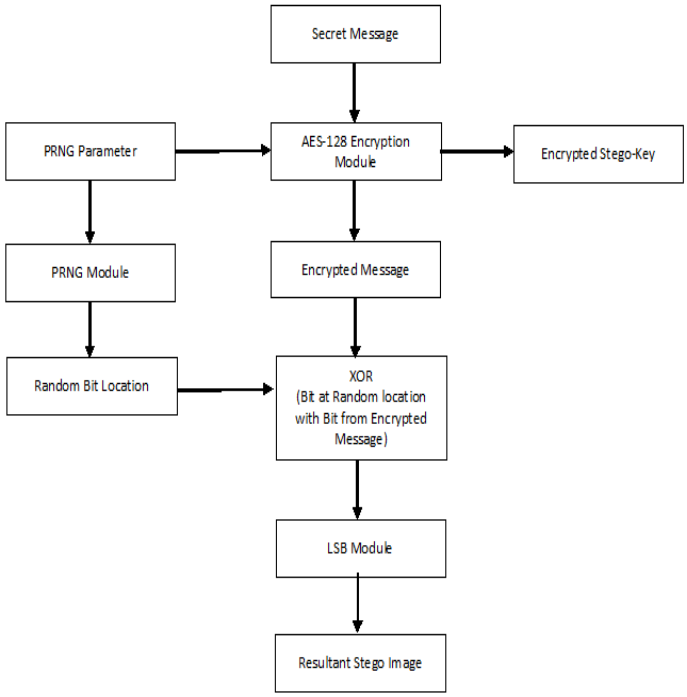


Fig. 4. Details of Proposed Algorithm.

V. Experimental Results

The proposed algorithm has been implemented, in separate modules for LSB, PRNG, Diffie-Hellman, and AES public key encryption. The performance of the proposed implementation has been tested through the use of different secret messages in varying lengths. Each message used was hidden in different 24-bit RGB cover images. The same experiments were performed for 512x512 and 256x256 standard images to properly evaluate the effectiveness of the proposed method.

The two major metrics for evaluating picture quality are Mean Square Error (MSE) [14] [16], and Peak Signal to Noise Ratio (PSNR) [15] [17].

MSE is the measurement of the square of error, the error is the amount by which the original image's pixel value is different to the encrypted image's pixel value. MSE can be calculated as follows [14] [16]:

$$MSE = \sum_{i=1}^{M} \sum_{j=1}^{N} \frac{[f(i,j) - f'(i,j)]^2}{MN} \quad (1)$$

M and N represent the image's height and width respectively. The term $f(i,j)$ is the pixel value at row i, column j of the original image and the term $f'(i,j)$ is the value of the pixel at the same location of the decrypted image.

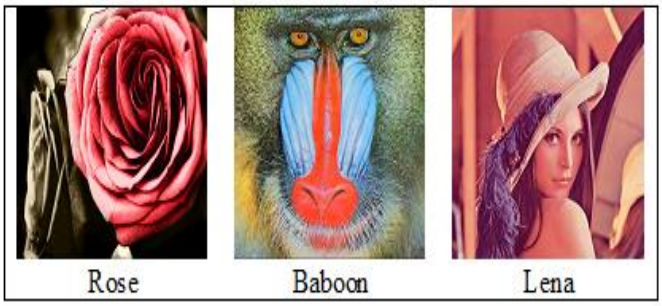
PSNR represents the ratio between the maximum probable signal power and the power of corrupting noise which influences the fidelity of its representation. PSNR is typically represented in terms of the logarithmic decibel as follows [15] [17]:

$$PSNR = 10 * \log \frac{(2^n - 1)^2}{MSE} \quad (2)$$

The implemented method has been evaluated using MATLAB using three popular images (Rose, Lena, and Baboon), in both sizes 512x512 and 256x256, as shown in Fig. 5. Message lengths for 512x512 image experiments ranged from 16KB to 64KB. On the other hand, for 256x256 image tests, message lengths ranged between 4KB and 16KB.

As a sample visual image comparison, the Rose image is shown before and after the application of the proposed method. For better visualization, both images are shown side-by side in Fig. 6. It is clear that the resulting distortion can be barely perceived by the human eye. Nonetheless, this visual outcome was further tested mathematically through calculating the PSNR and MSE values.

A high PSNR reading indicates a high quality of a stego image. Researchers consider a PSNR reading of above 40db for stego images to be considered as good quality images [18]. The MSE and PSNR results are shown in Table I and Table II, for the 512x512 and 256x256 experiments respectively. It has been proven that the resultant stego images; the Rose image as an example, had very high PSNR values.



(a) (b)

Fig. 5. Cover Images Used for Evaluation.

Fig. 6. Sample Image Comparison: (a) Rose Original Image, (b) Rose Modified by Proposed Method.

TABLE. III. MSE AND PSNR VALUES FOR 512X512 COVER IMAGES

Cover Image (512x512)	Message Length	MSE	PSNR
Rose	16K	0.00195	99.29586
	32K	0.00227	98.63595
	64K	0.00352	96.73078
Baboon	16K	0.00219	98.79176
	32K	0.00236	98.46709
	64K	0.00298	97.45404
Lena	16K	0.00332	96.98482
	32K	0.00457	95.59704
	64K	0.00504	95.1719

TABLE. IV. MSE AND PSNR VALUES FOR 256X256 COVER IMAGES

Cover Image (256x256)	Message Length	MSE	PSNR
Rose	4K	0.00432	95.84137
	8K	0.00469	95.48448
	16K	0.00501	95.19783
Baboon	4K	0.00436	95.80134
	8K	0.00469	95.48448
	16K	0.00482	95.36574
Lena	4K	0.00549	94.80048
	8K	0.00575	94.59953
	16K	0.00611	94.33579

The proposed system scheme achieved competitive results. On an average, the system achieved a Peak Signal-to-Noise Ratio (PSNR) of 96.3 dB and a Mean Square Error (MSE) of 0.00408. The results obtained demonstrate that the proposed system offers high payload capabilities with immunity against visual degradation of resultant stego images. In comparison with standard LSB, the proposed system obtained the same PSNR values, except for the fact the secret message is actually hidden in a random bit position. Due to this random position situation, even if attackers are certain of its existence, they cannot retrieve the secret message without prior knowledge of the system's stego key for PRNG. The added security provided by AES encryption, diminishes the chance of successful attacks. Hence, the proposed method has proven to provide robust, secure image steganography for secured communication.

VI. CONCLUSIONS

The algorithm of steganographic protection of information according to the LSB method is developed, and the program code is implemented, which increases the level of protection of information from unauthorized access by hiding it in multimedia files, namely in image files. Hiding data occurs in the lower bits of the pixels of the image files while randomly selected bit locations of the pixels manipulates the standard LSB replacement policy, thus concealing the reference of the real data. The algorithm does not change the visual quality of the image, which makes it impossible to detect the fact of hiding information. Testing completely confirmed the correctness of the algorithm and the software. The results obtained demonstrate unnoticeable image degradation making it almost impossible to attract the attention of attackers.

This method will provide more security to the information being transmitted than any other cryptographic or steganographic system as it combines both features. On one hand, extra level of security can be achieved by using grid cipher encryption. On the other hand, distortion in the final multimedia image will be very negligible as we are using modified bit insertion technique. The proposed system is believed to be applicable to various areas such as: Confidential communication and secret data storing, Protection of data alteration, Access control system for digital content distribution, as well Media Database systems with the help of advanced sorting algorithms [20].

Future work aims at attempting to try applying the proposed algorithm and implemented system on audio and video messages, in hopes of obtaining competitive results. On the other hand, further studies will aim at enhancing (i.e. increasing) the proposed system's capacity to much larger message lengths while maintaining similar PSNR readings. The author intends to further study the possibilities of broadening the areas to which this proposal can be applied.

REFERENCES

[1] Taha M S, et al. "Combination of Steganography and Cryptography: A short Survey", 2nd International Conference on Sustainable Engineering Techniques (ICSET 2019), IOP Conf. Series: Materials Science and Engineering, 518 (2019), doi:10.1088/1757-899X/518/5/05200.

[2] Douglas M, Bailey K, Leeney M and Curran K, "An overview of steganography techniques applied to the protection of biometric data", Multimedia Tools and Applications, July 2018, Volume 77, Issue 13, pp 17333–17373.

[3] AL-Shaaby A and AlKharobi T, "Cryptography and Steganography: New Approach", Transactions on Networks and Communications. Volume 5 No. 6, December (2017); pp: 25-38.

[4] Arya A and Soni S, "A Literature Review on Various Recent Steganography Techniques", International Journal on Future Revolution in Computer Science & Communication Engineering, ISSN: 2454-4248 Volume: 4 Issue: 1, January 2018 pp: 143 – 149.

[5] KASAPBAS M and ELMASRY W, "New LSB-based colour image steganography method to enhance the efficiency in payload capacity, security and integrity check", Sådhanå, (2018), 43:68 Indian Academy of Sciences, https://doi.org/10.1007/s12046-018-0848-4.

[6] Pradhan A, Sekhar, and Swain G, "Digital Image Steganography Using LSB Substitution, PVD, and EMD", Hindawi Mathematical Problems in Engineering, Volume 2018, Article ID 1804953, https://doi.org/10.1155/2018/1804953.

[7] Pelosi M, Poudel N, Lamichhane P, and Soomro D, "Steganography System with Application to Crypto-Currency Cold Storage and Secure Transfer", Advances in Science, Technology and Engineering Systems Journal, Vol. 3, No. 2, 271-282 (2018), ISSN: 2415-6698.

[8] Akinola S. and Olatidoye A., "On The Image Quality And Encoding Times Of LSB, MSB And Combined LSB-MSB Steganography Algorithms Using Digital Images", International Journal of Computer Science & Information Technology (IJCSIT), Vol 7, No 4, August 2015.

[9] Zakaria A, et al. "High-Capacity Image Steganography with Minimum Modified Bits Based on Data Mapping and LSB Substitution", Applied Sciences. 2018, 8, 2199; doi:10.3390/app8112199, www.mdpi .com/journal/applsci.

[10] Ali, Sohrawordi, Uddin, "A Robust and Secured Image Steganography using LSB and Random Bit Substitution", American Journal of Engineering Research (AJER), 2019, E-ISSN: 2320-0847, p-ISSN: 2320-0936, Volume-8, Issue-2, pp-39-44.

[11] Emam, Aly, Omara, "An Improved Image Steganography Method Based on LSB Technique with Random Pixel Selection", (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 7, No. 3, 2016 page 360.

[12] Swain G, "Very High Capacity Image Steganography Technique Using Quotient Value Differencing and LSB Substitution", Arabian Journal for Science and Engineering (2019) 44: 2995–3004, https://doi.org/10.1007/s13369-018-3372-2.

[13] Ramakrishna M et al, "Securing Information: Cryptography and Steganography", (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 3 (3), 2012, pp 4251 – 4255.

[14] Jaryal S. and Marwaha C., "Comparative Analysis of Various İmage Encryption Techniques", International Journal of Computational Intelligence Research, ISSN 0973-1873 Volume 13, Number 2 (2017), pp. 273-284, Research India Publications, http://www.ripublication.com.

[15] Zena M. Saadi and Matheel E., "Image Encryption Using DNA Addition", Thesis, Computer Science Department, University of Technology, 2017.

[16] Rahmani K, et al., "A Crypto-Steganography: A Survey", (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 5, No. 7, 2014, pp 149-155, www.ijacsa.thesai.org.

[17] Aung P P and Naing T M, "A novel secure combination technique of steganography and cryptography", International Journal of Information Technology, Modeling and Computing (IJITMC), 2014, 2, pp: 55-62.

[18] Kaur G and Madaan N, "A Comparative Study of AES Encryption Decryption", International Journal of Science and Research (IJSR), ISSN (Online): 2319-7064 Volume 3 Issue 4, April 2014.

[19] Whitfield Diffie and Martin Hellman, "New directions in cryptography", Institute of Electrical and Electronics Engineers., vol. IT-22, Transactions on Information Theory, no. 6, 1976, pp. 644–654.

[20] M. A. A. Alhija, A. Zabian, S. Qawasmeh, and O. H. A. Alhaija, "A heapify based parallel sorting algorithm," Journal of Computer Science, vol. 4, no. 11, pp. 897–902, 2008.

Scalable Data Analytics Market Basket Model for Transactional Data Streams

Aaron A. Izang[1], Nicolae Goga[2], Shade O. Kuyoro[3], Olujimi D. Alao[4], Ayokunle A. Omotunde[5], Adesina K. Adio[6]
Department of Computer Science, School of Computing & Engineering Sciences, Babcock University, Ogun State, Nigeria[1,2,3,4,5]
Department of Basic Science, School of Science and Technology, Babcock University, Ogun State, Nigeria[6]

***Abstract*—Transactional data streams (TDS) are incremental in nature thus, the process of mining is complicated. Such complications arise from challenges such as infinite length, feature evolution, concept evolution and concept drift. Tracking concept drift challenge is very difficult, thus very important for Market Basket Analysis (MBA) applications. Hence, the need for a strategy to accurately determine the suitability of item pairs within the available billions of pairs to solve concept drift chalenge of TDS in MBA. In this work, a Scalable Data Analytics Market Basket Model (SDAMBM) that handles concept drift issues in MBA was developed. Transactional data of 1,112,000 were extracted from a grocery store using Extraction, Transformation and Loading approach and 556,000 instances of the data were simulated from a cloud database. Calibev function was used to caliberate the data nodes. Lugui 7.2.9 and Comprehensive R Archive Network were used for table pivoting between the simulated data and the data collected. The SDAMBM was developed using a combination of components from elixir big data architecture, the research conceptual model and consumer behavior theories. Toad Modeler was then used to assemble the model. The SDAMBM was implemented using Monarch and Tableau to generate insights and data visualization of the transactions. Intelligent interpreters for auto decision grid, selectivity mechanism and customer insights were used as metrics to evaluate the model. The result showed that 79% of the customers from the customers' consumption pattern of the SDAMBM preferred buying snacks and drink as shown in the visualization report through the SDAMBM visualization dashboard. Finally, this study provided a data analytics approach for managing concept drift challenge in customers' buying pattern. Furthermore, a distinctive model for managing concept drift was also achieved. It is therefore recommended that the SDAMBM should be adopted for the enhancement of customers buying and consumption pattern by business ventures, organizations and retailers.**

Keywords*—Association rule mining; big data analytics; concept drift; market basket analysis; transactional data streams

I. Introduction

The exponential growth in the traditional transactional data made it imperative for businesses to take the lead in harnessing data in order to derive new insights for competitive advantage. In a bid to turn these insights into opportunities, business organizations are being challenged to review respective information management practices, break down organizational and data silos, and improve business collaboration which has led to the existence of sizably voluminous transactional data [1].

The process of classifying this voluminous transactional data has been a major challenge to the data mining community. This is due to the sreaming nature of transactional data thus, suffer from the same challenges associated with data streams such as concept drift, infinite length, feature evolution and, concept-evolution [2]. The infinite length refers to the continuous nature of transactional data streams whereby the amount of data has no bounds while concept-evolution is said to occur when new class evolves in a data stream. Feature-evolution is a recurrent process occurring in numerous streams as such as in mining text streams, where newer features (e.g. phrases or words) appear as the data stream increases and concept drift is a common phenomenon in data streams which occurs when the underlying concepts change [3].

Market basket analysis (MBA) is a data mining technique for analyzing the association of items that frequently occurs simultaneously from everyday buying and selling through the use of a transactional dataset. In order to promote the purchase of specific items together by controlling the stocks concurrently, and increasing the probability of purchasing, managers in a superstore can place item pair that are associated to the shelf beside them; thus, giving business organizations a better chance of profit-making by controlling the order of goods and marketing control. The rudimental conception in MBA helps to discover the item pairs associated in the store.

Concept drift in relation to the market basket is an attempt to study a customer's buying behavior by utilizing the exponential quantity of data stored by businesses to determine when there will be a change in the buyer's preference [4]. The aim of studying this is to allow the business organizations prepare for such occurrences thereby satisfying the customers and also help the business organization improve their revenue. In order to achieve this, a crude approach would have been to generate all item pairs from the transactional data streams in each market basket; store periodically and execute a suitable algorithm to find the most frequent item pairs. However, such a solution will be unrealistic in an environment where millions of market baskets contain billions of different item pairs. Static assumptions by training and testing Association Rule Mining (ARM) algorithms on a transactional dataset from the same population have been proposed. However, such an approach does not encourage the adaptiveness required in handling concept drift characteristics.

The focus of this work is on developing a scalable data analytics market basket model for a transactional data stream that can handle any size of data as well as provide real-time

visualization of different transactions thereby presenting the trend in concept drift. The specific objectives are to (1) develop a Scalable Data Analytics Market Basket Model (SDAMBM) for Transactional Data Streams; (2) implement and evaluate the developed model.

II. Related Works

Author in [5] surveyed data mining algorithm for Market Basket Analysis in a bid to provide existing data mining algorithms for MBA. The research reveals that among the existing data mining algorithms surveyed Apriori algorithm was discovered to outperform others for association rule mining. Some of the drawbacks include the length of time taken to scan the database, and the multiplicity of scans creates additional work for the database search.

Author in [6] examined "Market basket analysis for a supermarket based on frequent item-set mining." The study aimed to conduct an association rule mining for a superstore. Data were obtained from the transactional database of the store in Microsoft Excel spreadsheets and Microsoft Access databases. The K-Apriori algorithm was used on the database to pull out rules. The frequent item-sets and association rules were generated for those categories separately. The K-Apriori algorithm tries to find consumer behaviors in groups in other to selectively satisfy the specific group.

Author in [7] examined frequent pattern mining using Apriori ARM algorithm from an inventory database. The authors sought to identify the challenges of mining association rules among items in a large database that contains sales transactions used in understanding customer-buying behavior in other to improve the sales in a business venture. Apriori ARM algorithm was used to generate strong association rules from the inventory database. The algorithm was implemented using PHP and MySQL. Hence, due to the robustness of the system because of the large number of transactional datasets, there is a need for a hybrid ARM algorithm to be used for generating the strong association rule.

Author in [8] developed an Android Application for Searching and Shopping Based on Cloud. The objective was to design and develop an Android shopping application for Amravati city. The app helps to show offers and deals of a particular shopping mall and market locally within. The app was created as a three-tier architecture which has a backend, middleware, and frontend. The front end houses the Android mobile app which connects to the backend where the relational databased houses all the products through the middleware. The study made it possible for mobile users to be able to access shopping malls on their mobile phones through an android mobile app. The Application displays offer and also provide analytics to the seller to know the breakdown of all the products they are purchasing.

Author in [9] examined Market Basket Analysis in other to identify customer behaviors through the use of Transaction Data. The study actually examined the sales transactions of a particular company to better understand their customers. Furthermore the research implemented the apirori algorithm which had a support value of 1.78% and confidence interval of 46.69% as a desktop application which is capable of re-logging the existing transactions to make predictions. The flaw of this work is that it considered only 30 rules which is not enough to create association rules.

It was however observed from the related works that most of the work did not consider the influence of using the amount of data in a transactional database usually have on the outcome. This, therefore, highlighted the need to use a large amount of data stored in the data store, in order to discover hidden associations as well as boost the confidence and support of association rules identified by influencing the outcome of the recommendations that will be given to customers thus the choice of big data analytics for this study. Also, the concept drift problem inherent with the transactional data in concert with Market basket analysis was not directly considered by any of the previous research. Hence this study tends to tackle the concept drift problem in data streams for market basket analysis by applying big data analytics to critical study each customer and provide a visualization of the transactions thereby solving the concept drift challenge.

III. Methodology

In this work, a semi-experimental methodological approach by way of software development and big data analytics technique was adopted to develop the required market basket analysis model for the transactional data stream. This method best suite this research which involved not only implementing a data analytics technique towards solving concept drift problem inherent in transactional data stream used for market basket analysis, but also performing some association rule mining as well as developing a scalable data analytics market basket model for transactional data streams. In other to achieve this, the following methodology was followed to build a data analytics market basket model for transactional data stream which is in line with the study objective.

In developing the SDAMBM for transactional data stream, the Elixir big data model, components of the conceptual model as well as the theoretical framework, were adopted to develop the model for this study, which helps to create measures and dimensions that are relevant for the proposed model. Calibev function algorithm was used to calibrate data nodes, and Toad Modeler was then used to assemble the model.

The data used for this study was collected from a University Superstore which comprises of One million, one hundered and twele thousand (1,112,000) transactions. Five hundred and fifty-six thousand (556,000) instances of the data was then uploded to Amazon RedShift Database online and simulated to represent the real time data stream of the transactions known as new transactions.

The data collection process for this study was done using the ETL approach (Data Extraction, Data Transformation, and Data Loading). At the extraction phase, only items like the snacks (bread and chips), drinks and bread spread item sets were exacted from the superstore transactional data. The data transformation was done using two methods; data cleaning which involves removing unwanted item pairs from the data and data blending which involves putting the data in a way it will be suitable to work with on the data mining tool used for the study.

The implementation of the developed model was done following these procedures.

- The simulated University superstore data on Amazon Redshift was streamed using the Tableau data analytics visualisation tool which was used to create the measures and dimensions for the customers transactions against the frequent items set generated (previous transactions) in methodology one to show the data visualization of the frequent items bought by the customer thereby determining if there will be a drift in the buying concept of the customers in feature.
- Tableau was used to match the previous transactions with the new transactions coming from Amazon Redshift database online to show the drift in buying concept of the customers. The R stat feature in Tableau was used to generate statistical insights of the results visualization. This was evident in the visualization report for iViews, Concept Drift, extended effects and restock level of the itemsets analyzed.
- Luigi, and CRAN were used to enhance table pivoting between the two datasets used for this study.
- The outcome of the visualization which shows the iViews, Concept Drift, extended effects and restock level was exported to an HTML 5 enabled environment in, other to view the statistical report.

The data analytics visualization was evaluated using the following metrics: intelligent interpreters for Auto decision grid in restock level, consumption summary, concept drift, and extended effects. The selectivity mechanism was used to map specific customer profile against item_sets and descriptions. Evaluation of customer insights was viewed based on the overall consumption pattern summary embedded in the Hadoop panel on Tableau to select the appropriate attributes in the data that convene the required result.

A. Data Collection and Description

The dataset used for this research is the transactional data gotten from a university superstore. The data is compatible with both .csv, xlx, and .xlxs file formats. The data set contains 1,112,000 instances which is a representation of each transaction for the period of 24 months being January 01, 2017 to December 31, 2018. The dataset has labels for the training data that includes Invoice number, quantity of the items, the items sets, unit price, and transaction date. For the purpose of this work, the invoice number, unit price, and items label were used from the dataset that addresses market basket analysis which helps reflect the concept drift of each customer considering the instances of the transactions over time.

Furthermore, a domain dataset was gotten by simulating the University superstore online. A total of 556,000 instances of transactions was gotten from the simulation done and the dataset generated which helps this research study the customer buying behaviors. The simulated superstore transactional dataset were stored in the amazon redshift cloud database linked with the tableau big data visualization tool. Tableau was used in analyzing the concept drift of customers transactions, by studying the buying pattern from the numerous items generated from the transactional data by matching the previous and new transactions together.

1) Identification of data sources variables: The study adopted two primary data sources making use of the selectivity mechanism of big data analytics which helps in ensuring data protection. The sources are:

a) Domain Sources: these are the data source that comes in streaming form, as customers are buying items stored in the superstore.

b) Nominal Sources: this source of data variables contains non-numerical values such as gender, occupation among others. The nominal sources used for this data was adapted from customer data profile gotten from the student transactions performed through the simulated online superstore in other to generate the online transactional data streams. The variables used include students' transaction ID, item set ID same with the items sets for the superstore data, price, and transaction date.

2) Application of calibev and hovritz-thompson estimator: Calibev and Hovritz-Thompson Estimator were both applied to calibrate the simulated transaction data stream on the simple random sampling without replacement (srswor) distribution. This calibration was carried out through the use of the Hadoop data panel on tableau visualizer as the data analytic tool which helps to ensure that only accurate data is processed. The Horvitz-Thompson estimator was applied to help compute the simulated University store data streamed online to run a predictive analysis.

a) Calibev Function: The Calibve function is a standard method used to ensure the measurement produce accurate results. The variable data used for calibration is customer transactional data and the simulated customer data which were used to create the indicators. Probability and the response probabilities were computed.

The class size data frame (customers transactions is N = 556,000)

The variables are: Bread, Drinks, and Spread

The Element variables are: Unit tags as a,b,c,d,e,f and the price range variables that following the tags respectively are 100-600, 700-1200, 1300-1900, 2000-3500, 3600-5000, and above 5000. The selected bread, drink, spread and customer school profile variable (Transaction ID, Item sets ID, Price) are generated randomly using the uniform distribution. The stratification variables are the element variables. 150 was used as the sample stratum size, using the 'srswor' (simple random sampling without replacement) method.

b) Horvitz-Thompson Estimator: The Horvitz-Thompson estimator variant was used to compute customer profile and compare the result with the calibration prediction process. In other to obtain accurate result recommendation on the conceptual drift of customer's transaction, the predictive analysis was run

B. The Elixir Big Data Architectural Framework

This study adopted a modified layered Elixir big data analytics Architecture towards solving the concept drift problem of transactional data in Market Basket Analysis. There are six layered that were adapted from the elixir architecture as against the seven layers present in the architecture. The layers incorporated are as follows: Data Ingestion layer, Data collection layer, Data processing layer, and Data storage layer. The data ingestion layer and data collection layer combined to form the data Pipelining layer as seen in Fig. 1.

1) Data ingestion layer: The data coming in from various data source are being prioritized in the database. This data come in both batches for example, the one residing in the database and the stream data (customer profile, and spending behaviors) that comes in as customers perform transactions. Both data come in the .xlxs format of Microsoft Excel which is an acceptable data format in Hadoop data panel feature found in Tabluea.

2) Data pipelining layer: After ingesting the data, the collector layer will collect the data and creates data pipelines that will orchestrate the transformation and movement of data from the various sources till it gets to the final destination for processing. Each step in this study made use of a separate solution software. Luigi version 3.7 was used as the pipeline scheduler to build a complex batch of data pipelines. It is also used for table pivoting, management of workflows, handling filed processes and visualization.

3) Data processing layer: The pipelined data were routed to different destinations, and the respective data flows were classified using the data model from the semantic library. For example, the different transactional data gotten from the superstore are used to predict the customer's concept drift by appending it to the customer profile data streams at various levels. This routing is meant to interface with big data analytics visualization of each instance of the transactions towards predicting customer concept drift in market basket analysis.

4) Data storage layer: In this layer, the University superstore transactional data stream which was collected that comprises of 1,112,000 instances of the transaction which was too lager to store in external storage hence the need to employ a cloud database. The cloud platform used in this layer is Amazon Redshift and Amazon Kinesis which store the data in the MySQL relational database. The data stored in the database also include streamed data of customer's profile of over 556,000 instances which contains their buying pattern simulated online.

C. The Scalable Data Analytics Market Basket Model (SDAMBM) for Transactional Data Stream

The data analytics model for modelling customer behavior was modelled by adopting some components of the Elixir layered big data model and some components of the research conceptual model is as shown in Fig. 2. The model helps in defining the dimensions and measures used in the design of the Scalable Data Analytics Market Basket Model (SDAMBM) for processing transactional data streams. The design was done by curating the different dimensions adapted from the Elixir and the research conceptual model. The curation process involves adding filters to the chosen dimension which form part of the Business management visualization layer. The SDAMBM for transactional data streams was designed using a combination of Toad Modeler, Corel Draw and CRAN for customer management towards solving concept drift problem of transactional data streams in market basket analysis.

1) Business management visualization: this section curates intelligent visualization method adopted from Elixir model and some features of the adopted consumer behavior theorems. This therefore gives business organizations the ability to use big data analytics method to boost customer retention in market basket analysis thus solving concept drift problems.

2) Interoperability: helps improve analytics processing of transactional data streams data in retail marketers. Luigi version 3.7 an interoperation software was used in monitoring concept drift of customers by studying their buying pattern in market basket analysis across a variety of analytics processing.

3) Big data analytics: this platform was designed to allow the University superstore utilize big data processes in studying their customer's buying pattern. The platform creates a customer management results thereby helping top management to support decision making in managing the relationship that exists between their customers. Big data analytics inventory tools were used to analyze transactional data stream to produce reports thereby help in taking improved business decisions.

4) Customer management strategies: This platform helps in improving the relationship between the customers and the business ventures by studying the buying pattern in the concept drift of the customer's transactions, help institutional research by accreting the extent a customer's consumption affects his academics and health which is known as extended effects of concept drift, solved using big data analytics.

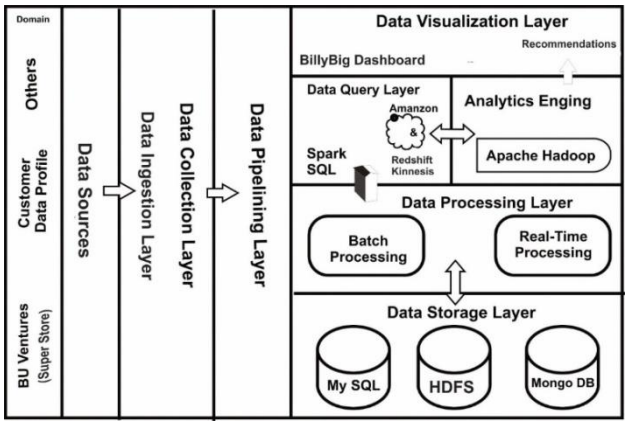


Fig. 1. Remodified Elixir Big Data Architecture Framework for the Transactional Data Stream Adapted from (Source: [10]).

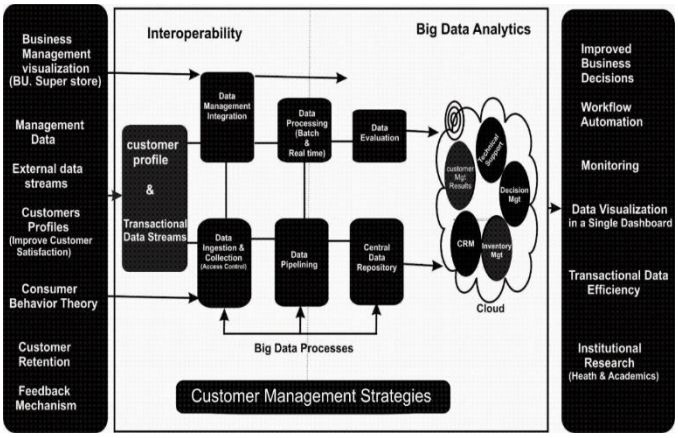


Fig. 2. The Scalable Data Analytics Market Basket Model (SDAMBM) for Transactional Data Stream.

D. System Design

This section presents the system flowchart and the use case diagram. The flowchart shows all the steps involved in performing big data analytics in market basket analysis as shown in Fig. 3, which. In searching for consumer behavior, the big data coming from various data sources were queried to generate frequent itemset through the help of ARM algorithms. A big data analytics was performed through the support of Hadoop in tableau to create the visualization report that shows the summary of the customer's consumption which represents the concept drift. Fig. 4 shows the use case diagram of the SDAMBM for transactional data streams. This use case is a reflection of all the functional requirements of the model showing all the major components and its outcome.

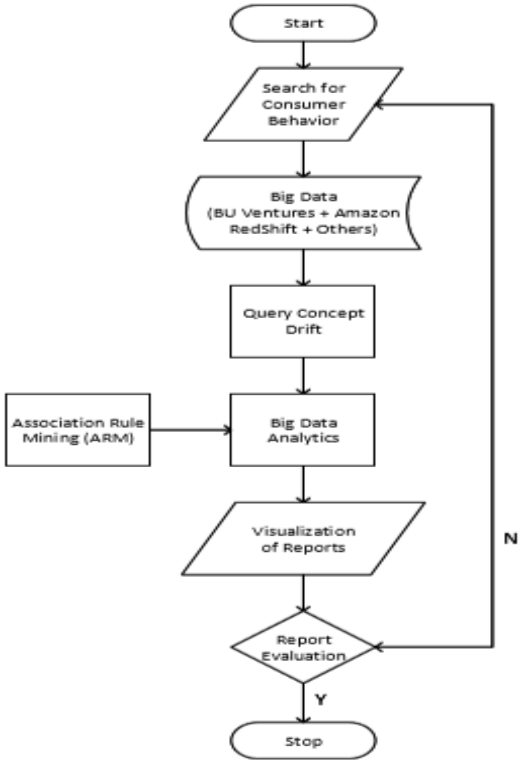


Fig. 3. The System Flowchart.

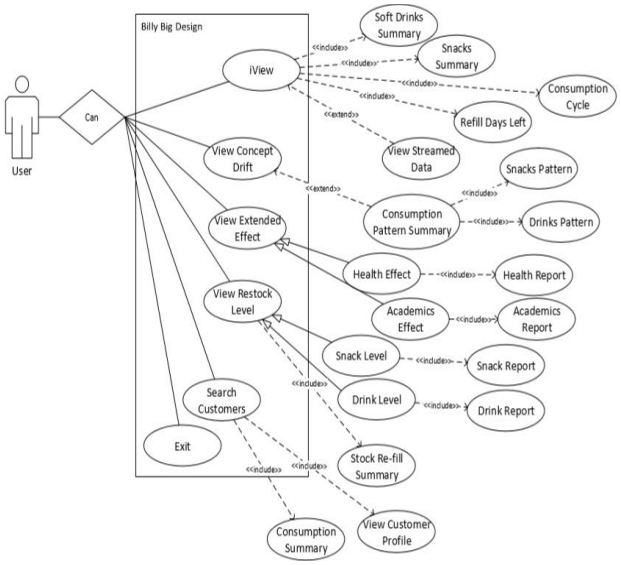


Fig. 4. The use Case Diagram of the Model.

E. Development Tools

The SDAMBM for transactional data stream was developed using a combination of tools such as Apache Hadoop data panel found in Tableau, Tableau and MongoDB. Apache Hadoop was used as the big data processor engine for data analytics, Tableau a big data visualization tool was used to implement the designed model in other to view the concept drift visualization of the customer's transactions. MongoDB is NoSQL document-orient storage that was used as the database storage. HTML 5 and MySQL was used for exporting the analytics so that it can be viewed offline.

IV. System Implementation Evaluation and Discussion

The model implementation was designed to have four tabs which include the iView, concept Drift, Extended Effects and Restock Level. The diagrams for each of the tags are shown in Fig. 5 to Fig. 7, respectively.

A. System Implementation

The iView Module helps top managers to view individual transactional object properties in real time, which is as new transactions are coming in, the view keeps changing. In other to view the object stream reports, the manager logs in to view the object summary visitation frequency and spending measures as shown in Fig. 6.

Fig. 6 shows a summary of how often customers visit the superstore for shopping, which could either be every day, weekly, monthly a few months per months or annually. The concept drift tab shows the consumption pattern summary for items pairs bought together, for example, the combination of bread and drink was more than bread and bread spread as shown in Fig. 7.

The extended effects tabs contain the impact of what customers are buying and eating as against how it affects their health and academic performance. Now it is not enough to have big data analytics performed without making meaning out of the analytics. Therefore this tabs helps to extend the

effects of the analysis on consumer's health and academics. Fig. 8(a), (b) and (c) show the figure of extended effects on the consumer's health and academics.

Fig. 8(b) shows that of all the customers that responded to the online survey on spending behavior. 19.24 % attested to the fact that what they buy and eat affects their health very often, 28.15% said they fall sick often, 32.6 % said they seldom fall ill, while 20.01% don't fall sick at all. This shows that customer's consumption has a significant effect on their health.

Fig. 5. The iView Module.

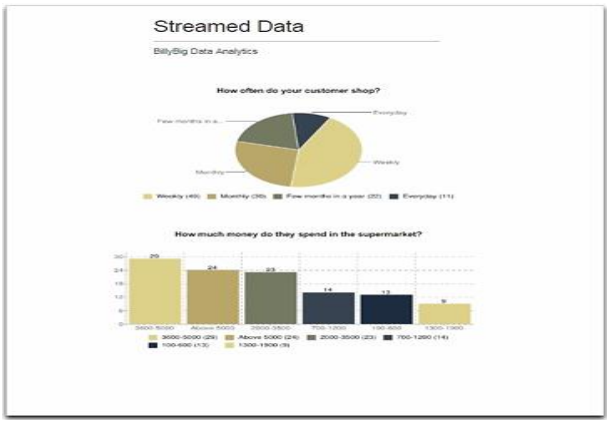


Fig. 6. Superstore Visitation Summary and Spending Measure.

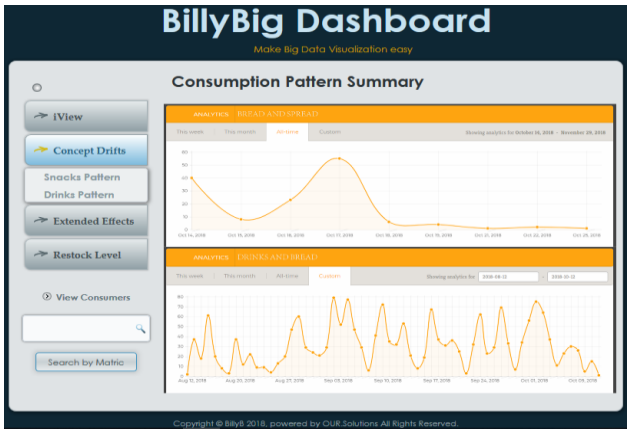
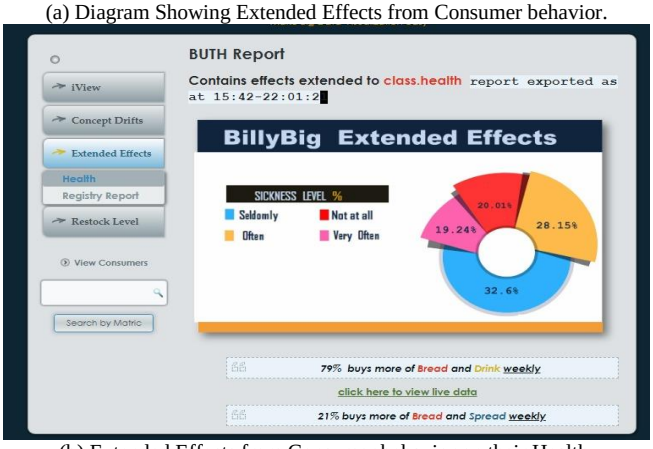


Fig. 7. Consumption Summary for Frequent Item Pairs.

(a) Diagram Showing Extended Effects from Consumer behavior.



(b) Extended Effects from Consumer behavior on their Health.

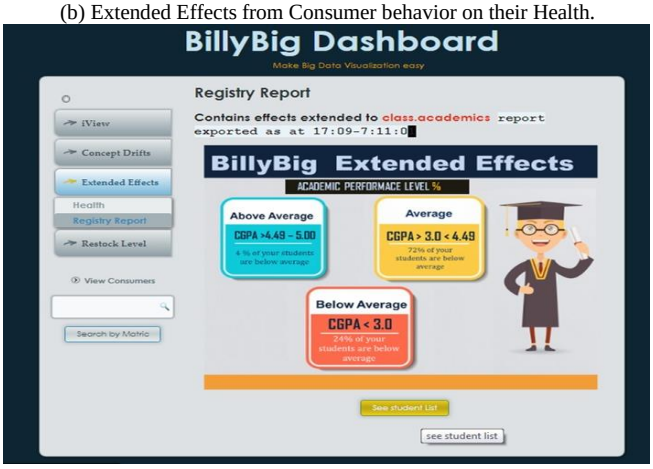


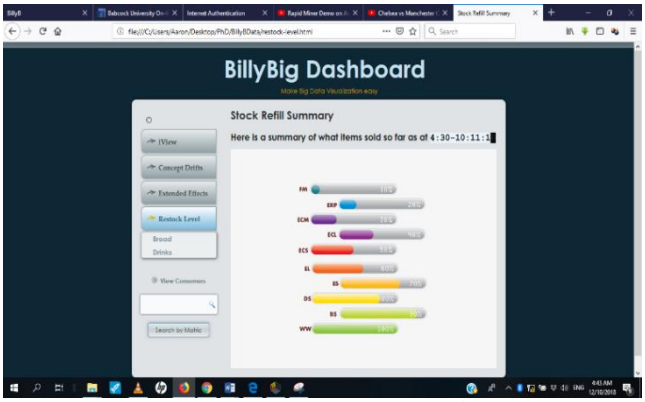
Fig. 8. (c) Extended Effects from Consumer behavior on their Academics.

Fig. 8(c) gives a summary of how customer's consumption pattern affects their academics performance.

The restock level tab shows the percentage of items currently left in the store inventory system. This tab helps the superstore take note of stock-taking as it updates automatically as customers perform transactions in the store. This tab helps reduces the stress in the manual method of stock-taking currently be done in the superstore. Fig. 9(a) and (b) show the restock level for items in the store. Fig. 9(a) shows the restock level summary for the bread item sets showing all the bread category and the percentage of the bread that has been restocked and ready for sale.

Fig. 9(b) shows the percentage of each bread category been sold as at the time of this analysis. Doing this help the inventory officer knows at what time they need to restock a particular item.

Fig. 10 shows the summary of an individual consumer consumption pattern, indicating which items pairs were frequently bought by the consumer and how much the consumer contributes to the revenue of the superstore in percentage. This analysis also shows how much an individual customer spends on the average per month.



(a) Showing the Restock Level Summary for Bread.

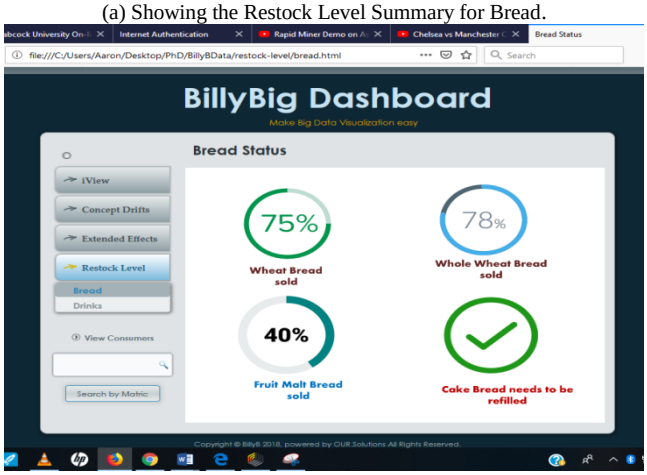


Fig. 9. (b) The Percentage of Bread Sold.

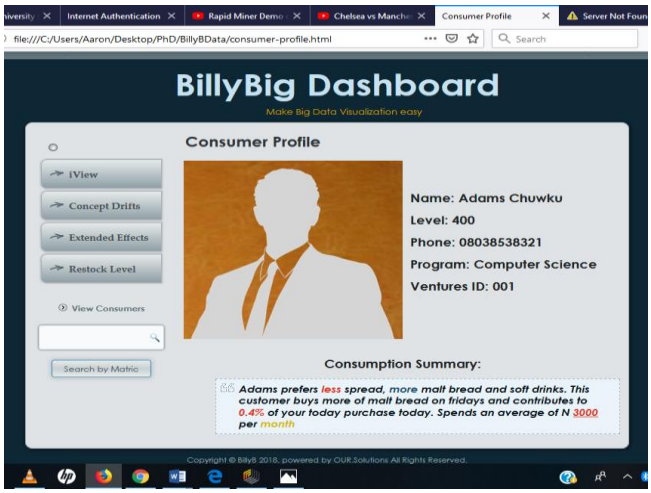


Fig. 10. Individual Consumer's Consumption Summary.

B. Evaluation of the Scalable Data Analytics Market Basket Model

In evaluating the designed model, three standard evaluation matrices; intelegent interpreters for Auto decision grid, The selectivity mechanism and customer insights available in tableau were used as the evaluation method.

The intelligent interpreters for Auto decision grid was evaluated in restock level, and extended effects on academic performace and extended effects on health status as shown in Fig. 9(a) and (b), and Fig. 8(a), (b) and (c). The selectivity mechanism was used to map specific customer _sets IDs profile agaisnt item and descriptions as shown in Fig. 10. Evaluation of customer insigts was viewed based on the overall consumption pattern summary embedded in Hadoop platforms to select the appropriate attributes in the data that convene the required result as shown in Fig. 7. Also Customer insights can be evaluated by querying the analysis with questions not directly linked to the transactional data. This helps to display thing such as major drink bought by males, the effect of customer's consumption on their health, how the customer consumes what they buy. These are the primary evaluation done on the scalable data analytics market basket model designed.

C. Discussion of Findings

The results from the model implementation done using Tableau shows that the SDAMBM for transactional data streams, was able to accurately study the customer consumption pattern over time. These was done towards solving the concept drift problem inherent in the transactional data stream. This study verifies the submission of [9]. Regarding considering consumer behavior theories, which recognize four factors that contribute to the reason why customers purchase the items in a particular shop. This study verified the four-factor and expanded on things that can cause a changed of behavior by a consumer using two main consumer behavior theories (reasoned action and the planned behavior theories) which were not used in [9] study. Previous studies such as [4] and [2] that tried to handle concept drift problems, did not attribute it to market basket analysis; instead, they only decided to solve the problem in stream mining applications. However, this study solved the concept drift problem in concert to MBA which deals with understanding customer's behavior concerning their purchase. Therefore the study discovered that in other to solve concept drift problems in MBA, it is imperative to use an enormous amount of transactional data stream of customers over a very long period. The data will help in predicting the customers buying pattern whether there will be a drift or it will remain the same. This study also agrees with [11] which insist on increasing the number of transactions in other to be able to predict customers buying behaviors. The study of [12] also corroborates with this study by using big data analytics tools such as spark to study customer's behaviors in MBA but did not consider visualization of the transactions.

In solving this concept drift issue in MBA, multiple sources of data were used to feed the data analytics market basket model to be able to visualize the concept drift of customers transactions throughout a period of two year. The

BillyBig data visualizer showed not only the customer's consumption pattern, but also the effects of the consumption on the health and academics status of the consumers through the customer profile data stream streamed online. These data served as new transaction stored on Amazon RedShift, the previous transactional data stored on MySQL and other data sources used in this study.

V. Conclusion and Recommendation for Further Study

This study, in general, provided a data analytics strategy for managing drift in the buying concept of customers, hence help improve the customers shopping experience as well as help the superstore retain their customers. This is enhances monitoring the buying pattern of the customers. The study focused on implementing a scalable data analytics market basket model for transactional data Streams through the use of big data analytics. The study looked critically into the problems inherent in transactional data streams and solved the concept drift problems in MBA. This was done by studying customers buying pattern, and making predictions to determine if there will be a drift in the buying concept or they will continue to purchase the same item set as the case may be.

Furthermore, in solving the concept drift problem, transactional data was gotten from the University superstore that covers the period of two years (January 2, 2017, to December 31, 2018), and simulated University store streamed data from customer's transactions online was also used. However, in monitoring the concept drift of consumers, the selectivity mechanism was applied to aggregate the data source for the sake of data protection. Also, the data sets were calibrated, using the calibration function algorithm before the data analysis an evaluation process was done.

A Scalable data Analytics Market Basket model (SDAMBM) for transactional data streams were designed to interact and interface with the University superstore through the management of the superstore. The model provides a generalized view of customer transactions as well as a personalized view through the BillyBig data visualization dashboard designed using Tableau analytics tool. A consumption pattern summary of all customers can be viewed as well as the extended effects of what customers consume on their health and academic performance. This helps in giving the big data analysis meaning. The analysis also has a restock level which tells the University super stock the level of goods remaining in the inventory system so as for them to know when to restock a particular item.

The customer management model was designed in other to harness the concept drift of customers from their consumption pattern generated from the data gathered and analyzed. Thereby helping to strengthen the relationship between the customers and the University superstore.

This research contributed to the existing body of knowledge by providing a scalable data analytics market basket model for transactional data stream and a more efficient method for effective concept drift management of customer's transactional data streams in market basket analysis. These thereby contributes to the methodological discourse on the development of big data analytics platforms for predicting concept drift of transactional data in market basket analysis using previous and current transactions.

Future research can investigate the possibility of providing big data analytics from other data sources such as monitoring health history from customer's consumption pattern and inform the customers through a Hospital to take note of the consumption behaviors. Also, the research can link what the customers buy from other stores within the University campus, such as the cafeteria and hall of residence. Forecasting and predictions can also be done using future dimensions from the dataset provided.

References

[1] Rick F. van der Lans, (2012) in Data Virtualization for Business Intelligence Systems, A volume in MKSeries on Business Intelligence Published by Elsevier, retrieved fromhttps://www.sciencedirect .com/book/978012394425data virtualization-for-business intelligence-systems.217-229, ISBN: 978-0-12-394425-2 DOI:https://doi.org/10. 1016/C2011-0-07129-6.

[2] Gajbhiye, P. R., & Vaidya, S. G. (2016). Classification and Adaptive Novel Class Detection of Feature-Evolving Data Streams. International Journal of Engineering Research and General Science, 4(3), 616-622.

[3] Masud, M. M., Chen, Q., Khan, L., Aggarwal, C. C., Gao, J., Han, J., Oza, N. C. (2013). Classification and Adaptive Novel Class Detection of Feature-Evolving Data Streams. IEEE Transactions on Knowledge and Data Engineering, 25(7), 1484-1497.

[4] Ojugo, A.A, & Eboka, A.O (2018). Modeling the Computational Solution of Market Basket Associative Rule Mining Approaches using Deep Neural Network. Digital Technologies, 3(1), 1-8.

[5] Dhanabhakyam, M., & Punithavalli, M. (2011). A Survey on Data Mining Algorithm for Market Basket Analysis. Global Journal of Computer Science and Technology, XI(11), 13-21. Retrieved Feburary 8, 2017.

[6] Annie, L., & Kumar, A. (2012). Market Basket Analysis for a Supermaket Based on Frequent item Mining. International Journal of Computer Science, 6(5), 34-43. Retrieved January 10, 2017

[7] Adewole, K., Akintola, A., Ajiboye, A., & Abdulsalam, S. (2014). Frequent pattern and association rule mining from inventory database using apriori algorithm. African Journal of Computing & ICT, VII(3), 35-42.

[8] Deshmukh, H., Ankit, R., Lalit, V., Dhiraj, G., & Rahil, K. (2016). Android Application for Searching and Shopping Based on Cloud. International Journal Of Pure And Applied Research In Engineering And Technology, 4(9), 1368-1374.

[9] Kurniawan, F.; Umayah, B.; Hammad, J.; Mardi, S.;Nugroho, S.; & Hariadi, M. (2018) Market Basket Analysis to Identify Customer Behaviors by Way of Transaction Data, Knowledge Engineering and Data Science (KEDS), Vol 1, No 1, pp. 20–25, ISSN 2597-4602.

[10] Gill, N.S., (2017), Data Ingestion, Processing and Architecture layers for Big Data and IoT, retrieved from https://www.xenonstack .com/blog/big-dataengineering/ingestion processing-big-data-iot stream/, accessed 12/10/2018.

[11] Phani, P., & Murlidher, M. (2013). A Study on Market Basket Analysis Using a Data Mining Algorithm. International Journal of Emerging Technology and Advanced Engineering, III(6), 361-363. Retrieved from www.ijetea.com.

[12] Woo, J. (2015). Market Basket Analysis using Spark. ARPN Journal of Science and Technology, V(4), 207 209.

Haze Effects on Satellite Remote Sensing Imagery and their Corrections

Asmala Ahmad[1], Mohd Mawardy Abdullah[5]
Centre for Advanced Computing Technology (C-ACT)
Fakulti Teknologi Maklumat dan Komunikasi (FTMK)
University Teknikal Malaysia Melaka (UTeM)
Melaka, Malaysia

Shaun Quegan[2]
School of Mathematics and Statistics
University of Sheffield, Sheffield, United Kingdom

Suliadi Firdaus Sufahani[3]
Fakulti Sains Gunaan dan Teknologi
Universiti Tun Hussein Onn Malaysia
Johor, Malaysia

Hamzah Sakidin[4]
Department of Fundamental and Applied Sciences
Universiti Teknologi PETRONAS
Perak, Malaysia

***Abstract*—Imagery recorded using satellite sensors operating at visible wavelengths can be contaminated by atmospheric haze that originates from large scale biomass burning. Such issue can reduce the reliability of the imagery and therefore having an effective method for removing such contamination is crucial. The principal aim of this study is to investigate the effects of haze on remote sensing imagery and develop a method for removing them. In order to get a better understanding on the behaviour of haze, the effects of haze on satellite imagery were initially studied. A methodology of removing haze based on haze subtraction and filtering was then developed. The developed haze removal method was then evaluated by means of signal-to-noise ratio (SNR) and classification accuracy. The results show that the haze removal method is able to improve the haze-affected imagery qualitatively and quantitatively.**

Keywords*—Haze effects; haze removal; remote sensing; accuracy; visibility

I. Introduction

Haze occurs almost every year in Malaysia and is caused by smoke that originates from forest fires in nearby regions. The recent September 2019 haze was considered among the worst as the air pollutant index (API) in Sri Aman, Sarawak reached 407 indicating 'hazardous level' [1] . Previously, the worst haze episode was recorded in 1997 when API in Miri, Sarawak hit 839 ('emergency level'). This was followed by 2005 (541 in Kuala Selangor), 2010 (432 in Muar), 2013 (762 in Muar) and 2015 (308 in Shah Alam) [2]. Haze causes visibility to drop and therefore affecting the images acquired for this area using optical sensor such as that onboard the Landsat-5 TM satellite. In Malaysia, haze monitoring is carried out by the Malaysian Meteorological Department and Department of Environment Malaysia in terms of visibility and API respectively. Malaysia has a typical tropical monsoon climate characterized by uniformly high mean temperature with temperature approximately 27oC, a relatively high mean annual rainfall that exceeds 2000 mm per year and humidity 70% to 90% throughout the year. The wind over the country is generally mild and variable. However, there are some periodic changes in the wind flow patterns that describe the two monsoon seasons namely the north-east monsoon, known as the wet season that occurs from November to March and the south-west monsoon, known as the dry season that occurs from June to September. The remaining months, April to May and October to November, are known as the transitional periods. Because the wind comes from the south-west and there is much less rain during the south-west monsoon and the second transitional period, smoke from the forest fires in Sumatra remains suspended in the atmosphere for a long time and drifts to Malaysia, causing haze. This paper focuses on the 2005 haze episode that caused a drop in visibility in most places in Malaysia. Fig. 1 shows photos of clear and hazy conditions in Putrajaya, the federal administrative centre of Malaysia, located about 30 km from Kuala Lumpur. Due to the hazardous properties of the haze constituents, a sudden increase in respiratory and eye-related illnesses cases was reported. The drop in visibility conditions also badly affected economy-related activities including tourism, transportation, fisheries and production sectors, which caused a big loss to Malaysia.

Visibility measurement is carried out by the Malaysian Meteorological Department on a daily basis through a network of 149 monitoring stations. For public convenience, haze severity is categorised into five levels; visibilities more than 10 km represent 'clear', 5 to 10 km visibilities represent 'moderate', 2 to 5 km visibilities represent 'hazy', 0.5 to 2 km visibilities represent 'very hazy' and visibilities less than 0.5 km represent 'extremely hazy' (Table I).

The Department of Environment Malaysia operates a network of 51 stations, where 36 stations are in West Malaysia (or Peninsular Malaysia) and 15 in East Malaysia. Due to the potential harm to human health, five main pollutants are measured which are SO_2, NO_2, CO, O_3 and PM_{10} [4]. Based on their locations and the types of pollutant measured, the stations are categorised into Residential (20 stations), Industrial (12 stations), Traffic (1 station), Background (1 station) and PM_{10} (2 stations). The difference between these categories is the types of pollutant measured (Table II). The location of air quality monitoring stations in West Malaysia and a typical monitoring station are shown in Fig. 2 [5].

(a) (b)

Fig. 1. Putrajaya, the Federal Administrative Centre for Malaysia During (a) Hazy (8 August 2005) and (b) Clear (27 June 2005) [3].

TABLE. I. VISIBILITY LEVELS USED BY THE MALAYSIAN METEOROLOGICAL DEPARTMENT [6]

Severity	Horizontal Visibility (km)
Clear	> 10
Moderate	5 – 10
Hazy	2 – 5
Very hazy	0.5 – 2
Extremely hazy	< 0.5

TABLE. II. STATION CATEGORIES AND THE TYPE OF POLLUTANTS MEASURED

Category	SO_2	NO_2	CO	O_3	PM_{10}
Industrial	X	X	-	-	X
Residential	X	X	X	X	X
Traffic	X	X	-	X	X
Background	X	X	X	X	X
PM_{10}	-	-	-	-	X

Fig. 2. Location of Air Quality Monitoring Stations in West Malaysia (Left) with an Enlarged Version of Selangor State (Sub-section in the Lower Left) and a Typical Monitoring Station (Right) [5].

In the API system, the air quality levels are categorised into: good (0 – 50), moderate (51 – 100), unhealthy (101 – 200), very unhealthy (201 – 300), hazardous (300 – 500) and emergency (> 500) (Table III). The API value reported for a given time period represents the highest API value among all pollutants during that particular time period; the predominant pollutant during haze episodes is PM_{10} [6].

The Recommended Malaysian Air Quality Guidelines forms the basis for calculating the API and consists of two key aspects: the averaging time and the Malaysian guidelines (Table IV) [4]. The averaging time differs for different air pollutants and represents the period of time over which the measurements are made and recorded in running averages. For reporting purposes, the same averaging times are used: PM_{10} and SO_2 (24-hour running averages), CO (8-hour running averages), and O_3 and NO_2 (1-hour running averages). The Malaysian guidelines represent the safe level for each pollutant and were derived based on human health data and recommendations from the World Health Organisation (WHO). For example, a PM_{10} concentration of 150 $\mu g/m^3$ corresponds to 100 API, and is the upper limit for the safe level; PM_{10} concentrations exceeding this are likely to cause adverse health effects. Conversion of the PM_{10} concentration from $\mu g/m^3$ to API can be done using the equations shown in Table V.

TABLE. III. API RANGE, STATUS, LEVEL OF POLLUTION AND HEALTH MEASURE [4]

API	Status	Level of Pollution	Health Measure
0 to 50	Good	Low, no ill effects on health.	No restriction of activities to all groups.
51 to 100	Moderate	Moderate, no ill effects on health.	No restriction of activities to all groups.
101 to 200	Unhealthy	Mild aggravation of symptoms and decreased exercise tolerance in persons with heart or lung disease.	Restriction of outdoor activities for high-risk persons. General population should reduce vigorous outdoor activity.
201 to 300	Very Unhealthy	Significant aggravation of symptoms and decreased exercise tolerance in persons with heart or lung disease.	Elderly and persons with known heart or lung disease should stay indoors and reduce physical activity. General population should reduce vigorous outdoor activity. Those with any health problems to consult doctor
300 – 500	Hazardous	Severe aggravation of symptoms and endangers health.	Elderly and persons with existing heart or lung disease should stay indoors and reduce physical activity. General population should reduce vigorous outdoor activity.
> 500	Emergency	Severe aggravation of symptoms and endangers health.	General population advised to follow the orders of National Security Council and always follow announcements through the mass media.

TABLE. IV. AIR QUALITY MEASUREMENT GUIDELINES [4]

Pollutant	Averaging Time	Malaysian Guidelines	
		(ppm)	(μgm^{-3})
O_3	1 hour	0.10	200
	8 hours	0.06	120
CO	1 hour	30	35
	8 hours	9	10
NO_2	1 hour	0.17	320
	24 hours	0.04	-
SO_2	1 hour	0.13	350
	24 hours	0.04	105
PM_{10}	24 hour	N/A	150
	1 year		50

TABLE. V. EQUATIONS FOR API CALCULATION BASED ON PM_{10} 24-HOUR RUNNING AVERAGES [4]

PM_{10} concentration, C ($\mu g/m^3$)	Equation used for conversion to API
$C \leq 50$	$API = C$
$50 < C \leq 350$	$API = 50 + [(C-50) \times 0.5]$
$350 < C \leq 420$	$API = 200 + [(C-350) \times 1.43]$
$420 < C \leq 500$	$API = 300 + [(C-420) \times 1.25]$
$C \geq 500$	$API = 400 + (C-500)$

Fig. 3 shows visibility and PM_{10} intensity against Landsat overpass date in 2005 for Klang Port, Petaling Jaya, Kuantan and Kota Bharu. The sudden increase in PM_{10} and drop in visibility in August 2005, particularly in Klang Port and Petaling Jaya, was associated with the occurrence of haze in that year. It can be seen that extreme haze occurred between 6 and 22 August 2005. Klang Port and Petaling Jaya, which are located on the west of Malaysia, with average visibility and PM_{10} concentration approximately 11 km and 70 API respectively, experienced lower visibility and higher PM_{10} intensity than Kuantan and Kota Bharu, with average visibility and intensity approximately 14 km and 40 API respectively, which are located on the east. Since extremely hazy and very hazy conditions are quite rare in Malaysia, we are more concerned on a more frequently occurring conditions, specifically moderate; in which later the haze removal will be tested onto an image with moderate haze.

Fig. 4 shows scatterplots of visibility for Petaling Jaya vs. Klang port, Petaling Jaya vs. Kuantan, Petaling Jaya vs. Kota Bharu and Kuantan vs. Kota Bharu, together with linear fits to these plots. It is clear that the visibility correlation between nearby stations, Petaling Jaya and Klang Port (0.708) is much higher than non-neighbouring stations, Petaling Jaya and Kuantan (0.04), Petaling Jaya and Kota Bharu (0.02) and Kuantan and Kota Bharu (0.08). In this thesis, the testing of the developed haze removal method will be carried out over Bukit Beruntung area, by using PM_{10} measurements from Petaling Jaya station.

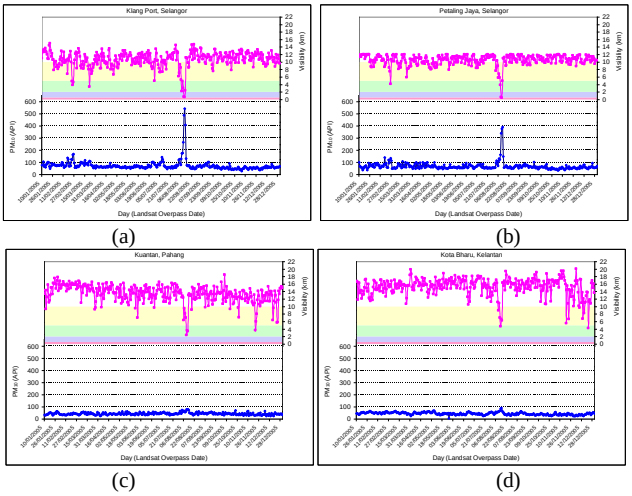


Fig. 3. Visibility and PM_{10} Intensity for (a) Klang Port, (b) Petaling Jaya, (c) Kuantan and (d) Kota Bharu Stations. White, Yellow, Green, Violet and Red Colours Indicate Clear (above 10 km), Moderate (5 – 10 km), Hazy (2 – 5 km), Very Hazy (0.5 – 2 km) and Extremely Hazy (Less than 0.5 km) Conditions Respectively.

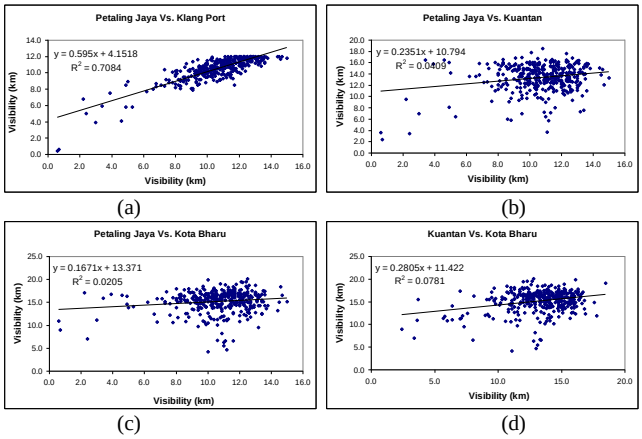


Fig. 4. Visibility Correlation for (a) Petaling Jaya vs. Klang port, (b) Petaling Jaya vs. Kuantan, (c) Petaling Jaya vs. Kota Bharu and (d) Kuantan vs. Kota Bharu.

II. HAZE EFFECTS ON REMOTE SENSING IMAGERY

A. Simulating Hazy Images

6SV1 is the vector version of the 6S (Second Simulation of the Satellite Signal in the Solar Spectrum) [7], [8], though it also works in scalar mode. The vector version is introduced to account for radiation polarisation, due to Rayleigh scattering in a mixed molecular-aerosol atmosphere, which is to be used when performing atmospheric correction. In our study, the 6SV1 was used in simulating haze effects, therefore the radiation polarisation effect was assumed negligible. Hence, our interest was in the scalar mode of 6SV1, which was similar to 6S.

B. ML Classification on the Simulated Hazy Images

ML classification was carried out using all 6 bands to produce 11 classes, which were coastal swamp forest, dry land forest, oil palm, rubber, cleared land, sediment plumes, water, coconut, bare land, urban and industry [9], [10], [11]. To carry out ML classification on the hazy scenes, we need training pixels within the hazy scene. For this purpose, the ROIs for different land classes (different colours) that were applied on the clear scene were used as a template. Fig. 5 shows bands 3, 2 and 1 assigned to red, green and blue channels respectively (left). ML classification using training pixels from hazy images were performed for 20 km (clear) downto 0 km visibility (right).

C. The Effects of Haze on the Hazy Images

We carried out spectral signature analysis by plotting mean radiance versus band 1, 2, 3 4, 5 and 7 for all 11 land covers and for visibility 20 km (clear) down to 0 km [12]. The outcome for visibility 16 km and 2 km are shown in Fig. 6. Mean radiances versus bands of individual classes for a scene with haze (black) and without haze (red) were simultaneously plotted to signify the effects of haze. Vertical bars indicate standard deviations in km visibility. It is clear that the spectral signature of the land covers is severely modified at 2 km compared to 16 km visibility. At 16 km visibility the modification can be hardly seen due to the insignificant scattering that occurred and moreover it still considered as good visibility. On the other hand, significant modification can

be seen at 2 km visibility indicating severe scattering particularly for bands with shorter wavelengths (band 1, 2 and 3) compared to longer wavelengths (band 5 and 7). When the plotted together for all 1l land covers (Fig. 7), the spectral signatures get narrower at 2 km compared to 16 km visibility indicating that the land covers are becoming visually inseparable as visibility gets very low.

To understand better the effects of haze on remote sensing images, band correlation versus visibility was plotted for all possible combinations and for all 11 land covers (Fig. 8). It can be seen that for oil palm and urban, correlation gets close to '1' as visibility reduces. This is due to the fact that haze has greater effects at low visibility due to the very severe scattering that makes the radiance becomes very similar although when measured from different bands and eventually giving correlation close to '1' signifying highly correlated.

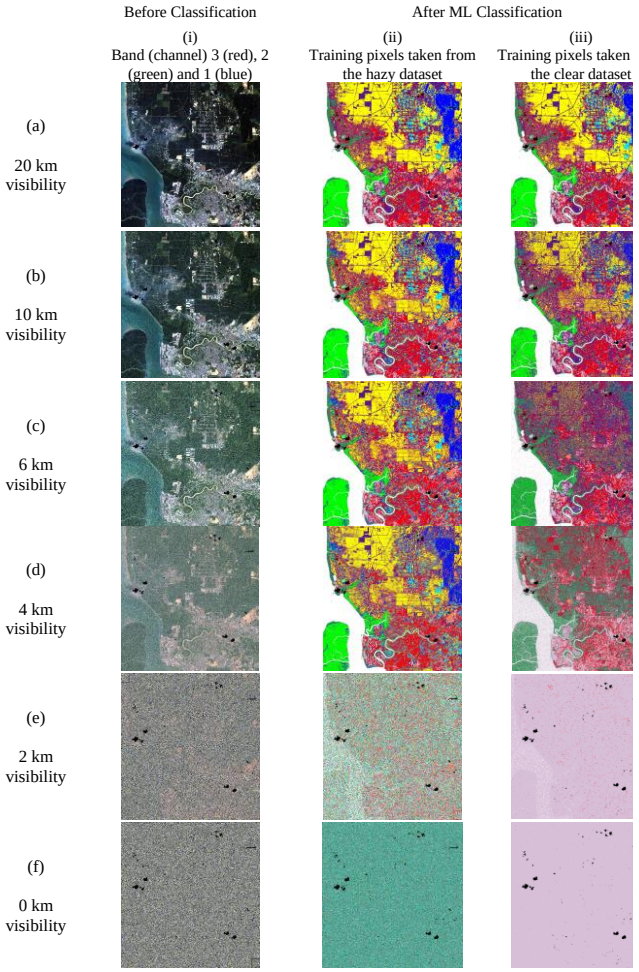


Fig. 5. Bands 3, 2 and 1 Assigned to Red, Green and Blue Channels Respectively (Left), the ML Classification using Training Pixels from Hazy Images (Middle) and ML Classification using Training Pixels from Clear Images for (a) 20 km (Clear), (b) 10 km, (c) 6 km, (d) 4 km, (e) 2 km and (f) 0 km Visibility. Note that Images a(ii) and a(iii) are the Same and are Displayed for Convenience. Black Patches are Cloud and its Shadow (Masked Black).

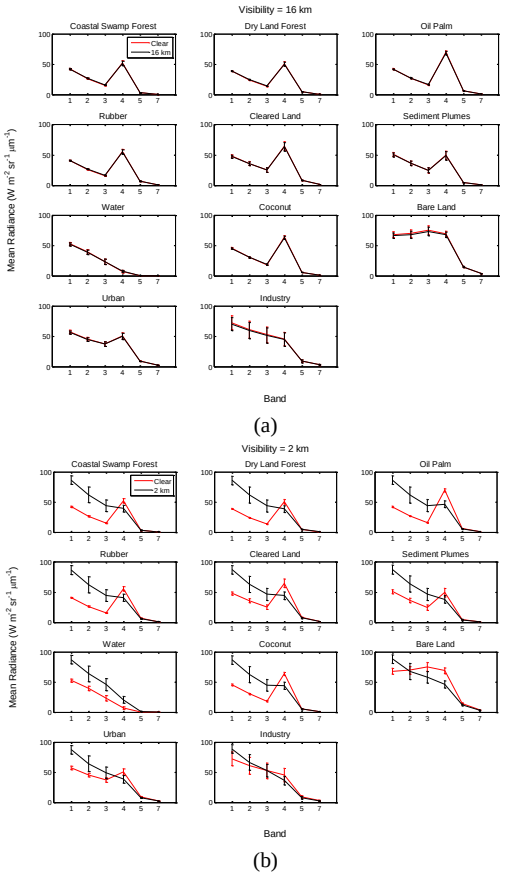


Fig. 6. Mean Radiances Versus Bands of Individual Classes for a Scene with Haze (Black) and without Haze (red) at Visibility (a) 16 and (b) 2 km. Vertical Bars Indicate Standard Deviations in km Visibility.

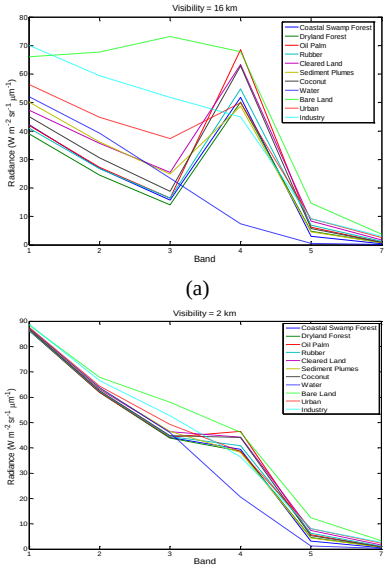


Fig. 7. Mean Spectral Signatures of the 12 Classes at Visibilities (a) 16 and 2 km.

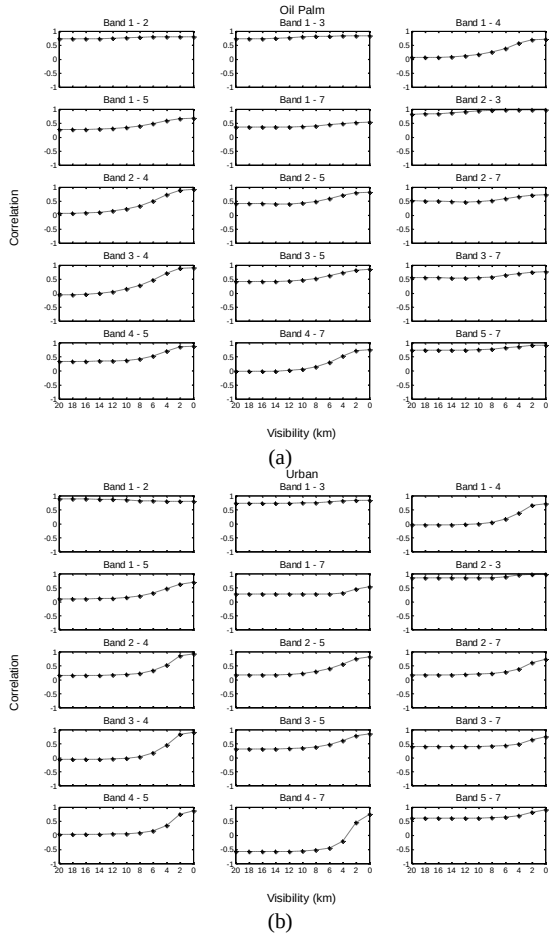


Fig. 8. Correlation between bands with Reducing Visibility for (a) Oil Palm and (b) urban.

Subsequently, classification accuracy versus visibility was plotted for all 11 land covers as shown in Fig. 9 [13], [14]. As expected, a drop in accuracy can be seen as visibility gets low. However, the drop trend varies for different land covers. Due to the similar physical properties, oil palm and coconut show somewhat similar trend. Similarly, a common trend also can be seen for dryland forest and rubber. A faster drop can be seen for industry compared to others particularly due to mixed pixels issue. It is also obvious that accuracy drop for water only occurs at 2 km visibility due to the fact that water has somewhat uniform spectral properties and tend to be classified correctly at 20 km downto 2 km visibility.

The reason for the drop in accuracy can be clarified by plot of pixels versus classes for oil palm and urban as shown in Fig. 10. Different coloured lines indicate different visibilities. In an ideal situation, when classified as oil palm. Oil palm pixels should be 100% at all visibilities as for 20 km visibility. However, migration of oil palm pixels to other land cover classes seems to occur as visibility reduces causing a decrease in classification accuracy.

To understand the overall trend on how haze affects classification, overall classification accuracy versus visibility was plotted for 20 km downto o km visibility images. Overall classification accuracy and Kappa coefficient versus visibility are shown in Fig. 11.

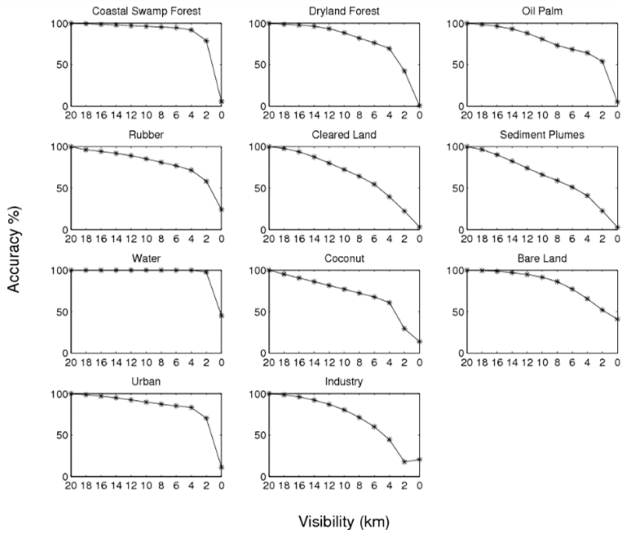


Fig. 9. Classification Accuracy for Each Class with Reducing Visibility.

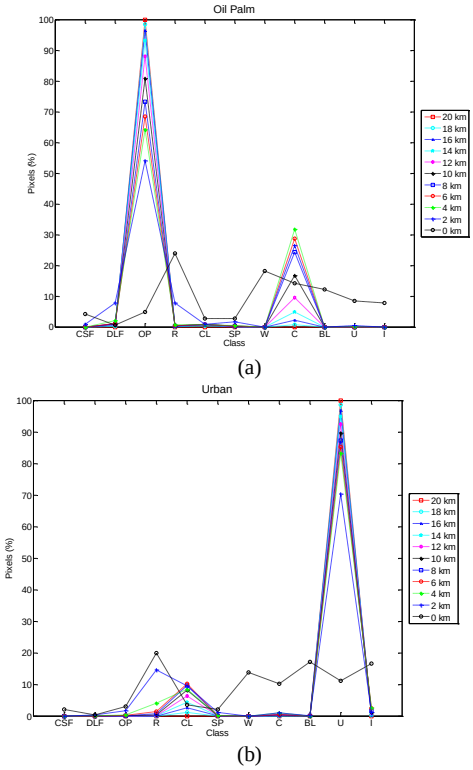


Fig. 10. Percentage of Pixels for (a) Oil Palm and (b) urban.

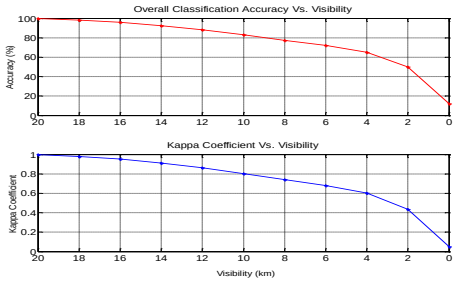


Fig. 11. Overall Classification Accuracy (top) and Kappa Coefficient (Bottom) Versus Visibility.

III. Haze Correction

This section attempts to correct for the haze effects based on the findings in the previous sections. The simulated hazy images undergo mean subtraction and three types of filtering, namely average, median and Gaussian. The signal-to-noise (SNR) of the filtered images versus visibility were plotted for each filtering type. The outcomes are shown in Fig. 12.

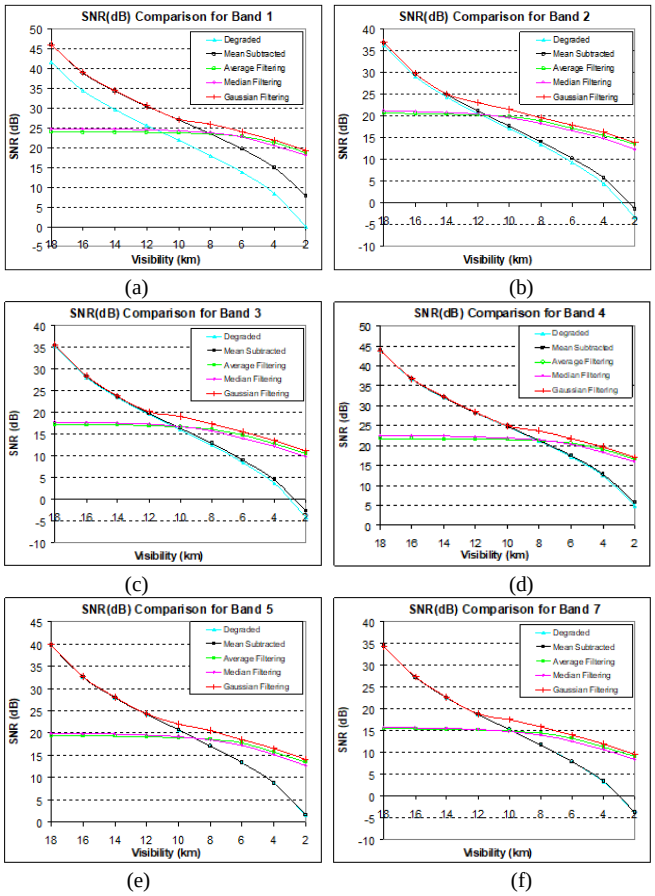


Fig. 12. SNR Versus Visibility for Degraded images, after mean Subtraction and after Applying Average Filtering, Median Filtering, and Gaussian Filtering for band 1, 2, 3, 4, 5 and 7 (a to f).

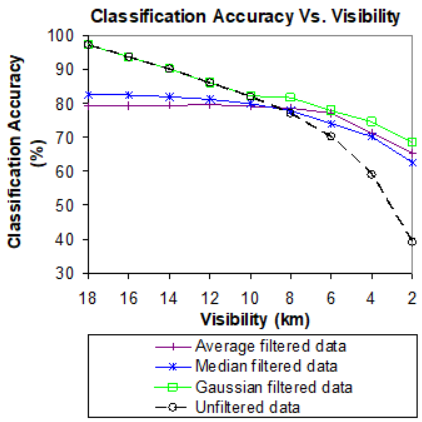


Fig. 13. Classification Accuracy Against Visibility for Average, Median and Gaussian Filtering.

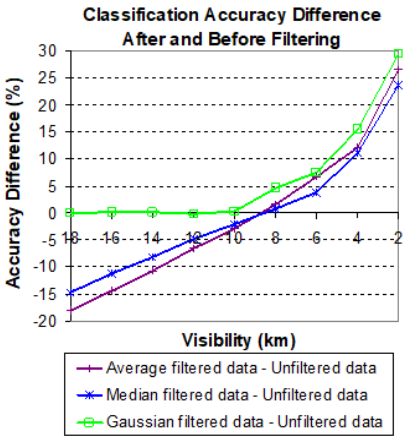


Fig. 14. Accuracy difference between Filtered and unfiltered Images for Average, Median and Gaussian Filtering.

To examine how far the haze correction is able to improve the hazy images, we plotted classification accuracy versus visibility for filtered and unfiltered images for average, median and Gaussian filtering. The accuracy difference between after and before filtering was also determined to predict the improvement made for the hazy images. Fig. 13 shows classification accuracy against visibility for average, median and Gaussian filtering. Fig. 14 shows accuracy difference between filtered and unfiltered images for all the three types of filtering.

IV. Implementation on Real Hazy Images

Based on the outcomes from the previous sections, a procedure was developed to implement the haze correction on real hazy images. The procedure can be represented by a flowchart as shown in Fig. 15. The study area within the real hazy images was located in Selangor, Malaysia. Based on the flowchart, the haze correction procedure involves two key phases, namely haze removal and quality assessment.

A. Haze Removal

The real hazy images were initially examined to check whether having uniform haze or not. If the haze was uniform, the weighted haze mean was to be estimated based on pseudoinvariant features (PIF) technique and subtracted from the hazy images [15]. On the other hand, if the haze was not uniform, the haze was to be segmented first using minimum noise fraction (MNF) technique. Subsequently, Gaussian spatial filtering was performed onto the hazy images [16].

B. Quality Assessment

In this phase, the performance of the haze correction was to be quality assessed. For such purpose, ML classification was first performed onto the hazy images. Finally, classification accuracy was calculated and examined.

The result is of the implementation is shown in Fig. 16. The top row shows the colour composite image of band 3, 2 and 1 assigned to red, green and blue respectively. The middle row shows ML classification while the bottom row shows the corresponding enlarged version. The left and middle column shows the image before and after haze removal while the right column shows the clear image representing non-hazy

condition. Visually, in the top row, the middle image shows that most of the haze have been eliminated, making it looked very close to the clear image in the right column. This is more obvious as can be seen from the images in the third row. A more significant effect can be seen on dark areas [16], [17], [18], [19]. In the second row, the misclassification between urban, rubber and cleared land as can be seen in the first column has been corrected making the classification very close to that of the right column. In the third row, the effects before and after the haze correction can be seen more clearly in the selected area. The outcomes also suggest that dealing with homogenous haze is likely to be simpler compared to heterogenous haze [20], [21], [22], [23].

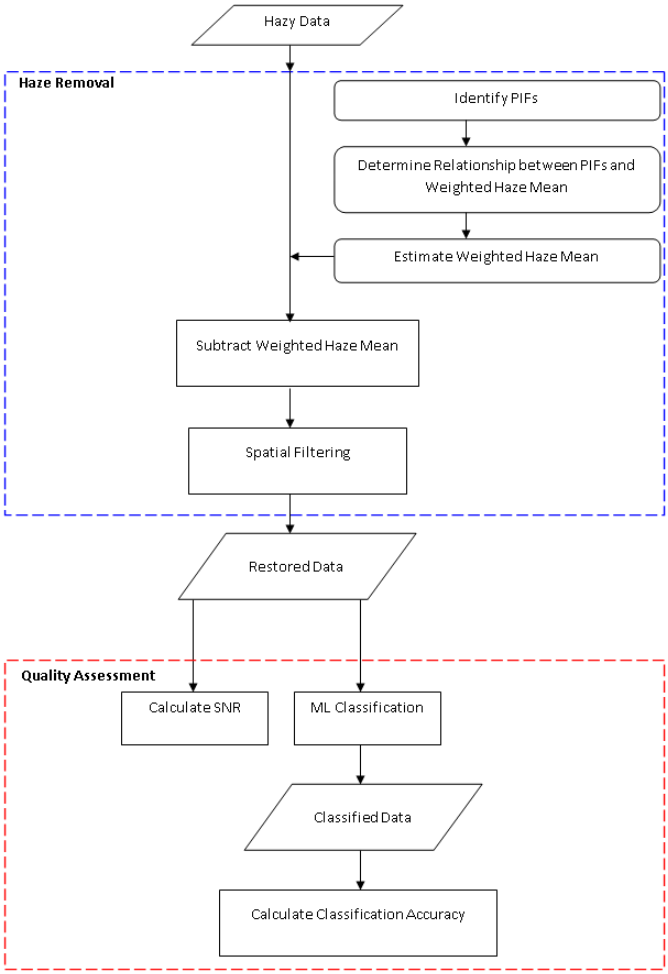


Fig. 15. Flowchart of the Haze Removal and Quality Assessment Procedures using Real Hazy Images.

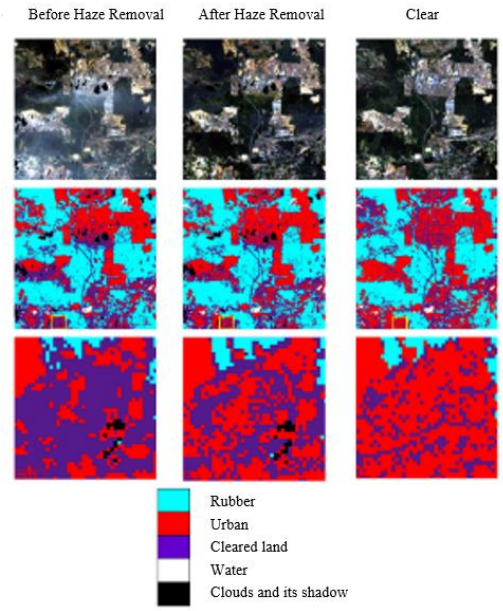


Fig. 16. Colour Composite Image of Band 3, 2 and 1 Assigned to Red, Green and Blue (Top Row) Respectively, ML Classification (Middle Row) and the Corresponding Enlarged Version (Bottom Row) before and after Haze Removal (Left and Middle Column) and the Clear Image (Right Column). The Enlarged Version Represents the Area within the Yellow Box in the ML Classification Image.

V. Conclusions

In this paper, haze effects on remote sensing imagery and their corrections have been studied. To understand the effects of haze on remote sensing imagery, haze was initially simulated over real remote sensing images to represent hazy images. Spectral signature analysis, correlation analysis and classification accuracy analysis have been carried out to assess the effects of haze on the simulated hazy images. Subsequently, a methodology for correcting haze has been developed involving weighted mean subtraction and filtering for correcting haze. For assessing the quality of the corrected images, SNR and classification accuracy have been used. Eventually the developed haze correction has been tested onto real hazy images. The result shows that the method was able to remove most haze from the hazy images effectively. The developed method is expected able to increase the reliability of remote sensing data in haze affected areas. However, the performance of the method might be hampered by heterogenous haze since the haze mean reflectance cannot be easily subtracted. Future studies should seriously look into this matter to ensure remote sensing imagery can be used optimally in various applications for the benefit of mankind.

ACKNOWLEDGMENT

The Authors are grateful to Universiti Teknikal Malaysia Melaka (UTeM) for providing the funding and support for this research.

REFERENCES

[1] New Straits Times, 2019. Haze: Haze in Sri Aman hits 'hazardous' level, API at 407 (Updated 17 September 2019). Available at: https://www.nst.com.my/news/nation/2019/09/522107/haze-sri-aman-hits-hazardous-level-api-407 [Accessed: 25 September 2019].

[2] Academy of Sciences Malaysia, "Air quality and haze episodes in Malaysia". Stakeholder Consultation Workshop, 2016.

[3] The Star Online, 2005. Open burning in Klang Valley banned (Updated 9 August 2005). Available at: http://www.thestar.com.my/news/story.asp?file=/2005/8/9/nation/11717460&sec=nation [Accessed: 13 September 2019].

[4] Department of Environment 2000, A Guide to Air Pollutant Index (API) in Malaysia. Department of Environment, Kuala Lumpur.

[5] Department of Environment. Air Quality. [online] Available at: https://www.doe.gov.my/portalv1/wp-content/uploads/2013/01/Air-Quality.pdf, 2019 [Accessed 30 Aug. 2019].

[6] Department of Environment. Air Pollutant Index (API). [online] Available at: https://www.doe.gov.my/portalv1/en/info-umum/english-air-pollutant-index-api/100, 2019 [Accessed 30 Aug. 2019].

[7] S.Y. Kotchenova and E.F.Vermote, "Validation of a vector version of the 6S radiative transfer code for atmospheric correction of satellite data. Part II: Homogeneous Lambertian and anisotropic surfaces," Applied Optics, vol. 46, no. 20, pp. 4455 – 4464, 2006.

[8] S.Y. Kotchenova, E.F. Vermote, R. Matarrese and F.J. Klemm Jr., "Validation of a vector version of the 6S radiative transfer code for atmospheric correction of satellite data. Part I: Path Radiance," Applied Optics, vol. 45, no. 26, pp. 6726 – 6774, 2006.

[9] A. Ahmad and S. Quegan, "Haze modelling and simulation in remote sensing satellite data," Applied Mathematical Sciences, vol. 8, no. 159, pp. 7909-7921, 2014.

[10] U.K.M. Hashim and A. Ahmad, "The effects of training set size on the accuracy of maximum likelihood, neural network and support vector machine classification," Science International-Lahore, vol. 26, no. 4,. pp. 1477-1481, 2014.

[11] A. Ahmad, U.K.M. Hashim, O. Mohd, M.M. Abdullah, H. Sakidin, A.W. Rasib and S.F. Sufahani, "Comparative analysis of support vector machine, maximum likelihood and neural network classification on multispectral remote sensing data " International Journal of Advanced Computer Science and Applications(IJACSA), vol.9, no. 9, pp. 529 - 537, 2018.

[12] A. Ahmad and S. Quegan, "The effects of haze on the spectral and statistical properties of land cover classification," Applied Mathematical Sciences, vol. 8, no. 180, pp. 9001-9013, 2014.

[13] A. Ahmad and S. Quegan, "The effects of haze on the accuracy of satellite land cover classification," Applied Mathematical Sciences, vol. 9, no. 49, pp. 2433-2443, 2015.

[14] M.F. Razali, A. Ahmad, O. Mohd and H. Sakidin, "Quantifying haze from satellite using haze optimized transformation (HOT)," Applied Mathematical Sciences, vol. 9, no. 29, pp. 1407 – 1416, 2015.

[15] H. Zhou, S. Liu, J. He, Q. Wen, L. Song and Y. Ma, "A new model for the automatic relative radiometric normalization of multiple images with pseudo-invariant features," International Journal of Remote Sensing, vol. 37, no. 19, 4554 – 4573, 2016.

[16] G. Luo, G. Chen, L. Tian, K. Qin and S. Qian, "Minimum noise fraction versus principal component analysis as a preprocessing step for hyperspectral imagery denoising," Canadian Journal of Remote Sensing, vo. 42, no. 2, 106 – 116, 2016.

[17] S. Haouassi, W. Di, M. Hamidaoui and T. Rachida, "An efficient image haze removal algorithm based on new accurate depth and light estimation algorithm" International Journal of Advanced Computer Science and Applications (IJACSA), vol. 10, no. 4, pp. 64 -76, 2019.

[18] K.B. Gibson, D.T. Vo, T.Q. Nguyen, "An investigation of dehazing effects on image and video coding," IEEE Transaction on Image Processing, pp. 662-673, 2012.

[19] Q. Zhu, S. Yang, P.A. Heng, X. Li, "An adaptive and effective single image dehazing algorithm based on dark channel prior," IEEE International Conference on Robotics and Biomimetics, 2013.

[20] J.P. Tarel, N. Hautiere, L. Caraffa, ; A. Cord, H. Halmaoui, D. Gruyer,"Vision enhancement in homogeneous and heterogeneous fog," IEEE Intelligent Transportation Systems Magazine, pp. 6-20, 2012.

[21] K. Tang, J.C. Yang, J. Wang, "Investigating haze-relevant features in a learning framework for image dehazing". IEEE Conference on Computer Vision and Pattern Recognition, 2014.

[22] A. Singh, "Review article digital change detection techniques using remotely-sensed data," International Journal of Remote Sensing, vol. 10, no. 6, pp. 989-1003, 1989.

[23] K.R. Manjula, J. Singaraju J. and A.K. Varma, "Data preprocessing in multi-temporal remote sensing data for deforestation analysis," Global Journal of Computer Science and Technology Software & Data Engineering, vol. 13, no. 6, pp. 1-8, 2013.

A Semantic Ontology for Disaster Trail Management System

Ashfaq Ahmad[1], Roslina Othman[2], Mohamad Fauzan[3], Qazi Mudassar Ilyas[4]
Kulliyyah of Information and Communication Technology
International Islamic University Malaysia, Kuala Lumpur, Malaysia[1, 2, 3]
College of Computer Science & Information Technology, Jazan University, Jazan, Saudi Arabia[1]
College of Computer Sciences and Information Technology, King Faisal University, Saudi Arabia[4]

Abstract—Disasters, whether natural or human-made, leave a lasting impact on human lives and require mitigation measures. In the past, millions of human beings lost their lives and properties in disasters. Information and Communication Technology provides many solutions. The issue of so far developed disaster management systems is their inefficiency in semantics that causes failure in producing dynamic inferences. Here comes the role of semantic web technology that helps to retrieve useful information. Semantic web-based intelligent and self-administered framework utilizes XML, RDF, and ontologies for a semantic presentation of data. The ontology establishes fundamental rules for data searching from the unstructured world, i.e., the World Wide Web. Afterward, these rules are utilized for data extraction and reasoning purposes. Many disaster-related ontologies have been studied; however, none conceptualizes the domain comprehensively. Some of the domain ontologies intend for the precise end goal like the disaster plans. Others have been developed for the emergency operation center or the recognition and characterization of the objects in a calamity scene. A few ontologies depend on upper ontologies that are excessively abstract and are exceptionally difficult to grasp by the individuals who are not conversant with theories of the upper ontologies. The present developed semantic web-based disaster trail management ontology almost covers all vital facets of disasters like disaster type, disaster location, disaster time, misfortunes including the causalities and the infrastructure loss, services, service providers, relief items, and so forth. The objectives of this research were to identify the requirements of a disaster ontology, to construct the ontology, and to evaluate the ontology developed for Disaster Trail Management. The ontology was assessed efficaciously via competency questions; externally by the domain experts and internally with the help of SPARQL queries.

Keywords—Semantic web; ontology; information retrieval; disaster trail management

I. INTRODUCTION

A large number of human beings are being affected by disasters every year. In disaster-affected areas, the survivors suffer a lot due to an interruption in the essential services like health care, communication, transportation, etc. Infrastructural damages can also affect food and water supply. Although the man has made considerable progress in the field of science, engineering, and technology, yet he is unable to control the occurrence of disasters. All his efforts, so far, aim at managing hazards, mitigation and to reduce the impact of disasters. Due to the devastating effects of disasters on human lives, catastrophes and crises management have always been given vital importance.

Disaster management is planning, arrangement, and deployment of resources with a precise aim of reducing disaster's damaging effects. Socio-economic conditions of the affected area and existence of effective information system regarding the occurrence of emergency are the significant factors that influence this management. Timely information plays a vital role in reducing disaster impact up to a certain level. The arrangements and organization of resources and efforts for mitigation majorly depend upon disastrous areas' situation and effects of the disaster on the local population. Efforts are made for gathering, organizing, and disseminating factual information to various stakeholders taking part in the mitigation process. Efficiency in the deployment of resources is one of the significant concerns in disaster management as it can minimize the disastrous aftereffects to a great extent.

A. Overview

The word 'disaster' itself shows that it is something troublesome that needs to be avoided or requires mitigation to bring down its outcomes if it ever happens again. Disaster mitigation focuses on long-term measures for diminishing risks. These measures can be structural or non-structural. Developing technological solutions and training of key personnel are examples of structural measures, whereas legislation and communicating potential threats to the public are considered as non-structural measures. Disaster mitigation or management process can be divided into three major phases:

- The data collection and analysis: Data is collected through observation techniques of the data collection and visualization, knowledge modeling, event forecasting, and information management after critical analysis.
- Data communication: Data communication or interconnectivity involves the mode of communication for information sharing among stakeholders.
- Data integration: Data integration phase involves combining the data from several disparate sources into meaningful and valuable information and providing a unified view to users.

Traditional Information and Communication Technology (ICT) can contribute significantly to all the three phases discussed above. For collecting and compiling data with a view to its dispersal and assimilation, semantic web-based ICT solutions provide all these levels in a plausible way.

"The word 'disaster' comes from ancient Greek words *dis* means 'bad' and *aster* means 'star'. The astrological sense of disaster based on calamity blamed on star positions." (ewonago.wordpress.com)

Ontology is getting importance for providing clear and definite search by focusing the concepts in documents collection and data sources. Ontologies are designed to help improve communication, whether it is between human and machine or is between computers. In other words, ontology helps in managing knowledge.

An ontology primarily comprises of concepts (classes), properties (attributes), and possible relationships (slots) among concepts. There may exist some constraints (facets) on slots, or cardinalities on relationships among concepts. Collectively, the components and instances (individuals) form the knowledge base that helps in reasoning.

There are various types of ontologies which have been defined or discussed by multiple researchers, including:

- Upper ontology: very general concepts familiar to numerous domains for supporting the development of an ontology
- Domain ontology: domain-specific concepts
- Interface ontology: concepts relevant to the juncture of two disciplines
- Process ontology: knowledge domain of processes

Domain ontology is one of the classifications of ontology. Ontological design can better accumulate the knowledge of diverse nature as the disaster domain does. Hence, there is a need for a specific domain ontology to conceptualize the disaster trail management (DTM).

The primary purpose of designing ontologies is to formulate sketches for disaster plans. Operational centers set up for emergency may be aided with task ontology like study and planning of objects in disastrous scenes. Upper ontologies are enigmatic and abstract hence hamper understanding for those who are alien to its application. The developed DTM ontology covers nearly all sovereign states like nature of the hazard, occurrence date, damages like mislaying including the loss in infrastructure, refugee camps and facilities available or required in the refugee camp, rehabilitation tasks associated with the contributor, location, and relief index, and so forth.

Disasters cannot be avoided, but their effects can be minimized by active warning systems and better disaster trail management systems. In disaster management, real-time availability of information can improve the result-oriented rescue operations. Folk yield an enormous mass of information over blogs and social media that can be employed to aid relief services. A system can be devised to extract electronically the precise information related to disaster damages, filter, arrange, and format appropriately so that it can be utilized in disaster trail management. Consequently, semantic web technologies can perform a vigorous role in rendering up-to-date information that can later help disseminate to other stakeholders.

Disaster trail management is a challenging task due to its complexity and enormous requirements. "Insufficient coping capacity, pathetic communication, and collaboration between different concerned departments, lack of community awareness, resources gathering, and insufficient budgeting, lack of technology awareness, adoption and integration are the most common barriers in disaster management domain" [4].

Many efforts had been made in the field of ICT to breathe new life into dying humanity is itself not less than panacea in its benevolent magnitude. There are some ICT solutions available, but these solutions depend on hand-operated data entry. A massive amount of current data, shared on the internet, can be searched and utilized. Information from the internet can be retrieved via search engines, either keyword-based or semantic-based. Semantic-based search is more relevant to the user's information needs as it makes use of an ontology to get relations among query words to understand the meaning of words instead of searching only keywords and using page ranking algorithms which are the base of conventional keyword-based search. The machine-readable semantic features of the ontology result in the more contextual and significant search output.

Moreover, no domain ontology for disaster trail management has been developed and evaluated by earthquake-prone area domain experts for completeness and relevance by scrutinizing the competency questions. Some disaster-related ontology research work exists, but it does not serve the purpose of disaster trail management. To enhance the previous research work, and to overcome the highlighted issues, the development of disaster trail management ontology was needed to benefit the relevant users' group. This research will not only play its role to improve the ontology development in the disaster management domain but also add value to information retrieval in general. The research paper is divided into five sections. Remaining part of the article is organized in the following segments.

Section II reviews the existing ontologies for disaster management. Section III discusses the proposed disaster trail management ontology. Section IV deals with the ontology evaluation, and finally, the last part is dedicated to the conclusion and future work.

II. Literature Review

The research, as shows its title, carries some terms including ontology and disaster management; the literature review discusses both one by one. This section starts talking about previous ontology works. Then the discussion focuses on disaster-related ontologies and disaster management systems beginning with a brief description of disaster management phases; existing technological and semantic web-based solutions to disaster management.

A. Ontology: State of the Art

Information Retrieval Systems not only have to deal with the structural complexity of complex databases but also with the semantic relationships between data which encourages the use of ontologies for knowledge representation [5]. Ontologies are growing more prevalent as a means for knowledge management, knowledge representation, knowledge sharing, and information retrieval, especially after the evolution of the Semantic Web technologies. An ontology represents a machine-understandable grammar consisting of concepts and relationships among these concepts to describe an area of knowledge [6, 7]. Among the causes of the increased prevalence of ontology is its capability to aid the information exchange between various systems, which is the significant success factor of the semantic web [8].

Many knowledge domains have successfully implemented and benefitted from ontologies for knowledge management including Genes analysis [9], chemical assessment framework [10], dairy industry [11], healthcare [12, 13], crises management [14], the music industry [15], agriculture [16], and so forth.

An ontological approach is establishing more practical in all developments of information retrieval, whether relating to opinion mining or cybercrime classification schemes. Practicing ontology with big data yields noteworthy gains in efficiency and productivity. Ontology finds extensive use in many domains, including machines learning, medical science, and genetic algorithms. Gruber [17, 18] defined ontology as "a formal, explicit specification of a shared conceptualization."

A need always drives every development; the same applies to ontology development as well. Following are some salient reasons that motivate researchers to develop an ontology.

- to share common domain knowledge
- to detach domain knowledge from the operational ones
- for a thorough analysis of domain knowledge to make it definite
- To qualify optimal reuse of domain knowledge in a specific area

B. Disaster Management

Due to the devastating effects of disasters on human beings, catastrophes and crises management have always been given vital importance. Disaster management is planning, arrangement, and deployment of resources with a precise aim of reducing disaster's damaging effects. Socio-economic conditions of the affected area and existence of an effective information system regarding the occurrence of emergency are the significant factors that influence this management. Timely information plays a vital role in reducing disaster impact up to a certain level. Efficiency in the deployment of resources is one of the significant concerns in disaster management as it can minimize the disastrous aftereffects.

Disaster management has four phases, namely, mitigation, preparedness, response, and recovery. Fig. 1 briefly describes the disaster management phases.

Fig. 1. The Disaster Management Cycle [19].

C. Technological Advancements and Disaster Ontologies

When disasters occur, government agencies, non-government organizations, and volunteers come forward for immediate rescue operations. First and foremost, the rescuers need to know about nature and disaster intensity, and the resulting damages and causalities. Secondly, the timeliness of information is critical. Disaster relief or control process executes three primary tasks, specifically data acquisition and interpretation, data communication, and data synthesis. Authoritative information and communication technology can offer notably to all the fundamental functions and expedite collaboration among workers and organizations. The evolution of ICT solutions has supported experts and researchers to devise such routines that operate more reasonably while incorporating all the necessary measures to alleviate and control the emergency. The research is improving present-day systems and is continuously making efforts to develop a perfect solution for disaster management.

The computer system deals with only those operations which run fluently without facing any hurdle. Disaster preparedness in computer science is a word depending wholly on a computer system, the central aim of which is data recovery. There is no much scientific contribution in improving the tools at hand and reshaping the ideas in this field. It must be the humanitarian duty of the scientists to study the problems related to the areas and affectees and provide prior research before callous mayhem. The research community has proposed many solutions, including semantic-based ontological solutions to address various needs of disaster management. Following are some worth noting semantic web-based contributions:

Kontopoulos et al. [14] represent an ontology for climate crises management. The proposed solution is claiming to cover all relevant aspects of the domain to facilitate a decision support system for crises management. The authors pointed out the overwhelming flow of varied information as the most critical challenge for decision making authorities and proposed a semantic ontological solution. The following set of three figures helps to understand the complete model of the proposed ontology. Fig. 2 elaborates natural disasters, Fig. 3 depicts analyzed data, whereas the Fig. 4 semantically represents the response unit assignments.

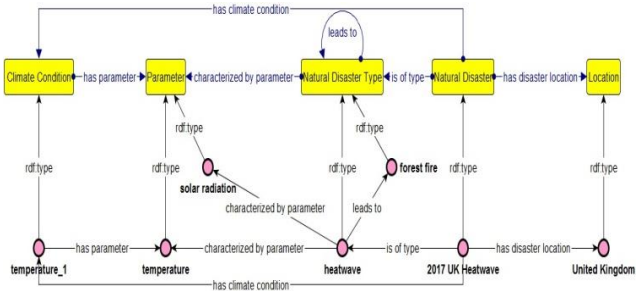


Fig. 2. Representation of Climate-Related Natural Disasters in the Proposed Ontology.

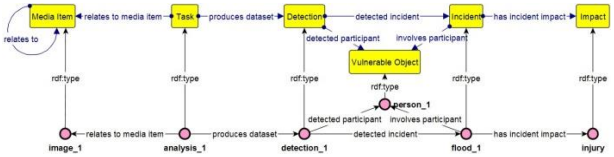


Fig. 3. Representation of Analyzed Data in the Proposed Ontology.

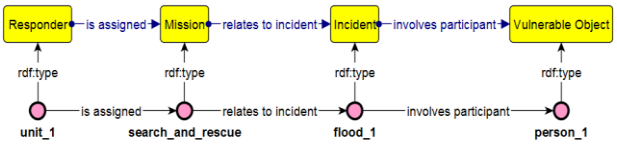


Fig. 4. Representation of Mission Assignments to First Responder units in the Proposed Ontology.

Notable Research Gaps: This research provides a knowledge base to help give authorities in decision support for emergency management. Although research challenges to include all the pertinent aspects of the domain, yet the focus of the study is on the response phase of disaster management. Thus, it has limitations to fulfill the requirements of the recovery phase like the orphan care, relief camps' services, facilities, and so on.

The study by Isbandono et al. [20] concentrates the capacity building of society through research, education, and training for handling disastrous situations. The study aims at disaster awareness in people by training in a planned and controlled manner along with handling media for information spreading regarding the emergency. The interest of the community to participate in disaster management activities can improve institutes' efficiency.

Notable Research Gaps: The research does not produce any concrete solution in the form of software or analytical methodology, instead, propose a program for developing awareness in society about crises to strengthen and provide support to the catastrophe management institutions by the participation of the community.

Bouyerbou et al. [21] proposed a geographic ontology to process satellite images after the disastrous event. Damages maps are prepared with the help of pre and post-disaster images by the photo-interpreter team, which is a complex and time-demanding task. The use of automatic or semi-automatic tools can make this activity easy and efficient. Automated processing has semantic limitations. This research proposed an ontological solution to reduce the semantic gap to help improve automatic processing and is evaluated with processing the Haiti 2010 satellite images. It consists of three sub-ontologies, namely surface, disaster, and damage. The surface sub-ontology illustrates geographical concepts. The concepts of disaster sub-ontology and damage sub-ontology are divided into two groups each—the former has Manmade and Natural, whereas the latter has Land Cover Damage and Material Damage groups. "The ontology aims to describe the content of satellite images, but a large number of concepts may cause complexity for an automatic process."

Notable Research Gaps: The ontology is aimed at the semantic annotation of satellite images but lacks in comprehensive domain representation, change detection, and detection of operational roads and the location of the highest priority areas like hospitals, residential buildings, and schools in the impacted areas.

Ahmad et al. [22] highlighted data problems of a disaster information management in setup and planning for emergency response and recovery stages and suggested improvements. They pointed out some challenges regarding data transmission that include data fragmentation, data transfer capacity of the correspondence channel, heterogeneity of the information structures. They described a data framework for system administration, apparatus arrangement, and resource reservation.

Peterson et al. [23] conducted a case study by engaging a team of 20 digital volunteers to capture medical-related information shared on social media after an earthquake disaster in Nepal. This study discusses potential strategies for future research joint ventures between the research and practitioner communities to utilize social media content. The research claims that near-real-time mission-specific actionable information can be generated during disasters and then used in decision-making.

Notable Research Gaps: The proposed system has some significant gaps. The data shared on social media has a lot of replication, and there should exist some mechanism to avoid duplications. The entire data floating on the public data stream is not factual; fake news or unauthentic information is also widespread, which need identification. Data shared in different forms, including text and multimedia. Only relevant data in an appropriate data type must be collected and analyzed. The data collection mechanism should be smart enough to accept only relevant data. Usage of abbreviation instead of complete words is widespread in messages on social media and needs to address correctly. Information shared in multiple languages, including native languages, require translation. Ignoring sharing in the local language may cause missing of essential data. The commonly used descriptive terms and area names need to be identified.

Zhou et al. [24] elaborated the model and faces of emergency decision making. In an emergency, decisions have to be taken in many areas of activity and at different levels; this increases complexity in forming a decision-makers group. Also, the natural difference in human perception, cognitive level, interest, and limited information can raise conflicts. Situation evaluation relies on experience and knowledge, which is not always enough in unexpected events. Also, the use of mathematical models and knowledge management tools

in emergency decision making have their limitations. The study proposed a model for seismic infrastructure hazard by using Bayesian networks but lacks in the verification of the usefulness of the model in risk reduction.

In 2018, Inan et al. [25] proposed a decision support system for disaster management. The DSS mechanisms adopt an either bottom-up or top-down approach for decision making depending upon the knowledge trigger. Knowledge triggering factors maybe internal, i.e., the initiatives of disaster management authorities or may be external, i.e., the environmental changes. The study aims at specific disaster plans related to the volcanic eruption. A case study of Mt. Agung volcano eruption demonstrates the efficacy of proposed mechanisms. "The adopted knowledge analysis framework (KAF) allows the authorities to deal with uncertainties in the DM domain by understanding, analyzing, and finally structuring them into a format acceptable by the familiar stakeholders."

Notable Research Gaps: The authors feel that the system requires performance and efficacy evaluation in a real-time operational environment. They are also of the view that the DM agencies are lacking in fully documented DM plans. Although the research discusses the general scenario of disaster management domain yet, it focuses on addressing the disastrous situations caused by the volcanic eruption.

An effective early warning system for emergencies is a service to humanity because the intended population can take precautionary safety measures if they are aware of the crisis well in time. Moreira et al. [26] proposed an ontology-based EWS for alerting of distress. The study aims to develop an epidemiological surveillance EWS for the detection of infectious disease outbreaks in an area. Model-driven engineering framework of the system relies on the Situation Modeling Language (SML). The authors claim that their model is also suitable for the detection of floods, landslides, and wildfire.

Notable Research Gaps: The study proposed an ontology-based EWS for generating alerts to make the population aware of the imminent disaster. The focus of research is to detect infectious deceases outbreaks well in time although the authors are confident of their model to be suitable for detection of other catastrophes. The proposed model is not designed to work with post-disaster situations.

Anbarasi [27] proposed an ontology-based solution to crises management using data mining approaches. The study aims at developing a decision support system to address the information requirements of the disaster response. The software uses ontology concepts in the data mining framework. The authors named the ontology as a Humanitarian Assistance Ontology (HAO). Disaster-related data shared on social media can be collected for processing. Data integration and usage in the decision-making process in an emergency become difficult because of the data obtained from social media has structural and semantic heterogeneity. Fig. 5 illustrates the structure of HAO-system, whereas Fig. 6 portrays the architecture of this system.

Fig. 5. Structure of HAO-System [27].

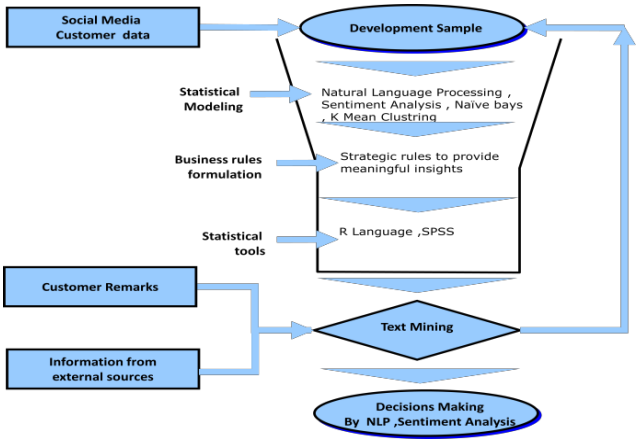


Fig. 6. Architecture of HAO-System [27].

Notable Research Gaps: The data acquisition from social media has some dilemmas and challenges which has been briefly discussed above in research gaps of [23]. The limitations of this research are quite similar to that.

Zhong et al. [28] presented a geo-ontology in 2016 as an emergency management solution for meteorological disasters. The factors of a meteorological disaster are typically time and space bound. Thus, the semantic relationships between concepts of the disaster domain are geographic location-specific. Due to the geographic characteristics, the proposed solution to the meteorological disaster system is a Geo-Ontology. The primary objective of the ontology is to address the information needs of the preparedness and the response phases of meteorological disasters.

A geo-ontology based semantic conceptual model for earthquake emergency response knowledge was proposed by Xu et al. [29]. Geo-ontology can represent the geospatial aspects of the knowledge and satisfy the semantic needs of information interchange in the modeling process. "The model aims to solve knowledge problems to improve earthquake

disaster response." The architecture classifies knowledge into four categories, namely factual knowledge, rule knowledge, procedural knowledge, and meta-knowledge. "The study presents a geo-ontology; and geo-ontology-based knowledge modeling primitives contain the spatial and earthly characteristics needed to adequately represent 'earthquakes on the ground,' rather than earthquakes in general."

Notable Research Gaps: The research focused on addressing response phase of disaster management and proposed a knowledge architecture only for earthquake disaster response.

Disaster management requires solutions for acquiring, analyzing, disseminating, and integrating data for which the information and communication technologies can play a viable role. Among several disaster management systems, Sahana has been exercised in numerous crises globally and recognized as the most mature DMS. Strenuous work of manual data entry is one of the vital issues of disaster management systems to date, which is quite a time consuming and tough, especially in case of crises. Immediate availability of essential information is always critical in crises management, which encourages to process the real-time data. Secondly, the existing DMS systems are semantically deficient, which is another significant problem to address.

A semantic web-based disaster management system is the solution to the issues highlighted, which is the best strategy to acquire, investigate, and share essential data where required. The semantic web uses ontologies as a fundamental constituent. Above discussions notified numerous ontologies, though all have limitations and expect structural reforms. Most of the research conducted so far aims at specific perspectives of the catastrophe administration domain.

III. The Proposed Disaster Trail Management Ontology

There exist multiple ways to accomplish ontology development. In other words, there exists no exact and definite way or methodology for developing the ontologies. In the development of disaster trail management ontology, this research followed the methodology proposed by Noy & McGuinness [1] in addition to taking guidance from the Protégé practical guide by Horridge et al. [30]. They proposed an iterative approach to ontology development by starting with a rough first pass at the ontology, revise and refine the evolving ontology and fill in the specifications. The research also uses a naming convention in ontology development to maintain uniformity and consistency of the ontology structure. The concept names start with a capital letter followed by lowercase letters, whereas the relationships and data properties begin with a lowercase letter. Relationship names are mostly of the form '`hasRelationship`' and inverse relationship is of the type '`isRelationshipOf`'. Following steps have taken into consideration during the ontology development.

A. The Domain and Scope of the Ontology

Competency questions and their answers can be used as a tool to better understand the domain and scope of an ontology [31]. These questions are used as a litmus test for ontology because they determine whether the ontology contains enough information to answer this type of queries or not. This test also prompts whether the answers require a specific level of detail or representation of a particular area or not. The disaster trail management ontology should answer these competency questions. The list of prepared questions has been divided into three groups according to their nature, including Disaster-related questions, Effects and Losses related questions, and Services and Facilities related questions. Although the competency questions are just a sketch and not the exhaustive list of inquiries, yet it includes the most appropriate questions which are enough to judge the domain and scope of the disaster trail management ontology. Following is a sample of a few questions from the list of competency questions.

- What is the magnitude and depth of the earthquake disaster?
- A secondary disaster is caused by which disaster?
- Floods are generated by bursting or seiche of which dam/water reservoir?
- How much area was damaged due to forest fire?
- How much is crops area affected by the disaster?
- What are relief items provided in the disaster area?
- What facilities are available in a refugee camp?

B. Reusing Existing Ontologies

It is admirable to see what others have achieved over time and to look forward to improving and enhancing the accomplishments for the specific domain. Reusing of existing ontologies may be essential in situations where the proposed ontology has to interact with other applications that have already been entangled with the controlled vocabularies [1]. This research has explored various ontology libraries but could not find any existing disaster ontology that answers the complete list of prepared competency questions. So, it was assumed that no relevant ontologies existed and started to develop the ontology from scratch.

C. Enumeration of Important Terms in the Ontology

It is a convenient approach to list down the comprehensive list of relevant terms of the concept, which are either required for making statements or need to clarify to a user. As the terms are the building blocks of an ontology, so, it is essential to be specific and clear about the principal terms and their related properties. This step addresses the basic concepts of the ontology.

For example, important earthquake disaster-related terms include, Earthquake, Disaster, name (disaster name), date (when the disaster occurred), magnitude, depth, Epicenter, Location (affected by the disaster), Activity (demanded), Damage, CalamityArea, Concomitant. There exist different relationships among these terms, including hasConsequence, hasEpicenter, hasAffect, hasDemand, and hasDamage. An earthquake may cause other disasters, secondary/concomitant disasters. For concomitant disaster-related terms may include the terms like Avalanche, Faulting, Fire, Flood, Landslide, RadioactivityFromNuclearPlant, Rockslide, SoilLiquefaction, spillOfChemicals, Tsunami, VolcanicEruption,

areaTemperature, WaterReservoir and some relationships including isCausedByBurstOf, isCausedBySeicheOf, and isConsequenceOf, etc. (This is not an exhaustive list of defined terms).

D. The Classes and the Class Hierarchy

As far as the strategy of defining classes and class hierarchy is concerned, there are three types of approaches, namely top-down, bottom-up, and mixed designing approach. All three ontology design approaches are equally good. A developer can select any of these approaches depending on his/her personal view of the domain. According to Rosch [32], the combination design approach is the most convenient and practical approach for ontology development because the concepts "in the middle" tend to be more clear concepts in the domain.

Regardless of the adopted design approach, the development usually starts by defining classes. From the list of terms created in the "enumeration of important terms in the ontology" step, it is more convenient to start with selecting the terms describing the objects with independent existence. These terms become classes in ontology. After analyzing the disaster domain and having a critical view from the domain experts, the domain is conceptualized in the following way.

"Every OWL class is a subclass of Thing" (w3.org). Under the Thing class, the very first level of classes is considered as the top-level concepts in this documentation, such as Activity, CampFacility, Damage, Disaster, Location, Person, Miscellaneous, Organization, RefugeeCamp, ReliefItem, and Service are shown in Fig. 7.

Next level in the class hierarchical taxonomy is to define subclasses. For example, the concept of Activity is further divided into subclasses of StrategicPlanning and Vaccination. Among them, the concept, StrategicPlanning has specialized concepts of ResponseTeam, Rehabilitation, TaskReview, ScopeOfAction, and Evacuation. The hierarchical class taxonomy of Activity class is illustrated in Fig. 8.

The top-level concept of Damage is fractionated into sub-concepts of Agriculture, Building, Crop, Forest, Infrastructure, and Livestock as illustrated in Fig. 9. Next level of subclasses is defined for Infrastructure which contains further specialized concepts of Airport, Bridge, CommunicationLine, FireStation, Road, ElectricitySupplyLine, FuelStation, GasSupplyLine, Seaport, MobileCommunicationTower, ParkOrPlayGround, RailwayTrack, SewagePipeLine, WaterReservoir, and WaterSupplyLine. Although this research did not capture all type of damages, it is tried to cover all those damages that are likely to occur.

E. The Properties of Classes–Slots

The properties of classes or the slots are defined to describe the internal structure of concepts as the defined terms of classes alone, do not contain enough information to answer the competency questions.

Some of the terms from the prepared enumerated list of important terms in the ontology are the concepts, called, classes and rest of the terms are the properties of the classes (slots) and facets to the slots. The remaining list of terms (except classes) is including the terms: `address`, adminName, age, animalHeads, animalType, area, areaTemperature, building, buildingType, byBurstHasCaused, bySeicheHasCaused, campNo, capacity, causeOfDeath, city, cnic, count, country, crop, damagedArea, damageEndPoint, damageStartPoint, damageType, date, dateOfDeath, deceased, depth, description, district, email, evacuated, fax, gender, handoverDate, hasAdopt, hasAffect, hasAreaUnit, hasBaseLocation, hasCalamityArea, hasCapacityUnit, hasCategory, hasConsequence, hasCurrency, hasDamage, hasDemand, hasEpicenter, hasExecute, hasFacility, hasGrant, hasLengthUnit, hasLocation, hasItem, heirs, injured, injury, isAdoptedBy, isAffectOf, isBaseLocationOf, isCalamityAreaOf, isCausedByBurstOf, isCausedBySeicheOf, isConsequenceOf, isDamageOf, isDemandOf, isEpicenterOf, isExecutionOf, isFacilityOf, isGrantOf, isLocationOf, item, itemType, lastClothing, lastSeenDate, lastSeenLocation, latitude, length, longitude, magnitude, missing, monetaryValue, name, noOfBeds, noOfBuildings, noOfRefugees, noOfStories, orgType, phone, quantity, regNo, reportedOn, state, supplyDate, tehsil, website, width, and zipCode.

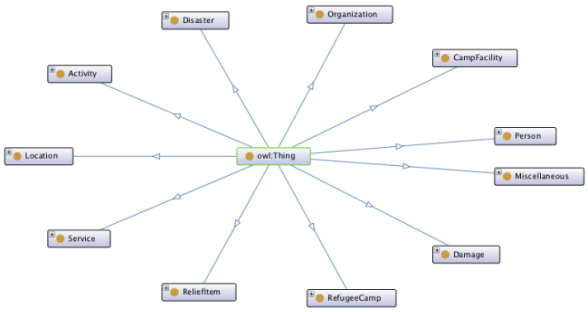


Fig. 7. Top-Level Concepts of DTM Ontology.

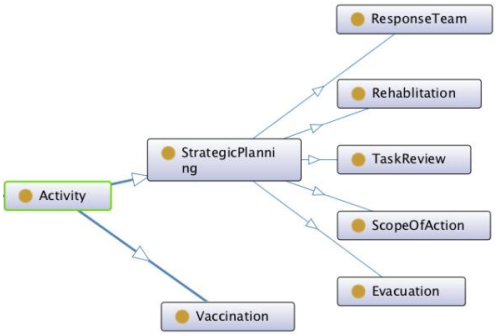


Fig. 8. Class Hierarchy of Activity Class.

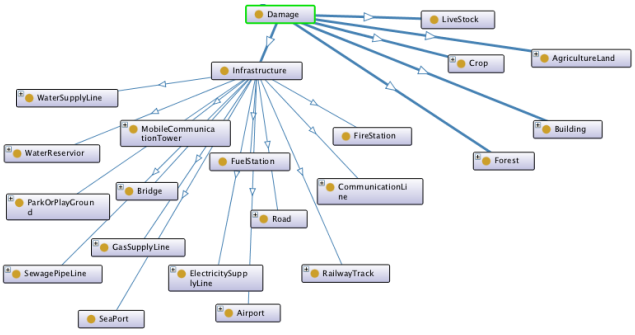


Fig. 9. Class Hierarchy of Damage Class.

Now from the prepared list of properties of classes, it is required to determine which property is described for or related to which class. The properties of classes become slots attached to the classes.

For example, from the list of terms including Disaster, name, date, Location, Activity, CalamityArea, Damage, hasAffect, hasConsequence, hasDamage, and hasDemand, the terms hasAffect, hasConsequence, hasDamage, and hasDemand are the object properties because they associate the concept Disaster with some other concept. Whereas, the terms name and date are taken to be the data properties because they correlate the concept Disaster with some datatype value like string and dateTime, etc.

The properties defined in the above paragraph are assumed to be the essential part of every disaster; hence, are set at the root level. The focus of this study is on disaster trail management of earthquake, but an earthquake can cause other disasters as well. Thus, the concept Disaster has component classes of Earthquake and Concomitant (the concept to capture the knowledge of concomitant concepts of the earthquake).

In the class hierarchy, the properties of the parent class are inherited by its subclasses. Hence, the subsumed classes of Disaster, that is, Earthquake and Concomitant, inherit the properties from their subsuming class Disaster and also have additional properties defined at their level. For example, the Earthquake class adds the properties like hasConsequence (that associates Earthquake with its Concomitant disasters), hasEpicenter, depth, and magnitude, whereas, the concept Concomitant has the additional property isConsequenceOf, which is the inverse relationship of hasConsequence and correlates the concomitant disaster to its causing earthquake.

Concomitant is a generalized concept which is further fractionated into specialized concepts of disasters caused by the earthquake, like Avalanche, Faulting, Fire, Flood, Landslide, RadioactivityFromNuclearPlant, Rockslide, SoilLiquefaction, SpillOfChemical, Tsunami, and Volcanic Eruption. These inherited concepts share the properties defined in their parent concept Concomitant and grandparent concept Disaster along with their specific properties added at their level. For example, the concepts Avalanche, Faulting, Landslide, RadioactivityFrom NuclearPlant, Rockslide, SoilLiquefaction, SpillOfChemical, and VolcanicEruption also require the hasEpicenter property. Fire adds the properties of areaTemperature (data property), hasDamage (associate the Fire concept with Forest) and hasEpicenter. Along the same lines, the concept Flood needs additional properties of isCausedByBurstOf and isCausedBySeicheOf to associate this concept with another concept WaterReservoir. A volcanic eruption may also cause Tsunami; that's why the concept Tsunami requires an additional property hasConsequence to correlate this concept with its causing concept VolcanicEruption.

F. The Facets of the Slots

Facets are the restrictions on slots. A property restriction describes an anonymous class. All individuals that satisfy the restriction become a member of the anonymous class. A facet may represent the value type, value domain, cardinality, and other such feature related to a slot value. A slot may have different facets.

For example, the value of the slot name (as in "the name of a disaster") is a string, with a single value. That is, the name is a slot with value type string. A slot hasAffect (as in "a disaster has affected these locations") can have multiple values, which are instances of the class Location. That is, hasAffect is a slot with value type Instance with Location as an allowed class.

The value types used in the ontology are the integer, decimal, unsignedLong (for huge, whole numbers), string and dateTime. "Instance-type slots allow the definition of relationships between individuals. Slots with value type Instance must also define a list of allowed classes from which the instances can come [1]".

Let's start explaining the facets with the most prominent concept Disaster in the ontology. This concept is created with some other restrictions (anonymous classes), i.e., date exactly 1 dateTime, hasAffect some Location, hasConsequence some CalamityArea, hasDamage some Damage, hasDemand some Activity, name exactly 1 string, etc.

The restricted property hasAffect, is an object property whose domain is Disaster, the restriction type is some (existential) and the restriction filler is Location (the range of hasAffect). In other words, the restriction hasAffect some Location is an existential restriction (as denoted by the keyword, some), that works along with the hasAffect property, and has a filler Location. This restriction demonstrates the class of individuals that have at least one hasAffect relationship to an individual of the class Location. The restriction is a class which holds the individuals that satisfy the restriction. The restriction hasAffect is also depicted in Fig. 10, along with the other restrictions related to Disaster.

G. The Hierarchical Taxonomy of Disaster

Fig. 11 illustrates all the restrictions on the Disaster concept, which is the domain of all these restrictions. It is shown in the depiction that all object properties are existential whereas the datatype restrictions are exactly 1. The restrictions hasConsequence, hasDamage and hasDemand have the concepts CalamityArea, Damage, and Activity as their respective ranges.

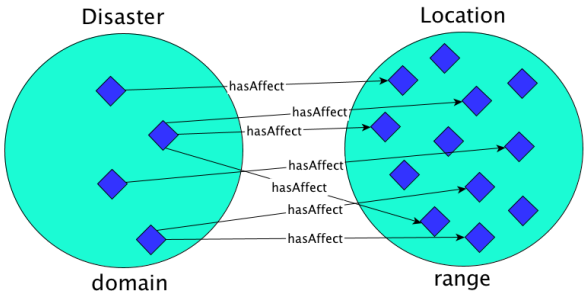


Fig. 10. HasAffect Object Property with Disaster as its Domain and Location as its Range (hasAffect Some Location).

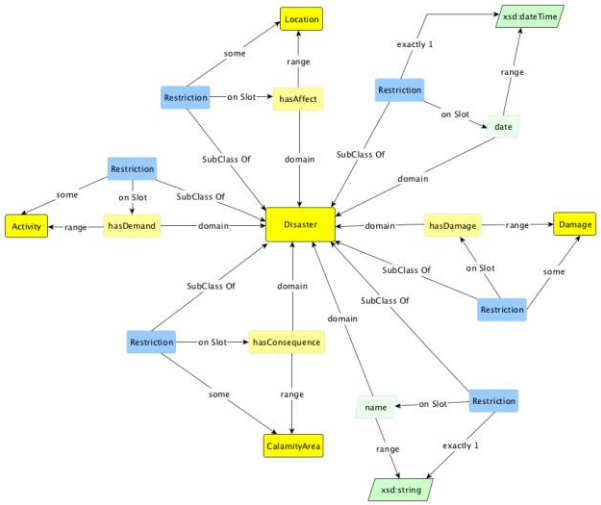


Fig. 11. The Concept Disaster with its Slots and Facets of the Slots.

The mathematical representation of the concept Disaster with its slots and facets is defined in Description Logic (DL) as follows.

Disaster ⊆ ∃**hasAffect**.Location ∩ ∃**hasConsequence**.CalamityArea ∩ ∃**hasDamage**.Damage ∩ ∃**hasDemand**.Activity ∩ |∃**date**.dateTime|=1 ∩ |∃**name**.string|=1

The concept Disaster has two inherited concepts Earthquake and Concomitant. The following figure depicts the slots and facets of slots of subsumed concept Earthquake. The concept Earthquake, has two additional object properties, namely hasConsequence and hasEpicenter (along with the inherited properties from subsuming concept Disaster), as illustrated in the following figure. The slot, hasConsequence some Concomitant, as shown in the representation, has restriction type existential (some) and the slot is linked with the concept Earthquake as the domain of the slot and the concept Concomitant as the range. Another slot, hasEpicenter exactly 1 Epicenter, has exact cardinality equal to 1 and attached to the concept Epicenter as the range of the slot. Earthquake is defined with two additional datatype properties, namely depth, and magnitude. Both the slots have existential facets and are linked to decimal datatype as their range.

The mathematical representation in DL, of the concept Earthquake, as portrayed in Fig. 12, can be defined as follows.

Earthquake ⊆ Disaster ∩ **∃hasConsequence.Concomitant** ∩ |**∃hasEpicenter.Epicenter**|=1 ∩ **∃depth.decimal** ∩ **∃magnitude.decimal**

Another inherited concept of Disaster, the Concomitant, with all its additional slots and inherited concepts are described in Fig. 13. For simplicity of the representation, the subsumed concepts of Concomitant shown in the blue-bordered rectangle are not shown with their slots and is portrayed in Fig. 14. Concomitant has one additional existential object property is consequence of some Earthquake which is an inverse object property of the concept Earthquake (has consequence some Concomitant, presented in Fig. 12).

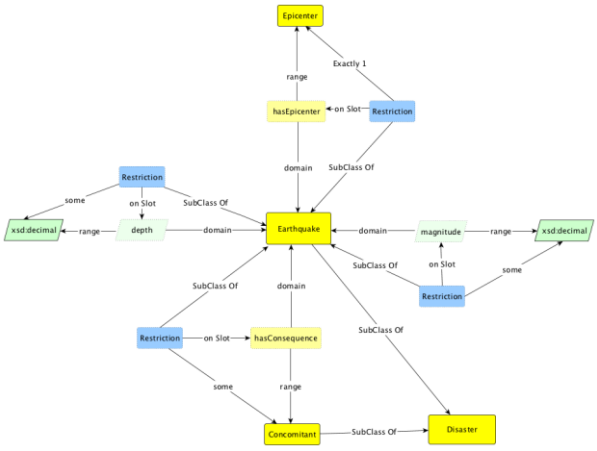


Fig. 12. The Concept Earthquake with its Slots and Facets of the Slots.

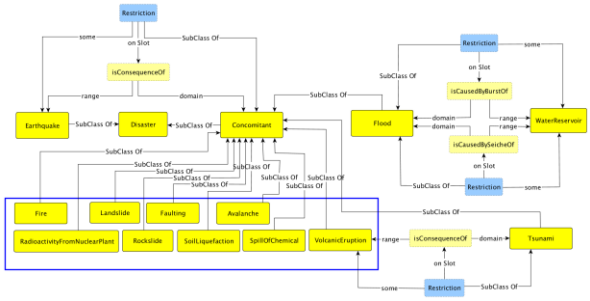


Fig. 13. The Concept Concomitant with its Slots and Facets of the Slots.

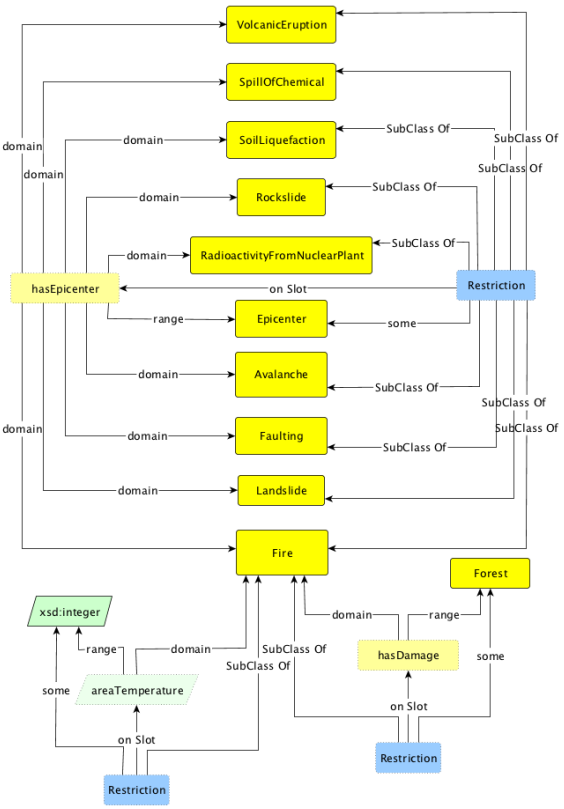


Fig. 14. The Subpart of the Concept Concomitant with its Slots and Facets of the Slots

The inherited concept Flood of Concomitant has two additional existential object properties; isCausedByBurstOf some WaterReservoir and isCausedBySeicheOf some WaterReservoir as presented by the following figure. Two subclasses of Concomitant, Tsunami, and VolcanicEruption are linked to each other via an existential slot isConsequenceOf having Tsunami as the domain and VolcanicEruption as the range.

Avalanche, Faulting, Fire, SoilLiquefaction, Landslide, Rockslide, RadioactivityFromNuclearPlant, SpillOfChemical, and VolcanicEruption are the inherited concepts of Concomitant, all having an addition slot hasEpicenter some Epicenter which is an object property of existential restriction type and is illustrated by the Fig. 14. The concept Fire has another addition existential object property hasDamage some Forest and a datatype property areaTemperature some integer which also has an existential facet.

Mathematical representations in DL, of all the concepts presented in the above Fig. 13 and 14 are as follows.

$$\text{Concomitant} \subseteq \text{Disaster} \cap \exists \textbf{isConsequenceOf}.\text{Earthquake}$$

$$\text{Avalanche} \subseteq \text{Concomitant} \cap \exists \textbf{hasEpicenter}.\text{Epicenter}$$

$$\text{Faulting} \subseteq \text{Concomitant} \cap \exists \textbf{hasEpicenter}.\text{Epicenter}$$

$$\text{Fire} \subseteq \text{Concomitant} \cap \exists \textbf{hasEpicenter}.\text{Epicenter} \cap \exists \textbf{areaTemperature}.\text{integer} \cap \exists \textbf{hasDamage}.\text{Forest}$$

$$\text{Flood} \subseteq \text{Concomitant} \cap \exists \textbf{isCausedByBurstOf}.\text{WaterReservoir} \cap \exists \textbf{isCausedBySeicheOf}.\text{WaterReservoir}$$

$$\text{Landslide} \subseteq \text{Concomitant} \cap \exists \textbf{hasEpicenter}.\text{Epicenter}$$

$$\text{RadioactivityFromNuclearPlant} \subseteq \text{Concomitant} \cap \exists \textbf{hasEpicenter}.\text{Epicenter}$$

$$\text{Rockslide} \subseteq \text{Concomitant} \cap \exists \textbf{hasEpicenter}.\text{Epicenter}$$

$$\text{SoilLiquefaction} \subseteq \text{Concomitant} \cap \exists \textbf{hasEpicenter}.\text{Epicenter}$$

$$\text{SpillOfChemical} \subseteq \text{Concomitant} \cap \exists \textbf{hasEpicenter}.\text{Epicenter}$$

$$\text{Tsunami} \subseteq \text{Concomitant} \cap \exists \textbf{isConsequenceOf}.\text{VolcanicEruption}$$

$$\text{VolcanicEruption} \subseteq \text{Concomitant} \cap \exists \textbf{hasEpicenter}.\text{Epicenter}$$

IV. Ontology Evaluation

Pinto & Martins [33] expressed ontology evaluation as a technical process of judging the quality of the ontology. Various ontology evaluation techniques are found in past research work. The ontology evaluation of this research follows the guidelines and criteria recommended by Gomez et al. [2] and Kreider [3]. Ontology evaluation is essential to promise the overall quality of the developed ontology. It not only assesses the technical aspect of the ontology but also encourages the domain experts' involvement for their worthy judgment. The efficacy of ontological knowledge depends on the quality of the ontology, and evaluation is a way to gauge the level of quality of the ontology.

This section presents some ontology evaluation techniques accompanied by significant ontology evaluation results. The results produced by the process of assessment delineates the correctness and usefulness of the ontology. The term "Evaluation" subsumes the terms "Validation" and "Verification". The validation process is completed by involving domain experts, whereas, for the verification process, the use of a software technique is brought into work. As a first step and to measure the domain and scope of ontology, some appropriate competency questions (CQs) are fabricated, which are then evaluated by the domain experts. The relevance and completeness of these CQs validate the ontology. Verification process gauges the correctness and usefulness of the ontology, which is done by developing queries in SPARQL to provide solutions to the CQs.

According to Fernández et al. [34], verification speaks about the activity that assures the correctness of an ontology. Vrandečić [35] refers to verification as an evaluation task for assessing that the ontology has been built correctly. This task can be performed during each phase of ontology development or between phases of the development life cycle. This technical process of verification guarantees the usefulness and accuracy of an ontology according to the accepted understanding of the domain of specialized knowledge sources. The verification process can be performed by technically generating answers to the CQs using some appropriate query language. This research is using SPARQL query language.

The methodology of ontology evaluation by generating answers to CQs using a query language is adopted by many researchers.

This section furnishes the results produced from the execution of CQs codified in SPARQL, a query language. CQs are among the foremost applied and familiar context for ontology assessment. This competency appraisal is performed to examine the preciseness of the ontology using query language in the ontology development tools, for example, DL queries or SPARQL queries. SPARQL query is the commonly used plugin within Protégé. The SPARQL Query is used as a tool to gauge the adequacy of the ontology. In the frame of reference for this research, SPARQL queries will be developed for the execution of CQs. CQs are composed at the ontology specification stage to define the scope of the ontology. The concluded set of CQs are then codified in the query language before the execution on SPARQL Query.

"SPARQL allows for a query that consists of triple patterns, conjunctions, disjunctions, and optional patterns. SPARQL does not have a native inference mechanism incorporated into the language. SPARQL queries return what is contained in the information model in the form of graph bindings [36]". To get some appropriate results from a SPARQL query, the individuals can be added to the ontology with some actual or sample data. These queries will help evaluate the ontology and may also help to improve the architecture of the ontology. The CQs are listed in section III (A). The representation is in three folds starting with natural language query (question) followed by the SPARQL query and finally the result produced by the execution of SPARQL query.

Following PREFIXs are used in all SPARQL queries

```
PREFIX rdf:
<http://www.w3.org/1999/02/22-rdf-syntax-
ns#>

PREFIX owl:
<http://www.w3.org/2002/07/owl#>

PREFIX rdfs:
<http://www.w3.org/2000/01/rdf-schema#>

PREFIX xsd:
<http://www.w3.org/2001/XMLSchema#>

PREFIX dtm:
<file://ashfaqahmad/DTM.owl#>
```

CQs:

3. When and where the earthquake disaster occurred?
4. What is the magnitude and depth of the earthquake disaster?
5. What are the latitude and longitude of the earthquake Epicenter?

SPARQL Query:

```
  SELECT ?Disaster_Name ?Date
?Magnitude ?Depth ?Epicenter_Name
?Latitude ?Longitude

  WHERE {?disaster rdf:type ?class

      FILTER REGEX (STR(?class),
"Earthquake")

      OPTIONAL {?disaster dtm:name
?Disaster_Name}

      OPTIONAL {?disaster dtm:date
?Date}

      OPTIONAL {?disaster
dtm:magnitude ?Magnitude}

      OPTIONAL {?disaster dtm:depth
?Depth}

      ?disaster dtm:hasEpicenter
?Epicenter

      OPTIONAL {?Epicenter dtm:name
?Epicenter_Name}

      OPTIONAL {?Epicenter
dtm:latitude ?Latitude}

      OPTIONAL {?Epicenter
dtm:longitude ?Longitud}

   }

   ORDER BY ?Disaster_Name
```

Execution of the above SPARQL query produces results as shown Fig. 15.

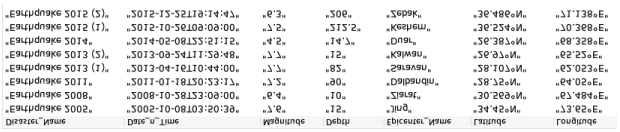


Fig. 15. Results of SPARQL Query for CQs 1-3.

CQ 4: A secondary disaster is caused by which disaster?

SPARQL Query:

```
    SELECT ?PrimaryDisaster
?SecondaryDisaster

    WHERE {?SecondaryDisaster rdf:type
?class

          FILTER REGEX ( STR(?class),
"Disaster")

          ?SecondaryDisaster
dtm:isConsequenceOf ?PrimaryDisaster

    }

    ORDER BY ?PrimaryDisaster
```

CQ 5: Floods are generated by bursting or seiche of which dam/water reservoir?

SPARQL Query:

```
  SELECT ?DisasterName
?WaterReservior
  WHERE {?disaster rdf:type ?class
      FILTER REGEX (STR(?class),
"Flood")
      OPTIONAL {?disaster dtm:name
?DisasterName}
        OPTIONAL {?disaster
      dtm:isCausedBySeicheOf
      ?WaterReservior}
        OPTIONAL {?disaster
      dtm:isCausedByBurstOf
      ?WaterReservior}
  }

ORDER BY ?DisasterName
```

CQs:

6. What is the total area of the forest, under fire?
7. How much area was damaged due to forest fire?
8. What was the area temperature (degree Celsius) during the fire?

SPARQL Query:

```
SELECT ?DisasterName ?ForestName
?DamagedArea ?TotalForestArea
?AreaUnit
?AreaTemperatureDuringFire_DegreeC
?EpicenterName

WHERE {

    ?Disaster rdf:type ?class

    FILTER REGEX (STR(?class),
"Fire")

    OPTIONAL {?Disaster dtm:name
?DisasterName}

    OPTIONAL {?Disaster
dtm:hasDamage ?Forest}

    OPTIONAL {?Forest dtm:name
?ForestName}

    OPTIONAL {?Forest dtm:area
?TotalForestArea}

    OPTIONAL {?Forest
dtm:damagedArea ?DamagedArea}

    OPTIONAL {?Forest
dtm:hasAreaUnit ?AreaUnit}

    OPTIONAL {?Disaster
dtm:areaTemperature
?AreaTemperatureDuringFire_DegreeC}

    OPTIONAL {?Disaster
dtm:hasEpicenter ?Epicenter}

    ?Epicenter dtm:name
?EpicenterName

}
```

CQ 9: How much crops area is affected by the disaster?

SPARQL Query:

```
SELECT ?DisasterName (SUM(?da) AS
?TotalDamagedArea) ?AreaUnit

WHERE {

    ?c rdf:type ?class

    FILTER REGEX (STR(?class),
"Crop")

    OPTIONAL {?c dtm:isDamageOf
?x}

    OPTIONAL {?x dtm:name
?DisasterName}

    OPTIONAL {?c dtm:damagedArea
?da}

    OPTIONAL {?c dtm:hasAreaUnit
?AreaUnit}

}

GROUP BY ?DisasterName ?AreaUnit
```

CQ 10: What relief items are provided in the disaster area?

SPARQL Query:

```
SELECT DISTINCT ?DisasterName
?ItemName ?ItemCategory

WHERE {

    ?ri rdf:type ?class

    FILTER REGEX (STR(?class),
"ReliefItemProvided")

    ?ri dtm:isDemandOf ?d

    OPTIONAL {?d dtm:name
?DisasterName}

    OPTIONAL {?ri dtm:hasItem
?ItemName}

    OPTIONAL {?ItemName
dtm:hasCategory ?ItemCategory}

}

ORDER BY ?DisasterName ?ItemName
```

CQ 11: What facilities are available in a refugee camp?

SPARQL Query:

```
SELECT ?Disaster ?RefugeeCamp
?Location ?Organization
?NumberOfRefugees ?Facility ?Count

WHERE {

    ?x rdf:type ?c

    FILTER REGEX (STR(?c),
"RefugeeCamp")

    OPTIONAL {?x dtm:isDemandOf
?d}

    OPTIONAL {?d dtm:name
?Disaster}

    OPTIONAL {?x dtm:isGrantOf
?org}

    OPTIONAL {?org dtm:name
?Organization}

    OPTIONAL {?x dtm:hasLocation
?loc}

    OPTIONAL {?x dtm:name
?RefugeeCamp}

    OPTIONAL {?loc dtm:district
?Location}

    OPTIONAL {?x dtm:noOfRefugees
?NumberOfRefugees}

    OPTIONAL {?x dtm:hasFacility
?f}

    OPTIONAL {?f dtm:hasFacility
?Facility}
```

```
      OPTIONAL      {?f      dtm:count
?Count}
   }
   ORDER   BY   ?Disaster   ?Location
?Facility
```

V. Conclusion and Future Work

On the first hand, the ontology designing is an innovative development. Thus, different ontology developers would undoubtedly come up with ontologies designed for different purposes. Secondly, multiple ontologies may serve the object for a domain correctly. This research proposes an ontology for disaster trail management. The study included the relevant concepts very carefully after analyzing the real data from credible sources, disaster-related news, and discussion of the scenario with domain experts. Positive comments by the domain experts on ontology validation assessment and generated results of SPARQL queries executed for relevant CQs showed that the ontology meets the required criteria. The research proposed a distinct and cardinal ontology which encompasses the entire domain of earthquake disaster trail management for Pakistan using appropriate semantic relationships among the ontology concepts. It is hoped that the semantic web research community will contribute further to enhance the ontology to make it fit for all type of disasters including human-made disasters and for accommodating region-specific requirements of other countries in the world.

Whether we talk about ontology development or an architectural model for an application, these are completed through a progressive approach. Thus, no such work can be assumed as ultimate, and there is always room for modification and enhancement. Following are the recommendations by this study as future work to enhance the proposed semantic web-based ontology.

- The proposed ontology can be improved to a multilingual corpus.
- The ontology aims at addressing the disaster trail management in Pakistan, which can be modified or enhanced to fit the region-specific requirements of other countries.
- The ontology design can be improved to accommodate human-made disasters like war.

References

[1] Noy, N. F., & McGuinness, D. L., "Ontology development 101: A guide to creating your first ontology," 2001.

[2] Gómez-Pérez, A., Fernández-Lopez, M., & Corcho, O., "Ontological Engineering: with examples from the areas of knowledge management, ecommerce and the Semantic Web," Book by Springer, 2004.

[3] Kreider, R. G., "An ontology of the uses of building information modeling," 2013.

[4] Shafiq, F., & Ahsan, K., "An ICT based early warning system for flood disasters in Pakistan," Res. J. Recent Sci. ISSN, 2277, 2502, 2014.

[5] Munir, K., & Anjum, M. S., "The use of ontologies for effective knowledge modelling and information retrieval," Applied Computing and Informatics, 14(2), 116-126, 2018.

[6] Kapoor, B., & Sharma, S., "A comparative study ontology building tools for semantic web applications," International Journal of Web & Semantic Technology (IJWesT), 1(3), 1-13, 2010.

[7] Ranpara, R., Yusufzai, A., & Kumbharana, C. K., "A Comparative Study of Ontology Building Tools for Contextual Information Retrieval," In Emerging Trends in Expert Applications and Security (pp. 401-408), Springer, Singapore, 2019.

[8] Noy, N. F., "Semantic integration: a survey of ontology-based approaches," ACM Sigmod Record, 33(4), 65-70, 2004.

[9] Liu, S. Q., Cheng, J. Y., Jiang, Y. J., Li, Y., Li, Q. H., & Pang, T. X., "Bioinformatics Analysis and Verification of Aging-Related Genes of Bone Marrow Mesenchymal Stem Cells in Patients with Acute Myeloid Leukemia. Zhongguo shi yan xue ye xue za zhi," 27(2), 311-317, 2019.

[10] Ouya, S., "Chemical Assessment Framework and Ontology," In Mobile Technologies and Applications for the Internet of Things:, Proceedings of the 12th IMCL Conference (p. 385), Springer, 2019.

[11] Sun, Y., Wang, C., Sun, X., & Guo, M., "Comparative Proteomics of Whey and Milk Fat Globule Membrane Proteins of Guanzhong Goat and Holstein Cow Mature Milk," Journal of food science, 84(2), 244-253, 2019.

[12] Cahyani, D. E., Prabanuadhi, A., Irfan, R. I., & Febrianto, L. A., "Ontology Model for Dietary of Children with Autism Spectrum Disorders," Journal of Telecommunication, Electronic and Computer Engineering (JTEC), 10(2-4), 129-132, 2018.

[13] Afandi, R. R., Radman, A., Bahari, M., Zakaria, L. Q., Mustapha, M., & Ismail, W., "Ontology Development in Patients Information System for Stroke Rehabilitation," In CEUR Workshop Proceedings (Vol. 2137), January 2017.

[14] Kontopoulos, E. Mitzias, P.Moßgraber, J.Hertweck, P.van der Schaaf, H.Hilbring, D.Lombardo, F.Norbiato, D.Ferri, M.Karakostas, A.Vrochidis, S.and Kompatsiaris, I., "Ontology-based Representation of Crisis Management Procedures for Climate Events," 1st Int. Workshop on Intelligent Crisis Management Technologies for climate events (ICMT), 2018.

[15] Xu, H., "Whether the Work Type Debates in Higher-Level Musical Ontology Are Useful Just for Philosophy Itself?," 2018.

[16] Deb, C. K., Karn, S. K., Das, M., & Marwaha, S., "Microbial Taxonomy Ontology for Agriculturally Important Microorganisms (AMO) Coupled with Sequence Alignment Reinforcement Options," Int. J. Curr. Microbiol. App. Sci, 7(4), 3154-3166, 2018.

[17] Gruber, T. R., "A Translation Approach to Portable Ontology Specifications," Knowledge Acquisition 5(2), 199-220, 1993a.

[18] Gruber, T. R., "Toward Principles for the Design of Ontologies Used for Knowledge Sharing," International Journal of human-computer studies, 43(5), 907-928, 1993b.

[19] Ahmad, A., Othman, R., & Fauzan, M., "A Social Semantic Web Based Conceptual Architecture of Disaster Trail Management System," International Journal of Advanced Computer Science and Applications (IJACSA), 8(4), http://dx.doi.org/10.14569/IJACSA.2017.080437, 2017.

[20] Isbandono, P., Prastyawan, A., & Gamaputra, G., "The capacity building of disaster management in Bojonegoro regency," In Journal of Physics: Conference Series (Vol. 953, No. 1, p. 012162). IOP Publishing, January 2018.

[21] Bouyerbou, H., Bechkoum, K., & Lepage, R., "Geographic ontology for major disasters: Methodology and implementation," International Journal of Disaster Risk Reduction, 2018.

[22] Ahmad, S., Rahman, I., Mallik, A., & Arefin, A., "Integrated Information System for Disaster Management: A Creative Case Study," International Journal of Information, Business and Management, 10(2), 64-76, 2018.

[23] Peterson, S., Thompson, C., & Graham, C., "Getting Disaster Data Right: A Call for Real-time Research in Disaster," 15th International Conference on Information Systems for Crisis Response and Management (ISCRAM), May 2018.

[24] Zhou, L., Wu, X., Xu, Z., & Fujita, H., "Emergency decision making for natural disasters: An overview," International journal of disaster risk reduction, 27, 567-576, 2018.

[25] Inan, D. I., Beydoun, G., & Pradhan, B., "Developing a decision support system for Disaster Management: Case study of an Indonesia volcano eruption," International journal of disaster risk reduction, 31, 711-721, 2018.

[26] Moreira, J. L., Pires, L. F., van Sinderen, M., & Costa, P. D., "Ontology-Driven Conceptual Modeling for Early Warning Systems: Redesigning the Situation Modeling Language," In MODELSWARD (pp. 467-477), February 2017.

[27] Anbarasi, C., Mayilvahanan, P., & Pallavaram, C., "Humanitarian Assistance Ontology Implementation during Disaster Management in Chennai Flood-2015 Using Text Mining Techniques," International Journal of Pure and Applied Mathematics, 116(21), 729-739, 2017.

[28] Zhong, S. B., Wang, C. L., Yao, G. N., & Huang, Q. Y., "Emergency Decision of Meteorological Disasters: a Geo-Ontology Based Perspective," DEStech Transactions on Computer Science and Engineering, (cmsam), 2016.

[29] Xu, J., Nyerges, T. L., & Nie, G., "Modeling and representation for earthquake emergency response knowledge: perspective for working with geo-ontology," International Journal of Geographical Information Science, 28(1), 185-205, 2014.

[30] Horridge, M., Jupp, S., Moulton, G., Rector, A., Stevens, R., & Wroe, C., "A practical guide to building owl ontologies using protégé 4 and co-ode tools edition1.2," The University of Manchester, 107, 2009.

[31] Grüninger, M., & Fox, M. S., "Methodology for the design and evaluation of ontologies," IJCAI-95 Workshop on Basic Ontological Issues in Knowledge Sharing, Montreal, 1995.

[32] Rosch, E., "Principles of categorization," Cognition and categorization, ed. by Eleanor Rosch & Barbara B. Lloyd, 27-48, 1978.

[33] Pinto, H. S., & Martins, J. P., "Ontologies: How can they be built?," Knowledge and information systems, 6(4), 441-464, 2004.

[34] Fernández, M., Gómez-Pérez, A. & Juristo, N., "METHONTOLOGY: From Ontological Art Towards Ontological Engineering," AAAI-97 Spring Symposium on Ontological Engineering, Stanford University, March 24-26th, 1997.

[35] Vrandečić, D., "Ontology evaluation," In Handbook on ontologies, Springer, Berlin, Heidelberg, 2009, pp. 293-313.

[36] Pedro, V.C., Nyberg, E., and Carbonell, J., Federated ontology search (Doctoral dissertation, Carnegie Mellon University, Language Technologies Institute, School of Computer Science), 2009.

Design of Embedded Vision System based on FPGA-SoC

Ahmed Alsheikhy[1], Yahia Fahem Said[2]
Electrical Engineering Department, College of Engineering, Northern Border University, Arar, Saudi Arabia[1, 2]
Laboratory of Electronics and Microelectronics (LR99ES30), Faculty of Sciences of Monastir, University of Monastir, TUNISIA[2]

***Abstract*—The advanced micro-electronics in the last decades provide each year new tools and devices making it possible to design more and more efficient artificial vision systems capable of meeting the constraints imposed. All the elements are thus brought together to make artificial vision one of the most promising, even unifying scientific "challenges" of our time. This is because the development of a vision system requires knowledge from several disciplines, from signal processing to computer architecture, through theories of probability, linear algebra, computer science, artificial intelligence and analog and digital electronics. The work proposed in this paper is located at the intersection of embedded systems and image processing domains. The objective is to propose an embedded vision system for video acquisition and processing by adding hardware accelerators in order to extract some image characteristics. With the introduction of reconfigurable platforms, such as new All Programmable System on Chip (APSoC) platforms and the advent of new high-level Electronic Design Automation (EDA) tools to configure them, FPGA-SoC based image processing has emerged as a practical solution for most computer vision problems. In this paper, we are interested in the design and implementation of an embedded vision system. This design facilitates video streaming from the camera to the monitor and hardware processing over real-time FPGA-SoC.**

Keywords*—Embedded vision; video processing architecture; real-time; All Programmable System on Chip (APSoC)

I. Introduction

The discipline that aims to automate the understanding of images, computer vision, is a branch of artificial intelligence whose objective is precisely to enable a machine of perception and understand what it sees when it is connects to one or more cameras. With the emergence of increasingly powerful processors, it becomes practical to incorporate computer vision algorithms to embedded systems, to analyze their environments through video inputs [1]. Products like Mobileye's Helper System and Nest Cam surveillance camera are raising awareness of the incredible potential of embedded vision technology. As a result, many embedded system designers are beginning to implement computer vision algorithms.

Embedded vision is the integration of computer vision in embedded systems, which use an infinity of algorithms to decode the scene and obtain meanings. In fact, this type of artificial vision is developing little by little and becomes the major and most used solution in the field of industry, medical, etc [2]. It can be defined as the application of computer vision to problems. Its principle is to equip machines with the ability to see in order to automate control tasks. This automation makes it possible to increase production performance and production rates in the industry, for example, to make production more reliable, to improve the quality of products, to ensure their traceability, and to guarantee safety.

Today's progress has successfully integrated specially dedicated processors for the embedded vision to facilitate the processing task and improve the result, which helps the embedded vision to replace the majority of human functions.

Thanks to its learning and treatment capabilities, a trend towards miniaturization has been established in many areas of electronics. Embedded vision technology will be the technological future, which will be deployed widely in the fields: medical, industrial, agricultural, maritime, military and become among the important necessities in all technological industries.

Relatively good performance processors can be implemented by the users in the FPGA and speak of complete System on Chip SoC. The new FPGAs now have processor cores. FPGA-SoC based architecture with processor cores is the most appropriate solution for a context requiring to constantly evolve image processing applications, with the development of computing units of increasing complexity. In addition, a SoC platform allows different variations of computational architectures, which makes it possible to address different families of vision systems that are defined, according to constraints of performance and consumption. Although generating a natural extra cost in terms of silicium surface, an FPGA-type component makes it possible to produce low-cost vision systems while choosing the right partitioning of software and hardware operation.

An embedded vision system based on FPGA-SoC is proposed in this paper. Images captured by the sensor, are processed internally by integration of hardware and software processing in the same platform. This paper is organized as follows. Related works on embedded vision systems are presented in Section 2. Then, the proposed system architecture is described in Section 3. Section 4 details experiments and results. Finally, Section 5 concludes the paper.

II. Related Works

Computer vision is the use of computers to extract meaningful meaning from images, such as those from real-time photographs, videos, and camera streams. With the profusion of low-power parallel processors, increasing sensor availability, and an active ecosystem of algorithms, it is now

possible for many embedded devices to analyze their environments.

Embedded vision is the application of computer vision to problems. Its principle is to equip machines with the ability to see in order to automate control tasks. Recently there has been a significant increase in research in building embedded vision systems [7, 9, 10, 11, 12, 13, 16].

Bravo et al. [4] proposed an intelligent ad-hoc camera with embedded processing. A Virtex 4 FPGA device for internal image processing was used. However, the amount of resources available on the chosen device was not sufficient. An FPGA platform with more slices is needed for implementing complex image processing algorithms.

A high-speed camera with high-resolution based on a CMOS image sensor and a Xilinx Virtex-II FPGA platform was proposed by Mosqueron et al. [3]. Images with SXGA resolution (1280×1024) were acquired and processed at 500 fps. Real-time image processing algorithms (Sobel filter, fast marker extraction, etc.) were implemented.

Lee et al. [5] proposed an embedded implementation for efficient SLAM algorithm for low-cost indoor navigation robots. The NXP4330Q platform equipped with forward-viewing mono-camera was used for experiments and testing. The proposed architecture achieved high performance under various challenging constraints.

An embedded system with hardware/software co-design for stereo vision is proposed by Stefania et al. [6]. Disparity maps are optimized by custom hardware module and software routine controls data streaming and communication. High performances and accuracy was achieved by the proposed architecture.

A Computer-on-Module (CoM) for embedded vision applications based on FPGA SoC is proposed in [8]. The platform integrated a Xilinx Zynq SoC combined with Adapteva Epiphany processor. Indoor robot navigation and collision avoidance applications have been implemented and performed increased energy efficiency and accuracies.

Ismail et al. [14] proposed a real-time FPGA-based tracking system. The system is composed by DE1-SoC platform and D5M camera. Particle filter algorithm has been applied. By the proposed implementation, multiple objects with multiple colors can be tracked up to 30 meters for 15×15 cm size.

A video streaming module for smart camera system is implemented on a Xilinx Virtex-5 platform in [15]. Hardware/software co-design was performed using the Xilinx EDK design tool targeting real-time video processing applications.

Bonny introduced in [17] an algorithm for similarity measurement between two sequences in a database. The proposed method is validated on Zedboard FPGA device using custom HW/SW partitioning and achieved an acceleration time of 60% compared to other strategies.

Abdelkader et al. [29] implemented an embedded architecture for corner detection and tracking system in video sequence, using the HW/SW partitioning flexibility of Zynq platform. They used Harris algorithm for corner detection and Kalman filter for feature tracking. The processing time of the proposed system was improved by 50% using several approximations and innovations.

III. Proposed Architecture

An embedded system with a camera and a monitor, together form a complete vision system, which allows the acquisition of video data and, depending on the application that will run, the processing can be real-time. In this paper, using a platform-based design approach, an embedded architecture for the acquisition of video and processing modules for the design of a vision system is proposed. This design facilitates real-time video streaming from the sensor to the monitor via DDR3 memory and hardware processing over FPGA. The proposed system architecture is shown in Fig. 1. It consists of a VITA-2000 image sensor [18], the 'FPGA Mezzanine Card' (FMC) module [19], the Xilinx ZedBoard platform [20] and a HDMI monitor for viewing the output video.

The VITA-2000 is an Ultra eXtended Graphics Array (WUXGA) CMOS camera configurable in HD (1920 x 1080) or (1600 x 1200) format [18]. The FMC module [19] provides several high definition video interfaces. It features on-board HDMI I/O interfaces, LCEDI interface to connect the VITA-2000, as well as an LPC interface to connect to the FPGA. The FMC module is ideal for developing vision, motion monitoring and security applications.

The ZedBoard development platform (XC7Z020 CLG484-1), is a low cost Zynq-7000 platform whose FPGA is based on Artix-7, with a capacity of 13300 Logic Blocks, 220 DSP48E1 and 140 RAM Blocks (32K) [20]. ZedBoard provides an ideal platform for the implementation of flexible SoCs: 'All-Programmable SoC (AP SoCs)'. It consists of two main parts: a Processing System (PS) built around a dual core ARM Cortex-A9 processor and Programmable Logic (PL) equivalent to that of an FPGA. It also has built-in memory, a variety of peripherals, and high-speed communication interfaces.

The PL section is ideal for implementing logical subsystems, arithmetic and high-speed data flow, while the PS supports routines and/or operating systems, which means that the functionality overall system can be properly partitioned between hardware and software. The links between PL and PS are made using the Advanced eXtensible Interface (AXI) interface [21].

Fig. 2 shows the Vita-2000 camera that is connected to the FMC module via the LCEDI port and coupled with the ZedBoard platform via the LPC port. In this design, the ARM processor is used for interfacing the different FPGA-based IPs used for streaming, as well as configuring platform peripherals. The software environment of the system consists of a software application and drivers of peripherals. The hardware part of the system includes configurable logic blocks, AXIs interfaces and different memories used such as DDR3. This integration of software and hardware provides the complete functionality of the proposed system.

Xilinx provides in its tool pack, various software for the creation of on-chip embedded systems. These tools include Vivado Design Suite, Vivado HLS and SDK. These three tools offer us the possibility to have a Bitstream for FPGA programming according to the targeted application.

The Vivado Design Suite is a Xilinx tool, provides a design flow that revolves around the philosophy of IP design, reuse and integration. It makes it possible to create IP modules, but also to pack IP modules for repeated use and to easily integrate third party applications [22]. The custom IP is packaged for use, according to IP-XACT before being available in the IP catalog.

Vivado High-Level Synthesis HLS [25] is part of the Xilinx tools suite. The tool is based on an Eclipse integrated development environment (IDE) [24] and uses precompile directives to generate RTL code from C code. The IDE also includes RTL compilation and simulation of the component. During the transcription process, the tool generates representations in SystemC, VHDL and Verilog. It is possible to directly export a component as an IP block from the HLS, easily integrated into a project on Xilinx AP SoC devices. It speeds up the creation of intellectual property (IP) without having to RTL manually.

The Software Development Kit (SDK) is an Xilinx tool that provides an environment in which fully functional software applications can be created, compiled, and debugged into a single tool. It is used for the C code development of the ARM processor included in the Zynq SoC. It includes Board Support Package (BSP), drivers for IPs, the GNU compiler database, and libraries for application-specific functions [23].

At first, the proposed design is used to display in real time on a monitor the scene observed by the camera without any processing that is to say: the video data is captured by the camera with a resolution of 1920 x 1080P at 60MHz. Then, this data is sent to the FPGA, where there is a chain of IPs to bring this data to the output: the 'VITA Receiver' IP is responsible for receiving the video data that will subsequently undergo operations processing pipeline to correct defective pixels with the IP 'DPC' (Defective Pixel Correction), and apply the interpolation filter with the IP 'CFA' (Color Interpolation Filter) which is used to interpolate the missing colors for each pixel; followed by another treatment with the IP 'TPG' (Test Pattern Generator) which is used to evaluate the color performance and the quality of movement (see Fig. 3). After all these treatments, the video data will be stored in a 'VDMA' (Video Direct Memory Access) memory.

Image processing pipeline will be controlled by the PS, which synchronizes the different IP blocks and manages the different clocks to each operating domain via AXI interfacing, as well as initializing platform devices and controlling video processing by reading and writing control registers in the system. After recording to the VDMA, the video data will undergo the last operation with the IP 'Xylon Controller' before being displayed on the screen. Among these operations that contain the display IP 'Xylon Controller', we note the conversion RGB to YUV, 444 to 422 (in IP LOGICVC_0) to transfer this data to IP 'HDMI OUTPUT' which ensures the output of data to the monitor.

Fig. 3 shows a screenshot of the Co-designed system including different IPs that are connected with the ARM processor (Zynq PS).

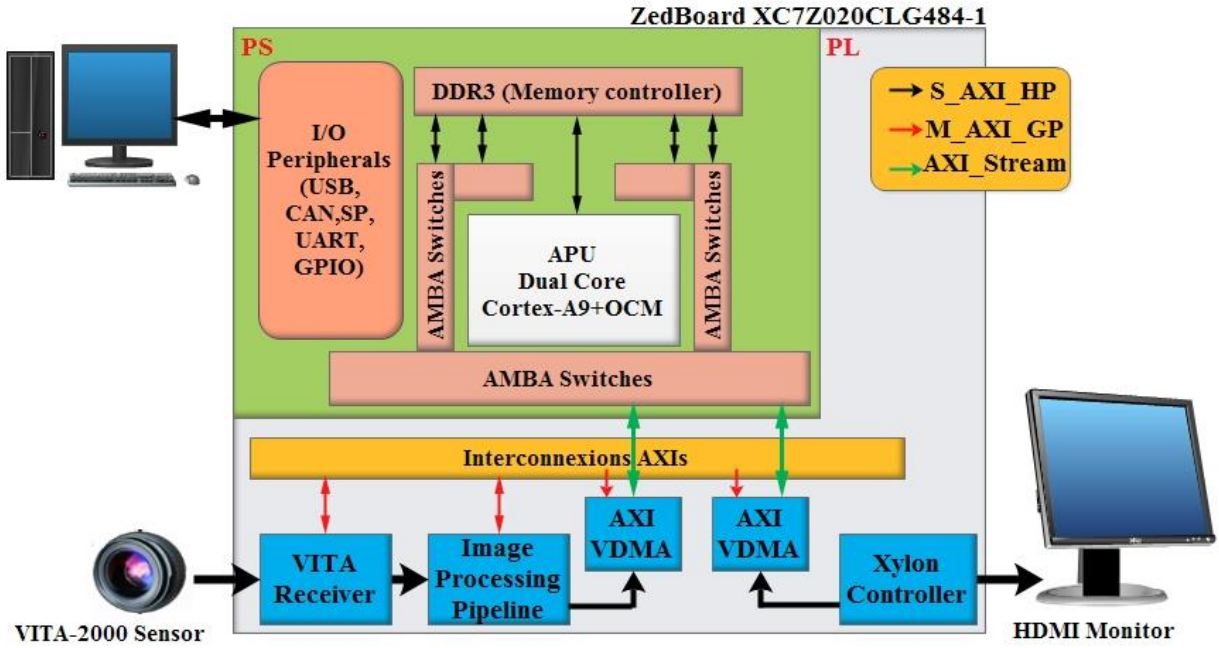


Fig. 1. Proposed Embedded Video Processing Architecture.

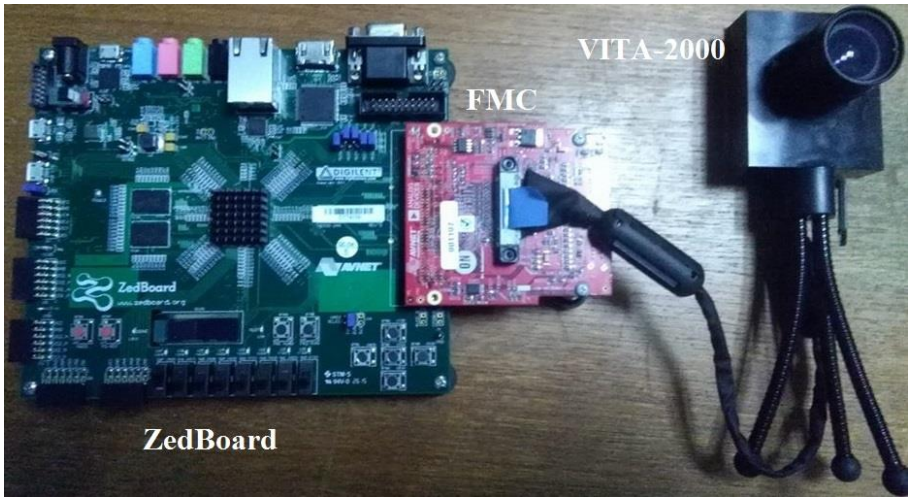


Fig. 2. The ZedBoard Platform Coupled with the FMC Module and the VITA-2000 Camera.

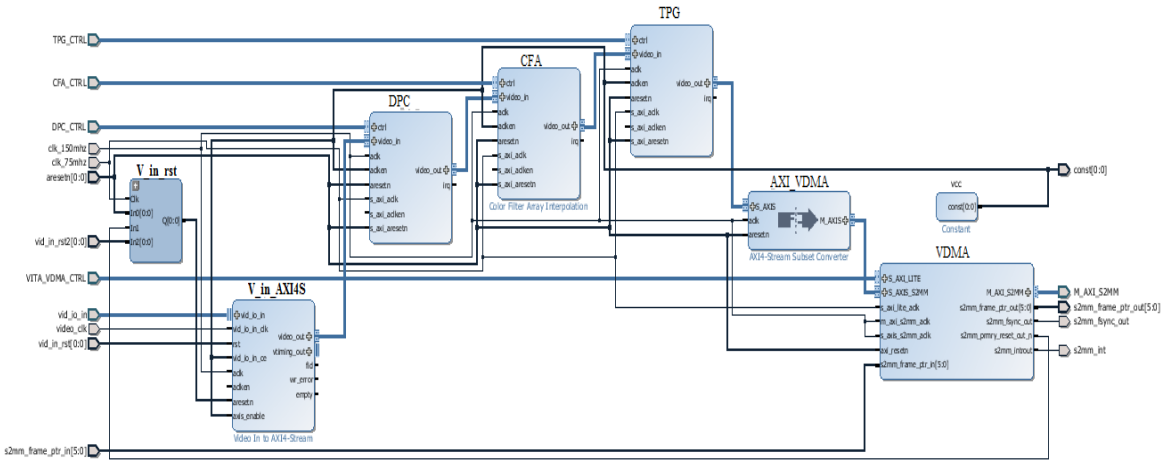


Fig. 3. Screen Capture of IPs that Constitute the Image Processing Pipeline.

IV. Experiments and Results

The previous proposed system is none other than an architecture that can process video data in real time without any operation to be applied to the captured images. In the following, this architecture must keep the processing in real time, but this time with a processing operation on the images, in the form of hardware accelerators.

To validate the proposed embedded video processing architecture, two algorithms were added: the 'FAST Corners' filter and the 'Sobel' filter, which are designed from the OpenCV library and the Vivado HLS tool, which is used to synthesize the C codes of the library used and make it in the form of a hardware accelerator, which is subsequently going to be exported as an IP block usable in the architecture.

These accelerators (FAST/Sobel) must work in synchronization with the other IP blocks and process the data in pipeline so that the architecture remains functional in real time. The general concept is that the added processing IP is connected with the VDMA via the AXI VDMA (see Fig. 4). A 'Video Processing' block is added which contains the IP filter as well as an AXI interface which guarantees the communication of the ARM processor with the proposed accelerator and the communication of the latter with the VDMA.

A. Design of the IP Fast_Corners Filter and Implementation

In computer vision and image processing, the detection of areas of interest of a digital image (feature detection) consists in highlighting areas of this image deemed "interesting" for the analysis, that is, with remarkable local properties. Such zones can appear, according to the methods used, in the form of points, of continuous curves, or incurring connected regions rectangular or not and which constitute the result of the detection.

Points of interest detection algorithms generally focus on particular selected contour points, according to a specific criterion. Thus the corners are the points of the image where the contour (of dimension 1) abruptly changes direction.

The 'Feature from Accelerated Segment Test' (FAST) method is a corner detection algorithm introduced by Cambridge University researchers for the first time in 2006 [26]. Angle detection or 'Fast Corners' algorithm is frequently used in computer vision systems for object detection, image recording and 3D reconstruction.

The algorithm works in two steps: in the first step, a segment test based on the relative luminosities, which are applied to each pixel of the processed image. The second step allows to refine and limit the results by the method 'non-maximum suppression'. The whole process can be summarized mathematically as follows: Where 't' is the threshold for detection.

$$V = \max \begin{cases} \sum (\text{pixel values} - p) \text{if}(\text{value} - p) > t \\ \sum (p - \text{pixel values}) \text{if}(p - \text{value}) > t \end{cases}$$

The design of an IP block requires source codes. The OpenCV library offers these codes in C or C ++. These source codes are the essential and the basis of the design, which will be synthesized by the HLS Vivado in order to implement it as a hardware accelerator.

Vivado HLS also provides the simulation of a test Bench code: it requires a single image data. Vivado HLS treats both the synthetic code (hardware) and the OpenCV version (software) and he looks for differences between these two approaches and reports them as a failure (because these functions should be identical). The result of Co-simulation is given in Fig. 5. The summary report gives us an idea of the performance such as the frequency of the IP block, the hardware resources used on the target platform. All these results are presented in Table I, compared with the design proposed by [27], implemented on a ZedBoard FPGA card.

As this table shows, the design of [27] requires 4 BRAMs, 5963 LUTs and 8281 Flip Flops, with a maximum frequency of 134 MHz. On the other hand, the proposed IP required about 11 BRAMs, 8425 LUTs and 4252 Flip Flops with a working frequency of 150 MHz. With this implementation, this hardware architecture achieves high-speed performance with fairly large hardware resources than the design of [27], which is explained by the increased degree of parallelism, due to the numbers of nested loops added in the proposed design.

The integration of the IP block is done by exportation in the IP Integrator (IPI) library. Once the filter block is added, the design should be validated without error, and the IP address should be checked and updated. Subsequently, the implementation of the proposed architecture with IP FAST_Corners on the ZedBoard platform is completed by Xilinx Vivado Design Suite. Fig. 6 shows the experimental result of the proposed architecture with IP FAST_Corners. Table II shows the hardware resources required and the maximum operating frequency of the complete system (proposed architecture and IP FAST_Corners).

To calculate the video data processing rate, the programmable logic design contains three submodules that implement video pipelines in the design: Video Capture, Video Processing, and Video Display. These submodules communicated with VDMA memory with a 1080p60 video resolution with an image quality of 1920x1080 i.e. that the video rate is 60 frames/second and with a 32bit memory bus width, the broadcast rate of the video data in the memory can be calculated: 1920 * 1080 * 60 /s * 32 = 4 GB/s.

TABLE. I. QUANTITY OF HARDWARE RESOURCES USED BY IP FAST_CORNERS COMPARED WITH OTHER DESIGN

Resources		**Proposed**		**[27]**	
	Available	**Used**	%	**Used**	**%**
BRAMs	140	11	7	3	2
LUTs	53200	8425	15	5963	11
Flip Flops	106400	4252	4	8281	7
Maximum frequency		150 MHz		134 MHz	

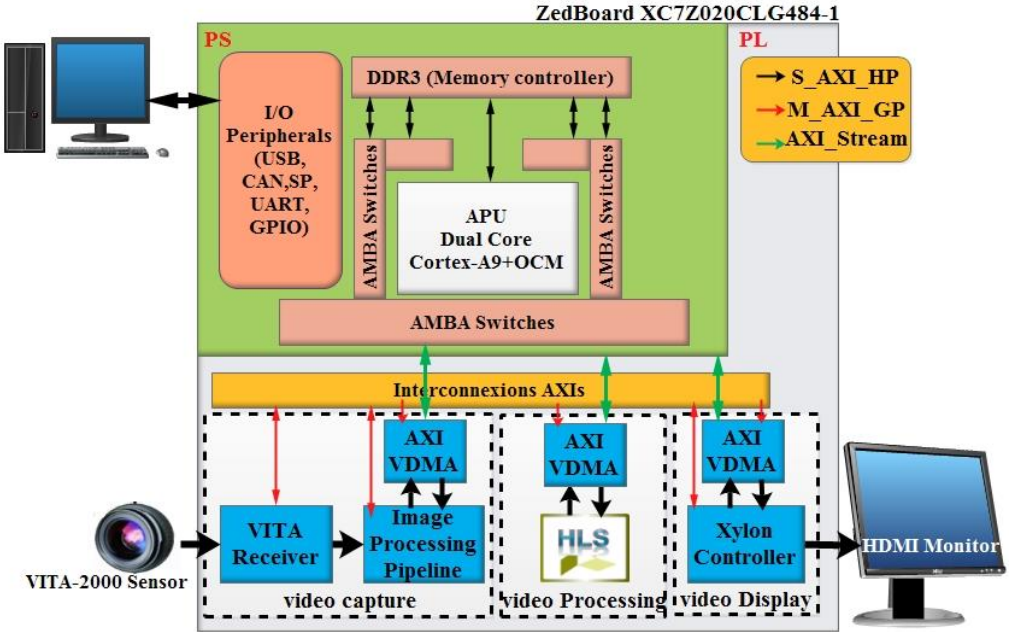


Fig. 4. Embedded Vision System Architecture with Added Video Processing.

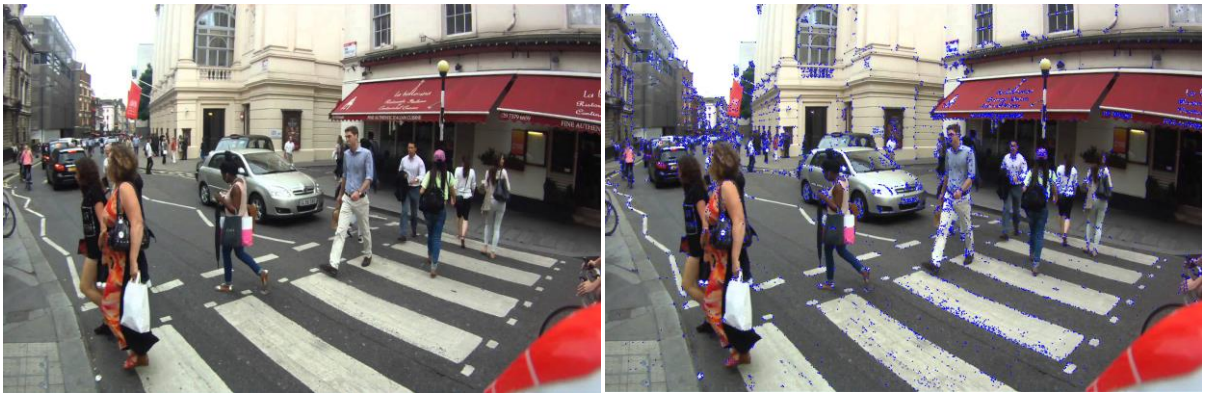


Fig. 5. Test Image (Left) and the Result after the FAST Corners Filter (Right).

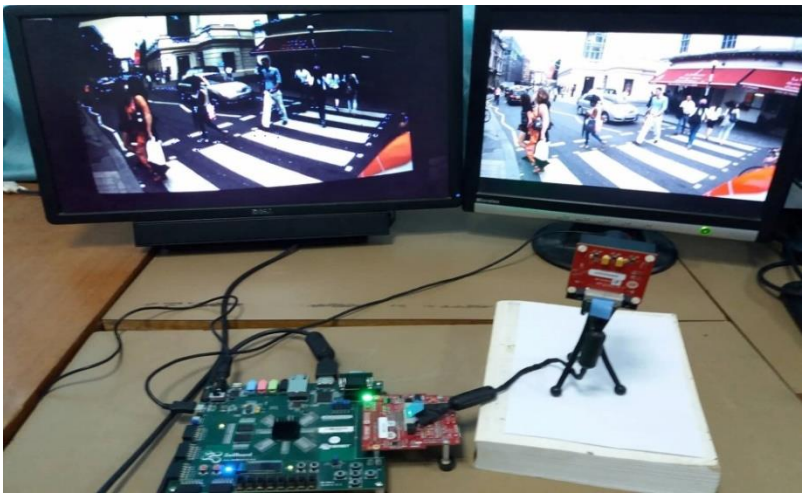


Fig. 6. Experimental Result of the Proposed Architecture with IP FAST_Corners.

TABLE. II. RESULTS OF THE SYNTHESIS OF PROPOSED SYSTEM WITH IP FAST_CORNERS

Resources	**Available**	**Used**	%
BRAMs	140	90	64
LUTs	53200	32770	62
Flip Flops	106400	34306	32
DSP48E1	220	44	20
Maximum frequency	150 MHz		

B. Design of the IP Sobel Filter and Implementation

Edge detection is the process of locating the image points that correspond to a sudden change in light intensity. It is a basic operation in many image processing applications. Sobel Filter is one of the efficient algorithms for edge detection. It uses convolution matrices. The 3×3 matrix is convolved with the image to calculate approximated horizontal and vertical gradients Gx and Gy as follows:

$$Gx = \begin{bmatrix} +1 & 0 & -1 \\ +2 & 0 & -2 \\ +1 & 0 & -1 \end{bmatrix} * I \quad \text{and} \quad Gy = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * I$$

Then, the gradient magnitude G is calculated:

$$G = \sqrt{Gx^2 + Gy^2}$$

The Sobel edge detector is built as a hardware video processing accelerator, using Xilinx Vivado HLS and the OpenCV library, by applying the same procedures that were applied to FAST_Corner IP. The result of the Co-Simulation of the Sobel filter is given in Fig. 7. Table III shows the amount of hardware resources used by the proposed IP, compared with the design of [28], implemented on a Zynq 7000 FPGA-SoC card. The proposed Sobel edge detection IP occupies 6% of RAM blocks, 1% of Flip Flops, and 4% of LUTs, with a maximum frequency of 150MHz. On the other hand, the design of [28] requires 2% BRAMs, 1% LUTs and 1% Flip Flops with the same 150MHz working frequency.

The integration of IP Sobel into the design is done first by exporting the IP from the HLS to the IP Integrator IPI library in RTL form, afterwards just add in the design diagram and make connections, in the same way as IP FAST_Corners. The IP Sobel will communicate with the VDMA memory via AXIs interfaces with a bit rate of 4Gb/s. The result of the complete system implementation (proposed architecture and IP sobel) also allows us to determine the numbers of material resources consumed (see Table IV). The experimental result of the IP Sobel implementation is shown in Fig. 8.

Fig. 7. Test Image (Left) and the Result after the Sobel Filter (Right).

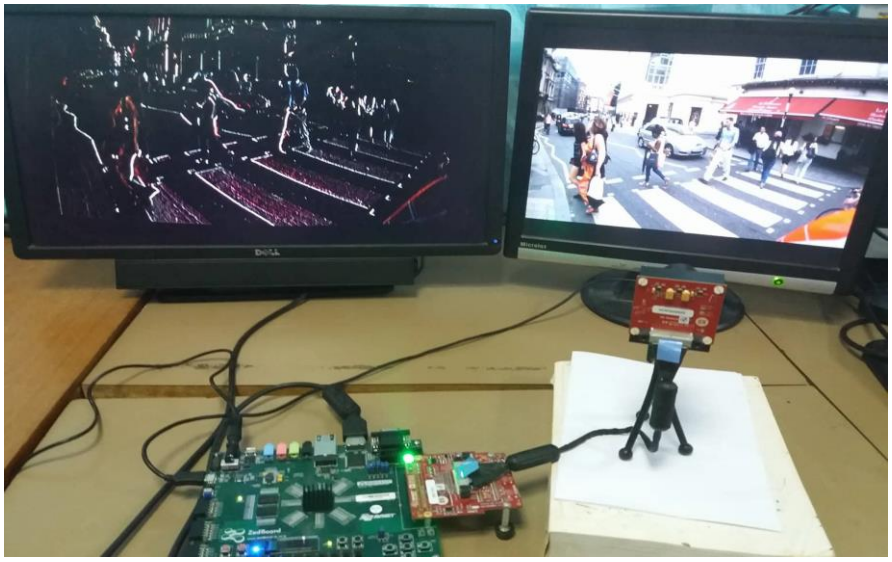


Fig. 8. Experimental Result of the Proposed Architecture with IP Sobel.

TABLE. III. QUANTITY OF HARDWARE RESOURCES USED BY IP SOBEL COMPARED WITH OTHER DESIGN

Resources		**Proposed**		**[28]**	
	Available	**Used**	%	**Used**	**%**
BRAMs	140	9	6	3	2
LUTs	53200	1946	4	746	1
Flip Flops	106400	1445	1	579	1
Maximum frequency		150 MHz		150 MHz	

TABLE. IV. RESULTS OF THE SYNTHESIS OF PROPOSED SYSTEM WITH IP SOBEL

Resources	**Available**	**Used**	%
BRAMs	140	65	46
LUTs	53200	29951	56
Flip Flops	106400	31989	30
DSP48E1	220	39	18
Maximum frequency	150 MHz		

V. CONCLUSIONS

In this paper, an embedded vision architecture implemented on a FPGA-SoC platform was proposed. Firstly, a system that allows the acquisition of video data in real time at 60 fps and displays it on a monitor was designed. We subsequently integrated two hardware accelerators that are designed using the OpenCV and the Vivado HLS. The first accelerator is the FAST_Corner which is used to detect corners in an image/video, the second accelerator is the Sobel which is used to detect the edge of objects. The sequence is obtained from a VITA_2000 sensor and the output is delivered through an HMDI monitor to check the video processing results in real time.

ACKNOWLEDGMENT

The authors wish to acknowledge the approval and the support of this research study by the grant N° ENG-2018-3-9-F-7705 from the Deanship of the Scientific Research in Northern Border University, Arar, KSA.

REFERENCES

[1] Embedded Vision Alliance: https://www.embedded-vision.com.

[2] B. Deepayan, and K. Appiah. "Embedded vision systems: A review of the literature," In International Symposium on Applied Reconfigurable Computing, pp. 204-216. Springer, Cham, 2018.

[3] R. Mosqueron, J. Dubois, M. Paindavoine, "High-Speed Smart Camera with High Resolution," J. Embed. Syst, 2007.

[4] I. Bravo, J. Balinas, A. Gardel, J. L. Lazaro, F. Espinosa, and J. Garcia, "Efficient smart CMOS camera based on FPGAs oriented to embedded image processing," Sensors, vol.3 , pp.2282- 2303, 2011.

[5] L. Tae-Jae, C. H. Kim, and D. D. Cho. "A monocular vision sensor-based efficient SLAM method for indoor service robots," IEEE Transactions on Industrial Electronics vol.66, no .1, pp.318-328, 2019.

[6] P. Stefania, et al. "Design of Real-Time FPGA-based Embedded System for Stereo Vision," 2018 IEEE International Symposium on Circuits and Systems (ISCAS), IEEE, 2018.

[7] D. T. Tin, et al. "Evaluation of Embedded Systems for Automotive Image Processing," 19th IEEE/ACIS International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD), IEEE, 2018.

[8] K. Daniel, et al. "Resource-efficient Reconfigurable Computer-on-Module for Embedded Vision Applications," IEEE 29th International Conference on Application-specific Systems, Architectures and Processors (ASAP). IEEE, 2018.

[9] E. Osman, and A. M. Mutawa. "Embedded vision system with hardware acceleration," IEEE Conference on Evolving and Adaptive Intelligent Systems (EAIS), IEEE, 2018.

[10] G. Li, et al. "Lossy Compression for Embedded Computer Vision Systems," IEEE Access, vol. 6, pp. 39385-39397, 2018.

[11] C. Bui et al., "A Hardware/Software Co-Design Approach for Real-Time Object Detection and Tracking on Embedded Devices," IEEE SoutheastCon 2018, pp.1-7, 2018.

[12] P. J. Gopal, et al. "Platform-Based Design Approach for Embedded Vision Applications," Journal of Image and Graphics, vol. 1, no. 1 ,pp.1-6, 2013.

[13] B. Deepayan and A. Kofi (2018). "Embedded vision systems: A review of the literature," 14th International Symposium on Applied Reconfigurable Computing (ARC), Santorini, Greece, 2-4 May 2018.

[14] S. N. Ismail, H. S. Muataz, and Y. Wahab, "Design and implementation of embedded vision-based tracking system for multiple objects using FPGA-SOC," ARPN Journal of Engineering and Applied Sciences, Vol. 13, No. 3, February 2018.

[15] J. G. Pandey, S. Purushottam, A. Karmakar, and C. Shekhar "Platform-Based Extensible Hardware-Software Video Streaming Module for a Smart Camera System," International Journal of Modeling and Optimization, vol. 2, no. 4, August 2012.

[16] A. Oetken, S. Wildermann, J. Teich, D. Koch, "A Bus-based SoC Architecture for Flexible Module Placement on Reconfigurable FPGAs," International Conference on Field Programmable Logic and Applications, 2010.

[17] B. Talal, "Heterogeneous HW/SW FPGA-Based Embedded System for Database Sequencing Applications," International journal of advanced computer science and application, IJACSA, vol. 9. no 10, pp. 244-251, 2018.

[18] VITA2000: CMOS Image Sensor, Global Shutter, 2.3 Megapixel: http://www.onsemi.com/PowerSolutions/product.do?id=VITA2000.

[19] FMC cards: https://www.xilinx.com/products/boards-and-kits/fmc-cards.html.

[20] Avnet zedboard: http://www.zedboard.org/overview-zedboard-kit.

[21] Xilinx, Inc., 'AXI Reference Guide', UG761, v14.3, November 2012: http://www.xilinx.com/support/documentation/ip_documentation/axi_ref_guide/latest/ug761_axireference_guide.pdf.

[22] Vivado Design Suite User Guide UG910 (v2014.1) April 2, 2014: https://www.xilinx.com/support/documentation/sw_manuals/xilinx2014_1/ug910-vivado-getting-started.pdf.

[23] Xilinx, Inc., "Zynq-7000 All Programmable SoC Software Developers Guide", UG821, v9.0: http://www.xilinx.com/support/documentation/user_guides/ug821-zynq-7000-swdev.pdf.

[24] Eclipse desktop IDEs: https://eclipse.org/ide/.

[25] Vivado High-Level Synthesis: https://www.xilinx.com/products/design-tools/vivado/integration/esl-design.html.

[26] OpenCV FAST Algorithm for Corner Detection: https://docs.opencv.org/3.0-beta/doc/py_tutorials/py_feature2d/py_fast/py_fast.html.

[27] F. Brenot, P. Fillatreau, qnd J. Piat, "FPGA based accelerator for visual features detection," 2015 IEEE International Workshop of Electronics, Control, Measurement, Signals and their Application to Mechatronics (ECMSM), IEEE, pp. 1-6, 2015.

[28] A., Haythem, A. Helali, H. Maaref, and A. Youssef, "Implementation of real time edge detection system for HD video on Zynq," 3rd International Conference on Automation, Control, Engineering and Computer Science (ACECS'16), Proceedings of Engineering and Technology (PET), pp. 41-45, 2016.

[29] A. B. amara, M. Atri et al., "Zynq FPGA based and Optimized Design of Points of Interest Detection and Tracking in Moving Images for Mobility System," International Journal of Advanced Computer Science and Applications, IJACSA, vol. 9, no. 10, pp. 430-437, 2018.

Using Brain Imaging to Gauge Difficulties in Processing Ambiguous Text by Non-native Speakers

Imtiaz Hussain Khan
Department of Computer Science
King Abdulaziz University Jeddah Saudi Arabia

***Abstract*—Processing ambiguous text is an ever challenging problem for humans. In this study, we investigate how native-Arabic speakers face problems in processing their non-native English language text which involves ambiguity. As a case study, we focus on prepositional-phrase (PP) attachment ambiguity whereby a PP can be attached to the preceding noun (aka low attachment) or the preceding verb (aka high attachment). We setup an experiment in which human participants read text on a computer screen and their brain activity is monitored using near infrared spectroscopy. Participants read two types of text: one involving PP-attachment ambiguity and the other unambiguous text which is used as a control for comparison purposes. The brain activity data for ambiguous and control text are clustered using hierarchical-clustering technique available in Weka. The data reveal that Arabic speakers face more difficulty in processing ambiguous text as compared to unambiguous text.**

Keywords*—Prepositional-phrase attachment ambiguity; near-infrared spectroscopy; Arabic speakers; hierarchical clustering

I. Introduction

Ambiguity is a challenging problem for human when they process natural language for different tasks, including text comprehension, text summarization or machine translation. State-of-the-art research in natural language processing suggests that people use different strategies in comprehending potentially ambiguous text [1, 2, 3, 4, 5, 6]. Research also suggests that generally human are good at comprehending potentially ambiguous text because of the availability of the context in which the text is processed or because they use their common sense knowledge in an effective manner to disambiguate text. At present, English is considered as a universal language for communication worldwide. A large body of the existing work focusses on how human process their native language, but there is very little work reported in literature on how non-native speakers process their second language, which involves ambiguities. This is an important problem to address in a systematic manner because there is more than one-third population whose native language is not English.

In the Arabic world, English language is commonly used as the second languge, mostly as a medium of instruction in educational institutions or among the business community. Therefore, it is imperative to study systematically how native Arabic speakers process English language, especially when the language text involves ambiguities. This is important because once we are able to understand how Arabic speakers process English language, it would be easier to develope sophisticated language processing tools to aid Arabic speakers. For instance, a personalized language model could be built to inform the design of, for example, a pararphrasing system to produce text which is easy to comprehend as well as fluent for a special group of readers.

As a starting point, in this study, we undertake the task of how Arabic speakers process English lanugage text, which involves one of the most notorious ambiguities in almsot every human language called prepositional-phrase (PP) attachment ambiguity. This is the first study of its kind which thoroughly investigates the problem using brain imaging by near infrared spectroscopy (NIRS) [7, 8]. Briefly, we conducted an empirical study in which human participants read text and their brain activity was monitored using NIRS to gauge the difficulty they faced during the text reading task. Participants read two types of texts, one involving PP-attachment ambiguity and the other unambiguous text, which is used as a control for comparison purposes. The brain activity data for ambiguous and control text were recorded. Subsequently, the NIRS data are clustered using hierarchical-clustering technique to discriminate between the processing of ambiguous and unambiguous texts. We found that Arabic speakers face significant difficulty in processing ambiguous text as compared to unambiguous text; our NIRS results corroborate with the previous findings, which are mainly based on self-paced reading paradigm.

The rest of this article is organized as follows. In Section II, state-of-the-art research work is presented. Section III describes the emirical study. Results are discussed in Section IV. Finally, the article concludes in Section V with pointers and open questions for future work outlined in Section VI.

II. Related Work

Ambiguity is an interesting phenomenon which has received considerable attention by researchers in language studies [1, 3, 2, 9, 10]. Among these researchers, in an earlier interesting work [2], the authors proposed minimal attachment and right association principles. These principles have been dominating the field for many years and the authors argued that they are effective in resolving ambiguities of different kinds, especially PP-attachment ambiguity. Other notable contribution which received much attention is by [10] who proposed probability based constraint satisfaction theories for structural ambiguity resolution. Their work paved the way for many modern

corpus-based approaches to resolve ambiguities of different kinds.

PP-attachment ambiguity has thoroughly been investigated in literature and different approaches, including corpus based [4, 11], statistical [12, 13], and machine learning [14, 15] have been proposed to resolve it. Some interesting work is reported in literature where researchers have tackled such ambiguities in Arabic language. Notable among them is work done by [16, 17, 18, 19]. In these studies, the authors have primarily tried to resolve different ambiguities, including structural ambiguity in Arabic language. These are important contributions, for example [19] used a corpus-based approach to resolve PP-attachment ambiguity in Arabic. However, little attention has been paid to investigate how people, especially Arabic speakers process text involving PP-attachment ambiguity in English as their second language. One notable exception [20], where authors used a sample size of 60 Arabic native speakers to investigate how they interpret English language text involving different types of ambiguities. Unlike our methodology, they asked the participants to translate the given text, involving ambiguity, in to Arabic language. The number of sentences in their experiment was only 18, which arguably a small sample size keeping in view the format of their study. They found that participants faced significant difficulties in translating all type of ambiguous sentences.

Some other interesting work is reported in literature where researchers tried to investigate how people generally process their second language. In one such work [21], the authors reported on an empirical study on Greek students to examine the difficulties they face while learning English as their second language. They found that Greek students who were facing difficulties in their native language also face difficulties in their second language, thus concluding that there is a strong linkage between processing native and non-native language. In another related work [22], the authors investigated in a cognitive-based experimental setting the effects of their native language on the non-native language. They showed that those constructions which are governed by the same linguistic rules, they exhibit similar neural processing. However, the lexically-driven constructions, which are different, similar neural activity does not occur for them. In [23], the authors report on a detailed literature review showing the effects of first language on the second language. They have observed that by and large researchers are agreed that the role of the native language in learning the second language depends on some similarities and dissimilarities between the two languages. In [24], the author investigated how the Spanish students learn and process the new content word in English as their second language. The limitation of their work is that they do not report convincingly on their findings, so it is difficult to assess their contribution. In [25], the researchers explored three different hypotheses for relative clause processing in the learners who learnt English as their second language. They observed a complementary relationship among the hypotheses in processing the relative clauses. In an interesting work [26], the authors studied the cognitive aspect of learning English as their second language. They found that those students who take English as their second language as medium of instruction, their reasoning capabilities in science-based subjects dropped significantly. In [27], the researchers investigated that second language learners perform better in judging long-distance object extraction than subject extraction. They conducted their study with a medium sample of 25 Chinese students whose second language was English. They found that it is parsing difficulty and lack of grammatical understanding which makes the sentence processing task challenging to the second language learners.

NIRS is a popular noninvasive brain-imaging technique [8], which has successfully been used in different studies, including language processing task [28, 29, 30, 31]. It uses light in a very narrow band (700-1000 mm), which propagates through different tissues in the human body and ultimately either it is absorbed or scattered. In the brain, changes in the optical absorption are related to the changes in both oxygen hemoglobin (oxy-Hb) and deoxygenated hemoglobin (deoxy-Hb). The multiple wavelengths' changes in the absorption of light can be used to estimate the concentration of oxy-Hb and deoxy-Hb, thereby localizing the brain areas, which were active or otherwise against a given task like language comprehension. Such changes in the brain concentration are assumed to be due to human's response to a given stimulation task, for example finger tapping, called functionally-evoked responses. In literature, it is very little reported how such changes in brain's concentration are happening when people process ambiguous text. Therefore, our study is timely and it is expected that our findings will pave way for further investigation in this interesting area.

III. Empirical Study

We conducted an experiment with human participants whose task was to read text on a computer screen. While the participants were reading the text, their brain activity was monitored using NIRS. Each participant completed 24 trials, where a trial consisted of a target sentence followed by a comprehension question. The trials were presented to the participants one trial at a time fashion, where all participants received all trials in exactly the same order.

A. Materials and Methods

We constructed a balanced dataset of 24 trials where 12 sentences involved potentially ambiguous PP-attachment noun phrases and the remaining 12 sentences were unambiguous; the latter are used as control for comparative analysis. A comprehension question was also associated with each sentence to ensure that participants carefully read the text to make sense of it. For instance, in one trial, the target sentence was 'Hassan saw Bilal with the telescope and then went away', and the comprehension question was 'Did Bilal held the telescope?'. For the purpose of brain imaging during the reading task, we opted for a block-design paradigm, in which a Rest-Task-Rest pattern is used. Since our task consisted of reading a piece of text followed by a comprehension question, we adapted the design as Rest-Task-Task, where first task was associated with reading the text and the second task was associated to answer the comprehension question. The task protocol setting is shown

in Fig. 1, which indicates that 5 seconds each are assigned to rest, the first task and the second task, respectively. The 5 seconds for reading the target sentence and comprehension question each were informed by a self-paced reading pilot study before running this experiment proper. This setting requires 15 seconds to complete a trial, and a total 360 seconds (24 trials x 15 seconds, i.e. 6 minutes) to complete the experiment for one participant.

For the brain-imaging purpose, we used Shimadzu's 44-channel LABNIRS system, with its default parameter settings, for example, the sampling time was 26 milliseconds for data acquisition. We used the well-known international 10-20 reference system [32] (as shown in Fig. 2) for positioning the channels (i.e., emitter-detector pair). Even though the channels were covering the area between occipital and temporal lobes, we are primarily interested in those channels that were positioned on Wernicke's area (as shown in Fig. 3, encircled area # 11) as it is associated with language comprehension.

Fig. 4 depicts a sample of the experiment setting during NIRS data acquisition while the participant is in the rest mode, i.e., with the blank computer screen. The NIRS computer screen shows the time-course for concentration in oxy-Hb, deoxy-Hb, and average of oxy-Hb and deoxy-Xb, which is extracted for a selected channel and shown in Fig. 2 for further analysis.

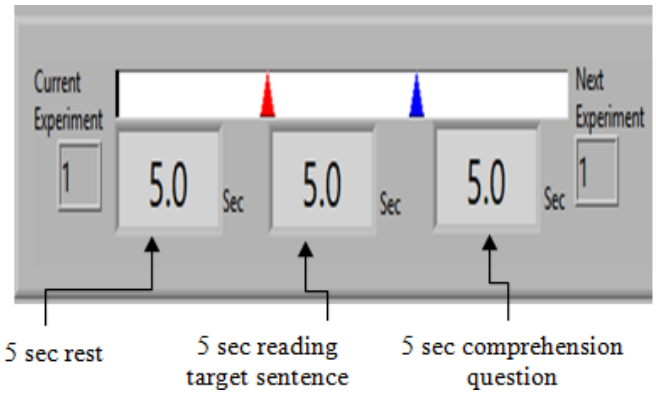


Fig. 1. Task Protocol.

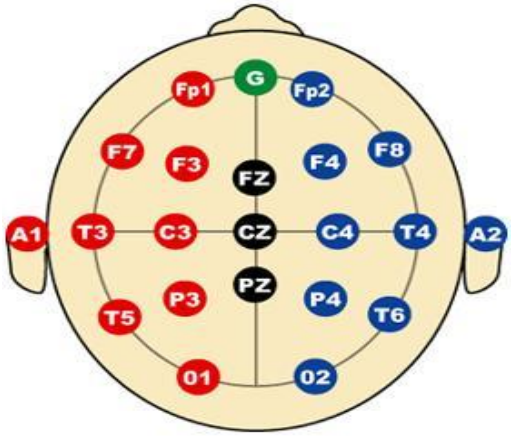


Fig. 2. International 10-20 System.

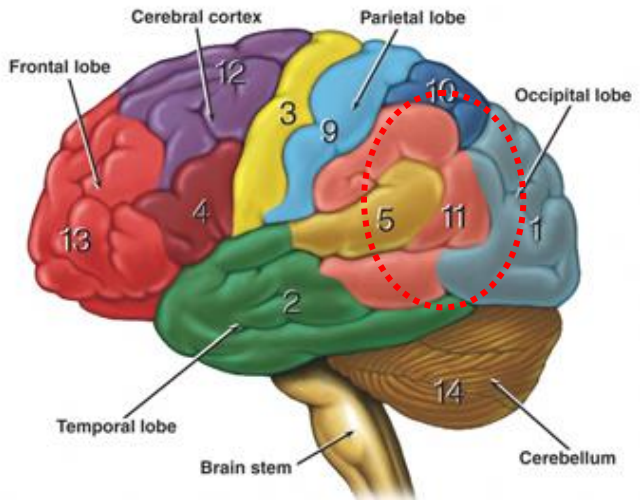


Fig. 3. Functional Areas of Human Brain.

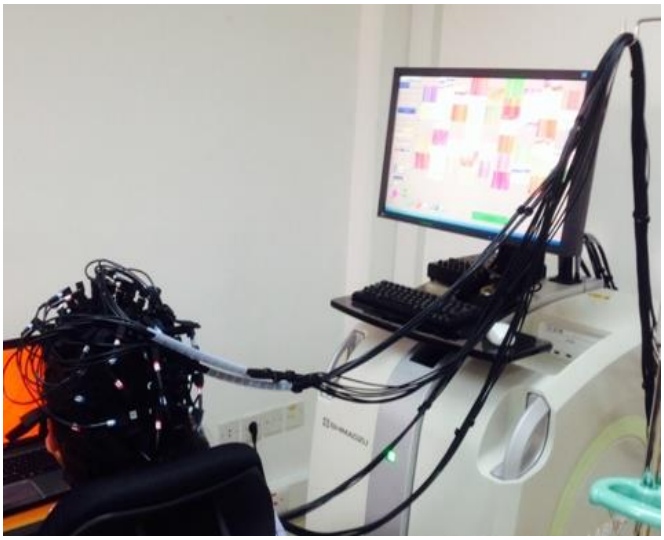


Fig. 4. Data acquisition using LABNIRS

B. Participants and Procedure

Twelve native-Arabic speakers who were self-reportedly fluent in English took part in this study. The participants were male students having normal vision with average age of 20 years. The study was conducted in accordance with the university code of ethics and all participants signed consent before the experiment. Before conducting the experiment, they were briefed about the purpose of the study and any effects of NIRS brain imaging. Before running the experiment proper, participants were presented with a sequence of 5 practice trials to familiarize themselves with the experiment procedure. The data from the practice trials were not recorded for analysis purposes. Participants were also briefed that they can willingly withdraw from the experiment at anytime if they want to; however, all the participants complete all the experiment trials.

Participants were presented with a sequence of trials where each trial began with a 5-seconds rest period during which participants were just relaxing. After the rest period, the target sentence appeared in a customized moving window fashion, in three parts. That is, first, a sequence of n words appeared on the screen for 1 second, then another sequence of m words appeared on the screen for 1 second and finally the last sequence of k words appeared on the screen for 1 second. For example, in the above example target sentence 'Hassan saw Bilal with the telescope and then went away', 'Hassan saw Bilal' appeared first for 1 second, then 'with the telescope' appeared and finally 'and then went away' appeared. This moving window fashion was driven by necessity in this study as we were interested more in the brain activity just after processing the ambiguity-inducing part (i.e., the second part 'with the telescope', in this example). The whole target sentence stayed on the screen for 5 seconds, which was sufficient time to comprehend the text. After the target sentence, the comprehension question appeared for 5 seconds. The participant had to answer the comprehension question by pressing left (Yes) or right (No) arrow key, which they were briefed as part of the instructions.

IV. Results and Discussion

We recorded the NIRS data for 10 channels at a sampling rate of 26 milliseconds. Each channel recorded both oxy-Hb and deoxy-Hb, but we used only oxy-Hb for analysis purposes as studies suggest that oxy-Hb and deoxy-Hb generally complement each other. Each channel recorded the time-series data for 24 trials (12 ambiguous sentences and 12 control sentences). Since NIRS provides markers to mark the end of a particular trial, we extracted the time series data for each trial from each channel for data-mining purposes. Additionally, NIRS also provides 3 markers to separate the Rest-Task-Task periods, we also extracted another set of data for 5 seconds, which covers the brain activity during which the target sentence was onset; these data are used for statistical analysis by using a paired t-test.

We used the hierarchical clustering in Weka for clustering the trials. This clustering technique is widely used in literature for data mining of time-series data, especially when the data size is reasonably large. There were a total of 2880 rows (= 10 channels x 24 trials x 12 participants) of time-series data. Initially, hierarchical clustering considers all 2888 data points as separate clusters and then it keep on merging them on similarity basis until some stopping criterion is met. Since in our case, there are two types of sentences, ambiguous and unambiguous, the clustering process stopped when there were only two clusters left in the hierarchy. The results elucidate that the hierarchical clustering was able to achieve 87% accuracy in discriminating between the brain activity required for processing ambiguous and unambiguous texts.

Fig. 5 shows the brain-activity data, where high peaks of oxy-Hb are associated to the time span when an ambiguous sentence was onset. Fig. 6 shows the brain-activity data for a channel that was positioned in the brain location, which does not involve in language related tasks. We used such channels as controls to ensure that NIRS data can be faithfully used to observe brain activity in certain regions of the brain and contrast them from other regions that remain passive during a certain task. It is clear from Fig. 5 that as expected, for the control sentences, oxy-Hb values are relatively higher than the rest period; however, these oxy-Hb values are significantly lower than the ones corresponding to ambiguous sentences.

Descriptive statistics of the oxy-Hb concentration during the task is shown in Table I. It is clear from Table I that as shown in Fig. 5, participants used more effort (mean oxy-Hb $\approx$ 0.027) in processing ambiguous sentences than the unambiguous sentences (mean oxy-Hb $\approx$ 0.018). The mean oxy-Hb values for the rest period (oxy-Hb $\approx$ 0.011) is less than reading both ambiguous and unambiguous sentences. A paired t-test was administered over the oxy-Hb peak values. We found that the difference between oxy-Hb for ambiguous and control text is significant ($p < 0.05$).

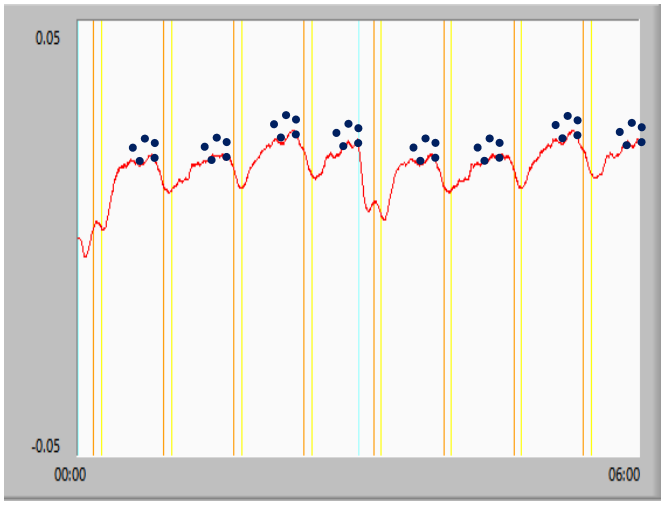


Fig. 5. Time-Course for Concentration in oxy-Hb for the Select Channel Indicating Brain Activity (Encircled Peaks Correspond to Brain Activity when a Trial Related to an Ambiguous Sentence was Onset).

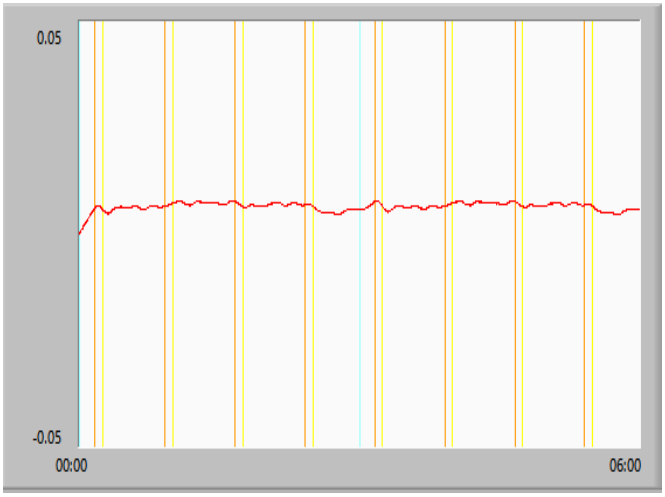


Fig. 6. Time-Course for Concentration in oxy-Hb for the Select Channel Indicating no Brain Activity in the Brain Region where the Channel was Positioned.

TABLE. I. DESCRIPTIVE STATISTICS OF THE OXY-HB CONCENTRATION DURING THE TASK

Task	Mean oxy-Hb	Standard deviation
Reading ambiguous sentence	0.0269	0.0107
Reading unambiguous sentence	0.0183	0.0096
Rest	0.0107	0.0018

These results suggest that Arabic speakers face significant difficulty while processing ambiguous text as compared to unambiguous text. Therefore, it is important to use sophisticated techniques to avoid (or manage) ambiguity while authoring English language documents for Arabic speakers who learn or use English as their second language. Our findings also corroborate with previous findings that non-native speakers generally face difficulty in processing their second language.

One limitation of our work is that we explored a small dataset and the number of participant was also relatively small. However, depending on the nature of the study this limitation is not very much daunting as in such studies it is generally difficult to recruit large number of participants and also it is difficult to manage such experiment when the number of trials increases. The latter is true because with six minutes of NIRS data recoding for a participant, the size of one NIRS generated data goes beyond 35 MB; so with large number of participants and the large number of trials it would be very hard to analyze the data in a meaningful way.

V. CONCLUSION

In this study, we investigated empirically how native-Arabic speakers process English as their second language, especially when English language text involves ambiguity. As a case study, we focused on PP-attachment ambiguity, which is a challenging task for human in processing language. We conducted an empirical study with 12 native Arabic speakers who were fluent in English language. Their task was to read two types of texts, one involving PP-attachment ambiguity and the other unambiguous text (control), during which their brain activity was also monitored using NIRS to gauge the difficulty they faced during the reading task. The NIRS data for ambiguous and control text were recorded and subsequently analyzed using hierarchical-clustering technique to discriminate between the processing of ambiguous and unambiguous text. We found that Arabic speakers generally face difficulty in processing ambiguous text. Our findings are consistent with previous findings in this area, especially using self-paced reading paradigm with native speakers.

VI. FUTURE WORK

In future, we intend to extend this study by using other types of ambiguities as well on relatively a large pool of dataset. We also intend to pursue a self-study paradigm, with non-native English speakers, to examine whether self-paced reading data can be trustfully used to predict human brain activity, which otherwise needs more expensive and difficult techniques to be administered like brain imaging using NIRS or functional magnetic resonance imaging (aka fMRI).

ACKNOWLEDGMENT

This work was funded by the Deanship of Scientific Research (DSR), King Abdulaziz University, Jeddah, under grant No. 611-010-D1433. The author, therefore, acknowledge with thanks DSR technical and financial support.

REFERENCES

[1] G. T. Altmann, "Ambiguity in sentence processing.," Trends in cognitive sciences., vol. 2, no. 4, pp. 146-152, 1998.

[2] L. Frazier and K. Rayner, "Resolution of syntactic category ambiguities: Eye movements in parsing lexically ambiguous sentences.," Journal of memory and language., vol. 26, pp. 505-526, 1987.

[3] F. Ferreira and C. Clifton, "The independence of syntactic processing.," Journal of memory and language., vol. 25, no. 3, pp. 348-368, 1986.

[4] D. Hindle and M. Rooth, "Structural ambiguity and lexical relations.," Computational Linguistics, pp. 103-120, 1993.

[5] J. Kimball, "Seven principles of surface structure parsing in natural language.," Cognition., vol. 2, pp. 15-47, 1973.

[6] C. Phillips, "Right association in parsing and grammar.," in Proceedings in language processing and acquisition., 1995.

[7] H. Heekeren, H. Obrig, R. Wenzel, K. Eberle, J. Ruben, K. Villringer, R. Kurth and A. Villringer, "Cerebral haemoglobin oxygenation during sustained visual stimulation: a near infrared spectroscopy study.," Philosophical Transactions of the Royal Society of London B: Biological Sciences, vol. 352, no. 1354, pp. 743-750, 1997.

[8] A. Villringer and B. Chance, "Non-invasive optical spectroscopy and imaging of human brain function.," Trends Neurosci, vol. 20, no. 10, pp. 435-442, 1997.

[9] S. Stevenson, "A Competition-based explanation of syntactic attachment preferences and garden path phenomena.," in Proceedings of the 31st annual association for computational linguistics., 1993.

[10] J. C. Trueswell and M. K. Tanenhaus, "Toward a lexicalist framework of constraint-based syntactic ambiguity resolution.," in Proceedings in perspectives on sentence processing., Hillsdale, NJ, US, 1994.

[11] P. Nakov and M. Hearst, " Using the web as an implicit training set: application to structural ambiguity resolution.," in Proceedings of the conference on human language technology and empirical methods in natural language processing., 2005.

[12] A. Ratnaparkhi, J. Reynar and S. Roukos, "A maximum entropy model for prepositional phrase attachment.," in Proceedings of the ARPA human language technology workshop., 1994.

[13] M. Collins and J. Brooks, "Prepositional phrase attachment through a backed-off model.," in Proceedings of the third workshop on very large corpora., 1995.

[14] S. Zhao and D. Lin, "A nearest-neighbor method for resolving PP-attachment ambiguity.," in Proceedings of the first international joint conference on natural language processing (IJCNLP-04)., 2004.

[15] M. Olteanu and D. Moldovan, "PP-attachment disambiguation using large context.," in Proceedings of human language technology conference and conference on empirical methods in natural language processing (HLT/EMNLP)., 2005.

[16] K. Daimi, "Identifying syntactic ambiguities in single-parse Arabic sentence.," Department of mathematics and computer science, University of Detroit Mercy, 2001.

[17] E. Othman, K. Shaalan and A. Rafea, "A chart parser for analyzing modern standard Arabic sentence.," in MT summit IX workshop on machine translation for semitic languages: issues and approaches, New Orleans, Louisiana, USA, 2003.

[18] E. Othman, K. Shaalan and A. Rafea, "Towards resolving ambiguity in understanding Arabic sentence.," in Proceedings of international conference on Arabic language resources and tools, 2004.

[19] R. Al-sabbagh and K. Elghamry, "A Web-based approach for Arabic PP-attachment.," in Proceedings of the 6th international conference on informatics and systems., Cairo, Egypt, 2008.

[20] M. I. Khawalda and E. M. Al-Saidat, "Structural ambiguity interpretation: a case study of Arab learners of English.," Global journal of human social science., vol. 12, no. 6, 2012.

[21] G. Andreou and M. Segklia, "Learning difficulties in first and second language: preliminary results from a cross-linguistic skills transfer.," English linguistics research., vol. 6, 2017.

[22] L. Sabourin and L. Stowe, "Second language processing: When are first and second languages processed similarly?," Second language research., vol. 24, pp. 397-430, 2008.

[23] P. Durán Escribano, "Exploring cognition processes in second language acquisition: the case of cognates and false-friends in EST.," Ibérica revista de la asociación Europea de lenguas para fines específicos., pp. 87-106, 2004.

[24] A. Derakhshan, "The interference of first language and second language acquisition.," Theory and practice in language studies., vol. 5, no. 10, pp. 2112-2117, 2015.

[25] S. Izumi, "Processing difficulty in comprehension and production of relative clauses by learners of English as a second language.," Language learning., vol. 53, no. 2, pp. 285-323, 2003.

[26] A. H. Johnstone and D. Selepeng, "A language problem revisited.," Chemistry education: Research and practice in Europe., vol. 2, no. 1, pp. 19-29, 2001.

[27] A. Juffs and M. Harrington, "Parsing effects in second language sentence processing: subject and object asymmetries in wh-extraction.," Studies in second language acquisition., vol. 17, no. 4, pp. 483-516, 1995.

[28] A. Ehlis, M. Herrmann, M. Plichta and A. Fallgatter, "Cortical activation during two verbal fluency tasks in schizophrenic patients and healthy controls as assessed by multi-channel near-infrared spectroscopy.," Psychiatry Research., vol. 156, no. 1, pp. 1-13, 2007.

[29] B. Ambridge and C. F. Rowland, "Experimental methods in studying child language acquisition.," Cognitive science., 2015.

[30] O. Takeuchi, M. Ikeda and A. Mizumoto, "The cerebral basis for language learner strategies: A near-infrared spectroscopy study.," Reading in a foreign language. , vol. 24, no. 2, pp. 136-157, 2012.

[31] M. A. Hall, Temporal mapping and connectivity using NIRS for language related tasks., Florida international university., 2012.

[32] V. Diekmann, W. Becker, R. Jürgens, B. Grözinger, B. Kleiser, H. Richter and K. Wollinsky, "Localisation of epileptic foci with electric, magnetic and combined electronic models.," Electroencephalogr Clin Neurophysiol, vol. 106, pp. 297-313, 1998.

Discovering Gaps in Saudi Education for Digital Health Transformation

Adeeb Noor
Department of Information Technology
Faculty of Computing and Information Technology (FCIT)
King Abdulaziz University (KAU), Jeddah (80221), Kingdom of Saudi Arabia (KSA)

***Abstract*—The growing complexity of healthcare systems worldwide and the medical profession's increasing dependency on information technology for accurate practice and treatment call for specific standardized education in health informatics programming, and accreditation of health informatics programs based on core competencies is progressing at an international level. This study investigates the state of affairs in health informatics programs within the Kingdom of Saudi Arabia (KSA) to determine (1) how well international standards are being met and (2) what further development is needed in light of KSA's recent eHealth initiatives. This descriptive study collected data from publicly available resources to investigate Health Informatics programs at 109 Saudi institutions. Information about coursework offered at each institution was compared with American Medical Informatics Association (AMIA) curriculum guidelines. Of 109 institutions surveyed, only a handful offered programs specifically in health informatics. Of these, most programs did not match the coursework recommended by AMIA, and the majority of programs mimicked existing curricula from other countries rather than addressing unique Saudi conditions. Education in health informatics in KSA appears to be scattered, non-standardized, and somewhat outdated. Based on these findings, there is a clear opportunity for greater focus on core competencies within health informatics programs. The Saudi digital transformation (eHealth) initiative, as part of Saudi Vision 2030, clearly calls for implementation of internationally accepted health informatics competencies in education programs and healthcare practice, which can only occur through greater collaboration between medical and technology educators and strategic partnerships with companies, medical centers, and governmental institutions.**

Keywords*—Health informatics; education; information technology; American Medical Informatics Association (AMIA); Saudi Arabia; vision 2030

I. Introduction

The professions of healthcare cover a vast and growing number of fields, many of which are ever evolving and increasingly interdisciplinary. The broad span of healthcare requires a complex conglomeration of skills and knowledge that both generates and utilizes a staggering network of biomedical data for the study, research, analysis, and administration of our physical quality of life. The management and leveraging of these resources has led to the developing interdisciplinary field of health informatics [1, 2]. One of the challenges to this development lies in addressing the ambiguity and sheer breadth of health informatics, which is referenced in literature and in practice under many names and categories, including medical informatics, medical information technology, and others. Several organizations have created a spectrum of subcategories in an attempt to classify the many faces of health informatics, with considerable emphasis on establishing and maintaining standards of education.

In comparing curricula of biomedical and health informatics programs in the United States, Kampov-Polevoi and Hemminger [3] determined that programs varied widely in terms of the professional competencies required for health informatics and in the key content of supporting curricula. This gap provided the impetus for their research, which attempted to provide a holistic view of current educational options. Kampov–Polevoi and Hemminger also acknowledged that, at the time of their study, the debate surrounding the definition of the fields of biomedical and healthcare informatics had already spanned decades [4-11]. By 2012 the effects of this identity confusion finally became a priority for those seeking to clarify the competencies needed for accreditation in these fields.

In 2012, a white paper from the American Medical Informatics Association (AMIA) [1] outlined an initial set of competencies to serve as the basis for collaboration with the Commission on Accreditation for Health Informatics and Information Management (CAHIIM) in 2015. Out of this collaboration, the Health Informatics Accreditation Council (HIAC) was born, an organization whose mandate was to set "Accreditation Standards for Masters' Degree Programs in Health Informatics." This process resulted in the establishment of a set of foundational domains defining health informatics. These efforts of AMIA and other members of the International Medical Informatics Association (IMIA) have attempted to standardize programs of study in health informatics on an international level. However, colleges and universities have historically developed their curricula based on internal decision-making processes, not necessarily based on the recommendations and practices of outside organizations, whether academic, industrial, or governmental.

As our world continues to evolve technologically, politically, and in size of population, standardizations in the management of healthcare systems are becoming increasingly critical. The days of small clinics and independent hospitals with extremely proprietary filing systems are approaching extinction. With the growing complexity and variety of methods, treatments, services, and equipment, the breadth and

complexity of the corresponding informatics for managing this growth naturally follows closely behind. As is the case with most changes at the national level in any country, the adaptation of the healthcare industry varies by culture and established institutions and practices.

From these observations in the international environment, we shift our focus specifically to the current state of affairs for obtaining education in health informatics in the Kingdom of Saudi Arabia (KSA). Understanding the challenges faced by the Saudi government in implementing nationwide standards of education in health informatics provides a perspective that could have broader implications for international education in this field. A study of these challenges could provide insight to students seeking technical education for healthcare fields, institutions working toward accreditation, researchers tracking the progress of development in the field of health informatics, and administrators seeking guidance for addressing the current state of affairs in their own contexts. Additionally, development of educational programs in health informatics across Saudi Arabia fits squarely within the purview of the eHealth strategy of the Saudi Ministry of Health (MOH) because of the government's Saudi Vision 2030 initiative to achieve digital transformation in healthcare. A recent study shows a strong need for E-health systems to be integrated on a national level [12], thus highlighting the demand for qualified new graduates who can lead this transformation.

The aim of this paper is to study the importance of education standards in achieving health digital transformation specifically in the KSA. First, the paper begins with a literature review of related work (Section II), followed by a description of the methods used (Section III) and results found (Section IV). The paper concludes with discussion of findings and challenges in the evaluation of KSA's health informatics programs (Section V) and suggestions for curriculum improvements and future research (Section VI).

II. Related Work

Several studies have already begun exploring the context of Saudi health informatics education. Altwaijiri and Aldosari [13] published a paper proposing the creation of a master's program adaptation based on the programs of three universities in the USA, Canada, and Australia. While this effort was a notable and organized attempt at developing health informatics programs for a single university, the approach taken was one of wholesale adoption and adaptation of targeted foreign programs rather than identifying and weighing specific core competencies for robust development and future-proofing. Four other works [14-17] have demonstrated the importance of health informatics in learning and decision-making but without focusing on the development of specific health informatics programs. Asiri [18] published a brief overview of some health informatics programs offered by Saudi educational institutions and attempted to address the challenges faced in the KSA and the international community as health informatics education is improved. These efforts to address and advise based on current research are laudable, though there is still room for other perspectives and no definitive solutions have yet surfaced. Fortunately, awareness is growing. Fallatah [19] published a work focusing on the need for collaboration and teamwork as a part of inter-professional education (IPE) in order to prevent medical errors and promote the advancement of healthcare in the KSA. Another recent work suggests that the Saudi Health Informatics Competency Framework (SHICF) could be used to establish health informatics standards for the kingdom [20].

This interdisciplinary and collaborative aspect of healthcare education, already well-recognized in the west, is beginning to make its way into the curricular programs of the KSA. By focusing on these programs, the following research provides a rapid, precise, and professional vision for those with a vested interest in health digital transformation development, not only in Saudi Arabia but also in other Arab and developing nations.

III. Methods

As with the ambiguities that have persisted in classifying and standardizing the skills and education of the fields of health informatics on an international level, ambiguities also exist when reviewing related educational programs and courses within the KSA. In an attempt to clarify some of these ambiguities, the Faculty of Computing and Information Technology at King Abdulaziz University conducted a descriptive survey in August 2018 to learn about the structure of educational programs and availability of key courses at schools listed by the Saudi Ministry of Education (MOE). This work is the exposition and analysis of the findings of that survey.

Public information sources were used whenever possible in order to replicate the experience of a layperson seeking knowledge through government resources, official websites, information published (officially or tangentially) on the public internet, and direct email and voice communications with those officially involved in the administration of programs and courses. Searches were carefully limited to reliable channels that would be accessible and comprehensible to persons with a moderate understanding of the nature and fields of health informatics, such as potential students or non-specialized professionals seeking information about educational offerings or trying to evaluate the merits of enrollment. Thus, initial internet data was collected through use of a simple Boolean logic search ([URL of the University] OR [Name of the University in Arabic] OR [Name of the University in English]) AND (health Informatics OR medical Informatics OR bioinformatics)) was used. When the Boolean search did not return information about health informatics programs at a given institution, the researchers contacted institutional administrators directly in order to ascertain whether the university, in fact, offered no health informatics coursework or whether these courses were simply not included as a part of the institution's online presence.

Using these methods, a sample was collected consisting of information about programs and courses at 109 colleges and universities located throughout the KSA, including public, private, and military schools. For those schools listing specific programs in health informatics, the availability of course offerings matching the AMIA recommendations were also examined.

IV. Results

For the current research, determination of the origins and motivations for existing programs and courses specific to health informatics proved inconclusive due to the lack of information made publicly available by the surveyed academic institutions. Only 10 of the 109 academic institutions surveyed openly offered programs specific to health informatics, with most of these being bachelor's degree programs. Programs related to medical coding appeared to be disproportionately prevalent. This is most likely because medical coding is considered a certification path rather than simply one course offered within a curriculum. For the programs specifically pertaining to "Health Informatics", all 109 academic institutions were considered by region and by type in order to provide a geographic and political breakdown.

Fig. 1 shows a geographic breakdown indicating that the number of surveyed academic institutions located in the central and western regions of the KSA dominated more than 50% of the sample.

This is unsurprising as those regions include the cities of Riyadh, Jeddah, Madinah, and Makkah, which have longstanding academic institutions. However, Fig. 2 shows that surveyed academic institutions with specific health informatics programs were concentrated in the central and eastern regions of the KSA with 80% of the sample.

Fig. 3 shows a political breakdown by type of academic institution and indicates that the surveyed academic institutions were overwhelmingly public by a nearly 3 to 1 margin over the private institutions and an 11 to 1 margin over the military institutions.

In even greater relief, Fig. 4 shows that 4 out of 5 of the surveyed academic institutions with specific health informatics programs were public with military institutions having no showing at all. As previously mentioned, out of the 109 surveyed institutions, only 10 had programs specifically labeled as "health informatics". Information was gathered regarding the curricula of these 10 surveyed programs regarding the similarity of their courses to 22 courses recommended by AMIA for health informatics programs.

This review only took into account whether a comparable course was offered in each program. It was found that on average each program offered half of the 22 courses, although which of the 22 courses varied considerably by program. Only 6 of the 22 recommended courses were offered in 7 or more programs. The minimum number of the recommended courses offered by any program was 3, while the maximum number offered by any one program was 20. These minimal and maximal cases were extreme outliers with all remaining numbers of courses being heavily concentrated between 7 and 14. Table I demonstrates the list of courses along with an indication of how many of the 10 universities offered each course.

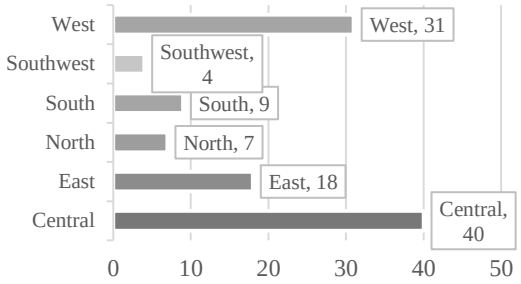


Fig. 1. Number and Proportion of Schools Aurveyed by Region.

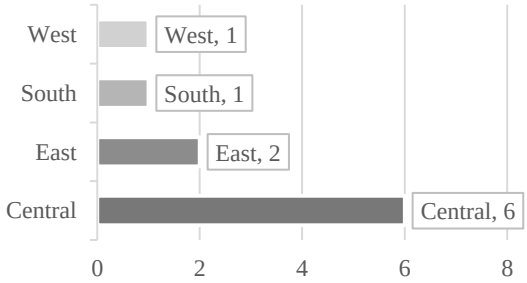


Fig. 2. Number and Proportion of Schools Aurveyed with a Health Informatics Program by Region.

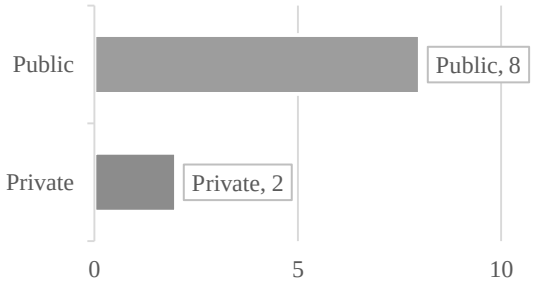


Fig. 3. Number and Proportion of Schools Surveyed by Type.

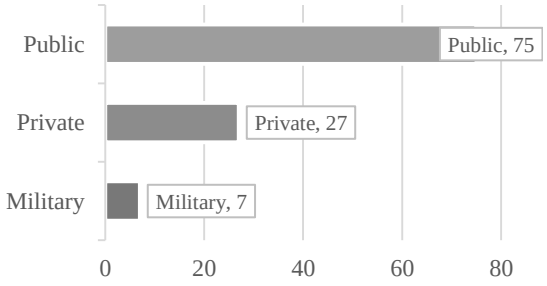


Fig. 4. Number and Proportion of Schools Surveyed with a Health Informatics Program by Type.

TABLE. I. COURSES RECOMMENDED BY THE AMERICAN MEDICAL INFORMATICS ASSOCIATION[3]

Name of course	Occurrences out of 10 universities
Introduction to Health Informatics	5
Public Health Informatics	6
Electronic Health Records	5
Coding System	7
Research Methodology	8
Epidemiology	8
Biostatistics	7
Data Mining	3
Data Warehousing	3
Decision Support System	5
System Analysis and Design	5
Computer Programing	4
Database Management Systems	7
Information Security	6
Human Computer Interaction	1
Health Promotion and Education	4
Global Health	3
Legal and Ethics in Health Informatics	9
Health Economics	4
Interdisplinary Perspectives	1
Organization Behaviors	5
Leadership in Healthcare	2

V. DISCUSSION

Although the findings seem to show clear gaps in health informatics education in the KSA, several limitations of the research must be noted. One limitation was the use of common Boolean search patterns for gathering internet-based information. The breadth of competencies that fit into the interdisciplinary field of health informatics is vast and often difficult to specifically label as pertinent to health informatics. The ever-evolving nature of health informatics, particularly regarding education and training, is still being defined.

In addition, because health informatics is referred to by many different names and can be housed in many different academic departments, the Boolean search did not always yield complete results, even when related courses existed. Health Informatics programs were offered within various departments, such as medical or computer science departments, with little indication as to where to search. This is likely due to the interdisciplinary nature of the field and the lack of attribution of data-related and analysis courses specifically pertinent to health informatics. Many of the websites of the academic institutions did not provide specific descriptions of the courses offered within their departments. Offline efforts to inquire further into the programs did not usually yield any additional information. These outcomes are not necessarily specific to health informatics but are potentially exacerbated by lack of awareness and focus on health informatics at the departmental level. In short, programs and courses exist, but finding them and specifically identifying them proved difficult, thus showing that popularity and awareness of health informatics fields is not yet pervasive. To help address this, there is an ongoing annual conference for health informatics (http://www.saudi-ishic.com) directed at increasing awareness in the KSA.

From the onset of the survey, attempts to inquire into programs and courses related to health informatics for the 109 colleges and universities throughout the KSA proved difficult. A vast array of fields and subcategories fall within the scope of health informatics with most institutions either not providing any specifics or focus in fields related to health informatics or only referencing specifics when the nature of the course was strongly oriented towards a specific field. For example, Research Chair for Health Informatics (http://rchip.org) was found to be a specialized training program specific to health informatics. However, the lack of specification for health informatics programs and courses appeared to be greater than the inconsistencies noticed in documentation of other programs and courses in more traditional fields.

At some universities, health informatics coursework was offered through medical or healthcare departments, whereas at other institutions it was housed under the umbrella of information technology or computer science. To further complicate matters, academic programs at Saudi universities are not always well documented. Some institutions do not offer specific course descriptions on their websites, necessitating direct communication with faculty and administrators in order to determine the nature of coursework within their departments. These communications sometimes provided inaccurate or inconsistent information or referrals. For instance, officials in some cases communicated that existing programs did not exist or made referrals to incorrect contacts or departments at the institution. These situations presented significant challenges for gathering consistent information about each school's health informatics offerings.

For these and other reasons, names of specific institutions have not been mentioned in this paper. This is to prevent undue criticism where such criticism may not be warranted. In many cases, health informatics may not have matched the primary focus of an institution, while in other situations the very changing nature of the health informatics field presented challenges in documenting exactly what training was being provided.

Despite efforts to standardize accreditation at the international level through the IMIA, of which the KSA is a member via the Saudi Association for Health Informatics (SAHI), the effects of such standardizations require prioritization and time. As health informatics is a still-evolving collection of fields, skills, and knowledge, it is necessary for the institutions of education to be constantly vigilant and to remain apprised of current best practices. Unfortunately, at the time of writing of this manuscript, the SAHI website (http://www.sahi.org.sa/) was advertising conferences and seminars for 2015 and 2017, nearly four and two years out of date. Clearly, if the focus on events provided by the national representative of the KSA in IMIA is this outdated, this does not bode well for the programs and courses of the educational institutions of the KSA, which take far more time to develop and update. This observation is also reinforced by the lack of published literature regarding health informatics programs in the KSA. Hopefully, the information gathered and surveyed for this work regarding existing curricula and programs will contribute to filling this gap and

provide greater focus on the state of Saudi health informatics education.

VI. Conclusion

While standardization efforts have been made at the international level for identifying and classifying core competencies in health informatics at the graduate level, this is an ongoing process due to the relative newness of the discipline as well as the ever-changing skills and knowledge associated with managing and maintaining the well-being of humanity. With each nation adopting and interpreting courses and programs pertaining to health informatics in its own academic institutions, this study has found that there is great room for advancement in standardizing accredited programs and courses in the field of health informatics in the Kingdom of Saudi Arabia. The general lack of information and specifics about health informatics programs found from surveying 109 universities and colleges in the KSA is due partly to incomplete or missing descriptions of courses and programs on websites and other materials made available to the public. It was not usually apparent which department or program to search for when looking for this information, and attempts to contact departments for additional information were often misleading or inconclusive.

If health informatics education in KSA is to improve, research must be prioritized at both academic and national levels, especially in understanding core competencies within the fields of health informatics. Out of the 109 institutions surveyed in this research, only 10 offered specific programs in health informatics, and those programs offering, on average, only half of the 22 courses recommended by the AMIA. Is this because international standards do not match the needs of KSA healthcare programs or facilities? Is more financial investment in health technology needed, or is the critical issue one of human resources and better training in the use and teaching of health informatics? These questions can be answered through further research and focused development of KSA's health informatics education programs.

To support this research, the Ministries of Health and Education may need to not only augment their own collaboration but also forge new strategic partnerships with companies, medical centers, and governmental institutions, all with the objective of promoting specific educational programs in health informatics that will lead to practical healthcare applications. Such partnerships would provide opportunity to develop benchmark programs for health digital transformation within the Arab World and developing nations, realizing the MOH's eHealth initiative and helping to achieve Saudi Vision 2030.

Declaration of Interest--The authors report no declarations of interest.

Acknowledgments

We acknowledge support from King Abdulaziz University, Jeddah, Saudi Arabia.

References

[1] Kulikowski, C., Shortliffe, E., Currie, L., Elkin, P., Hunter, L., Johnson, T., Kalet, I., Lenert, L., Musen, M., Ozbolt, J., Smith, J., Tarczy-Hornoch, P. and Williamson, J. AMIA Board white paper: "Definition of biomedical informatics and specification of core competencies for graduate education in the discipline." J Am Med Inform Assn, vol. 19, no. 6, pp.931-938, 2012.

[2] Fridsma, D. "The scope of health informatics and the Advanced Health Informatics Certification." J Am Med Inform Assn, vol. 23, no. 4, pp.855-856, 2016.

[3] Kampov-Polevoi, J. and Hemminger, B. "A curricula-based comparison of biomedical and health informatics programs in the USA." J Am Med Inform Assn, vol. 18, no. 2, pp.195-202, 2011.

[4] Hasman, A., Haux, R. and Albert, A. "A systematic view on medical informatics."Comput Meth Prog Bio, vol. 51, no. 3, pp.131-139, 1996.

[5] Huerta, M., Downing, G., Haseltine, F., Seto, B., and Liu Y. "NIH working definition of bioinformatics and computational biology." US National Institute of Health, Jul 17, 2000.

[6] Miller, P. "Opportunities at the intersection of bioinformatics and health informatics: A case study."J Am Med Inform Assn, vol. 7, no. 5, pp.431-438, 2000.

[7] Mantas, J. and Hasman, A. Textbook in health informatics. Amsterdam: IOS Press. 2003.

[8] Staggers, N. "The evolution of definitions for nursing informatics: A critical analysis and revised definition." J Am Med Inform Assn, vol. 9, no. 3, pp.255-261, 2002.

[9] Shortliffe, E.H. and Blois, M.S. "The computer meets medicine and biology: emergence of a discipline." In Biomedical Informatics, pp. 3-45. Springer, New York, 2006.

[10] Gardner, R., Overhage, J., Steen, E., Munger, B., Holmes, J., Williamson, J. and Detmer, D. "Core content for the subspecialty of clinical informatics." J Am Med Inform Assn, vol. 16, no. 2, pp.153-157, 2009.

[11] Hersh, W. "A stimulus to define informatics and health information technology." BMC Med Inform Decis, vol. 9, no. 1, 2009.

[12] Noor, A. "The Utilization of E-health in the Kingdom of Saudi Arabia." International Research Journal of Engineering and Technology, vol. 6, no. 9, pp. 1229-1239, Sep, 2019.

[13] Altwaijiri, M. and Aldosari, B. "Health informatics Master program at King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia."Yearbook of Medical Informatics, vol. 17, no. 1, pp.145-149, 2008.

[14] Albarrak, A. "Designing e-learning systems in medical education: A case study." International Journal of Excellence in Healthcare Management, vol. 183, no. 3119, pp. 1-9, Jun, 2010.

[15] Albarrak, A.I. "E-learning in medical education and blended learning approach." Learning, vol. 13, pp. 14-20, 2011.

[16] Househ, M.S., Saddik. B., and Al-Dosari. B. "Development of a graduate level course in e-health and emerging technology in Saudi Arabia." St Heal T, pp. 69-73, Feb 9, 2011.

[17] Bahkali, S., Almaiman, A., Almadani, W., Househ, M.S., and El Metwally, A. "The state public health informatics in Saudi Arabia." St Heal T, pp. 257-260, Jul 24, 2014.

[18] Asiri, H. A. "Challenges of the health informatics education in the Kingdom of Saudi Arabia: What stands in our way?" Journal of Health Informatics in Developing Countries, vol. 8, no. 1, Apr 8, 2011.

[19] Fallatah, H. "Introducing inter-professional education in curricula of Saudi health science schools: An educational projection of Saudi Vision 2030." Journal of Taibah University Medical Sciences, vol. 11, no. 6, pp.520-525, 2016.

[20] Almalki, M., Househ, M., and Alhefzi, M. "Developing a Saudi Health Informatics Competency Framework: A Comparative Assessment." St Heal T, vol. 264, pp. 1101-1105, 2019.

Performance Comparison of Collaborative-Filtering Approach with Implicit and Explicit Data

Fitri Marisa*[,1], Sharifah Sakinah Syed Ahmad[2], Zeratul Izzah Mohd Yusoh[3], Tubagus Mohammad Akhriza[4]
Wiwin Purnomowati[5], Rakesh Kumar Pandey[6]

Informatics Engineering, University of Widyagama, Jl. Borobudur no. 35 Malang, +62-341-482282, Indonesia[1]
Research fellow of Department of Science Technology (DST) under AIRTF Program -RTF/2018/000033 India[1]
Centre for Advanced Computing Technology, Faculty of Information and Communication Technology
Universiti Teknikal Malaysia Melaka, Jalan Hang Tuah Jaya, Durian Tunggal, Melaka 76100, Malaysia[1,2,3]
Pradnya Paramita School of Informatics and Computer, Jl. LA Sucipto no. 249A Malang, Indonesia[4]
Accounting, University of Widyagama, Jl. Borobudur no. 35 Malang, +62-341-482282, Indonesia[5]
Kirori Mal College – University of Delhi – North campus Delhi 110007- India[6]

***Abstract*—Challenge in developing a collaborative filtering (CF)-based recommendation system is the problem of cold-starting of items that causes the data to sparse and reduces the accuracy of the recommendations. Therefore, to produce high accuracy a match is needed between the types of data and the approach used. Two approaches in CF include user-based and item-based CFs, both of which can process two types of data; implicit and explicit data. This work aims to find a combination of approaches and data types that produce high accuracy. Cosine-similarity is used to measure the similarity between users and also between items. Mean Absolute Error is also measured to discover the accuracy of a recommendation. Testing of three groups of data based on sparseness results in the best accuracy in an explicit data-based approach that has the smallest MAE value. The result is that the average MAE value for user based (implicit data) is 0.1032, user based (explicit data) is 0.2320, item based (implicit data) is 0.3495, and item based (explicit data) is 0.0926. The best accuracy is in the item-based (explicit-data) approach which is the smallest average MAE value.**

Keywords—Recommender system; collaborative-filtering; user-based; item-based; implicit-data; explicit-data

I. INTRODUCTION

Mining on data of the small-medium enterprises (SME), is currently needed to improve their progress [1]. Many data mining approaches can be used to explore and utilize the data, such as to make use the data in developing recommendation system (RS). Among the existing aspects, type of data to be processed by RS is an important knowledge to know by the analysts.

RS is defined as an intelligent agent that advises users to find items that are more attractive to them, where users do not need to be involved with data stacks that are not related to their needs [2]. RS can be applied in many fields, for example in e-commerce, RS is useful for recommending items that suit the interests and needs of users; In digital libraries, RS provides recommendations about books or other media that are relevant to user needs [3].

Currently the recommendation system is classified into three: Content-based-filtering, Collaborative-filtering, and hybrid-recommender-systems[4],[5],[6]. One well-known RS approach is the collaborative filtering (CF) method which processes data to produce recommendations based on user's rating preference on the item, where recommendations are generated from implicit or explicit data[7],[8].[9],[10]. The first data type is generated from the flow of transactions that already exist in the system that can be indirectly claimed as customer behavior, such as data on transactions for the purchase of goods, rental of goods; whereas the second type is data generated from planned data collection strategies obtained from users and to be managed in RS. These two types of data certainly have different characters and if processed in a CF approach will produce different results as well [11],[12],[13]. Because suggested objects can be either users or items, CF methods are also developed based on these targets. To simplify, we use terms user-based and item-based RS to represent these approaches respectively. In user-based CFs, as recommended objects are items, each user is represented as an item vector. Conversely, when recommending users in item-based CF, each item is presented as a user vector. Similarities between users are measured using the cosine similarity metric, as well as measuring the similarity of items.

However, the CF method must overcome the cold-start problem on new items that have not been rated by any user. [14] As a result, the data and hence also the matrix representing the data become sparse and can result in decreased accuracy of the recommendations produced.

This paper discusses the performance comparison of user-based and item-based CFs on implicit and explicit data. The data used in experimental work is a real transaction data taken from SMEs that sell electronic cellular data. The data is divided into three groups based on 10%, 30%, and 50% of rating sparseness in the matrix. Calculations are performed to determine accuracy using an average of Mean Absolute Error (MAE); and as a result, the smallest average MAE value is found in item-based CFs with explicit data that shows the highest level of accuracy.

*Corresponding Authors

II. Related Works

A. Recommender System

The RS is designed to help users by proposing options of needed items which can also be presented in the form of personalization to predict user interests and preferences by relying on information-seeking behavior so that they can make the search process effective [2][13]. Some studies categorize Recommender-Systems with different categories. According to [13], RS is categorized as four categories: CF, Content-Based Filtering, Knowledge-Based Filtering, and Hybrid-based. In another study, RS is defined based on information gathered and classified into some different types in addition to those mentioned earlier i.e. Demographic based RS, Knowledge based RS, and Utility based RS [5].

B. Collaborative Filtering based Recommender System

The CF based RS is the earliest and most successful method in RS development and implementation. CF has shown good performance in managing data-sets to extract preference information that is more difficult to find intuitively. It is a method that makes an automatic prediction by filtering user interests by gathering information preferences from the number of collaborating users. One of its advantages over content-based is that CF can recommend items without additional computing costs or copyright issues involved with processing items directly. Collaborative filtering is generally claimed to be one of the most successful recommendation techniques [7] [15]. There are two types in Collaborative-Filtering: User-based and Item-based [16]. User-based is oriented to user preference data, while Item-based is oriented to product item preferences.

In general, CF relies on explicit feedback collected directly from users by means of a direct survey presented with a rating model. However, explicit-data has some challenges in difficulty of data collection. It is not easy to get data users who voluntarily give an assessment of the product.[16]. Therefore, implicit-data becomes an alternative to be used in processing data using Collaborative-filtering. The term ''implicit'' is used here somewhat excessively, so as to express that a user is never actually prompted to express a degree of preference to categories [20]. Implicit data can be generated from customer purchase data taken from transaction data. Researches in [16] [9] and [10] claimed that study of CF method with implicit data, conclude that its performances are depended on the type of data. Hence, it is important to do a performance comparison based on data types.

In addition, cold-start and data sparseness problems are still challenges and weaknesses of this approach. Cold-start problems are caused by new items or users that have never sent or received a previous rating. If a new item appears in the database, there is no way available to recommend it to the user until more information about it has been obtained through another user who assesses or determines other similar items. Sparseness problem is how in general the item-user matrix is rarely filled, making it difficult to identify users and similar items, due to lack of rank and overlapping [14]. Therefore, studies are needed to examine this approach toward data sparseness.

C. Similarity Calculation in CF based RS

CF-based approach relies on calculating similarity between users and between items when recommending an object. When recommending items to users, each user is represented as an item vector or user-item matrix; and analogous to that, when recommending users to other users based on items (category), then each item is presented in a user vector or item-user matrix, such as shown in Fig. 1. In this figure, zero means the item is not rated by a user, and one means the vice versa. After becoming vectors, the similarity between users (and also items) can be calculated by measuring distances between vectors using well-known metrics, such as cosine-similarity and Pearson coefficient correlation. The greater the value of the similarity of the vectors, the items (or users) are seen as more relevant to other users (or items) [17], [18], [19].

Implementation of Pearson coefficient correlation to user-based and item-based CF can be found in [20]. Given the following sets:

- A set of *m* users $U = \{u_x : x = 1,2, \dots, m\}$,
- A set of *n* items $I = \{i_x : x = 1,2, \dots, n\}$, and
- A set of *p* categories $C = \{c_x : x = 1,2, \dots, p\}$.
- A set of q explicit rating $R = \{r_x : x = 1,2, \dots, q \wedge q \leq m * n\}$
- A set of t implicit rating $R = \{r'_x : x = 1,2, \dots, t \wedge t \leq m * p\}$

As well, the explicit rating of a user u_x with reference to an item i_h is represented with r_{u_x,i_h}, and the average explicit rating of a user u_x as $\overline{r_{u_x}}$.

Variables of $K_{x,y}$ and $\lambda_{x,y}$ in (1) and (2) respectively are Pearson coefficient correlation of explicit and implicit data. The item set that is rated together by u_x and u_y is denoted as $I' = \{i_x : x = 1,2,3, \dots n' \wedge n' \leq n\}$, where n is total number of items. Similarity between u_x and u_y is denoted as the Pearson correlation coefficient of associated rows of them in the user-item matrix.

$$K_{x,y} = sim(u_x, u_y) = \frac{\sum_{h=1}^{n'} \left(r_{u_x,i_h} - \overline{r_{u_x}}\right) - \left(r_{u_y,i_h} - \overline{r_{u_y}}\right)}{\sqrt{\sum_{h=1}^{n'} \left(r_{u_x,i_h} - \overline{r_{u_x}}\right)^2} \sqrt{\sum_{h=1}^{n'} \left(r_{u_y,i_h} - \overline{r_{u_y}}\right)^2}} \quad (1)$$

The implicit approach can actually be interpreted as an approach that utilizes the absence of *obvious* user preferences for an item; by taking advantage that an item consists of several categories so that it is possible to build a category-based user model. It means that it is possible to infer the preference of a user $u_x \in U$ to $c_x \in C$ user category by the user-category matrix. This preference can be claimed as an implicit rating $r'_{u_x,c_x} \in R$. Pearson correlation coefficient of the implicit ranking of the two users for all categories $c_x \in C$ where *p* identifies the number of categories notated in (2).

USER BASED -CF					
user	item1	item2	item3	item4	item5
Alice	1	1	1	1	0
User1	1	1	1	0	1
User2	1	1	0	1	0
User3	0	0	1	1	1
ITEM BASED-CF					
item	alice	user1	user2	user3	
item1	1	1	1	0	
item2	1	1	1	0	
item3	1	1	0	1	
item4	1	0	1	1	
item5	0	1	0	1	

Fig. 1. Items Vector (upper) and users Vector (Lower).

$$\lambda_{x,y} = sim(u_x, u_y) = \frac{\sum_{h=1}^{p}\left(r'_{u_x,c_h} - \overline{r'_{u_x}}\right)-\left(r'_{u_y,c_h} - \overline{r'_{u_y}}\right)}{\sqrt{\sum_{h=1}^{p}\left(r'_{u_x,c_h} - \overline{r'_{u_x}}\right)^2}\sqrt{\sum_{h=1}^{p}\left(r'_{u_y,c_h} - \overline{r'_{u_y}}\right)^2}} \quad (2)$$

For item-based approach, formulas in (3) describe Pearson coefficient correlation for explicit data which are represented in variables of $\mu_{x,y}$. Here, the user set that have rated both items i_x and i_y is denoted as $U' = \{u_x : x = 1,2,\dots,m' \wedge m' \leq m\}$, where m is total number of users. The similarity between i_x and i_y is denoted as the Pearson correlation coefficient of the associated columns of them in the user-item matrix.

$$\mu_{x,y} = sim(i_x, i_y) = \frac{\sum_{h=1}^{m'}\left(r_{u_h,i_x} - \overline{r_{i_x}}\right)-\left(r_{u_h,i_y} - \overline{r_{i_y}}\right)}{\sqrt{\sum_{h=1}^{m'}\left(r_{u_h,i_x} - \overline{r_{i_x}}\right)^2}\sqrt{\sum_{h=1}^{m'}\left(r_{u_h,i_y} - \overline{r_{i_y}}\right)^2}} \quad (3)$$

Formula (4) applies when we use item-category bitmap matrix, where p is the number of categories and v_{u_h,i_x} is a Boolean value of value which equal to *1* provided that item *x* is owned by category *h* or equal to *0* otherwise.

$$v_{x,y} = sim(i_x, i_y) = \frac{\sum_{h=1}^{p}\left(v_{c_h,i_x} - \overline{v_{i_x}}\right)-\left(v_{c_h,i_y} - \overline{v_{i_y}}\right)}{\sqrt{\sum_{h=1}^{p}\left(v_{u_h,i_x} - \overline{v_{i_x}}\right)^2}\sqrt{\sum_{h=1}^{p}\left(v_{u_h,i_y} - \overline{v_{i_y}}\right)^2}} \quad (4)$$

D. Prediction and Recommendation Values

For the User-based approach, the closest neighbor subset user is selected based on its similarity to the active user. The steps are to find the closest neighbor user with the greatest similarity value, then calculate the predicted value of items that have been selected by the nearest neighbor user but have never been chosen by an active user. Supposed *a* is an active user being examined, *p* is the item whose prediction is calculated, and r_u has *a* value of '1', indicating that the closest neighbor user *u* has chosen item *p*. The prediction value of user *a* with respect to item *p* is calculated using (5).

$$pred(a,p) = r_u * sim(a,u) \quad (5)$$

For Item-based approach, the nearest neighbor subset item is selected based on their similarity to items that have been selected by the active user. The steps are to find the nearest neighbor item with the greatest similarity value, then calculate the predicted value of the closest neighbor items that have never been selected by an active user based on its similarity to items that have been selected by an active user.

$$pred(a,p) = r_a * sim(i,p) \quad (6)$$

The prediction value calculated using (6), where r_a has *a* value of '1', indicating that the active user has chosen item *i*.

E. Mean Absolute Error (MAE)

MAE, also known as Mean Median Regression [20],[21], is used to measure the accuracy of forecasting models [22]. Based on the formula, a small error value will be proven with a small MAE value and a large error value will be proven with a greater MAE value. The formula is defined in (7):

$$\text{MAE} = \sum_{i=1}^{N} \frac{|p_i - q_i|}{N} \quad (7)$$

Where p_i = value of *i*, q_i = prediction of i, and N = number of records in the given data.

III. Research Methodology

The proposed model for comparing the performance of the CF approach is given in Fig. 2 with the explanation as follows.

1) Preparing and determining normalization of implicit and explicit data.

2) Calculating the similarity with pearson coefficien correlation for each type of dataset based on formulas as defined in (1), (2), (3) and (4).

3) Calculating the prediction value for each type of dataset using (5),(6).

4) Calculating MAE for each dataset using (7).

5) Calculating the average of MAE.

6) Comparing four MAE values: User-based with implicit data, Item-based with implicit data, User-based with explicit data, and Item-based with explicit data.

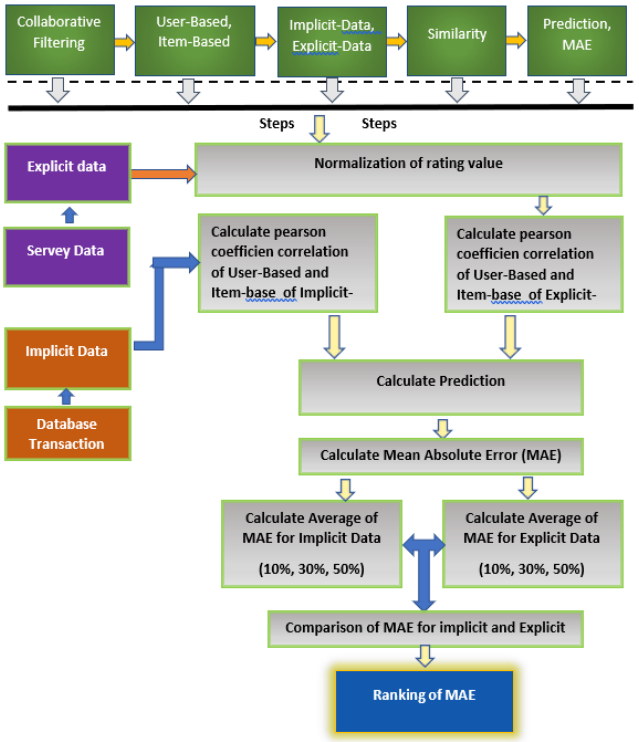


Fig. 2. Model of Comparison of Performance in Collaborative-Filtering Type [23],[24].

IV. Experimental Research

The results of this experiment are the presentation of MAE results with the process steps described in Fig. 3. The steps taken are calculating similarity with the Pearson coefficient correlation, calculating predictions, and calculating MAE.

A. Performance of User-based with Implicit-Data

Based on the test results on the sample data of user-based matrics, the data has been grouped based on the number of random ratings vacancies in three groups namely 10%, 30%, and 50%. Then each group was calculated similarity, prediction, and MAE. the results of the test have been described in Table I, and illustrated in the graph (Fig. 4).

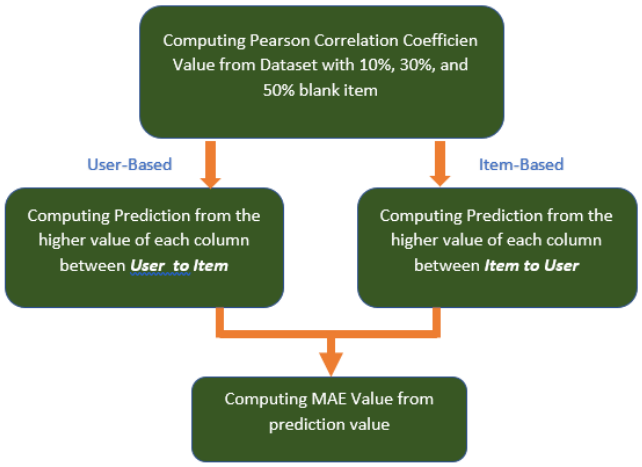


Fig. 3. Process to Compute Similarity with Pearson Correlation, Prediction, and MAE [12],[23].

TABLE. I. Comparison of MAE in user-based with Implicit Data

Blank Rating	MAE
10%	0
30%	0.066277635
50%	0.243543221
Average of MAE	0.103273619

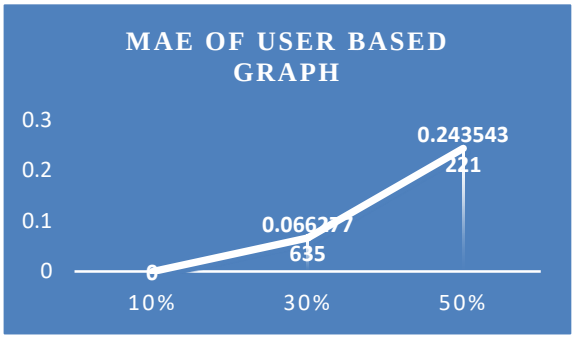


Fig. 4. Graph of MAE Comparison in user-based with Implicit-Data.

The lowest MAE value = 0 is in the dataset with a blank rating of 10%. It can be concluded that in a user-based Collaborative-Filtering approach involving implicit data, the smaller the value of the blank rating, the more accurate the results are evidenced by the small MAE value.

B. Performance of Item-based with Implicit-Data

Based on the experiment on the sample data of item-based matrics, the data has been grouped based on the number of random ratings vacancies in three groups namely 10%, 30%, and 50%. Then each group was calculated similarity, prediction, and MAE. The results of the test have been described in Table II and illustrated in the graph (Fig. 5).

TABLE. II. Comparison of MAE in Item-based with Implicit Data

Blank rating	MAE
10%	0
30%	0.048660458
50%	1
Average	0.349553486

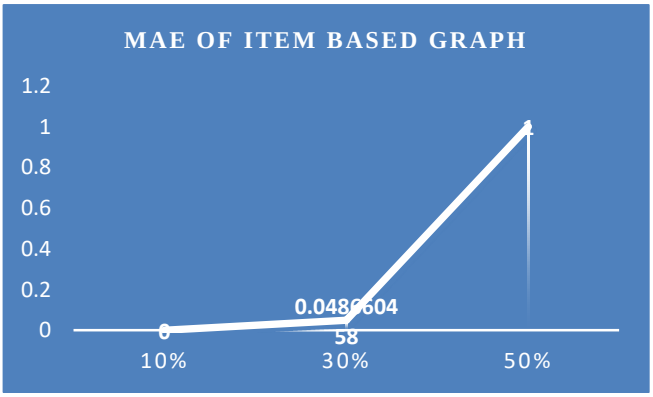


Fig. 5. Graph of MAE Comparison in Item-based with Implicit-Data.

The lowest MAE value = 0 is in the dataset with a blank rating of 10%. It can be concluded that in an item-based Collaborative-Filtering approach involving implicit data, the smaller the value of the blank rating, the more accurate the results are evidenced by the small MAE value.

C. Comparison between User-Based and Item-based use Implicit Data

Table III and Fig. 6 have described the comparison of MAE values between user-based and item-based that involve implicit data. The smallest MAE value generated from this test is a user-based CF approach with a value of 0.103 which means a user-based CF approach that involves implicit data is more accurate than an item-based CF approach involving the same type of data.

D. Performance of User-Based with Explicit Data

Based on the test results on the sample data of user-based metrics, the data has been grouped based on the number of random ratings vacancies in three groups namely 10%, 30%, and 50%. Then each group was calculated similarity, prediction, and MAE. The results of the test have been described in Table IV, and illustrated in the graph (Fig. 7).

TABLE. III. COMPARISON OF MAE BETWEEN USER-BASED AND ITEM-BASED USE IMPLICIT DATA

Blank rating	User-based	Item-Based
10%	0	0
30%	0.066278	0.04866
50%	0.243543	1
Average	0.103274	0.349553

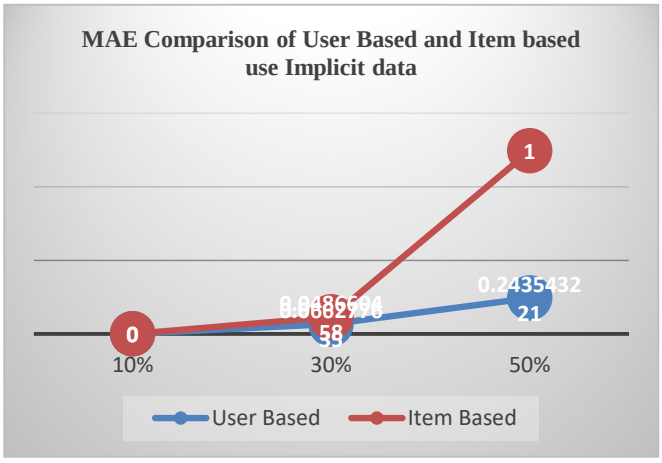


Fig. 6. Graph of MAE Comparison in Item-based and user-based in Implicit-Data.

TABLE. IV. COMPARISON OF MAE IN USER-BASED WITH EXPLICIT- DATA

Blank rating	MAE
10%	0.425972049
30%	0.054072837
50%	0.216221325
Average	0.232088737

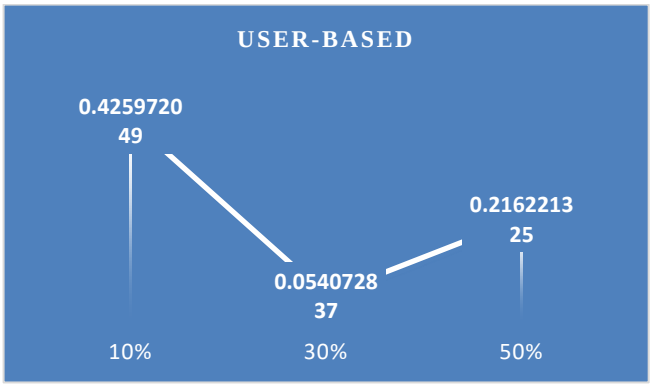


Fig. 7. Graph of MAE Comparison in user-based with Explicit-Data.

The lowest MAE value = 0.054 is in the dataset with a blank rating of 30%. It can be concluded that the smallest MAE value is unpredictable and cannot be identified by the least amount of rating blanks as well. And this has shown differences in results compared to testing involving implicit data.

E. Performance of Item-Based with Explicit Data

Based on the experiment on the sample data of item-based metrics, the data has been grouped based on the number of random ratings vacancies in three groups namely 10%, 30%, and 50%. Then each group was calculated similarity, prediction, and MAE. The results of the test have been described in Table V, and illustrated in the graph (Fig. 8).

The lowest MAE value = 0.0450 is in the dataset with a blank rating of 10%. It can be concluded that in an item-based Collaborative-Filtering approach involving explicit data, the smaller the value of the blank rating, the more accurate the results are evidenced by the small MAE value.

TABLE. V. COMPARISON OF MAE IN ITEM-BASED WITH EXPLICIT- DATA

Blank rating	MAE
10%	0.045066008
30%	0.095425989
50%	0.13727043
Average	0.092587476

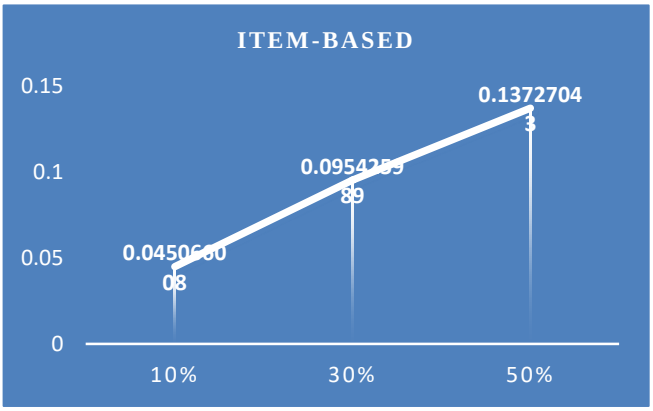


Fig. 8. Graph of MAE Comparison in Item-based with Explicit-Data.

F. Comparison between of User-Based and Item-Based use Explicit Data

Table VI and Fig. 9 have described the comparison of MAE values between user-based and item-based that involve explicit data. The smallest MAE value generated from this test is an item-based CF approach with a value of 0.092 which means an item-based CF approach that involves explicit data is more accurate than user-based CF approach involving the same type of data.

G. Comparison of MAE in All Types and Data

The final step is to compare the MAE values of the four experimental groups, which are described in Table VII and Fig. 10. From this study, the best accuracy is that the item-based CF approach involves explicit data, as evidenced by the smallest MAE value (0.0926).

TABLE. VI. COMPARISON OF MAE IN EXPLICIT-DATA

Blank rating	MAE of User-based	MAE of Item-Based
10%	0.425972	0.045066
30%	0.054073	0.095426
50%	0.216221	0.13727
Average	0.232089	0.092587

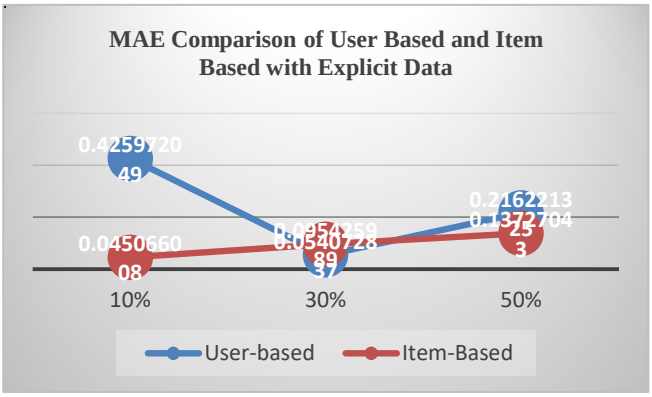


Fig. 9. Graph of MAE Comparison in Item-based and user-based in Explicit-Data.

TABLE. VII. COMPARISON OF MAE IN ALL TYPE AND DATA

Blank Rating	UB-Boolean	IB-Boolean	UB-Nom	IB-Nom
10%	0	0	0.426	0.0451
30%	0.066	0.0487	0.0541	0.0954
50%	0.244	1	0.2162	0.1373
Average	0.103	0.3496	0.2321	0.0926

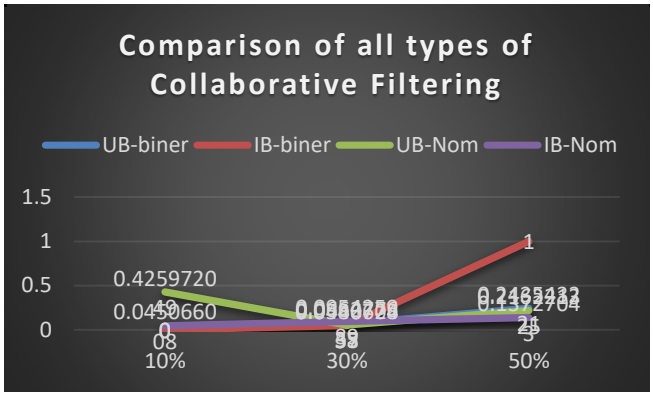


Fig. 10. Graph of Comparison all types of Collaborative Filtering.

V. CONCLUSION AND FUTURE WORK

The results of this study are Comparison models of User Based CF and Item Based CF performance involving Implicit and Explicit data.

User-Based CF with Implicit Data produces the smallest MAE value of 0, in the lowest empty-rating dataset (10%). It can be concluded that the smaller the number of blank ratings in the dataset, the more accurate the recommendations it produces.

Item-Based CF with Implicit Data produces the smallest MAE value of 0, in the lowest empty-rating dataset (10%). It can be concluded that the smaller the number of blank ratings in the dataset, the more accurate the recommendations it produces.

The average MAE value of the User-Based CF approach is 0.103, which is smaller than the item-based CF approach. It can be concluded that User Based CF performance is more accurate for processing implicit data than Item Based.

The User-Based CF Approach with Explicit Data yields the smallest MAE value of 0.054 in the blank rating dataset group (30%). It can be concluded that the number of blank ratings in the Explicit data applying the User Based CF approach cannot predict the level of accuracy of the resulting recommendation recommendations.

Item-Based CF with explicit Data produces the smallest MAE value of 0.045, in the lowest empty-rating dataset (10%). It can be concluded that the smaller the number of blank ratings in the dataset, the more accurate the recommendations it produces.

The average MAE value of the Item-Based CF approach is 0.092, which is smaller than the user-based CF approach. It can be concluded that Item Based CF performance is more accurate for processing explicit data than user Based CF.

Based on the four approaches tested, the smallest average MAE is Item-Based CF with Explicit-Data. So based on this research, the highest level of accuracy performance for Collaborative-Filtering is the Item-Based CF approach with explicit data.

ACKNOWLEDGMENT

We would like to thank all those who contributed to this research starting from the Universiti Teknikal Malaysia Melaka (UTem); Malaysia, DRPM of Ministry of Research and Technology & Higher Education, Indonesia; Widyagama University Malang, Indonesia; Department of Science and Technology (DST) under AIRFT India (RTF / RTF / 2018/000033); AR-PulsaBiz Reload Malang, Indonesia which is one of the SMEs in Indonesia; and last but not least, all reviewers who provided some valuable criticisms and suggestions to improve this paper quality.

REFERENCES

[1] F. Marisa et al., "Segmentation Model of Customer Lifetime Value in Small and Medium Enterprise (SMEs) using K-Means Clustering and LRFM Model," Int. J. Integr. Eng., vol. 11, no. 3, pp. 169–180, 2019.

[2] S. Ayyaz, U. Qamar, and R. Nawaz, "HCF-CRS: A Hybrid content based fuzzy conformal recommender system for providing recommendations with confidence," PLoS One, vol. 13, no. 10, pp. 1–30, 2018.

[3] R. Burke, "Hybrid Web Recommender Systems," Adapt. Web, pp. 377–408, 2007.

[4] Y. Cai, H. F. Leung, Q. Li, H. Min, J. Tang, and J. Li, "Typicality-based collaborative filtering recommendation," IEEE Trans. Knowl. Data Eng., vol. 26, no. 3, pp. 766–779, 2014.

[5] R. Burke, "A Knowledge Based Recommender System," Int. J. Comput. Intell. Syst., vol. 1, no. 3, pp. 1–23, 2008.

[6] Y. A. Pratama, D. Wijaya, and A. Halim, "Digital Cakery Dengan Algoritma Collaborative Filtering," JSM STMIK Mikroskil, vol. 14, no. 1, pp. 79–88, 2013.

[7] T. Osadchiy, I. Poliakov, P. Olivier, M. Rowland, and E. Foster, "Recommender system based on pairwise association rules," Expert Syst. Appl., vol. 115, pp. 535–542, 2019.

[8] J. Chen, C. Miller, and G. G. Dagher, "Product recommendation system for small online retailers using association rules mining," Proc. 2014 Int. Conf. Innov. Des. Manuf. ICIDM 2014, vol. 17, pp. 71–77, 2014.

[9] M. Prasasti, R. Saptono, and Winarno, "Sistem Rekomendasi Peminjaman Buku di UPT Perpustakaan UNS dengan Metode Item-based Collaborative Filtering dan Rating Implisit," vol. 1, pp. 280–287, 2017.

[10] K. Choi, D. Yoo, G. Kim, and Y. Suh, "A hybrid online-product recommendation system: Combining implicit rating-based collaborative filtering and sequential pattern analysis," Electron. Commer. Res. Appl., vol. 11, no. 4, pp. 309–317, 2012.

[11] L. Dzumiroh and R. Saptono, "Penerapan Metode Collaborative Filtering Menggunakan Rating Implisit pada Sistem Perekomendasi Pemilihan Film di Rental VCD," J. Teknol. Inf. ITSmart, vol. 1, no. 2, p. 54, 2016.

[12] M. K. Najafabadi, M. N. ri Mahrin, S. Chuprat, and H. M. Sarkan, "Improving the accuracy of collaborative filtering recommendations using clustering and association rules mining on implicit data," Comput. Human Behav., vol. 67, pp. 113–128, 2017.

[13] Z. Dehghani and H. R. Jamali, "A multi-layer contextual model for recommender systems in digital libraries," in Aslib Proceedings, 2011, vol. 63, no. 6, pp. 555–569.

[14] Y. S. Kim and Y. S. Kim, "Text recommender system using user ' s usage patterns," 2011.

[15] G. Li, Y. Chen, Z. Zhang, J. Zhong, and Q. Chen, "Social personalized ranking with both the explicit and implicit influence of user trust and of item ratings," Eng. Appl. Artif. Intell., vol. 67, no. August 2017, pp. 283–295, 2018.

[16] T. Q. Lee, Y. Park, and Y. T. Park, "A time-based approach to effective recommender systems using implicit feedback," Expert Syst. Appl., vol. 34, no. 4, pp. 3055–3062, 2008.

[17] E. Setiawan and A. Muttaqin, "Implementation of K-Nearest Neightbors Face Recognition on Low-power Processor," TELKOMNIKA (Telecommunication Comput. Electron. Control., vol. 13, no. 3, p. 949, 2016.

[18] M. Yusril, H. Setyawan, R. M. Awangga, and N. A. Lestari, "K-Nearest neighbor algorithm on implicit feedback to determine SOP," TELKOMNIMA, vol. 17, no. 3, p. 12928, 2019.

[19] H. Kalhori, M. M. Alamdari, and L. Ye, "Automated algorithm for impact force identification using cosine similarity searching," Meas. J. Int. Meas. Confed., vol. 122, no. July 2017, pp. 648–657, 2018.

[20] A. de Myttenaere, B. Golden, B. Le Grand, and F. Rossi, "Mean Absolute Percentage Error for regression models," Neurocomputing, vol. 192, pp. 38–48, 2016.

[21] Kenji Paskal, "Peningkatan Akurasi Metode User Based Collaborative Filtering Menggunakan Agglomerative Clustering pada Sistem Rekomendasi," UNIVERSITAS SANATA DHARMA, 2018.

[22] P. H. Franses, "A note on the Mean Absolute Scaled Error," Int. J. Forecast., vol. 32, no. 1, pp. 20–22, 2016.

[23] M. Papagelis and D. Plexousakis, "Qualitative analysis of user-based and item-based prediction algorithms for recommendation agents," Eng. Appl. Artif. Intell., vol. 18, no. 7, pp. 781–789, 2005.

T. Badriyah, I. Restuningtyas, and F. Setyorini, "Sistem Rekomendasi Collaborative Filtering Berbasis User Algoritma Adjusted Cosine Similarity," 2017.

A Prediction-based Curriculum Analysis using the Modified Artificial Bee Colony Algorithm

Reir Erlinda E. Cutad[1], Bobby D. Gerardo[2]
Graduate Programs, Technological Institute of the Philippines, Quezon City, Philippines[1]
West Visayas State University, Iloilo City, Philippines[2]

***Abstract*—Due to the vast amount of students' information and the need of quick retrieval, establishing databases is one of the top lists of the IT infrastructure in learning institutions. However, most of these institutions do not utilize them for knowledge discovery which can aid in informed decision-making, investigation of teaching and learning outcomes, and development of prediction models in particular. Prediction models have been utilized in almost all areas and improving the accuracy of the model is sought- after this study. Thus, the study presents a Scoutless Rule-driven binary Artificial Bee Colony (SRABC) as a searching strategy to enhance the accuracy of the prediction model for curriculum analysis. Experimental verification revealed that SRABC paired with K-Nearest Neighbor (KNN) increases the prediction accuracy from 94.14% to 97.59% than paired with Support Vector Machine (SVM) and Logistic Regression (LR). SRABC is efficient in selecting 14 out of 60 variables through majority voting scheme using the data of the BSIT students of Davao Del Norte State College (DNSC), Davao del Norte, Philippines.**

Keywords*—Binary artificial bee colony; rule-driven mechanism; prediction model; curriculum analysis

I. Introduction

One of the important factors for nation's sustainable economy which aimed in the improvement of proficiency of general public is education [1]. Knowledge discovery from learning institution's databases through different techniques in data mining can aid in informed decision-making [2],[3] and when paired with advances of machine learning algorithms, it can build prediction models with enhanced accuracy[4],[5]. However, the application of these techniques in learning institutions still need more interest [6].

The goal of higher learning institutions is to have higher percentage of on-time graduates particularly for colleges and universities that are government-funded because when students enrol for another semesters, this will put in more expenditure in the government budget. Hence, to attain such goal, curriculum analysis must be join in the process of addressing the problems. In curriculum analysis, courses that students have difficulty to pass can be determine, can aid in the inquiry if graduates' skills are relevant to job market at least at the minimum and a tool for verification if observance to standards from the governing bodies is followed.

According to studies of [7]-[9], the most influential factors in prediction model in the field of education is academic data. Also in [10], it is stipulated that academic data, the course performance in particular, is utilized in constructing model for curriculum analysis; thus, this study.

This study will discover the most relevant courses in relation to on-time graduation. The output will empower the learning institution academic heads to determine the most common skills among the on-time graduates which can be utilize to verify if it matches the job skills requirements of the nation and locality in particular.

Discovering most relevant courses can be characterized as a variable selection problem and is solved through optimization. Variable selection is a technique of finding the highly most important subset of variables having the highest accuracy and minimum error [11], [12]. However, traditional variable selection methods suffered from cost of computational time if implemented in high dimension problems. This is where swarm-based intelligences came in as one of the solutions [13].

Swarm-based algorithms, which form a sub-field of artificial intelligence, has gained particular importance because of workability and simplicity in implementation [14], [15]. Particle Swarm Optimization (PSO), Artificial Bee Colony (ABC) and Ant Colony Optimization (ACO) were some of the state-of-the-art algorithms [16], [17]. Among these, ABC has a simple structure, few parameters for tuning [18], [19], adaptable and robust [20] which become its advantage compared with other swarm-based algorithms.

Nevertheless, as stated in the literature, same with other algorithms, ABC has a widely-known performance problem which is poor exploitation ability [21]-[23]. Hence, modification is necessary before its application to actual case scenario, specifically if the variables dimension is high like in this case. Also, based on readings, there is no recent verified performance of ABC and its variants which was utilized in academic data.

To realize the goal of this study, a novel Scoutless Rule-driven binary Artificial Bee Colony (SRABC) is presented as tool to enhance the accuracy of prediction model through selecting the most relevant variables. This is done through the use of simple reverse mechanism, replacement of operators from arithmetic to mathematical set, fourths-uniform crossover, and on-mutation strategies. Being a scoutless ABC is inspired from the study of [24]. Before the implementation of SRABC to actual case scenario, its performance was verified and compared to recent ABC's in the literature such as Novel binary ABC algorithm (NBABC) [25] and hybrid

ABC and gradient boosting decision tree algorithm (ABCoDT) [26] using some of their utilized datasets from UCI, and the results used for comparison was obtained from their respective studies.

The dataset utilized in the study has 60 variables representing the student's course grades from School Years 2015- 2016 to 2018-2019 of the BSIT curriculum, College entrance exam and High School's general average or general average from previous school attended for transferees. These information were extracted from the Enrolment Information System of Davao Del Norte State College (DNSC), Davao del Norte, Philippines. The framework of the study is made up of SRABC paired with three machine learning algorithms such as KNN, SVM and LR to discover the best model among them. Further, majority voting scheme is applied in the final selection process for the most relevant variables to address non-deterministic behavior of the algorithm.

II. Literature Review

A. Prediction-Based Models Applied in Learning Institutions

In this section, the most recent and varied studies based on prediction which employed in learning institutions are presented.

In the study of [27], a hybrid GA-KNN was employed to build a prediction model using records of student responses to reduce the variables in the evaluation instrument of faculty instructional performance in State Colleges and Universities in Caraga Region, Philippines. The study achieved an accuracy of 95.53% and 66.66% data reduction. The study of [28] was implemented to find the most relevant activities for physics course at the Universidad Loyola Andaluc´ua, in Seville, Spain, it utilized different classification algorithms such as Naive Bayes, C5.0, SVM and Fast Correlation Based Filter (FCBF), Scatter Search (SS) and Genetic Algorithm (GA) as searching strategy for variable selection. Two datasets containing evaluation based on daily work (D-5) and evaluation focused on knowledge (D-7) were created. Based on experimental results, in D-5, the SS obtained the lowest number of subset with an average accuracy of 89.43% for all classifier algorithms, while in D-7, FCBF obtained the lowest subset with an average of 76.43%. An adaptive support vector machine framework is called as RF-CSCA-SVM was implemented to predict college students' entrepreneurial intention and was built through a combination of random forest, support vector machine, and sine cosine algorithm (SCA), a new swarm- based intelligence algorithm. SCA is modified by introducing a chaotic local search. The performance of the modified SCA (CSCA) has been verified through comparison to other swarm-based algorithms and the results showed that it outperformed the others by having an average prediction accuracy of 83.5% [29].

B. Original ABC Algorithm

The Artificial Bee Colony (ABC) algorithm, proposed by Karaboga and Basturk [30], is an optimization algorithm that reached the global optima in an iterative manner. The original algorithm's approach is composed of initialization phase, repeat, employed bees phase, onlooker bees phase, scout bees phase, memorize the best solution achieved so far, until the maximum cycle number[31]. The employed bees have in their mind the position of a particular food source which can be a possible solution, then, the onlooker bees select the food source with high quality through the dance of the employed bees. The scout bees were employed bees that exhausted a particular food source, it will generate new food source in a random manner once activated[32]. At the initialization phase the food source is generated using the equation.

$$x_{ij} = x_j^{min} + rand(0,1)\,(x_j^{max} - x_j^{min}) \quad (1)$$

Where i=1,...N, the size of the food source, j=1,...D, the dimension of the food source, x_{ij} is the jth dimension of the i^{th} food source, and x_j^{min} and x_j^{max} are the lower and upper bound of j^{th} dimension.

At the employed bees phase, after sending them to the assigned solution in her memory, they will find new candidate solution using the equation.

$$v_{ij} = x_{ij} + rand(-1,1)(x_{ij} - x_{kj}) \quad (2)$$

After a candidate and a current solution is evaluated and compared, a greedy selection is applied, the better solution will be place in the memory, and reset the abandonment counter, otherwise, is incremented by 1. Evaluation of the quality of the food source is through their probability (P_i) and fitness (fit_i) values using the equations (3) and (4).

$$fit_i = \begin{cases} |f_i|, & fi < 0 \\ 1/f_i, & fi \geq 0 \end{cases} \quad (3)$$

$$P_i = \frac{fit_i}{\sum_{n=1}^{N} fit_n} \quad (4)$$

At the onlooker bees phase, to exploit the found better solution, sources with higher probability have chances to be selected using a selection method such as the roulette wheel and undergoes same procedure as the employed bees. Lastly, scout bees phase will be activated once the abandonment counter is higher than the predetermined limit value and utilized again the equation (1) to generate new food source[33].

C. Binary Artificial Bee Colony

To implement ABC for binary optimization, equations (1) and (2) should be modified. The equation (1), which represents the food source is converted into binary vector through the Bernoulli process, whereas, arithmetic operators in equation (2), was modified into logical, bitwise or genetic operators.

1) Multiple strategies: MDisABC, a modified binary ABC, introduced an effective mechanism of information sharing, instead of selecting one neighborhood in the generation of a new solution, a selection mechanism to create three neighborhood mutant solution was introduced and embed a recombination operator for selection mechanism among the solutions [34].

2) Logical and bitwise operators: BitABC replaced the arithmetic operator of equation (2) into combined bitwise operations of XOR, AND, and OR [35], while binABC[36] utilized the XOR operation in the generation of solution.

3) Mutation and crossover: GB-ABC, a binary ABC which utilized genetic operators such as two-point crossover to the current and neighborhood food source to produce a child food source and swap operator for grandchildren food source. This is also utilized to select the best food source[37]. Recently, PrBABC, a probabilistic binary artificial bee colony introduced a strategy which composed of partial-mapped crossover operator and bitwise AND operator. The random generation of two points as the start and endpoint was implemented before the two operators were applied, and after each iteration, a probability equation was used to determine if which operator will be selected [38].

III. Scoutless Rule-Driven Binary Artificial Bee Colony

To address the exploitation ability problem of artificial bee colony, new strategies are applied in the exploration and exploitation equations of the algorithm. These strategies will improve the exploitation ability of the ABC and also addresses the computational cost specifically for high dimension problems. In this study, the crossover and mutation are modified along with the introduction of reverse mechanism in the initialization phase and the mathematical set operators as replacement to bitwise operators. Fig. 1 shows the diagram of the modified ABC algorithm.

A. Initialization Phase

1) Migration: To generate food sources, SRABC utilize the equation (5). This equation is not new because most of the algorithm for binary optimization used the concept with distinction on threshold value. Each food sources is a fixed-size array depending upon the number of variables in the dataset and each arrays is composed of 1's and 0's since the algorithm is implemented for variable selection problem.

$$x_{iD} = \begin{cases} 1, & n \geq 0.5 \\ 0, & n < 0.5 \end{cases} \quad (5)$$

The migration occurs when the food sources were reversed in which the n^{th} position in the array will become the new 1^{st} position. Algorithm 1 and Fig. 2 display the concept.

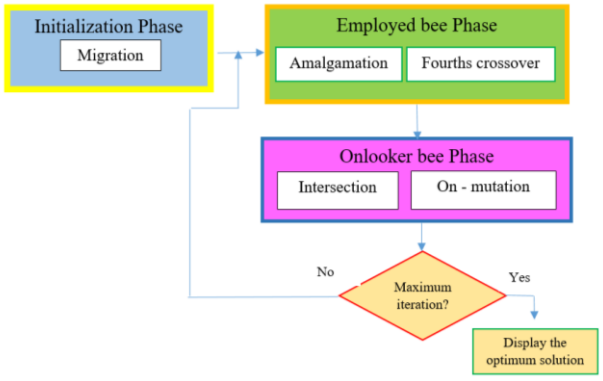


Fig. 1. Diagram of SRABC.

Algorithm 1: Migration

1. Utilize the equation (5) to check the generated value and if the value is greater than the threshold, append 1, otherwise, append 0, repeat until the fixed-size array is produced.
2. Reverse each array as shown in figure 2.
3. Execute same process for all food sources.

B. Employed Bees Phase

Multiple strategies were implemented in this phase which aimed to reinforce the strong exploration ability of ABC. The random and greedy selections were still observed in the process of finding the neighborhood and better food source.

Algorithm 2: Employed bees phase

1. For each food source, a new neighborhood food source is selected through a random selection procedure;
2. For each current and selected neighborhood food sources;
   2.1 create new solution through the application of amalgamation which takes in all the position with value of 1's.
   2.2 produce another two new solutions through the application of fourths-crossover, if one of the solutions has an empty array consider the current food source;
3. Apply greedy selection to the three created solutions;
4. The found better solution will be the new current food source.

1) Amalgamation: Instead of implementing the widely utilized OR bitwise operator in binary optimization, the strategy implements a union mathematical set operator to produce a new solution. The strategy has the same concept with OR bitwise, but computationally not costly because it will not compare each position in the array through iterative manner.

2) Fourths-crossover: To produce two new solutions, the two food sources are split into 25% for the first-fourths and 75% for the three-fourths. The first solution is composed of the first-fourths of the current food source and the last three-fourths of the neighborhood food source. While, the other solution is composed of the last three-fourths of the current food source and the first-fourths of the neighborhood food source. The diagram is shown in Fig. 3.

Fig. 2. Reverse Method.

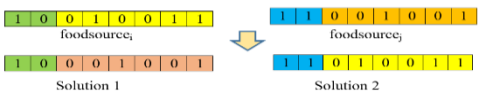


Fig. 3. Fourths Crossover Method.

C. Onlooker Bees Phase

An intensive multiple exploitation strategies are implemented in this phase to improve the found better solution. The concept of higher fitness will have a higher probability to be chosen are still observed in this algorithm.

1) Intersection: A replacement of the widely utilized AND bitwise operator for binary optimization. The strategy implements the intersection mathematical set operator between the current and neighborhood food sources. The new solution is produced through selection of positions with the same value of 1, if the same position has different values or same value but is 0, a zero value is append in that particular position. Fig. 4 illustrates the concept.

2) On-mutation: The on-mutation strategy will change the value from 0 to 1 of the position whose location is the same in the generated random number. However, if the position's value is 1, no changes will be made. The number of times that random number will be generated is equivalent to the 20% of the dataset's variables. This strategy is both implemented in the current and neighborhood food sources to exploit more the found better food sources.

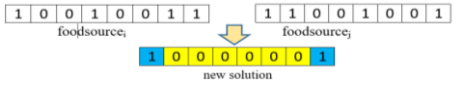


Fig. 4. Intersection Method.

IV. Experiments

A. Benchmark Dataset and Settings

The effectiveness of SRABC is verified through the comparison of prediction accuracy and number of selected variables using three datasets from the UCI machine learning repository [39] as shown in Table I.

Each datasets is split into 70% for training and 30% for testing sets respectively. To predict the accuracy of the selected variables, 10-folds cross-validation and KNN classifier having K=5 were used, these parameters were same with those algorithms that SRABC was compared.

The equation (6) is the fitness function formula for multi-objective variable selection problem where α is set to 90% to give importance to the accuracy. SF defines the number of selected variables for each solution and TF is the total number of variables in the dataset.

$$\text{Fitness} = \alpha * \text{accuracy} + (1 - \alpha)\left(1 - \frac{SF}{TF}\right) \quad (6)$$

The program is implemented in Python 3.6.4 and experiments are conducted on a computer with Intel Core i5-6200U CPU at 2.30 GHz and 4G of installed memory using 64 bit Windows 10 operating system.

TABLE. I. Properties of the Datasets

Dataset	Instances	Features	Classes
Wine	178	13	3
Ionosphere	351	34	2
Arcene	900	10,000	2

B. Comparative Study

NBABC and ABCoDT are recent state-of-art ABC which has experiments conducted for variable selection problem using publicly available datasets. Table II is the description of the performance of the algorithms.

Table III illustrates the comparative results of the experiments, the == in the said table signifies that the experiment for such dataset is not conducted in their study. Based on the experiments conducted, SRABC exhibit a superior performance in terms of prediction accuracy and number of selected variables, though for wine, ABCoDT performance is better in terms of number of selected variables but the accuracy was deteriorating, while Table IV shows the efficiency of SRABC in selecting the minimum number of variables without compromising the prediction accuracy, particularly in the very high dimension dataset.

TABLE. II. Description of the State-of-the-Art Binary ABC Variants

Algorithm	Description
NBABC	The algorithm was compared to other five binary ABC variants and tested in eight datasets with 166 features as the highest. Based on experiments conducted, the algorithm is superior to the other five variants in six out of eight datasets in which wine is one among the two datasets that the algorithm is not superior.
ABCoDT	The algorithm was tested in eight datasets with 10,000 features as highest. It was compared to six state-of-the-art methods and results showed that it was effective in reducing the number of features. However, there were three datasets that the algorithm is not superior and among them is the arcene dataset.

TABLE. III. Comparative Results of Accuracy and Number of Selected Variables

Dataset	SRABC	NBABC	ABCoDT
Wine Testing accuracy Selected variables	95.00 3.00	66.80 7.20	90.91 1.00
Ionosphere Testing accuracy Selected variables	93.00 3.00	84.20 3.55	==
Arcene Testing accuracy Selected variables	85.00 353	==	80.20 2,103

TABLE. IV. The Reduction Rate of SRABC from the Original Variables

Dataset	Original variables	# of selected variables	Reduction rate
Wine	13	3.0	76.9 %
Ionosphere	34	3.0	91.17%
Arcene	10,000	353	96.47%

Aside from the better performance of SRABC in terms of its ability to reach a very good accuracy and minimal number of selected variables which is called the global optima, it also exhibit a good balance between exploration and exploitation to avoid trapping in the local optima. It is shown in Fig. 5 that during fitness evaluations the algorithm selected varied number of variables which supports the strong exploration ability of ABCs and make use of the found better solution for exploitation towards convergence. While, Fig. 6 shows that convergence rate is enhanced when reaching the global optima thru a smaller number of iterations.

C. Curriculum Analysis-the Case Study

The conceptual framework of the study is shown in Fig. 7. The process includes extraction of data from the College Information System database and students' manual archive. The data were Pre-processed before the application of SRABC with majority voting scheme to find the most relevant variables with increase prediction accuracy. SRABC is paired with three machine learning algorithms to attain a best model.

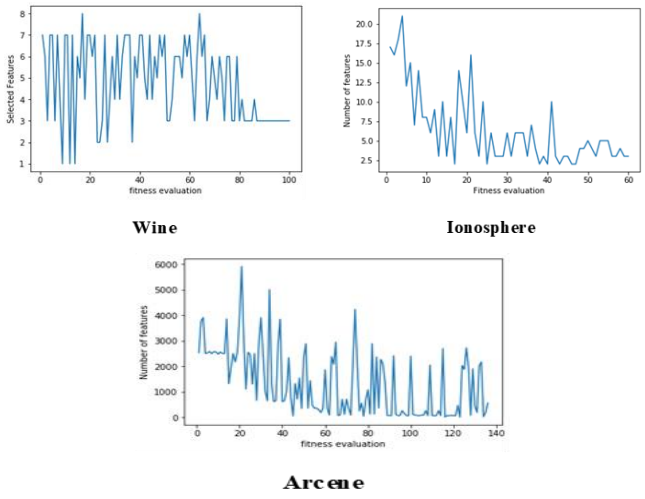


Fig. 5. Illustration of Exploration-Exploitation Ability.

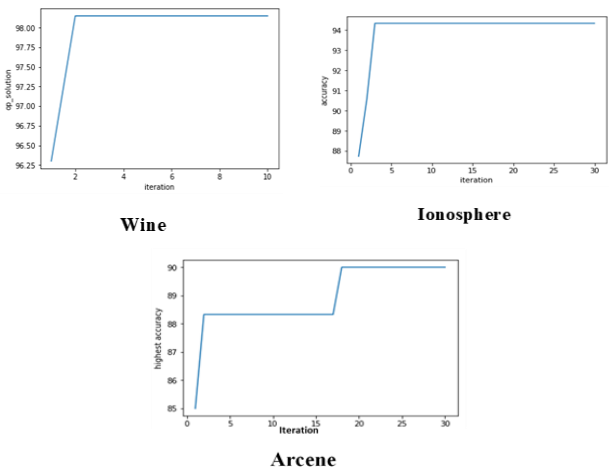


Fig. 6. Highest Prediction Accuracy Per Iteration.

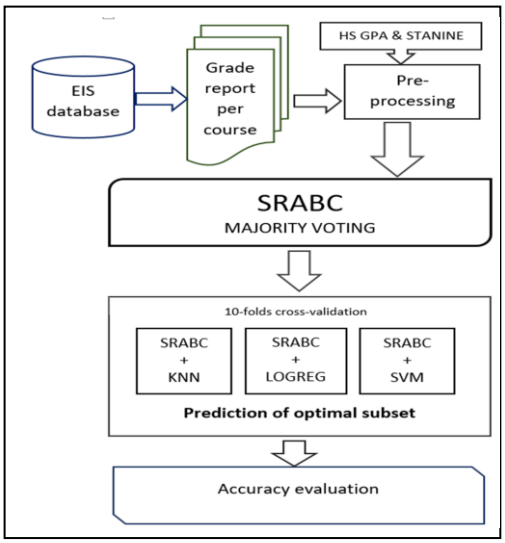


Fig. 7. Diagram of the Prediction-based Model for Curriculum Analysis.

1) Data collection: The study utilized the high school general average or general average from previous school attended for transferees, stanine and course grades from School Year 2015- 2016 to School Year 2018-2019 of the Information Technology students of Davao Del Norte State College (DNSC). The Grade reports per semester were extracted from the Enrolment Information System while others were manually taken from the students' archive. A total of 343 student records were obtained including those who dropped or transferred to other learning institutions.

2) Data preparation: The collected grade reports per semester and other data were converted into a dataset having column name of their corresponding code number as shown in Fig. 8. Following such, is the transformation of values for suitability in building the model. The class variable with a value of 1 means that the students graduated on-time and 0 for not on-time. The transformed data were processed to remove records of students who stop enrolling in the BSIT program which resulted into a dataset of 216 records, comprised of students who graduated on-time, graduated during summer and soon to graduate within the School year 2019-2020.

0	GPA	22	PE3	44	FELECT 1
1	STANINE	23	IT9	45	STAT
2	SS2	24	IT8	46	SS 3
3	SS1	25	IT7	47	ITE ELECT 2
4	PE1	26	IT6	48	IT 3
5	NSTP1	27	IT10	49	IT 24
6	MATH4	28	HUM1	50	IT 23
7	LIT1	29	ENG2	51	IT 22
8	IT2	30	PHY 2	52	IT 20
9	IT1	31	PE4	53	IT 25
10	FIL1	32	IT15	54	ITELECT3
11	ENG+	33	IT14	55	ITELECT4
12	PI2	34	IT13	56	FELECT2
13	PE2	35	IT12	57	FELECT3
14	NSTP2	36	IT11	58	SS4
15	MATH5	37	ENG3	59	CAPSTONE
16	IT5	38	ITE ELECT 1		
17	IT4	39	IT 21		
18	HUM2	40	IT 19		
19	FIL 2	41	IT 18		
20	ENG1	42	IT 17		
21	PHYSICS1	43	IT 16		

Fig. 8. Courses, GPA and Stanine with their Corresponding Code Number.

3) Data analysis approach: In the literature, many modifications for swarm-based algorithms have integrated schemes of directions during the search process because this algorithms are stochastic in nature. But still, they behave with different outputs in different runs, called non-deterministic behavior, specifically when implemented in very high dimensions problems. To address such, a majority voting is applied to the outputs of SRABC to develop a model that behaves in a deterministic manner in the process of finding the optimal subset of variables. The optimal subset is composed of variables getting the most number of votes in relation to the average number of variables from the 30 runs. This technique is integrated to ensure that experimental results is precise in all conducted experiments. Also, the said technique fosters stability of the model, as stated in [40] that stability in variable selection technique is similarly significant to the accuracy of the prediction model. The study of [41] also a utilized majority voting scheme.

Experiments were conducted for different types of machine learning algorithms such as KNN, SVM and LR using 10-folds cross-validation to come up a model having best prediction accuracy and lowest root mean squared error. Some statistical tools such as Precision, Recall and F-measure were also utilized to evaluate the model.

4) Majority voting results: Each expirements conducted is composed of 30 runs; in all runs, Capstone Project is always present as expected, because it is the thesis course of the curriculum. The rest of the courses that comprised the optimal subset were IT3, IT7, IT8, IT18, ITE ELECT4, PE1, NSTP2, HUM2, ENG1, PHY1, HUM1, ENG2, and SS3. The new subset has a total of 14 courses and having a data reduction rate of 76.6%. The tally of scores is shown in Fig. 9.

5) Prediction evaluation: When using the KNN algorithm, tuning of the algorithm is conducted through iteration of k values from 1 up to 10 to find the value of k that has the best prediction accuracy as shown in Fig. 10, based on the result, K=1 has the highest prediction accuracy.

Also, an experiment to verify the prediction accuracy of the machine learning algorithms using all variables was conducted to be used in the comparison of accuracy. Table V shows the prediction accuracy using the three machine learning algorithms.

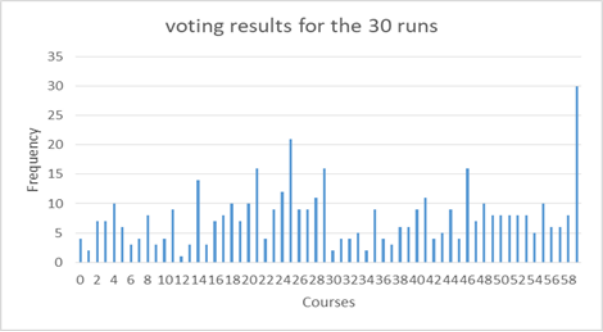


Fig. 9. Majority Voting Results.

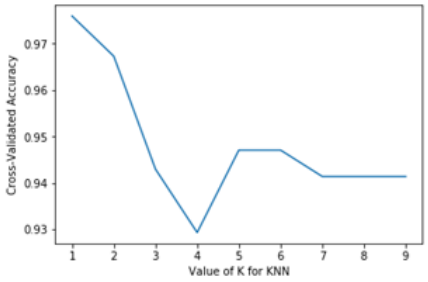


Fig. 10. Accuracy Per K Value.

TABLE. V. PREDICTION ACCURACY USING ALL VARIABLES

Algorithms	Prediction accuracy
KNN	94.14%
SVM	94.79%
LR	91.98%

TABLE. VI. EVALUATION MEASURES OF SRABC PAIRED WITH KNN, SVM AND LR

Model	***Accuracy***	***RMSE***	***Precision***	***Recall***	***F-Measure***
SRABC + KNN	**97.59%**	**0.1**	**.97**	**.98**	**.9736**
SRABC + SVM	92.38%	0.24	.93	.91	.9161
SRABC + LR	91.54%	0.26	.90	.94	.9114

Table VI shows the evaluation measures of the prediction-based model of SRABC paired with KNN, SVM and LR in the selected 14 courses as optimal subset.

Based on the results, the prediction accuracy of the model has increase from 94.14% to 97.59% and reduced the dimensionality from 60 variables to an optimal subset of 14 variables.

V. CONCLUSION

The goal to develop a prediction-based model for curriculum analysis is achieved with the integration of SRABC as the searching strategy paired with KNN. The SRABC discovered the most relevant variables and exhibit an increased prediction accuracy through the aid of majority voting scheme which addresses the non-deterministic behavior of the algorithm, specifically for high dimensions problem. The superior performance of SRABC is due to the reverse mechanism in the initialization of food sources, new exploration and exploitation strategies in the employed and onlooker bees phase which composed of amalgamation, fourths-crossover, intersection and on-mutation.

Hence, it is recommended that the prediction-based model for curriculum analysis will be utilize to the remaining program offerings of Davao del Norte State College and further be implemented to higher learning institutions in the region.

For future works, it is recommended to verify the performance of SRABC in various actual case scenario as prediction-based model and further study can be investigated to implement SRABC to decision trees.

REFERENCES

[1] H. Sun, S. Wei-feng, Y. Geng, X. Yang, and B. K. Edziah, "How does natural resource dependence affect public education spending ?," Environ. Sci. Pollut. Res., vol. 26, no. 4, pp. 3666–3674, 2019.

[2] A. Peña-ayala, "Educational data mining : A survey and a data mining-based analysis of recent works," Expert Syst. with Appl., vol. 14, no. 4, pp. 1432–1462, 2014.

[3] I. A. Adekitan and O. Salau, "The impact of engineering students ' performance in the first three years on their graduation result using educational data mining," Heliyon, vol. 5, no. 2, p. e01250, 2019.

[4] H. Ji, K. Park, J. Jo, and H. Lim, "Mining students activities from a computer supported collaborative learning system based on peer to peer network," Peer-to-Peer Netw. Appl., vol. 9, no. 3, pp. 465-476., 2016.

[5] S. Fedushko and T. Ustyianovych, "Predicting Pupil ' s Successfulness Factors Using Machine Learning Algorithms and Mathematical Modelling Methods," in International Conference on Computer Science, Engineering and Education Applications, 2019, pp. 625–636.

[6] H. Aldowah, H. Al-samarraie, and W. M. Fauzy, "Educational Data Mining and Learning Analytics for 21st century higher education: A Review and Synthesis," Telemat. Informatics, 2019.

[7] A. A. Saa, M. Al-Emran, and K. Shaalan, "Factors Affecting Students ' Performance in Higher Education : A Systematic Review of Predictive Data Mining Techniques," Technol. Knowl. Learn., pp. 1–32, 2019.

[8] S. Morsy and G. Karypis, "A Study on Curriculum Planning and Its Relationship with Graduation GPA and Time To Degree," in Proceedings of the 9th International Conference on Learning Analytics & Knowledge, 2019, pp. 26–35.

[9] N. M. Suhaimi, S. Abdul-Rahman, S. Mutalib, N. Hamimah, A. Hamid, and A. M. Malik, "Review on Predicting Students ' Graduation Time Using Machine Learning Algorithms," Int. J. Mod. Educ. Comput. Sci., vol. 11, no. 7, pp. 1–13, 2019.

[10] S. A. Priyambada, E. Mahendrawathi, and B. N. Yahya, "Curriculum Assessment of Higher Educational Institution Using Aggregate Profile Clustering," in Procedia Computer Science, 2018, vol. 124, pp. 264–273.

[11] S. Yu and J. Principe, "Simple Stopping Criteria for Information Theoretic Feature Selection," entropy, vol. 21, no. 1, 2019.

[12] M. Mafarja, I. Jaber, S. Ahmed, and T. Thaher, "Whale Optimisation Algorithm for high- dimensional small-instance feature selection," Int. J. Parallel, Emergent Distrib. Syst., pp. 1–17, 2019.

[13] N. Nayar, S. Ahuja, and S. Jain, "Swarm Intelligence for Feature Selection : A Review of Literature and Reflection on Future Challenges," Adv. Data Inf. Sci., pp. 211–221, 2019.

[14] J. C. Bansal, A. Gopal, and A. K. Nagar, "Analysing Convergence , Consistency , and Trajectory of Artificial Bee Colony Algorithm," IEEE Access, vol. 6, pp. 73593–73602, 2018.

[15] A. Nayyar, V. Puri, and G. Suseendran, "Artificial bee Colony optimization population-based meta-heuristic swarm intelligence technique.," Data Manag. Anal. Innov. Springer, Singapore, pp. 513–525, 2019.

[16] E. Figueiredo, M. Macedo, H. Valadares, C. J. Santana, A. Gokhale, and C. J. A. Bastos-filho, "Swarm intelligence for clustering — A systematic review with new perspectives on data mining," Eng. Appl. Artif. Intell., vol. 82, no. May, pp. 313–329, 2019.

[17] L. Cui et al., "A smart artificial bee colony algorithm with distance-fitness-based neighbor search and its application," Futur. Gener. Comput. Syst., no. 89, pp. 478–493, 2018.

[18] S. Aslan, H. Badem, and D. Karaboga, "Improved quick artificial bee colony (iqABC) algorithm for global optimization," Soft Comput., 2019.

[19] K. Liu, C. Wang, and S. Liu, "Artificial Bee Colony Algorithm Combined with Previous Successful Search Experience," IEEE Access, vol. 7, pp. 34318–34332, 2019.

[20] T. Saw and P. H. Myint, "Swarm Intelligence Based Feature Selection for High Dimensional Classification : A Literature Survey," Int. J. Comput., vol. 33, No 1, pp. 69–83, 2019.

[21] S. K. Agarwal and S. Yadav, "A Comprehensive Survey on Artificial Bee Colony Algorithm as a Frontier in Swarm Intelligence," Ambient Commun. Comput. Syst., pp. 125–134, 2019.

[22] W. Xiang, Y. Li, R. He, X. Meng, and M. An, "An improved artificial bee colony algorithm with fitness-based information," IEEE Access, vol. 7, pp. 41052–41065, 2019.

[23] H. Gao, Y. Shi, C. Pun, and S. Kwong, "An Improved Artificial Bee Colony Algorithm with its Application," IEEE Trans. Ind. Informatics, vol. 15, no. 4, pp. 1853–1865, 2018.

[24] K. Hussain, M. Najib, M. Salleh, S. Cheng, Y. Shi, and R. Naseem, "Artificial bee colony algorithm : A component-wise analysis using diversity measurement," J. King Saud Univ. - Comput. Inf. Sci., 2018.

[25] C. Santana Jr, M. Macedo, H. Siqueira, A. Gokhale, and C. J. Bastos-filho, "A novel binary artificial bee colony algorithm," Futur. Gener. Comput. Syst., vol. 98, pp. 180–196, 2019.

[26] H. Rao, X. Shi, A. Kouassi, and J. Feng, "Feature selection based on artificial bee colony and gradient boosting decision tree," Appl. Soft Comput. J., vol. 74, pp. 634–642, 2019.

[27] A. J. P. Delima, A. M. Sison, and R. P. Medina, "Variable Reduction-based Prediction through Modified Genetic Algorithm," Int. J. Adv. Comput. Sci. Appl., vol. 10, no. 5, 2019.

[28] M. Garcia-Torres, D. Becerra-alonso, F. A. Gomez-Vela, F. Divina, I.L. Cobo, and Martinez-Alvarez, F., "Analysis of Student Achievement Scores : A Machine Learning Approach," In International Joint Conference: 12th International Conference on Computational Intelligence in Security for Information Systems(CISIS 2019) and 10th International Conference on EUropean Transactional Education(ICEUTE 2019), 2019, pp. 275–284.

[29] J. Tu, A. Lin, H. Chen, Y. Li, and C. Li, "Predict the Entrepreneurial Intention of Fresh Graduate Students Based on an Adaptive Support Vector Machine Framework," Math. Probl. Eng., 2019.

[30] D. Karaboga and B. Basturk, "A powerful and efficient algorithm for numerical function optimization : artificial bee colony (ABC) algorithm," J. Glob. Optim., pp. 459–471, 2007.

[31] D. Karaboga and B. Gorkemli, "A quick artificial bee colony (qABC) algorithm and its performance on optimization problems," Appl. Soft Comput., vol. 23, pp. 227–238, 2014.

[32] J. Yang et al., "An adaptive encoding learning for artificial bee colony algorithms," J. Comput. Sci., 2018.

[33] H. Habbi, Y. Boudouaoui, D. Karaboga, and C. Ozturk, "Self-generated fuzzy systems design using artificial bee colony optimization," Inf. Sci. (Ny)., vol. 295, pp. 145–159, 2015.

[34] E. Hancer, B. Xue, D. Karaboga, and M. Zhang, "A binary ABC algorithm based on advanced similarity scheme for feature selection," Appl. Soft Comput. J., vol. 36, pp. 334–348, 2015.

[35] D. Jia, X. Duan, and M. Khurram, "Binary Artificial Bee Colony optimization using bitwise operation," Comput. Ind. Eng., vol. 76, pp. 360–365, 2014.

[36] M. S. Kiran and M. Gunduz, "XOR-based artificial bee colony algorithm for binary optimization," Turkish J. Electr. Eng. Comput. Sci., pp. 2307–2328, 2013.

[37] C. Ozturk, E. Hancer, and D. Karaboga, "A novel binary artificial bee colony algorithm based on genetic operators," Inf. Sci. (Ny)., vol. 297, pp. 154–170, 2015.

[38] Z. B. Ozger, B. Bolat, and B. Diri, "A Probabilistic Multi-Objective Artificial Bee Colony Algorithm for Gene Selection," J. Univers. Comput. Sci., vol. 25, no. 4, pp. 418–443, 2019.

[39] A. Asuncion and D. Newman, "UCI machine learning repository," 2007.

[40] U. M. Khaire and R. Dhanalakshmi, "Stability of feature selection algorithm : A review," J. King Saud Univ. - Comput. Inf. Sci., 2019.

[41] S. S. Bhowmick, D. Bhattacharjee, and L. Rato, "Identification of tissue specific tumor biomarker using different optimization algorithms," Genes Genomics, vol. 41, no. 4, pp. 431–443, 2018.

Comparative Analysis between a Photovoltaic System with Two-Axis Solar Tracker and One with a Fixed Base

Omar Freddy Chamorro Atalaya[1], Dora Yvonne Arce Santillan[2], Martin Diaz Choque[3]
Faculty of Engineering and Management
Universidad Nacional Tecnológica de Lima Sur, Lima, Perú

***Abstract*—In this article, the comparative analysis of the stored energies between a photovoltaic system with a two-axis solar tracker, controlled by Arduino with respect to the energy stored by a fixed-base photovoltaic system is done. This with the option of using electrical energy efficiently, since the optimal installation of photovoltaic systems plays an important role in its efficiency. Once the comparative analysis was performed, the performance of the photovoltaic system with solar tracker is determined to be 24.06% higher than the second fixed-base photovoltaic system. The correlational analysis was also carried out for the data collected from the stored energy with respect to time, thus determining that the photovoltaic system with a solar tracker has a low correlation of 0.334, given that in the solar tracker the energy stored without dependence on time or moment when the energy is captured, since, if there is a variation during the day of the direction of the sun's rays, the photovoltaic system will always seek to focus as much as possible on the sun's rays, guaranteeing sustainability in flexible storage of energy; while the fixed-base photovoltaic system has a moderate inverse correlation of - 0.489, that is, as the hours of the day pass the orientation of the sun's rays changes, and in the absence of dynamism in the orientation of the solar cells (for be fixed-based), limited energy as the hours of the day increase. Taking these reference results, it is expected to implement photovoltaic system projects with solar tracker in rural areas of Peru that lack electrical services, since it is more efficient than the fixed base photovoltaic system.**

Keywords*—Photovoltaic system; solar cells; displacement; two axes; performance; orientation; stored energy

I. Introduction

Thanks to the growing need to make energy use more efficient and the imperative demand to deal with climate change, the development and implementation of alternative energy sources arises [1]. Photovoltaic solar energy is one of the energies with the greatest projection to be used worldwide. It is also the cleanest form of energy; however, the implementation of a solar panel power generation system has shown that its reliability and efficiency depend on many factors [2]. Sometimes it is believed that the productivity of a solar panel depends on the quality and price of the panel, however, there are other factors that can affect the way we use solar energy.

The output of the photovoltaic system is fundamentally affected by various environmental factors such as dust, orientation, irradiation, shading, etc. [3]. These factors are classified as own or external according to their nature of operation or environment respectively.

Climatic variations, high temperature or cell orientation, for example, can significantly affect the performance of solar panels. In relation to external factors strictly speaking, an important aspect such as the angle of inclination of the solar panel can be found, so the importance of analyzing this variable when determining the performance of a photovoltaic system is highlighted [4].

It is clear that photovoltaic systems depend on the sun as the first and most important factor, a well-done orientation is not only more aesthetically pleasing, but also implies an economic saving, since each panel watt for which the price was paid is used [5]. To achieve, in a simple way, the use of the sun as an energy resource, knowledge of the solar trajectory, the profile of the needs and the conditions of the location is essential [6].

The angle of inclination of the cell affects the solar radiation that reaches its surface. When the panel is placed perpendicularly in the direction of the sun's rays, it absorbs the maximum radiation for a certain period of time, considering this as the optimum inclination angle [7]. That is, the energy produced by a solar panel varies specifically from the time of day and the amount of sunlight it needs [8]. This angle is associated with factors such as latitude and solar radiation characteristics.

The optimum angle of inclination of the capture surfaces of a solar system is determined by many factors, including the incident radiation in the place where the installation is located, and the solar sky, where the shadow of objects that cannot be eliminated influences, like buildings, mountains, etc. [9]. In addition, the characteristics of the installation, that is, if it is unique or hybrid, autonomous or coupled to the network and the purpose of the installation, which defines the use and consumption regime [10].

In any case, the optimization of a solar system is given by the economic factor of the installation as a whole and not by the optimum efficiency of one of the parts [11]. Among the proposed methods, an expression is obtained to determine the optimum angle for a collector taking into account direct and diffuse radiation separately. The variation of the transmissivity of a glass cover with the angle of incidence is also considered.

Also, being this technology, for several years, there are still knowledge gaps, leading to accidents, bad calculations or poorly made facilities, which then need to be corrected [12]. Hence the importance of learning enough about the sun's trajectory day by day and its displacement throughout the year [13]. Some of the mistakes are that a module or a solar panel is installed, but as the stations progress, shadows begin to arrive when it was not installed.

An element that makes the generation of photovoltaic solar energy impossible is uneven lighting or partial shading. This last element causes voltage and current mismatches that influence the performance of photovoltaic cells [14]. Partial shadow photovoltaic systems cannot function with maximum efficiency, due to the shadows cast by the surrounding structures and the cloud cover.

Generation systems that use solar panels should collect as much energy as possible in a given place, this condition requires that the surface of the solar panel, at all times be perpendicular to the sun's rays and, therefore, an optimal collection only it can be achieved if said surface is provided with a solar tracking movement [15].

Solar cells are oriented to move the structure that supports them, this displacement can be performed in one or two axes. [16] Although these systems with orientation capability according to the sun's rays turn out to be more expensive; However, it is much more profitable than the normal solar installation, since the solar energy obtained by the cells located in the followers is 20% higher than that obtained by fixed panels and represents a more profitable investment than the acquisition of a larger number of photovoltaic modules.

In this sense, this article seeks to evaluate the performance of a photovoltaic system with solar tracker with two-axis displacement capability, controlled by an electronic system with Arduino; This evaluation will be carried out by comparing the capacity of the stored energy with respect to a static-based system; These tests will be carried out at the facilities of the National Technological University of South Lima, located in the coastal area of the capital of Peru; during the days of the month of March, month considered with high level of solar radiation.

For this reason, this article is structured in four points, in which the determination of the methodology to be used, the analysis of the results obtained, the development of the discussion of the results and the presentation of the conclusions will be made.

II. Methodology

A. Research Level

The level of research addressed in this article is Descriptive /Correlational. It is descriptive since initially I seek to observe and quantify the stored energy, between a photovoltaic system with a solar tracker, and a static one; then by means of a comparison of stored energies expressed in watts / h, the performance of the system under analysis is established. Descriptive research seeks to analyze variables autonomously by measuring or quantifying them based on an observation process [17].

And it is correlational, since I seek to discover the degree of association between the times in which the storage of the sun's rays occurs with respect to the energy stored by the photovoltaic system with solar tracker, which is part of the analysis units. Arias (2017) states, the utility and the main purpose of correlational studies is to know how a variable can behave knowing the behavior of other related variables [18]. That is, try to predict the approximate value that a variable will have, from the value obtained in the variable or related variables.

B. Population and Sample

The population and sample are composed of two units of analysis, the first being the photovoltaic system with stake base and the second the photovoltaic system with solar tracker with two-axis displacement capability, controlled by Arduino; it is important to specify that in order to achieve the displacement of the base of the photovoltaic system, 4 LDRs were used (Light Dependent Resistor), the same that will allow to achieve the movement of two servomotors.

C. Technique used in Data Collection

Since my data were collected from the quantitative type, the structured observation technique was used, since the indicators to be quantified in the unit of analysis are known. Observation is a technique that consists of observing or systematically observing by sight, some fact, phenomenon or situation that occurs in the unit of analysis, depending on pre-established research objectives [19].

The indicators to be observed were: the time in which the measurement of stored energy is performed, the angle of horizontal displacement, the angle of vertical displacement and the energies stored in both the photovoltaic system with solar tracker and with fixed base.

III. Results

As part of the procedure, in Fig. 1, the architecture of the photovoltaic system with solar tracker is shown.

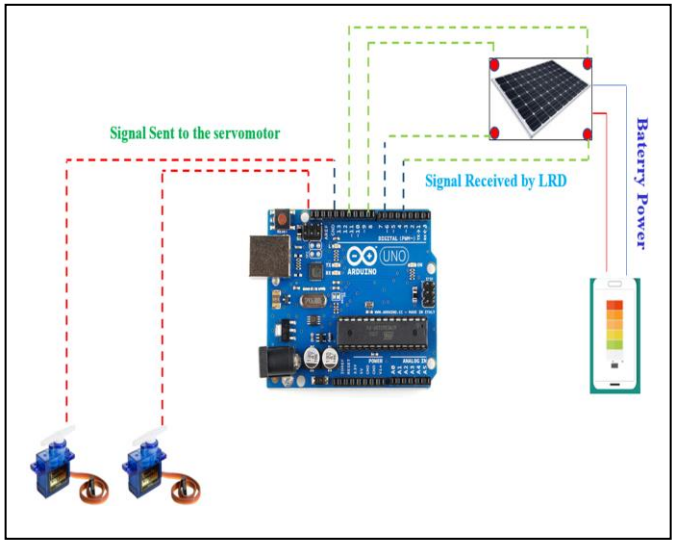


Fig. 1. Architecture of the Photovoltaic System with Solar Tracker. (Own Elaboration).

In Fig. 1, the architecture of the solar tracking system is shown, using the Arduino-UNO software, the necessary algorithm with the programming language C. The Arduino was used to signal the servomotor so that it turns on and can move the panel according to the direction of the light. In the following Fig. 2, the first programming segment that allows defining the angular displacement intervals of each servomotor is shown, being in this case 3 degrees; It should be noted that the first servomotor controls the movement of the base on the horizontal axis in a range of 0 ° to 90 °. For the second servo motor that controls vertical or azimuthal displacement, the same angular displacement resolution and the same angle of rotation were established.

The following Fig. 3 shows the second segment of the programming; here the displacement reading of the two servomotors, for which the automatic capture of the analog ohm values of each LDR; it is important to keep in mind that the ohmiaje in the LDR depends largely on the incidence of light, which falls on it.

The 4 LDRs are grouped into four different variables to perform the movement of each servomotor, the variables are called avgtop, avgbot, avgleft, avgright. To obtain the analog outputs of these variables, it was defined in the programming to make an average incidence of light in each of the LDRs as shown in Fig. 4.

```
#include <Servo.h>

Servo servohorizontal;
int servoh = 0;
int servohHigh = 90;           // DEFINITION OF THE FIRST SERVO
int servohLow = 0;

Servo servovertical;
int servov = 0;
int servovHigh = 90;            // DEFINITION OF THE SECOND SERVO
int servovLow = 0;

int ldrtopA = 2; // TOP LEFT LDR
int ldrtopB = 1; // TOP RIGHT LDR
int ldrbotA = 3; // BOTTOM LEFT LDR
int ldrbotB = 0; // BOTTOM RIGHT LDR

 void setup ()
 {
  servohorizontal.attach(10);
  servohorizontal.write(0);
  servovertical.attach(9);
  servovertical.write(0);
  delay(500);
 }

void loop()
```

Fig. 2. First Programming Segment in the Arduino Software - UNO. (Own Elaboration).

```
servoh = servohorizontal.read();
servov = servovertical.read();

int topA = analogRead(ldrtopA);
int topB = analogRead(ldrtopB);          // CAPTURING ANALOG VALUES OF EACH LDR
int botA = analogRead(ldrbotA);
int botB = analogRead(ldrbotB);

int avgtop = (topA + topB) / 2; //AVERAGE OF THE LDRS TOP
int avgbot = (botA + botB) / 2; //AVERAGE BOTTOM LDRS
int avgleft = (topA + botA) / 2; //AVERAGE OF LEFT LEDRS      // CALCULATING THE AVERAGE
int avgright = (topB + botB) / 2; //AVERAGE OF RIGHT LDRS
if (avgtop < avgbot)
{
  servovertical.write(servov +1);
  if (servov > servovHigh)
   {
    servov = servovHigh;
   }
  delay(10);
}
else if (avgbot < avgtop)
{
  servovertical.write(servov -1);
  if (servov < servovLow)
{
  servov = servovLow;
 }
   delay(10);
 }
 else
 {
   servovertical.write(servov);
 }

 if (avgleft > avgright)
 {
   servohorizontal.write(servoh +1);
   if (servoh > servohHigh)
   {
   servoh = servohHigh;
   }
   delay(10);
 }
 else if (avgright > avgleft)
 {
   servohorizontal.write(servoh -1);
   if (servoh < servohLow)
    {
    servoh = servohLow;
    }
   delay(10);
 }
 else
 {
   servohorizontal.write(servoh);
```

Fig. 3. Second Programming Segment in the Arduino Software - UNO. (Own Elaboration).

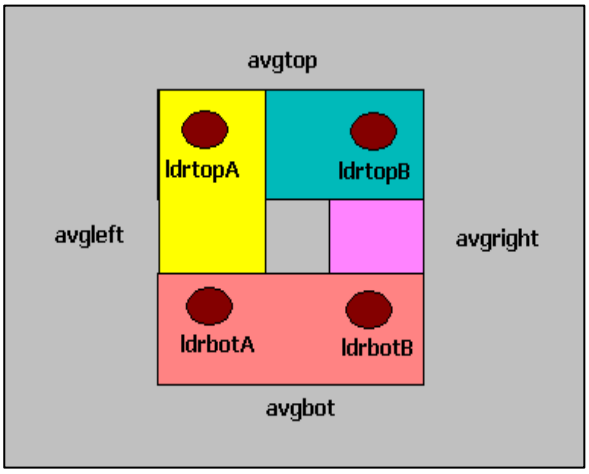


Fig. 4. LDR Distribution. (Own Elaboration).

Once the data was captured, they were analyzed, initially descriptively; for which the behavior of the energy stored by the cells with respect to time, both of the photovoltaic system with solar tracker and of the fixed base photovoltaic system was represented in Fig. 5.

In Fig. 6, it can be seen that the average of the energy stored in the fixed axis is 10.8265, while in the photovoltaic system with solar tracker it is 13.431.

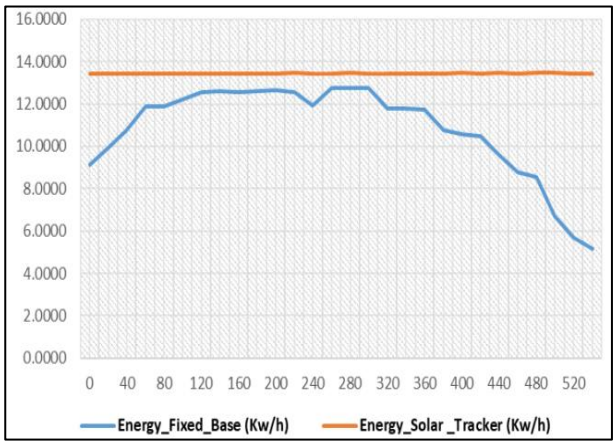


Fig. 5. Variation of the Energies Stored by the Two units of Analysis. (Own Elaboration).

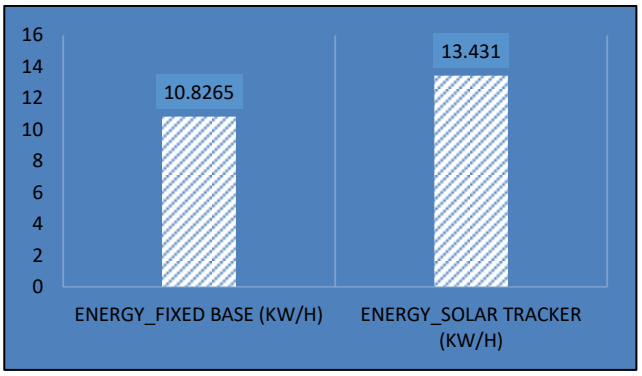


Fig. 6. Average Energy Stored in the Two Analysis units. (Own Elaboration).

Therefore, it can be concluded that the average energy stored in the photovoltaic system with solar tracker is 24.06% higher than the fixed-base photovoltaic system.

In order to determine if there is a relationship between the energy stored by the analysis units (two-axis photovoltaic system controlled by Arduino and the fixed base). The following Table I shows the Spearman test; The results show the association between the time (time of day) of the energy capture. The following Table I shows that there is a moderate inverse correlation of 0.489 between the time and energy of the warehouse by the fixed-base photovoltaic system; that is, as the hours of the day pass, the orientation of the sun's rays changes, and in the absence of dynamism in the orientation of the solar cells (controlled energy as the hours of the day increase) [20].

Table II shows the results of the correlation between time and energy stored in the photovoltaic system with the solar tracker.

On the other hand, in the correlational analysis between the energy stored by the photovoltaic system with solar tracker and the time, in which said energy is captured, it is observed that the correlation is low 0.344; since in the solar tracker the stored energy does not depend on the time or the moment in which the energy is captured, since, if there is a variation during the day of the direction of the sun's rays, the photovoltaic system will always seek to orientate itself as much as possible to the sun's rays, guaranteeing sustainability in the optimal storage of energy.

TABLE. I. SPEARMAN CORRELATION BETWEEN TIME AND ENERGY STORED BY THE FIXED BASED PHOTOVOLTAIC SYSTEM

			Time in Seconds	**Energy Fixed Base**
Rho de Spearman	Time in seconds	Correlation coefficient	1,000	-,489**
		Sig. (bilateral)	.	,008
		N	28	28
	Energy Fixed Base	Correlation coefficient	-,489**	1,000
		Sig. (bilateral)	,008	
		N	28	28
**. The correlation is significant at the 0.01 level (bilateral).				

[a.] SPSS

TABLE. II. SPEARMAN CORRELATION BETWEEN TIME AND ENERGY STORED BY THE PHOTOVOLTAIC SYSTEM WITH SOLAR FOLLOWER

			Time in Seconds	**Energy Solar Tracker**
Rho de Spearman	Time in seconds	Correlation coefficient	1,000	,344
		Sig. (bilateral)	.	,073
		N	28	28
	Energy Fixed Base	Correlation coefficient	,344	1,000
		Sig. (bilateral)	,073	
		N	28	28
**. The correlation is significant at the 0.01 level (bilateral).				

[b.] SPSS

Another aspect to analyze was the dispersion model (Table III), which defines the behavior of the captured data, both of the fixed-base photovoltaic system and the photovoltaic system with solar tracker.

In Table IV, it is observed that the model that best describes the dispersion of the selected energy data stored by the fixed-base photovoltaic system is the quadratic one, whose coefficient of determination turned out to be equal to 0.969; The coefficients of determination of other dispersion models analyzed (linear and exponential) are also evidenced, qualifying them with a low level of determination compared to the coefficient of determination of the quadratic model.

The previous figure (Fig. 7) shows the dispersion model analyzed for the energy stored by the static photovoltaic system.

In the case of the photovoltaic system with solar tracker, in the analysis of the dispersion model of the stored energy data, it is observed in the following table, obtained from the SPSS software, that both the linear and the quadratic determination factor are low, 0.126 and 0.312; which can be interpreted that said energy is almost constant or rather sustainable over time; This occurs because being the dynamic base, the panels always seek the best orientation with respect to the sun's rays.

TABLE. III. ANALYSIS OF TH DISPERSION MODEL OF THE ENERGY ACCESSED BY THE PHOTOVOLTAIC SYSTEM WITH A FIXED BASE

Equation	Model Summary					Parameter Estimates		
	R square	*F*	*gl 1*	*gl 2*	*Sig.*	*Constant*	*b1*	*b2*
Linear	,352	14,12	1	26	,001	12,949	-,008	-7,216E-005
Quadratic	,969	391,9	2	25	,000	9,572	,031	
Exponential	,361	14,65	1	26	,001	13,434	-,001	

[c.] SPSS

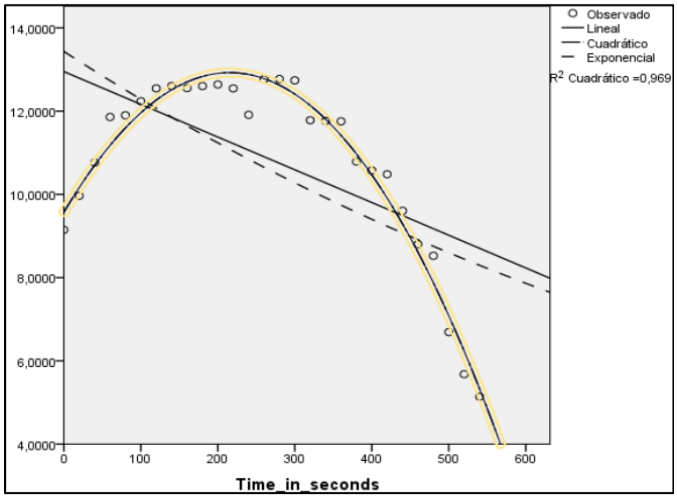


Fig. 7. Dispersion Model Analyzed for the Energy Stored by the Static-based Photovoltaic System. (SPSS).

TABLE. IV. ANALYSIS OF TH DISPERSION MODEL OF THE ENERGY ACCESSED BY THE PHOTOVOLTAIC SYSTEM WITH A SOLAR FOLLOWER

Equation	Model Summary					Parameter Estimates		
	R square	*F*	*gl 1*	*gl 2*	*Sig.*	*Constant*	*b1*	*b2*
Linear	,088	2,498	1	26	,126	13,424	2,691 E-5	
Quadratic	,089	1,220	2	25	,312	13,423	3,896 E-5	2,231 E-8

[d.] SPSS

The following Fig. 8 shows the behavior of stored energy with respect to time; which shows that these values represent almost constant behavior during the period of observation of the data.

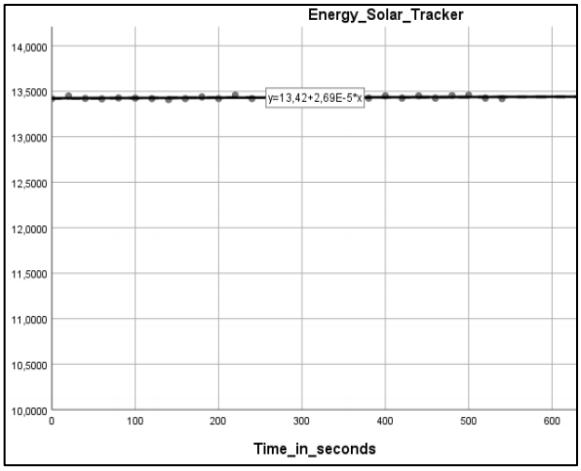


Fig. 8. Dispersion Model Analyzed for the Energy Stored by the Photovoltaic System with Solar Tracker. (SPSS).

IV. DISCUSSION

Taking into account the results obtained, the detail is discussed below:

In relation to the comparative analysis of the energy stored between a photovoltaic system with a two-axis solar tracker controlled by Arduino analyzed in this article, with respect to another system with fixed base; the storage performance of the first photovoltaic system (with solar tracker) is 24.06% higher in relation to the second system (fixed base); So also according to Abu-Khader et al., obtained a global increase of around 30-45% in the output energy for the solar tracking system in the north-south axis (N-S), compared to a fixed photovoltaic system. On the other hand, Huang et al., Determined that, on a day with high sun, a single-axis follower can obtain 35.6% more energy compared to a fixed photovoltaic system. In addition, Kacira et al., Notes that, the average daily gain is 29.3% in solar radiation and 34.6% in power generation for a day and two-axis solar tracker with respect to a fixed cell. In that sense, we agree with the other controlled authors because there is always a higher performance between a photovoltaic system with a solar tracker in relation to a fixed one. It is important to highlight the energy values granted by the aforementioned authors are in relation to the level of solar radiation in each city [15].

V. CONCLUSIONS

From the analysis carried out in this article, the following conclusions are reached.

The energy stored by the photovoltaic system with two-axis solar tracker controlled by Arduino stored on average 2.6045W /h, in relation to the fixed-base photovoltaic system. This was achieved using 4 LDRs, in such a way that, by capturing the incidence of the sun's rays, it sent a signal to the Arduino so that it processed said value to establish a displacement angle of two servomotors, whose displacement resolution was set to 3rd.

In the correlational analysis between the energy stored by the fixed-base photovoltaic system and the time in which said energy is captured, a moderate inverse correlation of -0.489 was obtained; while for the photovoltaic system with two-axis solar tracker, controlled by Arduino, a low correlation of 0.334 was obtained, allowing to understand that the energy stored by this last system will be almost independent of the hours of the day, since through the LDR, it will seek to guide where there is a greater incidence of solar rays.

Finally, it was determined that the linear and quadratic determination factor for the data collected from stored energy of the photovoltaic system with solar tracker, are low, around 0.088 and 0.089; which allows to interpret that said energy is almost constant in time; This occurs because being the dynamic base, the panels always seek the best orientation with respect to the sun's rays. While for the fixed-base photovoltaic system, the data collected responds to a quadratic dispersion model, whose determination factor is 0.969.

REFERENCES

[1] Arencibia-Carballo, G. (2016). The importance of using solar panels in the generation electric power. España: REDVET. pp. 1-4. ISSN 1695-7504.

[2] Bholt, R., Dash, R., Pradhan, A., & Ali, S. (2015). Environmental effect assessment on performance of solar PV panel. 2015 International Conference on Circuits, Power and Computing Technologies [ICCPCT-2015], 1- 5. doi:10.1109/ICCPCT.2015.7159521.

[3] Cepeda, A., & Sierra, J. (2017). Aspects that affect panel efficiency photovoltaic and its potential solutions. Repository of the University Santo Tomás. Perú.

[4] Castañeda, J.; Mazari, I. & Molano, M. (2019). Cost-benefit analysis of panel installation plots in the homes of the population more marginalized from Mexico. IMCO. México.

[5] Arana, L. (2016). Ubicación de los paneles solares. IMCO. México.

[6] Palacios, J. & Morales, A. (2017). Productivity of monocrystalline solar panels, México: SOMIM 73-81, ISSN 2448-5551.

[7] Vega de Kuyper, J. C., & Ramírez, S. (2015). Energy, renewable and non-renewable sources. México: Alfaomega grupo editor, S.A. de C,V.

[8] Vidanalage, I. & Kaamran, R. (2017). Tilt angle optimization for maximum solar power generation of a solar power plant with mirrors. IEEE.

[9] Eliseo, S. (2019). Tilt angle by panels. Perú. Solar Energy.

[10] Minnota, M. & Villavicencio, A. Design of alternatives for the generation of electrical energy connected to the network by means of solar energy for the almond trees building of the Universidad Javeriana Cali. Colombia: Universidad Javeriana.

[11] Obando-Paredes, E. & Vargas-Cañas, R. (2016). Performance of an autonomous photovoltaic system against environmental conditions of a particular region. Rev. Acad. Colomb. Cienc. Ex. Fis. Nat. 40(154):27-33.

[12] Manzano S.; Guevara D. & Ríos, A. (2015). Technological Evolution of Remote Monitoring Systems in Photovoltaic Installations. Ecuador: Revista Politécnica. Vol. 36, No. 1.

[13] Gonzalez, P., Jurado, F., Granados, D. & Ortiz, F. (2018). Analysis of efficiency and degradation of a system photovoltaic interconnected to the power grid. México: Revista Iberoamericana de Ciencias.

[14] Montano, B., Rombaoa, D., Pena, R., & MacAbebe, E. (2016). Effects of shading on current, voltage and power output of total cross-tied photovoltaic array configuration.IeeeXplore,2016-Janua,2-6.doi:10.1109/T ENCON.2015 .7372757.

[15] Arreola, R., Quevedo, A., Castro , M., Bravo, A., & Reyes , D. (2015). Design, construction and evaluation of a solar tracking system for a photovoltaic panel. Magazine Mexicana of Agricultural Sciences, 6(8), 1715-1727.

[16] Arrieta, D., & Puello, S. (2015). Design and construction of a solar tracker to increase the energy efficiency in photovoltaic panels of a pumping system. Universidad of Córdova.

[17] Arias, F. (2017). The research project. Caracas: Episteme.

[18] Hernández-Sampieri, R. & Mendoza, C (2018). Investigation methodology. Quantitative, qualitative and mixed routes (Sexta ed.). Mexico: Mac Graw Hill Education.

[19] Muñoz, C. (2015). Investigation methodology. Mexico: Oxford

[20] Pelayo, J., Luna, A., Bernabe, F., & Guzmán, B. (2017). Comparison between the efficiency of a photovoltaic system with solar tracking and that of a fixed photovoltaic system. México: Revista Iberoamericana de las ciencias biologicas y agropecuaria.

Merge of X-ETL and XCube towards a Standard Hybrid Method for Designing Data Warehouses

Nawfal El Moukhi*[1], Ikram El Azami[2]
Abdelaaziz Mouloudi[3]
MISC Laboratory, Faculty of Sciences
Ibn Tofail University, Kenitra, Morocco

Abdelali Elmounadi[4]
LASTIMI Laboratory
Mohammadia School of Engineers,
Mohammed V University, Rabat, Morocco

***Abstract*—There is no doubt that the hybrid approach is the best paradigm for designing effective multidimensional schemas. Its strength lies in its ability to combine the top-down and bottom-up approaches, thus exploiting the advantages of both approaches. In this paper, the authors try to identify and analyze the different hybrid methods developed for building data warehouses. The analysis revealed that the existing methods are too complicated and time consuming in the deployment phase. In order to solve this problem, the authors introduced a new hybrid method that is easy to use and saves a huge amount of deployment time. This new method consists of two main steps: the first data driven step allows an analysis of the source models by using the X-ETL method and gives rise to star models. The second requirements driven step performs a semantic analysis of the needs expressed in natural language by using the XCube Assist method. This analysis allows to improve the quality of star models generated by the X-ETL method without the intervention of a designer.**

Keywords*—Data warehouse design; hybrid method; relational model; multidimensional model; star model; X-ETL; semantic analysis; XCube assist

I. Introduction

There is no doubt that the data warehouse design is a crucial phase in any project of setting-up a decision support system. Therefore, it is very important for data warehouse designers to follow a well-founded and a well-consolidated design methodology which allows them to get a model that best meets the decision-maker's needs during the analysis and the data mining phases. Thus, several researchers have been interested in this question and a lot of research has been done on the design of data warehouse models. These works have led to the development of several design methods but none of them has been the subject of consensus to become a standard in the field. According to the adopted paradigm, these methods can be divided into two different categories: data-driven methods and others driven by requirements.

The data-driven methods, also known as supply-driven methods, aim to define multidimensional schemas by using model-driven engineering techniques on data sources. The approach followed by these methods offers the advantage of fully automating the design process but neglects the user's needs; contrary to requirements-driven methods that define multidimensional models on the basis of business goals and decision-maker's needs. However, these latter methods can lead to incompatibility between needs and data sources. These two approaches are contradictory and complementary at the same time since each of them has an advantage missed in the other. This complementarity has inspired researchers to define a new hybrid approach that combines these two classical approaches and includes all their advantages.

Today, the hybrid approach is the best paradigm for developing a unified and efficient design method that meets both user's needs and the issue of data availability. Thus, several studies have recently been conducted to develop hybrid methods for designing data warehouses. However, the methods developed so far remain too complicated and require a lot of time for deployment. In this sense, the authors introduced through this paper, a new hybrid method that is easy to use with a reasonable deployment time. The new hybrid method is based on a combination between the data-driven method X-ETL [1] and the requirements-driven method XCube Assist [2]. The paper is organized as follows: Section 2 presents the different hybrid methods developed to date as well as a critical analysis and comparison between these different methods. Sections 3 and 4 summarize the X-ETL methodology and the XCube Assist methodology and present the advantages and disadvantages of each of these methods. In Section 5, the authors present their new hybrid method and describe the entire semi-automatic process. Section 6 applies the new method on a case study from the literature.

II. Related Work

There are multitudes of methods for designing data warehouses. Among these methods, there are those that follow the hybrid approach.

- Cabibbo & Torlone, 1998 [3]: present one of the most frequently cited multidimensional design methods. It allows to generate a logical schema from ER (Entity-Relationship) diagrams and to produce multidimensional schemas in the form of relational databases or multidimensional tables. At first glance, this method appears to follow a data-driven paradigm since it allows for in-depth analysis of data sources. However, no formal rules for identifying multidimensional concepts from data sources are provided. Indeed, multidimensional concepts are identified from user requirements, hence its consideration as a hybrid method. This method consists of four essential steps: The first two steps aim to identify facts and dimensions and to restructure the

*Corresponding Authors

entity-association diagram. These two steps can be performed simultaneously to benefit from the feedback of each step. The authors even suggest that they should be carried out iteratively in order to refine the results obtained. After manually identifying the multidimensional concepts, each fact is represented as an entity and the dimensions missed in the schema that could be derived from external sources or associated metadata must be added. At this stage, it is also necessary to refine the levels of each dimension by means of the following transformations: (i) replacing many-to-many relationships, (ii) adding new concepts to represent new levels of interest, (iii) selecting a simple identifier for each entity level and (iv) deleting irrelevant concepts. Finally, two final steps aim to derive the multidimensional scheme. Some clues are provided to derive a multidimensional graph that will be directly mapped into the multidimensional schema. In general, this method remains informal like Kimball's. However, it established the foundations that were later used by the other methods;

- **Böehnlein & Ulbrich-vom Ende, 1999** [4]: present a hybrid method for deriving logical schemas from SER (Structured Entity Relationship) diagrams. According to the authors, SER is a better alternative for identifying multidimensional structures since it allows to visualize the existence dependencies between objects. This method has three main steps:

  - Pre-process: This step consists of transforming the ER diagram into a SER diagram.
  - Step 1: consists of identifying business measures from goals. The authors suggest looking for business events to discover interesting measures. Once these measures are identified, they are mapped to one or more objects in the SER diagram and will eventually generate facts.
  - Step 2: According to the authors, the hierarchical structure of SER diagrams is useful for identifying potential aggregation hierarchies. Thus, aggregation dimensions and hierarchies are identified by means of direct and transitive functional dependencies. However, the authors point out that the discovery of dimensions is a creative task that must be complemented by a good knowledge of the application field.
  - Step 3: In this step, each fact table is created using all the primary keys of its analysis dimensions as a compound primary key and denormalizing or normalizing the aggregation hierarchies. Finally, a star or snowflake schema is derived;
- **Bonifati et al., 2001** [5]: is the first method to introduce a formal hybrid approach and generating at the end a multidimensional schema. It is a semi-automatic method that consists of three main steps:

  - The first demand-driven step: consists of collecting user needs through interviews and by using the Goal/Question/Metrics paradigm (GQM). GQM consists of a set of forms and guidelines developed in four phases: (i) a first phase aims to formulate the goals in abstract terms, (ii) a second phase to identify the goals through interviews, (iii) a phase of integration and reduction of the number of goals identified by grouping those with similarities and finally, (iv) a more detailed analysis and description of each goal. Then, the authors present guidelines for deriving a logical multidimensional schema from requirements.
  - The second supply-driven step: conducts a comprehensive analysis of the ER diagrams of the data sources and produces graphs that can eventually give rise to star schemas. These graphs are created as follows:
    + Potential fact entities are marked according to the number of its additive attributes. Each identified fact is taken as the central node of a graph.
    + The dimensions are identified by means of many-to-one and one-to-one relationships from the central node. In addition, many-to-many relationships are transformed into one-to-many relationships.

  An algorithm is presented at the end to derive the snowflake schemas of each graph. These schemas are then transformed into star schemas by flattening the dimension hierarchies (denormalized dimensions).

  - The third step aims to integrate and conciliate the two paradigms and generate a feasible solution that best reflects the user's needs. It allows you to map demand-driven schemas to supply-driven schemas in three main steps:
    + Terminology analysis: Before integration, both demand-driven and supply-driven schemas must be converted into a common terminology language.
    + Schema matching: supply-driven schemas are compared with demand-driven schemas. A match occurs if both schemas have the same fact. Some metrics on the number of measures and dimensions are calculated.
    + Ranking and selection: supply-driven schemas are ranked according to the metrics calculated in the previous step and presented to the user;
- **Giorgini, Rizzi & Garzetti, 2008** [6]: present a hybrid method that consists first of all in gathering multidimensional requirements and then in mapping them on the data sources during a conciliation process. The method can also be considered purely demand-driven if the user does not wish to consider the data sources. According to the authors, it is important to design the organization setting in which the data warehouse will operate (organization modeling) and to capture the functional and non-functional requirements of the data warehouse (decisional modeling). If the method follows a hybrid paradigm, the next step would be to match the requirements with the ER diagrams or the relational diagrams describing the operational sources. This mapping phase consists of three steps:

  - Requirements mapping: the facts, dimensions and measures identified during the requirements analysis are mapped on the data sources. Depending on the type of data sources, the authors present a set of tips for

mapping each concept. For example, facts are mapped on entities or n-ary associations in ER diagrams and on relations in relational diagrams.
- Hierarchy construction: For each identified fact, data sources are analyzed in order to search for functional dependencies based on the algorithm discussed in [7].
- Refinement: this step aims to reorganize the fact shcema in order to better meet the user's needs. During this process, it is possible to distinguish between available concepts (mapped from requirements), unavailable concepts (requested in the requirements but cannot be mapped to the data sources) and what is available and not necessary. The authors propose to use this information to reorganize the dimensions (grafting and pruning of aggregation hierarchies) and/or to try to find new directions for analysis;

- **Mazón, Trujillo & Lechtenbörger, 2007** [8]: present a semi-automatic method that first allows to obtain a conceptual schema from the users' needs, then to verify and correct this schema in comparison to relational data sources using QVT (Query / View / Transformation). In the first demand-driven phase, users have to state their requirements by means of business goals. These goals will be used to derive information requirements and both must be modeled by an adaptation of the i* framework. At the end of this phase, a multidimensional schema must be derived from this formalization and must be modeled by using a UML extension (UML profile) proposed by the authors. For the second phase of verification, the authors propose five QVT relations based on multidimensional normal forms (MNF) to align the conceptual schema derived from the requirements with the relational schema of the data sources. These relations are presented as follows:

  - 1MNF (a): a functional dependency in the conceptual schema must have a corresponding functional dependency in the relational schema.
  - 1MNF (b): Functional dependencies among dimension levels contained in the source databases must be represented as aggregation relationships in the conceptual schema. Therefore, they complement the conceptual schema with additional aggregation hierarchies contained in the sources.
  - 1MNF (c): additive measures derived from other measures must be identified in the conceptual schema.
  - 1MNF (d): measures must be assigned to facts so that the atomic levels of the fact form a key. In other words, the authors require to place the measure in a fact while preserving the appropriate granularity of the data.
  - 2MNF and 3MNF: these two forms require the use of concept specializations when structural NULL values in data sources do not guarantee the completeness of the information.

Recently, the authors have improved the demonstration phase in [9] [10] [11] by proposing two new approaches to detecte facts and multidimensional metadata in order to further exploit data source schemas;

- **Romero & Abelló, 2010** [12]: propose a hybrid method for deriving multidimensional conceptual schemas from the needs expressed in SQL queries. it is a fully automatic method that was introduced for the first time in a previous paper [13]. Unlike the methods mentioned above, it performs both phases (data-driven and demand-driven) simultaneously and at the same time. In this manner, each paradigm benefits from the feedback of the other. This method allows to produce constellation schemas from requirements expressed as SQL queries and the logical schema of relational data sources even when the latter are denormalized. The construction of the multidimensional schema is done via two different steps:

  - The first step extracts the multidimensional knowledge contained in the SQL query (i.e. the multidimensional role played by each concept in the query as well as the conceptual relationships between concepts), that is properly stored in a graph. At this point, the logical schema of the data sources will play a crucial role in inferring the conceptual relationships among the concepts.
  - The second step validates each multidimensional graph according to a set of constraints defined by the authors. These constraints must be respected in order to place the data in a multidimensional space and produce a data cube without summarizability problems. If the validation process fails, the method ends because the requested data could not be analyzed from a multidimensional point of view. Otherwise, a multidimensional schema is directly derived from the multidimensional graph.

Unlike data-driven methods, this method focuses on data that interests the end user by considering his or her needs expressed in SQL queries. At the same time, and unlike requirement-driven methods, it is able to offer new interesting multidimensional knowledge that is ignored by the user by analyzing only concepts that are closely related to the user's needs. Finally, solid and significant multidimensional schemas are proposed at the end of the validation process;

The analysis of these different methods led to distinguish two types of hybrid design:

- Fully hybrid methods: these are methods that follow a fully hybrid process. The process steps can only be interpreted in the whole process which follows a hybrid approach;
- Compound hybrid methods: These methods consist of a data-driven phase and a demand-driven phase, and each of these two phases results in a multidimensional model. In other words, it is the fusion between a data-driven and a demand-driven method that gives these methods a hybrid character. This type can also be divided into two subtypes, namely:

- Sequential hybrid methods: in this subtype, the two methods are executed sequentially. The first method results in a multidimensional model that is an input to the second method. In this way, the second method uses the results of the first one to produce a more complete

and comprehensive multidimensional model which consider both data sources and user requirements.

- Parallel hybrid methods: allow both methods to be executed independently and at the same time. Each of the two methods results in a multidimensional model and it is only at the end of the process that these two models are merged to obtain a final result.

In addition to this identified typology, and in order to better analyze these different methods, the authors used the following criteria: operating mode (guide - semi-automatic - automatic) / input data / tool / cost / consumed time. Table I lists the methods already mentioned and analyses them using these criteria.

According to the comparative table, five hybrid methods between six are composed. However, and despite their diversity, none of these composite methods offers a reasonable time of realization as that offered by the Romero & Abello method. In addition, two of them (the Cabibbo & Torlone and Böehnlein & Ulbrich-vom Ende methods) are presented only as a simple implementation guide and the other three (Bonifati et al. / Giorgini, Rizzi & Garzetti / Mazón, Trujillo & Lechtenbörger) are semi-automatic unlike the Romero and Abello method which is completely automatic. It should also be noted that in these composite methods, only the method of Bonifati et al. which is parallel while the other four are sequential. This choice of the research community is largely due to a major disadvantage of the parallel approach. This disadvantage is the low exploitation of the results of the data-driven phase and the demand-driven phase since the two phases are executed independently.

TABLE. I. COMPARATIVE TABLE OF THE DIFFERENT HYBRID METHODS

Hybrid methods	**Type**	**Operating mode**	**Input data**	**Tool**	**Time consumption**
Cabibbo & Torlone, 1998	Compound hybrid: sequential	Guide	ER	No	Very high
Böehnlein & Ulbrich-vom Ende, 1999	Compound hybrid: sequential	Guide	SER	No	Very high
Bonifati et al., 2001	Compound hybrid: parallel	Semi-automatic	ER	No	Very high
Giorgini, Rizzi & Garzetti, 2008	Compound hybrid: sequential	Semi-automatic	ER Relational	Yes	Very high
Mazón, Trujillo & Lechtenbörger, 2007	Compound hybrid: sequential	Semi-automatic	Relational	Yes	Very high
Romero & Abelló, 2010a	Fully hybrid	automatic	Relational	No	Average

It is clear that the Romero and Abello method is the best hybrid method for designing multidimensional schemas. However, this method has a major disadvantage since its use requires either an intervention by the developer who is supposed to understand the users' needs and formalize them in the form of requests, or that users of the BI system have some knowledge of databases and query languages and in the latter case the method cannot be used by all users.

In order to overcome these gaps, the authors tried through this paper to present a new hybrid method of the sequential compound type that allows to offer relevant results in a reasonable time and to collect and analyze requirements expressed in a natural language that can be used by all users and without the intervention of any developer or designer. To carry out this new method, the authors used their previous works [1], [2], [14]–[17] by combining the data-driven method X-ETL with the requirements-driven method XCube Assist.

III. METHODOLOGY

A. X-ETL Method

The X-ETL method is a data-driven method that transforms a relational model into a multidimensional model in a completely automatic way. It is based on 3 main components.

- Relational meta-model: to which the input source model must be conform. This metamodel is composed of three main elements: a database containing tables and these tables contain columns;
- Multidimensional meta-model: to which the output model must be conform. It is a meta-model describing the elements and relationships in a star model. Thus, it is composed of a single fact table containing one or more measures and related at least to 2 or more dimensions;
- Transformation engine.

The transformation engine is the core of the X-ETL method since it is the engine that transforms the relational model into a multidimensional model. This engine is based on a set of rules for detecting facts and dimensions tables. The most important of these rules states that the relationship between a fact table and a dimension table is many-to-one and can never be one-to-many or many-to-many. Thus, the engine first detects the fact tables by calculating the number of foreign keys in each table and retaining those containing the highest number. Then, the program uses the cardinalities to detect the dimensions that are directly related to the fact table. Finally, the program identifies the dimensions indirectly related to the fact table by using the principle of the transitivity of cardinalities. A star model validated by the multidimensional meta-model is generated at the end of the process. Fig. 1 represents the Framework of the X-ETL method:

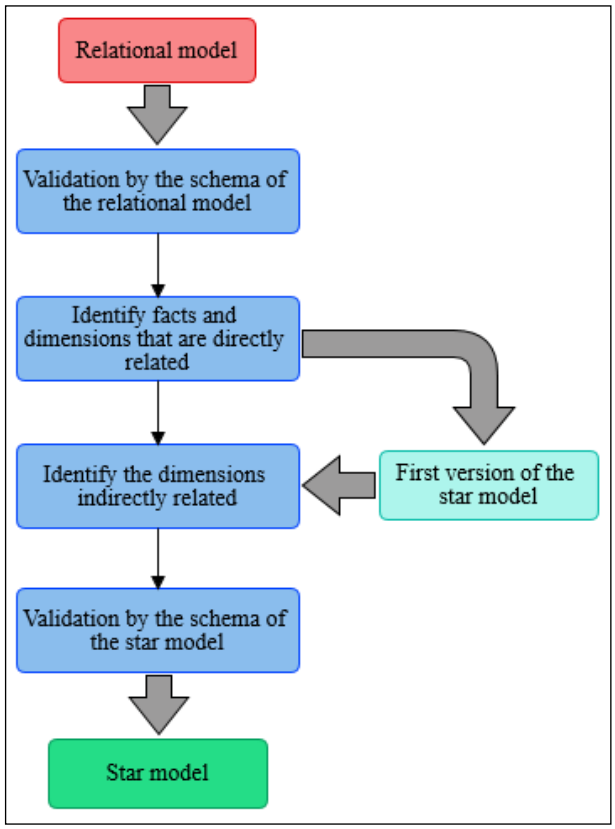


Fig. 1. Framework of X-ETL Method.

In order to evaluate the X-ETL method, the authors have used two relational models from the literature with their multidimensional reference models. The first example represents a sales activity and the second an activity in the field of medicine. The choice of two different domains allowed to test the validity of the method for different fields of application. The comparison between the results obtained with the X-ETL method and the multidimensional reference models revealed a similarity of the fact tables and the majority of the dimensional tables with some differences in the measures and the attributes hierarchy. According to this comparison, and since the appropriate choice of fact table and dimensions guarantees the availability of the necessary data for a possible aggregation of the data and modification of the attributes hierarchy, it can be said that the X-ETL method allows to get satisfactory results.

However, and like any data-driven method, the X-ETL method has some disadvantages. The first of these disadvantages lies in the nature of the method, which is based only on an input model to perform all the next steps and generate a multidimensional model at the end of the process. Therefore, the success of the whole process and the accuracy of the resulting multidimensional models depend largely on the quality of the input model. If the latter one is poorly designed, there is a high risk that the program will retain the wrong fact tables and thus generate a multidimensional model that makes no sense. The second disadvantage is the risk of retaining unnecessary dimensions since the program considers only the constraint of modeling to identify these dimensions. Therefore, if the program offers the advantage of generating multidimensional models with all possible dimensions, there is a risk that these models may be overloaded and generate an over-information of the user of the decision-making system.

The disadvantages of the X-ETL method are mainly due to the approach followed, which is limited to data analysis and excludes the users' and decision-makers' needs. Thus, and in order to overcome these disadvantages and obtain more effective results, it is necessary to integrate a demand-driven method that will allow the multidimensional models generated to be further refined.

B. XCube Assist Method

It is a semi-automatic method that allows to generate multidimensional models from the users' needs. This method is mainly based on the semantic analysis of decision questions expressed in natural language and a comparison with the search history and the source model. As shown in Fig. 2, the history file structure contains a set of reference questions that have been retained by the system with answers in the form of pre-defined metrics and multidimensional models.

As a result, semantic comparison with search history helps to guide the user in his decision-making search by offering similar reference questions, metrics and corresponding multidimensional models. If no correspondence has been detected or the proposed metrics do not answer the user's question, the system retains the new question or metric and moves on to a semantic comparison between the user's search and the table and field names of the source relational model. This semantic comparison helps to detect semantic relationships between terms searched by the user and terms in the components of the relational model. So, the table that has a semantic relationship, especially of the synonymy type, with the strategic axis defined by the user is retained as a fact table and the tables that have a relationship with the analysis dimensions are retained as dimensions. At the end of the process, the XCube Assist program generates a star model for the user and adds it to the reference models for possible use in future research.

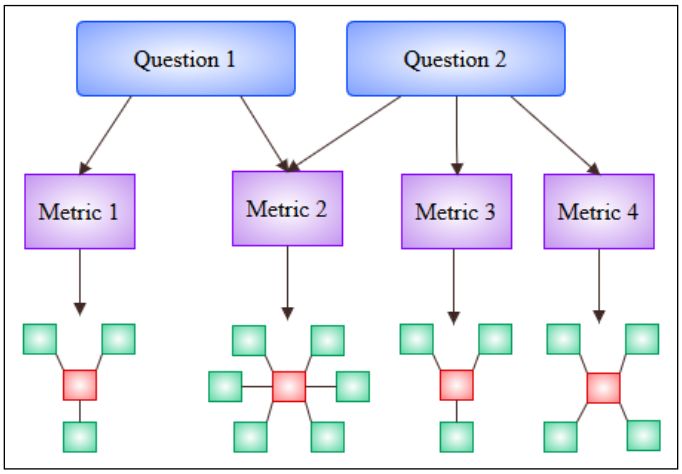


Fig. 2. The Structure of the History Files.

The test of the XCube Assist method on an example from the literature and the comparison of the results obtained with the multidimensional model provided, revealed that the program always retains the right fact table even when the user expresses his need with expressions different from the table and fields names of the relational model, and this is due to the semantic analysis performed previously. The most important thing is that the user must know exactly what he is looking for and identify his need regardless of the jargon and the language used to express it. The comparison also showed that the method does not generate a complete multidimensional model but only the part that meets the user's needs. However, the recursivity of the method allows, not only to feed the data warehouse with new multidimensional models, but also to improve the quality of the multidimensional models already generated and thus to ensure that these models evolve according to the new needs expressed.

While the XCube Assist method has the advantage of verifying the availability of data in the source model, it has the disadvantage of not considering the constraints of the cardinalities of the relational model. Consequently, the resulting multidimensional model may contain dimensions that cannot be related to the fact table because of a relational constraint and their retention requires deep transformations in the source model. It is true that the definition of this type of dimension can be useful for designers in order to carry out these transformations. However, the non-checking of the constraint of the cardinalities results in retaining this type of dimension in the same way as the other dimensions and without any particular indication that allows designers to distinguish them from the other dimensions.

Therefore, the completeness of the models generated by the method depends on the complementarity of the needs expressed and the assimilation by users of all the multidimensional possibilities that data sources can offer. In addition, users may sometimes have latent needs that need to be stimulated to express them.

According to this analysis, it is clear that the XCube Assist method can lead to more complete and efficient results if it is combined with a data-driven method that will integrate data constraints into the process while exposing to the user all the decision-making potential hidden in the data sources.

C. The Hybrid Method HX-ETL

The new hybrid method consists of combining the X-ETL method with the XCube Assist method. As shown in Fig. 3, it is sequential method composed of two successive steps:

- A first data-driven step: which consists of executing the X-ETL method on a relational source model to get star models. This method is only based on modeling constraints to retain the components of the star schema.
- A second demand-driven step: this step is based on the XCube Assist method to identify users' needs and conciliate them with the results of the previous step in order to generate valid multidimensional models that meet users' needs.

The conciliation stage is not limited to a simple mapping of needs on the results of the X-ETL method. Rather, it allows an exchange of information between the second step and the results of the first step. This interactivity in the process not only allows the verification of the modeling constraints of the requested multidimensional model but also to guide users in their research and stimulate their latent needs by proposing new dimensions. Indeed, the semantic analysis of the user-defined need and its comparison with each fact table of the star models give rise to a percentage of correspondence. The fact table that has the highest match rate while exceeding the 50% threshold is the one that best meets the user's need. This fact table is therefore retained in the final multidimensional schema and the dimensions to which it is related in the star schema will be proposed to the user even when these analytical dimensions have not been expressed in his need. In this way, the system will help the user to enrich his multidimensional model with new dimensions by exposing to him all the dimensional potential offered by the data. Fig. 4 shows the BPMN diagram that illustrates the interactivity between the two stages of the HX-ETL method.

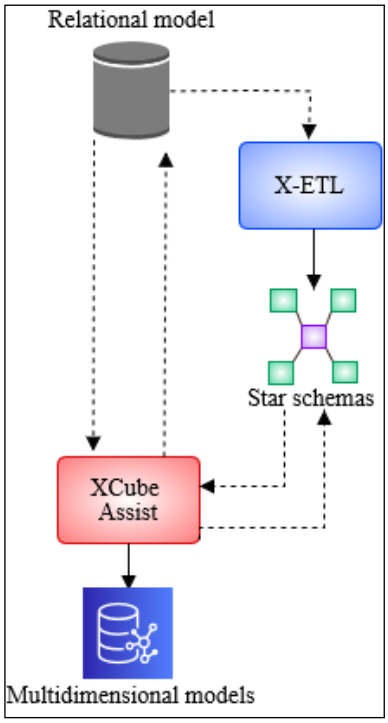


Fig. 3. General Schema of the New Hybrid Method.

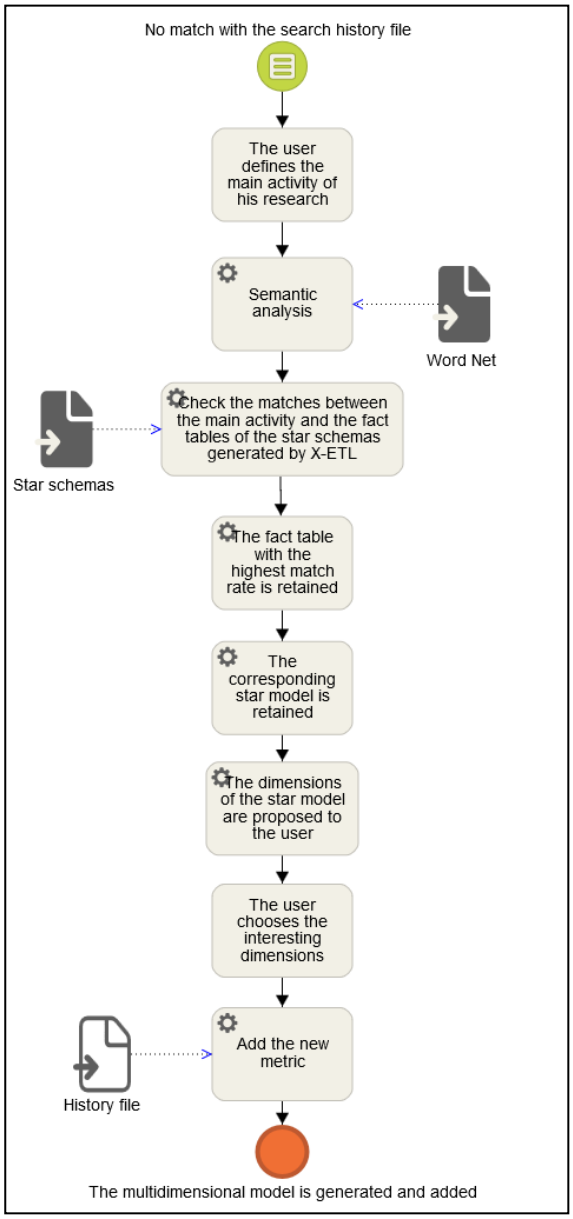


Fig. 4. BPMN Schema of the First Semantic Comparison in the HX-ETL Method

The algorithm below represents the process of the first semantic comparison between the defined need and the results of the X-ETL method.

1 **BEGIN**
2 Retain the main activity of the research defined by the user
3 Perform Semantic analysis basing on the WordNet library
4 Check matches between the main activity and the fact tables of the star schema generated by X-ETL
5 Retain the table with the highest match rate as fact table
6 Retain the corresponding star model
7 Propose the dimensions of the star model to the user
8 Retain the interesting dimensions chosen by the user
9 Add the new metric to the history file
10 Generate and add the multidimensional model
11 **END**

Since the star models do not represent all the data of the source model, a second comparison between the expressed need and the tables of this model is performed. This comparison identifies the fact table and dimensions in the source model in case the program does not find a match in the results of the X-ETL method. This phase is of crucial importance as it allows designers to be informed of multidimensional components that are requested by users but that have not been retained by the X-ETL method because of a modelling constraint. In this way, designers will then be able to introduce modifications and readjustments in the source relational model to make it more appropriate for the decision-making system and more flexible for multidimensional modeling. Fig. 5 shows the BPMN schema of this second semantic comparison.

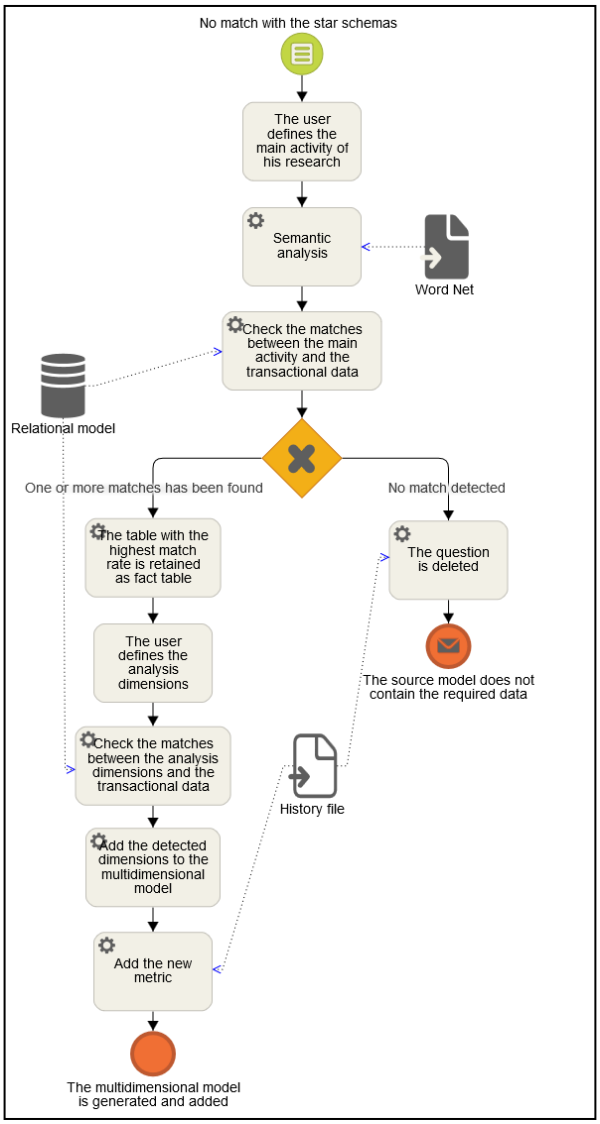


Fig. 5. BPMN Schema of the Second Semantic Comparison in the HX-ETL Method.

Below is the algorithm that describes the process of the second semantic comparison in the new hybrid method.

```
BEGIN
    Retain the main activity of the research defined by the user
    Perform Semantic analysis basing on the WordNet library
    Check matches between the main activity and the transactional Data basing on the relational model
    IF one or more matches has been found THEN
        Retain the table with the highest match rate as fact table
        Define the analysis dimensions by the user
        Check the matches between the analysis dimensions and the transactional data
        Add the detected dimensions to the multidimensional model
        Add the new metric to the history file
        Generate and add the multidimensional model
    ELSE
        Delete the question from the history file
        Return message explaining that the source model does not contain the required data
    ENDIF
END
```

Fig. 6 represents the process of the data-driven step as well as the requirements-driven step and the conciliation phase between these two steps.

The multidimensional model generated at the end of the process contains 3 types of dimensions:

- Dimensions retained from the star schema: they are the dimensions that are retained during the first semantic comparison. These dimensions are valid since they are requested by users and at the same time meet modeling constraints. These dimensions are labelled in the final multidimensional model by the expression < dimension type = valid >;
- Dimensions retained from the transactional model: These dimensions are retained at the end of the second semantic comparison between the user's need and the transactional model. These dimensions do not meet the modeling constraints and are therefore labelled by the expression < dimension type = invalid >;
- Non-existent dimensions: This third type represents the dimensions that are requested by the users but that do not exist anywhere. They are marked in the final result by the expression < dimension type = nonexistent >.

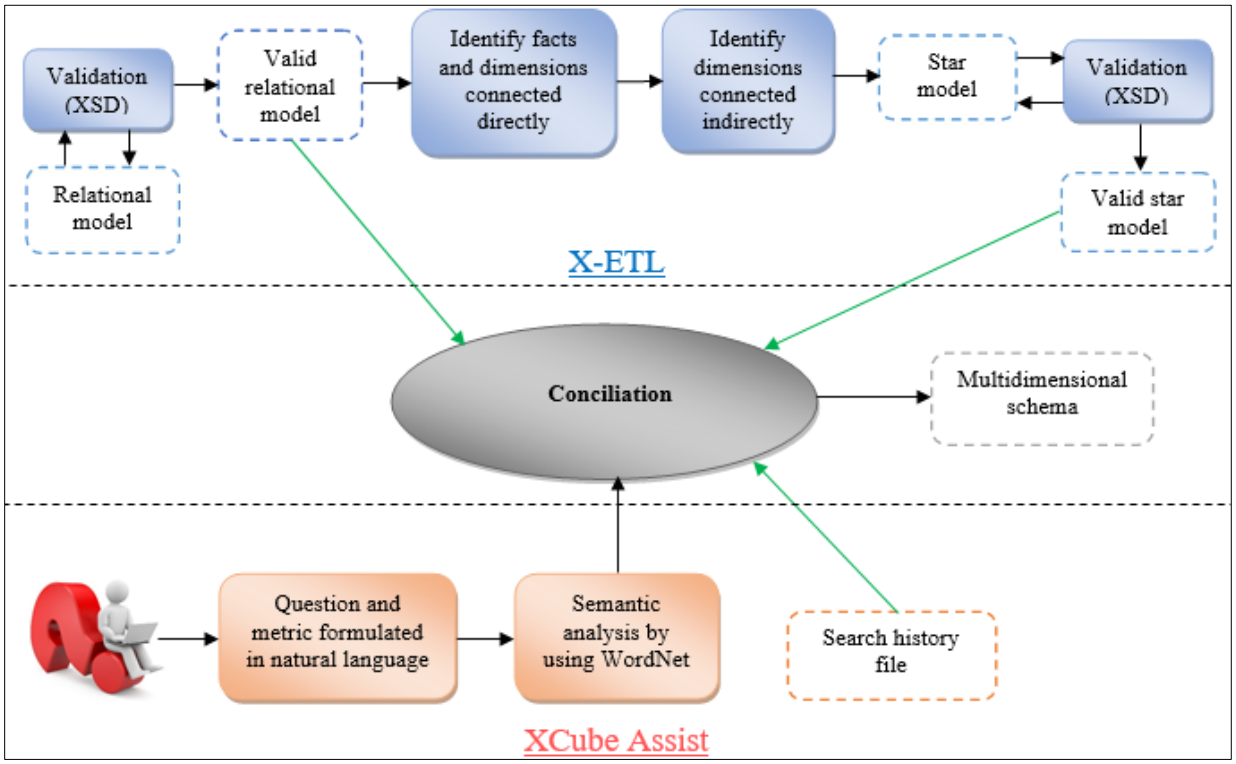


Fig. 6. Detailed Schema of the New Hybrid Method.

IV. Empirical Case Study

In order to test and evaluate the HX-ETL method, the authors used the "sales" example shown in Fig. 7 and previously used in the X-ETL method and the XCube Assist method. The use of the same example will help to verify and show the improvements that will be made by the hybrid method compared to the other two methods.

The first step of the hybrid method will give rise to the results of the X-ETL method. They are the three star models shown in the Table II.

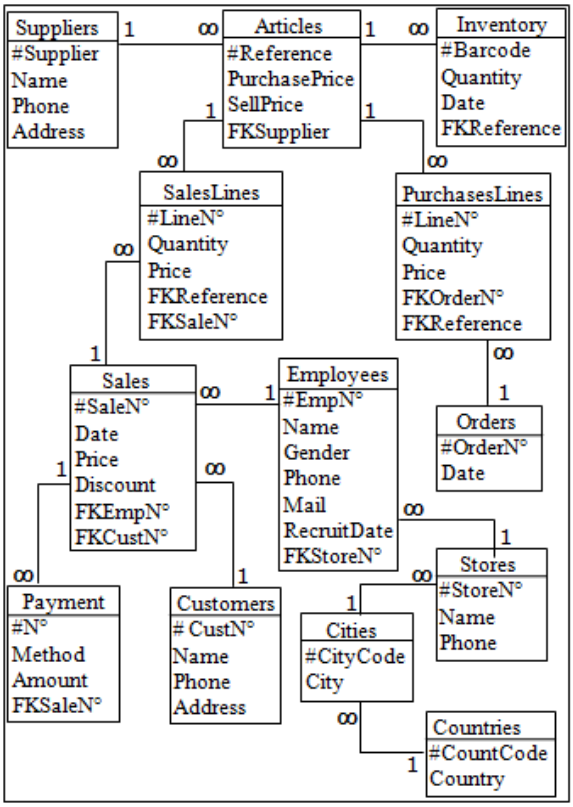


Fig. 7. Relational Model of the Sales Example.

TABLE. II. The Star Models Generated by the First Step of the Hybrid Method

	Fact tables	Dimension tables
1st star model	SalesLines	Articles – Customers – Suppliers – Sales – Stores – Cities – Countries – Employees – Time.
2nd star model	Sales	Employees – Customers – Stores – Cities – Countries – Time.
3rd star model	PurchasesLines	Orders – Articles – Suppliers – Time.

In the second requirement-driven step, assuming that the user asks the following question: **Are our products sold enough?** Once the question is submitted, the system will perform a semantic analysis to look for possible matches with the reference questions stored in the history file. If a match is found it will be proposed to the user. Assuming now that the system does not detect any correspondence and retains the new question. In this case, the user will have to determine the metric that will be able to answer his question by first defining the strategic axis of his research. Assuming, for example, that the user defines the term "Sales" as a strategic axis. The program will perform a semantic analysis of this term and make a comparison with the fact tables of the star models generated at the end of the first step. In this example, the system will retain the "Sales" fact table since it has the highest match rate. Then, the system will extract the corresponding star model (2nd model) and propose all its dimensions to the user: Employees, Customers, Stores, Cities, Countries and Time. Assuming, for example, that the user selects all the proposed dimensions and requests two more dimensions: Products and Categories. In this case, the program will move on to the second semantic comparison with the transactional model, which will result in a single correspondence between Products and Articles. This last table will be proposed to the user who will have the choice to select it or not. At the end of the process, the multidimensional model shown in Fig. 8 will be generated as an XML file.

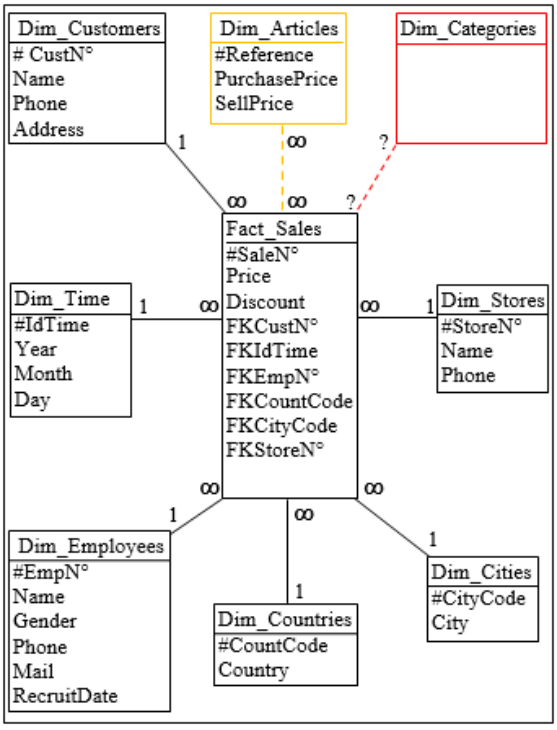


Fig. 8. Multidimensional Model Generated by the HX-ETL Method.

V. Analysis and Criticism

Compared to the other hybrid methods cited in the second section, and according to the results obtained in the empirical case study, it is possible to state that the new method is the first formal method that allows both to obtain satisfactory results in a reasonable time while being based on needs expressed in natural language and data sources. However, the new method has some limitations:

- The method does not allow to generate hierarchies in dimensions;
- The measures are always selected manually in the fact table (X-ETL);
- The method does not allow to automatically merge two or more tables to obtain a single dimension. In the multidimensional model in Fig. 8, the tables "Dim_Stores", "Dim_Cities" and "Dim_Countries" can be merged into a single table: "Dim_Place".

Therefore, the research perspectives will be to introduce improvements in the HX-ETL method to overcome these limitations while automating the method process as much as possible.

VI. Conclusion

In general, the hybrid approach considers both the analysis needs and the data for the construction of the schema. Nowadays, this approach is the one that is the subject of more investigation. The general idea is to build candidate schemas from the data (bottom-up approach) and compare them with the schemas defined according to users' requirements (top-down approach). Thus, the constructed schema is a response to real analysis needs and it is also possible to implement it with data sources. However, there are several design logics in this approach: there are fully hybrid methods, sequential compound hybrid methods and parallel compound hybrid methods.

The authors tried through this paper to present a new hybrid method of the sequential compound type by combining their data-driven method called X-ETL with the requirements-driven method XCube Assist. This combination enabled to collect and analyze needs expressed in natural language while obtaining relevant results in a reasonable time. The new method also allows to demonstrate the shortcomings and deficiencies of the source model for eventual improvements by identifying in the final results the dimensions that cannot be modelled and the dimensions that are solicited and non-existent.

References

[1] N. El Moukhi, I. El Azami, A. Mouloudi, and A. Elmounadi, “X-ETL: A Data-Driven Approach for Designing Star Schemas,” Int. J. Recent Contrib. Eng. Sci. IT, vol. 7, no. 1, pp. 4–21, Mar. 2019.

[2] N. El Moukhi, I. El Azami, A. Mouloudi, and A. ElMounadi, “Requirements-based approach for multidimensional design,” Procedia Comput. Sci., vol. 148, pp. 333–342, 2019.

[3] L. Cabibbo and R. Torlone, “A Logical Approach to Multidimensional Databases,” in Proceedings of the 6th International Conference on Extending Database Technology: Advances in Database Technology, Berlin, Heidelberg, 1998, pp. 183–197.

[4] M. Boehnlein and A. Ulbrich-vom Ende, “Deriving initial data warehouse structures from the conceptual data models of the underlying operational information systems,” in Proceedings of the 2nd ACM international workshop on Data warehousing and OLAP-DOLAP ’99, Kansas City, Missouri, United States, 1999, pp. 15–21.

[5] A. Bonifati, F. Cattaneo, S. Ceri, A. Fuggetta, and S. Paraboschi, “Designing data marts for data warehouses,” ACM Trans. Softw. Eng. Methodol., vol. 10, no. 4, pp. 452–483, Oct. 2001.

[6] P. Giorgini, S. Rizzi, and M. Garzetti, “GRAnD: A goal-oriented approach to requirement analysis in data warehouses,” Decis. Support Syst., vol. 45, no. 1, pp. 4–21, Apr. 2008.

[7] M. Golfarelli and S. Rizzi, Data Warehouse Design: Modern Principles and Methodologies. McGraw-Hill Education, 2009.

[8] J.-N. Mazón, J. Trujillo, and J. Lechtenbörger, “Reconciling requirement-driven data warehouses with data sources via multidimensional normal forms,” Data Knowl. Eng., vol. 63, no. 3, pp. 725–751, Dec. 2007.

[9] J. Pardillo, J.-N. Mazón, and J. Trujillo, “Model-Driven Metadata for OLAP Cubes from the Conceptual Modelling of Data Warehouses,” in Data Warehousing and Knowledge Discovery, Berlin, Heidelberg, 2008, pp. 13–22.

[10] J.-N. Mazón and J. Trujillo, “A hybrid model driven development framework for the multidimensional modeling of data warehouses!,” ACM SIGMOD Rec., vol. 38, no. 2, p. 12, Oct. 2009.

[11] A. Carmè, J.-N. Mazón, and S. Rizzi, “A Model-Driven Heuristic Approach for Detecting Multidimensional Facts in Relational Data Sources,” in Data Warehousing and Knowledge Discovery, Berlin, Heidelberg, 2010, pp. 13–24.

[12] O. Romero and A. Abelló, “Automatic validation of requirements to support multidimensional design,” Data Knowl. Eng., vol. 69, no. 9, pp. 917–942, Sep. 2010.

[13] O. Romero and A. Abelló, “Multidimensional Design by Examples,” in Data Warehousing and Knowledge Discovery, Berlin, Heidelberg, 2006, pp. 85–94.

[14] N. El Moukhi, I. El Azami, A. Mouloudi, and A. El Mounadi, “Requirements-driven modeling for decision-making systems,” in 2018 International Conference on Electronics, Control, Optimization and Computer Science (ICECOCS), Kenitra, 2018, pp. 1–7.

[15] N. El Moukhi, I. El Azami, A. Mouloudi, and A. El Mounadi, “Towards a new automatic data warehouse design method,” Electron. J. Inf. Technol., no. 11, pp. 1–22, 2018.

[16] N. El Moukhi, I. El Azami, and A. Mouloudi, “Towards a new method for designing multidimensional models,” Int. J. Bus. Inf. Syst., vol. 28, no. 1, pp. 18–41, 2018.

[17] N. El Moukhi, I. El Azami, and A. Mouloudi, “X-ETL: A new method for designing multidimensional models,” in 2017 3rd International Conference of Cloud Computing Technologies and Applications (CloudTech), Rabat, 2017, pp. 1–6.

Object Detection System to Help Navigating Visual Impairments

Cahya Rahmad[1], Rawansyah[3], Tanggon Kalbu[4]
Department of Information Technology
State Polytechnic of Malang, Malang, Indonesia

Kohei Arai[2]
Department of Information Technology
Saga University, Saga City, Japan

Abstract—The number of people with severe visual impairments and blind people in the world is 216.6 million and 38.5 million, respectively in 2018 and that number will increase every year. While the development of Computer Vision technology became popular after that method is used in automatic driving system using an object detection system to detect surrounding object, this technology can be a solution to help blind people too. This can be done by implementing Harris Corner Detection method. Harris Corner Detection method is used to detect the corner of the object in the image taken. The number of corner and location of corner in detection result can be used for predicting position and distance. To predict the distance, a triangle rule will be used in finding the distance. Furthermore, it can predict the location and distance of the object in the picture taken. From the results of the implementation above it was found that the accuracy of object detection using Harris Corner Detector's angle detection method is 88%. Therefore, this application can help detecting objects based on the number of corner and location detected using a Smartphone.

Keywords—Object detection; corner detection; computer vision; visual impairments; blind people

I. INTRODUCTION

Computer Vision is a technology that aims to mimic the function of human vision electronically [1]. Computer Vision relies a lot in feature extraction [2]. Feature extraction is the initial stage of object detection [3]. This technology works by taking features in the image. Images have many features such as lines, contours, angles and colors. These features are very important in the field of image processing and computer vision [4]. The example of feature detection methods are Harris Detector, Canny, Laplacian of Gaussian, and Sobel. In the past few years, this system is used in a cars as a tool to navigate when driving [5]. Using edge detector to detect road markings as guide line for driving navigation and corner detector to detect traffic signs [6].

This system also could be useful especially for people who have visual impairments. This system could replace human eye because its function that resemble human vision. Statistics says that there are 216.6 million people who have visual impairments and as many as 38.5 million people who suffer from total blindness are predicted to increase each year [7]. That is the challenge that we must face. To maintain the safety of the community and the people that have visual impairments, access to visual information about surrounding object is necessary.

Apart from existing methods to help such as personal assistants who help people with visual impairments, an intelligent system needs to be developed that can automatically help people with visual impairments carry out their daily activities to help navigate and detect objects around them [8]. So from that it is necessary to create a system that detects objects around it on the android platform. By using the Harris Corner Detection method that will be implemented on a smartphone, users can retrieve information about object around them even if the user has a visual impairment.

Quite recently, E. Rosten and T. Drummond proposed "Machine learning for high-speed corner detection," in the European Conference on Computer Vision [9]. Also, Leonardo Trujillo and Gustavo Olague reported: "Automated design of image operators that detect interest points" [10]. Meanwhile, Ivan Laptev and Tony Lindeberg proposed "Space-time interest points" [11]. On the other hand, Geert Willems, Tinne Tuytelaars and Luc van Gool proposed "An efficient dense and scale-invariant spatiotemporal-temporal interest point detector" [12]. Meantime, Tony Lindeberg proposed "Spatio-temporal scale selection in video data" [13]. Also, I. Everts, J. van Gemert and T. Gevers proposed "Evaluation of color spatio-temporal interest points for human action recognition" [14]. These are alternatives of the proposed Harris Cornet Detection Algorithm.

By utilizing a smartphone camera, the user can press volume button on the headset or earphone that has been programmed to take pictures with back camera. The captured image will be processed using the Harris Corner Detection method to get information in the form of text about what is caught on the camera. The information is then converted into audio so that users can listen to the location and distance of the object in front of it. So that it is expected to help to detect objects around it and help navigate its users.

II. HARRIS CORNER DETECTOR

Harris Corner Detection is a method that aims to take and detect corner on an image. This corner extraction feature is the initial stage of detection of this object. Corner detection is used to detect the angle of an object in the image. So that it functions to detect objects that have angles such as doors, the lower end of the wall, etc.

This method works by considering 8 pixels next to a pixel that will detect the angle. For example pixel p is a pixel whose corner will be detected. If the intensity of 8 pixels next to pixel p is almost the same as pixel p, then it is a flat region. If there

is a significant change but there is no change in the surrounding pixels in the same direction, it is called the edge region. If there is a significant change in each direction, the pixel is a corner. Fig. 1 is the following illustration of flat, edge, and corner region.

To achieve Harris Value in every pixel in an image, this following steps must be taken [2]:

- Grayscaling the image. Give a grayscale effect on the original image. This aims to reduce the number of matrix dimensions from 3 x 3 to 2 x 2 in order to simplify calculations [15].
- Smoothing the image. Using blur block to convolute the grayscale image. This also reduce noise and unwanted corner.
- Computing gradient of the image using convolution between grayscaled and blurred image with gradient masks.
- Computing autocorrelation matrix.
- Computing eigen value.
- Computing corner strength.

A. Image Gradient

In order to get the gradient difference between 8 neighbor pixel, Harris and Stephens [16], using central difference for gradient masks. Central difference will be convoluted with grayscaled and blurred image. Central difference kernel can be seen in Fig. 2. While the horizontal kernel is Ix and vertical kernel is Iy.

B. Autocorrelation Matrix

The product of derivatives (image gradient) Ix and Iy will be inserted to A, B, and C variable. This variable is used for matrix M. In which A is Ix^2, B is IxIy, and C is Iy^2. Therefore matrix M will be written like in Equation (1).

$$M = \begin{bmatrix} I_x I_x & I_x I_y \\ I_x I_y & I_y I_y \end{bmatrix} = \begin{bmatrix} A & B \\ B & C \end{bmatrix} \quad (1)$$

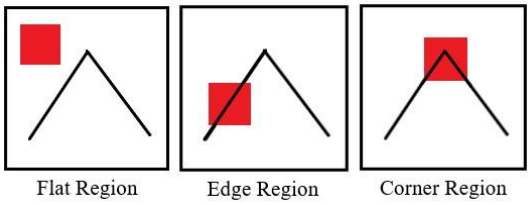


Fig. 1. Illustration of Flat, Edge, and Corner Region.

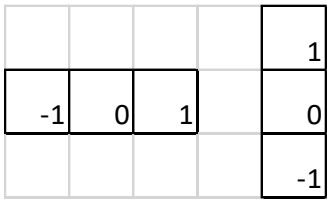


Fig. 2. Central difference Gradient Masks.

C. Eigen Value

The eigen value is symbolized by the lambda symbol (λ) which is important step when looking for corner. Eigen Value in Harris Corner Detector method is used to find corner from intersection edges that are not horizontal or vertical.

$$\det M = \lambda_1 \lambda_2 = AC - BB \quad (2)$$

$$trace\ M = \lambda_1 + \lambda_2 = A + C \quad (3)$$

$$\lambda = \frac{traceM \pm \sqrt{traceM^2 - 4detM}}{2} \quad (4)$$

D. Harris Value

Harris value can be symbolized by R. Which R equal in equation (5). With k value is 0.04. What define a pixel is a corner, edge, or flat region is based on the product of R. If R <0 means $\lambda_1 > \lambda_2$or vice versa then the area is classified as the edge region. If R> 0 and the score is high then λ_1 and $\lambda_2$are high, then the area is classified as a corner region. If R is low, then it is a flat region. There is no fixed value of how low is R classified as flat region, so it is a personal preference about how low r can be classified as flat region. In Fig. 3 is a classification how to define flat, edge, or corner by how much R is.

$$R = detM - k(traceM)^2 \quad (5)$$

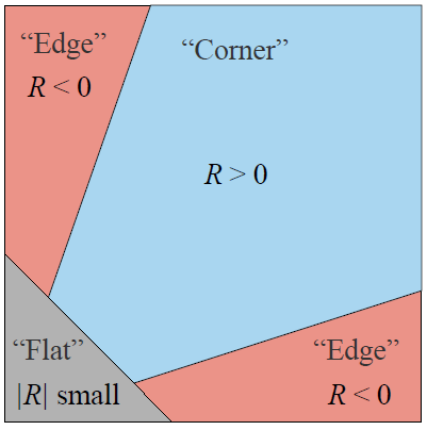


Fig. 3. R Classification Illustration.

III. Triangle Rule

It is a simple method on triangles that can be used as a guide to find distance. Fig. 4 is an illustration of a person who uses a smartphone. Variable a is the distance between the land and the smartphone. This distance can be obtained from 83% of the user's height. Variable b is the prediction of the distance between the user and the object that was detected. Variable c is the direction of the camera's angle of view. While the angle θ is the angle formed by the point of view of the camera with the distance from the ground to the smartphone. Variables Distance 1, Distance 2, and Distance 3 are three groups of distance predictions. Object A is in the distance group 1, Object B is in the distance group 2, and Object C is in the distance group 3.

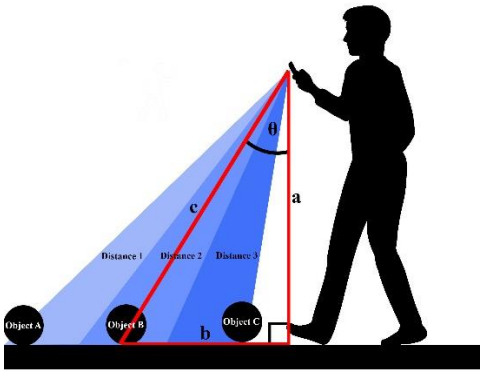


Fig. 4. Triangle Illustration

If the user tilts his smartphone to the point of view of the camera forming an angle θ then the value of b can be calculated which is the prediction of the distance between the user and Object B using Equation (6). If distance of Object B has been found, the distance of Object A is further from Object B. The distance of Object C is closer than the distance of Object B.

$$b = \mathrm{a} * \tan\theta \tag{6}$$

IV. Measuring Distance and Position

In Fig. 5, the object distance determination is done by dividing the image into nine equal parts.

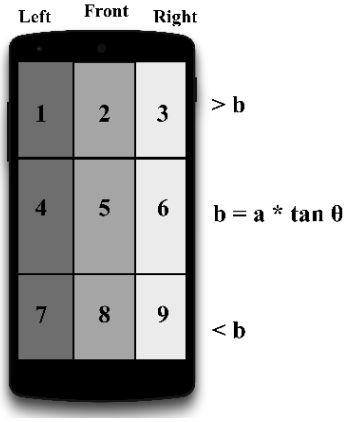


Fig. 5. Corner Position and Distance by Image.

The division is done based on the length and width of the image. Each width and height divides by 3 equally. The distance is determined using the triangle rule as in equation (6). The angle taken has a range between 40-60 degrees. Determination of the angle is done using an accelerometer.

V. Implementation

In Fig. 6, it is explained that the application starts by declaration the required variables. The y variable is used to store the y value which is related to the slope of the smartphone. The ACL variable is a variable to store the type of sensor that will be used and the variable v stores the vibrating function that is on the smartphone.

After that the application waits for variable input from OnKeyDown. If you press the volume down button, the application will continue. If the volume is not down, then it is volume up. Volume up button is used for entering user heights. It can be done by saying the default height value, which is 150 centimeters. In height settings, up and down volume button is for adjusting the user's height by 10 centimeters. When height is fixed, user shall press volume up button for 3 seconds and out from height settings. When out of the height settings, the volume down button have function to retrieve the y value from the accelerometer sensor. This value is a consideration for determining the camera's angle of view based on the tilt of the smartphone. If it does not meet the angle range of 40 to 50, the smartphone will vibrate.

Angles 40 to 50 if scaled with a value of y then the angle of 40 is equivalent to 4.4 and the angle of 50 is equivalent to 5.5. If the angle is within that range, the application will stop the vibration using v.cancel(). After the vibration stops, the application will automatically take pictures, calculate the HCD value, determine the position and distance based on the HCD value, and voice it. The time needed from the four processes is around 1 to 2 seconds. The faster the information variables that have to be voiced are few and the longer the more information that has to be voiced.

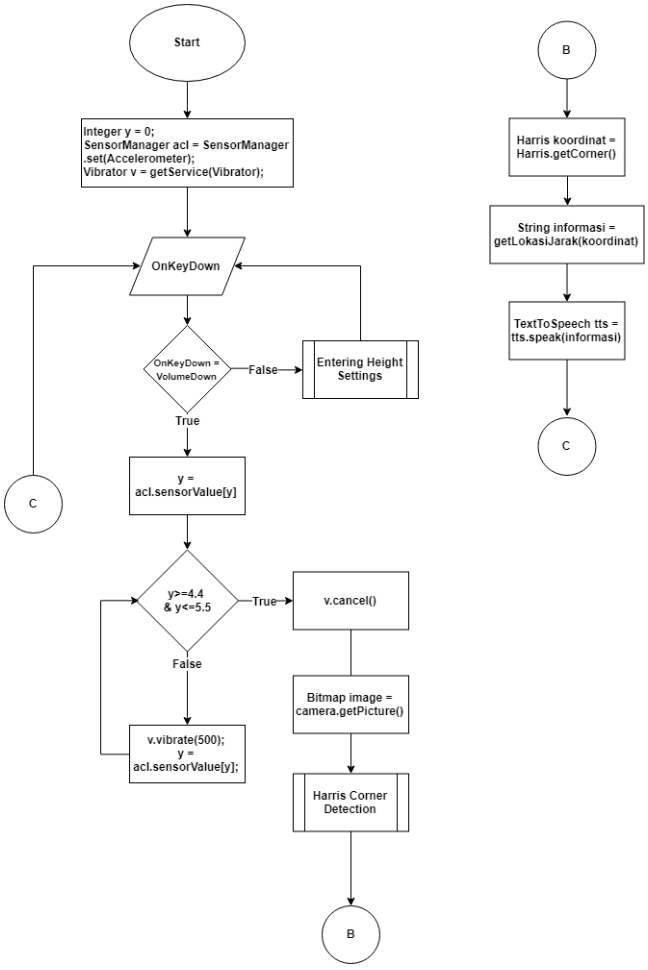


Fig. 6. Full Application Flowchart.

VI. TESTING

Testing is done by taking pictures 50 times in each area. After that, checking the truth using human vision with normal vision to find out whether the location and distance variables of the object in the application are true. Accuracy can be calculated by adding up the number of correct predictions then divided by the total number of predictions. Image testing can be accessed in this references [17]. Example of testing images is shown in Fig. 7.

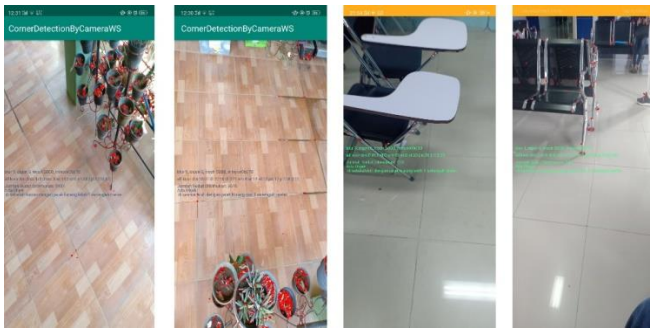


Fig. 7. Example of Testing Images.

After testing, obtained an accuracy of 88%. This number is taken from 44 times true and 6 times false. The prediction will be wrong if there is a lot of noise and unnecessary patterns on the floor. This results in misinformation. The application detects the pattern of the floor as an object. Floors or environments that have many holes or are uneven or have a certain pattern can cause the object to be detected. Even though there are no objects in front that gets in the way.

VII. CONCLUSION

- Detecting objects using the HCD method on a smartphone can be done with the processing time from taking pictures until finished talking for 1 to 2 seconds.
- Predicting the distance of the object and providing information about the position of the object can be done using the rules of the triangle. By utilizing the hegiht of the user as b and tan the angle of 45 to 60 to get 3 distance categories b meters, more than b meters and less than b meters.
- Based on testing with real objects, obtained an 88% of accuracy with the correct number of predictions 44 and 6 wrong.

REFERENCES

[1] S. Milan and H. Vaclav, Image Processing, Analysis, and Machine Vision. Thomson, 2008.

[2] Sánchez, N. Monzón, and A. Salgado, "An Analysis and Implementation of the Harris Corner Detector," Image Process. Line, 2018.

[3] K. Jeong and H. Moon, "Object detection using FAST corner detector based on smartphone platforms," in Proceedings - 1st ACIS/JNU International Conference on Computers, Networks, Systems, and Industrial Engineering, CNSI 2011, 2011.

[4] Y. Li, S. Wang, Q. Tian, and X. Ding, "A survey of recent advances in visual feature detection," Neurocomputing, 2015.

[5] R. Gandhi, "R-CNN, Fast R-CNN, Faster R-CNN, YOLO — Object Detection Algorithms," Towards Data Science, 2018. [Online]. Available: https://towardsdatascience.com/r-cnn-fast-r-cnn-faster-r-cnn-yolo-object-detection-algorithms-36d53571365e. [Accessed: 04-Dec-2018].

[6] T. Wenzel, T. W. Chou, S. Brueggert, and J. Denzler, "From corners to rectangles-Directional road sign detection using learned corner representations," in IEEE Intelligent Vehicles Symposium, Proceedings, 2017.

[7] R. R. A. Bourne et al., "Magnitude, temporal trends, and projections of the global prevalence of blindness and distance and near vision impairment: a systematic review and meta-analysis.," Lancet. Glob. Heal., vol. 5, no. 9, pp. e888–e897, 2017.

[8] F. S. Bashiri, E. LaRose, J. C. Badger, R. M. D'Souza, Z. Yu, and P. Peissig, "Object detection to assist visually impaired people: A deep neural network adventure," in Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2018.

[9] E. Rosten and T. Drummond (May 2006). "Machine learning for high-speed corner detection,". European Conference on Computer Vision.

[10] Leonardo Trujillo and Gustavo Olague (2008). "Automated design of image operators that detect interest points" (PDF). Evolutionary Computation. 16 (4): 483–507. doi:10.1162/evco.2008.16.4.483. PMID 19053496. Archived from the original (PDF) on 2011-07-17.

[11] Ivan Laptev and Tony Lindeberg (2003). "Space-time interest points". International Conference on Computer Vision. IEEE. pp. 432–439.

[12] Geert Willems, Tinne Tuytelaars and Luc van Gool (2008). "An efficient dense and scale-invariant spatiotemporal-temporal interest point detector". European Conference on Computer Vision. Springer Lecture Notes in Computer Science. 5303. pp. 650–663. doi:10.1007/978-3-540-88688-4_48.

[13] Tony Lindeberg (2018). "Spatio-temporal scale selection in video data". Journal of Mathematical Imaging and Vision. 60 (4). pp. 525–562. doi:10.1007/s10851-017-0766-9.

[14] I. Everts, J. van Gemert and T. Gevers (2014). "Evaluation of color spatio-temporal interest points for human action recognition". IEEE Transactions on Image Processing. 23 (4). pp. 1569–1589.

[15] P. Ram and S. Padmavathi, "Analysis of Harris corner detection for color images," in International Conference on Signal Processing, Communication, Power and Embedded System, SCOPES 2016 - Proceedings, 2017.

[16] C. Harris and M. Stephens, "A Combined Corner and Edge Detector," 2013.

[17] Cahya Rahmad Image Testing. [Online]. Available: http://bit.ly/CahyaRahmadImageTesting.

AUTHORS' PROFILE

Cahya Rahmad: He received BS degrees from Brawijaya University Indonesia in 1998 and MS degrees from Informatics engineering at Sepuluh Nopember Institute of Technology Surabaya Indonesia in 2005. He is a lecturer in The State Polytechnic of Malang Since 2005. He received Doctoral degrees at Saga University japan in 2013, His interest researches are image processing, data mining and patterns recognition.

Kohei Arai, He received BS, MS and PhD degrees in 1972, 1974 and 1982,respectively.He was with The Institute for Industrial Science and Technology of the University of Tokyo from April 1974 to December 1978 also was with National Space Development Agency of Japan from January, 1979 to March, 1990. During from 1985 to 1987, he was with Canada Centre for Remote Sensing as a Post-Doctoral Fellow of National Science and Engineering Research Council of Canada. He moved to Saga University as a Professor in Department of Information Science on April 1990. He was a counselor for the Aeronautics and Space related to the Technology Committee of the Ministry of Science and Technology during from 1998 to 2000. He was a councilor of Saga University for 2002 and 2003. He also was an executive councilor for the Remote Sensing Society of Japan for 2003 to 2005. He is an Adjunct Professor of University of Arizona, USA since 1998. He also is Vice Chairman of the Science Commission "A" of ICSU/COSPAR since 2008 then he is now award committee member of ICSU/COSPAR. He wrote 37 books and published 570 journal papers. He received 30 of awards including ICSU/COSPAR Vikram Sarabhai Medal in 2016, and Science award of Ministry of Mister of Education of Japan in 2015. He is now Editor-in-Chief of IJACSA and IJISA. http://teagis.ip.is.saga-u.ac.jp/index.html

Faculty's Social Media usage in Higher Education Embrace Change or Left Behind

Seren Başaran
Computer Information Systems, Near East University, Lefkoşa 98010, via: Mersin 10 Turkey, Cyprus
European Centre for Research and Academic Affairs (ECRAA), PO Box 1045, Lefkoşa, via: Mersin 10, Turkey, Cyprus

***Abstract*—This paper addresses faculty members' (academic staff) viewpoints on benefits, barriers and concerns of utilizing social media and also investigates differences with respect to their social media experience in teaching, age and the purpose of using social media. The data was collected through an adopted questionnaire from 324 faculty members of two public and two private universities in north part of Cyprus and was analyzed through descriptive statistics, independent samples t-test and one-way ANOVA. Results revealed that, although faculty members appreciate benefits of using social media, they do have concerns and they are aware of barriers almost as to same degree as benefits of using social media. Those who are familiar and have used social media before think more about concerns than those who haven't used it. Elder faculty members possess less concern about using social media than their younger and middle age colleagues. Furthermore, the purpose (personal, educational, professional) of using social media has no effect on faculty members' viewpoints on benefits, concerns and barriers of using social media. Abundant literature on social media usage from students' perspective and relatively limited studies examining teachers/instructors point of views on social media use particularly for developing countries constitute the primary motivation behind the emergence of such research. Faculty members should be endorsed to adopt social media for instructional and professional purpose and misconceptions about using social media and barriers should be eliminated to enhance conscious utilization of social media for teaching.**

Keywords—Academic staff; age; purpose; social media experience; social networking sites; university

I. Introduction

Social media platform offers sharing of information through enabling digital communication and interaction among all stake holders. It offers not only use of emerging technologies but also maintains open, flexible, anytime accessible environment for all individuals from diverse backgrounds [1]. The most popular social media tools with remarkably growing usage rates in recent years which caught salient attention are; Facebook, YouTube, Wikipedia, Twitter, LinkedIn, Pinterest and Instagram.

Utilization of such social media tools has been the central focus of recent studies which emphasize current advancements in educational aspects of digitally interactive and mobile technologies within the last decade. Social media tools are used predominantly by students subsequently by teachers and by faculty members (academic staff) and to some extent by higher educational institutions' administrations who try to keep up with such new emerging trend with attempts to incorporate social media into their educational milieu.

Today it is not uncommon for a higher education professional to own an account in any of those social media platforms for disseminating information in the combination of either text, link, photo or video, and engage actively for personal, instructional or profession related purposes. With the emergence of such new technologies, social media usage has been growing fast and rapidly penetrates educational settings. This pervasive characteristic of social media has made it possible either formally or most of the time informally to integrate itself into educational environments and it has already gained acceptance from students while it has been recently considered by faculty and educational institutions [2]. With this recent and ongoing development, higher education professionals particularly faculty members could not ignore anymore the influence of social media on students [3], [4].

Despite ubiquitous utilization of social media, little is known about faculty members' readiness and willingness to adopt social media in their instruction as an emerging tool. As mentioned in majority of the studies, benefits of utilizing social media could not be underestimated however, higher education professionals who are thought to be regarded as more refined users as compared to students, are still acting cautiously about embracing and integrating social media into daily life and into educational practice due to numerous existing concerns, barriers and challenges [2], [5], [6], [7], [8], [9]. While some higher education professionals take social media as an opportunity to communicate digitally with their highly connected, technologically savvy students who require immediate online response, others still consider it as complicated tool for implementation [10], [11].

At this point, understanding barriers, concerns of using social media along with benefits from faculty members' viewpoints are crucial for identifying and determining best practices to encourage faculty-student interaction and promoting effectiveness of teaching and learning. In addition, once challenges are identified, taking necessary precautions shall follow easily. Moreover, identifying benefits is essential for grasping current trends and the state of social media usage in higher education institutions which will definitely provide valuable clues to foresee emerging future directions in that respect.

II. Related Research

Extensive body of literature focused on various aspects of social media usage. Despite the diverse literature on the utilization of social media focusing on student perspectives, relatively limited studies have been located which primarily concentrated on how faculty perceive, adopt and utilize social media [2], [9], [12]-[24]. This paper intends to focus on faculty viewpoint rather than students' views in order to fill this important gap in the literature.

Studies involving higher education professionals have identified three different purposes of using social media as; personal, professional and educational/instructional/ pedagogical. The personal use is defined as using social media as a tool for communication, interaction for individual needs and for self-enjoyment. Professional use of social media is defined as using social media for academic engagement, improvement and collaboration. Instructional use is defined as implementing social media into teaching and learning practices. Principally, personal use of social media has been constantly reported to outscore professional and/or educational use among faculty members [9]. Relevant literature additionally addressed the utilization of social media either through descriptive information about usage, benefits, major concerns and/or barriers. For instance, researchers in [17] conducted a qualitative study where three faculty members were interviewed in order to understand their experiences with social media usage. Some of the findings are about concerns of establishing clear cut boundaries between professional and personal use, and lack of efficient time usage. Different uses of social media has not been fully identified and yet sought to be investigated further.

The extant literature shows notable variations between the personal, professional and instructional use of social media with respect to different regions. For instance, authors in [25] conducted a study to understand the functions of social media usage and opinions of 31 faculty members' towards instructional use of social media. The study revealed positive opinions on delivering content to meet the requirements of their technologically eligible students through interaction. Yet there is paucity of research on how professionals prefer to use social media particularly in a developing country namely north part of Cyprus or whether they are using it for both aforementioned three purposes evenly or whether they heavily rely on personal use only. Nevertheless instructional use of social media is overlooked by the literature in general. It is important to identify and differentiate between three different purposes of utilizing social media and the effect of these on the faculty viewpoints. The results of this paper may shed light upon on how to maintain balanced use of social media.

In addition, vast majority of the studies predominantly rely upon the data obtained through self-report surveys as data collection tool. Such studies are known to be quite beneficial to acquire initial insights about current status and future trends. This research in a similar fashion intends to use self-report study design for convenience.

The two existing wide scale self-report surveys conducted by the Babson survey Research Group and Pearson have revealed that while more and more faculty members are using social media for professional purpose, each year instructional use has fallen behind the professional use. This result might have different explanations; either faculty members as users can be regarded 'picky' in selecting particular type of social media tools for their instruction or they are not adequately equipped with potential skills to choose and employ proper social media tools for their teaching and learning practices or they do not wish to adjust their usual conventional, educational strategies which they are quite comfortable with. Furthermore, faculty are aware of and engage actively with popular social media tools however, still major concerns about privacy and integrity continue to exist.

Similar self-report data studies additionally referred various demographic attributes based differences on the utilization of social media. The authors in [26] conducted a self-report study to examine advantages and barriers of social media usage among faculty members (n=116) with respect to gender, academic position and interaction based differences which no significant discrepancies have been reported. There is still dearth of research on demographic attributes based on the differences of social media usage by faculty. Addressing the impacts of age, social media usage experience and purpose on the challenges and opportunities of using social media are barely the major concerns of current studies [27].

The important attributes such as age and utilization namely voluntariness of use are correspondingly among influential components of widely recognized model of the Unified Theory of Acceptance and Use of Technology (UTAUT). This well recognized model is used to interpret individuals' likelihood of adopting and utilizing specific technology, in this case; social media. Gender, age, experience, voluntariness of use, income and education are well known demographic attributes of this model. Starting off from this inspirational point, this study aims to inspect any variations with respect to age, experience of using social media and purpose of using it.

Poor and well implementations of social media into instruction could lead to immense difference. While social media is thought to facilitate communication, active engagement, group work and it enhances the teaching activities when utilized in class sessions, it could be recognized as an essential element in providing such features for faculty members as well. However, if not utilized well, it could also lead to distraction.

Studies indicated that although leading perception about the use of social media technologies for education is positive, faculty still faces with problems to overcome stated barriers in adopting social media. Faculty members encounter many demands in implementing social media tools with varied support, and eventually they approach to the implementation of such tools up to some degree of hesitation as to whether these tools are worth the effort.

Furthermore, studies occasionally indicated opposing results on student/faculty concerns about educational adaptation of social media. Most of the time studies reported benefits of the use of social media as their primary purpose and have stated exceedingly optimistic results about social media [2], [18]. Thus, on the contrary to the existing literature, the

aim of this paper is to elaborate primarily on concerns and barriers along with benefits of using social media.

A systematic review of the literature of 11 studies in the field of business education conducted by [2] revealed that faculty greeted adaption of Web 2.0 applications namely social media less warmly and moreover they reflected upon the diverse amount of social media tools and the lack of supportive knowledge and IT maintenance in using such tools. In a study conducted by [28] which was also reviewed by [2], it was remarked that faculty and administration resist against the instructional adaptation of social media which might be as a result of elder faculty members hesitate to leave their 'comfort zone' of ongoing conventional approaches. It was pointed out that young academic staff already integrated social media in their personal, educational and professional practices while older faculty could not fully embrace the use of social media yet [29]. Moreover, in self-report study conducted by [24], faculty responded negative views about instructional use of social media due to the wide diversity of available tools and faculty's lack of knowledge on how to use them. The results indicated that social media are seen as complicated tool to be used particularly by older faculty members. Another study reporting about the concerns is [30] which conducted a qualitative study based on semi-structured interviews with 51 academicians on the professional use social media. They found out that academicians most widely use Wikis, Facebook and Blogs along with other tools. They remarked that they use social media for making connections with peers, to collaborate and to publicize their research. They pointed out that protection of privacy is a main concern. They have expressed ambivalent statements about adopting it due to the lack of social media tools particularly for professional use. In addition, authors in [31] summarized that risk of security and privacy issues, loss of control, teachers' unwillingness to adapt social media in their teaching are considered among the main barriers to social media usage in higher education.

To sum up, there exist numerous gaps in the current state of field and this study aims to fill these gaps. Firstly, faculty perspective is less focused in literature as compared to student views; secondly, in contrast to prevalent overstated optimistic findings about social media usage, the primary purpose of this paper is to address predominantly barriers and concerns together with benefits; thirdly, relatively few studies located addressing on demographic/affective differences on the utilization of social media which are regarded as influential components UTAUT model; and lastly to portray social media usage trends of higher education professionals particularly in north part of Cyprus which constitutes a noteworthy case on potential usage of social media in higher education institutions in developing countries. The paper should be of interest to readers in the areas of higher education, social media and technology acceptance research particularly for developing countries. Identified concerns and barriers as the outcomes of this study could be considered by policy makers, higher education administrations in order to resolve current conflicts and challenges of social media usage.

III. Methodology

A. Research Questions

The corresponding research questions are:

1) What are the current state of faculty members' viewpoints on benefits, barriers and concerns on social media usage?

2) Do faculty members' viewpoints on benefits, concerns and barriers of using social media differ with respect to experience with social media use in their teaching?

3) Do faculty members' viewpoints regarding benefits, concerns and barriers of social media usage differ with respect to age?

4) Do faculty members' viewpoints on benefits, concerns and barriers of using social media differ with respect to the purpose (personal, professional and educational) of using social media?

a) Is there a significant difference with respect to rate of utilizing social media for personal purpose on faculty's viewpoints about benefits, concerns and barriers of social media usage?

b) Is there a significant difference with respect to rate of utilizing social media for educational purpose on faculty's viewpoints about benefits, concerns and barriers of social media usage?

c) Is there a significant difference with respect to rate of utilizing social media for professional purpose on faculty's viewpoints about benefits, concerns and barriers of social media usage?

B. Participants

The data was collected from both public and private universities through purposive sampling technique. The sample was rigorously selected in a manner to represent general population. Initially, two public and two private universities were selected then among four universities, common departments were chosen in a way that half of the faculty members are believed to be more familiar with social media and use it more often and the other half are thought to utilize social media less and hence likely to possess less experience with social media. The reason for such selection process is to free results from biased judgments and to maintain balance in responses.

400 faculty members in total accepted the questionnaire and only 324 valid questionnaires were collected from participants. Demographic information about participants were given in Table I. Participants are 53.3% female (n=173) and 46.6% male (n=151). 45.4% (n=146) of the faculty are of age less than 30, 47.2% (n=153) of the faculty are between 30-50 years of age. Only 7.7% (25) of the faculty is older than 50 years of age. 41.7% (n=135) of the faculty has teaching experience less than 5 years and between 5-10 years (n=135). Only 16.7% (n=54) of the faculty have teaching experience more than 10 years. Regarding the social media usage, 43.5% (n=141) of the faculty have used social media in their teaching and 56.5% (n=183) of the faculty haven't used social media in their teaching before.

TABLE. I. DEMOGRAPHIC INFORMATION OF PARTICIPANTS

		Frequency	Percentage (%)
Gender	*Female*	173	53.4
	Male	151	46.6
Age	*< 30*	146	45.4
	30-50	153	47.2
	>50	25	7.7
Teaching Experience	*< 5 years*	135	41.7
	5-10 years	135	41.7
	>10 years	54	16.7
Social media experience in teaching	*Yes*	141	43.5
	No	183	56.5

Using Social Media for personal, professional and educational purposes were given in Fig. 1. 8% (n=26) rarely, 36.7% sometimes use (n=119) while 55.2% (n=179) often use social media for personal purposes. 11.7% (n=38) rarely, 50.6% (n=164) sometimes while 38.0% (n=122) often use social media for educational purposes. 43.2% (n=140) rarely, 40.0% (n=130) sometimes and 16.7% (n=54) often utilize social media for professional purposes.

C. Data Collection

As for conceptual basis, social media usage in higher education is still approached by many faculty members with some degree of hesitation and hence they are not willing to integrate social media in their educational practices. On the other hand, it has been noted in considerable amount of studies that faculty has greater incentive to employ such tools for personal purposes, given increasing dependence on such tools in the profession, final research questions of this study will shed light on the current status of social media usage by faculty members.

It is very important to understand the viewpoints that faculty members develop which might differ from other faculty members with respect to aforementioned attributes. In order to strengthen the conceptual basis for understanding the effect of benefits, barriers, concerns have on the successful adoption of social media at universities this study provides a basis for a framework for identifying and prioritizing issues and barriers affecting successful adoption of social media in instruction. In addition, identification of these barriers enables a greater understanding and developing effective strategies to implement social media into classroom environment. Relative benefits, barriers and concerns have been mainly drawn from UTAUT studies, diffusion of innovation (DOI) and TAM (Technology acceptance model).

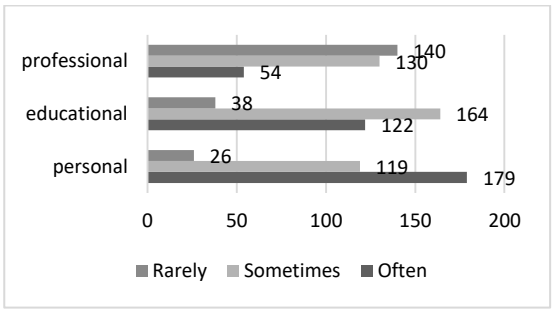


Fig. 1. Purpose of using Social Media.

To investigate these issues, a questionnaire was adapted from similar studies to measure relevant variables. Specifically, the questionnaire was designed to ask participants about potential anticipated factors that take part in the emergence of faculty members' utilization of social media.

Questions from a similar survey conducted in the United States by Babson research Group were adapted to capture the status and differences universities in north part of Cyprus. After necessary changes were made to determine the perceived benefits, current concerns and barriers faced by faculty members. To determine the current status of social media usage, respondents were asked if they have already used social media in their teaching and the rate and purpose of using social media.

The first part of the questionnaire includes personal information such as gender, age, teaching experience, social media usage experience and purpose of using social media. This questionnaire is designed to develop a strategy to that requires an understanding of both benefits to be gained and barriers to be overcome. The demographic items regarding age, gender, teaching experience and purpose of using social media, usage trends of faculty members and concerns related items and barriers were revised from Pearson social media survey [9]. The benefits dimension (items 1-10) and some items regarding concerns dimension (11-18) Likert type items were adapted from [26]. The last section is divided into three dimensions as; benefits of using social media (BNF, 10 items), concerns (CRN, 13 items) and barriers (BRR, 9 items). The items were rated by 5 option Likert scale ranging from "Strongly Disagree" to "Strongly Agree".

D. Procedure and Research Design

The questionnaire was conducted in English to faculty members of the predetermined departments. The questionnaire were distributed to 400 faculty members in four universities in north part of Cyprus and the responses were retrieved from all faculty members in every five day intervals. From these public and private universities faculties and departments which are common were chosen to represent sample adequately. The data was collected within 3 months from a valid sample of 324 faculty members at the academic year 2016.

This study is a cross-sectional and quantitative investigating discrepancies among already existing groups in order to identify consequences of these differences which can be classified as causal comparative design. The independent variables are 'age', 'social media experience' and 'purpose of utilizing social media'. The dependent variables are calculated average scores of the item responses for sub-dimensions of the questionnaire which are BNF (benefits), CRN (concerns) and BRR (barriers).

E. Data Analysis

In order to answer research question 1, descriptive statistics such as means and standard deviations were employed; Independent samples t-test was applied for investigation of the research question 2 and for research questions 3 and 4, one-way ANOVA between subjects were executed to analyze data in SPSS. SPSSv26 was used for conducting exploratory factor analysis and LISRELv8.80 was used to perform confirmatory factor analysis.

F. Validity and Reliability

Since benefits, barriers and concerns dimensions were adapted from different studies initially exploratory and subsequently confirmatory factor analyses were executed to 32 Likert type items for predetermined dimensions of the questionnaire as benefits, concerns and barriers in order to obtain evidence for construct related validity.

The measure of the sampling adequacy was obtained as 0.881 is between 0.80 and 0.89 which was rated as meritorious [32] and Bartlett's test of sphericity was significant ($\chi2(496) = 3096.596$, $p < .05$). The communalities were all higher than 0.4 showing the items contribute to other items' variances. Principle components analysis with Varimax rotation of the three factor solution, explained 42.02% of the variance, was used due to its theoretical foundation which was also supported by the Scree plot result where eigenvalues level off three factors. The descriptive statistics, eigenvalues, percentage, and cumulative percentages and Cronbach's alpha reliability values of theses 3 factors were presented in Table II. The factor loading matrix for this final solution is presented in Table II. The results of the factor analysis matched with the predetermined dimensions supporting the evidence for construct related validity. Table III shows both factor loadings of each item and also it's mean and standard deviation for convenience. The Cronbach's alpha reliability of the sub-dimensions of the questionnaire are as follows; BNF (1-10 items) 0.82, CRN (11-23 items) 0.79, BRR (24-32 items) 0.84. Cronbach's alpha reliability for the questionnaire in total was computed as .89 having good internal consistency [33]. Thus, the adapted questionnaire is considered as valid and reliable instrument and further statistical analyses on the data could then be executed.

Confirmatory factor analysis was later performed in order to justify the results of exploratory factor analysis which the model comprised of 3 latent variables (benefits, barriers and concerns) in the original scale and 32 observed variables (items of scale; item1(Q1), item2(Q2) ,item32(Q32) which is given in Fig. 2. Reported goodness of fit indices are; Chi-square($\chi2$), chi-square/df ratio (acceptable if less than 2.0), non-normed fit index (NNFI, acceptable if .90 or greater), normed fit index (NFI, best if .90 or greater, acceptable if greater than .80), root-mean-square error of approximation (RMSEA acceptable if .05 or less), goodness of fit index (GFI), adjusted GFI(AGFI), comparative fit index(CFI), incremental fit index(IFI) is best if .90 or greater, acceptable if greater than .80) , and standardized root mean square residual(S-RMR) is best if less than or equal to .08 [34] The maximum likelihood estimation of the three factor model indicated that the model was good fit of the data with the indices calculated as:

$\chi2(311, N=324)=476.15$; $\chi2$ /df = 1.53; NNFI = .91; NFI = .82; RMSEA = .04, S-RMR= 0.0562, GFI= 0.90, AGFI= 0.88, CFI= 0.92, IFI= 0.93. In addition, all factor loadings were statistically significant at the $p <.01$ level suggesting that the three factors were well constructed by the items. It could be concluded that there exists an adequate fit of the aforementioned attributes to the data.

IV. Results

A. The Current State of Faculty Members' Viewpoints

Sought for an answer for the research question 1, Table III depicts faculty members' responses to 32 Likert type items regarding benefits, concerns and barriers of using social media in teaching. According to the mean scores shown at the Table III, the constructs with the largest mean ("Strongly disagree" is coded as 1 and "Strongly agree" is coded as 5) are those that the faculty respondents have deemed to be the most agreeing. The mean scores for faculty members' viewpoints on barriers (M=3.69, SD=0.65), benefits (M=3.74, SD=0.62) and concerns (M=3.72, SD=0.50).

The findings showed that faculty almost agrees with benefits of using social media while they also agree almost as the same degree on specified concerns about using social media in their teaching. On the other hand, faculty members could not ignore barriers regarding the social media usage. Altogether, they possess positive opinions about social media usage in teaching while keeping in mind barriers and not ignoring the concerns when using social media in their classrooms.

B. Impact of Social Media Experience on Faculty Viewpoints

To answer research question 2, independent samples t-test was performed to compare benefits, concerns and barriers of using social media with respect to former experience of social media use. There are significant differences in the average scores of concerns on using social media not before (M=3.77, SD=0.51) and having used social media in teaching before (M=3.65, SD=0.49); t(322)=-2.04, p=0.04). Faculty members who have used social media in their classes before possess less concerns about using social media as compared to faculty members who haven't used social media before.

In addition there exist significant differences detected in the average scores of barriers on using social media not before (M=3.79, SD=0.67) and having used social media before (M=3.56, SD=0.62); t(322)=-3.18, p=0.00). Faculty members who have used social media before are less concerned about barriers of using social media in their instruction as compared to faculty members who haven't used social media before. There exists no significant difference with respect to benefits of using social media (t(322)=-0.70, p=0.48).

To sum up while earlier experience with social media in teaching has effect on concerns and barriers it does not have any effect on benefits of using social media. Specifically, findings suggest that faculty members who have used social media in teaching before are significantly less worried about concerns and barriers of using social media.

C. Impact of Age on Faculty Members' Viewpoints

To answer research question 3, one-way ANOVA between subjects was performed to compare the effect of age less than 30 years, between 30-50 years and more than 50 years on benefits, barriers and concerns of using social media. There was a significant effect of age on faculty's concerns of utilizing social media at the $p<0.05$ level [$F(2, 321) = 5.26$, $p = 0.01$.]

Post hoc comparisons using the LSD test was used for the correction of unequal group sizes yielded that mean scores of age range less than 30 (M=3.73, SD=0.50) and more than 50 (M=3.41, SD=0.59) a significant difference exists. Faculty members of less than 30 years of age have more concerns as compared to faculty members more than 50 years of age in utilizing social media.

In addition, Post hoc comparisons using the LSD test for correction of unequal group sizes yielded that mean scores of age range between 30 and 50 (M=3.76, SD=0.47) and more than 50 (M=3.41, SD=0.59) a significant difference exists. Faculty members between 30-50 ages old have more concerns as compared to faculty members more than 50 years of age in utilizing social media.

To sum up, older faculty members have less concern about using social media than their young and middle age colleagues.

D. Impact of Purpose on Faculty Members' Viewpoints

To answer research question 4a, one-way ANOVA between subjects was performed to compare the effect of using social media for personal purposes on benefits, barriers and concerns of using social media. There was no significant effect of using social media for personal purposes on the three dimensions [F(2, 321) = 1.38, p = 0. 25] for BNF, [F(2, 321) = 0.77, p = 0. 46] for CRN, [F(2, 321) = 0.67, p = 0. 51] for BRR at the significance level of 0.05. To sum up, personal use of social media has no effect on faculty members' viewpoints on benefits, concerns and barriers of using social media.

To answer research question 4b, one-way ANOVA between subjects was performed to compare the effect of using social media for professional purposes on benefits, barriers and concerns of using social media. There was a no significant effect of using social media for professional purposes on the three dimensions [F(2, 321) = 0.26, p = 0. 77] for BNF, [F(2, 321) = 0.32, p = 0. 72] for CRN, [F(2, 321) = 0.61, p = 0. 54] for BRR at the 0.05 level of significance. To sum up, professional use of social media has no effect on faculty members' viewpoints on benefits, concerns and barriers of using social media.

To answer research question 4c, one-way ANOVA between subjects was performed to compare the effect of using social media for educational purposes on benefits, barriers and concerns of using social media. There was a no significant effect of using social media for educational purposes on the three dimensions [F(2, 321) = 1.99, p = 0. 14] for BNF, [F(2, 321) = 0.04, p = 0. 95] for CRN, [F(2, 321) = 0.31, p = 0. 73] for BRR. To sum up, educational use of social media has no effect on faculty members' viewpoints on benefits, concerns and barriers of using social media.

In overall, the type of purpose of using social media has no effect on faculty members' viewpoints regarding benefits, concerns and barriers of utilizing social media.

V. Discussion

This study sought to understand barriers, benefits and concerns of utilizing social media among faculty members in personal, professional and instructional practices concurrently with numerous differences with respect to age, experience and purpose of usage.

Faculty possesses positive opinions about social media usage in teaching while keeping in mind barriers and not ignoring the concerns when using social media in their classrooms. Personal use is most preferred type of usage and then comes educational use and lastly professional use. Faculty members having used social media before significantly possess less concern and think less about barriers of using social media in their instruction. Therefore faculty members who haven't utilized social media are more likely to be less positive about using social media in their practices. Older faculty members have less concern about using social media than their young and middle age colleagues. The purpose (personal, educational, professional) of using social media has no effect on faculty members' viewpoints regarding benefits, concerns and barriers of utilizing social media.

At first glance, findings indicated that major concerns are related to privacy, losing authority over students in a digital environment and copyright issues. Similar threats were mentioned other researchers in the literature [30], [31], [35]. The faculty agrees to use social media if they see that students and colleagues use social media dominantly. This could be explained by 'social influence' factor as in the model of UTAUT (Unified Theory of Acceptance and Use of Technology) which is believed to influential factor in the adoption of any technology in this case, social media usage [30].

Another noteworthy aspect is faculty's awareness of most popular social media tools. Further measures of faculty utilization of social media for personal and professional purposes can then be adjusted by the familiarity of faculty members for popular social media platforms. As an expected outcome, the majority of faculty members are familiar and are aware of popular social media tools and use them. This finding is in line with previous studies [9], [36]. In this study, faculty often uses social media for personal purposes while they sometimes use it for instructional purposes and rarely use it for professional purposes.

While personal use of social media is culminated in other sources as well, the precedence is that professional use followed lastly by instructional use [9], [36]. The reason for this contradictory finding might be due to students are already comfortable in using social media which established crucial motive for faculty to adapt social media for instructional purpose. Some studies indicated that boundaries between professional and personal use of social media are not clearly set or lost [15], [30]. Hence in this case, professional use might have been subsumed by the personal use.

Although faculty members agree and appreciate benefits of using social media in instruction they have concerns and are aware of the barriers almost as same degree as being aware of benefits of using social media. This is in agreement with [37] who conducted a study with 195 faculty members where almost half of faculty respondents have used social media for instructional purposes and reflected more on the concerns of using social media which they believe social media yields to distraction. It was remarked by the author in [2] that the nearly

half of the studies that he reviewed (n=12) faculty stated contrary findings, negative results, expressed concerns, and restrictions about using social media. Additionally, studies might have overstated positive aspects of using social media for educational purpose and might tend to overlook potential disadvantages causing misleading ideas about implementation of social media [2]. In this respect, this study is believed to equally mentioned pros and cons of social media utilization. Besides, consistent findings were mentioned by authors in [18] who also addressed that faculty is positive about using social media within educational milieu. At the same time, they seem to be careful about adopting it and they also conveyed their concerns about it. Similar alertness to partial approval of social media usage also exists in other studies. For instance, [13] examined faculty's adoption of Web 2.0 technologies with 136 university instructors; faculty appreciate the value of social media usage in instruction, but for some reason they do not plan to use it for instructional purpose. In another study by [24] barriers of using social media for instructional purpose were investigated. Although they were positive about instructional use, they are cautious about certain perils to social media adoption such as lack of time and the vast amount of available tools. In [30], participants stated privacy as the major concern behind the hesitation of faculty's thoroughly adopting social media tools. Apparently, faculty seems to value non-negligible potential of social media and it's adaptation to instructional practice. However, as it was also pointed out with this research, concerns about privacy, copyright issues and difficulty of monitoring student experiences still remain as the main concerns in the literature. In literature, wholeheartedly adoption of social media by the faculty will remain limited till then [2], [18], [21].

The aforementioned concerns that were persistently mentioned in studies could be classified into four main categories as; individual, student, institution and management related issues. The researchers remarked upon all these concerns might be due to a fallacy of perceiving that social media could only be used for social/personal purposes and is not suitable for instructional purpose [21].

Faculty members having used social media before significantly possess less concern and think less about barriers of using social media in their instruction. Therefore faculty members who haven't utilized social media are very likely to hold less positive views about using social media.

Older faculty members have less concern about using social media than their young and middle age colleagues. Reason behind this outcome would be while young faculty are more actively engaged in social media, the burden of using social media could be more tangible to them as compared to the elder faculty who engage less with social media. In contrast, [38] indicated an opposing result in a qualitative study conducted with 10 university advisers with ages ranging from 25 to 74, no eloquent relation detected between age and social media usage where older academic advisers appreciate the positive impact of social media usage in higher education environments as same degree as their younger counterparts. Authors in [12] noted non-significant effect of age on social media usage in teaching among 65 faculty members with faculty agreeing almost same to the benefits and barriers of social media use. Faculty members quite often use social media for personal purposes and they sometimes use it for instructional/educational purposes and lastly they indicated that they rarely use it for professional purposes. It was reported that social media tools used for professional purpose were listed from highest to lowest popularity are Wikis, Facebook and Blogs [30].

The purpose (personal, educational, professional) of using social media has no effect on faculty members' perspectives on benefits, concerns and barriers of utilizing social media. There exists paucity of research in detecting certain discrepancies on opportunities and challenges of utilizing social media. One of the rarely located studies is that, authors in [26] who conducted a survey with 15 Likert type questions, some demographic information and open ended questions to faculty members (n=112) to identify concerns and barriers of using social media and to note differences with respect to gender and academic position. They reported no difference in the concerns and barriers with respect to gender. In addition, there was no interaction between academic position and gender to the concerns and barriers related perspectives of the faculty. Factors like age, experience and utilization which are among influential components of well-known model of the UTAUT model for adopting and utilizing specific technology, in this case social media which should be focused more in future.

It was remarked that academic staff should invent new ways to keep in touch with their students to dissolve existing detachments between teaching, learning and real life [39]. In addition, increase interest on social media by students encourages academic staff more to embed social media in their classroom practices [40]. Exponential growth in educational use of social media is expected to continue [41]. However addressed issues should be resolved regarding concerns about the privacy and integrity which cause premature adoption and will continue to interrupt faculty's use of social media particularly in instructional and professional practices. Similar concerns were noted by faculty regarding confidentiality of data in using cloud environment for educational practices [42]. Embedding social media into flipped learning and exploring learning, engagement, motivation and interaction of learners, particularly faculty will provide valuable insights in that respect [43].

VI. Limitations

As a limitation, self-report data obtained through surveys yield to depend on the honesty and insight of the participants which likely to result with misleading inferences to some extent. Faculty members of from local universities completed the questionnaire. Thus, the external validity and generalizability could be limited.

VII. Conclusion

With the immense diversity and pervasiveness of social media tools, faculty members who are already aware and use social media in their daily practices started to embrace social media more and more for educational practices as well. In contrast to prevalent impression which young faculty are thought to be more capable of using social media, older faculty seems to value and use social media as much as their young

colleagues. In addition, faculty feels agreeable to use it if they see that students and colleagues use social media dominantly. This is due to the pervasive impact and social influence as mentioned in UTAUT theory.

Most of the faculty members are aware of popular social media tools and use them. While they often use social media for personal purposes, they sometimes use it for educational purposes and rarely use it for professional purposes. Professional use with the introduction of emerging, innovative solutions will be expected to inflate within a decade. Although faculty members agree and appreciate benefits of using social media in instruction they still have concerns and are aware of the barriers almost as same degree as being aware of benefits of using social media.

Majority of faculty members lack knowledge to leverage social media properly. It is imperative that faculty members must themselves be very competent in social media usage to explore opportunities to implement a social media in their instruction, and should keep up regularly following recent trends and adapt it to demands of todays' students.

Research findings provide up-to-date picture of social media usage among faculty members and intend to aid policy makers, higher education institution administrations and faculty to develop a future plan for the adaptation of social media more for professional and instructional practices through minimizing barriers and concerns mentioned in this study.

VIII. Future Recommendations

The ubiquity of social media in the classroom is inevitable and could lead to certain challenges. While use of social media is extremely high among faculty, the impact of these in implementation to the educational setting is relatively low compared to more traditional forms. Implementations on how to leverage social media requires further investigation.

Faculty members mostly indicated concerns are about privacy issues, losing authority over students in a digital environment and copyright issues. Unless novel solutions are not proposed in near future, these issues may resist to exist and prevent faculty members from wholeheartedly accepting social media.

A longitudinal data could be beneficial in more depth understanding of faculty's use of social media which may yield to identifying general outline, critical contributors and the transition over time. More empirical based research is required to understand adoption of social media in higher education in future.

Faculty should be endorsed by training programs provided by academic institutions on how to implement social media in their educational practice and how they can benefit from social media for their professional development. Risks like privacy, resolving the issues of the complexity of usage and implementation are essential. Training programs for transformation of conventional teaching into social media tools embedded classroom practices should be provided particularly for the older faculty members.

Acknowledgment

The author would like to thank A. K. Mohammed for contributing to this research merely in the collection and coding of the data.

References

[1] A. Ratliff, "Are they listening? Social media on campuses of higher education," The Journal of Technology in Student Affairs, vol. 38, pp. 65-69, 2011.

[2] C. Piotrowski, "Emerging research on social media use in education: A study of dissertations," Research in Higher Education Journal, vol. 27, pp. 1-12, 2015a.

[3] C. H. F. Davis III, R. Deil-Amen, C. Rios-Aguilar, and M. S. González Canché, "Social media, higher education, and community colleges: a research synthesis and implications for the study of two-year institutions," Community College Journal of Research and Practice, vol. 39, no. 5, pp. 409–422, 2014.

[4] M. Thomas and H. Thomas, "Using new social media and web 2.0 technologies in business school teaching and learning," Journal of Management Development, vol. 31 no. 4, pp. 358–367, 2012.

[5] T. Anderson,"Challenges and opportunities for use of social media in higher education, " Journal of Learning for Development - JL4D, vol. 6, no.1, pp. 1-9, 2019.

[6] B.A. Legaree, "Considering the changing face of social media in higher education," FEMS microbiology letters, vol. 362, no.16, pp. 1-3, 2015.

[7] S. Manca and M. Ranieri, "Implications of social network sites for teaching and learning. where we are and where we want to go," Education and Information Technologies, vol. 22, no. 2, pp.605-622, 2015.

[8] S. Manca and M. Ranieri, "Facebook and the others. potentials and obstacles of social media for teaching in higher education," Computers & Education, vol. 95, pp. 216–230, Apr. 2016.

[9] J. Seaman, and H. Tinti-Kane, Social media for teaching and learning, UK: Pearson Learning Systems, 2013.

[10] J. E. Rodriguez, "Social media use in higher education: key areas to consider for educators," Journal of Online Learning and Teaching, vol. 7, no. 4, pp.539-550, 2011.

[11] N. Selwyn, "Social media in higher education," The Europa world of learning, vol. 1, pp.1-10, 2012.

[12] A.Y. Abdelraheem and A.M. Ahmed, "Electronic social media in teaching: usages, benefits, and barriers as viewed by sudanese faculty members," American International Journal of Social Science, vol. 4, no. 5, pp.58-68, 2015.

[13] H. Ajjan, and R. Hartshorne, "Investigating faculty to adopt web 2.0 technologies," Theory. Internet and Higher Education, vol. 11, pp. 71-80, 2008.

[14] S. D. Frazier, "An analysis of the current use and intentions to use mobile learning strategies among full-time community college faculty," (Unpublished Doctoral dissertation). University of South Carolina, 2013.

[15] A. J. Lenartz, "All my rowdy "friends": the use of social media in higher education," ProQuest LLC. (Ed. Doctoral dissertation) Northern Arizona University, 2012.

[16] E. A. Mansour, "The use of social networking sites (snss) by the faculty members of the school of library & information science," The Electronic Library, vol. 33, no. 3, pp. 524-546, 2015.

[17] G. Veletsianos, and R. Kimmons, "Scholars and faculty members' lived experiences in online social networks," The Internet and Higher Education, vol. 16, pp.43-50, 2013.

[18] C. Piotrowski, "Scholarly research on educational adaptation of social media: is there evidence of publication bias?, " College Student Journal, vol. 49, no. 3, pp. 447-451, 2015b.

[19] M. D. Robyler, M. McDaniel, M. Webb, J. Herman, and J. Witty, "Findings on facebook in higher education: a comparison of college faculty and student uses and perceptions of social networking sites," The Internet and higher education, vol. 13, no. 3, pp. 134-140, 2010.

[20] S. K. Sahu, "The impact of social media on university learning," Journal of Library and Information Sciences vol. 2, no.1, pp. 83-97, 2014.

[21] A. E. Sobaih, M. A. Moustafa, P. Ghandforoush, and M. Khan, "To use or not to use? social media in higher education in developing countries," Computers in Human Behavior, vol. 58, pp. 296-305, 2016.

[22] S. Manca, and M. Ranieri, "Yes for sharing, no for teaching!": social media in academic practices," The Internet and Higher Education, vol. 29, pp.63-74, 2016.

[23] P. A. Tess "The role of social media," Computers in Human Behavior, vol. 29, pp. 60-68, 2013.

[24] T. Tuten, and M. Marks, "The adoption of social media as educational technology among marketing educators," Marketing Education Review, vol. 22, no. 3, pp. 201-214, 2012.

[25] N. Kosarassawadee, A. Sukweses, and C. Tantarangsee, "The role of social media for instructional purposes," International Journal of Languages, Literature and Linguistics, vol. 4, no. 1, pp. 11–17, Mar. 2018.

[26] D. Roebuck, S. Siha, and R.L. Bell, "Faculty usage of social media and mobile devices: analysis of advantages and concerns," Interdisciplinary Journal of E-Learning and Learning Objects, vol. 9, pp.171-192, 2013.

[27] A. J. Y. Zaidieh, "The use of social networking in education: challenges and opportunities", World of Computer Science and Information Technology Journal (WCSIT), vol. 2, no.1, pp. 18-21, 2012.

[28] M. Thomas, and T. Howard, "Using new social media and web 2.0 technologies in business school teaching and learning," Journal of Management Education, vol. 31, no.4, pp. 358–367, 2012.

[29] E. Mutekwe, "Higher education and the social media technology: a dilemma unfolding in institutions of higher learning," Journal of Education and Human Development, vol. 4,no. 3, pp. 119–33, 2015.

[30] A. Gruzd, K. Staves, and, A. Wilk, "Connected scholars: examining the role of social media in research practices," Computers in Human Behavior, vol. 28, pp. 2340-2350, 2012.

[31] M. Au, J. Lam, and R. Chan, "social media education: barriers and critical issues. technology in education. transforming educational practices with technology," pp.199–205, 2015.

[32] M. O. Kaiser, "Kaiser-Meyer-Olkin measure for identity correlation matrix," Journal of the Royal Statistical Society, vol. 52, pp.296-298, 1974.

[33] D. George, and M. Mallery, "Using spss for windows step by step: a simple guide and reference", Boston, MA: Allyn & Bacon, 2003.

[34] E. K. Kelloway, Using lisrel for structural equation modeling: a researcher's guide. Thousand Oaks, CA: Sage, 1998.

[35] E. Collins, and B. Hide, "Use and relevance of web 2.0 resources for researchers", In Publishing in the Networked World: Transforming the Nature of Communication 14th International Conference on Electronic Publishing, pp. 271-289, 2010.

[36] M. Moran, J. Seaman, and H. Tinti-Kane, Blogs, wikis, podcasts and Facebook: how today's higher education faculty use social media. Boston, MA: Pearson Learning Solutions, 2012.

[37] R. G. Henderson, and B.F. Chapman, "Business educators' perceptions concerning mobile learning (m-learning)," Delta Pi Epsilon Journal, vol. 54, no. 1, pp. 16–26, 2012.

[38] M. D. Gonzalez, B. P. Davis, D. Lopez, C. Munoz, and G. Soto , "Integration of social media in higher education environments," Insights to a Changing World Journal, vol. 3, pp. 43-62, 2013.

[39] J.A. Delello, R.R. McWhorter, and K.M. Camp, "Using social media as a tool for learning: A multi-disciplinary study," International Journal on E-Learning, vol. 14, no.2 , pp.163-180, 2015.

[40] M.V. Vivakaran, and M. Neelamalar, "Utilization of social media platforms for educational purposes among the faculty of higher education with special reference to tamil nadu," Higher Education for the Future, vol. 5, no. 1, pp. 4-19, 2018.

[41] S. Başaran, S. Rukundo, "University students' and faculty's views on ethical use of facebook within ict context," INTED2018 Proceedings. pp. 3679-3688. DOI:10.21125/inted.2018.0706, 2018.

[42] S. Başaran, G. O. Hama, "Exploring faculty members' views on adoption of cloud computing in education," International Scientific Conference "Society, Integration, Education - SIE2018". DOI: 10.17770/sie2018vol1.3290, 2018.

[43] S. Başaran, "Investigating university students' views on flipped classroom approach," INTED2019 Proceedings. pp. 8050-8059. DOI: 10.21125/inted.2019.1998, 2019.

APPENDIX

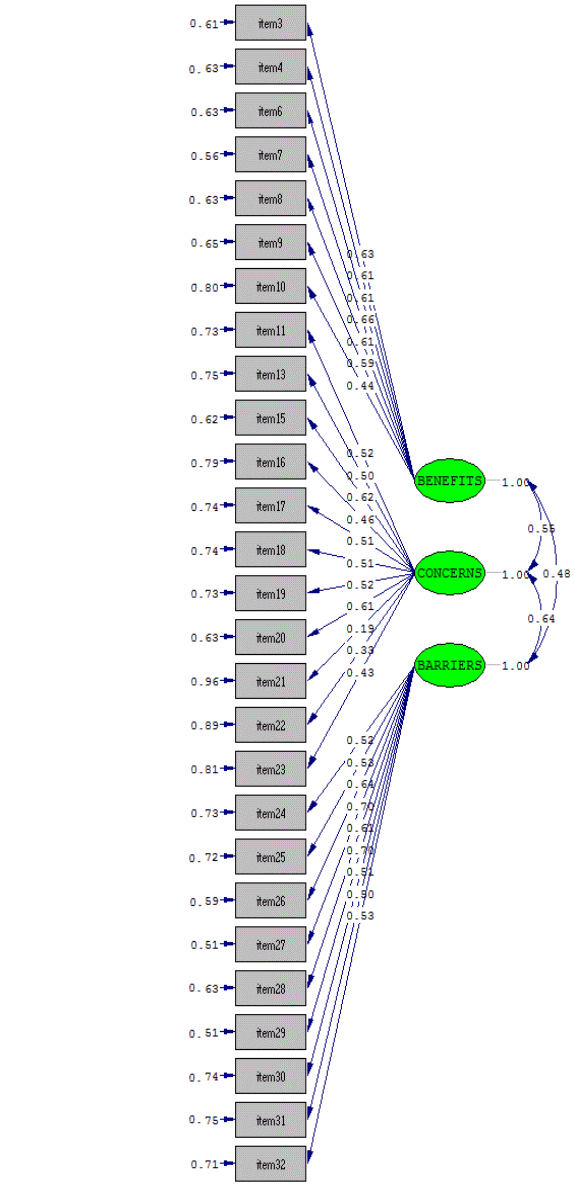


Fig. 2. Confirmatory Factor Analysis LISREL Output.

TABLE. II. MEAN, STANDARD DEVIATION, ROTATION SUM OF SQUARED LOADINGS AND RELIABILITY (N=324)

FACTOR	No. of Items	M	SD	Total	%ofVariance	Cumulative%	Cronbach α
BRR	9	3.69	0.65	4.550	14.218	14.218	0.84
BNF	10	3.74	0.62	3.917	12.240	26.458	0.82
CRN	13	3.72	0.50	3.701	11.564	38.022	0.79
TOTAL	32	-	-	-	-	-	0.89

TABLE. III. ROTATED FACTOR MATRIX, MEANS AND STANDARD DEVIATIONS

FACTORS	1	2	3	M	SD
BARRIERS				3.69	.65
Q29 - Grading and assessment	.73			3.61	.99
Q26- Takes too much time to learn or use	.69			3.58	1.06
Q27 - Lack of integration with LMS	.67			3.56	1.04
Q28 - Inability to measure effectiveness	.67			3.61	.97
Q31- Concerns about privacy	.62			3.73	.94
Q32 - Integrity of student submissions	.60			4.01	.98
Q25 - Lack of support at my institution	.60			3.63	.97
Q30 - Separate course and personal accounts	.59			3.73	.96
Q24 - Lack of knowledge of the use of social media in education	.49			3.72	.96
BENEFITS				3.74	.62
Q9 - Using social media improves students' creativity and output.		.73		3.67	1.03
Q8 - Using social media allows my students to receive informative and rewarding feedback from multiple sources.		.73		3.71	.99
Q4 - I do believe that the information-sharing feature of social media greatly enhanced my learning experiences.		.68		3.78	1.01
Q3 - I believe social media used as a supplementary learning tool holds promise for enhancing sense of classroom community.		.67		3.79	1.12
Q10 - I believe using social media allows more interaction between students from different countries.		.65		3.68	.98
Q7 - Exposing students to the latest technology helps prepare them for work and provides an opportunity for them to acquire additional skills.		.60		3.77	.98
Q6 - I believe the interactive nature of social media allows students to participate in collaborative work and create work where the Quality of the whole may well exceed the sum of its parts.		.49		3.73	.97
Q5 - I think students are more engaged with Social Media learning than other e-learning platforms used. because students have more interactional opportunities for sharing personal interests and exchanging learning resources in addition to discussing course.		.36		3.68	1.01
Q2 - Social media allows me to find and share educational resources.		.38		3.78	.88
Q1 - Social media allows me to discuss topics of interest and/ or to communicate with my fellow students about course-related topics		.32		3.84	.99
CONCERNS				3.72	.50
Q12 - Using social media to supplement face-to-face courses can become too time intensive.			.34	3.90	.86
Q17 - I believe there should be an institutional approach to how and what social media is used for learning.			.62	3.66	.99
Q16 - I am concerned over who would be responsible if students or professors say something online that results in lawsuit against.			.60	3.84	.82
Q14 - I sometimes feel overwhelmed by overabundance of information shared.			.59	3.53	.96
Q15 - I have concerns about vague copyright and intellectual property issues involved in social media.			.58	3.67	1.04
Q18 - I am concerned who is monitoring the social media for inappropriate or offensive use and how we deal with it.			.55	3.71	.82
Q20 - Risks to the personal privacy of students.			.51	3.42	.93
Q13 - I believe using a private social networking appears to be the answer to struggle with issues of privacy and information security.			.46	3.65	1.11
Q19 - Risks to the personal privacy of faculty.			.45	3.54	1.02
Q11- I feel concerned about the threat of spam and phishing attacks when using social media in the classroom.			.43	3.70	.97
Q22 - Others outside of class should not be able to view class discussions.			.39	3.94	.86
Q21 - Others outside of class should not be able to view class-related content.			.34	3.96	.84
Q23 - Others outside of class should not be able to participate in class discussions.			.33	3.82	.96

Multi-Band and Multi-Parameter Reconfigurable Slotted Patch Antenna with Embedded Biasing Network

Manoj Kumar Garg*[1], Jasmine Saini[2]
Department of Electronics and communication
Jaypee Institute of Information and Technology Noida, Uttar Pradesh, India[1, 2]

***Abstract*—RF PIN diodes are used to achieve reconfigurability in frequency, polarization, and radiation pattern. The antenna can be used in different bands by controlling ON and OFF states of two PIN diodes using the embedded biasing network (EBN). The antenna can be used for ultra-wideband (UWB) applications (1.0 GHz to 15.2 GHz) with a resonant frequency of 9.2 GHz. Besides ultra-wideband, it can also be switched to other bands (C, X, and Ku) with different operating frequencies (5.75 GHz, 12.3 GHz, and 15.5 GHz) at other biasing combinations. With this type of antenna, Linear and Circular polarization are achievable. The radiation pattern reconfigurable behavior in the vertical plane has also been achieved. Single Design of the proposed antenna is optimized for the multi-band and multi-parameter reconfigurability applications.**

***Keywords*—Multi-band; Multi-parameter reconfigurability; EBN; UWB; PIN diode**

I. Introduction

Ultra-wideband antenna design with multiple notches using a finite ground plane approach and the hierarchy process method was reported by Padmavathy et al. [1] and Zehforoosh [2]. Recently, multi-parameter reconfigurable antennas have gained considerable attention in the design of modern communication systems [3]. Earlier papers focused on single-parameter reconfigurability, but so far very little work has been done on multi-parameter reconfigurable behavior. The dependency of antenna characteristics i.e. frequency bandwidth, return loss, gain, etc. makes the design of the multi reconfigurable antenna a complex task. A frequency-reconfigurable microstrip patch slot antenna at nine different frequency bands between 1.98 and 3.59 GHz was proposed by Huda A et al. [4]. A frequency reconfigurable multiband antenna with the embedded biasing network for microwave access, mobile and wireless network was proposed by Adisak Romputtal et al. [5]. For wideband applications, slot antennas are very popular. Hui Li et al. have proposed a simple compact reconfigurable slot antenna with a very wide tuning range [6]. A polarization and radiation pattern reconfigurable antenna for different applications was presented by Zi-Xian et al.[7] and J. Constantine [8].The large gain of 3.19 dBi, high bandwidth of 162.91o and patch size reduction of 56.5 % have been achieved in a single layer hexagonal patch antenna by using two triangles and one rectangular slot on patch [9]. The monopole antenna with T slot on the partial ground plane and the LC equivalent model of the same structure were simulated using ADS platform. The simulated results of the structure and its electrical equivalent model were found to be in good agreement with each other. [10]. A UWB of 3.1 to 10.6 GHz with a notched frequency band was achieved by using an arc-shaped slot on a circular patch [11]. A UWB antenna with dual band-notched characteristics in the WiMAX/WLAN bands by etching two C shaped slots in the rectangular patch was proposed [12]. A comparative study of the rectangular patch antenna on Terahertz frequency with and without superstrate has been done and achieved the large matching bandwidth and gain (22.47%, 10.43 dBi) [13].

In the present scenario, reconfigurable antennas play a significant role in the modern communication system and provide multifunction abilities to perform multiple tasks. By integrated active components with a patch antenna, the reconfigurable behavior can be achieved. This paper has implemented a viable ultra-wideband microstrip patch antenna with reconfigurable behavior in frequency, radiation pattern and polarization. The multi-parameter reconfigurable characteristics of the proposed antenna can be achieved by using different switching combinations of two PIN diodes. The first PIN diode is integrated into the slot of microstrip patch and the second PIN diode is integrated between two partial ground planes. The switching of these two PIN diodes is achieved by suitable biasing circuits. In this design, we have used a rectangular patch with two corner arcs and two slits. This antenna enables us to use in any of the three bands C, X, and Ku depending upon the requirement. The antenna also provides us the freedom to operate either in linear or circular polarization such as in WLAN and VSAT applications. The proposed antenna is capable to transmit/receive in any of the four directions, $\varphi=0^o$, 90^o, 180^o, and 270^o as per the requirement.

II. Antenna Design and Formulation

The design formulation is divided into two parts. The first part discusses the design of an antenna. The second part shows how multi reconfigurable behavior is achieved. In this work, two designs of antennas are proposed. The patch design for an antenna is shown in Fig. 1(a). In the first design, the antenna is presented with the single partial ground as shown in Fig. 1(b) and the second design are presented with two partial grounds as shown in Fig. 1(c).

*Corredponding Authors

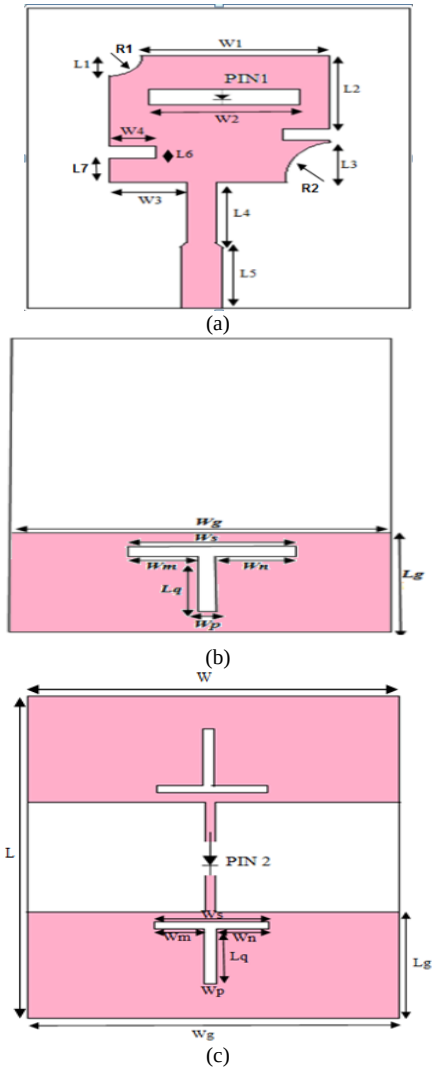


Fig. 1. Antenna Geometry (a) Patch (b) Single Partial Ground (c) Two Partial Ground.

In the designing part, a number of techniques like corner truncation, cutting a rectangular slot and side slit on the patch are used to archive a large bandwidth. The location of slots and slits is optimized for achieving maximum bandwidth. A T slot is used on partial ground of antenna as shown in Fig. 1(b). This T slot provides good impedance matching between the antenna and coaxial cable so that maximum power can be transferred to the antenna. For ultra-wideband applications, a rectangular slot is designed on the patch to enhance the bandwidth of the proposed antenna. Without slot, antenna (with the single partial ground) resonates at 10 GHz frequency only and when rectangular slot is taken on the patch, a second higher mode at 15 GHz is obtained, as evident from Fig. 2.

According to the size of the slot, the equivalent inductance and capacitance of slot, as well as resonating frequency of higher mode, can be calculated by the formulas given in equation (1) [14]. By varying the length and width of the slot, a different higher mode of different resonant frequency is generated and with the help of these higher modes, the bandwidth of the antenna can be enhanced.

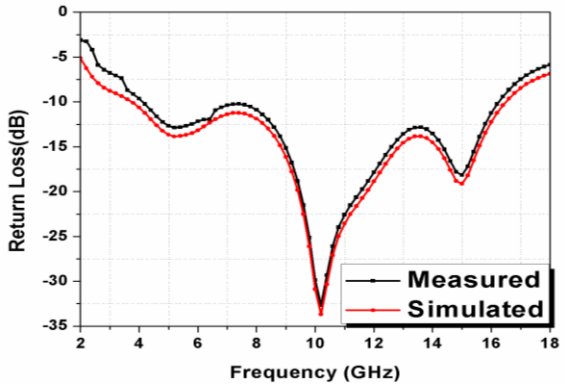


Fig. 2. Measured and Simulated Return Loss of Single Partial Ground Antenna with a Rectangular Slot on Patch.

$$Ls = \frac{h\mu o\pi}{8}\left(\frac{l}{w}\right)^2,\ Cs = \frac{\varepsilon o \varepsilon rA}{D} \quad \text{and} \quad fr = \frac{1}{2\pi\sqrt{LsC}} \tag{1}$$

Where

Ls= Equivalent Inductance of the slot;

Cs= Equivalent capacitance;

l= length of slot;

w= width of slot;

fr= Resonate frequency.

The present design is usable for RT Duriod 5880 with a thickness of 1.6 mm, the relative permittivity of 2.2 and dielectric loss tangent of 0.0009. The length and width of the substrate are selected as 36 mm× 34 mm. The calculated patch size is of 18 mm×11.7 mm, where two corner arcs and two slits are cut. For Proper impedance matching a two-step, the microstrip feed line is used. The dimensions of the proposed antenna are tabulated in Table I.

For achieving the reconfigurable behavior of the proposed antenna, another partial ground is introduced at the ground plane with the same dimensions. A PIN diode is used to connect these two partial grounds as shown in Fig. 1(c). Another PIN diode is embedded between the slots on the patch as shown in Fig. 1(a). These two PIN diodes (SMP1345-079LF, Ls=7nH SC-79) are used to control frequency, polarization, and radiation pattern reconfigurable behavior of the proposed antenna. Fig. 3 shows an equivalent circuit of PIN diode in forward and reverse bias. When the forward biasing voltage of 0.89V and above is supplied, the PIN diode turns on and behaves as a short circuit with a series resistance of 1.5Ω. Without biasing voltage the PIN diode acts as an open circuit and has the capacitance of 0.15pF [3].

TABLE. I. DIMENSIONS OF THE PROPOSED ANTENNA (MM)

L_1	3 mm	**L_7**	2 mm	**W_4**	2 mm
L_2	7.9 mm	**L_q**	5 mm	**W_g**	36 mm
L_3	3 mm	**L_g**	10 mm	**W_m**	2.25 mm
L_4	6 mm	**W_1**	15 mm	**W_n**	2.25 mm
L_5	5.15 mm	**W_2**	10 mm	**W_p**	0.5 mm
L_6	0.8mm	**W_3**	36 mm	**$R_1 = R_2$**	**3mm**

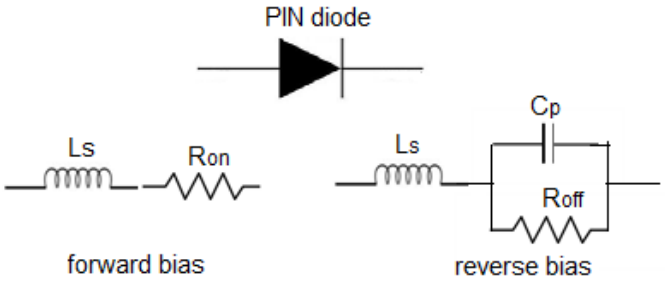


Fig. 3. Equivalent Circuit of PIN Diode (SMP1345-079LF).

III. Embedded Biasing Network

A biasing circuit for switching off the PIN diode is shown in Fig. 4. In this biasing circuit, two blocking capacitors of value 0.1µF and two RF coils of value 6.8 nH are used. The blocking capacitor prevents microstrip antenna with the DC bias voltage given to the PIN diode and passes AC (high frequency) signal through the diode. RF coil allows DC current and prevents the microcontroller board from AC (high frequency) signal. Instead of using DC power supply along with various lumped components for switching PIN diodes, a microcontroller-controlled embedded biasing network (EBN) is used with the antenna to regulate the PIN diode switching and it overcomes the various problems like cost, weight, and complexity as shown in Fig. 5 [15]. The ON and OFF timing of a PIN diode can be controlled by using a microcontroller (ATMEGA 2560).

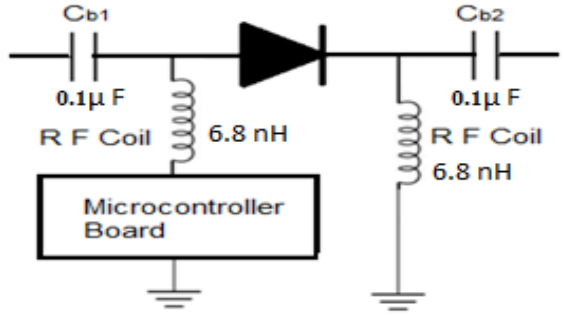


Fig. 4. Biasing Circuit for Switching of a PIN Diode.

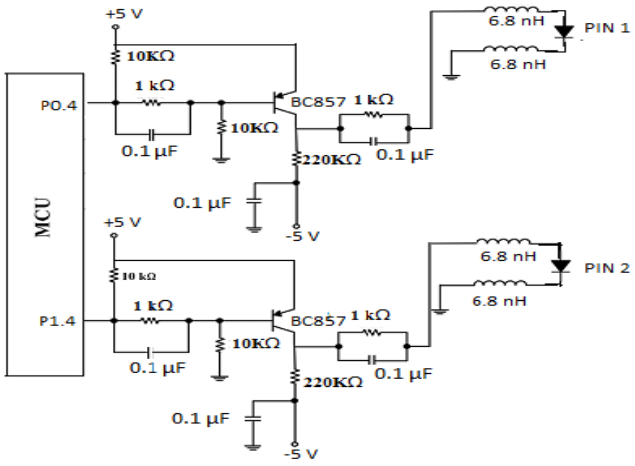
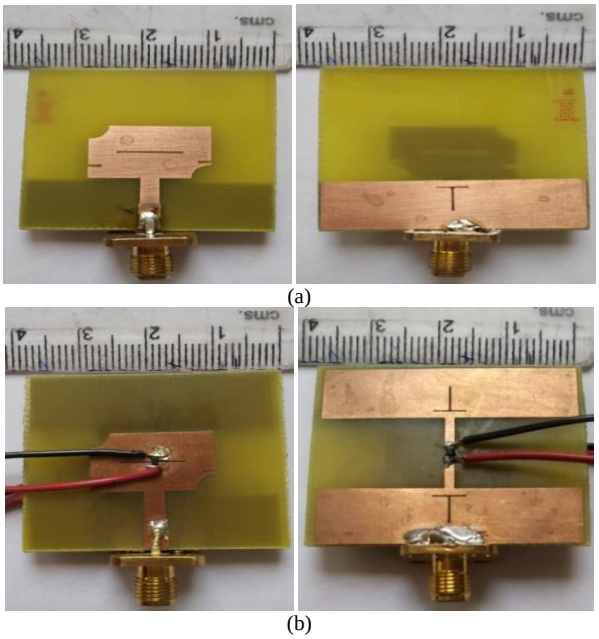


Fig. 5. Embedded Biasing Network using ATMEGA 2560 Microcontroller.

IV. Results and Discussion

For ultra-wideband applications, a single partial ground patch antenna is fabricated at a frequency of 10 GHz. It provides a large bandwidth from 3.5 GHz to 16 GHz as shown in Fig. 2. The experimental and simulated results are in good agreement with each other, and hence, the proposed antenna model with a single partial ground plane is recommended for the ultra-wideband application. For achieving multiple reconfigurable behaviors another microstrip patch antenna with two partial grounds is designed and fabricated as shown in Fig. 6(b). By using two PIN diodes, the reconfigurable behavior of the antenna is achieved. The simulated and measured return loss of the proposed antenna with two partial ground plane s at different switching positions of two diodes is shown in Fig. 7. It is clearly evident that the antenna provides different resonant frequency and return loss according to different switching combinations of two PIN diodes. A frequency shift of 1GHz to the left side has been observed in the measured return loss graph of fabricated antenna. Fig. 7(a) shows the return loss graph of the antenna model when both diodes (PIN 1 and PIN 2) remain OFF and in this situation; the antenna provides UWB similar to a single partial ground antenna. The simulated and experimental results of the antenna model using different switching combinations of PIN diodes are obtained and tabulated in Table II.

Table III tabulates the axial ratio at different switching combinations of PIN diodes. In position 1 (when both PIN diodes are OFF) and in position 2 (when PIN 1 is ON and PIN 2 is OFF) the antenna attains circular polarization as the axial ratio is nearly unity. In position 3 (when PIN 1 is OFF and PIN 2 is ON) and in position 4 (when both PIN diodes are ON) antenna shows linear polarization because the axial ratio is far greater than 1. The simulated and measured radiation patterns of the antenna models at all four combinations are shown in Fig. 8.



(a)

(b)

Fig. 6. Fabricated Antenna (a) with the Single Partial Ground (b) with Two Partial Ground.

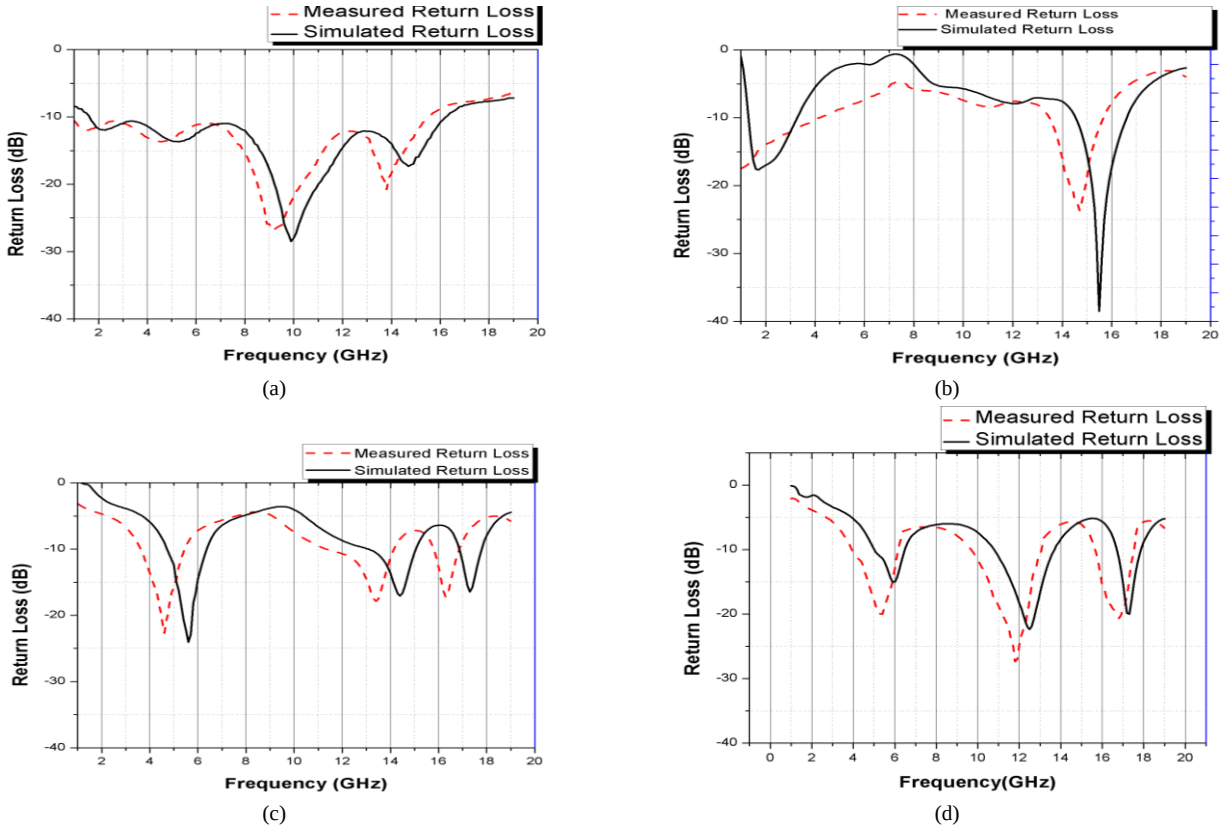


Fig. 7. Return Loss at different Switching Positions of PIN Diodes. (a) PIN 1 OFF and PIN 2 OFF (b) PIN 1 ON and PIN 2 OFF (c) PIN 1 OFF and PIN 2 ON (d) PIN 1 ON and PIN 2 ON.

TABLE. II. COMPARATIVE PARAMETRIC STUDY ON DIFFERENT SWITCHING COMBINATIONS OF PIN DIODES

Switching		Resonant frequency (GHz)		Band (GHz)		Return Loss (dB)		Band Name
PIN 1	**PIN 2**	**Simulated**	**Measured**	**Simulated**	**Measured**	**Simulated**	**Measured**	
OFF	OFF	9.9	9.2	1.6 -16	1.0-15.2	-28	-26	UWB
ON	OFF	15.5	14.3	14.7-16.6	12.7-15.4	-38.8	-24	Ku
OFF	ON	5.75	4.5	4.6-6.3	3.6-5.5	-24.5	-23	C
ON	ON	12.3	11.9	10.8-13.6	9.4-13.0	-22	-27	X

TABLE. III. THE AXIAL RATIO AT DIFFERENT SWITCHING COMBINATIONS OF PIN DIODES

S. No	PIN 1	PIN 2	Axial Ratio (dB)	Type of polarization
1	OFF	OFF	1.5	Circular
2	ON	OFF	1.3	Circular
3	OFF	ON	16.5	Linear
4	ON	ON	20	Linear

The radiation patterns are plotted in the elevation plane i.e at $\varphi = 0^o$. In the first case (PIN 1 OFF and PIN 2 OFF) this antenna radiates in a vertical direction from $\theta = -40^o$ to $\theta = +40^o$ as shown in Fig. 8(a). In second case (PIN 1 ON and PIN 2 OFF) it radiates in horizontal direction i.e. $\theta = -70^o$ to $\theta = -110^o$ shown in Fig. 8(b).

In the third case (PIN 1 OFF and PIN 2 ON) it radiates in the vertical direction (opposite to the direction of the first case) from $\theta = -140^o$ to $\theta = +140^o$ as shown in Fig. 8(c).

In the fourth case (PIN 1 ON and PIN 2 ON) this antenna radiates in the horizontal direction and this time opposite to the direction of to the second case that is it is radiating from 60^o to 120^o as shown in Fig. 8(d). By observing radiation patterns on different switching combinations it is evident that the antenna model is radiating along with different directions. Thus reconfigurable behavior of the proposed antenna in radiation pattern is achieved.

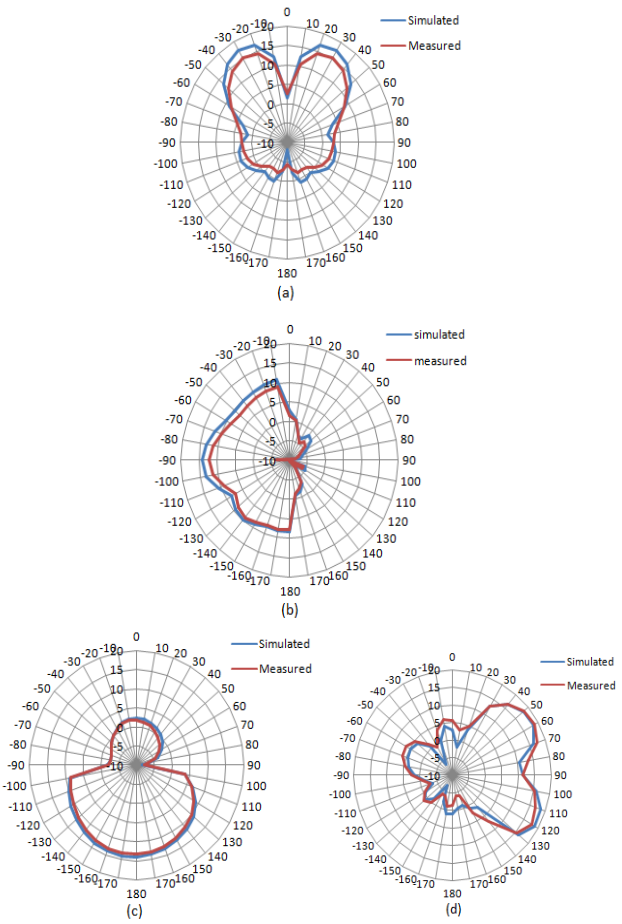


Fig. 8. Radiation Pattern at different Switching Positions of PIN Diodes (a) PIN 1 OFF & PIN 2 OFF, (b) PIN 1 ON & PIN 2 OFF, (c) PIN 1 OFF & PIN 2 ON, (d) PIN 1 ON & PIN 2 ON.

V. CONCLUSION

It is observed that the proposed antenna model provides not only multi-band operation but also executes as a multi-parameter reconfigurable antenna with a high gain of 10 dB. The proposed antenna model provides different frequency bands (C, X, and Ku) with different switching combinations of two PIN diodes. The radiation pattern of the proposed antenna can be switched in multiple directions by controlling ON and OFF positions of both diodes. The proposed antenna model will be very useful in commercial and military applications because the proposed antenna provides the freedom to choose the different types of applications.

ACKNOWLEDGMENT

Authors would like to thank the Department of Electronics and Communication Engineering, JIIT Noida and AIT New Delhi for providing the necessary facility to carry out the measurement of the antenna. We thank Manoj Vishwakarma, Assistant Professor IEC College of Engineering and Technology for comments that greatly improved the manuscript.

REFERENCES

[1] A.P Padmavathy and M.Ganesh Madhan, “An improved UWB patch antenna design using multiple notches and finite ground plane,” Journal of Microwaves, Optoelectronics, and Electromagnetic Applications, Vol.14, No1, pp.133-142, June 2015.

[2] Y. Zehforoosh and M. Mohammadifar, “Designing four notched bands microstrip antenna for UBW applications assessed by analytic hierarchy process method,” Journal of Microwaves, Optoelectronics and Electromagnetic Applications, Vol. 16, No 3, pp. 765-776, September 2017.

[3] K.Chung, Y. Nam and T. Yun, “Reconfigurable microstrip patch antenna with frequency and polarization-diversity functions,” Microwave Optical Technology Letters, Vol. 47, No .6, pp. 605–607, 2005.

[4] Huda A. Majid, “Frequency-Reconfigurable Microstrip Patch-Slot Antenna,” IEEE Antennas And Wireless Propagation Letters, Vol. 12, 2013.

[5] Adisak Romputtal, Chuwong Phongcharoenpanich, “Frequency reconfigurable multiband antenna with the embedded biasing network,” IET Microw. Antennas Propag., Vol. 11, pp. 1369-1378, 2017.

[6] Hui Li, Jiang Xiong, Yufeng Yu, and Sailing He, “A Simple Compact Reconfigurable Slot Antenna With a Very Wide Tuning Range,” IEEE Transactions on Antennas and Propagation, Vol. 58, No. 11, November 2010.

[7] Zi-Xian Yang and Hong-Chun Yang, “Bandwidth Enhancement of a Polarization-Reconfigurable Patch Antenna With Stair-Slots on the Ground,” IEEE Antennas and Wireless propagation letters, Vol. 13, 2014.

[8] J. costantine, RKanj, Z. Ghorayeb, T. Ai Bahar, Y. Itani, Y Tawk and C.G. Chistodoulou. “A radiation pattern reconfigurable antenna for WLAN access,”. USNC-URSI NRSM. IEEE Xplore 21 March 2016.

[9] S. Jana, Bipadtaran Sinhamahapatra, Sudeshna Dey, Arnab Das, Bipa Datta, Moumita Mukherjee, and Samiran Chatterjee, “Single-layer monopole hexagonal microstrip patch antenna for satellite television,” International Journal of Soft Computing and Engineering, pp. 2231-2307, 2013.

[10] Manoj Garg, Jasmine Saini, Sandeep Kumar, B.K.Kanaujia and Gunjan Mittal, “Extracted LC Model of Monopole antenna with-slot for UWB application,” IEEE Xplore, pp.79-82, July 2017.

[11] Schantz, H. G., and G. P. Wolenec, “Ultra-wideband antenna having frequency selectivity," U.S. Patent No. 6774859B2, August 2004.

[12] Chu, Q. X. and Yang Y. Y., “A compact ultra-wideband antenna with 3.4/5.5GHz dual band-notched characteristics,” IEEE Trans. Antennas Propag, Vol. 56, No.12, pp.3637-3744, December 2008.

[13] M. Younis, Achraf Jaoujal, M. H. Diallo Yaccoub, Ahmed El Moussaoui and Noura Aknin, “Study of a microstrip antenna with and without superstrate for terahertz frequency,” International Journal of Innovation and Applied Studies, Vol. 2, No.4, pp.369-371, April 2013.

[14] Fan Yang, Juha Virtanen, Atef. Z. Elsherbeni and Leena Ukkonen, “Reconfigurable Sensing Antenna: A Slotted Patch Design with Temperature Sensation,” IEEE Antennas and Wireless propagation letters, Vol. 11, 2012.

[15] Lin, C.-C. and H.-R. C. Lin, “A 3-12 GHz UWB planar triangular monopole antenna with ridged ground-plane,” Progress In Electromagnetics Research, Vol. 83, pp. 307-321, 2008.

Bioinspired Immune System for Intrusions Detection System in Self Configurable Networks

Noor Mohd[*,1], Annapurna Singh[2], H.S. Bhadauria[3]
Computer Science and Engineering, G. B. Pant Institute of Engineering and Technology, Pauri Garhwal, Uttarakhand (India)[1]
Computer Science and Engineering, Graphic Era Deemd to be University, Dehradun, Uttarakhand, (India)[1]
Computer Science and Engineering, G. B. Pant Institute of Engineering and Technology
Pauri Garhwal, Uttarakhand (India)[2, 3]

***Abstract*—In the last couple of years, the computer frameworks have become more vulnerable to external attacks. The PC security has become the prime cause of concern for every organization. To achieve this objective Intrusion Detection System (IDS) in self-configurable networks has played a vital role in the last few decades to guard LANs. In this work, an IDS in self-configurable networks is deployed based on Bioinspired Immune System. IDS in self-configurable networks are accustomed to monitor data and network activity and alert when any suspicious activity observed security heads are alerted. A vital and common application space for versatile frameworks swarm-based is that of PC security. A PC security framework ought to protect a machine or accumulation of machines from unapproved gatecrashers. The framework seems to be capable of counteracting against external activity. Also it is comparable in usefulness to secure framework shielding from intrusion by external threats like in case of attacking microorganisms. A counterfeit insusceptible framework is a PC programming framework that mirrors a few sections of the conduct of the human resistant framework to shield PC systems from infections and comparable digital assaults. This paper demonstrates the need of a novice substring seeks calculation based on bio-roused calculations. Tests are required to create system for Network Intrusion detection that aids in securing a machine or clusters of machines from unapproved intruders. In this paper IDS in self-configurable networks is implemented by using Bio-inspired Immune System and KMP algorithm as a model IDS.**

***Keywords*—Networks security; intrusion detection system; AIS algorithm; KMP algorithm; self-configurable networks**

I. INTRODUCTION

With the automation of computational processes and involvement of personal computer in daily life is needed to be additionally smart and more secure to active as well as passive attacks. It has been also noted that the PC are more and more exposed to assaults, because of its broad range web accessibility. For this reason PC security has become the fundamental cause of worry for developing IDS. Interruptions cause calamity inside LANs and the time and cost to assess and comeback the damage could be immense.

Interruption Detection Arrangements (IDA) [1] are used to observed information concerning them and depicting them to security heads.

An indispensable and normal demand territory for versatile courses of action swarm built up is that of PC security. A computer protection arrangement such as Web Intrusion detection Arrangement should prevent a contraption or assembly of mechanisms from unauthorized intruders. The arrangement ought to additionally be able stop opposing an external program that is comparable in functionality with the immune arrangement protecting itself from conquest by microbes. An Artificial Immune Arrangement (AIS) [2] is a computer multimedia arrangement that depicts little parts of the action in case of human immune arrangement. It protects computer webs from harmful viruses in addition to comparable cyber-attacks.

A. Intrusion Detection System

Interruption discovery is the full components for observing the different type of incident that happened in PC framework environment. The system investigates for signs of various contravention or dangers of breaching PC security methodologies, suitable utilized approaches, or normal security hone. Threats to PC systems are extending because of increased used of internet and local region systems [3, 5, 14, 16, 17 and 18]. Laptops are evolving so one can get more involved to fight automobile endemic network connectivity. They have been attacking work targets of many malicious threats that invariably morph into actual intrusions. This is often what's causing its computer security in a dynamic concern for the network. Intrusions may lead to adverse effects on LANs in addition to the wasted time price to renovate the destruction can grow to great proportions. As an alternative employing passive measures automobile and patch security hole once and will be exploited, it may appear far more proficient to get a proactive measure to intrusions. IDS in self-configurable networks are widely accepted and used to monitor the facts about them, also reporting the crooks to security administrators.

The fundamental model of IDS in self-configurable networks demonstrated in Fig. 1 is consisting of a data collection section, detection rule section and response section.

Intrusion Detection Systems support various type of information systems plan for, and treat with attacks. They do this by collecting related information from various types of systems and network sources and then analyzing the results for occurring possible security problems.

*Corresponding Author

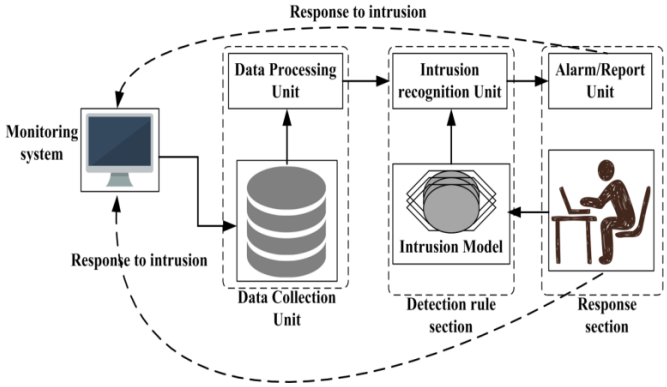


Fig. 1. Fundamental Model of Intrusion Detection System in Self Configurable Networks.

1) Monitoring and study of user behavior and system activity.

2) Defining the system configurations and susceptibilities?

3) Integrity access to important critical system and related data files.

4) The Statistical analysis of activity prototype using the signature-based matching attacks.

5) Irregular different type of activity analysis, Operating-system audit.

B. IDS Methodologies

Interruption discovery framework utilizes numerous procedures to make note of occurrences. Essentially IDPS advances utilize different discovery procedures, either discretely or incorporated, to allow more wide and precise location.

Signature Based Detection: A signature can be an example that compares with a known danger. Mark based discovery is components for divergent marks against inspected occasions with feasible occurrences. Mark based location could be exceptionally gripping at distinguishing known threats however, mostly insufficient at identifying beforehand doubtful threats [6].

Illustration: A contact with the principle theme of free pictures and connection filename of freepics.exe, these attributes shows known type of malware. On the off chance that assailants alter the document name freepics.exe to freepics1.exe, signature based recognition will battle to distinguish this malware.

Constraints: It wouldn't see already unidentified dangers.

Abnormality Based Detection: Abnormality based recognition is a task of contrasting meanings of what exercises is respected typical against watched occasions to perceive real deviations. IDPS utilizing change based recognition has profiles that speak to standard conduct of territories like a purchaser, has arranged associations or applications. The profile is delivered by observing and qualities of run of the mill exercises, an assortment of email send by the client, assortment of fizzled login endeavors for tons and the state of processor use for tons with a period of time. Oddity based recognition is very capable of identifying beforehand obscure dangers.

Confinements: Building profile is greatly testing

Stateful Protocol Analysis: Stateful convention investigation is a task of looking at foreordained profiles of by and large acknowledged the meanings of favorable agreement exercises for every agreement state against observed distances to perceive deviations. Stateful convention examination relies upon merchant created public profiles that determine the way of specific convention ought to and ought not to be utilized. The Stateful in Stateful convention analysis [9] implies the IDPS is ideal for comprehension and following the state of transport, system and application conventions that have a generally thought of state.

Constraints: It's restricted by looking at one single demand or reaction. Numerous assaults are not identified by survey one demand – the assault may include various solicitations.

The rest of paper is organized in the following manner. Section I is used to represent introduction about IDS and their respective methodologies. Section II is discussed about the techniques about IDS. The next section (Section III) is consisting of propose work and KMP string matching algorithm. The simulation and results are discussed in Section IV. Finally whole work is concluded in Section V and future scope of the proposed work has been described in Section VI.

II. Techniques of Intrusion Detection System

IDS in self-configurable networks uses as a few strategies, including the IDS halting the assault itself, altering the security condition (Like- reconfiguration a firewall), or changing the assault's substance. The types of IDS technologies [15] are separated principally by the sorts of occasions build by screen and also ways that they have been conveyed.

Network Behavior Analysis (NBA): This analyzes arrange guests distinguish dangers that produce uncommon movement streams, as dispersed refusal and administrations data assaults, such as assortments malware, and strategy infringement (e.g. an individual framework giving system administrations to systems). Behavior-Based Analysis [10] learns customary conduct of activity and frameworks at that point persistently looks at them for potentially harming oddities and with conduct that oftentimes go with episodes. This procedure distinguishes assaults by their business, rather their code matches strings found in a particular past episode. "It stops activity that is not malevolent all over but rather that will do noxious things", said by Allan Paller.

Remote Intrusion Recognition Framework: This strategy checks remote system movement. It anatomizes to differentiate doubtful action for the remote systems administration agreements themselves.

Host-Based Intrusion Location Framework: With the capacity to break down exercises relating for the host it screens quickly when contrasted and propelled a more elevated amount angle, it could quite every now and again pick which forms or potentially clients encounter malevolent exercises. When they

may each concentration utilizing one host, have based IDS in self-configurable networks frameworks promptly operator comfort demonstrate where specialist run utilizing (and screen) singular has yet they are responsible to a specific unified reassure (so on the off chance that you experience the ill effects of an individual support can design, direct, and unite information from various hosts). Host-based IDSs can see assaults undetectable with your system based IDS in self-configurable networks and can check assault impacts precisely.

System Based Intrusion Location Framework: It inspects or screens an entire, incredible system with a not very many all-around arranged hubs or gadgets and forces minimal overhead on organize implement. It breaks the system and application agreement action to differentiate doubtful incidents. The system based IDSs in self-configurable networks are regularly detached gadgets that screen continuous system action without including huge overhead or aggravating system operation [13]. They're extremely all too simple to control assault and can be imperceptible to assailants; moreover, they merit giving little exertion and fit and utilize on existing systems. A sensor is sent in 1 of 2 modes inline mode and aloof mode.

Inline Mode: An inline sensor is conveyed so your system activity it happens to screen must go all through, much the same as the movement stream of a firewall. Personally, some inline sensors are half and half firewall/IDS gadgets, mortgage holders are essentially just IDSs. The main inspiration for arranging IDS in self-configurable networks sensors inline is ordinarily to help them to stop assaults by blocking system activity.

Detached Mode: A latent sensor is sent all together that it screens a copy of that system activity; no movement passes employing the sensor. Inactive sensors are normally sent with a specific end goal to screen key system areas, for example, the divisions amongst systems, and key system sections, similar to action even on a neutral territory (DMZ) subnet.

Problem Formulation: The inclusion in gazing at the resistant component is expanding over the past couple of years. PC researchers, engineers, mathematicians, thinkers alongside different scientists are especially intrigued with the capacities for this framework, whose unpredictability is practically identical to that of the cerebrum. An inventive area of research called Artificial Immune Systems has emerged [4, 7 and 12]; however no formal basic structure was introduced yet.

Numerous properties on the resistant instrument are engaging for PC researchers and specialists:

1) Uniqueness: Everyone has a particular invulnerable system, including its specific vulnerabilities and abilities.

2) Recognition of Nonnative: The (unsafe) molecules which are not indigenous to the body's cells are identified and eliminated within view of the insusceptible instrument.

3) Anomaly Location: The safe system can recognize and behave to pathogens that the body's cells have not experienced previously.

4) Distributed Discovery: The cells networks on the framework are circulated all around the body and, uncovered this as a main priority, aren't represented by any unified control.

5) Imperfect Location (Clamor Resilience): The correct acknowledgment on the pathogens isn't important; hereafter the hole is adaptable.

6) Reinforcement Learning and Memory: It can "take in" the structures of pathogens, to verify that future reactions with similar pathogens are quicker and more grounded.

The resistance instrument is greatly confounded and resembles it's correctly tuned with the issue of identifying and wiping out infections [8]. It's accepted since it likewise offers a convincing commendable instance of your dispersed data preparing framework, the person who we can consider for, to guarantee planning better artificial versatile frameworks.

A major and regular application area for versatile frameworks swarm-based is the one about PC security. Some kind of PC security measure such concerning case Network Intrusion identification System ought to ensure an instrument or wide assortment of machines from unapproved gatecrashers. These gadgets prerequisites find a route avoid against outside code that will be comparable in usefulness with the safe framework shielding the self from intrusion by microorganisms (quiet). Thus convincing similitude among the self and non-self codes, outline for this "counterfeit insusceptible framework". (AIS) may be ensuring PC systems dependent on safe legitimate standards, calculations and design. This proposition goes enhancing Naïve String Search calculation for used in artificial body; the entire Naive string looking calculation discovers all events related with a solitary given string inside another. These have running time multifaceted nature is corresponding with the volume of the lengths out of your strings in the altered calculation may potentially be stretched out to keep up considerably more broad example coordinating issues.

Fake insusceptibility framework is unquestionably programming applications framework that impersonates tune for the conduct out of your human resistance framework to shield PC systems from infections alongside other alike digital assaults. The first thought could be the human resistance framework, which is unquestionably a complicated framework involving lymphocytes.

In this work KMP String Search calculation is implemented with regards to illustration in c# environment for fake insusceptible framework. The Modified Generic KMP string looking calculation brings about lymphocyte in the swarm-based fake resistant framework. The authors are trying to compose a reproduction instrument encountering how AIS acts. All reproduction tests and mimicking programs are in the like manner written in the C# programming dialect or client Defined sources of info.

A noteworthy and regular application space for versatile frameworks swarm-based speaks to PC security. Your PS security such with regards to illustration Network Intrusion discovery System ought to ensure one device or measure of machines from unapproved interlopers. What's more, it needs to have the decision anticipate against outside code, which is proposed to be comparable in usefulness considering the

invulnerability framework shielding the self from intrusion by microorganisms.

Thus convincing closeness among the self and non-self-codes, outline for this "Artificial Immune System" (AIS) [11 and 19] may be ensure PC systems dependent on invulnerable coherent standards, calculations and engineering. This proposition goes enhancing Naïve String Search calculation for use in artificial body; the entire Naive string looking calculation discovers all events related with a solitary given string inside another. These have running time intricacy is relative with the volume of the lengths out of your strings in the altered calculation may potentially be reached out to keep up much more broad example coordinating issues.

Fake insusceptibility framework is unquestionably programming applications framework that impersonates tune for the conduct out of your human invulnerability framework to shield PC systems from infections alongside other alike digital assaults. The first thought could be the human insusceptibility framework, which is certainly a many-sided framework containing lymphocytes.

III. Proposed Work

AIS for network intrusion detection are an automated system tot models some components of the behavior in the human immunity system. It aims to safeguard the computer networks from harmful viruses as well as other attacks like active or passive. Considering that the human immunity method is problematic system composed of lymphocytes, antibodies as well as other components have evolved and energy to will protect you against harmful pathogens. Hence, modeling the behavior in the human immunity system must provide a prospering method against attacks.

The major elements of a simplified immune system are illustrated in Fig. 2. It consisting of harmful nodes called antigens shown as red. The human body also contains many healthy antigens called self-antigens shown as green in Fig. 2 and some naturally occurring proteins are shown as rounded ovals.

A. Implementation of AIS for Network Intrusion Detection Development

For the development of a swarm-based system which is in particularly targeted towards Network Intrusion Detection in self-configurable networks, few key factors are considered like.

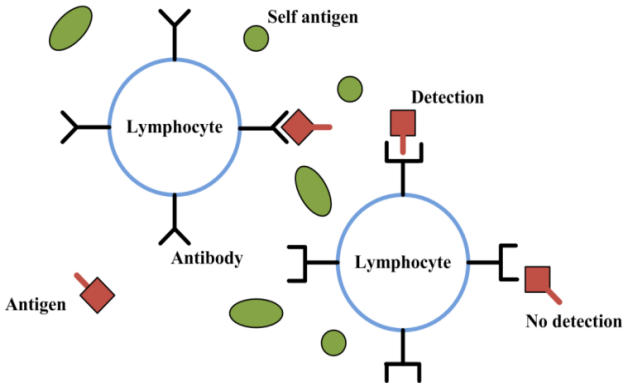


Fig. 2. Elements of IS.

- The safe framework ought to be assorted, which enormously enhances heartiness, on both a populace and individual level, for instance, extraordinary individuals are helpless against various organisms; in the event of systems the framework ought to have the capacity to recognize expansive IP swarm if there should be an occurrence of Denial of Service Attacks.
- It ought to be circulated, comprising of numerous segments that cooperate locally to give worldwide assurance, so there is no focal control and henceforth no single purpose of disappointment.
- It ought to be blunder tolerant in that a couple of missteps in grouping and reaction are not calamitous.
- It ought to be dynamic in nature, i.e. singular segments are persistently made, devastated, and are flowed all through the body, in the event of Network the framework ought to have the capacity to distinguish any kind of Addressed for instance Ipv4 or Ipv6 in any case.

B. KMP Algorithm

KMP Algorithm detects all circumstance of just one identified substring within another string, in dynamic manner corresponding to the actual length of the string. The proportionality constant is very small to produce given algorithm run practical, and hence the process is required to be further enlarging to manage even two or more basic pattern-matching problems. A conceptual application in this approach implies that the group of concatenations of even palindromes like the language could be accepts in linear time.

Text-editing programs are often requisition to search through a string of characters focus for occurrence of a given "pattern" string. In this work authors desire to find all type of positions, or perhaps only the leftmost position, in which the pattern occurs as a contiguous substring of the text. For example, "*B u t t e r f l y*" contains the pattern "*f l y*", but we do not regard "*B u t t e r f l y*" as a substring.

The decided way to search for a matching pattern is to try searching at every starting position of the text, leave the search as soon as an incorrect character is search. But in this approach can be very ineffective, for example when we are considering for an occurrence of aaaaaaab in aaaaaaaaaaaaab.

When the given pattern is $a^n b$ and the text is $a^2 b$, we will find ourselves making $(n+1)$ comparisons of given characters. Furthermore, the conventional approach involves "backing up" the input text as we go through it, and this can add provoking complications when we consider the buffering operations that are usually involved.

However KMP Algorithm finds all occurrences of a routine of length ***m*** in just a text of length ***n***. Time Complexity of KMP algorithm is

$$O(m+n) \tag{1}$$

The algorithm needs only $O(m)$ locations of internal memory if the writing is read from an additional file, and only $O(\log m)$ units of time elapse between consecutive single-character inputs. All the constants of proportionality implied by these "O" formulas are independent of the alphabet size.

C. Working of KMP Algorithm

The working of KMP algorithm is given as

Step 1: Initialize the input variables:
n = Amount for the Text, m = Amount for the Pattern,
u = Prefix –function of pattern (p) and
q = Lots of characters matched.

Step 2: Define the variable: q=0, the start of match.

Step 3: Compare initial character for the pattern with first character of text. If the match isn't found, substitute the worthiness of u[q] to q. If the match can be found at, then increment the worthiness of q by 1.

Step 4: Check whether lots of the pattern elements are matched considering the writing elements. Or simply, repeat the search process. If yes, print the level of shifts taken via the pattern.

Step 5: Often search for another match.

D. Modified KMP Algorithm for a Lymphocyte

The Lymphocyte Detects uses the Knuth-Morris-Pratt substring algorithm that may be affixed to any Pieces of an IP Address. The KMP algorithm Detects accepts a look pattern such a few instance 1010100 and returns true if the present object's antigen, such a few instance 101, matches the pattern.

Algorithm

The modified KMP algorithm for proposed IDS in self-configurable networks is given as

Initialize the parameters
$n \leftarrow length[S];\ m \leftarrow length[p];$
$a \leftarrow compute\,Prefix Function;\ q \leftarrow 0;$
for $i \leftarrow 1$ to *n* **do**
while $q \geq 0$ and $p[q+1]$,
$S[i]$ **do // S is the gene search table**
$q \leftarrow a[p]$ **// p is the Incoming Gene Pattern**
if $p[q+1] = S[i]$ **// Match Pattern in the gene database then**
$q \leftarrow q+1$
end if;
if $q == m$ **then**
$q \leftarrow a[q]$ **// The Gene Pattern is Detected**
end if;
end while;
end for;

IV. Simulation and Results

The working flow chart of the designed IDS in self-configurable networks is given in Fig. 3.

The simulation parameters opted for this work is listed in Table I. From the Table I, it has been observed that virus gene size is equal to 32 and antibody size is 10 considered for this simulation. The used threshold value for this experiment is 3, swarm size is 10. The maximum age of virus is 10 and maximum simulation count is 1000 considered for this experiment.

The performance of the developed IDS in self-configurable networks system has been evaluated by the help of optimal number of Lymphocyte for Ipv4 packets, Ipv4 detection time vs. number of Lymphocytes and simulation time.

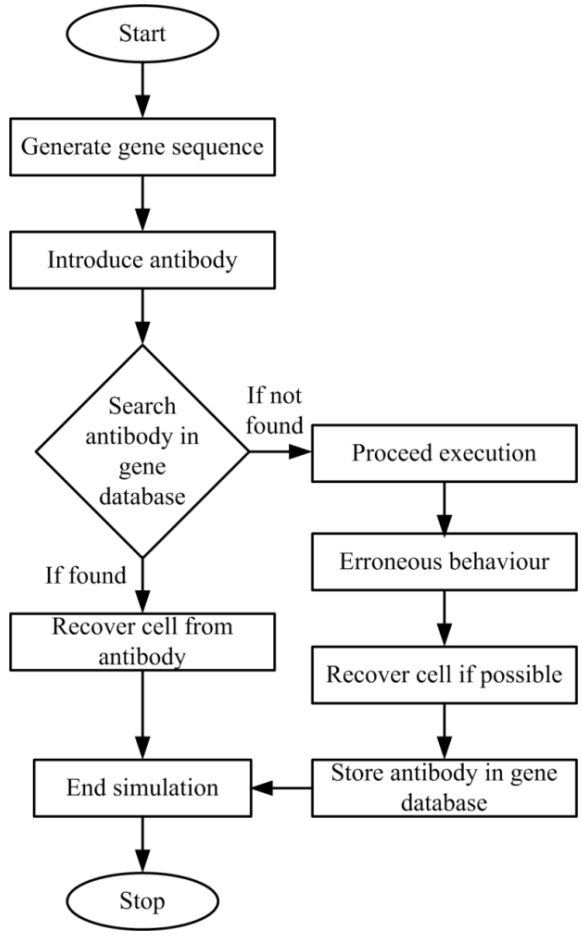


Fig. 3. Working flow Chart of the Proposed Work.

TABLE. I. Simulation Parameters

Parameter Name	Value
Virus Gene Size	32
Anti Body Size	10
Threshold	3
Swarm Size	10
Max Age	10
Simulation Count	1000

A. Simulation Results

The optimal number of Lymphocyte for Ipv4 Packets and average detection time are given in Table II for above said simulation parameters. The graphical representation of results is shown in Fig. 4.

From the Table II and Fig. 4, it has been observed that optimal number of Lymphocytes is 14 and average detection time is 1.4 milliseconds.

Further, the developed IDS in self-configurable networks have been repeatedly simulated in same environment using artificial immunity simulator as per shown in Fig. 5.

The simulation time results of Ipv4 simulation for various simulation counts have been reported in Table III and also shown in Fig. 6.

TABLE. II. IPV4 DETECTION TIME VS. NO OF LYMPHOCYTES

No of Lymphocytes	Ipv4 Detection Time(AVG)
1	0.51
2	0.68
3	0.70
4	0.85
5	0.88
6	1.06
7	1.21
8	1.41
9	1.60
10	1.77
11	1.79
12	1.45
13	1.41
14	1.41
15	1.43
16	1.41
17	1.42
18	1.41
20	1.41

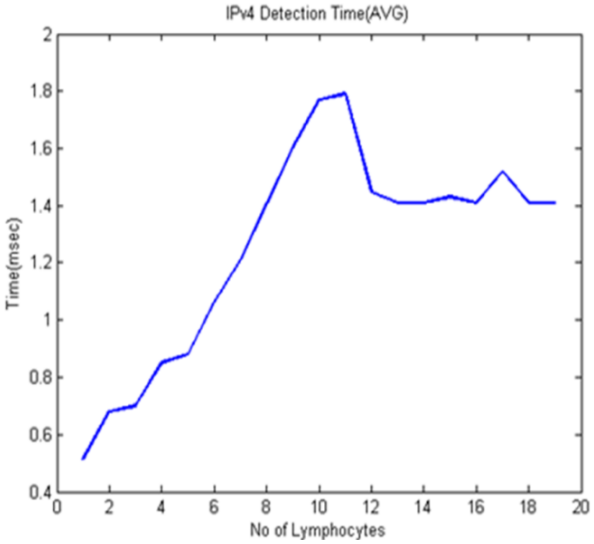


Fig. 4. Ipv4 Detection Time vs. No of Lymphocytes.

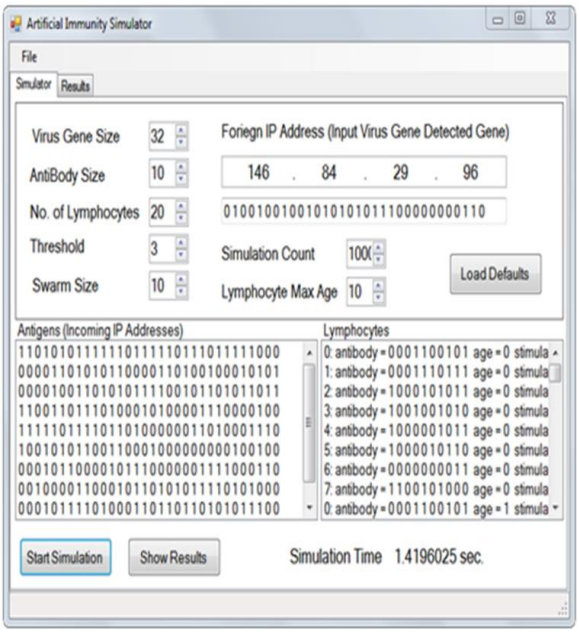


Fig. 5. Artificial Immunity Simulator.

TABLE. III. IPV4 SIMULATION TIME

Simulation Count	Simulation Time
100	0.0811
200	0.1286
300	0.1794
400	0.2246
500	0.2808
600	0.3274
700	0.3665
800	0.4289
900	0.4782
1000	0.5147

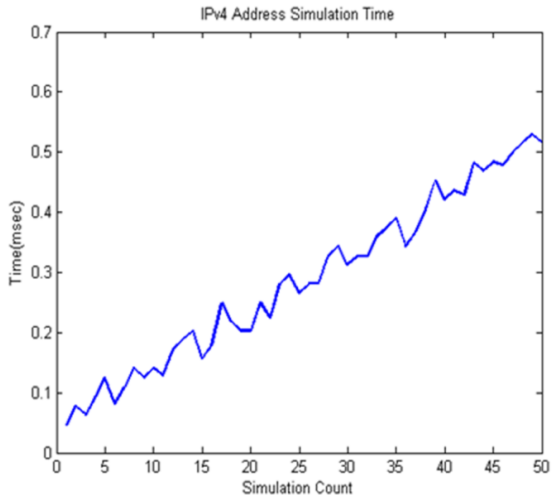


Fig. 6. Graph Showing Ipv4 Simulation Time.

B. Comparative Analysis

The present work is compared with the study performed by Belouch [16] in terms of simulation time. It is worth to mention that the minimum simulation time for 100 nodes is 0.08 seconds. The total simulation time for study performed in study [16] is 0.20 seconds. Therefore, it has been observed that the IDS based on KMP string matching and AIS based system is more fast that machine learning based system.

V. Conclusion

The insusceptibility procedure is considered that conveys both guard and upkeep inside the body. Numerous reasons exist why the insusceptibility procedure is surely seen as path for you to motivation for any plan of novel calculations and frameworks. This proposition concerned utilizing Naïve String Search calculation for used for counterfeit resistance process; the aggregate Naïve string looking calculation discovers all events of a specific string inside another. You can discover running time multifaceted nature is corresponding to measure of one's lengths inside the strings also; the adjusted calculation can be stretched out to hold other general example coordinating issues.

We created Algorithms that were bio motivated and given reenactments to Network interruption recognition situations. The Algorithm utilized the versatile credulous string look calculation as Pattern Matching calculation to copy the conduct of a man or lady Lymphocyte. The calculation gave fruitful and fulfilling the results.

VI. Future Scope

A swarm-based artificial invulnerable algorithm is among numerous calculations enlivened by natural frameworks, including developmental calculations, swarm knowledge, neural systems and layer processing. AIS are naturally enlivened calculations that take their motivation from a human or creature resistant framework. Inside AIS, classes of sorts of calculations, and principals are centered chiefly at the speculations of invulnerable systems including, clonal choice and negative choice. These hypotheses have just been consolidated into different calculations and been given wear various application territories.

In any case, necessary and normal application space for versatile frameworks swarm-based is PC security. Your working PC framework security including Network Intrusion recognition System ought to ensure a PC gadget or few machines from unapproved interlopers. The sewing machine ought to in like manner give you the possibility averts against outside code that is similar in usefulness to insusceptibility process shielding the self from attack by organisms (non-self).

We can readily see following areas are suitable in the foreseeable future:

1) Improve Lymphocyte performance for Ipv4 and particularly Ipv6 Networks.

2) Capability auto load Network addressed into cache for faster detection.

3) Improved clone selection and negative selection.

4) Using Devised Methodologies for coming of spam detection framework and actual implementation of AIS algorithms for spam Detection.

References

[1] Casas, P., Mazel, J., & Owezarski, P. (2012). Unsupervised network intrusion detection systems: Detecting the unknown without knowledge. Computer Communications, 35(7), 772-783.

[2] Dasgupta, D. (Ed.). (2012). Artificial immune systems and their applications. Springer Science & Business Media

[3] Subashini, S., & Kavitha, V. (2011). A survey on security issues in service delivery models of cloud computing. Journal of network and computer applications, 34(1), 1-11.

[4] Hunt, J and Cooke, D. 1996. Learning using an artificial immune system. Journal of Network and Computer Applications: Special Issue on Intelligent Systems : Design and Application. 19 189-212.

[5] Bakshi, A., & Dujodwala, Y. B. (2010, February). Securing cloud from ddos attacks using intrusion detection system in virtual machine. In 2010 Second International Conference on Communication Software and Networks (pp. 260-264). IEEE.

[6] Nikolai, J., & Wang, Y. (2014, February). Hypervisor-based cloud intrusion detection system. In 2014 International Conference on Computing, Networking and Communications (ICNC) (pp. 989-993). IEEE.

[7] Dasgupta, D (1998). An overview of artificial immune systems. Artificial Immune Systems and Their Applications. 3-19. Springer-Verlag

[8] Mafraq, J. Proposed anticipating learning classifier system for cloud intrusion detection (ALCS-CID). Probe, 4107, 0-83.

[9] Kholidy, H. A., Erradi, A., Abdelwahed, S., & Azab, A. (2014, August). A finite state hidden markov model for predicting multistage attacks in cloud systems. In 2014 IEEE 12th International Conference on Dependable, Autonomic and Secure Computing (pp. 14-19). IEEE.

[10] Gupta, M., Gao, J., Aggarwal, C., & Han, J. (2014). Outlier detection for temporal data. Synthesis Lectures on Data Mining and Knowledge Discovery, 5(1), 1-129.

[11] Khattak, S., Ramay, N. R., Khan, K. R., Syed, A. A., & Khayam, S. A. (2013). A taxonomy of botnet behavior, detection, and defense. IEEE communications surveys & tutorials, 16(2), 898-924.

[12] Lee, Dong-Wook and Sim, Kwee-Bo. 1997. Artificial immune network based co-operative control in collective autonomous mobile robots. 58-63 Proceedings of IEEE International Workshop on Robot and Human Communication. Sendai, Japan. IEEE.

[13] Hu, W., Gao, J., Wang, Y., Wu, O., & Maybank, S. (2013). Online adaboost-based parameterized methods for dynamic distributed network intrusion detection. IEEE Transactions on Cybernetics, 44(1), 66-82.

[14] Butun, I., Morgera, S. D., & Sankar, R. (2013). A survey of intrusion detection systems in wireless sensor networks. IEEE communications surveys & tutorials, 16(1), 266-282.

[15] Kaur, R., & Singh, M. (2014). A survey on zero-day polymorphic worm detection techniques. IEEE Communications Surveys & Tutorials, 16(3), 1520-1549.

[16] Belouch, M., El Hadaj, S., & Idhammad, M. (2018). Performance evaluation of intrusion detection based on machine learning using Apache Spark. Procedia Computer Science, 127, 1-6.

[17] Kim, J., Kim, J., Thu, H. L. T., & Kim, H. (2016, February). Long short term memory recurrent neural network classifier for intrusion detection. In 2016 International Conference on Platform Technology and Service (PlatCon) (pp. 1-5). IEEE.

[18] Yin, C., Zhu, Y., Fei, J., & He, X. (2017). A deep learning approach for intrusion detection using recurrent neural networks. Ieee Access, 5, 21954-21961.

[19] Mohd, N., Annapurna, S., & Bhadauria, H. S. (2014). Taxonomy on Security Attacks on Self Configurable Networks. World Applied Sciences Journal, 31(3), 390-398.

ANNEXURE –A

TABLE. A. LIST OF ABBREVIATIONS

S.No.	Abbreviations	Description
1.	IDS	Intrusion Detection System
2.	LAN	Local Area Networks
3.	AIS	Artificial Immune System
4.	IDPS	Intrusion Detection and Prevention Systems
5.	NBA	Network Behavior Analysis
6.	DMZ	Demilitarized Zone
7.	KMP	Knuth-Morris-Pratt Substring Algorithm
8.	Ipv4	Internet Protocol Version 4
9.	Ipv6	Internet Protocol Version 6
10.	IDA	Interruption Detection Arrangements

An Immunity-based Error Containment Algorithm for Database Intrusion Response Systems

Nacim YANES[1], Ayman M. MOSTAFA[2], Nasser ALSHAMMARI[3], Saad A. ALANAZI[4]
College of Computer and Information Sciences–Jouf University–KSA[1, 2, 3, 4]
RIADI Laboratory–La Manouba University–Tunisia[1]
FCI–Zagazig University–Egypt[2]

***Abstract*—The immune system has received a special attention as a potential source of inspiration for innovative approaches to solve database security issues and build artificial immune systems. Database security issues need to be correctly identified to ensure that suitable responses are taken. This paper proposes an immunity-based error containment algorithm for providing optimum response in detected intrusions. The objective of the proposed algorithm is to reduce the false positive alarms to the minimum since not all the incidents are malicious in nature. The proposed algorithm is based on apoptotic and necrotic signals which are parts of the immunity structure in human immune system. Apoptotic signals define low-level alerts that could result from legitimate users but could be also the prerequisites for an attack, while necrotic signals define high-level alerts that result from actual successful attacks.**

***Keywords*—Database security; artificial immune system; error containment algorithm; database auditing; apoptotic signal; necrotic signal; secret sharing**

I. INTRODUCTION

Artificial immune system (AIS) is a field of research that links different disciplines such as immunology, computer science and engineering [1] [2]. AIS is considered the artificial simulation of natural immune system (NIS). The immune system is responsible for guarding the human body against the foreign and dangerous microorganisms called pathogens. To overcome these pathogens, the immune system depends on innate and adaptive immune subsystems [3]. The innate immune subsystem is considered the immutable first line of defense for alarming danger signals around suspicious item. The adaptive immune subsystem relies on a faster response to unknown detected patterns.

Over the last two decades, a rich set of biological immune inspired algorithms have been developed to solve computational problems. Different researches of AISs have been developed and applied based on immune modeling, theoretical artificial immune system, and applied AISs [4]. Works on immune modeling cover several models based on natural immune systems, while theoretical artificial immune system discusses the theoretical field of artificial immune system.

The most active field in AIS is the development of immune-inspired algorithms to apply artificial immune system in diverse real world applications. Negative selection algorithms, clonal selection algorithms, artificial immune networks, and danger theory; are four major algorithms of artificial immune system that are applied in different domains such as intrusion detection systems, neural networks, and data analysis [2, 4].

Protecting the privacy and integrity of data with maintaining high detection rate with low false positive and false negative alarms is a challenging issue for database security. As presented in our previous work [2], the immunity-based detection algorithms are used to protect database from malicious users or intruders who may abuse their privileges to produce hostile acts. The developed detection algorithms produce efficient results in preventing attacks from breaching the security system but the security system may still have vulnerabilities. However, there are two vulnerability cases into which the intruder may attack the immunity-based detection algorithms. First, if the malicious user succeeds in obtaining some confidential information about the privileges of authorized users, he can predict the authentic factor of the authorized user. Second, the malicious user can perform a brute-force attack on the authentic factor set of an authorized user until a valid factor is obtained or the authentic factor set which is considered as a detector of the system fails in detecting the intruder. In both cases, the malicious user can breach the system and obtain confidential information from database. That's why an error containment strategy is crucial and helps identify post-security issues and resolve them quickly.

The main goal of this paper is to propose an error containment strategy with the objective to reduce the false positive alarms to the minimum. The proposed strategy is biological immune inspired; it is based on apoptotic and necrotic signals that are parts of the immunity structure in human immune system. Apoptotic signals define low-level alerts that could result from legitimate or illegitimate users, while necrotic signals define high-level alerts that result from actual successful attacks. Database auditing mechanisms will be embedded in the proposed error containment strategy in order to monitor and audit all user transactions.

The body of this paper is structured as follows. A review of the related works is presented in Section 2 whereas the proposed immunity-based error containment strategy is detailed in Section 3. Section 4 deals with the implementation of most common mechanisms for database auditing. Finally, the paper ends with a conclusion and future works.

II. Related Works

Artificial immune system covers different models and algorithms inspired by biological immune systems [1].

The main mechanism of artificial immune system (AIS) is based on detecting computer viruses, intruders, or threats by generating a set of detectors whose role is to defend application environments. The detectors are used to scan the developed applications and if there is a matching between the detector and any intrusion, the intrusion will be blocked.

One of the researches of artificial immune system is presented in [5]. In this research, a cryptographic algorithm was developed based on the inspiration of artificial immune systems. The developed cryptographic algorithm uses the advanced encryption standard (AES) in order to generate a random output which cannot be predicted by intruders.

The developed algorithm is based on the interaction between antigen and antibody. The key and plaintext are represented as antigen and antibody respectively. A lockup table is developed based on a combination between the key and plaintext for generating the cipher-text. The process of generating cipher-text is executed in 10 rounds to produce random output.

A survey on artificial immune system as an inspiration for anomaly based intrusion detection systems has been presented in [6]. In this research, a set of unique features of human immune systems has been presented such as: dynamic, distributed, diverse, parallel management, self-learning, self-adaptation and self-organization. The features of human immune system can encourage researches to simulate these features in the artificial immune system to provide wide applications. This research focuses also on intrusion detection systems (IDS) using artificial immune systems (AIS).

Another adaptive intrusion tolerance strategy in light of artificial immune systems has been presented in [7]. In this research, the authors introduced two approaches in the intrusion tolerance system: attack response and attack mask.

In the attack response sub-system, when an attack is detected, the reaction time is activated and all system resources are reallocated to continue working normally under attack. In the attack mask sub-system, the overall system will mask the affected part by redundancy, and majority voting.

The first method is simple and has low cost because the structure of the original system is not changed while the second method redesigns the whole system using artificial immune technology, and redundant technology for cloning the system resources. As a result, the method cost will be high.

An important model for the classification of heterogeneous data with artificial immune system is presented in [8]. The transformation of data from their original form into any other specific types cannot only reduce its originality but it can also occupy more space and require more preprocessing time. This model is able to process data with any type without resorting to data transformation.

A new framework for access control in light of the immune mechanism is presented in [9]. In this article, the framework of access control comprises the following: subject, object, access control decision facility (ACDF), access control enforcement facility (ACEF), as well as access control information / access control rule (ACI / ACR). Subject which is the user of certain processes sends out the access. Object is the program, process, data, and information. Access control decision facility (ACDF) enables the subject to visit the object according to the access control rule (ACR) and the access control information (ACI) and provides the result to ACEF. Access control enforcement facility (ACEF) governs the access of the subject to the object. As for Access control information / access control rule (ACI / ACR), it is used to refer when ADF conducts the decision-making, perhaps being deposited in the database, the data file, and chooses other access methods, in light of the security sensitivity and the access control information quantity.

Another intrusion detection system for computer networks based on artificial immune systems is presented in [10]. In this research, a set of randomly generated binary strings that represent the detectors are trained to draw a distinction between the self and non-self connections. When the detector has been provided to all the self and non-self connections, it forms the “Mature Detector Set” and is not subject to further change. This is considered as one of the limitations in this research. This research assumes that the detectors are complete and cannot be changed. This means that if any antigen (intruder) succeeds in passing from the mature detectors, the system will not be able to modify the mature detectors to be capable for detecting the unknown intruder. Another limitation in this research arises during the training of the detector set. The non-self is classified as a hole when a non-self (anomaly) cannot match 3 detectors or more. The authors overcome the problem of holes by developing a solution that randomly generates detectors until the anomaly matches not less than 3 detectors. This solution will cause a great space complexity because the system will generate large number of detectors to detect intruders.

Chen et al. [11] developed an immunity-based intrusion detection proposal for database systems. The developed model provides each detector with an age and an alarm to automatically detect malicious transactions. The Immune System is in charge of producing as well as managing the immunocytes for possible malicious transactions.

Most artificial immune database security researches focus on detecting intrusions that breaches database authentication mechanisms. Although the proposed detection algorithms produce efficient results in preventing attacks from breaching the security system, the security system may still have vulnerabilities. An additional layer of security can be added by applying database auditing that is considered a crucial mechanism for post-security countermeasures.

Database auditing is the mechanism for monitoring user behavior in database. By implementing access control policies, authentication, and other cryptographic techniques, the security of database can be elevated.

Different frameworks are presented to audit database systems. One of the recent security frameworks was presented in [12]. This framework is based on an auditing strategy

management for configuring database authorizations and alarms. Several event actions are applied to track all transactions such as event manager, event generator, event collector, event reporter, event analyzer and event memorizer.

Another auditing framework was introduced in [13] to avoid database performance delays. This framework is used by applying a three-way handshake of TCP data flows. A hash table is used to manage connections for new data packets.

Database auditing can be also used to secure statistical database [14]. In statistical database, users can acquire statistical queries like (average, sum, count, etc.) but specific individuals' information should remain confidential. The aim of the key representation auditing scheme is to guard online and dynamic SDBs from disclosure. The idea relies on the conversion of the original database D into key representation database D|. Thus, before being stored in the Audit Query table (AQ table), each new user query q would be converted from string into key representation query q|.

Another auditing method for auditing mathematical statistics was presented in [15]. In that research, a statistical analysis was conducted to analyze user behavior based normal records. The method is based on memory mathematical statistics to store auditing objects into the memory to analyze user behavior. The authors in [16] present a logging scheme for database auditing used for analyzing and monitoring network traffic. The architecture of this scheme comprises three primary parts: packets capturing and parsing, as well as data storage. First the packets are captured to and from the database. After database communication protocols are analyzed, the captured packets are parsed and immediately used to support database audit.

Auditing the changes to a database is important for improving system performance, maintaining data quality and detecting malicious behaviors. However, an accurate audit log is a historical record that constitutes a serious threat to privacy. The policies that limit data retention clash with the purpose of accurate auditing. Thus, data owners should carefully assess the need for these policies in compliance with the accurate auditing goals. The authors in [17] develop a framework for auditing the changes to a database system while the data retention policies are still respected. The framework consists of a historical data model that supports flexible audit queries, besides a language for retention policies that conceal individual attribute values or delete entire tuples from history. The audit history is partially incomplete under retention policies. The interpretation of audit queries on the protected history is formalized and may contain imprecise results. Policy application and query answering are efficiently implemented in a standard relational system, and characterize the cases where the achievement of accurate auditing under retention restrictions is possible.

III. The Immunity-based Error Containment Strategy

The current section explains different mechanisms to secure database user transactions based on three interactive sequential processes starting with detecting malicious intruders using our proposed immunity-based detection algorithm that was published in [2]. The next process presents our proposed error-containment algorithm. The final process explores a system hibernation framework for auditing user transactions whether to be granted or denied.

A. The Intruder Detection Algorithm

In our paper [2], we proposed an immunity-based detection algorithm to protect database from malicious users or intruders who may abuse their privileges to produce hostile acts. As presented in Fig. 1, the proposed intruder detection algorithm is based on five nested stages. These stages are presented as follows:

1) Stage 1: Verified factor authentication (VFA): The user must pass his/her 18 bits in a correct manner so as not to be detected as a malicious user. If the user passes his/her authentic factor, he/she can move to the last layer of security which is user certificate authorization (UCA); otherwise the security system will perform a set of serial checking mechanisms which are factor length matching, antigen table matching, RCB matching, and DVS matching.

2) Stage 2: factor length matching (FLM): If the user fails in verifying his authentication factor, the first checking mechanism of the intruder detection algorithm is to match the privilege factor length with the user entry. If the factor length is not correct, the security system will raise the danger signal II alarm. Otherwise, the system will proceed to the next checking mechanism which is antigen table matching.

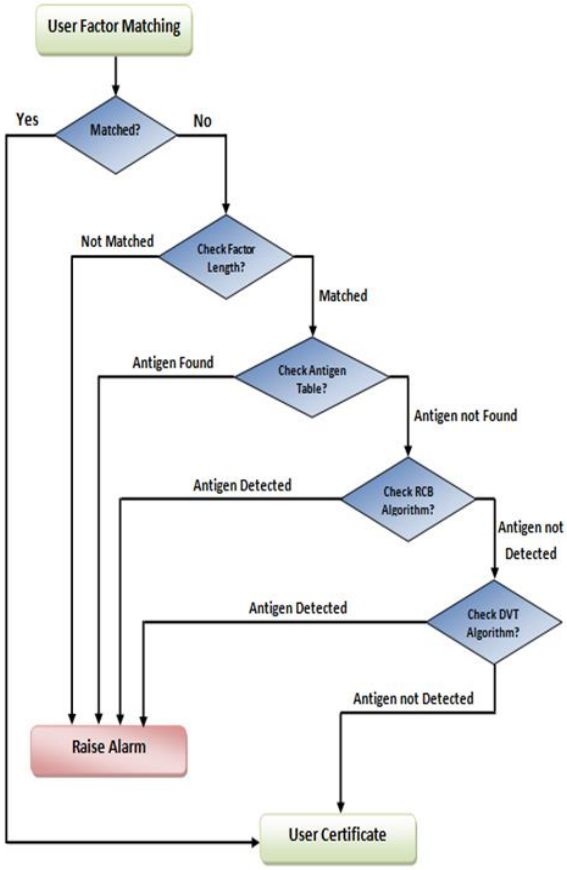


Fig. 1. Intruder Detection Checking Mechanisms.

3) Stage 3: antigen table matching (ATM): The developed antigen table is the learning and memorization stage that stores all previously detected users for performing fast detection response to unknown patterns. The security system searches the user factor in the antigen table to get a quick response instead of applying the detection algorithm.

4) R-Contiguous bit matching: The security system traces each bit of the user factor and matches it with the authentic user factor stored in the "system cache". As presented in [2], the security system will raise danger signal II alarm if at least R-contiguous bits are matched in both authentic and fake factors. Otherwise, the security system will activate the second detection algorithm which is the danger value algorithm (DVS).

5) Stage 5: danger value signal (DVS) algorithm: The last detection stage in the proposed intrusion detection algorithm is to initialize the danger value signal (DVS) algorithm. The main idea of this algorithm is to detect unauthorized users who succeed in passing the four previous detection mechanisms.

B. The Error Containment Algorithm

The intrusion detection algorithm, described in the previous section, produces efficient results in preventing attacks from breaching the security system but the security system may still have vulnerabilities. In fact, the intruder may attack the immunity-based detection algorithms into two vulnerability cases. First: if the malicious user succeeds in obtaining some confidential information about the privileges of authorized users, he can predict the authentic factor of the authorized user. Second: The malicious user can perform a brute-force attack on the authentic factor set of an authorized user until a valid factor is obtained or the authentic factor set which is considered as a detector of the system fails in detecting the intruder. In both cases, the malicious user can breach the system and obtain confidential information from database.

Algorithm 1 presents an error containment strategy for preventing malicious users from harming the system if they succeed in breaching the detection algorithms.

Algorithm 1: Apoptotic-Necrotic Signal Algorithm

```
Integer m=Apoptotic Signal
Integer n=Necrotic Signal
Get User Factor from System cache
Set Detector = User Factor
If strFactor = Cached Detector Then
 {
    Check User Certificate Authorization (UCA)
If UCA = TrueThen
     {
  Assign Authentic User
  Assign Predefined Privileges
  Transactions Committed
 }
Else
 {
    Raise Danger Signal III Alarm
    User Disconnect
 }
}
Else
{
Check RCB Algorithm  // Algorithm 5.2
   Check DVS Algorithm  // Algorithm 5.3
If strFactor = Detected Then
    {
Raise Danger Signal II Alarm
User Disconnect
    }
   Else
    {
Assign Suspicious User
       Classify Predefined Privileges
For Privileges Between 1 and m Loop
        {
Assign Apoptotic Signal
Transactions Pending
            System Hibernation
            Database Auditing
            Send DBA Broadcasting Request
            If Request = Approve Then
               Transactions granted
            Else
               Transactions denied
        }
For Privileges Between m+1 and n-1 Loop
        {
Assign Necrotic Signal
Transactions Pending
            System Hibernation
            Database Auditing
            Send DBA Broadcasting Request
            If Request = Approve Then
               Transactions granted
            Else
               Transactions denied
        }
For Privileges = n Then
        {
Assign Max Necrotic Signal
Transactions denied
            User Disconnect
        }
    }
}
```

As described in Algorithm 1, the strategy begins by defining apoptotic and necrotic signals. Apoptotic and necrotic signals are part of the immunity structure in human immune system [1]. Apoptotic signals define low-level alerts that could be issued by legitimate users or as a sign of a preliminary attack. Necrotic signals define high-level alerts that result from actual successful attacks. Defining the apoptotic and

necrotic signals are the responsibility of the super administrator (SA). The super administrator (SA) defines the apoptotic and necrotic signals to be used as countermeasure for preventing unauthorized users from disclosing confidential information from databases if they succeed in breaching the security system.

When a user connects to the security system, he must pass the intruder recognition system as presented in [2]. If the user passes the intruder recognition system with a valid username and password, then the user exceeds the first danger signal (Danger Signal I). As a result, the system verifies that the user could be an authorized user. Therefore, the security system retrieves the authentic factor set (AFS) of the user who owns the username and password. The security system retrieves the authentic factor set (AFS) from the system cache and this factor is kept secret until the user verifies his/her identity by passing the valid authentic factor set. The authentic factor set (AFS) is promoted to be the detector if the user fails in verifying his identity.

If the user factor matched the authentic factor set (AFS), then the user exceeds the second danger signal (Danger Signal II). The security system will pass the user to the final verification signal which is the user certificate authorization (UCA). If the user certificate authorization is authentic, the user will be a normal user and can use his/her predefined privileges in passing database transactions via the database server. These transactions will be committed in the database server as they have been executed from normal users. If the user certificate authorization is not authentic, then danger signal III alarm will be raised and the user will be disconnected from the security system.

If the user factor did not match the authentic factor set (AFS), the security system will activate the RCB and DVS algorithms to be used as detection algorithms to detect the malicious user. If the detector succeeds in detecting the malicious user, danger signal II alarm will be activated and the user will be disconnected from the security system.

If the detector failed in detecting the malicious user, the security system will assign the user as “suspicious user” and will pass the user to the final verification signal, which is the user certificate authorization (UCA). The suspicious user may perform a brute-force attack until a valid user certificate authorization is obtained. The apoptotic and necrotic signals which have been developed by the super administrator (SA) will be activated to limit the authorizations of the user.

Apoptotic and necrotic signals activation depends on the probability of three conditions. First: the malicious user succeeds in obtaining a valid username and password and passed the danger signal I alarm. Second: the malicious user succeeds in breaching the detection algorithms and passed the danger signal II alarm. Third: the malicious user succeeds in passing the danger signal III by performing a brute-force attack on the user certificate authorization until a valid certificate is obtained.

The super administrator (SA) defines the apoptotic signal by determining a number of privileges from 1 to m where m is the number of transactions allowed for the suspicious user to perform on the database server. The super administrator (SA) defines also the necrotic signal by determining a number of privileges from m+1 to n-1 where n is the maximum number of transactions allowed for the suspicious user to perform on the database server.

If the suspicious user passed the three danger signals, he can perform different transactions on database until the number of transactions equal m. At this point, apoptotic signal is raised and all transactions are suspended. If the suspicious user performed other transactions, the number of transactions will be incremented until the transactions equal n-1. At this point, necrotic signal is raised and all transactions are suspended. The Database administrator performs auditing mechanisms to monitor access to, and modification of, database objects and resources. These auditing mechanisms are employed to prepare a report to list all user operations underway within database. Upon the breach of the database security prevention and detection algorithms by malicious users, the auditing techniques are employed to report all transactions. Based on the auditing report, the database administrator sends a broadcasting request. A secret sharing mechanism is applied to monitor database administrator's transactions in a lowest possible time. If the number of transactions reached n, a max necrotic signal is raised and the user is disconnected from the security system.

The main objective of dividing the signals to apoptotic and necrotic signals is to reduce the false positive (FP) alarms to the minimum. The normal user can pass a valid username and password and may enter a wrong authentic factor set and the detector fails in detecting the wrong factor. The normal user can pass an authentic user certificate authorization (UCA). As a result, he can enter the security system. If the signals are not divided, the error alarm will disconnect the user although the user is normal one. As a result, the false positive (FP) alarms increases.

C. The System Hibernation

Once user transactions are suspended, the security system must be hibernated until the suspended transactions are approved or disapproved. As presented in [18], an alternate schema is developed to obtain all transactions from normal users until the suspension process is finished. As presented in Fig. 2, when the security system verifies a suspicious user, the suspicious user transactions are suspended in the original database which resides in the database server. The security system must verify the suspicious user transactions whether to be saved in the original database or not. The time spent in the verification process will delay other transactions that are executed from normal users. This will increase the time complexity.

In order to keep an efficient, flexible, and solid security system, data hibernation is executed by transferring data from their original source to their alternate designed source. As protective measures for data hibernation, an alternate data source in compliance with the original data source should be designed. The data can be only transferred from the original source to the alternate one only if both sources are in compliance with each other [18].

The original database schema is deactivated until the super administrator (SA) verifies the suspended transactions. Normal users are diverted to the alternate database schema that is activated to allow normal users performing their transactions with the ability to keep data integrity intact.

After the super administrator (SA) verifies the suspicious user transactions, the original database schema is activated again while the alternate database schema is deactivated. Normal users' transactions are merged in the original database schema to keep the database in a consistent state.

The submitted transactions of the apoptotic and necrotic actions are suspended until the super administrator (SA) verifies the transactions. The transactions are verified to be saved in the database server or rollback. The database server sends a request to the super administrator (SA) to grant or deny the suspended transactions. In order prevent intruders from sneaking to the security system; the connection between the database server and the super administrator (SA) must be secured.

IV. Database Auditing Mechanisms and Techniques

As we presented in previous section, the database administrator performs auditing mechanisms to monitor access to, and modification of, database objects and resources. Several popular mechanisms can be deployed to audit the database structures whether the transactions are carried out by malicious users or not. If regular users execute different database transactions, a report that lists all user operations inside database is created by the auditing mechanisms. In contrast, upon the breach of the database security prevention and detection algorithms by malicious users, the auditing techniques are employed to report all transactions.

We implemented the auditing mechanisms required in most environments, namely auditing the login and logout operations inside database, auditing database operations outside normal hours, auditing data dictionary language (DDL) activities, auditing database errors that may encounter with the database security system, auditing changes to the source database if malicious users succeed in breaching the system, and auditing changes to sensitive attributes to prevent any data disclosure. Based on the auditing reports, the database administrators (DBAs) and the super administrator (SA) can execute error containment operation by restoring all malicious transactions in the database.

A. Auditing Logon/Logout into Databases

The first category for auditing database is to provide a full audit trail of any user who has signed into the database. Two events must be recorded for the auditing operation: the sign-on event and sign-off event. The following schema presents a user login history table that records all login and logout operations inside database

```
Create table user_login_audit (
user_id          varchar2(30),
session_id       number(10),
host             varchar2(30),
ip_address       varchar2(30),
login_time       timestamp,
logout_time      timestamp );
```

As presented in the previous schema, the login name for signing on as well as the timestamp for the event must be recorded. The recording process must be also applied to the TCP/IP address of the client and the program initiating the connection. Logon and logoff activities can be audited with the help of database features or the external database security solutions.

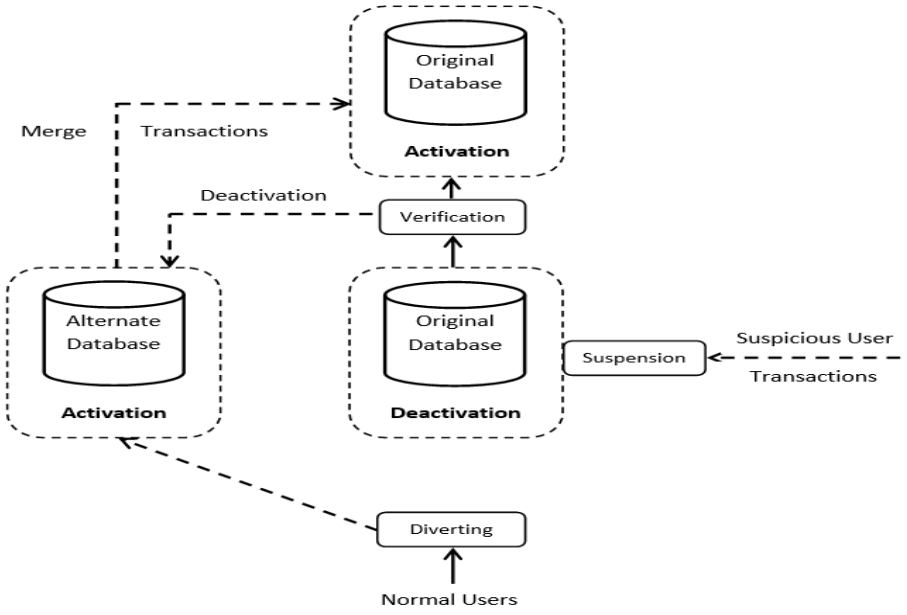


Fig. 2. System Hibernation.

In order to reduce the security cost complexity, all auditing operations are recorded using implemented database security features. In order to record all logging activities, we developed two database triggers to fire when any login attempt is initiated. The first trigger is fired at any login attempt while the second trigger is fired at any logout attempt. Table I records all login and logout attempts inside database.

```
Create or replace trigger user_login_trigger
After Logon on Database
Begin
Insert into user_login_audit
Values (User, sys_context ('USERENV',
'SESSIONID'), sys_context ('USERENV', 'HOST'),
ora_client_ip_address, Localtimestamp, null);
Commit;
End;
Create or replace trigger user_logout_trigger

Before Logoff on Database
Begin
Update user_login_audit
Set logout_time = Localtimestamp
Where sys_context('USERENV', 'SESSIONID') =
session_id;
Commit;
End;
```

As presented in Table I, all login and logout operations are recorded in the "user_login_audit" table. The super administrator (SA) needs to re-optimize all recorded information to obtain information about specific users. The super administrator (SA) can build an "audit_log_summary" table to view all usernames and the total number of logging times for each username as presented in the following schemas. The records resulted from the schemas are presented in Table II.

```
Create table user_log_summary (
User_id             varchar2(30),
Login_no            number);
Declare
Cursor C is
Select user_id, count(user_id)
From user_login_audit
GROUP BY user_id;
Begin
Open C;
Loop
   Fetch C into x, y;
   Insert into autdi_log_summary
   Values(x, y);
   dbms_output.put_line(' -User-' ‖x‖
'Connected ' ‖y‖ 'Times');
   Exit When C%notfound;
End loop;
End;


Select ' -User-'‖ user_id ‖'Connected ' ‖
sum(login_no) ‖ 'Times ' "Connection History"
From audit_log_summary
GROUP BY user_id
```

When an external security system is used, SQL firewall is used to block any connection after a given number of failed attempts by the same login name is reached. Under these circumstances, the database will not lose the connection attempts due to the rejection of the attempts at the firewall level. Instead of using external security system, database triggers are used to generate an alert following a fixed number of failed attempts as presented in Fig. 3. The alert is sent as a notification to the database administrator (DBA) to block the account. Blocking the user account requires the database administrator to join a secret sharing operation with other database administrators (DBAs) to grant or deny the operation.

All failed login attempts are recorded in the "Antigen Table Response" as presented in our intrusion detection algorithm [2]. If the same intruder attacks the system again, the security system will check the antigen table response first to detect the intruder and provides a quick response.

B. Auditing Databases outside Normal Operating

We implemented a second auditing mechanism recording activities that may be conducted beyond the regular operating business hours. From a business and a compliance perspective, this is a fundamental requirement. Auditing database usage beyond the regular business hours is critical given that off-hour activities enable unauthorized users to access or modify targeted data without suspicion. The following schemas are used to record all users who connect to the system outside normal hours. The super administrator generates a table called "operating_hours_history" which records the username, session ID, host name, and the login time for each user connected to the system outside normal hours. The records are presented in Table III.

TABLE. I. LOGIN/LOGOUT AUDITING MECHANISM

USER_ID	SESSION_ID	HOST	IP_ADDRESS	LOGIN_TIME	LOGOUT_TIME
SCOTT	20028	WORKGROUP\DESKTOP-247D553		01-SEP-19 01.50.31.226000 PM	01-SEP-19 01.50.47.468000 PM
SYSMAN	0	DESKTOP-247D553		01-SEP-19 01.50.43.245000 AM	01-SEP-19 01.50.43.256000 AM
HR	20029	WORKGROUP\DESKTOP-247D553		01-SEP-19 01.50.47.561000 PM	01-SEP-19 01.51.47.523000 PM
SYSTEM	20030	WORKGROUP\DESKTOP-247D553		01-SEP-19 01.51.01.643000 PM	
DBSNMP	20031	WORKGROUP\DESKTOP-247D553	10.66.32.16	01-SEP-19 01.51.05.643000 PM	01-SEP-19 01.51.05.943000 PM
DBSNMP	20032	WORKGROUP\DESKTOP-247D553	10.66.32.16	01-SEP-19 01.51.07.345000 PM	01-SEP-19 01.51.07.868000 PM
DBSNMP	20033	WORKGROUP\DESKTOP-247D553	10.66.32.16	01-SEP-19 01.51.09.008000 PM	01-SEP-19 01.51.09.086000 PM

TABLE. II. CONNECTION HISTORY

Connection History
User – HR – Connected – 1 Times
User – SCOTT – Connected – 1 Times
User – SYSTEM – Connected – 1 Times
User – SYSMAN – Connected – 1 Times
User – DBNMP – Connected – 1 Times

TABLE. III. SUSPICIOUS USERS OUTSIDE NORMAL HOURS

USER_ID	SESSION_ID	HOST	LOGIN_TIME
SYSTEM	30629	WORKGROUP\DESKTOP-247D553	07-SEP-19 02.41.55.481000 PM
SCOTT	30631	DESKTOP-247D553	07-SEP-19 02.44.36.057000 PM
HR	30633	WORKGROUP\DESKTOP-247D553	07-SEP-19 02.44.45.558000 PM
SYSTEM	30634	WORKGROUP\DESKTOP-247D553	07-SEP-19 02.44.54.435000 PM
SCOTT	30635	WORKGROUP\DESKTOP-247D553	07-SEP-19 02.45.01.799000 PM
SYSTEM	30636	WORKGROUP\DESKTOP-247D553	07-SEP-19 02.45.09.480000 PM

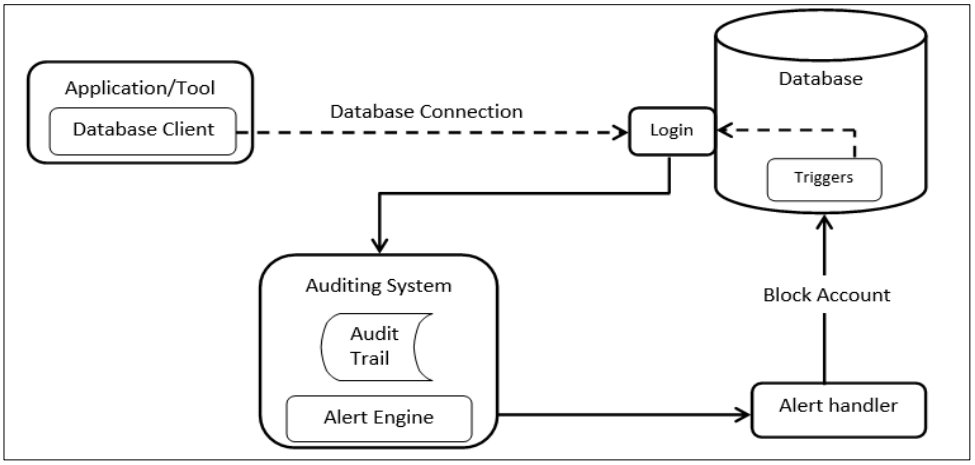


Fig. 3. Account Locking Database Procedure.

```
Create table operating_hours_summary(
user_id       varchar2(30),
session_id    number,
host          varchar2(30),
log_time      timestamp );


Create or replace trigger check_normal_hours
After Logon on Database
Begin
if  to_number(to_char(sysdate,  'HH24'))  not
between 8 and 14 OR to_char(sysdate, 'DY') in
('FRI', 'SAT')
then
Insert into operating_hours_summary
Values    (USER,    sys_context    ('USERENV',
'SESSIONID'), sys_context ('USERENV', 'HOST'),
localtimestamp);
End If;
End;
```

C. Auditing DDL Activities

Auditing data definition language (DDL) activity is considered one of the most important audit trail methodologies. The DDL commands are the most destructive as they can be exploited by intruders in order to attack the system and disclose confidential information. Many regulations require an auditing mechanism to prevent intruders from modifying the data structure such as tables or views. Three main methods for auditing schema changes exist. First: by using database audit features. Second: by using external auditing system. Third: by comparing schema snapshots. This latter method will be presented in the next subsection.

For auditing the schema changes using database audit features, the super administrator creates an audit DDL table called "audit_DDL" as explained in the following schema.

```
Create table audit_DDL(
user_id              varchar2(30),
ddl_date             timestamp,
event_type           varchar2(25),
object_type          varchar2(25),
owner                varchar2(25),
object_name          timestamp );
```

The super administrator generates a database trigger to audit all changes in schema structures and saves the changes in the "audit_DDL" table as presented in the following schema.

```
Create or replace trigger DDL_trigger
After DDL on Database
Begin
  Insert into audit_DDL
  Values (ora_login_user, localtimestamp,
             Ora_sysevent,
             Ora_dict_obj_type,
             Ora_dict_obj_owner,
             Ora_dict_obj_name);
End;
```

If the database schema changes by database administrator or users, all the changes will be recorded in the audit DDL table as presented in Table IV.

D. Auditing Changes to Database Source

As presented in the previous subsection, the first method for auditing database changes is to use database auditing features. The second method which is based on using external auditing system is costly. The third method for auditing schema changes is by using schema snapshots. The super administrator can take a snapshot from the schema source as presented in Fig. 4. By applying the Hash encryption technique (H), the source snapshot is encrypted (h1) and stored in the database server. If the malicious user modifies the source snapshot, the hash function will create a new snapshot called "suspicious snapshot" (h2). The super administrator matches the original snapshot hash (h1) with the suspicious one (h2). If there is no matching, an intrusion has happened otherwise no intrusion will be found.

E. Auditing Database Errors

Auditing errors returned by the database is among the first implemented audit trails for eliminating SQL injection, failed logins, and privilege elevation. For eliminating SQL injection, attackers may need to estimate the right number of columns. Obtaining the right number will be unlikely because the database will automatically return an error code claiming that the selected columns by the two SELECT statements do not correspond.

Another instance of an error that requires logging and monitoring is failed logins, even in the event that there are no auditing logins to the database. A failed endeavor to elevate privileges is an essential indication that an attack is underway. In order to record all database errors, the super administrator builds an audit error table as explained in the following schema.

```
Create table audit_error(
user_id      varchar2(30),
session_id   number,
host         varchar2 (30),
error_date   timestamp,
error_no     varchar2 (100),
error_txt    varchar2 (300));
```

The super administrator generates a system trigger to record all database errors in the audit error table as presented in the following schema. All recorded database errors are explained in Table V.

```
Create or replace trigger audit_error_trigger
After Servererror on Database
Begin
Insert into audit_error
Values (User, sys_context('USERENV',
'SESSIONID'), sys_context('USERENV', 'HOST'),
localtimestamp,
dbms_standard.server_error(1),
dbms_standard.server_error_msg(1));
Commit;
End;
```

TABLE. IV. DDL AUDITING TABLE

USER_ID	DDL_DATE	EVENT_TYPE	OBJECT_TYPE	OWNER	OBJECT_NAME
SCOTT	07-SEP-19 02.57.55.898000 PM	CREATE	TABLE	SCOTT	SALARY
HR	07-SEP-19 02.59.00.790000 PM	CREATE	VIEW	HR	V1
SYSTEM	07-SEP-19 03.01.01.925000 PM	ALTER	TABLE	SYSTEM	DEPT

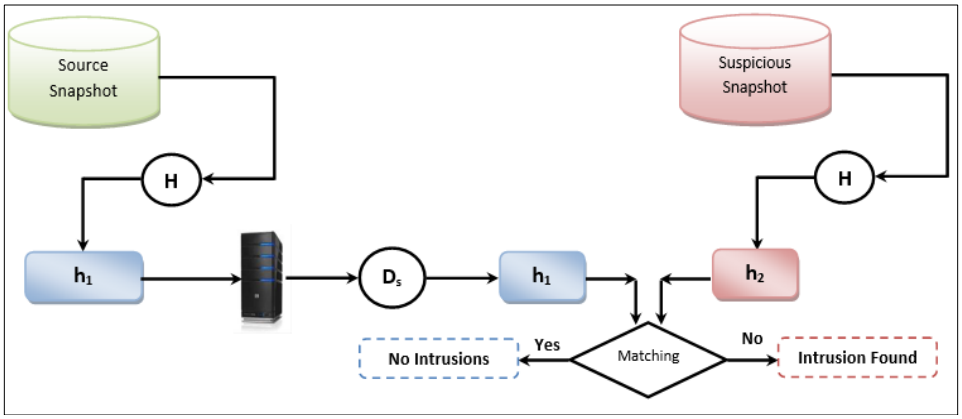


Fig. 4. Schema Snapshot Matching.

TABLE. V. ERROR AUDITING TABLE

USER_ID	SESSION_ID	HOST	ERROR_DATE	ERROR_NO	ERROR_TXT
SCOTT	30646	WORKGROUP\DESKTOP-247D553	07-SEP-19 03.03.08.490000 PM	942	ORA-00942: table or view does not exist
SCOTT	30646	WORKGROUP\DESKTOP-247D553	07-SEP-19 03.03.52.917000 PM	1	ORA-00001: unique constraint (SCOTT.PK_EMP) violated
HR	30648	WORKGROUP\DESKTOP-247D553	07-SEP-19 03.04.53.040000 PM	942	ORA-00942: table or view does not exist
HR	30648	WORKGROUP\DESKTOP-247D553	07-SEP-19 03.05.19.066000 PM	1031	ORA-01031: insufficient privileges

F. Auditing Security Attributes Changes

Auditing DML activity is an important requirement in database auditing systems. The auditing operation requires recording the old and new values for each DML activity. Two different requirements must be implemented to fully record the DML activity. First: to record any update operation, the user who has performed the update, which session has been used, and the time for the DML activity. Second: to record what the value was before and after the update operation.

The first requirement for recording the DML information is developed by building a DML audit table as presented in the following schema.

```
Create table DML_audit(
username          varchar2(20),
session_id        number,
host_name         varchar2(40),
insert_time       timestamp,
update_time       timestamp,
delete_time       timestamp
);
```

The super administrator develops a DML trigger that records all DML operations and stores the result in the DML audit table as presented in the Table VI.

```
Create or replace trigger DML_trigger
After Insert or Update or Delete On Scott.emp
For each row
Begin

If Inserting Then
Insert into DML_audit
Values (User, sys_context('USERENV',
'SESSIONID'), sys_context('USERENV', 'HOST'),
localtimestamp, Null, Null);

Elsif Updating Then
Insert into DML_audit
Values (User, sys_context('USERENV',
'SESSIONID'), sys_context('USERENV', 'HOST'),
Null, localtimestamp, Null);

Elsif Deleting Then
Insert into DML_audit
Values (User, sys_context('USERENV',
'SESSIONID'), sys_context('USERENV', 'HOST'),
Null, Null, localtimestamp);

End if;
End;
```

The second requirement for recording the DML information is developed by building an audit change table to record the updated value before and after the update operation as presented in the following schema.

```
Create table audit_changes
(
username          varchar2(20),
DML_time          timestamp,
oldempno          integer,
newempno          integer,
oldname           varchar2(20),
newname           varchar2(20),
oldhiredate       date,
newhiredate       date,
oldsal            number,
newsal            number,
oldcomm           number,
newcomm           number
);
```

The super administrator develops a DML trigger that records all old and new DML values and stores the result in the audit change table as presented in the Table VII.

```
Create or replace trigger
trigger_table_changes
After Insert or Update or Delete On Scott.emp
For each row
Begin
Insert into audit_changes
Values (User, localtimestamp, :old.empno,
:new.empno, :old.ename, :name.ename,
:old.hiredate, :new.hiredate, :old.sal,
:new.sal, :old.comm, :new.comm);
End;
```

Suppose that 1 million DML transactions are executed per day and each transaction updates a single value. The database contains 100 tables and each table contains 10 attributes. The database contains 10,000 records in each table. If the super administrator (SA) develops an auditing system that records all attributes changes before and after the update activity, then the database will grow 35 times larger than the original database after one year.

As presented in [19, 20, and 21], the DML activities must be recorded for sensitive attributes only in order to reduce the space complexity of database size.

TABLE. VI. DML ACTIVITY TIME

USER_ID	HOST_NAME	INSERT_TIME	UPDATE_TIME	DELETE_TIME
SCOTT	WORKGROUP\DESKTOP-247D553	07-SEP-19 03.08.30.853000 PM		
SCOTT	WORKGROUP\DESKTOP-247D553			07-SEP-19 03.09.51.031000 PM
SCOTT	WORKGROUP\DESKTOP-247D553		07-SEP-19 03.08.56.949000 PM	

TABLE. VII. DML AUDITING VALUES

USERNAME	DML_TIME	OLDEMP-NO	NEWEM-PNO	OLDENA-ME	NEWENA-ME	OLDHIRE-DATE	NEWHIR-EDATE	OLDSAL	NEWSAL	OLDCOM-M	NEWCO-MM
SCOTT	07-SEP-19 03.14.12.399000 PM	7369	7369	SMITH	SMITH	17-DEC-80	17-DEC-80	800	800		
SCOTT	07-SEP-19 03.14.12.403000 PM	7566	7566	JONES	JONES	02-APR-81	02-APR-81	2975	2975		
SCOTT	07-SEP-19 03.14.12.403000 PM	7788	7788	SCOTT	SCOTT	19-APR-87	19-APR-87	3000	3000		
SCOTT	07-SEP-19 03.14.12.403000 PM	7876	7876	ADAMS	ADAMS	23-MAY-87	23-MAY-87	1100	1100		
SCOTT	07-SEP-19 03.14.12.403000 PM	7902	7902	FORD	FORD	03-DEC-81	03-DEC-81	3000	3000		
SCOTT	07-SEP-19 03.14.37.229000 PM	7654	7654	MARTIN	MARTIN	28-SEP-81	28-SEP-81	1375	1650	1400	1400

G. Auditing Changes to Privileges, Users and Roles

The final auditing category is to keep a complete audit trail of any changes to the privileges, users, and roles. Different categories must be recorded to monitor the user activities in database. First: addition and deletions of users and roles. Second: privilege changes. Third: change to the security attributes at a server, database, statement, or object level.

As presented in [19, 20, and 21], the first and second categories are secured by using the secret sharing algorithm. A single database administrator (DBA) cannot add or delete users and roles, or modifies user privileges without the agreement of other database administrators (DBAs) according to the super administrator (SA) infrastructure.

The third category which is based on protecting security attributes from modification is based on preventing a single database administrator (DBA) from changing the sensitive and most sensitive attributes as presented in [2].

V. CONCLUSION

Artificial immune system (AIS) is a cover term for all the attempts that develop computational models in the spirit of biological immune systems. This paper presents an error containment algorithm as a post-security countermeasure for detecting malicious intrusions. A system hibernation framework is embedded with the proposed algorithm to monitor users' transactions. Different auditing mechanisms are implemented to track the users' behaviors whether they are authorized or not. Based on the results of the auditing mechanisms and users' authorizations, the transactions are committed or rolled back.

As short-term future work, we plan to implement the proposed artificial immunity-based algorithm and evaluate its accuracy by comparing our experimental results to those of post-security algorithms identified in the literature. The accuracy of the algorithms will be evaluated based on reducing the false positive and false negative alarms.

Over a medium-term research perspective, we propose to apply the artificial immunity-based algorithm on cloud service providers using different cloud deployment models.

REFERENCES

[1] C.M. Ou, “Host-based intrusion detection systems adapted from agent-based artificial immune systems”, International Journal of Neurocomputing, ELSEVIER, vol.88, 2012, pp.78-86.

[2] A. M. Mostafa, N. Yanes, and S. A. Alanazi, "A Cognitive adaptive artificial immunity algorithm for database intrusion detection systems", Journal of Theoretical and Applied Information Technology, vol. 97, no. 16, 2019, pp. 4387-4400.

[3] D. A. Fernandes, M. M. Freire, P. A. Fazendeiro, and P. R. Inácio, “Applications of artificial immune systems to computer security: a survey”, ELSEVIER Journal of Information Security and Applications, vol. 35, 2017, pp. 138-159.

[4] D. Dipankar, S. Yu, and F. Nino, "Recent advances in artificial immune systems: models and applications", Applied Soft Computing, vol. 11, no 2, 2011, pp. 1574-1587.

[5] S. Ariffin, R. Mahmod, A. Jaffar, and M. R. K. Ariffin, “Immune systems approaches for cryptographic algorithm”, IEEE International Conference on Bio-Inspired Computing: Theories and Applications, 2011, pp.231-235.

[6] F. Hosseinpour, K. Abu-Baker, A. H. Hardoroudi, and N. Kazazi, “Survey on artificial immune systems as a bio-inspired technique for anomaly based intrusion detection systems”, IEEE International Conference on Intelligent Networking and Collaborative Systems, 2010, pp.323-324.

[7] Z. Cui, X. Lu, and J. Wang, "Adaptive intrusion tolerance strategy of the system based on artificial immune", IEEE International Conference on Computational Intelligence and Software Engineering, 2009, pp.1-4.

[8] M. Puteh, K. Omar, A. R. Hamdan, and A. Abu-Bakr, "Classifying heterogeneous data with artificial immune system", IEEE International Symposium on Information Technology, 2008, pp.1-5.

[9] L. Wang, C. Yin, and H. Dong, "A Novel generalized framework for access control based on the immune mechanism", IEEE International Conference on Intelligent Control and Automation, 2008, pp.1427-1431.

[10] D. Dal, S. Abraham, A. Abraham, S. Sanyal, and M. Sanglikar, "Evolution induced secondary immunity: an artificial immune system based intrusion detection system", IEEE International Conference on Computer Information Systems and Industrial Management Applications, 2008, pp.65-70.

[11] K. Chen, G. Chen, and J. Dong, "An Immunity-based intrusion detection solution for database systems", International Conference on Web-Age Information Management, Springer, Berlin, Heidelberg, 2005, pp.773-778.

[12] H. Wang, "A Security framework for database auditing system", IEEE International Symposium on Computational Intelligence and Design, vol. 1, 2017, pp.350-353.

[13] K. Wu, L. Hua, X. Wang, and X. Ding, "The Design and implementation of database audit system framework", IEEE International Conference on Software Engineering and Service Science, 2014, pp. 553-556.

[14] A. A. Elshiekh, and P. D D. Dominic, "Three audit stages for securing statistical databases", IEEE International Conference on Information Management and Engineering, 2009, pp.283-286.

[15] Shao Zuozhi, Li Yunpeng, Zhang Kuo, Zeng Geng, Zhao Sitang, "An Audit Method Based on Mathematical Statistics Detection in Database Audit System", IEEE Conference on Intelligent Human-Machine Systems and Cybernetics, 2015, pp. 203-206.

[16] Q. Huang, and L. Liu, "A Logging scheme for database audit", IEEE International Workshop on Computer Science and Engineering, vol. 2, 2009, pp.390-393.

[17] L. Wentian, G. Miklau. "Auditing a database under retention restrictions", IEEE International Conference on Data Engineering, 2009, pp.42-53.

[18] S. Safdar, M. F. Hassan, M. A. Qureshi, and R. Akba, "Data hibernation framework in workflows under intrusion threat", IEEE Symposium on Computers and Informatics, 2011, pp.680-685.

[19] A. M. Hashem, I. M. El-Henawy, and A. M. Mostafa, "Interactive multi-layer policies for securing relational databases", IEEE International Conference on Information Society, 2012, pp.65-70.

[20] A. M. Mostafa, A. M. Hashem, and I. M. El-Henawy, "Design and implementation of multi-layer policies for database security", International Journal of Information Sciences, Natural Sciences, vol. 2, no.3, 2013, pp.147-153.

[21] A. M. Mostafa, A. M. Hashem, and I. M. El-Henawy, "Design and implementation of extensible service-oriented algorithms for securing relational databases", International Journal of Digital Content Technology and its Applications (JDCTA), Elsevier, vol.7, 2013, pp.753-763.

The Respondent's Haptic on Academic Universities Websites of Pakistan Measuring Usability

Irum Naz Sodhar[1], Baby Marina[2], Azeem Ayaz Mirani[3]
Post Graduate Student, Department of Information Technology
Quaid-e-Awam University of Engineering, Science and Technology, Nawabshah, Sindh, Pakistan

***Abstract*—This study based on survey, by using four higher educational (Universities) websites were selected for the usability testing with the help of response to the experience of eighty students of same age group and investigated to make pre-survey and post-survey based on an eight questionnaire for websites usability. The source for the survey was Laptops of windows 8.1 operation system used. The questionnaires were depends on two factors: one factor contains gender, nationality, respondents and second factor contains strongly agree, Agree, Undecided, Disagree, Strongly Disagree. The factor structure replicated across the study with data collected during usability test respectively in survey. There was evidence of usability with existing questionnaires, including the website usability testing by applying guidelines of webcredible. The overall results were acceptable and more meaningful for future researchers and web-developers. The questionnaire can be used to understand of websites quality and how well websites work.**

Keywords—Usability testing; survey; questionnaire; higher education websites; guidelines webcredible; operating system

I. INTRODUCTION

A. Human Computer Interaction

Now-a-days Information Technology has reached at advanced level in every field. Human–Computer Interaction (HCI) is also one of them, which shows the communication between peoples and computers in [1]. Usability is also part of the HCI in which user define their issues related to the computer applications in [2, 3]. Design of the websites (Information Design, Navigation Design, and Visual Design), preferences, colour of the web and many other functions were checked in usability of websites in [4, 5, 6].

B. Websites

Websites access is increasing day by day and now mostly peoples are using web to collect all kind of information such: as job advertisements, academic admissions, buy or sell products, read newspaper and so on. Author in [7] based on his research finding states that most of the users were diverse, websites were not organized in proper way according to user mentality and their wish. Users want easy and appropriate response from web sites they use for their purpose. Many design rules are available in literature to increase the usability on different domain. Authors in [8] worked on the educational websites and designed survey for the measurement of satisfaction of college websites users. Authors found 89.4% satisfaction ratio of the user team and they strongly agree on the college websites in [9].

C. Usability

Usability is a technique used to identify about the idea of users regarding websites by applying usability technique website how to work and find out errors where were occur in websites. Fig. 1 show the usability components and seven usability components which are following.

1) Navigation
2) Familiarity
3) Consistency
4) Error Prevention
5) Feedback
6) Visual Clarity
7) Flexibility and Efficiency

D. Usability Guidelines

Usability and accessibility of university website of Malaysia and used automatic evaluation by using WCAG 1.0 guidelines provide five steps to conducted research as under below in [9].

- One step is called by: Themes of accessible of design.
- Second step is called by: How the things are organized.
- Third step is called by: Check Priority Level.
- Fourth step is called by: Conformance of the documents.
- Fifth step is called by: Web contents Accessibility guidelines. The guidelines available are 14 present to access web contents which are:
  - Visual Contents on websites.
  - Don not rely on colour.
  - Use mark-up and style sheets.
  - Clarify the language usage.
  - Create tables that transform gracefully.
  - Support multiplatform or Ensure that pages featuring new technologies transform gracefully.
  - Ensure user control of time-sensitive content changes.
  - Direct accessibility of embedded user interfaces.
  - Design for device-independence.

- Use interim solutions.
- Follow the W3C guidelines.
- Provide informative Context.
- Provide clear navigate mechanism.
- Documents should be clear and simple.

There are many methods available for the usability testing such as novel cross-sequential method, cross-sectional method, longitudinal method, Retrospective method and Nielsen heuristics method [10] as shown in Fig. 2. Nielsen heuristics method is one of the appropriate methods for post-survey techniques in [11-14], before the post-survey, it is important to use pre-survey method for the testing usability of websites. From this type of survey issues related to the websites and users are identified, accordingly, these issues may be addressed in search, navigation and information required to the users in [6, 15].

Interaction of humans with computer is increased day by day. Due to increase of attention on computers by the majority of peoples (students) using search or getting information regarding education, jobs and news updates from educational websites, but they face many issues and problem. Survey is the best method to identify the issues/problems of computer users.

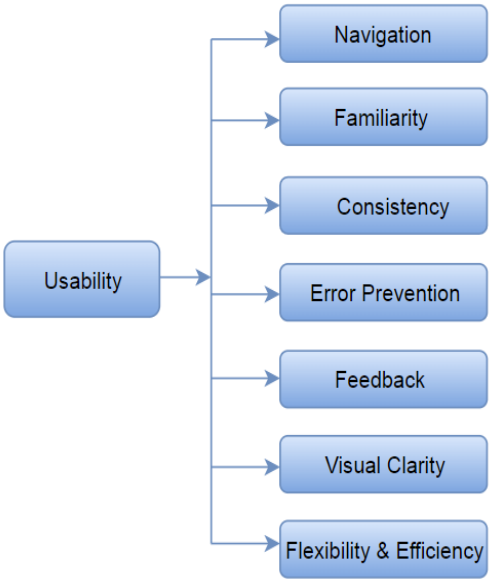


Fig. 1. Usability Snapshot.

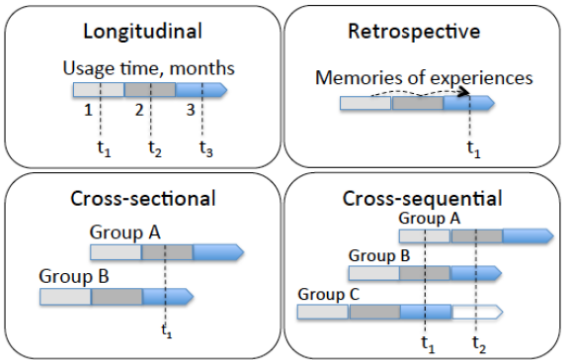


Fig. 2. Survey Methods for Measuring usability [10].

II. Usability Testing by using Survey Method

Internet is the source in which usability testing is evaluated and find out all the parameters of usability [14]. The process of usability testing of engineering university websites of Sindh-Pakistan is shown in Fig. 3. In this figure process of collection of data, based on the selected websites of engineering universities as described in Table I is given. These four universities are the top ranked government universities of Sindh province in and Pakistan. Majority of engineering students' are studies in these universities. These engineering students and job seekers are using these websites on daily basis to check universities information and news, advertisements for jobs, admissions, results and other purposes.

In this study, experimental survey was carried out in two phases, one is pre-survey and other is post-survey. Pre-survey gives information of respondents (detailed information of respondents is shown in Table III). The same is used in post-survey. Following are the Pre-survey questionnaires was designed [6, 16] and details of these questionnaires are given in Table II.

1) What is your gender?
2) How old are you?
3) What is your nationality?

Eighty numbers of respondents were selected for this of survey. All respondents were of age group between 18 years to 25 years. All eighty respondents were the students of 3rd years in Bachelor of Science (Information Technology). Out of eighty respondents, 18 respondents were females and others were the male students. All respondents have same nationality (Pakistani) and belong to province of Sindh.

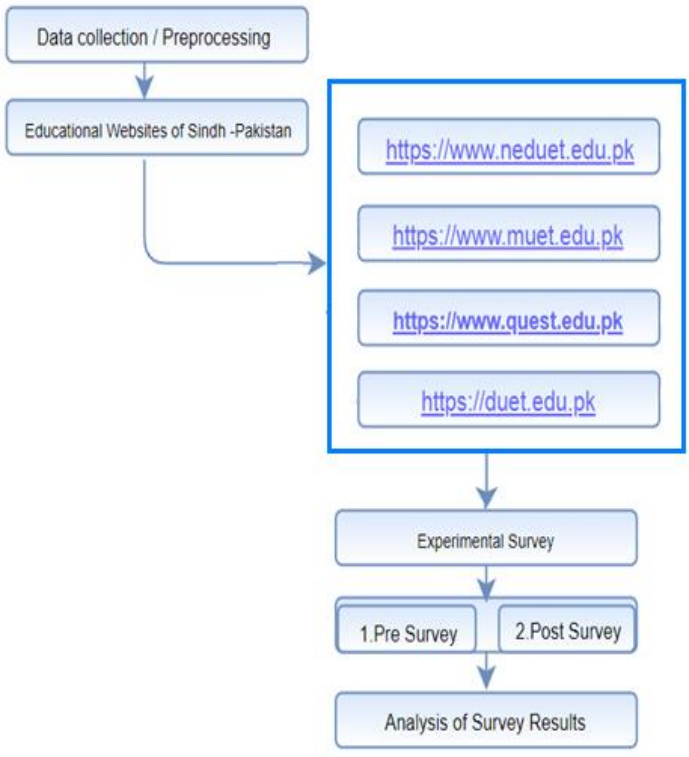


Fig. 3. Research Methodology.

TABLE. I. EDUCATIONAL WEBSITES OF ENGINEERING UNIVERSITIES OF SINDH

S. No	Name of University	University Websites
1	NED University of Engineering & Technology, Karachi	https://www.neduet.edu.pk
2	Mehran University of Engineering and Technology Jamshoro.	https://www.muet.edu.pk
3	Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah.	https://www.quest.edu.pk
4	Dawood University of Engineering & Technology Karachi.	https://duet.edu.pk

TABLE. II. PRE-SURVEY-QUESTIONS

Questions	Male	Female	Nationality	Respondents
What is your gender?	62	18	Pakistani	80
How old are you?	Between (18-25)	Between (18-25)	Pakistani	80
What is your Nationality?	62	18	Pakistani	80

TABLE. III. RESPONDENTS DETAILS OF AGE GROUP 18-25 YEARS

S.N.	Respondents Name	Study Year	Gender	S. No.	Respondents Name	Study Year	Gender
1	Anjum	3rd year	Female	41	Muneer Ahmed	3rd year	Male
2	Nida Sehar	3rd year	Female	42	Saeed Ahmed	3rd year	Male
3	Farzana	3rd year	Female	43	Adnan Eijaz	3rd year	Male
4	Chandini	3rd year	Female	44	Muhammad Awais	3rd year	Male
5	Laila	3rd year	Female	45	Mohammad Yousif	3rd year	Male
6	Aneela	3rd year	Female	46	Ubaid	3rd year	Male
7	Aisha	3rd year	Female	47	Nisar Ali	3rd year	Male
8	Ameena	3rd year	Female	48	Ashraf	3rd year	Male
9	Poonam	3rd year	Female	49	Muhammad Suleman	3rd year	Male
10	Dua Noor	3rd year	Female	50	Kashif Ali	3rd year	Male
11	Ilham khan	3rd year	Female	51	M.Farman	3rd year	Male
12	Humaira	3rd year	Female	52	Sajjad Hussain	3rd year	Male
13	Iqra	3rd year	Female	53	Muhammad Aamir Noor	3rd year	Male
14	Maheen	3rd year	Female	54	Haseeb Aziz	3rd year	Male
15	Nimra	3rd year	Female	55	Bilal Khan	3rd year	Male
16	Erum Muneer	3rd year	Female	56	Muhammad Zeeshan	3rd year	Male
17	Syeda Fizza	3rd year	Female	57	Manthar Ali	3rd year	Male
18	Nigarish	3rd year	Female	58	Abdul Nabi	3rd year	Male
19	Baqir Ali	3rd year	Male	59	Jazib Bilal	3rd year	Male
20	Allah Warayo	3rd year	Male	60	Abdul Samad	3rd year	Male
21	Muhammad Baig	3rd year	Male	61	Shahbaz Qureshi	3rd year	Male
22	Saifullah	3rd year	Male	62	Muhammad Awais Noori	3rd year	Male
23	Noshad Ali	3rd year	Male	63	M.Rajab Ali	3rd year	Male
24	Vinod Kumar	3rd year	Male	64	Abdul Hafeez	3rd year	Male
25	Muhammad Muneeb	3rd year	Male	65	Muhammad Adeel	3rd year	Male
26	Naseer Ahmed	3rd year	Male	66	Usama Jabbar	3rd year	Male
27	Saifullah Unar	3rd year	Male	67	Zubair Akram	3rd year	Male
28	Abdul Sallam	3rd year	Male	68	Sadam Hussain	3rd year	Male
29	Shakeeb Nasir	3rd year	Male	69	Sajjad Ali	3rd year	Male
30	Shahzaib	3rd year	Male	70	Anil	3rd year	Male
31	Zafar Ali	3rd year	Male	71	Awais Kareem	3rd year	Male
32	Muhammad Anwar	3rd year	Male	72	Farhan Brohi	3rd year	Male
33	Danish	3rd year	Male	73	Zubair	3rd year	Male
34	Mohammad Waqqar	3rd year	Male	74	Mehran	3rd year	Male
35	Tanveer Hussain	3rd year	Male	75	Abid Ali	3rd year	Male
36	Bilal	3rd year	Male	76	Ali Haider	3rd year	Male
37	Taimoor Ahmed	3rd year	Male	77	Bilal	3rd year	Male
38	Hassan Zaib	3rd year	Male	78	Saeed Rasool	3rd year	Male
39	Hamza	3rd year	Male	79	Masood Ali	3rd year	Male
40	Mohammad	3rd year	Male	80	M.Faizan	3rd year	Male

TABLE. IV. POST-SURVEY-QUESTIONS

Questions	SA	A	UD	D	SD
The site was easy to Navigate?	44	28	6	2	Nil
This site answered my questions?	12	52	12	4	Nil
I would like to visit this site again?	12	28	36	4	Nil
I would like to recommend this site to my friend?	24	44	10	2	Nil
Are you satisfied from this site visit?	14	54	9	3	Nil
SA = Strongly Agree A = Agree UD = Un-decided D = Disagree SD = Strongly disagree					

In Post-survey, an experimental procedure for the finding the usability issues related to websites is adopted. In this research work navigation related information, recommendations and satisfactions were studied for the usability testing. From the selected respondents forty four respondents were strongly agreed for the easy navigation of the websites and twenty eight showed agreed with the navigation but few of them were not clear (undecided) for navigational capabilities as described in Table IV.

Websites of engineering universities of Sindh-Pakistan used in this experimental survey had sufficient information for the majority of the users and they agreed that they found their information/news from the web but many of the respondents were undecided and were of the opinion that they would not like to visit again for information/news they require. Those who they showed satisfaction also stated that they will recommend these websites to their friends for useful information available and also majority of the respondents were satisfied from these websites.

Design methodology was divided in to four parts as shown in Fig. 2. First of all it was necessary to collect/select the data and then comes 2nd part of the methodology which also known as boundary lines of the research. After the deciding of boundary lines or limitation then it comes in 3rd round which is experimental survey and this survey was analysed in different ways.

III. RESULTS AND DISCUSSIONS

Post-survey is a technique used for the testing of usability of websites. In this study this technique was used for testing usability of websites of engineering universities of Sindh-Pakistan. Four university websites were selected. From the survey it was observed that many respondents strongly agreed as shown in Fig. 4(a-e).

In Fig. 5 comparison of post survey questionnaires are presented. In this comparison majority of respondent were agreed to visit these site again, but they highlight the problem of navigation and they need to improve this issue and also related feathers.

From the experimental study most of the frequent issues were addressed by respondent by using usability testing techniques for websites of engineering universities. Almost all the websites had issues like size, font, and animation as described in Table V. Majority of websites did not update on daily basis and information/news regarding users was not enough. Website of NED University of Engineering & Technology, Karachi lacks back to home page option directly from deep navigated pages. Also same issue in Website of Mehran University of Engineering and Technology Jamshoro was observed.

TABLE. V. MOST FREQUENT USABILITY ISSUES

Engineering University	Most frequent usability Issues
NED University of Engineering & Technology, Karachi	• Not available home page option in links of different pages. • Font size, style and colors issue. • Animation problem. • Improperly managed information/news. • Information regarding previous, current and future projects of the study programs was not updated.
Mehran University of Engineering and Technology Jamshoro	• Quick Search option was not working properly and takes more time for searching. • Improper management information/news. • Animations on main page were very high for all news and it may increase mental stresses. • Information regarding previous, current and future projects of the study programs was not updated.
Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah	• Current information/news was not updated. • Information regarding previous, current and future projects of the study programs was not updated.
Dawood University of Engineering & Technology Karachi	• Improve layout of the Site. • Font size, style and colors issue. • Information regarding previous, current and future projects of the study programs was not updated.

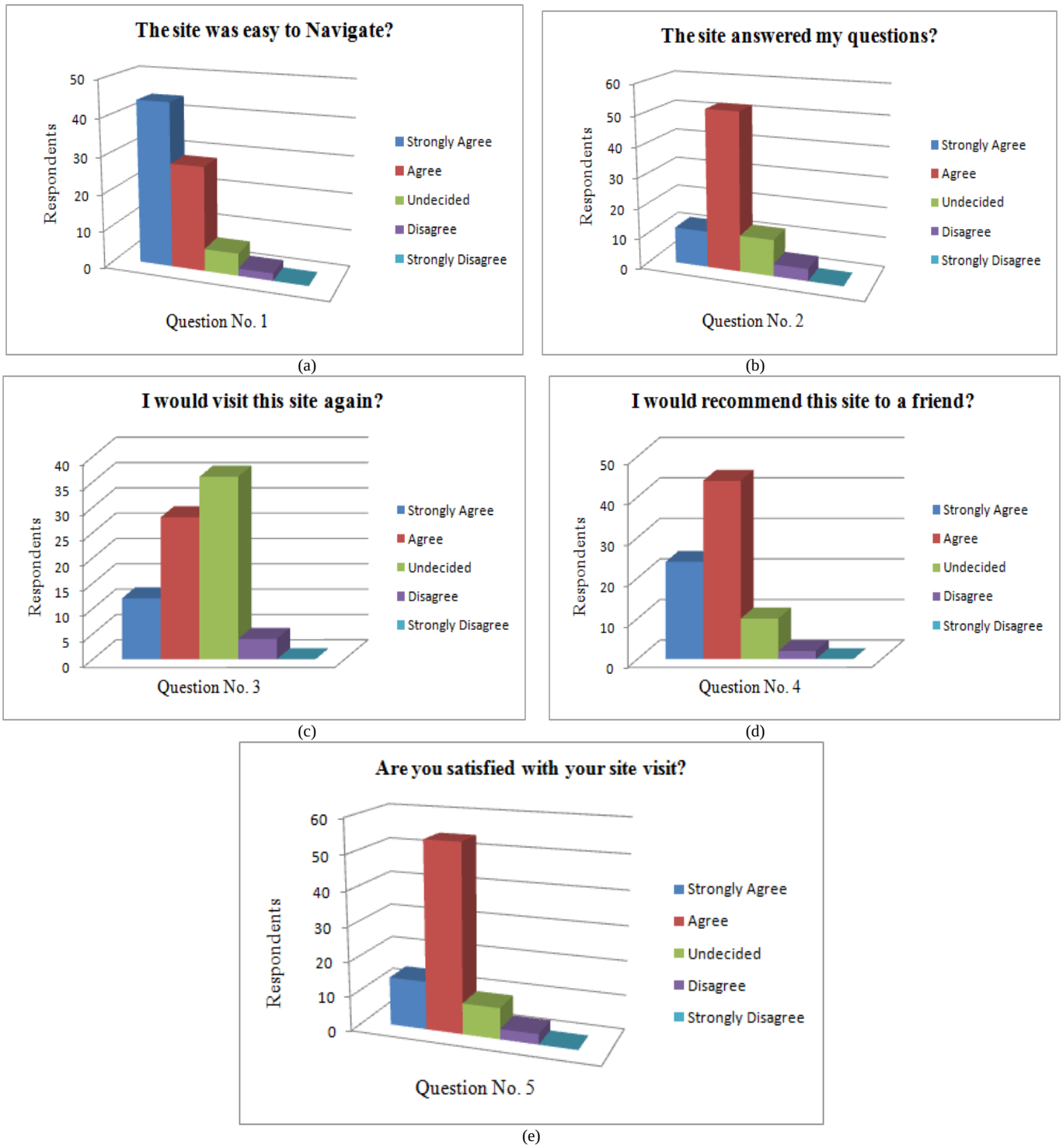


Fig. 4. Graphical Representation of Post-Survey Questionnaires (a) to (e).

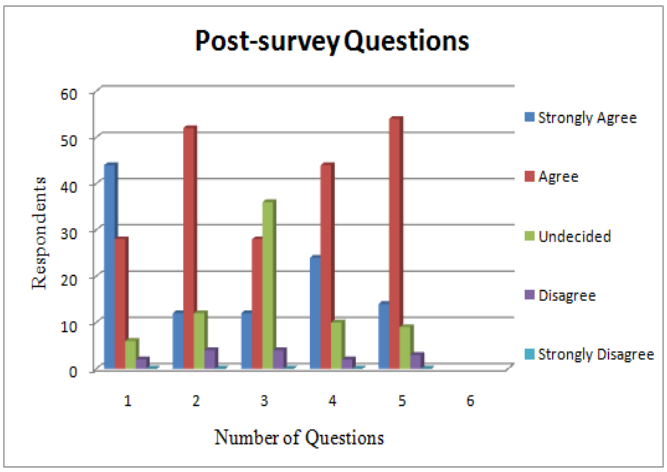


Fig. 5. Comparison of Post-Survey Questionnaires.

IV. Conclusion

The results suggest that the Nielsen heuristics method is useful in identifying the issues related to the usability of educational websites. This study gives an idea about the usability issues at different levels of website. Websites gives information/news related to users but these websites have many issues like; proper update on daily basis, page layout, font size and style, colours and lots of links available on sites. It is also observed that Information regarding previous, current and future projects of the study programs was not updated. Quick Search option was not working properly and takes more time for searching and improper management information/news. This research provides issues in educational websites which are mostly used by the students. University should take follow this type of survey results and improve their websites for above survey results.

V. Future Work

In future researchers paid more attention to the usability of websites in different domains.

References

[1] C. Dianne, H. Milena, and H. Larios, "Colour appeal in website design within and across cultures: A multi-method evaluation," International journal of human-computer studies, Vol. 68, No. 1-2, pp. 1-21, 2010.

[2] Nawaz, Ather, and T. Clemmensen, "Website usability in Asia "from within": an overview of a decade of literature," International Journal of Human-Computer Interaction Vol. 29, No. 4, pp. 256-273, 2013.

[3] C. Dianne, "Website design, trust and culture: An eight country investigation,"Electronic Commerce Research and Applications, Vol. 12, No. 6, pp. 373-385, 2013.

[4] Lazar, Jonathan, J. H. Feng, and H. Hochheiser, "Research methods in human-computer interaction," Morgan Kaufmann, 2017.

[5] Interaction Design Foundation, https://www.interaction- design.org/ literature/article /an-introduction-to-usability.

[6] I. Oakley-Girvan, J. M. Lavista, Y. Miller, S. Davis, A. Carlos, J. Hancock, and L. M. Nelson, "Evaluation of a Mobile Device Survey System for Behavioral Risk Factors (SHAPE): App Development and Usability Study," JMIR formative research, Vol. 3, No. 1, 2019.

[7] S. Nizamani, K. Khoumbati, S. Nizamani, S. Memon, and S. Nizamani, "Usability evaluation of the top 10 Universities of Pakistan through Guideline Scoring," Sindh University Research Journal-SURJ (Science Series), Vol. 51, No. 01, pp.151-158, 2019.

[8] S. Christoun, H. Aubin, C. Hannon, R. Wolk, "Web site usability in higher education," Director. 2006:07. Dec. 2010.

[9] Saeed, Saqib, and A. Amjad, "Understanding usability issues of Pakistani university websites," Life Science Journal, Vol:10, No. 6, pp. 479-482, 2013.

[10] Kujala, Sari, T. Miron-Shatz, and J. J. Jokinen, "The Cross-Sequential Approach: A Short-Term Method for Studying Long-Term User Experience," Journal of Usability Studies, Vol. 14, No. 2, 2019.

[11] Super User Friendly "Usability Testing Survey Template" https://sites.google.com/site/superuserfriendly/templates/usability-testing-survey-template.

[12] Ashraf, Mahmood, L. Khan, M. Tahir, A. Alghamdi, M. Alqarni, T. Sabbah, and M. Khan, "A study on usability awareness in local IT industry," Int. J. Adv. Comput. Sci. Appl, Vol. 9, pp. 427-432, 2018.

[13] Bhatt, Siddharth, A. Agrali, K. McCarthy, R. Suri, and H. Ayaz, "Web Usability Testing With Concurrent fNIRS and Eye Tracking," In Neuroergonomics, pp. 181-186, 2019.

[14] Rzeszewski, Michal, and J. Kotus, "Usability and usefulness of internet mapping platforms in participatory spatial planning," Applied geography, Vol. 103, pp. 56-69, 2019.

[15] Daniel, A. Olujimi, A. Oludele, R. Baguma, and T. Weide, "Cultural issues and their relevance in designing usable websites." (2011).

[16] Root, W. Robert, and S. Draper, "Questionnaires as a software evaluation tool," In Proceedings of the SIGCHI conference on Human Factors in Computing Systems, pp. 83-87. ACM, 1983.

A Built-in Criteria Analysis for Best IT Governance Framework

HAMZANE Ibrahim[1], Belangour Abdessamad[2]
Ben M'sik Faculty of Science, Hassan 2 University
Casablanca, Morocco

***Abstract*—The implementation of IT governance is important to lead and evolve the information system in agreement with stakeholders. This requirement is seriously amplified at the time of the digital area considering all the new technologies that have been launched recently (Big DATA, Artificial Intelligence, Machine Learning, Deep learning, etc.). Thus, without a good rudder, every company risks getting lost in a sea endless and unreachable goal. This paper aims to provide decision-making system that allows professionals to choose IT governance framework suitable to desired criteria and their importance based on a multi-criteria analysis method (WSM), we did implement a case study based on a Moroccan company. Moreover, we present a better understanding of IT Governance aspects such as standards and best practices. This paper goes into a global objective that aims to build an integrated generated meta-model for a better approach of IT Governance.**

***Keywords*—IT Governance; COBIT; ISO 38500; CMMI; ITIL; TOGAF; PMBOK; PRINCE 2; SCRUM**

I. Introduction

IT is a business asset that is gaining a lot of importance in the last decades in every industry especially regarding the spread of new technologies.

Following the statistics provided by the Club of Large French IT Companies (CIGREF) in 2017, 51% of companies rely on COBIT for the governance of their information systems (IT), while 16% use internal processes and 32% are not inspired by COBIT in the world [22]. Moroccan companies have to make a lot of effort regarding IT governance [20].

The goal of this paper is to provide the most complete IT governance approach based on existing models and complement this research with other best practices in several IT domains. In this paper, we will clarify the difference between several concepts similar to the definition of the standards. Then, we will carry out a comparative study between the different frameworks specifying their strengths and weaknesses then we will implement a decision system based on the analysis of a Moroccan company. Thus, companies can weigh the criteria and produce the choice of reference to adopt based on their own needs.

II. Standards vs Best Practices

Outside, when we focus on governance practices specifically in IT governance, we come across several sources (ITIL, CNIL, SOX, CMMI, ISO 9001, ISO 9002, ISO 14000, ISO 17799, ISO 27001, 27002, 27003, 27005...) each reference offer a partial view of IT Governance [10]. Thus, for better governance of this paper, we will first make a vocabulary distinction between theses references then we will define IT governance.

A. Standards

According to the International Organization for Standardization (ISO) and the International Electro-technical Commission (IEC): the standard is "a document established by consensus and approved by a recognized body, which provides, for common and repeated use, rules, guidelines or features, for activities or results that guarantee an optimal level of order in a given context." [1].

As consequence, standards are based on a tiered model can be recognized (certified or evaluated) by their own organization, it's a listing or a set of requirements to be fulfilled in order to claim the certification of the management systems of an organization, in a given management domain (services, information security, governance, etc.).

Find below some examples of standards:

- **ISO 38500**; Helps business leaders to ensure that the use of IT assets positively and contributes to the performance of the organization by meeting the requirements of ISO/IEC 38500, organizations are able to monitor the use of IT, ensure business continuity and sustainability, align IT assets to business needs and ensure proper implementation and operation of IT assets [16].
- **ISO 9001**; Standard that establishes the requirements for a quality management system. It helps businesses and organizations become more efficient and increase customer satisfaction [21].

B. Best Practices

Whereas best practices are a set of behaviors to adopt and adapt to effectively manage a given aspect of IT (governance, value and quality of services, projects, processes, application development, development architecture, etc.) that are considered essential by most professionals in the field, it can be found in the form of guides to good practice such as SCRUM or adopted by organization such as PRINCE 2 (organization), ITIL (organization) or COBIT (ISACA).

Best practices are generally based on 2 types of models:

- **Stepped models**; structured by maturity levels; For example CMMI, eSCM-CL

- "**Continuous**" or "**Cyclical**" **models**; structured by skill or phase domain; For example ITIL 2011, TOGAF 9.2, COBIT 5.

It should be noted that CMMI proposes both approaches. Below some definitions of most commune best practices used in IT services.

- **CMMI:** Capacity Maturity Model Integrated is a model for assessing the maturity level of a company in terms of IT developments [7]. Developed in 1987 by the Carnegie Mellon University Software Engineering Institute, CMMI is a model for the development and maintenance of computer systems and applications designed to capture, evaluate and improve the operations of engineering firms [3].
- **COBIT**: A framework for the development, implementation, supervision, improvement of the governance and administration practices of information systems. The COBIT framework is published by the IT Governance Institute and ISACA. Its purpose is to provide a common language for business leaders to discuss together their goals, objectives and results [16].
- **TOGAF**: The Open Group Architecture Framework is a set of concepts and an industry-standard covering the field of enterprise IT architectures [17].
- **ITIL**: Information Technology Infrastructure Library framework enables information technology (IT) to play a service delivery role rather than just specialized support [11], [12], [13], [14], and [15]. ITIL guidelines and best practices aim to adapt IT actions and budget to business needs and modify them as the company grows or changes direction. The goal is to improve efficiency and achieve predictable levels of service [9].
- **PMBOK**: Project Management Body Of Knowledge is a project management guide designed and produced by the PMI Project Management Institute. This fairly extensive guide aims to stabilize and structure the current knowledge needed to run a project in the best conditions [6]. It is a knowledge base on project management. It defines the fields of knowledge related to this field and describes the good practices to implement.
- **PRINCE 2**: PRojects IN Controlled Environment is a method developed by the British government and accredited by Axelos, based on best practices in project management. This flexible methodology applies to all companies and only for a defined scope project. “Built upon seven principles, themes and processes, PRINCE2 can be tailored to meet specific requirements” [19].
- **SCRUM**: An agile project management methodology, it is used particularly in software development. It’s “A framework within which people can address complex adaptive problems, while productively and creatively delivering products of the highest possible value.” [18].

III. IT Governance

Governance is the set of processes that tend to harmonize the world of business, projects, and experience [4].

According to CIGREF, governance is closely linked to the notion of company management.

IT governance [2]: "Organizational capacity exercised by the management committee, senior management and IS managers to oversee the formulation and implementation of the IS strategy".

The ITGI provides business executives and boards of directors with original research, online resources and case studies to help them meet their responsibilities in the area of IT governance.

It designed and authored COBIT V4.1, essentially as a teaching resource for information managers, general management, Information System management and control professionals [5].

Today, IT governance as defined by ITGI and ISACA boils down to the following five issues:

- IT Strategic Alignment
- IT Value Delivery
- IT Risk Management
- Performance Measurement
- IT Resource Management

According to the ISO, there are 6 guiding principles for corporate governance that apply to most organizations. The ISO specifies that each principle refers to what should exist, but does not describe how, when or by whom these principles are to be implemented. Nevertheless, decision-makers must demand that these principles be applied.

- Principle 1: Responsibility
- Principle 2: Strategy
- Principle 3: Acquisition
- Principle 4: Performance
- Principle 5: Compliance
- Principle 6: Ethics

IV. Comparative Study of IT Governance References

A. SWOT Analysis

Table I present a minimal SWOT analysis to summarize the strengths and weaknesses of the references:

TABLE. I. SWOT ANALYSIS MINIMAL

CMMI	
Positives	Improve the quality of the product delivered and the productivity of the project
	Increase customer satisfaction by better meeting its requirements
	Reduce costs and meet deadlines
	Give better visibility to management and enable better risk management
Negatives	The lack of precision.
	The level of maturity being global, it can mask areas of the organization that perform less well than others perform and hides gaps in certain process areas.
COBIT	
Positives	Meeting the needs of stakeholders
	Cover the entire company from end to end
	Application of a single Framework
	Provide a holistic approach to business decision-making
	Separating the governance from the management
Negatives	Difficulty of implementation
	Management guide not known in the framework
TOGAF	
Positives	A common language within the company
	Strength of the information system (as the growing complexity of IS)
	Maximize IT value
	Use a common framework to facilitate the search for skills
	Achieve a better quality of products
Negatives	Does not cover management processes
ISO 38500	
Positives	Assuring all stakeholders (including customers, shareholders, and employees) that if the standard is applied, they can trust the IT governance of their organization
	Informing and guiding leaders to steer the use of computers in their organization
	Providing a framework for an objective assessment of the company's IT governance
Negatives	Framework designed for top management.
	Does not cover support services, the build, and implementation services
ITIL	
Positives	Time-saving
	Cost reduction
	Defining more precise roles and responsibilities
	Better user satisfaction
	Better productivity/efficiency
	IT services of better quality
	Adaptation to customer needs to be facilitated
Negatives	Very little known to the general public
	There is very little information on the Internet
	Complex (you have to be expert as it concerns the network, system, application, BD and has a global vision of the IS)
PMBOK	
Positives	A guide to knowledge and good practice created by project management professionals who update it regularly.
	Standardize project management practices, which means that each department works in the same way.
CMMI	
	Find the same practices from one company to another.
Negatives	Respect all PMBOK processes to ensure the success of the project
	Adapt the methodology to the size and sector of the project
PRINCE 2	
Positives	Rational project management.
	The formalism makes it possible to define logic and a common vocabulary facilitating exchanges
	Continuous learning orientation
Negative	Systematic rationalization disguises the real subtleties of project management, in practice; project management is much more complex. The realities of the field, the human stakes, the immature technologies, the requirements of deadlines and budgets will not be solved by the obsession of the formalism
SCRUM	
Positives	Increase the fluidity of release and velocity of the team
	Easily master the risks and changes during delivery
	Encourage orientation, rigor, and energy in the teams
	Increase the capacity and quality of execution relative to customer requirements
	Substantially outperform the delivery of priority values that generate results faster
	Requires a united and motivated team
Negatives	Difficulty following the life cycle of a development
	Support needed by sponsors
	Essential adaptation phase (continuous changes)

B. Multi-Criteria Comparative Study

1) Multi-criteria analysis: After seeing the advantages and disadvantages of each framework, we will now develop a multi-criteria analysis between these frameworks. A Multi-Criteria Decision Analysis (MCDA) is a valuable tool that can be applied to many complex decisions. It can solve complex problems that Include qualitative and/or quantitative aspects in the decision- making process.

We aim to help the decision-makers by facilitating the choice of the best framework to be used according to desired criteria and their importance.

The score of a framework is calculated based on a number of criteria. So far we have identified ten criteria; Indeed, based on the set of principles of IT governance for the ITGI and ISO 38500, we have identified in almost complete governance pillar that will be the important criterias: IT Strategic Alignment, IT Value Delivery, IT Risk Management, IT Performance measurement, IT Acquisition, IT Resource Management, IT Responsibility, IT Compliance, IT Human Behavior and IT Control.

- **C1**: IT Strategic Alignment: An approach to align the information system strategy with the company's business strategy [8].
- **C2**: IT Value Delivery: Value creation refers to the financial purpose of companies for their IT. Value is created when investments are based on IT whose rate of return is higher than the costs that are made.

- **C3**: IT Risk Management: Operational and business risk related to IT domain, it is about setting up processes to manage IT risk.
- **C4**: IT Performance measurement: The implementation of KPIs to achieve the objectives. In addition to the indicators, it is also the right definition of the objectives to be put in place.
- **C5**: IT Acquisition: The management of the service providers and the external interventions makes it possible to carry out the objectives of the IT thus good piloting of the activity IT.
- **C6**: IT Resource Management: The main asset of the IT division is the human resources as well as the materials used, thus good management of the resources makes it possible to obtain good governance of the IT system.
- **C7**: IT Responsibility: The definition of roles and responsibility is a key factor of process success so it is a pillar to carry out the adopted processes.
- **C8**: IT Compliance: IT regulation has evolved a lot in the last decades, with user protection laws, a good benchmark allowing a good application of IT regulations will allow better governance.
- **C9**: IT Human Behavior: According to the CNIL, the respect of freedom is an important axis for good IT governance; several articles describe in detail this pillar.
- **C10**: IT Control: Set up a set of business processes / IT with KPIs to control the execution and performance of processes.

2) Multi-criteria analysis methods: There are several possible methods to make a comparison between the frameworks using many criterias. These methods can be divided into three main families.

- Complete aggregation (top-down approach): Aggregating the n criteria to reduce them to a single criterion.
- Partial aggregation (bottom-up approach): Comparing potential actions or rankings to each other, and establishing between them outranking relations.
- Local and iterative aggregation: Looking primarily for a starting solution, then, we proceed to an iterative search to find a better solution.

Table II shows the different existing multi-criteria methods sorted by family:

3) Weighted Sum Method (WSM): We chose the Weight Sum Method (WSM) to apply because this method allows us to find the best possible approach by assigning a weight to each comparison criterion, it allows to take into account all the criteria according to their value and without a criterion penalizing the other criteria.

TABLE. II. MULTI-CRITERIA ANALYSIS FAMILIES [17]

Family	Approach	Methods
Complete aggregation	top-down approach	Weighted Sum Method (WSM) TWO WAY ANOVA Weight Product Method (WPM) Analytic Hierachy Process (AHP) Multi Atribute Utility Theory (MAUT)
Partial aggregation	bottom-up approach	ELECTRE Prométhée Melchior Qualifex Oreste Regim …
Local and iterative aggregation	Local & iterative	Improving Cones Method (ICM) GOAL Programming STEM Branch and Bound

4) Comparison criteria and weight: We present in this section the ten comparison criteria cited on which the comparative study will be based, we notice that these criteria are based on the characteristics of each of the approaches presented in the comparative study and the SWOT analysis presented by the front, we summarized all the characteristics (strengths and weaknesses) in ten global criteria to ensure better analysis and optimize the comparison.

For us, these criteria have the same importance to us, there for the WSM weight accorded will be the same and equal to "1", however as we will see further in this paper the weigh of each criterion change depending on each companies, therefore we experience a case study on which we will expose the vision of a reel company weighs.

5) Multi-criteria choice matrix: The WSM method start with filling the multi-criteria choice matrix, it's matrix columns contain the frameworks to be compared and its lines contain criteria with the weight assigned to each criterion which we agree that it's "1" as all the criterions have the same importance, and in cells there is the score given to each framework based on the detailed comparative study of each framework [2] [3] [5].

About the score, we will then use the maturity model, which consists of five levels of maturity to weight the criterion on each framework, each level will give a score, for example, "level 1" will leave a score of "1".

We recall the definition of the five maturity levels by modifying the definitions, below the explanation of each level:

- **Level 1:** There is no formal method, nor coherence, nor standard, based on which the criteria would be constructed. The development process of the criteria is not described in the framework.
- **Level 2:** There is a consensus in the framework of how the criteria should be managed, but this has not been formalized or described.

- **Level 3:** The development process of the criteria is formalized, documented and applied. Reviews are conducted with compliance and the configurations are properly managed.
- **Level 4:** The reference has instituted a formal metric information collection process to track and manage the criteria development process as well as the resulting systems. Indicators monitor the smooth running of processes and the respect of the quality objectives of the criteria.
- **Level 5:** The reference uses measures to continuously optimize the criteria development process. It describes in detail a process of correcting the aspects that would be considered insufficient, by reading the indicators allowing manage the criteria.

Table III represents the resulting multi-criteria choice matrix according to the score of each criterion.

We convert the table into a spider chart for visual purposes; we notice that there is no complete reference; however, COBIT is the most completed according to the investigation, see Fig. 1.

6) Discussion: All the components of good governance are not applicable on all the reference systems, by analyzing the results, we find that CMMI covers 62% of the components of the IT governance whereas COBIT covers 65% of the foundations of a good governance, on the other hand PMBOK presents the least percentage of application with only a rate of 43% which is normal since it does not contain a methodology but it is a set of practice project in management grouped in a reference.

We will scan the components and dissect the key values of each of the components, indicating which repositories apply them best.

We found that COBIT and CMMI respond best to strategic alignment given their commitment to corporate values with a clear definition of the processes, so they allow a comprehensible vision by the management of what is done by the company. Due to the process approach and compliance, a clear attribution of ownership and responsibilities deal with the requirements for control of the IT environment.

Value creation is present in almost all repositories because it is the essence of the implementation of IT in the company whatever the chosen repository.

Risk management is an important component of IT governance; it allows identifying risks in a clear and structured way. With a clear knowledge of all the risks a company is exposed to, it can prioritize them and take the appropriate measures to reduce losses and reduce the total cost of risk, most of the standards are based at least on strategies of risk management according to the intervention layer, whether operational or organizational.

IT governance processes are evaluated, directed and controlled. Indicators are a monitoring mechanism helping the achievement of business and IT objectives.

TABLE. III. MULTI-CRITERIA CHOICE MATRIX

	CMMI	COBIT	TOGAF	ISO 38500	ITIL	PMBOK	PRINCE 2	SCRUM
C1	4	4	3	3	3	1	3	3
C2	3	4	4	4	4	3	3	3
C3	3	4	4	2	3	5	5	4
C4	4	5	3	4	3	4	4	4
C5	1	2	2	1	1	1	1	1
C6	1	1	2	1	2	4	2	2
C7	4	3	1	3	1	1	1	1
C8	3	2	2	1	1	1	1	1
C9	3	3	3	3	3	2	2	2
C10	4	4	2	2	3	1	5	1

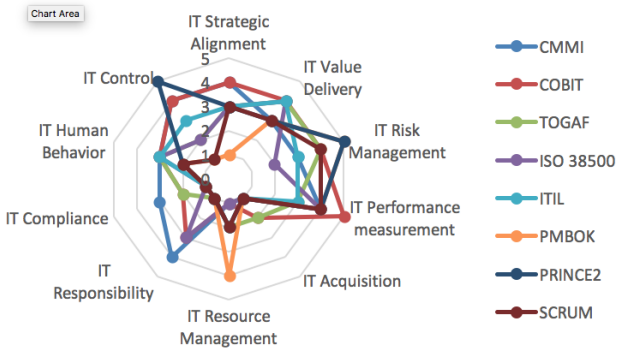


Fig. 1. Spider Chart Multi-Criteria Decision.

As a result, there is no complete repository of IT governance, however, the most complete reference is COBIT given the positions it takes on each of the components.

V. CASE STUDY

We consulted the company USA HOME, a company specialized in cameras installation, maintenance of pointing software, and office installation. Given the competition in the Moroccan market, the Chief Executive Officer (CEO) wants to optimize its IT resources and apply IT Governance to its IT department.

The study explained above lead us to build an application form to get the interests of the company on every criterion, below the result given by the CEO of USA HOME (Fig. 2).

Following the input of the CEO, the Multi-Criteria Choice Matrix has changed through the formula (1) below:

$$(5 * a * P) / S = P' \quad (1)$$

P' New score following the preferences of the company

P Initial score produced

a Weight according to the company

S Sum of weights regarding all the criterions

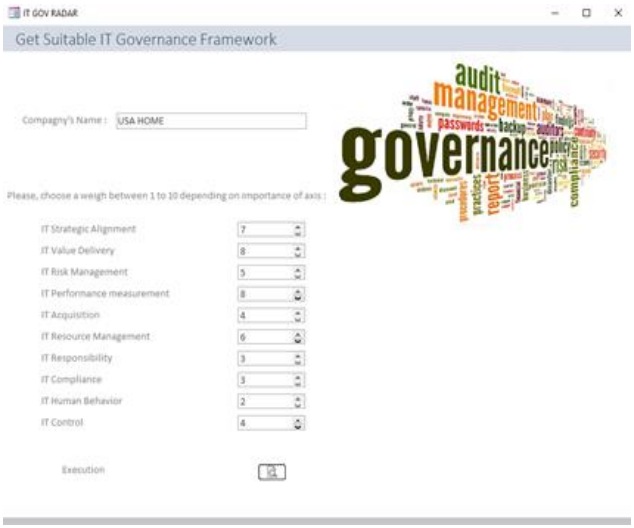


Fig. 2. The Application form that was Given to the Company USA HOME.

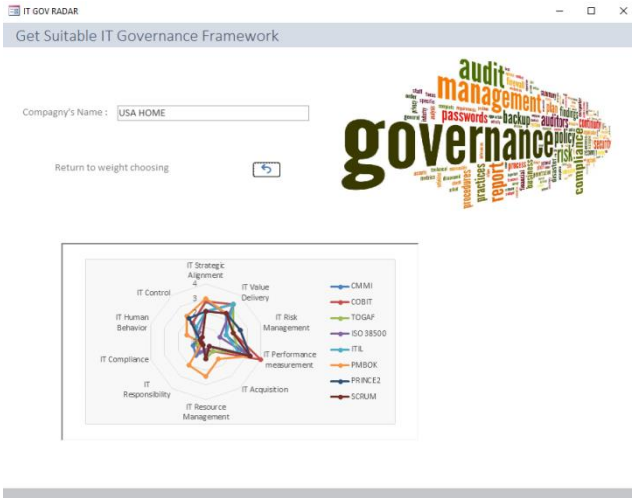


Fig. 3. Spider Chart Multi-Criteria Decision of USA HOME.

As a result, Spider chart Multi-Criteria Decision has changed according to the company's need (Fig. 3).

According to the Multi-Criteria Decision form, PMBOK will be a good reference based on the company USA HOME requirements. It will allow the company to enhance the potential of creativity, ensuring the realization and coordination of project actors and available resources according to the defined plan, it's also an effective way for a company very concerned by the projects.

VI. Conclusion and Future Work

IT assets have become directly linked to the results of the business; as the launch of new technologies and the digitalization of companies in all domains. Thus, the implementation of IT governance is important to lead and evolve the information system in agreement with stakeholders.

The choice of an IT governance framework is very important task before the implementation, a good choice will lead to a better result, this article has enabled us to implement a decision system according to the company needs; also, to understand the IT governance framework regarding their advantages and disadvantages.

We have seen that all frameworks have many challenges especially in covering all business areas and the difficulty of implementation. As future work, we will present solutions for these issues. This work gives a contribution for professionals to help them choose between different existing framework, and this according to their needs and criteria that matter most to them, as we have seen in the case study.

References

[1] Alexandre Steigmeier, Rolf Hauri, Gouvernance de la sécurité: comment articuler les différentes normes et méthodes, Novembre 2009.

[2] The National Computing Center, developing a successful governance startegy, Novembre 2005.

[3] Jarke, M. Mylopoulos,J. Schmidt,andVassilou Y. DAIDA, Conceptual Model-ing and Knowledge Based Suppor of Information Systems Development Process. Technique et Science Informatiques, 1990,122-133.

[4] Jean-François CARPENTIER, La gouvernance du Système d'Information dans les PME : Pratiques et évolutions, Editions ENI, Mars 2017.

[5] Bruno Ménard, CobiT : Pour une meilleure gouvernance des systèmes d'information, Eyrolles, janvier 2009.

[6] Frédéric Georgel, IT Gouvernance: Maîtrise d'un système d'information, Dunod, Mai 2005.

[7] Richard Basque, CMMI 1.3-Guide complet de CMMI-DEV et traduction de toutes les pratiques CMMI-ACQ et CMMI-SVC, Dunod, Mai 2011.

[8] Gmati, I., Nurcan, S., Gmati, I., &Nurcan, S. Un cadre de référence pour analyser les exigences d'alignement métier / système d'information, 2012.

[9] Abbadi, S. S.-M.-L..Proposition de méthode d'implémentation d'ITIL. 2eme édition du congre International de génie Industriel et Management des systèmes, 2015, Mai 21, pp. 5,6.

[10] Rolland, C.. A Comprehensive View of Process Engineering, 2012, 1–24.

[11] Commerce, O. o. ITIL 2011 Amélioration continue des services. stationery office, 2011.

[12] Commerce, O. o. ITIL 2011 Conception des services, stationery office. stationery office, 2011.

[13] Commerce, O. o. ITIL 2011 Exploitation des services. stationery office, 2011.

[14] Commerce, O. o. ITIL 2011 Stratégie des services. stationery office, 2011.

[15] Commerce, O. o.ITIL 2011 Transition des services. stationery office, 2011.

[16] Martine Otter, J. S. Guide des certifications SI. Dunod, 2009.

[17] Z. Ibn Batouta, Multi-criteria analysis and advanced comparative study between automatic generation approaches in software engineering, 2015. Vol.81. No.3.

[18] Ken Schwaber, Jeff Sutherland, "The Definitive Guide to Scrum: The Roles of the Game", 2017 Edition, available at www.scrum.org.

[19] AXELOS, "Managing Successful Projects with PRINCE2", 2017 Edition.

[20] H. Askari, H.Mohammad khan, L. Mydin, "Reformation and Development in the Muslim World: Islamicity Indices as Benchmark", Springer 2017 Edition.

[21] R. Tricker, "ISO 9001:2015 for Small Businesses", 2016 Edition.

[22] CIGREF, "Les référentiels de la DSI", 2009 Cigref Edition.

Achieving High Privacy Protection in Location-based Recommendation Systems

Tahani Alnazzawi[1], Reem Alotaibi[2], Nermin Hamza[3]
Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah, Saudi Arabia[1, 2, 3]
Faculties of Graduate Studies for Statistical Research, Cairo University, Cairo, Egypt[3]

***Abstract*—In recent years, privacy has become great attention in the research community. In Location-based Recommendation Systems (LbRSs), the user is constrained to build queries depend on his actual position to search for the closest points of interest (POIs). An external attacker can analyze the sent queries or track the actual position of the LbRS user to reveal his\her personal information. Consequently, ensuring high privacy protection (which is including location privacy and query privacy) is a fundamental thing. In this paper, we propose a model that guarantees high privacy protection for LbRS users. The model is work by three components: The first component (selector) uses a new location privacy protection approach, namely, the smart dummy selection (SDS) approach. The SDS approach generates a strong dummy position that has high resistance versus a semantic position attack. The second component (encryptor) uses an encryption-based approach that guarantees a high level of query privacy versus a sampling query attack. The last component (constructor) constructs the protected query that is sent to the LbRS server. Our proposed model is supported by a checkpoint technique to ensure a high availability quality attribute. Our proposed model yields competitive results compared to similar models under various privacy and performance metrics.**

Keywords*—Recommender models; attacker; privacy protection; dummy; encryption; checkpoint

I. Introduction

The expression data mining indicates to software tools and mathematical modeling techniques which are applied to detection patterns in data and used to build models [1]. In this concept of recommended applications, the expression data mining is used to describe the set of analysis techniques applied to deduce the rules of recommendation or construct recommendation models from large data groups. Recommender models that integrate data mining techniques build their recommendations based on the knowledge learned from the user's actions and attributes [2].

Fundamentally, recommender systems were categorized into three major types, including Collaborative Filtering (CF), Content-Based (CB) and Hybrid [3]. Later on, combining these based recommender types; novel recommender system types were introduced where location-aware systems are becoming more widespread due to massive usage of smart devices.

In Location-based Recommender Systems (LbRSs), the user requires recommendations for his/her Points of Interest (POIs). To make productive of the required functionality of a recommender system, personal information, along with the current position, is exposed. Fig. 1 shows the traditional way of using LbRSs.

However, disclosing the user's profile, mainly the information of the location, disclose various aspects of one's personal life, which raises many privacy issues because an attacker can deduce sensitive user data by tracing the actual position of the user, such as his/her habits, customs, or religious and political leanings. Therefore, a trade-off exists among recommender systems services usefulness and the privacy of the user.

Research questions: From a privacy perspective, user-based approaches are preferred over server-based approaches because the user has full control in protecting privacy. Based on the description that is presented above, four research questions must be answered in user-based approaches. They are as follows:

1) How we can we select strong dummy locations to achieve high privacy?

2) How can guarantee robustness versus semantic location attack?

3) How can robustness versus sampling query attack be guaranteed to guarantee the privacy of user queries?

4) How can the availability quality attribute be ensured at the user side?

Motivation: The researchers responded to this threat by proposing many privacy protections approaches. Some of them belong to the server-based category and others belong to the user-based category [4, 5]. Many techniques are provided under the server-based category, such as anonymization [6, 7], mix zones [8, 9], and obfuscation [10, 11]. However, the main drawback of the techniques in the server-based category is that the LbRS server itself can be an attacker. Hence, all the LbRS user information and activities are revealed to and attainable by the attacker. This large security gap changed the minds of the researchers, who moved towards the user-based category. In the user-based category, coordinate transform [12], space twist [13], cryptography [14, 15], and dummy [16, 17, 18, 19, 20, 21] techniques are used. In the latter, generating weak dummies enables the attacker to apply advanced inference attacks successfully (position homogeneity attack [22, 23], sampling query attack [24, 25, 26], and semantic position attack [27, 28]). The semantic position attack is considered the most advanced and dangerous among these attacks because the attacker exploits both the semantic meaning of the position and the duration for which the user remains at the position to

deduce personal information about the LbRS user. Therefore, a robust approach versus the semantic position attack is a top requirement. Moreover, in addition to the need to generate strong dummies, disconnection problems may occur any time for any reason, thereby forcing the LbRS user to regenerate the dummies from the beginning, which consumes the power of the LbRS user mobile phones. Dummy generation and short battery lifetime of the mobile device are considered the most important issues in the dummy-based privacy protection approaches.

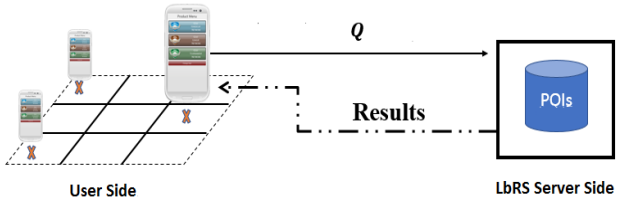


Fig. 1. The Traditional Way of using LbRSs.

To generate strong dummies, ensuring robustness against semantic location attacks, we can select dummy locations that are farthest from the true location of the LbRS user and farthest from each other. To solve the disconnecting problem and ensuring the availability quality attribute, we can use the checkpoint technique to save the last process performed before disconnecting problem happened. Generally, the paper has many contributions they are:

- We propose a new dummy-based privacy protection technique called: The Smart Dummy Selection (SDS) approach. The SDS approach protects the location privacy of the LbRS user by surrounding the actual location by dummy locations.
- To ensure robustness versus semantic location attack, the SDS approach selects the dummy locations such that they are distributed from one another, which weakens attacker ability to know the actual location of the LbRS user between the dummy (fake) locations.
- We strengthen the SDS approach by proposing an encryption-based approach.
- The proposed model is supported through a checkpoint technique for ensuring the availability quality attribute.

The remainder of the paper is arranged as follows: Section II reviews some related works. Section III provides our proposed approach. Security analysis of the proposed approaches is studied in Section IV. Section V shows the results of the experiments and the evaluations in Section VI. Finally, we write the conclusion of the paper to finish it in Section VII.

II. Related Work

Actually, the privacy protection approaches are classified into two main categories and each category has its own techniques, as shown in Fig. 2.

As shown in Fig. 2 above, many techniques are used to protect privacy. Here, we explore the techniques associated with each category.

A. Server-Based Approaches

The recognized feature of this category is that the privacy protection approaches are installed and executed in the LbRS server side. Therefore, the LbRS server is trusted and the privacy can be targeted by an external attacker.

According to [6], k-anonymity provides ensure from multiple k number of users, the concerned user is indistinguishable from k set of users. However, the probability of recognizing a targeted user is 1/k. The problem in this approach was that the user could easily approach to POI through anonymous data. Moreover, k-anonymity approach usually requires the location service as a TTP (trusted third party), which is knowing as exactly location, and work as an anonymizer. In their work [7], the authors provided a personalized K-anonymity approach, where LbRS server works as an anonymizer. This algorithm can be adapting to terms given from the user (i.e., to guarantee the privacy), such that a spatial-temporal mask is used on the location of the user, offering k-anonymity degree.

Likely, a Mix zone, another privacy-preserving approach, was proposed by Zuberi et al. [8]. In this approach, a number of zones are defined where multiple users are positioned in that mix zone. When any user is interest for any recommendation of his/her POI, instead of his/her original location, the whole zone is considered as his/her location for serving. Basically, it refers to a k-anonymization region in which users can change their pseudonyms such that the mapping between their old and new pseudonyms is not revealed. In a mix-zone, a set of k users enter in some order and change pseudonyms, but none leave before all users enter the mix-zone. Inside the mix-zone, the users do not report their locations and they exit the mix-zone in an order different from their order of arrival, thus, providing unlink-ability between their entering and exciting events. In such way, the attacker cannot identify the actual location of any particular user. Although a user's identity and spatial information are indistinguishable, extracting data from a number of zones is an overhead that sometimes causes inefficient results. The mix zone technique is developed by Memon et al. [9]. The core of the evolution concept is to give mix zones extra resistance versus the attackers. To finish this, the researchers considered different types of information which may be used to infer in detail paths such as temporal and geometrical constraints.

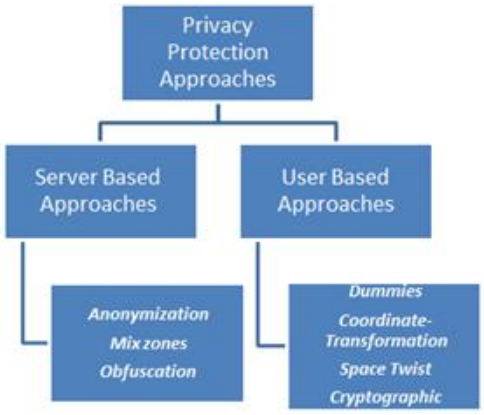


Fig. 2. Classification of privacy protection approaches.

Similarly, Obfuscation was introduced in [10], where reduced information of actual coordinate's location from an obfuscation area is sent to Location Service (LS) and return to the user in a similar way. The fundamental mechanism behind the obfuscation approach is that a query from the user is divided into a number of words where each word is considered as a distinct query. Now attach some dummy terms (anonymous data) along with each query. In response, the user makes the selection of the originally intended answer. Consequently, the precise user location is not shared with clients that maintain the privacy aspects. One problem with spatial obfuscation technique is that the adequate size of the intended obfuscation area can be reduced if an adversary applies background knowledge, last visit, map knowledge etc. in [11]. The obfuscation approach is improved to offer robustness versus semantic location attack.

B. User-Based Approaches

The recognized feature of this category is that the privacy protection approaches are installed and executed in the LbRS user side. Therefore, the LbRS server is untrusted. Even if the server is trusted, privacy can be targeted by an external attacker.

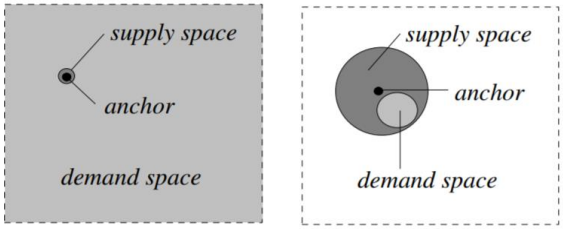
Coordinate transforms technique is presented in [12] to protect privacy. This technique depends on some mathematical operations performed on the coordinates of the true location of the user. The results ensure that the true location of the user will be in another place, which completely differs from the original one.

SpaceTwist was introduced by [13], where the user represents himself/herself as an anchor representative and sends his/her fake location instead of precise information. The further whole communication is based on this anchor location to get any POI as shown in Fig. 3 where supply space cantered at the anchor is the part of space already explored and demand space represents the space to be covered before the client is guaranteed to be able to produce an accurate result. Here the only user knows about these both spaces, but server knows only supply space. At the beginning (Fig. 3(a)), the demand space is set to the domain space, and the supply space is empty. As points are retrieved from the server, the supply space expands. When a retrieved point p is the closest point to the client seen so far, the results are updated, and the demand space shrinks. When the supply space eventually covers the demand space (Fig. 3(b)) it is termed final and the client is guaranteed to produce an accurate result.

Cryptography [14] is another way of protecting user privacy in location-based recommender system. Cryptography approach is based on encryption and decryption mechanism that provide strong privacy. From the user side, the data is firstly encrypted (with a private key depend on cryptography approach) using some algorithms and transferred over the network as shown in Fig. 4 below. The encrypted data is called 'Cyphertext'. On the other side, LS decrypts the data using the same key, which was used during the encryption. However, only LS knows this private key, which totally depends on TTP. Furthermore, as the devices are very smart and requiring results very efficiently, the encryption and decryption processes decrease the efficiency and sometimes cause some swear problems in real road networks.

The cryptography technique is developed by the authors of [15], where secret sharing idea is provided. The key idea is to share the information of the real location among some servers so that the attacker cannot obtain the real location unless collecting the all required information from all servers.

In [16], Yanagisawa et al. gives dummies concept to ensure the LBS user privacy. The conception was that the user generates a number of wrong locations (fake locations), constructing requests of the existing query using both the true location of the user and the dummies, and then submitting all the resulting queries to the LBS server that requesting for the similar POI. Mixing the true location with dummy locations, guarantee the user privacy preserving, where the LBS server cannot determine the true user location from a number of fake dummy locations. Similarly, [17] provides dummies to ensure LBS user privacy protection. It based on chosen the dummy by normalized distance to make the attacker confused and lower his capability to know or deduced important information related to the query generator. Another approach given dummies concept was displayed in [18] called DUMMY-Q, with the different way the dummies are applied to the query instead of the location. Therefore, hide the real query by generating various dummy queries with various features from the same location. To generate stronger dummies, two concepts are considered which is, first, the query form and second, the movement system. Hara et al. [19] improved a dummy algorithm, generate dummies depend on our reality. In this way, they considered the physical imperatives of this present reality. The feature which makes this approach different was that the paths of the fake locations cross the paths of the LBS user real motion. The authors of [20, 21] gave another concept to generate dummy locations, where they depend on selecting the cells that have the same area.



(a) The Beginning. (b) The Ending.

Fig. 3. Demand Space and Supply Space.

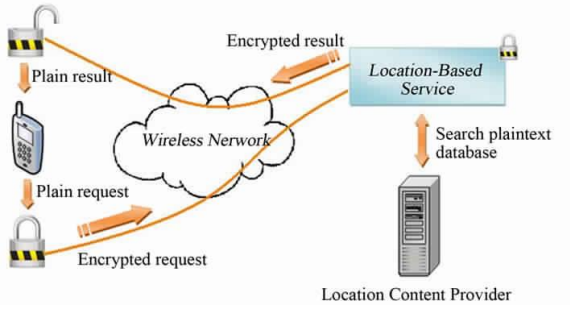


Fig. 4. Cryptography Scheme in LBS System.

III. The Proposed Model

In this section, we provide our idea that guarantees high LbRS users privacy protection. The threat model is presented in A and followed by the identical architecture of our proposed privacy protection model in B. Then, the task of every component located in the model architecture is provided in detail. Our proposed approaches represent the mission of each component. Finally, the architecture detail of the proposed model, which states the interaction among the components, is illustrated by a sequence diagram.

A. Threat Model

To display and identify the threat model, we define the attacker, his/her aim, the kind of the attack, and the skills of the attacker applied to get his aim.

For a given area (RE) split into $(n \times n)$ cells, and many of users (N_{user}) existing over the previous area. The user sends a query of form $Q^t(\langle ID\rangle, \langle Loc\rangle, \langle POI\rangle, \langle Range\rangle)$ to the LbRS server, where t: refers to the moment at which the query is submitted; ID: refers to the identity of the user; Loc: refers to the real position of the user; POI: refers to the queried point of interest; and Range: the range where the queried POI is located or (the search space).

After processing the sent query, the RLbS server returns the results. Since dealing with the LbRS server is inevitable, we consider that the LbRS server is trusted. An external attacker (i.e., a man in the middle) can eavesdrop the communication channel, as shown in Fig. 5.

In Fig. 5, the primary goal of the attacker is gathering personal information about the user to attack his/her privacy. This can be done by monitoring both the sent queries and the retrieved results. In this context, the kind of attack is passive, where the attacker benefits the gathering personal information to construct a malicious profile related to the victim (i.e., the LbRS user). Therefore, no alternation is performed on the sent query or the retrieved results. Specifically, Table I provides the attacker capabilities.

Because of the third capability, the attacker can deduce some user sensitive information based on the area where the user exists. In addition, the attacker can use the duration of time that the user spends in a specific location. Fig. 6 illustrates the way used by the attacker to apply the semantic location attack.

In Fig. 6, the region has three main places (Hospitals-Medical area, Sport clubs-athletic area, and Restaurants-Rest area). The user sends (m) queries $\{(Q_1^{t_1}), (Q_2^{t_2}), (Q_3^{t_3}), (Q_m^{t_m})\}$ to the LbRS server. If the user uses the locations marked by (×) symbols, the attacker can deduce that the user is a patient or an employee in a Hospital even if the user protected his privacy using dummy locations or coordinates transformation approaches. That is because all locations, including the real one, are belonging to the same place (i.e., Hospital or medical area). Moreover, if the attacker analyses the sent queries and discover that the user always asks about the hospitals, he/she will be sure that the user is patient definitely. Furthermore, the attacker can employ the time attached with the queries to estimate the duration that the user stays in this medical area to collect more sensitive information.

B. Our Proposed Model Architecture

The structure of the proposed system composed of trusted LbRS server and several mobile phones linked by a network. The model is work by three components ($selector_D$, $encryptor_{ID}$, and $constructor_Q$) as displayed in Fig. 7.

Table II shows the model components, determines the main job of every component and its installed place.

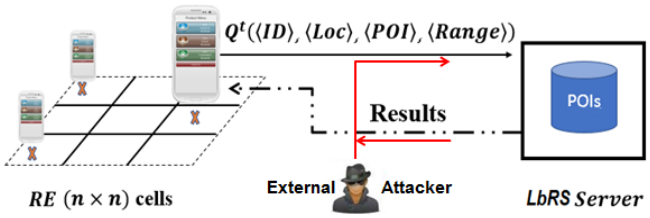


Fig. 5. The Classical Scenario of using LbRS with the Form of the Sent Query.

TABLE. I. The Attacker Capabilities

Capability	Illustration of the Capability
1	track the user location
2	analyze the submitted query after eavesdropping.
3	apply the semantic location attack.

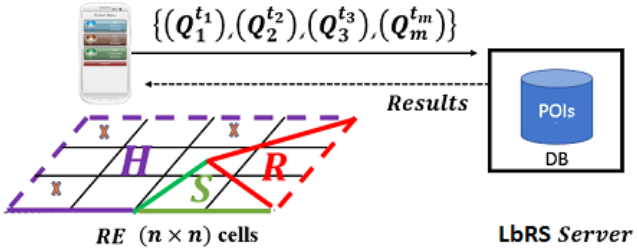


Fig. 6. The Concept of Semantic Location Attack.

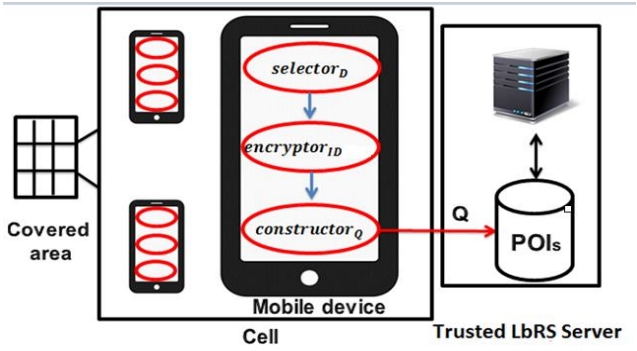


Fig. 7. Our Proposed Model Aachitecture.

TABLE. II. Components

Name	Main Mission	Location
$selector_D$	Dummy locations selection.	Each mobile device.
$encryptor_{ID}$	ID protection.	Each mobile device.
$constructor_Q$	Query construction.	Each mobile device.

The task of each component is combined with and compliant the task of the others. The following clarifies the functions of the components.

C. Roles of Components

Role of the $\text{selector}_{\text{D}}$ component: The eventual aim of this component is to preserve the user location privacy through protecting the location information including the submitted query and the time at which the query is issued (i.e., both information the spatial and the temporal). To end this, this component performs a novel approach called Smart Dummy Selection (SDS) approach as described below.

1) Smart Dummy Selection (SDS) approach: Considering the area (RE) split into a group of cells. Every cell has a query probability. For a particular user located in a cell inside RE, it is a weak solution to randomly select some cells to be the dummy locations. In contrast, it is an efficient solution to select the cells (which will be the dummy locations) that have a similar value probability of the query like the real user cell. Fig. 8 illustrates the idea, where RE is split depending on the coordinates (X, Y).

The method of choosing the locations which have a similar query probability as the true location of the user will confuse the attacker in determining the real location among the dummies. This, in turn, achieves a concept of k-anonymity, where k refers to the number of locations that the attacker cannot recognize the true location of the user between k-1 dummies [31].

Let Q_prob_{i} $(\text{i} = 1, 2, \dots, \text{k})$ refer to the probability that the i^{th} location is the true location. Then $\text{Q\_prob}_{\text{i}} = \frac{\text{qp}_{\text{i}}}{\sum_{\text{j}=1}^{\text{k}} \text{qp}_{\text{i}}}$.

In general, entropy can be defined as uncertainty condition in knowing the true location of a user from all the dummies. In this context, the entropy (ENT) of determining the true location out of the number of dummy locations is defined as [30]:

$$\text{ENT} = -\sum_{\text{i}=1}^{\text{k}} \text{Q\_prob}_{\text{i}} \times \log_2 \times \text{Q\_prob}_{\text{i}} \quad (1)$$

The first factor taken into consideration is to achieve the maximum entropy value in the dummy chosen procedure, which is given by the following formula:

$$\text{Max}\left(-\sum_{\text{i}=1}^{\text{k}} \text{Q\_prob}_{\text{i}} \times \log_2 \times \text{Q\_prob}_{\text{i}}\right) \quad (2)$$

2) The danger of semantic location attack (golden chance for the attacker: Suppose we select the dummy locations by the random way and submit them together with the true location to LBS server. Since the attacker knows the query probabilities of locations in the map, the obtained privacy degree will be down a level. That is because the probability of detecting the real location is $\frac{1}{k}$ which is the theoretic meaning of k-anonymity. Then, the attacker can guess that the real location is the location which has a higher query probability, in contrast, it will exclude all the locations which have low query probability. The gap that is used in selecting the dummy locations, in this case, is illustrated in Fig. 9.

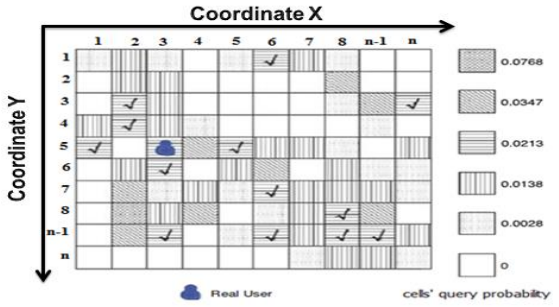


Fig. 8. Dummy Locations Selection in the SDS Approach.

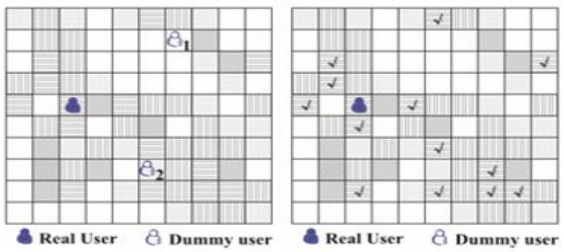


Fig. 9. The Gap in Selecting the Dummy Locations.

Fig. 9(a), since the query probabilities in locations 1, 2 and 3 are more different from each other, the attacker can easily infer the real location from the dummy locations based on the value of the entropy which will drop significantly from $\log_2$ k to $\log_2$ (k−kd), where kd refers to the number of fake locations that the attacker will exclude depend on their minimum query probabilities.

Fig. 9(b) shows the probability of knowing the true location through the server. Since all the candidates have a similar query probability to be aimed as the true location. So, it will be difficult for the attacker to recognize the real location from k locations.

So, our solution improves the user location privacy based on the smart selection of the dummy locations, bearing in mind the attacker may take some advantage of some side-by-side information. So, we select fake dummy locations which have similar query probabilities.

Notice that the temporal information is protected. That is because each dummy location selected by the $\text{selector}_{\text{D}}$ component is used to create a dummy query, which is in turn tightly coupled with the time. Therefore, all the dummy queries will be attached to the same moment at which the real query is issued.

Summarize the following main steps, which are:

1) Choose a suitable degree of k anonymity, which guarantee location privacy without causes system overhead.

2) To achieve maximum entropy, we must have k locations which have the similar probabilities to be aimed as the true location on the server so that we will read all the query probabilities of the cells then we will rank them based on the probabilities values for the inquiry.

3) In the organized set, if we found more than one cells that have the same value of query probability as the true location, we sort half of them before and the other half after the true location.

4) Generate the k cells right before and the k cells right after the real location as 2k candidates.

5) Originate m groups of cells from each with k cells, such that one cell is the true location, and the other (k −1) cells are selected randomly from the 2k candidates.

6) The j^{th} (j ∈ [1, m]) set can be mention as C_j = [c_{j1}, c_{j2},……. , c_{ji},… , c_{jk}]. Depend on the original query probabilities values of the selected locations, the normalized probabilities values of the queries for the included cells can be mentioned as np_{j1}, np_{j2},……, np_{ji},… , np_{jk} and calculated by:

$$np_{ji} = \frac{q_{ji}}{\sum_{l=1}^{k} q_{il}} \ , \ i = 1, 2, \ldots\ldots , k, \quad (3)$$

7) The probabilities sum is 1. The reason behind selecting 2k locations to be candidates of dummy locations is to maximize the anonymity degree, and the number of this group can be changed by the user.

8) Select an optimal list to effectively obtain k-anonymity for the user. We are measuring user's privacy by the entropy-based metric. Specifically, for a selected group C_j , we calculate the entropy by the formula:

$$ENT_j = -\sum_{i=1}^{k} np_{ji} \times \log_2 \times np_{ji} \quad (4)$$

9) In the end, the outputs of the SDS algorithm is the set with the highest value of the entropy:

$$EF_{dum} = \arg\max \ ENT_j \quad (5)$$

Algorithm 1 shows the pseudo code of the proposed SDS approach.

Algorithm 1: Smart Dummy Selection (SDS) algorithm

Input: Q_prob (probability of query for every cell), R_{loc} (the real location of the LbRS user), k (anonymity degree), number of sets m.

Output: EF_{dum}.

1: arrange the cells depend on the value of their query probabilities;

2: choose 2k dummy candidates (k candidates are right before l_{real} and k candidates are right after l_{real} in the sorted set);

3: **for** (j=1; j <=m; j ++)

4: build set Cj which include 1 real and k −1 other cells were chosen randomly from the 2k candidates;

5: calculate the normalized probability np_{ji} of each cell c_{ji} inside the set;

6: $ENT_j = -\sum_{i=1}^{k} np_{ji} \times \log_2 \times np_{ji}$

7: **end for**

8: output $EF_{dum} \leftarrow$ arg max ENT_j;

9: save checkpoint ();

Although the SDS approach can provide a significant level of privacy in entropy domain, as clarified before, it is better to enhance it in terms of protecting user identity by encryption technology.

3) Disconnecting and performance problems: Another task or mission is assigned to the selector_D component, which is dealing with the disconnecting problem that maybe happened to the user mobile device. The disconnecting problem forces the user to go back to the start point of selecting the dummy locations and encrypting the ID element. This, in turn, consumes the power of the device and leads to poor responding performance, where the mobile device of the user suffers from short life battery. To avoid this, the **selector**$_D$ component periodically uses checkpoints to save the performed stage. If the disconnecting problem is happened due to any an error in the user mobile device, the user can go back to the last checkpoint to continue. Notice that this ensures the availability of the system. Fig. 10 illustrates the idea.

Role of the encryptor_{ID} component: After the smart selecting of the dummy locations, these dummies are delivered to the constructor_Q component to create the corresponding queries (dummy queries). since the form of the went query is $Q^t(\langle ID\rangle, \langle Loc\rangle, \langle POI\rangle, \langle Range\rangle)$, we need to protect both the ⟨ID⟩ and the ⟨POI⟩. That is because the attacker can collect some private information from the process of associating the two elements with each other. Breaking this association leads to blocking the attacker from gathering the private data even if eavesdropping is applied on the communication channel. To end this, the encryptor_{ID} component extracts and encrypts the ⟨ID⟩ element. By doing so, the attacker can obtain the following information for example "unknown user is asking for POIs that are located within a specific range", which does not reveal any personal information.

4) Encryption based Approach: To perform the encryption process, we use AES encryption algorithm. Fig. 11 illustrates the extraction and encryption missions of the encryptor_{ID} component.

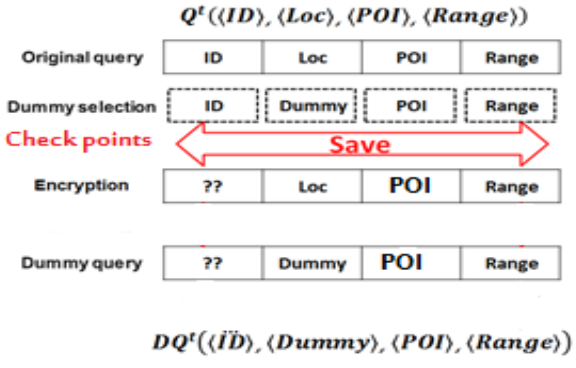


Fig. 10. Checkpoints.

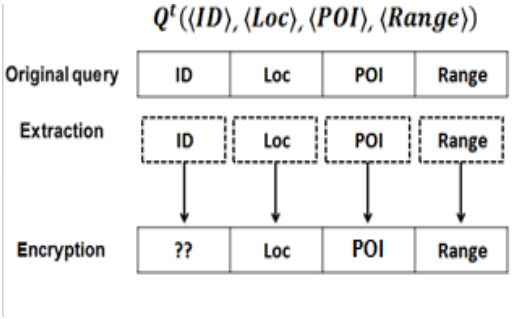


Fig. 11. The Missions of the $\text{Encryptor}_{\text{ID}}$ Component.

5) The danger of sampling query attack: In sampling query attack, the attacker targets the user that is located in an isolated area, focusing on analyzing the sent queries. Since the external attacker has the ability to eavesdrop the communication channel, as defined in the threat model above, he/she can steal the encryption key of the symmetric AES algorithm. This, in turn, facilitates applying the sampling query attack and reflects a gap in the proposed encryption-based approach.

To make a defense against sampling query attack, we need to ensure (1) safely exchanging the encryption key of the AES algorithm; and (2) establishing a secure communication channel between the user and the LbRS server. This can be achieved by using the asymmetric encryption algorithm, such as Diffie-Hellman, as an auxiliary hand.

The Diffie-Hellman key exchange is a secure method for exchanging cryptographic keys. This method allows two parties which have no prior knowledge of each other to establish a shared, secret key, over a public network. This key can then be used to encrypt subsequent communications using symmetric key encryption.

Finally, after safely receiving the session key by the LbRS server side, the two parties start the encryption session through a secure communication channel.

Role of the $\text{constructor}_{\text{Q}}$ component: After encrypting the ⟨ID⟩ element, the mission of the $\text{constructor}_{\text{Q}}$ component is coming. This mission is related to construct the dummy queries using both the dummy locations provided by the $\text{selector}_{\text{D}}$ component and the encrypted (protected) ⟨ID⟩ element by the $\text{encryptor}_{\text{ID}}$ component. The constructed dummy queries have the same form of the original one as shown in Fig. 12, where DQ^{t} refers to the constructed dummy query, $\langle \ddot{ID} \rangle$ refers to the encrypted ⟨ID⟩.

After constructing (k) dummy queries based on the $(k-1)$ dummy locations, the real location, and the encrypted ⟨ID⟩ element, the user sends the all queries to the LbRS server to be manipulated there.

D. Our Proposed Architecture Details

To display the scenario of the collaboration among the components existing in our proposed model we used sequence diagram as shown in Fig. 13.

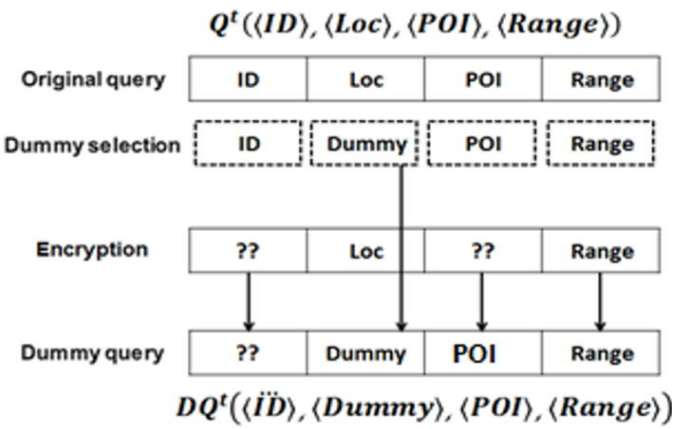


Fig. 12. Construction of Dummy Query.

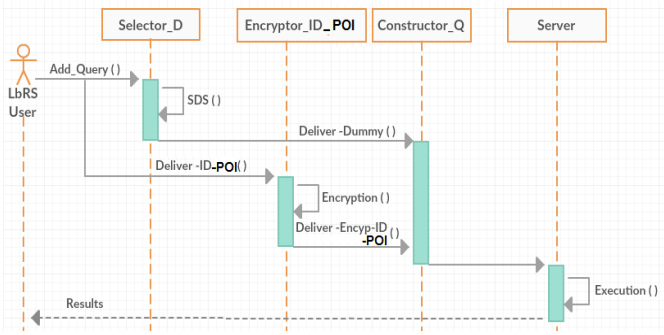


Fig. 13. The Proposed Architecture Details of Sending the Dummy Queries.

IV. Analysis of the Security of our Proposed Model

In this section, we study the robustness of the proposed system versus both the semantic location attack and the sampling query attack. In addition, we study the trial of reversing both the DSD and encryption-based algorithms by the attacker. In this context, we grant that attacker an additional capability, which knows both the SDS and encryption-based algorithms.

In this discussion, we depend on the assumption-evidence strategy to provide proof that the previous two attacks are failed, and the attacker cannot collect personal information about the LbRS user, as described below.

A. Security Analysis of Semantic Location Attack

Assumption 1. We say that our proposed SDS approach is resistant versus the semantic location attack.

Evidence 1. The attacker attempts to deduce the true location of the LbRS user between the dummy locations with the taking in to account the attacker has the following information: (6) the probabilities values of the queries for each cell Q_prob_{i} and (7) all k sent locations, which are mentioned as $l_1, l_2, \dots, l_k$. Let $PG_{(v)}$ indicate to the probability of the attacker successfully guesses whether an event$v$ occurred. The SDS approach is resistant against the semantic location attack if these two terms are achieved:

$$= PG_{(l_b)} \ \forall \ (0 < a \neq b \leq k) \quad (6)$$

First, because the selected fake locations are having the similar query probabilities Q_prob_i of the actual user's cell (i.e., actual location), the attacker cannot find useful information by using the query probabilities to know the actual locations. Second, as k locations are sent, each a probability of $\left(\frac{1}{k}\right)$ being the actual location. Thus, the first condition is achieved.

However, if we look to the time side, the semantic locations attack is very coupled with time, which means the attacker is given more information. Suppose the attacker knows how many queries that are submitted from a location through a specified time interval. Let $freq\left(Q_{l_a}^{tp}\right)$ and $\text{freq}\left(Q_{l_b}^{tp}\right)$ refer to the frequencies, or how many queries, that are submitted from locations l_a and l_b through the fixed time interval tp . A second condition, which represents robustness versus the semantic location attack, must be achieved when:

$$freq\left(Q_{l_a}^{tp}\right) = freq\left(Q_{l_a}^{tp}\right) \forall\, (0 < a \neq b \leq k) \quad (7)$$

Our proposed system based on the dummy generation process, so all submitted locations (the fake locations plus the user true location) have the same number of queries or the same value of query frequency. That is mean; the attacker only can randomly guess the actual location of the LbRS user because all locations have the same number query frequency. The semantic location attack fails since the two previous conditions are satisfied.

Regarding the SDS approach randomly selects the final dummies (from the candidate list, which is also randomly chosen), even if the attacker understood our proposed approach (SDS), and he tries to overturn the approach; however, this cannot be successful. Due to selecting the dummies by randomization processes, even if the attacker tries to run the proposed SDS approach many times, he will never know the true location of the user between the fake locations.

B. Security Analysis of Sampling Query Attack

We said that the attacker can eavesdrop on the communication channel to analyze the sent query in the description of the threat model above. The sampling query attack requires the original query (decrypting the ID and determining the actual location of the LbRS user) to be obtained. Hence, the attacker must obtain the session key.

Assumption 2. Our proposed encryption-based approach is resistant to query analysis.

Evidence 2. Our proposed encryption-based approach to be resistant to query analysis, the following two security requirements must be satisfied simultaneously:

1) Authentication, which is related to the LbRS server, that means the LbRS server is dealing with the intended user. In other words, if $user_a$ and $user_b$ want to protect queries PQ_a and PQ_b, the LbRS server must safely exchange the session key. (i.e., the LbRS server receives the correct session key that corresponds to the intended user to start the secure communication session).

2) Confidentiality, which is related to the user side, means that no one, except the trusted LbRS server, can obtain the exchanged session key via decryption.

Since the process of exchanging the session key depends on encryption using the Diffie-Hellman key, the previous two security requirements are guaranteed. That is because the received session key is decrypted using the Diffie-Hellman key at the server side. In contrast, if the server tries to decrypt S_{key} using any other key, the decryption process will fail. Since the LbRS server can only decrypt S_{key} using the Diffie-Hellman key, the authentication security requirement is satisfied, and the confidentiality security requirement is satisfied, the sampling query attack fails.

V. The Used Metrics

The metrics that are employed to evaluate our proposed approach are two types of metrics: one for the privacy and another one for the performance.

A. The Metrics of Privacy

Since the main objective of this paper is ensuring high privacy protection for LbRS users, we need to use some metrics related to location privacy and others related to query privacy.

The entropy *ENT*, represented by formula 1 above, is used to evaluate the location privacy of our proposed SDS approach. The entropy privacy metric measures the uncertainty information about the location in LbRSs queries. Consequently, it measures the information an LbRS user can gain from one (or a set) of location update(s) to preserve the privacy. Therefore, if *ENT* value is high, this refers to a higher location privacy protection is achieved, and the lower *ENT* value means a lower location privacy protection. It is worth mentioning that the highest *ENT* value is $log_2(k)$, where this is achieved when all selected dummy locations are exactly treated as the same as the real location.

ENT can be used as a query privacy metric according to [29, 30]. Our encryption-based approach ensures query privacy protection. However, the authors of [29] clearly stated that no query privacy metric can be used for encryption-based approaches. Therefore, we consider the result of encrypting the ID ($\langle \dot{I}\ddot{D} \rangle$) as dummies for the original ID. Here, the attacker tries to link the real location of the LBS user and the ID to infer personal information from the query analysis term. Thus, *ENT* can be used to evaluate our proposed encryption-based approach.

B. The Metrics of Performance

We study two performance metrics: total execution time t_{ext}, and encryption time t_{enc}.

For the time of total execution time, let (t_{ext}) refer the time that is required to extract both the ID at the LbRS user side, (t_{enc}) refer to the time that is required to encrypt the ID of the LbRS user, (t_{sel}) refers the time of selecting the dummy locations, and (t_{rep}) refer to the time that is required to replace the actual location of the LbRS user with a selected dummy location. Then, the total execution time is expressed as follows:

$$t_{ex} = t_{ext} + t_{enc} + t_{sel} + t_{rep} \quad (8)$$

VI. Experimental Results and Evaluations

This section is structured so that the simulation setup is described with configurations. Then, the evaluations and obtained results are represented based on the metrics used above.

A. Simulation Setup

R programming language is used to perform the proposed approaches. To evaluate the performance, we used a Genuine Intel(R) Core (i7) 1.8 GHz PC with 8.00 G RAM that is working Microsoft Windows 10. We download the data set from this link ("https://raw.githubusercontent.com/YunMai-SPS/DA643/master/DA643_final_project/business.csv"). The original dataset consists of 46058 rows and eleven columns: "business_id","name","neighborhood","address","city","state", "postal_code","latitude","longitude","stars","review_count". Due to system limitations, we used a subset of it. The final dataset that we used consists of 8982 rows. Table III lists the parameter settings. Query probability is generated randomly.

B. Evaluations and Discussions

For comparison purposes, we compare our proposed SDS approach with two approaches. One of them is proposed previously called, in this paper, Random Dummy Selection (RDS). RDS selects dummy positions in a random way [20]. The second approach called furthest. The furthest approach selects the dummy locations to depend on the furthest distance among the true location of the user and the chosen dummies without considering the query probability factor. Fig. 14 compares the three approaches under entropy privacy metric, where the K values vary from 12 to 50.

Fig. 14 shows the entropy values according to the increased *k* value of 1 step.

Among the approaches that are represented in Fig. 14, it is evident that the SDS approach overcomes both the random and furthest approaches. That is because of the positive impact of the factor that is considered (in the procedure of selecting the fake locations) in the SDS approach depends on the query probability factor ensures that the attacker cannot determine the true location between the dummy locations since all the locations (i.e., the true location and the fake locations) have the same query probability, which leads to high entropy values. Since both the random and furthest approaches did not deal with query probability as a major factor in the process of selecting dummy locations, this leads to lower entropy values. Compared to the furthest approach, the random approach achieves better privacy protection degree; this is because the random way used to select dummies may match the factor of SDS approach so that some of the selected dummies have a similar query probability as the true location of the user. Fig. 15 compares the three approaches under total execution time in seconds, where K values vary from 20 to 50.

TABLE. III. Configurations

Parameter	Setting
Search Region	5 km
Real User Location	latitude=43.64492 longitude=-79.383333

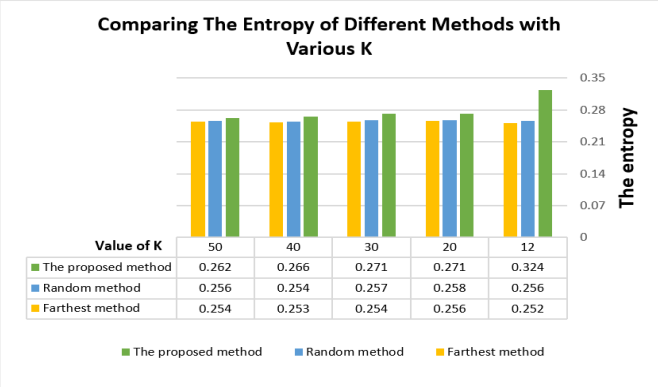


Fig. 14. Entropy vs. k.

Total execution time evaluation: In general, the time needed to execute a privacy protection approach differs from one approach to another due to the time spent to build defenses, as shown in Fig. 15.

It is obvious that the proposed SDS approach performs the worst. That is because (1) the time needed to select the dummy location undergoes the factor of query probability, which in turn consumes more time to end the process of selecting the dummies; and (2) the time needed to encrypt and decrypt the ID of the user. Compared to the random approach, the furthest approach performs less due to the time needed to calculate the distances between the user true location and the selected dummies. The random approach is ranked on the top because it has no factors to be taken into account in the method of chosen dummy locations. As a result, the proposed SDS approach is ranked on the bottom, reflecting the tradeoff among obtained a high privacy degree and execution time, which is a natural result. Fig. 16 compares the proposed approach under total execution time with encryption and without encryption, where K values vary from 20 to 50.

However, although the proposed approach is ranked on the bottom, the difference between the proposed approach under total execution time with encryption and without encryption, where K values vary from 20 to 50, is almost similar with a meager difference.

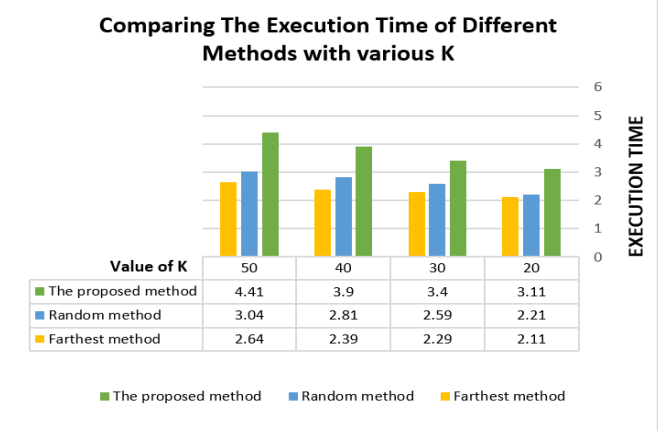


Fig. 15. Comparing the Execution Time of different Methods with Various k.

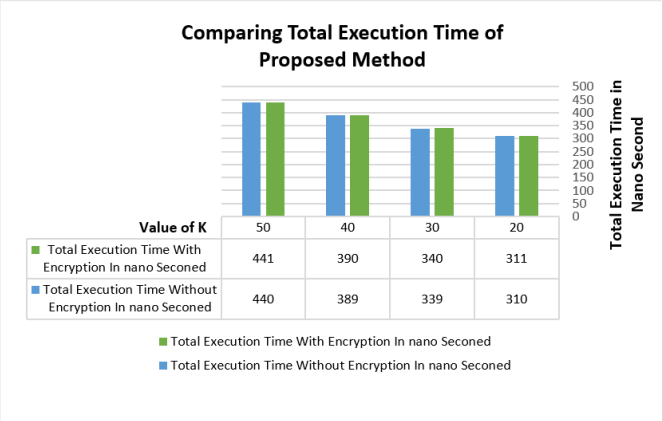


Fig. 16. Construction Time vs. Number of Sent Queries.

VII. Conclusion

Location-based recommendation systems (LbRSs) provide much functionality to users, such as searching for the nearest points of interest (POIs), which facilitates tasks in daily life and saves time. However, the valuable advantages of LbRSs are accompanied by risks since the users are forced to reveal their real locations, which can be exploited by attackers to attack the privacy of the LbRS users. In this aspect of the research field, we contribute by proposing a smart dummy selection (SDS) approach for preserving the location privacy of the LbRS users. To generate strong dummy locations, the SDS approach takes into consideration an essential factor in the process of generating (or selecting) the dummy locations: the query probability of the true location of the LbRS user is equal to each query probability of any selected dummy location. To ensure high privacy protection (i.e., preserving both the privacy of the location and the privacy of the query), we support the proposed SDS approach with an encryption-based approach, which protects the ID. Moreover, the supported SDS approach is strengthened by a checkpoint technique to ensure high availability. Under the threat of a semantic location attack, a sampling query attack, and a mixture of these two attacks, this SDS approach, which is supported by the encryption-based approach, showed higher resistance against such attacks compared to similar approaches.

VIII. Future Work

In future work, we tend to improve this work to deal with other attacks, such as location homogeneity attack. In addition, we will deal with the privacy issue, taking into consideration that the LbRS server itself is the attacker.

References

[1] X. Yang, Y. Guo, Y. Liu, and H. Steck, "A survey of collaborative filtering based social recommender systems," *Comput. Commun.*, vol. 41, pp. 1–10, 2014.

[2] N. A. Albatayneh, K. I. Ghauth, and F.-F. Chua, "Utilizing Learners' Negative Ratings in Semantic Content-based Recommender System for e-Learning Forum," J. Educ. Technol. Soc., vol. 21, no. 1, pp. 112–125, 2018.

[3] E. Aslanian, M. Radmanesh, and M. Jalili, "Hybrid Recommender Systems based on Content Feature Relationship," IEEE Trans. Ind. Informatics, p. 1, 2016.

[4] K. G. Shin, X. Ju, Z. Chen, and X. Hu, "Privacy protection for users of location-based services," IEEE Wirel. Commun., vol. 19, no. 1, pp. 30–39, 2012.

[5] X. Zhang and H. Y. Bae, "Location positioning and privacy preservation methods in location-based service," Int. J. Secur. Its Appl., vol. 9, no. 4, pp. 41–52, 2015.

[6] Z. Montazeri, A. Houmansadr, and H. Pishro-Nik, "Defining perfect location privacy using anonymization," in 2016 Annual Conference on Information Science and Systems (CISS), 2016, pp. 204–209.

[7] D. Li, X. He, L. Cao, and H. Chen, "Permutation anonymization," J. Intell. Inf. Syst., vol. 47, no. 3, pp. 427–445, 2016.

[8] R. S. Zuberi and S. N. Ahmad, "Secure mix-zones for privacy protection of road network location based services users," J. Comput. Networks Commun., vol. 2016, 2016.

[9] I. Memon, Q. A. Arain, M. H. Memon, F. A. Mangi, and R. Akhtar, "Search me if you can: Multiple mix zones with location privacy protection for mapping services," Int. J. Commun. Syst., vol. 30, no. 16, p. e3312, 2017.

[10] R.-H. Hwang, Y.-L. Hsueh, and H.-W. Chung, "A novel time-obfuscated algorithm for trajectory privacy," in 2012 12th International Symposium on Pervasive Systems, Algorithms and Networks, 2012, pp. 208–215.

[11] L. Wang, D. Yang, X. Han, T. Wang, D. Zhang, and X. Ma, "Location privacy-preserving task allocation for mobile crowdsensing with differential geo-obfuscation," in Proceedings of the 26th International Conference on World Wide Web, pp. 627–636, 2017.

[12] A. Gutscher, "Coordinate transformation-a solution for the privacy problem of location based services?," in Proceedings 20th IEEE International Parallel & Distributed Processing Symposium, p. 7–pp., 2006.

[13] M. L. Yiu, C. S. Jensen, J. Møller, and H. Lu, "Design and analysis of a ranking approach to private location-based services," ACM Trans. Database Syst., vol. 36, no. 2, p. 10, 2011.

[14] T. Hashem and L. Kulik, ""Don't trust anyone": Privacy protection for location-based services," Pervasive Mob. Comput., vol. 7, no. 1, pp. 44–59, 2011.

[15] G. F. Marias, C. Delakouridis, L. Kazatzopoulos, and P. Georgiadis, "Location privacy through secret sharing techniques," in Sixth IEEE International Symposium on a World of Wireless Mobile and Multimedia Networks, pp. 614–620, 2005.

[16] H. Kido, Y. Yanagisawa, and T. Satoh, "An anonymous communication technique using dummies for location-based services," in ICPS'05. Proceedings. International Conference on Pervasive Services, pp. 88–97, 2005.

[17] B. Niu, Q. Li, X. Zhu, G. Cao, and H. Li, "Achieving k-anonymity in privacy-aware location-based services," in IEEE INFOCOM 2014-IEEE Conference on Computer Communications, pp. 754–762, 2014.

[18] A. Pingley, N. Zhang, X. Fu, H.-A. Choi, S. Subramaniam, and W. Zhao, "Protection of query privacy for continuous location based services," in 2011 Proceedings IEEE INFOCOM, pp. 1710–1718, 2011.

[19] T. Hara, A. Suzuki, M. Iwata, Y. Arase, and X. Xie, "Dummy-based user location anonymization under real-world constraints," IEEE Access, vol. 4, pp. 673–687, 2016.

[20] M. S. Alrahhal, M. U. Ashraf, A. Abesen, and S. Arif, "AES-route server model for location based services in road networks," Int. J. Adv. Comput. Sci. Appl., vol. 8, no. 8, pp. 361–368, 2017.

[21] م. ن. مشرف, م. س. العرادي, عناب صالح, and, "Ensuring Privacy Protection in Location-Based Services Through Integration of Cache and Dummie." جامعة نايف العربية للعلوم الأمنية, 2019.

[22] M. Wernke, P. Skvortsov, F. Dürr, and K. Rothermel, "A classification of location privacy attacks and approaches," Pers. ubiquitous Comput., vol. 18, no. 1, pp. 163–175, 2014.

[23] X. Pan, W. Chen, L. Wu, C. Piao, and Z. Hu, "Protecting personalized privacy against sensitivity homogeneity attacks over road networks in mobile services," Front. Comput. Sci., vol. 10, no. 2, pp. 370–386, 2016.

[24] P. Jagwani and S. Kaushik, “Privacy in location based services: Protection strategies, attack models and open challenges,” in International Conference on Information Science and Applications, pp. 12–21, 2017.

[25] D. Kumar, "A study on Processing of Query with Privacy based Preservation." International Journal of Computer Science IJCSIS, vol.15.10, PP. 88-91, 2017.

[26] C. Lin, G. Wu, and C. W. Yu, “Protecting location privacy and query privacy: a combined clustering approach,” Concurr. Comput. Pract. Exp., vol. 27, no. 12, pp. 3021–3043, 2015.

[27] N. Pelekis and Y. Theodoridis, “Privacy-Aware Mobility Data Exploration,” in Mobility Data Management and Exploration, Springer, pp. 169–185, 2014.

[28] H. Li, H. Zhu, S. Du, X. Liang, and X. S. Shen, “Privacy leakage of location sharing in mobile social networks: Attacks and defense,” IEEE Trans. Dependable Secur. Comput., vol. 15, no. 4, pp. 646–660, 2016.

[29] M. S. Alrahhal, M. Khemakhem, and K. Jambi, “A Survey on Privacy of Location-based Services: Classification, Inference Attacks, and Challenges.,” J. Theor. Appl. Inf. Technol., vol. 95, no. 24, 2017.

[30] I. Wagner and D. Eckhoff, “Technical privacy metrics: a systematic survey,” ACM Comput. Surv., vol. 51, no. 3, p. 57, 2018.

[31] B. Niu, Q. Li, X. Zhu, G. Cao, and H. Li, “Enhancing privacy through caching in location-based services,” in 2015 IEEE conference on computer communications (INFOCOM), pp. 1017–1025, 2015.

Investigating Social Media Utilization and Challenges in the Governmental Sector for Crisis Events

The case of Saudi Arabia

Waleed Afandi
Management Information System Department
College of Business in Rabigh
King Abdulaziz University
Saudi Arabia

***Abstract*—The use and utilization of social media applications, tools, and services enables advanced services in daily routines, activities, and work environments. Nowadays, disconnection from social media services is a disadvantage due to their increasing use and functionality. The use of social media applications and services has provided different methods and routines for communications that ranges from posting, reposting, commenting, interacting, and live communication that can reach a mass population with minimum time, effort, and expenses compared with traditional media systems and channels. The current benefits of using social media can assist in providing better services in terms of communication and guidance for civil protection services within governmental sectors, as reported by different research studies. The use of social media has been found to be critically important by governmental agencies in different situations for directing, educating, and engaging people during different events. This study investigates the use of social media services in Saudi Arabia in governmental sectors to outline the opportunities and challenges faced, given the challenging situations faced annually during the Hajj and Ramadan rituals, and sporadic flood crisis events. This research focuses on defining the current stand and challenges of using social media services for providing mass communication and civil engagement during hazardous and challenging events in Saudi Arabia. The results of this study will be used as a roadmap for future investigation in this regard.**

Keywords*—Component; civil protection; hajj; social media; Saudi Arabia; governmental sector; flood crisis

I. Introduction

Nowadays, many governmental sectors are seeking to enhance their services through providing direct communication with the public via e-government facilities. Engaging the public in timely communication can provide faster and more responsive services, and better engagement, solving problems and providing better governmental services. Moreover, in the cases of unordinary events, the need for having timely and interactive communication is essential to mitigate hazards, guide people, and be informative concerning the situation. Different governmental authorities worldwide have realized the potentials of using these services in providing better far superior means of communication than traditional communications systems for general use or those for emergencies and hazardous events.

The use of traditional communication systems is inefficient and does not provide engagement for active communication with the public. With the advent of mass internet usage since the 1990s, different solutions embodying the use of social media systems have been utilized by official agencies during extraordinary events to overcome the problems of traditional communication systems and go beyond their abilities in providing real-time communication channels, employed for sharing valuable government-to-citizen and citizen-to-citizen information among users.

The rites associated with Hajj and Ramadan, particularly religious rituals for Muslim pilgrims from all over the world in the former, are considered one of the main challenges facing governmental sectors in the Kingdom of Saudi Arabia (KSA). Hajj is considered the oldest continuing mass gathering, with an average of three million people converging on the same area and performing the same rituals [1]. The high population density of 8-9 persons per square meter has resulted in frequent stampedes that have posed critical emergencies on many occasions, resulting in deaths and serious injuries. Moreover, different challenges such as fire, terrorism, and health issues have been reported during the Hajj [2]. Controlling and guiding such large masses of with traditional communication systems is impossible, especially as pilgrims are coming from different countries with diversity in ethnic origins and languages.

Other crisis events that have been reported in different locations in KSA include as man-made events and natural disasters, including epidemics, flooding, fire, and chemical and ecological impacts) [3]. In order to enhance preparedness for such events, including crisis mitigation and early resilience efforts against emergencies, the inclusion of social media services in government communication offers promising potential, as reported in many research studies. Using social media for strengthening the relations with governmental, local, and regional participants, including communities, is vital for mitigating the effects of and controlling the responses to situations concerning public behavior, through active communication and engagement [4].

The results of this research study provide a benchmark defining the challenges and changes in utilizing social media services among governmental sectors in KSA. Moreover, they assist in defining the main barriers and opportunities for engaging social media services during critical events. This

research contributes to filling the gap in the literature and provides awareness of the current situation and practices prior to implementing any future solutions. The following sections will introduce the used methodology and survey that was created, tested and used for investigating the current situation and stand toward the effective use of social media during crisis events in Saudi Arabia.

The aim and importance of this study is to investigate the current use of social media services in Saudi Arabia in governmental sectors, to be able to outline the opportunities and challenges faced, given the challenging situations faced annually during the Hajj and Ramadan rituals, and sporadic flood crisis events. Such information is needed prior to providing any solution that might be proposed in the future for mitigating the effects of crisis events and emergencies using social media technologies.

II. Methodology

This study investigates the status of social media usage in the governmental sectors involved with critical events and emergencies in KSA, and defines the challenges and opportunities facing future use. As no substantive information is available from previous studies or official reports concerning the subject of concern, this research deploys quantitative methods, through distributing a questionnaire to explore the uses of social media in critical events.

A list of 23 ministries in KSA was obtained, 13 of which were officially contacted as their work and responsibilities were identified with relevance to: (1) critical and emergency events, and (2) mass public interest, as shown in Table I.

Each ministry was contacted with an official letter explaining the purpose and importance of this research, and the benefits that may result from their cooperation. All of the approached ministries agreed to take part in this research study, and this agreement was used to contact different governmental agencies to investigate each ministry's operations. Each ministry has numerous directories, authorities, councils, chambers, and commissions. Those governmental entities were identified through visiting the official web sites of each ministry, and they were contacted via email with a questionnaire attached in April 2017 for the purpose of this research study, representing a total of 53 entities. The participation importance of those governmental entities was accentuated, as the result is believed to fill the gap in literature as well as helping in creating a better understanding for future services and operations, with recommendations for improvements in preparedness for and response to crisis and emergency events. The importance of this study lies in addressing a critical gap in literature (concerning e-government in KSA in genera), as well as assisting in the creation of a better understanding and future recommendations for using social media in crisis management.

The questionnaire used for this research had a mixture of open-ended and closed questions derived from major research studies in this field [5-7]. They were adapted to suite the particular purposes and scope of this research, focusing on Saudi governmental agencies.

TABLE. I. Saudi Ministries Investigated

No.	Ministries
1	Civil Services
2	Communication and Information Technology
3	Education
4	Higher Education
5	Foreign Affairs
6	Hajj
7	Health
8	Interior
9	Labor
10	Municipal and Rural Affairs
11	Social Affairs
12	Water and Electricity
13	Transport

The close-ended questions were analyzed based on frequency using MS Excel. The open-ended questions were provided to have better understanding and description of the challenges. The answers were collected and coded using a coding frame based on 25% of total participants. NVivo 7.0 was used for providing the coding and defining nodes, used to derive relationships and provide themes identified from answers to each question used in the questionnaire. The statistical significance of the used questionnaire is indicated by a 93% confidence level, with a difference of (+/- 5) between responses. Responses to open-ended questions are considered indicative.

The final responses analyzed from the studied governmental agencies came from 23 respondents who completed the questionnaire (a response rate of 43%). It is believed that the results from this research are significant as many governmental agencies who participated voluntarily were grouped to identify the common challenges they face, and to fill the gap in literature towards social media usage during crisis events. The governmental participants were informed that the data of this research will be used for research purposes only, and the results of this study will be shared with them.

III. Findings of the Study

The results offered in this paper are just a part of a larger research investigation carried out concerning governmental entities' utilization of social media services in KSA. The focus in this stage is related towards defining the status and outlining the challenges of using social media by governmental entities in KSA. The following sections present the outcomes relevant to the current investigation.

A. Governmental Entities' Utilization of Social Media

Fig. 1 shows the results obtained from governmental entities on their current official utilization of social media services with their job responsibilities. The question was (identify your current position with using social media towards public services and communication).

The results came from a closed-ended question, and they indicate that most (62%) participating governmental entities in this study answered (we decided not to use it). The results show that those entities have been introduced to social media

usage, and for some reasons that will be identified later in this study, they decided not to consider using it. This large percent shows a real concern towards choosing not to use social media services. The second highest percent (27%) was for the option of (we are planning to use it in the near future). This result shows that there is still a good level of receptiveness among governmental entities towards using social media services; the upcoming results define the driving forces for using social media services. The third highest percent (8%) was related to the answer of (we are using social media occasionally). It was found from content analysis methodology of the visited social media pages that 94% of pages are unidirectional in providing interactive communication with public, and they are mainly used for announcing information only. The same governmental attitude has been reported by a previous research study [8], which showed that within a period of three years no change has been found in governmental employees' attitudes towards using social media with the public. The last option of (we didn't consider using it) was selected by only 4%. The results show that those governmental agencies have not been introduced to the benefits or possibilities of using social media, and they are not aware of how to merge social media services with their governmental operations in communicating with the public.

The next question in this study was related to identifying the reasons for not using social media services within governmental entities' operations towards the public. The results are shown in Fig. 2.

The answers came from an open-ended question, and coding technique was performed to identify themes through the keywords repeated in participants' answers, known as nodes. The results show that the most commonly cited rationale for not adopting social media was related to (security issues) (42%). Security concerns have been reported in different studies related to social media use and are a main concern among different adopters of social media services [9-11]. Close behind this, the second-highest percentage (39%) selected (technical challenges). The nodes defined from participants' answers are shown in Table II.

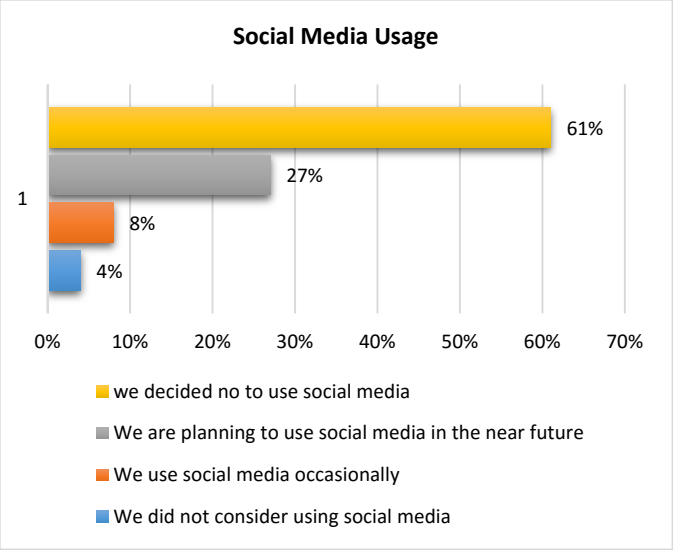


Fig. 1. Social Media usage in Saudi Governmental Entities.

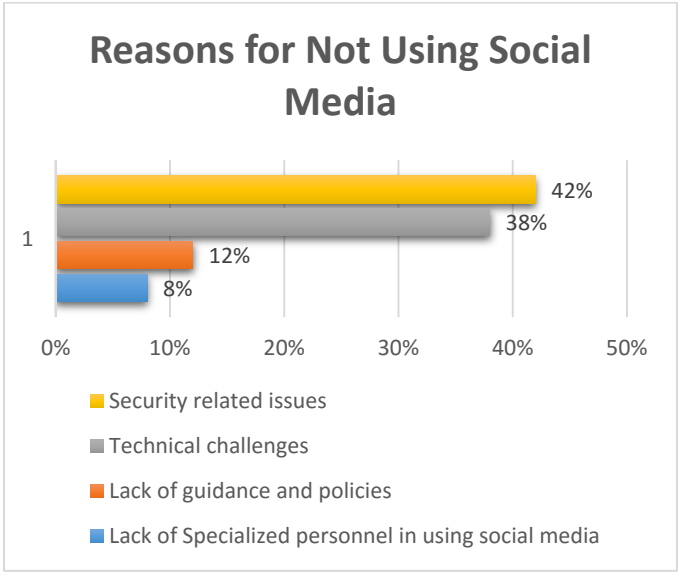


Fig. 2. Factors Affecting Social Media Adoption.

TABLE. II. DEFINED TECHNICAL CHALLENGES

	Technical Challenges	
1	Managing multiple accounts	83%
2	Managing response to public	67%
3	Staying compliant	24%

It can be seen from Table II that (managing multiple accounts) on different social media services is considered the main challenge for governmental entities in KSA by a large majority of participants (83%). This is related to the two points defined in Fig. 2 (lack of guidance and policies, lack of specialized personnel). However, this issue can be resolved by using social media management tools that are capable of managing different social media services and accounts from one portal or interface [11, 12]. The second-highest percentage (67%) was related to (managing responses to the public), and this issue can also be resolved by using social media management tools and trained and dedicated personnel working specifically with social media tools and services. The last technical challenge in this category is related to (Staying compliant), cited by almost a quarter (24%) of participants. This can be resolved through having dedicated training and policies for the staff managing social media services.

Going back to the reasons outlined as challenges towards using social media, it was found that the third-highest percent (12%) of total answers was related to (lack of guidance and policies). Having guidance and policies can be a critical factor for social media sustainability in governmental entities' operations and services. Different research studies have emphasized the importance of having well-documented and verified guidelines and policies for guiding staff on the use of social media services [12-15]. The last challenge in this category is related to (lack of specialized personnel) (8%). Having specialized personnel is seen as critical necessity, especially in the cases of crisis events or sensitive governmental entities, as people can rely on what is posted on those social media pages [16]. Most of the previous stated

challenges have been found in previous research studies, and it is evident that KSA governmental entities can learn from previous experiences through enhancing employee knowledge by revising the literature and following the solutions and recommendations of different research outcomes.

B. Ownership of Social Media within Governmental Agencies

This section investigated participants' responses on the driving forces for using social media services within their governmental entities' responsibilities and operations. The question was open-ended, and the following responses were outlined (Fig. 3).

The results show that the largest answer (32%) was (ensuring better communication with the community). The literature emphasizes the benefits of using social media for having better communication with the public [4, 13]. This result shows that the governmental entities are aware of the benefits of social media communication with the public in KSA. A close second was (enhancing services) (28%). This is closely related to the former point, as it is believed that social media can enhance the services of governmental sectors towards the public. The third highest percent (21%) was achieved by (benefits of the technology). Relating this to previous answers in this research study, it is evident that Saudi officials are aware of the benefits of social media technology, but lack of guidelines, policies, and specialized personnel, which is a major challenge to effectively adopting and using such tools. The fourth highest percent (15%) is related to (specialized staff), and it shows that there is a need for specialized staff that have deep knowledge in the field of using social media services and tools in e-government applications; basic knowledge or amateur experience cannot be relied on in such sensitive governmental entities' operations and tasks. The last answer for the provided question was (other governmental entities use) (4%). Although this result is minimal, it shows that some governmental entities can be affected and encouraged by the successful use of social media by others [17].

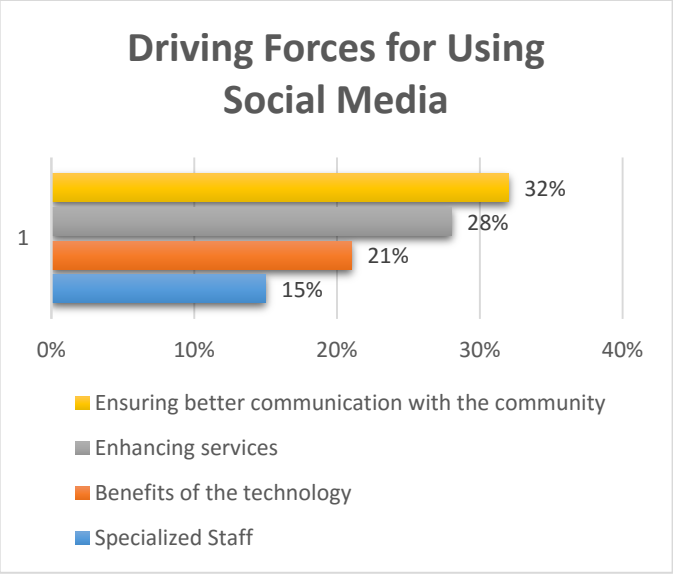


Fig. 3. Driving Forces for using Social Media.

The previous driving forces have been related to the case of KSA governmental entities. However, different driving forces can be outlined for adopting social media services within governmental entities, as some driving forces are similar to the ones defined in this study, as all depend on the intentions of use, position, and sensitivity of services and operations [5, 9].

Many research studies demonstrated that social media influences how the public anticipate crises through the reactions that they feel when exposed to crisis information [18]. Moreover, organizations like the Red Cross and Federal Emergency Management Agency (FEMA) have depended heavily on using social media for communicating with the public during crisis events, to manage and coordinate their own activities in addition to helping the public *per se*. For example, in 2009 the U.S. Army used social media services to update the public on the Fort Hood Shootings. In the same manner, the Red Cross uses social media services to communicate with the public regarding potential crisis. During the Virginia Tech shooting in 2007, the public used and interacted with social media services, as well as in the incidents of California wildfires, wherein the public pursued information from social media services, as they felt that traditional media sources were too general or imprecise [19]. The previous incidents show that communicating with the public in a wider scope using social media is its main advantage from a government services perspective, for all governmental entities or organizations involved in mass public communication and crisis events.

C. The Use of Social Media Policy

The study investigated the option of using social media policies by governmental entities in KSA with the close-ended question (does your organization have a social media policy?). The results obtained are shown in Fig. 4.

The results show that the great majority of Saudi governmental entities do not have social media policy (83%). (Currently developing) was selected by 13%, while only 4% declared that they have a policy for using social media. Social media policies can be issues with respect to governmental entities' nature of services and operations. Thus, many different social media policies can be developed. Many benefits are expected from having such policies, as adumbrated below [20, 21].

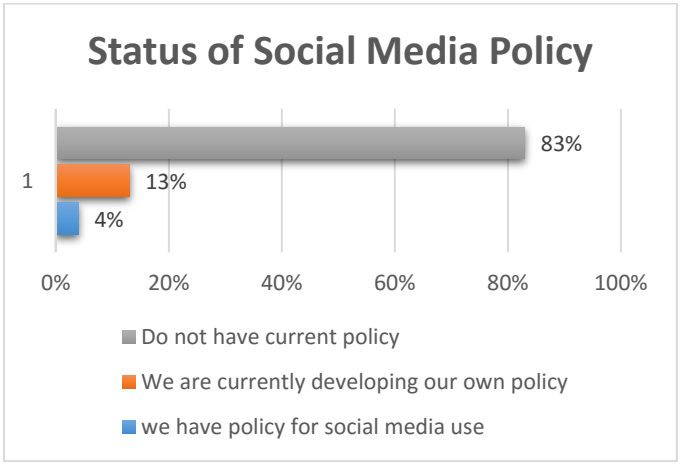


Fig. 4. Using Social Media Policy.

1) *Identifying services' scope*
2) *Protecting organizational reputation*
3) *Managing against rumors*
4) *Raising awareness of governmental operations*
5) *Defining confidential and private information*
6) *Defining the official voice responsible in the organization*
7) *Defining the proper way to engage with public and other governmental entities*
8) *Educating and training employees*
9) *Removing confusion about legal matters*

Using social media policies can be critical in many cases, especially in times of crisis and risk events. Thus, special consideration should be given towards establishing policies that go along with governmental entities' particular services, operations, and expected crisis events. The current practice of having many governmental entities using one general policy can jeopardize the use of social media, as such policies need to be more specific and oriented towards the governmental entities' work and services [22].

D. Adoption Stage for Social Media

The adoption process for social media in governmental entities has to come into three different stages [22]:

1) Entrepreneurship and experimentation
2) Constructive chaos
3) Institutionalization

Based on the previous stages, adopting social media by governmental entities starts by informal experimentation with social media outside of the used technological use policies. In the second stage, an order develops from the first disordered stage, as governmental entities recognize the need to draft rules, policies, and guidelines. The final stage consists of formalizing social media strategies and policies in terms of proper performance, types of engagements, and new modes of communication [22].

According to the previous definition of adoption stages, and based on the findings in this research study, it is to be concluded that many KSA governmental entities are classified in the (entrepreneurship and experimentation) stage, for non-adaptors of social media services, and in the (constructive chaos) stage for the governmental entities that have tentatively adopted social media services.

In order to develop the practices into the third stage, Saudi governmental agencies need to address the challenges defined in this study and work on forming dedicated policies with respect to each governmental entity's work, services, and operations.

IV. Conclusions

This paper investigated the current status of using social media services in governmental entities in KSA. The results showed that most governmental entities are not active in using those services towards promoting better services to the public or during crisis events. Different obstacles and challenges have been identified that warrant more consideration and planning to overcome the current status of a lack of or ineffective use of social media facilities. The literature related to social media usage in crisis events is full of different successful cases where social media services were adopted and helped during the different stages of crises events. In many cases, social media played critical role that served to save thousands of lives and promote better cooperation between the governmental entities and the public. Those cases should be introduced and considered by Saudi governmental entities by dedicated experts, to help in reforming the norms and regulations of use. However, despite the current low adoption of social media services, this research managed to outline the opportunities for better future utilization, and showed the current status of the use of such services in cases of crisis events and emergencies. Most Saudi governmental entities have been defined in stage 1 and 2 of the presented adoption stages previously presented in this research, and with a proper consideration of challenges, it is believed that Saudi governmental entities can make good use of social media services that can promote better services among governmental entities themselves, and with the public, including during Hajj, Ramadan rituals, and crisis events and emergencies. The future work associated with this research will be to create a framework that will enable different governmental and public entities to collaborate and share defined and structured policies for better cooperation among themselves in order to mitigate the impact of crisis events and emergencies using effective social media technologies.

Acknowledgement

This project was funded by the Deanship of Scientific Research (DSR) at King Abdulaziz University, Jeddah, under grant no. G: 1385-849-1440. The author, therefore, acknowledge with thanks DSR for technical and financial support.

References

[1] S. Yezli, B. M. Alotaibi, and A. A. Bin Saeed, "The Hajj health tequirements: time for a serious review?" The Lancet, vol. 387, no. 10021, pp. 845–846, 2016.

[2] A. Shujaa, and S. Alhamid, "Health response to Hajj mass gathering from emergency perspective, narrative review," Turkish Journal of Emergency Medicine, vo. 15, no. 4, pp. 172–176, 2015.

[3] E. Tambo, A. M. Fouad, and E. I. M. Khater, "Strengthening community emergency preparedness and response in threats and epidemics disasters prevention and management in Saudi Arabia," International Journal of Emergency Management, vol. 13, no. 3, pp. 288–303, 2017.

[4] S. Matar, N. Matar, W. Balachandran, and Z. Hunaiti, "Social media platforms and its application in natural disaster and crisis events: The case of Bosnia and Herzegovina," Information and Knowledge Management Journal, vol. 6, no. 5, pp. 50–56, 2016.

[5] Š. A. W. Matar, "Enhancing situational awareness and communication during flood crisis events using social media framework: the case of Bosnia and Herzegovina," doctoral dissertation, Brunel University London, 2017.

[6] Alharbi, N., "The impact of using YouTube on crisis communication during Jeddah floods in 2009 and 2011," doctoral dissertation, Bowie State University, 2015.

[7] UN OCHA, "Examples of coordination challenges," 2013. retrieved March 9 2013 from http://www.humanitarianresponse.info/en/system /files/documents/files/OCHA_Some Examples of Coordination Challenges.pdf.

[8] Y. Al-Saggaf, and P. Simmons, "Social media in Saudi Arabia: Exploring its use during two natural disasters," Technological Forecasting and Social Change, vol. 95, pp. 3–15, 2015.

[9] K. Njenga, "Social media information security threats: Anthropomorphic emoji analysis on social engineering," IT Convergence and Security 2017, 2018, pp. 185–192. Springer, Singapore.

[10] J. Kim, and M. Hastak, "Online human behaviors on social media during disaster responses," Journal of the NPS Center for Homeland Defense and Security, vol. 13, pp. 7–8, 2018.

[11] B. Tadic, M. Rohde, and V. Wulf, "CyberActivist: Tool for raising awareness on privacy and security of social media use for activists," International Conference on Social Computing and Social Media, Cham, Switzerland: Springer, July 2018, pp. 498–510.

[12] L. Ngamassi, A. Malik, J. Zhang, and D. Ebert, "Social media visual analytic toolkits for disaster management: a review of the literature," Proceedings of the 14th International Conference on Information Systems for Crisis Response and Management (ISCRAM), Albi, France, 2017, pp. 49–54.

[13] C. Reuter, and M. A. Kaufhold, "Fifteen years of social media in emergencies: A retrospective review and future directions for crisis informatics," Journal of Contingencies and Crisis Management, vol. 26, no. 1, pp. 41–57, 2018.

[14] C. Stohl, M. Etter, S. Banghart, and D. Woo, "Social media policies: Implications for contemporary notions of corporate social responsibility," Journal of Business Ethics, vol. 142, no. 3, pp. 413–436, 2017.

[15] D. Walster, "Information policy and social media: Accept or decline," TechTrends, vol. 61, no. 3, pp. 301–307, 2017.

[16] M. L. Jibril, I. A. Mohammed, and A. Yakubu, "Social media analytics driven counterterrorism tool to improve intelligence gathering towards combating terrorism in Nigeria," Ideas, vol. 107, pp. 33–42, 2017.

[17] A. Haro-de-Rosario, A., Sáez-Martín, and M. del Carmen Caba-Pérez, "Using social media to enhance citizen engagement with local government: Twitter or Facebook?" New Media and Society, vol. 20, no. 1, pp. 29–49, 2018.

[18] Y. Jin, B. F. Liu, and L. L. Austin, "Examining the role of social media in effective crisis management: The effects of crisis origin, information form, and source on publics' crisis responses," Communication Research, vol. 41, no. 1, pp. 74–94, 2014.

[19] J. B. Houston, J. Hawthorne, M. F. Perreault, E. H. Park, M. Goldstein Hode, M. R. Halliwell, S. E. Turner McGowen, R. Davis, S. Vaid, J. A. McElderry, and S. A. Griffith, "Social media and disasters: A functional framework for social media use in disaster planning, response, and research," Disasters, vol. 39, no. 1, pp. 1–22, 2015.

[20] J. C. Bertot, P. T. Jaeger, and D. Hansen, "The impact of polices on government social media usage: Issues, challenges, and recommendations," Government Information Quarterly, vol. 29, no. 1, pp. 30–40, 2012.

[21] M. W. DiStaso, T. McCorkindale, and D. K. Wright, "How public relations executives perceive and measure the impact of social media in their organizations," Public Relations Review, vol. 37, no. 3, pp. 325–328, 2011.

[22] I. Mergel, and S. I. Bretschneider, "A three-stage adoption process for social media use in government," Public Administration Review, vol. 73, no. 3, pp. 390–400, 2013.

Project Management Metamodel Construction Regarding IT Departments

HAMZANE Ibrahim[1], Belangour Abdessamad[2]
Ben M'sik Faculty of Science
Hassan 2 University Casablanca
Morocco

***Abstract*—Given the fast technological progress, the need for project management continues to grow in terms of methodology and new concepts. In this article, we will build a framework of generating a metamodel that we will apply on the project management to generate a generic metamodel of project management, in this approach we will be based on two methodologies of project management; predictive method (ex: PRINCE 2), Agile method (ex: SCRUM). The goal of this research is to validate and apply this methodology on all the components of IT Governance then to aggregate the metamodels to restore a global metamodel for all IT Governance domains.**

***Keywords*—MDA; MDE; SCRUM; PRINCE 2; PMBOK; IT**

I. Introduction

There is no truth; there are only viewpoints. In other words; we, our ability to see, to interpret is a result of a conception that we have produced during our life. Therefore, we can only perceive models designed and give points of view based on our repository. Thus, the human is adapted to model and reproduce the elements that surround him to better study and use them; as a result, we created programs and machines that help us in our various works.

The emergence of computers today has contributed to its trivialization, which gradually ranks it among other industries. Researchers and manufacturers have agreed that the rise of models and the separation between business and technology will be a very good asset to develop this area, also the fact of use modeling as a massive production tool rather than just a documentation task. This approach led to the birth of the notion of Model-Driven Engineering (MDE [7]).

As an example, IT project management is such a vast and evolving field [4], which allows structuring the different phases of projects, for an optimal organization to meet the objectives of the projects. So, is there a way to aggregate the set of methodologies in a single model that will serve as a basis for our studies in project management? In the following, we will create a project management metamodel using an MDE approach based on an agile framework and a predictive framework.

This paper is organized in the following sections. Section 2 describes related work, which somehow influence our work. Section 3 presents an overview of the Project Management and the MDE whose main goal is to focus on models in order to improve the process. Section 4 describes the approach of metamodel construction theoretically. In Section 5, we apply the approach to project management domain and present metamodel for the case study. Finally, Section 6 summarizes general considerations on present possibilities and announces future work.

II. Related Work

Recently, many research efforts have been devoted to develop a new project management models in different project management fields in order to get better results [18], improving the quality [17], securing projects, and representing project risks [19].

Moreover, the need for standardizing process descriptions in order to support interchange and fusion of process increased. Eric Knauss [20] described the advantages of using Object Management Group's standard Meta Object Facility (MOF) to represent requirement Engineering process. MOF is a standard supported by the Object Management Group (OMG) [21]: it defines a generic pattern for the construction of systems.

In the following we are going to propose an approach to extract a meta-model for project management based on MDE. The proposed approach is applied to two project management frameworks: Agile and Predictive.

III. Preliminaries

A. Project Management

Project management is an area that was born at the end of the 19th century when many companies have discovered the need for effective communication and coordination work between individuals [13]. It is an approach aimed at organizing the smooth running of a project from start to finish.

It has gained great popularity in recent decades. This is due to the wide range of benefits offered by project management in an organizational environment characterized by a rapid and changing environment, increasingly fierce competition and demanding customers.

Companies have huge expectations for their projects, but in reality, things are not happening as planned especially in the IT world.

The project management methodology helps managers through every step of a project. It starts by helping the manager to plan, initiate and implement the project. The methodologies even facilitate the closure of the project. Managers can use these templates to plan their tasks and achieve their goals.

But different methodologies will benefit different projects, and project management models are not all effective for different tasks. To find out which method is right for you, you will need to familiarize yourself with these methodologies and their differences.

B. MDE

Model-Driven Engineering is a discipline of software engineering, it is a generative approach used to generate systems or specific parties of information systems from their models, using several modeling languages called Domain-Specific Modeling Languages (DSML), these generic models are called Metamodel.

Thus, after the emergence of several forms of Meta-Model, it is necessary to define a common language of metamodeling format also known as Meta-Object Facility (MOF), and to define an approach to the construction of the models; which is the Model-Driven Architecture (MDA [9]).

The MDA defines a structured specification architecture divided into four distinct types of models namely:

- Computational Independent Model (CIM); Independent models of computerization called.
- Platform-Independent Models (PIM).
- Model Specific Platform (PSM); Platform-specific models.
- Platform Description Model (PDM); Platform descriptive models.

Note that a CIM models the requirements of a system and defines a common ontology in the system; the purpose of the PIM is to describe the business knowledge of a domain while the PDM models the system's execution platform. Once we know PIMs we can then transform the PIMs into other PIMs for interoperability needs or to produce PSMs targeting a specific platform based on PDM.

IV. Building a Metamodel Approach

To build a metamodel, our approach is based on four steps (Fig. 1).

First, we produce a reference framework of a given subject, it contains important elements that should be included in the metamodel. Then a second step is to gather existing models of the subject, note that the more models we gather the best is the quality of our metamodel. Then we analyze the concepts using matching technics. Them, finally we optimize the concepts in one metamodel containing an aggregation to all models.

Thus, find bellow the process to produce a model from a given subject:

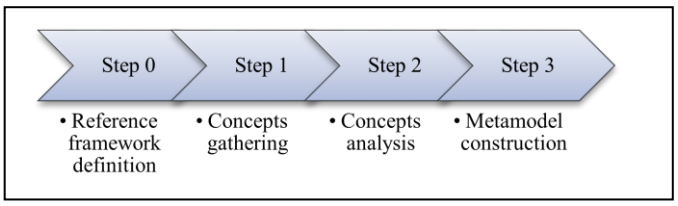


Fig. 1. Metamodel Construction Framework.

A. Step 0: Reference Framework Definition

The definition of a reference framework (Fig. 2) is an essential step to delimit the field of a search, it is a set of rules and concepts interconnected to carry out research and find out the relationship (R_i) between concepts (C_i).

In order to establish a metamodel of a target system, the reference framework allows us to delimit our system according to several views by framing system requirements [8] (as example using WH questions like what, who, by whom and how), so it allows us to generate a set of concepts and relationships (1) that must be included in the metamodel. It contains abstractions of the first layer of the metamodel.

$$Ref = \{Cj,Rj;\forall\ j \in N;\ Cj \in Ref,\ Rj \in Ref\ \}/Cj,Rj\ \in PIMG \quad (1)$$

Where **Ref** is the reference framework, $\mathbf{PIM_G}$ is the metamodel, $\mathbf{C_x}$ is a concept inside the reference framework and $\mathbf{R_x}$ is the relationship between concepts.

B. Step 1: Concepts Gathering

We have several models of the same system that we want to create the metamodel, it's deferent views of the same system, each model (PIM) has its specificities that everyone considers important during its implementation.

There are several intersections between the different PIMs, thus, to obtain a reliable metamodel it is necessary to include in the meta-model all the intersections between the different PIM that the system can represent.

Later on, we will consider that a reference framework is an ideal metamodel (PIM_{ideal}) and we will call PIM_i a given modelization of the system.

C. Step 2: Concepts Analysis

As technics of concepts analysis, we can rely on the following approach [3]:

- Generative approach (Based on the name of the reassembled concepts).
- Interpretive approach (Functional interpretation of concepts).
- Hybrid approach (a combination of generative and interpretative approach)
- Factorial Analysis of Concepts (AFC); consists in factoring concepts according to the axes defined in the reference framework
- Relational Analysis of Concepts (ARC); consist in factoring the concepts according to the hierarchical level of their relations

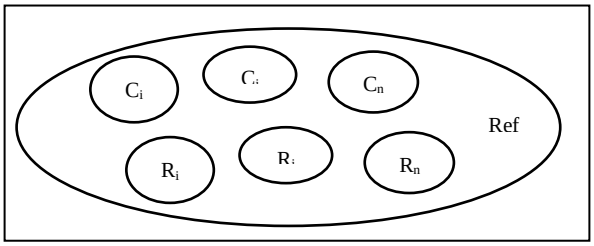


Fig. 2. Reference Framework Modelization.

D. Step 3: Metamodel Construction

The metamodel is an intersection of all models (see red zone in Fig. 3). Where Ideal PIM represents the frame of reference and PIM1, PIM2 and PIM3 are models of the same system.

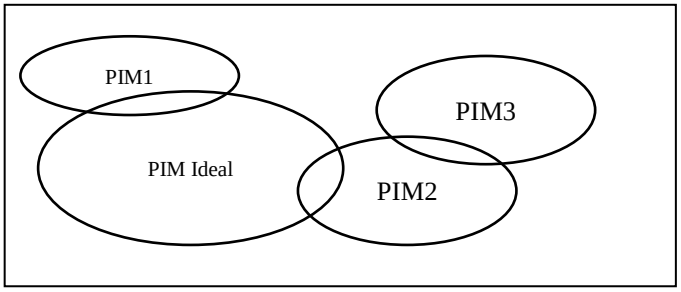


Fig. 3. Reference Framework Modelization.

Therefore, the metamodel will be the union of all analyzed concepts (2).

$$PIM_G = \bigcup_i^j PIMi \cap PIMj \quad / \; i \neq j \tag{2}$$

V. Case Study: Project Management

In the following, we will apply the explained approach to the Project Management business unit to produce a unique model for the project management field.

Among the most used project management methods [16], especially in the computer world, we find mainly the cyclic models (or agile mode such as SCRUM) and the stepped models (or predictive mode such as PRINCE 2, Y cycle or V cycle).

A. Project Management in Agile Mode

The way a project is managed is essentially characterized by two aspects: the division of the project into several stages also called "sprints" or iterations and the management of the team. Agile project management focuses on value. It allows project managers to provide methodically prioritized work of unparalleled quality.

At the end of each sprint, the team that intervened reviews the work done. The lessons learned from critiquing an iteration are used to determine what should be the next stage of the project.

As the name suggests, this project methodology is flexible [15]. This setting explains why it appeals to customers looking for flexibility. When customers are expected to finalize their needs before prototypes can be tested, the associated costs and long lead times often cripple the project. Agile project management is about adapting to change, even at an advanced stage of development. The first is to offer the features with the greatest commercial value and necessary to launch the product. In the context of a managed project in agile mode, the quality of the communication and the managerial abilities of the project manager are essential.

B. Manage a Project with Predictive Methods

There are several types of predictive project methodologies. The best known are the V cycle or cascade cycle [6]. Originally born in the industrial sector, the V cycle consists of cutting into 9 phases that are divided between the strategic pole and the technical pole and are always the same:

- Requirements analysis
- Specifications
- Architectural design
- Detailed design
- Production
- Unit tests
- Integration tests
- Validation tests
- Functional tests

The entire project is treated in one block and the project managers who use this method know it at the fingertips because it is always the same. But this implies that there is little room for maneuver if the customer needs change along the way. Similarly, predictive project management requires validation steps essential to the continuation of the project.

Particularly suitable for a client who knows exactly where to go and how to get there, the predictive project mode is much less so for a large and innovative project that will need to evolve over the water and new recommendations made by the team. Because it is by experience much more efficient and offers the customer a very significant latitude agile project management is more common in the IT world than the predictive methods.

C. Reference Framework Definition

As there are many facets to see a problem [14], there are several types of reference framework. It's aimed to clarify the subject of research, present a complete vision and give a structured form to the answers of any subject.

In the following, we will use the "four worlds framework" introduced by Rolland in 1998 [5].

The original system framework (Fig. 4) contains four axes:

- The **subject world** contains the knowledge of the domain about which the proposed IS has to provide information. It contains real-world objects, which become the subject matter for system modeling.
- **The system world** includes specifications at different levels of detail of what the system does. It holds the modeled entities, events, processes, etc. of the subject world as well as the mapping onto design specifications and implementations.
- **The usage world** describes the organizational environment of the information system, i.e. the activity of agents and how the system achieves the work, including the stakeholders who are system owners and users. The usage world deals with the intentional aspects of the IS to be built whereas the subject world refers to the domain it shall represent.

- **The development world** focuses on the entities and activities, which arise as part of the engineering process itself. It contains the processes which create the information system i.e. processes that involve analysis and understanding of the knowledge contained in the other worlds and representation of that knowledge.

By applying the same framework to project management applied to an IT department, we obtain the following (see Fig. 5):

- **The subject world** contains the response to **What** is the project management (set of processes, roles, and indicators to lead the project).
- **The system world** includes specifications of **By What** we manage projects (using metrics and models).
- **The usage world** describes the organizational environment, it gives a response to **Why** we use project management (to create value, manage time and improve the quality).
- **The development world** contains the activities, it's more like **How** the project management will get results (using activities, and phases in order to produce work products).

This reference framework is a very important tool that gives us a clear understanding of our subject; also it's the first step to model the system.

D. Concepts Gathering

As we explained previously, we have several Project Management Methodologies (stepped models and cyclic patterns), considering IT domain we have PRINCE 2, PMP, V cycle… as stepped models and SCRUM, XP, TDD… as cyclic patterns. In the following, we will choose PRINCE 2 and SCRUM in our study.

1) PRINCE 2: Projects In Controlled Environment is a process-oriented method developed by the British government and accredited by Axelos, based on best practices in project management [10]. This flexible methodology applies to all companies and only for a defined scope project. "Built upon seven principles, themes and processes, PRINCE2 can be tailored to meet specific requirements" [2]. In this methodology (see Fig. 6) each process is determined based on input elements, outputs, objectives, and activities.

2) SCRUM: An agile project management methodology, it is used particularly in software development. It's "a framework within which people can address complex adaptive problems, while productively and creatively delivering products of the highest possible value." [1].

The SCRUM method implies that the project progresses through the setting up of series of "sprints" [11]. Each time a sprint is launched, a planning meeting is organized so that each team member can commit to the number of tasks they will be able to perform, as well as the creation of the "sprint backlog", which is the overall list of tasks to be done during the sprint.

Each day of the sprint, all team members (as well as the product manager and the SCRUM Master) must attend the daily SCRUM meeting. It should not last more than 15 minutes [12], and allows team members to share with others what they did the day before, what they are working on the same day, and identifying any issues that could hinder the smooth running of the sprint. This meeting allows you to synchronize all members of the team.

The end of a sprint is marked by a debriefing session to present the completed work to the product manager, and share information that can influence the next sprint.

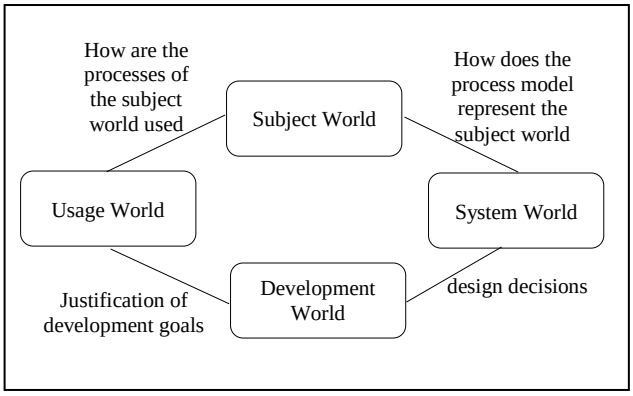


Fig. 4. The Four Worlds of Process Engineering.

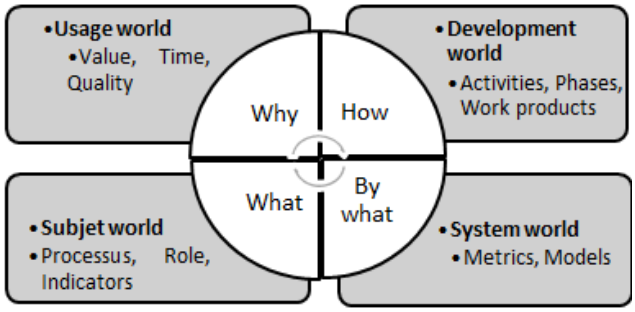


Fig. 5. Reference Framework Modelization.

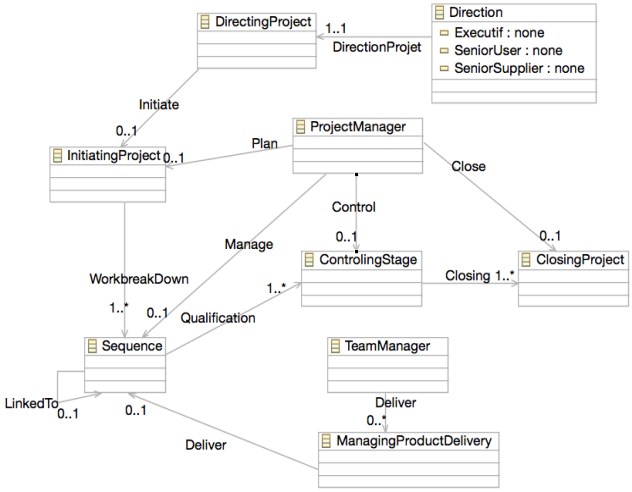


Fig. 6. PRINCE 2 Metamodel.

The method, therefore, proposes a very iterative approach to project management. The success of this method relies on the strict respect of each person's roles, as well as on short, rigorous and flexible work cycles. The respect of these rules grants at the same time a great autonomy and freedom to the whole team. Given the growing complexity of innovative projects, the SCRUM method seems to be the best solution to meet the execution requirements of the latter, which explains the success it meets today.

See in Fig. 7 below the model of SCRUM method:

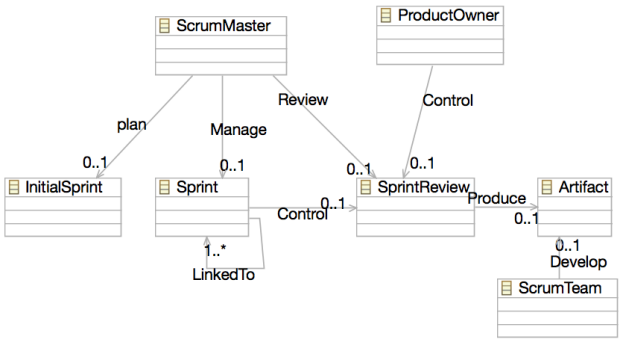


Fig. 7. SCRUM Metamodel

E. Concepts Analysis

A functional concept comparison will give us Table I.

TABLE. I. FUNCTIONAL COMPARISON BETWEEN PROJECT MANAGEMENT FRAMEWORKS

SCRUM MODEL	***PRINCE 2 MODEL***
Scrum Master	Project Manager
Sprint	Sequence
Development team	Team Manager
Initial Sprint	Initiating Project
Sprint Review	Controlling Stage
Artifact	Managing Product Delivery
Project Owner	Direction

F. Metamodel Construction

While making the intersection of the models, we got our final metamodel (Fig. 8).

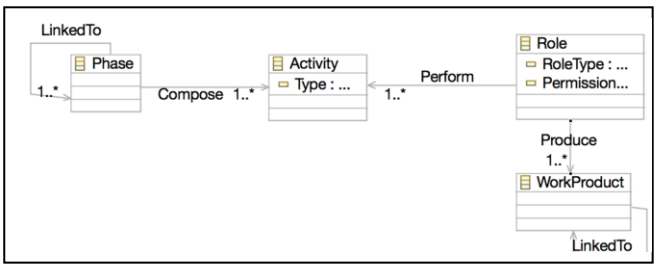


Fig. 8. Proposed Metamodel.

VI. CONCLUSION AND FUTURE WORK

We reviewed some basic concepts of MDA then we proposed an approach to extract a meta-model. Subsequently, we applied this approach to two project management frameworks (Agile and Predictive), using mechanisms to make the meta-models reliable. This work finally allowed us to establish a meta-model for project management that will later serve as the first step of our global meta-model of IT governance.

Our goal is to define a project management model that will be made up of other models by representing them more globally way.

Subsequently, our general model can constitute a foundation of communication between the different frameworks, so it can be at the origin of the enrichment of other frameworks.

REFERENCES

[1] Ken Schwaber, Jeff Sutherland, “The Definitive Guide to Scrum: The Roles of the Game”, 2017 Edition, available at www.scrum.org.

[2] AXELOS, “Managing Successful Projects with PRINCE2”, 2017 Edition.

[3] Z. Ibn Batouta, Multi-criteria analysis and advanced comparative study between automatic generation approaches in software engineering, 2015. Vol.81. No.3.

[4] HAMZANE, I., & BELANGOUR, A. (2019). Implementation of a decision system for a suitable IT governance framework. International Journal of Computer Science and Information Security (IJCSIS), 17(5).

[5] Rolland, C. (2012). A Comprehensive View of Process Engineering, 1–24.

[6] Bouchard, B., & Imbeau, G. (2019). Gestion de projets informatiques.

[7] S. Kent, “Model driven engineering,” in Proceedings of the Third International Conference on Integrated Formal Methods, pp. 286–298, Turku, Finland, May 2002.

[8] Gmati, I., Nurcan, S., Gmati, I., & Nurcan, S. (2012). Un cadre de reference pour analyser les exigences d’alignement métier / système d’information.

[9] A. Kleppe, J. Warmer, and W. Bast, MDA Explained: The Model Driven Architecture: Practice and Promise, AddisonWesley Professional, Boston, MA, USA, 2003, ISBN:032119442X.

[10] Christian Descheemaekere. AXELOS, La méthode Prince2, DUNOD.

[11] Chaplin David, SCRUM Méthode Agile, Editions ENI, OPEN IT.

[12] Ken Schwaber and Jeff Sutherland, The Scrum Guide, scrum.org.

[13] Jean-Claude Corbel, Management de projet : Fondamentaux - Méthodes – Outils, Eyrolles; Édition : 3 (28 juin 2012).

[14] Bégin, C. (2008). Les stratégies d’apprentissage: un cadre de référence simplifié. Revue des sciences de l'éducation, 34(1), 47-67.

[15] Rota, V. M. (2011). Gestion de projet agile: avec Scrum, Lean, eXtreme Programming... Editions Eyrolles.

[16] Peterson R., 2004, Information strategies and tactics for information technology governance, in Strategies for Information Technology Governance, book edited by Van Grembergen W., Idea Group Publishing.

[17] Eva-Maria Schön, Jorge Sedeño, A Metamodel for Agile Requirements Engineering, Journal of Computer and Communications, 2019, 7, 1-22, scientific research publiching.

[18] Souad AHRIZ, Abir EL YAMAMI, Cobit 5-Based Approach for IT Project Portfolio Management: Application to a Moroccan University, IJACSA, Vol. 9, No. 4, 2018.

[19] Abir EL YAMAMI, Souad AHRIZ, Representing IT Projects Risk Management Best Practices as a Metamodel, Engineering, Technology & Applied Science Research, Vol. 7, No. 5, 2017.

[20] Ferrari, R. (2019). Towards a Meta-model for Requirements-Driven Information for Internal Stakeholders. In Requirements Engineering: Foundation for Software Quality: 25th International Working Conference, REFSQ 2019, Essen, Germany, March 18-21, 2019, Proceedings (Vol. 11412, p. 262). Springer.

[21] OMG Meta Object Facility (MOF) Home Page (2006) www.omg.org/mof/

JsonToOnto: Building Owl2 Ontologies from Json Documents

Sara Sbai[1], Mohammed Reda Chbihi Louhdi[2], Hicham Behja[3], Rabab Chakhmoune[4]
LRI – Laboratory, ENSEM, Hassan II University, Casablanca, Morocco[1, 3, 4]
Research Laboratory on computer science innovation, Faculty of Sciences Ain Chock
Hassan II University, Casablanca, Morocco[2]

***Abstract*—The amount of data circulating through the web has grown rapidly recently. This data is available as semi-structured or unstructured documents, especially JSON documents. However, these documents lack semantic description. In this paper, we present a method to automatically extract an OWL2 ontology from a JSON document. We propose a set of transformation rules to transform JSON elements to ontology components. Our approach also allows analyzing the content of JSON documents to discover categorization in order to generate class hierarchy. Finally, we evaluate our approach by conducting experiments on several JSON documents. The results show that the obtained ontologies are rich in terms of taxonomic relationships.**

***Keywords*—JSON documents; OWL2 ontologies; ontology generation; transformation rules; information theory; classification; decision trees**

I. Introduction

A tremendous amount of documents exists on the web, especially semi-structured and unstructured documents, and it is continuously increasing which makes analyzing and retrieving these documents difficult. To overcome these difficulties, we need to consider their semantics.

Semi-structured documents on the web are available in different formats, such as XML, HTML and JSON.

JSON (JavaScript Object Notation) [1] is a lightweight data interchange format that was first specified and popularized by Douglas Crockford. It is based on a subset of the JavaScript Programming Language.

JSON has been widely used due to its simplicity and ability to be processed by both humans and machines easily. However, it lacks semantics due to the fact that it is schema less.

This work is supported by OCP group, Morocco.

Ontologies are essentially used to express semantics and integrate them in web applications.

Tom Gruber [2] defined an ontology as "an explicit specification of a conceptualization of a domain of interest", as for Swartout and colleagues [3], they defined an ontology as "a hierarchically structured set of terms for describing a domain that can be used as a skeletal foundation for a knowledge base". Most existing methods in ontology extraction from semi-structured data use XML documents as an information source.

In this work, we propose an automatic approach to build OWL2 ontology from a JSON document. We propose a set of transformation rules to translate JSON elements to ontology constructs. We also use data mining techniques to analyze the documents 'content in order to discover class hierarchy.

The remainder of this paper is organized as follows. Section II discusses related works in ontology extraction from semi-structured documents. Section III describes the proposed method for extracting OWL2 ontology from JSON document. Section IV presents the experimentations and the results. And finally, Section V concludes this paper, and discusses the perspectives of this work.

II. Related Works

For semi-structured data, we find different formats such as XML and JSON. In this section we will present a few existing methods in ontology extraction from JSON documents.

In [4], the authors propose an automatic approach to convert web data into OWL ontology. This method takes as input related JSON data objects transmitted from web services to applications. It builds semantic models for data instances.

The process of extracting and constructing semantics is divided into four steps: (1) JSON parsing: The authors parse the data according to key-value pairs in JSON objects and transform them into sets of triplets, (2) Semantic mapping: The data is stored as triplets similar to the description of RDF turtle [5]. During this step, triplet sets are analyzed to construct ontologies and their instances, (3) Semantic enrichment: The authors deploy automatic learning methods to improve the use of semantic data, they also take advantage of ontology reasoning to provide additional information on ontology (axioms definition, constraints definition, comments and labels addition) and finally, (4) Ontology merging: During this step, the authors align several ontologies according to the relations and concepts between them and refine the descriptions to build a unified ontology. The authors compare ontology constructs by using domain dictionaries and thesaurus and then merge ontologies according to semantic correspondences between them.

In [6], the authors proposed a protégé plugin named OWLET to assist the experts during the refinement phase of the ontology construction process. This plugin offers an approach to transform real world (image) objects to instances in order to import them to the existing ontology model for semi-automated classification. The image objects are first

transformed to GeoJSON files and then converted to instances to be imported to the existing ontology.

In [7], the authors proposed a method to build ontology knowledge base from semi-structured datasets (e.g. spreadsheet, JSON, XML…). The first step is extracting target columns from the semi-structured datasets. Then, the authors proposed a transformation table generator (TTG) and a cell value importer (CVI) to import values from semi-structured data sets. Next, the authors defined a Property expression (ProperyExp) to describe mapping information to map the extracted columns to properties. And finally, the ontology knowledge base is constructed.

In another approach [8], the authors propose KESeDa to extract knowledge from heterogeneous semi-structured data sources. The approach has several processing steps. Before the processing the authors detect the file format first. If the file is an XML or HTML document, the authors use existing tools to extract knowledge. However, if the file is a JSON document, the authors apply their own approach. The first step is preparing the source file for later annotations. Therefore, all values contained in a JSON object are encapsulated in a separate object. This object also contains a table structure as a placeholder to store all identified properties that can be assigned to predicates during the following processes. Then, the values are analyzed using a set of dictionaries. The collected results are stored in the reserved table structure. The approach also offers the possibility to combine several dictionaries to map compound predicates. The next step is analyzing the values according to their data type and format. Then, the keys of the JSON objects are analyzed. If the name of a key exactly matches a predicate, it will be stored in the table. Otherwise, synonyms for the key are searched in a dictionary and evaluated based on a possible mapping. Another step is to transform the extended JSON object source into a JSON-LD [9] representation by selecting an appropriate RDF predicate for each property. Finally, the authors try to find an appropriate RDF class for each object according to its set of predicates.

We tried to find other approaches that link ontologies to JSON documents. We found three existing research works that use document oriented databases for ontology learning. Document oriented databases store documents in JSON format.

NoSQL (Not Only SQL) [10] are databases that are not built on tables and do not use SQL to manipulate data. They are used to manage large amounts of data or big data. NoSQL databases do not support ACID transactions across multiple data partitions for scalability reasons. The NoSQL databases also respond to the CAP theorem which is more suitable for distributed systems.

NoSQL databases are generally classified into four categories:

- Key / Value: The data is simply represented by a key / value pair. The value can be a simple string of characters or a serialized object.

  Key / value databases are simple and allow quick retrieval of values required for application tasks such as managing user profiles or sessions or retrieving product names.

  Example: Dynamo (Amazon), Voldemort (LinkedIn), Redis, BerkleyDB, Riak.

- Column Oriented: Employ a distributed, column-oriented data structure that hosts multiple attributes per key. They are useful for distributed data storage, large scale and batch data processing, and exploratory and predictive analysis by statisticians and programmers.

  Example: Bigtable (Google), Cassandra (Facebook), HBase (Apache).

- Document oriented: They were designed to manage and store documents. These documents are in XML, JSON or BSON format. Document-oriented databases are useful for managing Big Data-sized document collections such as text documents, emails and XML documents.

  Example: CouchDB (JSON), MongoDB (BSON).

- Graph oriented: They are based on graph theory. It is based on the notion of nodes, relationships and properties attached to them. They are useful when one is interested in the relations between the data.

  Example: Neo4j, InfoGrid, GraphDB, AllegroGraph, InfiniteGraph.

In the first approach [11], the authors propose a framework for data integration. They use two NoSQL databases, namely MongoDB as document-oriented database and Cassandra as column-oriented database as a source of information an OWL ontology as a target. The approach is divided into three steps. First, the authors create a local ontology that matches each data source. They consider that each container defines a DL concept and each key label defines an object property or a data property. To organize the concepts in a hierarchy, methods of formal concept analysis (FCA) [12] were used.

In the second step, the authors align the local ontologies to create a global ontology. First they enrich each ontology using the IDDL reasoner [13], then they detect simple and complex correspondences between the two ontologies.

Finally, the authors propose a query language to translate SPARQL to the query language of each source.

In the second approach [14], the authors use MongoDB as a data source and an OWL ontology as a result. The authors define a set of transformation rules to create the ontology concepts and properties. This approach is divided into four stages: (1) Creating the ontology skeleton, (2) Identifying object properties and data type properties, (3) Identifying individuals and finally (4) Deducting axioms and constraints.

In the next section, we propose an automatic approach to build ontology from JSON documents.

III. Proposed Method

The process of building ontology from scratch is tedious and error prone, therefore, we propose an automatic approach to extract an OWL2 ontology from a single JSON document.

First, we analyze the data in these documents to discover categorization patterns in order to identify class hierarchy. This will eventually enable us to generate ontology with a deep taxonomy. Then we propose a set of transformation rules to convert JSON elements to OWL2 components.

A. Class Hierarchy Identification

1) Inheritance identification using key labels: In this step, we analyze key labels in nested JSON object to identify class hierarchy. First we extract all keys from every object, then we compare them. If we find keys that exist in an object and don't exist in another, we create a super class corresponding to the JSON array of objects. A dataProperty corresponding to the common keys is then extracted where the domain is the super class and the range is the type of the JSON value (i.e. String, Integer…). Then sub classes are created where the label is a concatenation of the word "SubClassOf" plus the label of the super class plus a number, this number ranges from 1 to the number of the obtained subclasses. In the example presented in Fig. 1, we have two common keys "ExternalID" and "Type". We will have a super class "Party", which will be the domain of two Data Properties "hasExternalID" and "hasType". Then we will create two sub classes, "SubClassOfParty1" and "SubClassOfParty2". We then extract four Data Properties, "hasFirstName" and "hasLastName" where the domain is "SubClassOfParty1", and "hasOrganizationName" and "hasListingName" where the domain is "SubClassOfParty2".

2) Inheritance identification using Data Mining techniques: Data mining techniques look for patterns in large data. One of the techniques that are widely used is classification. Classification is used to gather data instances with similar traits in categories or classes.

Classification methods include decision trees, Bayesian networks, and k-nearest neighbor. Decision trees aim to split a dataset into homogenous classes.

Our decision tree induction is a recursive algorithm. It is based on C4.5 algorithm (see Fig. 2).

C4.5 algorithm [15] was proposed by Ross Quinlan in 1993. It is the successor to ID3 (Iterative Dichotomiser 3), it takes into account continuous attributes. Decision trees have a leaf which indicates a class, or a decision node that specifies the test to be carried out. The outcome of the test can either be a leaf or a subtree. The nodes and leafs are connected with branches.

The decision node is chosen by using information theory [16]. Entropy and information gain are calculated. Shannon's entropy is a measure of uncertainty of a random variable. Entropy is defined by:

$$H(X) = -\sum_{i=1}^{n} p_i \log_b p_i \quad (1)$$

Where:

X : The set of examples

n: the number of values

b: The number of distinct values

p_i where i Є [1, n]: the probability of occurrence of an element

The information gain of a set of examples X with respect to a given attribute a_j is the entropy reduction caused by the partition of X according to a_j. It is defined by:

$$Gain(X, a) = H(X) - \sum_{v \in valeur(a)} \frac{|X_{a=v}|}{|X|} H(X_{a=v}) \quad (2)$$

```
{
"customer": {
"details": {
"party": [{
                    "type": "individual",
                  "externalID": "ABC123",
                    "firstname": "John",
                    "lastname": "Smith"
},
        {
                     "type": "organization",
                     "externalID": "Apple",
                         "organizationName": "AppleInc",
                   "listingName": "APPLE"
        }]
}
}
}
```

```
<owl:Class rdf:about="http://www.JsonToOnto.com#SubClassparty1">
<rdfs:subClassOf  rdf:resource="http://www.JsonToOnto.com#party"/>
</owl:Class>
<owl:Class  rdf:about="http://www.JsonToOnto.com#SubClassparty2">
<rdfs:subClassOf rdf:about="http://www.JsonToOnto.com#party"/>
</owl:Class>
```

Fig. 1. An Example of a JSON Object with the Proposed Transformation.

DecisionTreeConstruction {Decision Tree Construction Algorithm}
Input:
- A class C
- Attributes {A1, ..., An}
- A set of data N

Output:
- The decision tree

IF all the examples of N are in the same class C**THEN**
  Create a leaf and assign the the current value of C to it
ELSE
  Select the attribute A the largest information gain as the best attribute
  Assign the label of the attribute A to the current node
  Split the data set N according to the values of the attribute A v1...vn to sub data sets N1, ..., Nn
  FORi = 1 to n
    DecisionTreeConstruction (C, Ai, Ni)
  END FOR
END IF
Return the decision tree
END

Fig. 2. Decision Tree Construction Algorithm.

Where:

$X_{aj = v} \subset X$ is the set of examples where the attribute a_j takes the value v and

$|X|$ indicates the cardinal of X .

The attribute with the highest information gain is used as a decision node.

In our approach, the predefined class is unknown, therefore we consider every attribute as a predefined class and we construct a decision tree for each one. Next, we determine the depth of each tree and choose the tree with the least depth since it leads to homogenous categories the fastest. Finally, we consider its leafs as our categories. The next figure describes our algorithm (Fig. 3).

To illustrate our algorithm, we use the JSON object presented in Fig. 4 as example.

First we construct our decision tree. We obtain the result presented in Fig. 5.

We consider the leafs of our trees as our sub classes. We have the presented in Fig. 6.

As presented in our results, the names of our sub classes are a concatenation of "SubClass" and the name of the super class followed by a number.

B. Transformation Rules

In this paragraph, we present the proposed transformation rules. We illustrate these rules through the example presented in Fig. 7.

Rule 1: Every JSON object is transformed to a simple class in the ontology. Example:

<owl:Class rdf:ID="Class1"/>

<owl:Class rdf:ID="director"/>

"Class1" corresponds to the main JSON object.

Inheritance detection {Inheritance detection Algorithm}
Input:
- Attributes {A1, ..., An}
- A set of data N

Output:
- List V designating the categories

Let d: Positive integer designating the tree's depth
Let C: A class
FOR each attribute Ai
C <- Ai
DecisionTreeConstruction(C, Ai, Ni)
d <- The tree's depth
END FOR
Choose the tree with the least depth
Select the leafs of the tree and add them to the list V
Remove duplicates from the list V
Return V
END

Fig. 3. Inheritance Detection Algorithm.

Rule 2: We analyze the key-value pairs. If the value is a simple type (string, number (integer, double) or boolean (true, false)), then we have a dataProperty where the domain is the class corresponding to the object containing the key and the range is the type of the value into the ontology. The dataProperty name is the concatenation of the "has", the key label and the label of the domain class. For example, see Fig. 8.

Rule 3: If an object B is integrated into an object A, we transform this integration into an ObjectProperty where the domain is the class corresponding to object A and the range is the class corresponding to object B. The name of the object property relationship is the concatenation of the word "has" with the name of the object B. For example, see Fig. 9.


```
[ {
"id": "0001",
   "type": "donut",
   "name": "Cake",
   "ppu": 0.55,
   "batters":  {
        "batter": [
             { "id": "1001", "type": "Regular" },
             { "id": "1002", "type": "Chocolate" },
             { "id": "1003", "type": "Blueberry" },
             { "id": "1004", "type": "Devil's Food" } ]
},
   "topping": [
             { "id": "5001", "type": "None" },
             { "id": "5002", "type": "Glazed" },
             { "id": "5005", "type": "Sugar" },
             { "id": "5007", "type": "Powdered Sugar" },
             { "id": "5006", "type": "Chocolate with Sprinkles" },
             { "id": "5003", "type": "Chocolate" },
             { "id": "5004", "type": "Maple" }   ]
    },
    {
"id": "0002",
"type": "donut",
"name": "Raised",
"ppu": 0.55,
    "batters": {
         "batter": [ { "id": "1001", "type": "Regular" }]
             },
    "topping": [
             { "id": "5001", "type": "None" },
             { "id": "5002", "type": "Glazed" },
             { "id": "5005", "type": "Sugar" },
             { "id": "5003", "type": "Chocolate" },
             { "id": "5004", "type": "Maple" }]
   },
   ……..
]
```


Fig. 4. Inheritance Detection Algorithm.

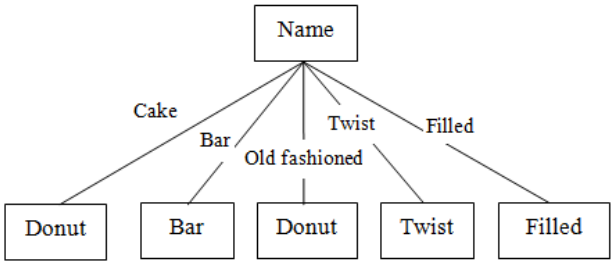


Fig. 5. Obtained Decision Tree with the Least Depth.

```
<owl:Class
rdf:about="http://www.JsonToOnto.com#SubClassClass11">
<rdfs:subClassOf
rdf:resource="http://www.JsonToOnto.com#Class1"/>
</owl:Class>
<owl:Class
rdf:about="http://www.JsonToOnto.com#SubClassClass12">
<rdfs:subClassOf
rdf:about="http://www.JsonToOnto.com#Class1"/>
</owl:Class>
<owl:Class
rdf:about="http://www.JsonToOnto.com#SubClassClass13">
<rdfs:subClassOf
rdf:about="http://www.JsonToOnto.com#Class1"/>
</owl:Class>
<owl:Class
rdf:about="http://www.JsonToOnto.com#SubClassClass14">
      <rdfs:subClassOf
rdf:about="http://www.JsonToOnto.com#Class1"/>
</owl:Class>
```

Fig. 6. Theresult OWL from the JSON Object in Fig. 4.

```
{
     "title": "The Social network",
     "summary": "On a fall night in 2003, Harvard undergrad
and
programming genius Mark Zuckerberg sits
                    down at his computer and heatedly begins
working (...)",
     "year": 2010,
     "director":   {    "last_name": "Fincher",
                         "first_name": "David"}
}
```

Fig. 7. Anexample of a JSON Object.

IV. Experiments and Results

To evaluate the efficiency of our approach, we implemented it with java and jena api. Our application allows building an OWL2 ontology from a JSON document. We use as an illustrative example the JSON object presented in Fig. 4. We obtained as a result the ontology presented in Fig. 10.

First, we used the inheritance identification using key labels to extract sub classes but we didn't find any results. Next, we applied our inheritance detection algorithm using decision trees. We were able to identify four sub classes. Finally, we applied our transformation rules to generate the final ontology. In total, we obtained seven data properties and three object properties.

```
<owl:DatatypeProperty rdf:about=http://www.JsonToOnto.com#hasfirst_name_director>
<rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
<rdfs:domain rdf:resource="http://www.JsonToOnto.com#director"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:about="http://www.JsonToOnto.com#haslast_name_ director">
<rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
<rdfs:domain rdf:resource="http://www.JsonToOnto.com#director"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:about="http://www.JsonToOnto.com#hasyear_Class1">
<rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#integer"/>
<rdfs:domain rdf:resource="http://www.JsonToOnto.com#Class1"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:about="http://www.JsonToOnto.com#hassummary_Classe1">
<rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
<rdfs:domain rdf:resource="http://www.JsonToOnto.com#Class1"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:about="http://www.JsonToOnto.com#hastitle_Class1">
<rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
<rdfs:domain rdf:resource="http://www.JsonToOnto.com#Class1"/>
</owl:DatatypeProperty>
```

Fig. 8. The Result OWL from the JSON Object in Fig. 7 by Applying Rule 2.

```
    <owl:ObjectProperty rdf:about="http://www.JsonToOnto.com#hasdirector">
    <rdfs:range rdf:resource="http://www.JsonToOnto.com#director"/>
    <rdfs:domain rdf:resource="http://www.JsonToOnto.com#Class1"/>
</owl:ObjectProperty>
```

Fig. 9. Theresult OWL from the JSON Object in Fig. 7 by Applying Rule 3.

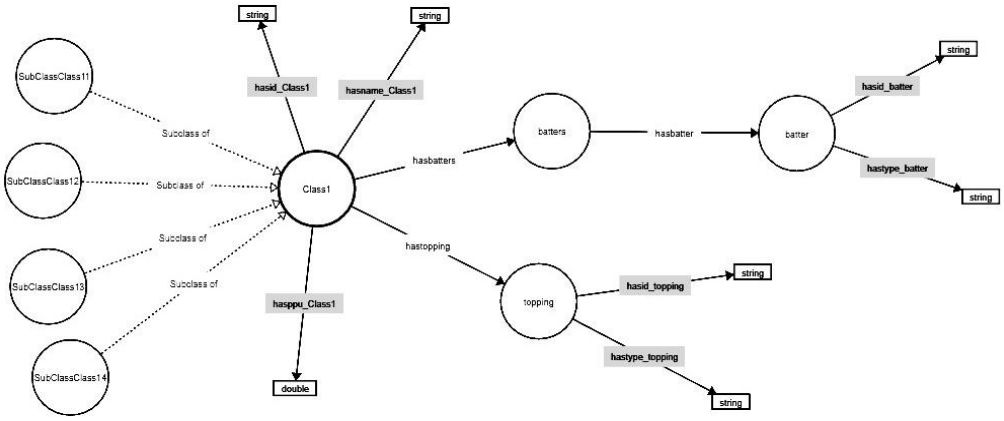


Fig. 10. The Result OWL 2 Ontology.

We also conducted our approach on five different data sets. The sets are all various JSON objects with different sizes. The results of our experiments are presented in the technical report available at http://apps.ensam-umi.ac.ma/jsontoonto/.

V. Conclusion and Perspectives

In this paper, we have proposed an automatic approach to extract an OWL2 ontology from a JSON document. We were able to extract deep taxonomies from JSON documents using the key labels and data mining techniques. We also were able to transform the JSON document elements to OWL components by proposing a set of transformation rules. In order to give the obtained ontology classes a meaningful name, we add the intervention of a domain expert to semantically validate the generated schema and rename the ontology classes.

We developed a prototype that implements our proposal and we tested it using various JSON documents. The obtained results were satisfactory. However, this is still the first version of our prototype and there is still plenty of room for improvement. We are currently working on converting larger JSON documents.

As we mentioned before, we used a single JSON document to extract an OWL2 ontology. We intend to improve our approach to handle multiple documents as an information source.

Acknowledgment

This work is supported by the project “Knowledge Management for Development in the Context of OCP Group (KM4Dev – OCP Group)” granted by OCP Group, Morocco.

References

[1] Crockford, D. JSON: The fat-free alternative to XML. Proc. OfXML. Vol. 2006.

[2] T.Gruber, “Ontology”, in the Encyclopedia of Database Systems, Ling Liu and M. Tamer Özsu (Eds), Springer-Verlag, 2009.

[3] B.Swartout, R. Patil, K. Knight and T. Russ, "Towards Distributed Use of Large-Scale Ontologies" Spring Symposium Series on Ontological Engineering. Stanford University, CA. 1997, Pages:138-148.

[4] Y. Yao, H. Liu, J. Yi, H. Chen, X. Zhao & X. Ma, “An automatic semantic extraction method for web data interchange”,The 6th International Conference on CSIT. ISBN: 987-1-4799-3999-2, 2014.

[5] RDF 1.1 Turle, W3C Recommendation–25 February 2014: https://www.w3.org/TR/2014/REC-turtle-20140225/.

[6] T.J. Lampoltshammer and T. Heinstracher, “Ontology Evaluation with Protégé using OWLET”, Infocommunications Journal, 2014.

[7] G.H. Baek, S.K. Kim & K.H. Ahn, “Framework for automatically construct ontology knowledge base from semi-structured datasets”, the 10th International Conference for Internet Technology and Secured Transactions (ICITST), 2015.

[8] M. Seidel, M. Krug, F. Burian & M. Gaedke,“KESeDa: Knowledge extraction from heterogeneous semi-structured data sources”, In Proceedings of the 12th International Conference on Semantic Systems, pages 129-136, 2016.

[9] JSON-LD 1.0, A JSON-based Serialization for Linked Data. W3C Recommendation – 16 January 2014: https://www.w3.org/TR/json-ld/.

[10] A. Nayak, A. Poriya & D. Poojary, “Types of NoSQL Databses and its comparison with Relational Databases”, International Journal of Applied Information Systems (IJAIS)–ISSN: 2249-0868 Volume 5– No.4, March 2013.

[11] O. Curé, M Lamolle & C Le Duc,”Ontology Based Data Integration Over Document and Column Family Oriented NOSQL”. SSWS 2011.

[12] O. Curé and R. Jeansoulin,“An fca-based solution for ontology mediation”. JCSE, 3(2):90-108, 2009.

[13] A. Zimmermann and C. Le Duc,“Reasoning with a network of aligned ontologies”.In Proceedings of the 2nd International Conference on Web Reasoning and RuleSystems (ICWRRS), pages 43-57, 2008.

[14] H. Abbes, S. Boukettaya & F. Gargouri, “Learning Ontology from Big Data through MongoDB Database”. In: the 12th ACS/IEEE InternationalConference on Computer Systems and Applications (AICCSA); 2015.

[15] J. Ross Quinlan, “C4.5. Programs for Machine Learning”, Elsevier Inc, 1993.

[16] T.M. Cover & J.A. Thomas, “Elements of Information Theory”, Second Edition, 2006.

Enhancement of Packet Delivery Ratio during Rain Attenuation for Long Range Technology

MD Hossinuzzaman[1], Dahlila Putri Dahnil[2]
Center for Software Technology and Management (SOFTAM)[2]
Faculty of Information Science and Technology (FTSM)[1,2]
Universiti Kebangsaan Malaysia (UKM) [1,2]

***Abstract*—Countries with tropical climates experience various weather changes throughout the year. The weather can drastically change from extremely hot and humid to a complete downpour in a twenty-four-hour cycle. Different atmospheric conditions such as atmospheric gas attenuation, cloud attenuation, and rain attenuation can cause interruption of electromagnetic signals and weaken the radio signals. The amount of attenuation is mostly depending on the raindrops. Rate of attenuation by rain depends on the composition, temperature, orientation, shape and fall velocity of raindrops. In this paper, we measure the effect of different atmospheric attenuations, particularly due to rain for non-line-of-sight environments and proposed a LoRa (Long Range) based wireless mesh network to enhance packet delivery ratio (PDR). We experimented with the LoRa based wireless network by taking the packet delivery ratio at different times of the day when there was no rain and performed some experiments while raining. The experiments conclude that PDR is affected by different volumes of rain where PDR decreases significantly from 100% when it was not raining and decreases to 89.5% when it rains. The results also show that the LoRa device can successfully transmit up to 1.7km in a line-of-sight environment and around 1.3km in a non-line-of-sight environment without rain. The results show the effect of atmospheric attenuation to LoRa wireless network and become a consideration factor when designing any LoRa applications for outdoor deployment.**

Keywords*—LoRa; packet delivery ratio; wireless mesh network; atmospheric attenuation; rain attenuation

I. Introduction

Internet of Things (IoT) is a fast-growing communication model to connect millions of devices to make our everyday life easier. IoT is related to sensors, wireless technology, cloud server services and possibly the applications. The main function of IoT is to identify each object digitally. An IoT system consists of processors, sensors, and communication of hardware collection. IoT devices connect to other devices or IoT gateway to collect the sensor data and act on the information they receive. In this present world, IoT is related to consumer segment, wearable devices, health care, smart buildings, smart city, and agriculture. It is expected that there will be 50.1 billion users of IoT by the year of 2020[1]. Bluetooth, WiFi, and Zigbee are the wireless communication technology that allows devices to transmit data wirelessly in a short-range compared to LoRa technology for a longer range [2-3]. LoRa uses low power consumption and highly secured data transmission [4]. Lora WAN is based on the low power wide area network (LPWAN) protocol. In LoRa technology, LoRa enables the connection between the end device and LPWAN to deliver data. LoRa offers to compile features for IoT applications. This technology can utilize in public, private and hybrid networks. Key features of LoRa technology are long-range, low power, secured data transmission, high capacity and low cost [5]. It is also easy to install, extremely economical and very flexible to implement. LoRa uses the license-free radiofrequency. It uses 169MHz, 433MHz, 868MHz, and 915MHz [6] bands and can transmit data more than 10km in rural areas.

Data packet that is transmitted between the sender and receiver occasionally failed to reach its specific destination causes packet loss [7]. For high priority data [8], any packet loss requires retransmission and thus requires more energy.

Earth atmosphere is one of the factors that can cause signal attenuation. Atmospheric attenuation is the discontinuation of the power of electromagnetic radiation due to weather or atmospheric variation [9]. There is no effect on millimeter-wave because of multipath. But some causes of the earth's atmosphere can affect the millimeter wavelengths. Like rain attenuation, gaseous absorption, cloud attenuation can affect the millimeter wavelengths. Any discontinuation of signals can create packet loss.

In this paper, we proposed a LoRa-based wireless mesh network [10] to improve the packet delivery ratio and to measure the effect of different atmospheric attenuations, particularly due to rain for non-line-of-sight environments. The testbed is also used to evaluate the maximum distance for LoRa data transmission during different line-of-sight and non-line-of-sight environments. We experimented with our LoRa based wireless network by taking the packet delivery ratio when there was no rain and performed at different timings of a day and some experiments while raining.

II. Related Works

Previous studies have been focusing on the packet delivery and some outdoor applications of LoRa technology. In [11], LoRa wireless mesh network system is used to monitor a large-area IoT sensor. They use 20 LoRa devices with mesh network topology deployed in 800*600 meters' area. A gateway was installed to collect data from each end node in 1-minute intervals. The LoRa wireless mesh network module used Nuvoton nano100LE3BN, ARM M0 microprocessor and Semtech SX1278 LoRa RF 430MHz transceiver with a 1.9dBi gain helical antenna. Nodes and gateways are powered by a 5-

V USB adapter. This system achieves an average packet delivery ratio of 88.84%.

In [12], the transmitter and receiver module RFM95W transceiver hope RF was used in high and low frequency. This unit is integrated with SX1276 which enables the comparison between frequencies and wireless transmission. The network was set up in a suburban/rural area to measure the performance in line-of-sight and non-line-of-sight environments. The effects of the spreading factor (SF) and bandwidth (BW) were tested on the Received signal strength indication (RSSI) value. Omni-directional 3dbi antenna was used. The transmit power was set to 23dBm. The result shows the minimum RSSI value recorded is -98dBm under a line-of-sight environment at a distance of 1.17km. The maximum RSSI value of -80dBm is in 20m distance. The research concludes that the topical climate has a big impact on radio signal attenuation.

In [13], researchers have proposed two approaches like nodes with modified IoT applications, which retransmit the lost data and another one is to help the neighbouring nodes to transmit data to solve and increase the success rate of massage delivery in LoRaWAN. They designed a network setup of 3.54dBi antenna with the RN2483 LoRa module. The gateway uses the IC880A LoRa concentrator with an 8dBi antenna. 8 sensor boxes are using the RN2483 module installed on the rooftop of a building. This network setup reduces the data loss rate from 100% to 25.51% by applying this IoT application-based node that retransmits the lost data and helps the neighbour to transmit data.

In research work [14], they designed a network set up to monitor and track mental disorder persons using LoRa technology. The end device is installed on the patient's body and the gateway is installed in the hospital and other public locations. The gateway is connected with several end devices and to the server. All end nodes are monitored from the server. The system is designed for line-of-sight and non-line-of-sight environments. The end device consists of LoRa shield, Arduino UNO, GPS sensor, WiFi module and set of batteries. The gateway is connected with an application server. They used a mobile application for monitoring by a medical officer. The result of this research shows that the increase of RSSI value and power consumption of the system depends on the distance of end nodes and gateway.

Research in [15], developed a remote monitoring system of radio data infrastructure that uses LoRa technology. The researcher used LoRa module RF1276, Arduino MEGA board, GPS module for tracking and SD card to save data on the transmitter side. The LoRa module RF frequency is 867MHz, RF factor is 2048 and RF bandwidth is 125KHz. The LoRa module connected with a whip antenna using the 867MHz band. The receiver side contained LoRa RF1276 module connected with the gateway and internet, which store the data in the Dataino server with latitude and longitude tracker included. After considering the communication power, cost, security, and bandwidth, the network system built in this research is a better option to deploy in a remote monitoring system, agriculture, smart home, and wireless sensor network.

Research [16], create a LoRa wireless technology-based network system to control the drip irrigation system. For the end device, researchers used LoRa module RA-02, Atmega 328p microcontroller, D-size battery and low-dropout voltage regulator to control the power for MCU. Researchers used the same components for master node and end-nodes but the master node was added with an extra WiFi module so that it can transmit signals or data to the controller. In the controller PC, there was a GUI application for controlling all the end devices and master devices. Implementation of this proposed system gives a cost-effective solution for the drip irrigation system with a reliable radio link that covers a large area and has long-time power backup.

III. Proposed Mesh Network

This section shows the proposed network model and the description of the physical components and software used in the project. A LoRa compatible temperature and humidity sensor DHT11 is attached to the end node for measuring temperature. Nodes are deployed at different locations, taking the reading at different weather conditions with different line-of-sight and non-line-of-sight environments. The temperature reading is sent from an end node to a master node which is then forwarded the data to a gateway. The network is built with LoRa RFM 915MHz shield, Arduino UNO board, 915MHz SMA antenna, 5V power supply is required to power this network. We show the flow chart of this proposed network in Fig. 1.

In this study, LoRa shield is used as a transmitter module with Arduino compatible device where it can transmit data for a long-range. The data rate for our network is taken as 50kbps. For the second part of this network, the master node is responsible for receiving data from the end node and sends it to the gateway. The master node also consists of the same components as the end node but without the temperature sensor. A gateway collects data from the master node and sends them to an application server. Gateway is connected to the application server through the USB port of Arduino UNO. In Fig. 2 the network architecture is shown.

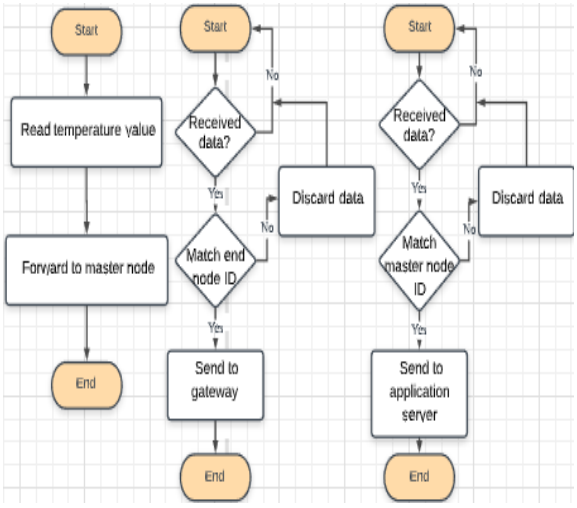


Fig. 1. Flow Chart for End Node, Master Node and Gateway.

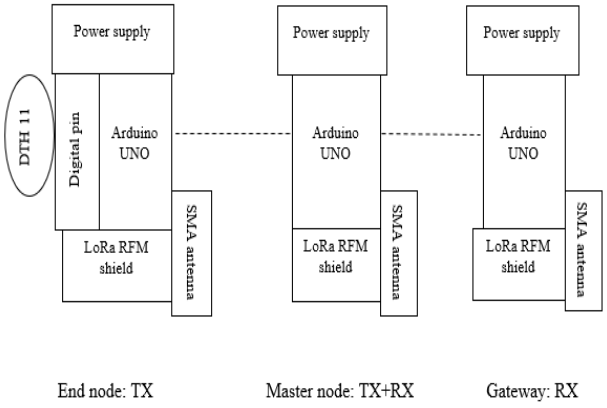


Fig. 2. The Proposed Network Diagram.

To visualize the data, we have taken the Arduino IDE application as our application server. All the data that the gateway received is displayed in the serial monitor of the Arduino IDE application. An example of a serial monitor is shown in Fig. 3.

In this research, PDR is taken to measure the performance evaluation. High PDR value indicates a smaller number of packet loss. To calculate the PDR value, the following equation is used:

$$Packet\ Delivery\ Ratio\ (PDR) = \frac{\text{Total packets received}}{\text{Total packets sent}} * 100 \qquad (1)$$

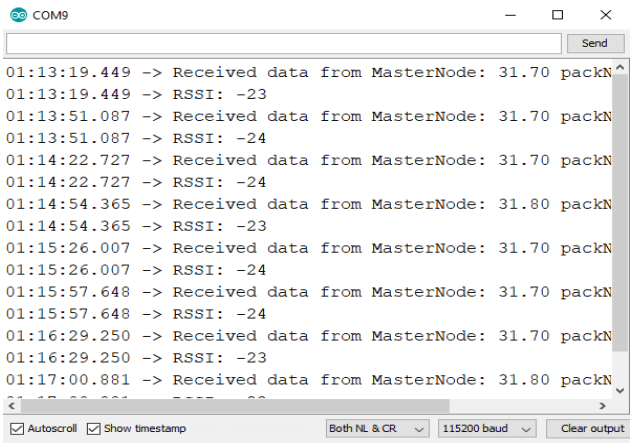


Fig. 3. Serial Monitor Graphical user Interface.

Fig. 4. Distribution of Nodes.

We have chosen different weather and location to deploy our network and carried out the experiments. Data received by the gateway is calculated to obtain the number of packet losses using the expression in (1). All data are visualized in the serial monitor of the gateway. The PDR results show the effects on data transmission in different weathers and locations.

Fig. 4 shows an example of locations where devices were installed at different places for the experiments. The figure shows the distribution of node, master node, and gateway.

IV. Results and Discussion

In this study, four types of experiments were conducted at different times of the day and different weather such as with and without rain. Four categories of experiments are performed as follows: 1) to measure PDR in a non-line-of-sight environment; 2) to measure PDR in a line-of-sight environment; 3) to measure PDR during rain and without rain; and 4) to measure maximum distance with the highest successful data transmission in mesh and star network.

1) PDR in Non-line-of-sight: We have tested our proposed LoRa based network by sending 38 data packet and a duration of 20 minutes is allocated to measure the PDR value in the non-line-of-sight environment. The network was installed in different places with obstacles between the devices. Experiments were conducted at 9.00 am, at 1.00 pm, 9.00 pm and 1.00 am with cloudy weather without rain. The distance between nodes and gateway were varied between 100m, 200m, 300m, and 400m. The experiments were performed with data sent from the end node to the master node which then forwarded to the gateway. The results show that the PDR value when we vary the distances from 100m to 400m remains 100%. We performed another experiment to verify our results by repeating the experiment with the same setup as before but on different days only at 400m area and the time recorded was 10.30 am. Fig. 5 shows the results of PDR value remain 100% on a different day at 10.30 am. Experiment results show that there is no difference in PDR for this experiment as well and verified the stability of our proposed network in a non-line-of-sight environment.

2) PDR in Line-of-sight: The experiments to measure PDR in a line-of-sight environment were conducted by sending 38 data packet and in 20 minutes. This network was installed in different places without any obstacles. Experiments were performed at 9.00 am, 1.00 pm, 9.00 pm and 1.00 am without rain. Distance variations from node to gateway were varied between 100m to 400m area. The experiments were conducted by data sent from the end node to the master node which then forwarded to the gateway. Data transmission of this network was visualized and collected from an application server. When we vary the distance from 100m to 400m the results show that the PDR value remains 100%. To verify the results, we performed another experiment with the same setup as before but on different days only at 400m area and the time recorded was 11.30 am. PDR value remains the same 100% shown in Fig. 6. The experiment results show that there is no difference in PDR for this

experiment as well. It verified the stability of our proposed network in a line-of-sight environment.

3) PDR during rain and without rain: To collect the PDR value during rain, we have tested our proposed LoRa based network in different amounts of rain. We observe closely the weather forecast to prepare for the experiments. Collecting the PDR values during rain is the most challenging phase in our experiments because the rain does not always occur according to the weather forecast. The experiments took more than three months to catch for rain. We repeat the same process in the experiment by sending 38 data packet and a duration of 20 minutes is allocated to measure PDR. We installed our devices in 200m area of non-line-of-sight and all the devices were placed under a roof to prevent rain from damaging the devices. This network was installed in a place with obstacles between them. The experiments were conducted in different amounts of rain. During the experiment time duration, the rain intensity was measured by a rain gauge. Captured rain intensities were 2.4mm, 3.1mm, 6.2mm, 10.7mm, 12mm, 21.1mm, 22.3mm, 29mm, 41mm, and 45mm. Table I shows the scale of measure the rain intensity.

PDR values in rain are shown in Fig. 7. Results show that the gradual increase of rain increases the amount of packet loss gradually. It shows the decrease of PDR value from 100% to 89.50% as the rain increased from light to heavy rain.

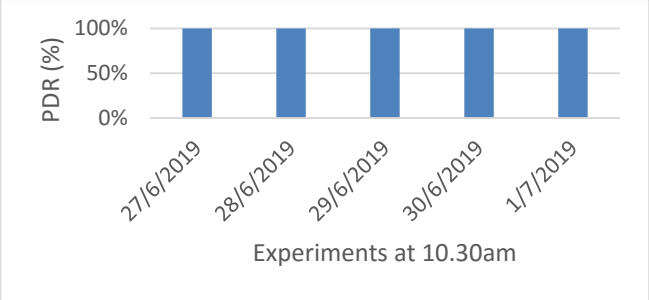


Fig. 5. PDR in 400m Non-Line-of-Sight.

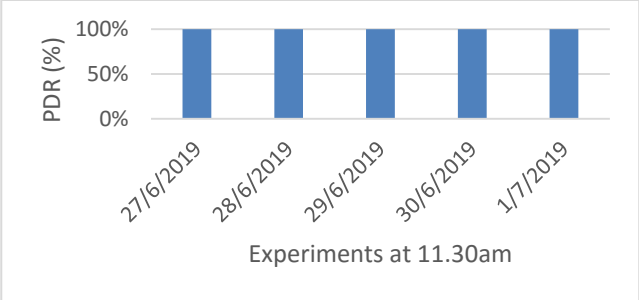


Fig. 6. PDR in 400m Line-of-Sight.

TABLE. I. RAIN INTENSITY MEASUREMENT SCALE

	Rain amount in mm	Category
1	1-10	Light rain
2	11-30	Moderate
3	30-60	Heavy
4	>60	Very heavy

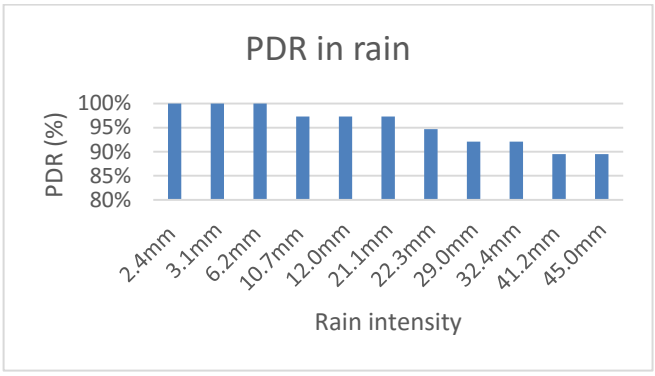


Fig. 7. PDR in Rain at 200m with Mesh Network.

We have installed our network at the same place where we installed our network during rain experiments to measure the PDR value without rain. We repeat the same process of sending 38data packets in a time duration of 20 minutes. Experiment results show that the PDR remains 100%. We repeat the experiments with the same setup but vary the distance between the end node, master node, and gateway to verify the results. The distance between devices varied between 100m to 400m area without rain. The experiment results are shown in Fig. 8. Results show that PDR value remains100% in every distance and there is no change in PDR.

We did the same experiments during rain with star network and deployed our devices in the same location and environment as installed during mesh network experiments. We conducted the experiments with the same amount of data packets and time duration. For these experiments, we used the end node and gateway with stat network configuration. The end node was installed at 200m and the gateway was installed at 0m and the data was visualized in the application server. Rain intensity was captured by a rain gauge and it was able to catch the rain of 3.2mm, 5.7mm, 6.1mm, 15.6mm and 23.1mm during experiments. Results show that the value of PDR starts decreasing with the increase of rain. It shows that the star network drops more packets with less intensity of rain. In Fig. 9 PDR in a different amount of rain at 200m with the star network is shown.

From the collected results of PDR value during rain and without rain, with different time, day, location and network, it proves that the different type of rain intensities attenuates the radio signal and affects the signal transmission process. The difference between experimental results of mesh and star network show that mesh network can provide better PDR value even in the high intensity of rain. In Fig. 10, the PDR value of mesh network in a different amount of rain from 2.4 mm to 45.0 mm and the PDR value of star network in a different amount of rain from 3.2 mm to 23.1 mm is shown.

4) Maximum distance with highest PDR: Our proposed network was built with the mesh network where all nodes sent data to their immediate node. To get the maximum distance of successful data transmission in line-of-sight and non-line-of-sight environments, we have deployed our network at different distances without rain. We started our experiments from a

500m distance by sending 38 data packets within 20 minutes of time duration and increased the distance gradually until the network starts dropping the PDR value from 100%. We have found that in a non-line-of-sight environment, this network can transfer the highest successful data of 100% PDR until 1.3 km from the end node to the gateway. During the experiment gateway was installed at 0 m, the master node was installed at 650 m and the end node was transmitting data from 1.3 km. In the line-of-sight environment it can provide 100% PDR value up to 1.7 km where the end node was at 1.7 km, the master node was at 850 m and gateway was installed at 0 m. After this distance, the PDR value starts decreasing. Results show that in 1.4 km of non-line-of-sight the PDR value decreases to 92.1% and in line-of-sight PDR drops to 97.3% in 1.8 km. Fig. 11 shows the highest successful transmission range in both environments and in Fig. 12 the device setup during the experiments is shown. In Fig. 13, the PDR value in different distances and PDR dropping points of this network and the maximum distance coverage with the highest successful PDR value in line-of-sight and non-line-of-sight is shown.

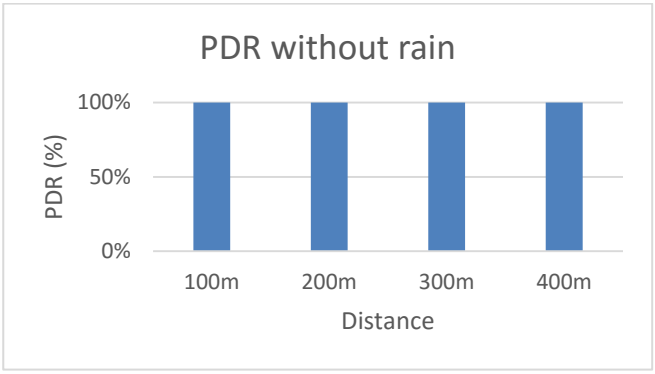


Fig. 8. PDR in without Rain.

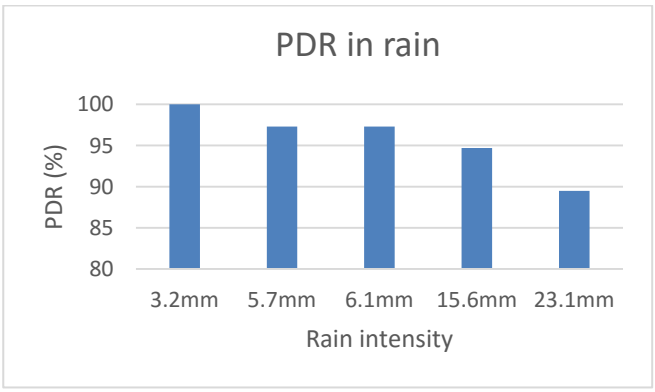


Fig. 9. PDR in Rain at 200m with Star Network.

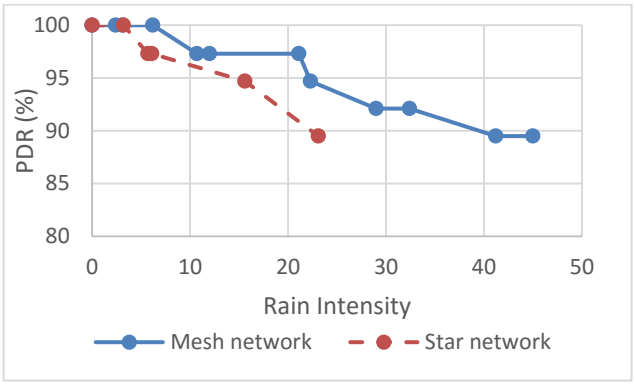


Fig. 10. PDR in different Rain Intensity.

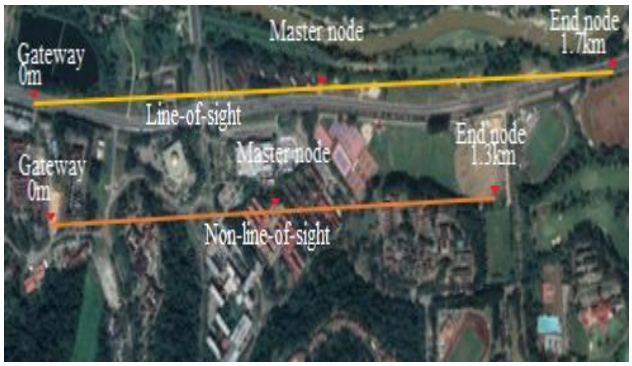


Fig. 11. Highest Successful Transmission Range.

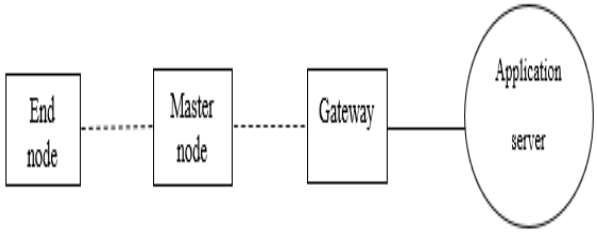


Fig. 12. Device Setup in the Mesh Topology.

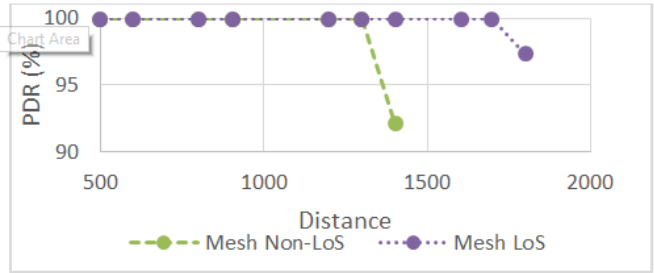


Fig. 13. PDR in Maximum Distance.

The main aim of this star network experiment is to measure the maximum distance of successful data transfer by the star network topology to compare it with the network that we have proposed, which is performing with a mesh network topology. For these experiments, we used the end node and gateway. Data received by gateway ware viewed in the Arduino IDE serial monitor. Experiments were conducted in line-of-sight and non-line-of-sight environments without rain. We started our experiments from a 200 m distance by sending 38 data packets within 20 minutes of time duration and increased the distance gradually until the network starts dropping the PDR value from 100%. Results from the experiments show that the maximum distance of successful data transfer value of PDR remains 100% unlit 500 m in a non-line-of-sight environment where the gateway was installed at 0 m and end node was transmitting data from 500 m, but when the distance increase to 600 m the PDR value decreases to 92.1%. In the line-of-sight environment, the maximum distance of receiving 100% PDR value is 800 m where the gateway was at 0 m and the end node was at 800 m. But in 900 m the PDR drops to 94.7%. In Fig. 14, we have shown the maximum successfully transmission range between nodes and gateway in both line-of-sight and non-line-of-sight environments and in Fig. 15 the device setup during experiments is shown. In Fig. 16, the experiment results and the dropping point of PDR for star network are shown.

Fig. 14. Highest Successful Transmission Range.

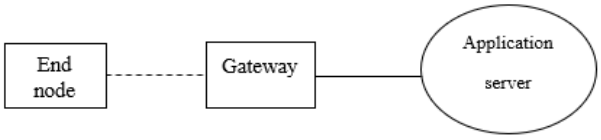


Fig. 15. Device Setup in the Star Topology.

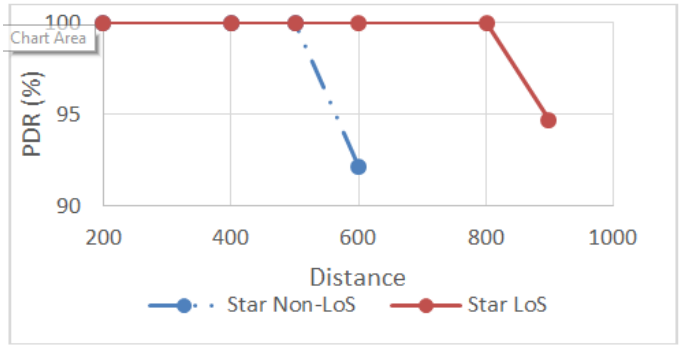


Fig. 16. PDR in Maximum Distance.

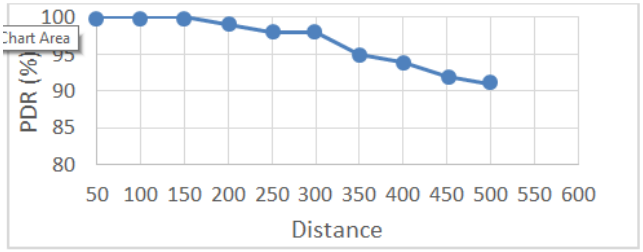


Fig. 17. PDR in the Maximum Distance for ZigBee.

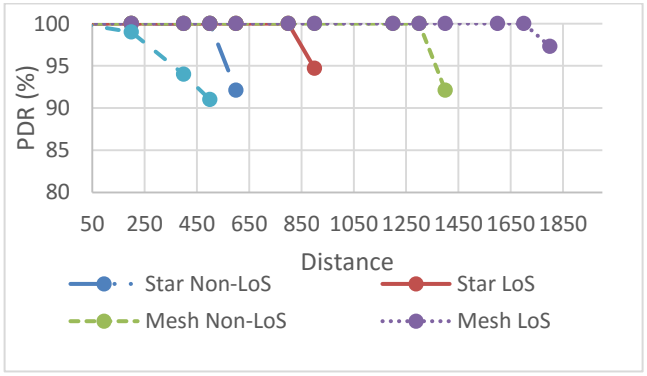


Fig. 18. PDR Value Comparison.

We make a comparison between our experiment with research done in [17] where the work designed and implemented data transmission by using Zigbee technology. The experiments show that when the distance increases, the packet loss rate also increases. The experiments started from 50 m distance and increase to 150 m where PDR was 100% but from 200 m PDR start decreasing. When the distance increased to 500 m the PDR decreases to 91%. In Fig. 17, the PDR of Zigbee in the different distances is shown.

Experiment results of the mesh network, star network, and ZigBee technology gives a clear indication that mesh topology covers longer distance than star topology or ZigBee technology in both line-of-sight and non-line-of-sight environments. Our proposed Mesh network provides better performance with a longer distance. In Fig. 18, the PDR comparison between LoRa based mesh and star network and a network based on Zigbee in the different distance is shown.

V. Conclusion

LoRa technology has become one of the most preferred wireless technology comparing to Zigbee, WiFi, and Bluetooth due to longer transmission range and low cost. However, data transmission during rain causes attenuation to radio signals. In this research, we proposed the LoRa-based mesh network to improve the packet delivery ratio in tropical climate experiencing rain and to provide the effects of atmospheric attenuation in the signal transmission process. The experiment results collected from different locations, during rain and without rain at various distances, shows that mesh network shows better performance with longer transmission distance compared to star network. The network behaves differently during different amounts of rain but it still shows that it can perform better than the star network in any weather conditions. One significant result obtained from the

experiment shows that the PDR decreases significantly from 100% to 89.5% by the effects of atmospheric attenuation. On the contrary, this network can successfully transmit data up to 1.7 km in line-of-sight and 1.3 km in non-line-of-sight environments with a 100% PDR value. The research concludes that atmospheric attenuation should be taken into consideration when designing any LoRa applications for outdoor deployment.

The future work can focus on processing a big volume of data received by the gateway, in the cloud. Our research is implemented on a fixed node for all end, master and gateway nodes. The enhancement can be done by having the end node as mobile nodes and see the mobility effect to the PDR.

ACKNOWLEDGMENT

The research is funded by Universiti Kebangsaan Malaysia (UKM) research project GUP-2017-068 and DCP-2018-001/2 under Research Centre for Software Technology and Management (SOFTAM), www.ftsm.ukm.my/softam, Faculty of Information Science and Technology.

REFERENCES

[1] F. Jindal, R. jamar, and P. Churi, "Future and Challenges of Internet of Things", International Journal of Computer Science & Information Technology(IJCSIT), vol. 10, no. 2, April 2018.

[2] M. Hasan, M. Rahman, M. Faruque, and M. Islam, "Bandwidth enhanced metamaterial embedded inverse L-slotted antenna for WiFi/WLAN/WiMAX wireless communication", Materials Research Express, vol. 6, no.8, 085805, 2019.

[3] D. Dahnil, S. Selamat, A. Bakar, R. Hassan, and A. Ismail, "A New Method for Battery Lifetime Estimation Using Experimental Testbed for Zigbee Wireless Technology. International Journal on Advanced Science", Engineering and Information Technology, vol.8, no.6, pp.2654-2662, 2018.

[4] M. Shahidul, M. Islam, A. Almutairi, G. Beng, N. Misran, and N. Amin, "Monitoring of the Human Body Signal through the Internet of Things (IoT) Based LoRa Wireless Network System", Applied Sciences 2019,9,1884, vol. 9, no. 9, 8 May 2019.

[5] N. Husein, A. Hadi, and D. Putri, "Evaluation of LoRa-based Air Pollution Monitoring System", International Journal of Advanced Computer Science and Applications, vol. 10, no. 7, pp. 391-396, 2019.

[6] A. Rahman, and M. Suryanegara, "The development of IoT LoRa: A performance evaluation on LoS and Non-LoS environment at 915MHz ISM frequency", 2017 International Conference on Signals and Systems (ICSigSys), pp-163-167, 03 July 2017.

[7] H. Overby, "Packet loss rate differentiation in slotted optical packet switched networks", IEEE Photonics Technology Letters, vol. 17, no. 11, pp. 2469 – 2471, 24 October 2005.

[8] A. Hajjawi, M. Ismail, N. Abdullah, R. Nordin, and O. Ertuğ, " A PDR-Based Scheduling Scheme for LTE-A Networks", Journal of Communications, vol. 11, no. 9, pp.856-861, September, 2016.

[9] A. Siles, J. Manuel, and P. García-del-Pino, "Atmospheric Attenuation in Wireless Communication Systems at Millimeter and THz Frequencies [Wireless Corner]", IEEE Antennas and Propagation Magazine, vol. 57, no.1, pp. 48-61, 2015.

[10] Q. Ameen, and R. Muniyandi, "Improvement at Network Planning using Heuristic Algorithm to Minimize Cost of Distance between Nodes in Wireless Mesh Networks", International Journal of Electrical and Computer Engineering (IJECE), vol. 7, no. 1 , pp.309-315, 2017.

[11] H. Lee, and K. Kee, "Monitoring of Large-Area IoT Sensors Using a LoRa Wireless Mesh Network System: Design and Evaluation", IEEE Transaction on Instrumentation and Measurement, Vol. 67, no. 9, pp.2177-2187, September 2018.

[12] K. Ahmed, J. Segaran, R. Hashim, and M.T. Jusoh, "LoRa propagetion at 433 MHZ in tropical climate environment". Journal of Fundamental and Applied Science, vol. 9, no. 3S, pp. 384-394, January 2018.

[13] S. Wang, and Tzu-Yang Chen, "Increasing LoRaWAN application - layer message delivery success rates", 2018 IEEE symposium on computers and communications, PoD. 1530-1346, 18268880, pp. 148-153, 19 November, 2018.

[14] Huang-Chen Lee, and Kai-Hsiang Ke, "Monitoring of large-area IoT sensors using a LoRa wireless mesh network system", IEEE Transactions on Instrumentation and Measurement, Vol. 67 , no. 9 , pp. 2177- 2187, September, 2018.

[15] Ravi Kishore Kodali, "Radio data infrastructure for remote monitoring system using LoRa technology", 2017 International Conference on Advances in Computing, Communications and Informatics (ICACCI), 14414681, pp. 467-472, 4 December 2017.

[16] M. Usmonov, and F. Gregoretti,"Design and implementation of a LoRa based wireless control for drip irrigation system", 2017 2nd International Conference on Robotics and Automation Engineering(ICRAE), 17580546, pp. 248-253, 15 February, 2018.

[17] W. Tuan, C. Keshan, X. Chao, and Li Hongjian, "Design and implementation for Zigbee long-distance wireless data transmission system", 2011 IEEE 2011 10th International conference on Electronic measurement and instruments, vol.1, pp. 61-61, 10 october 2011.

Design of an Efficient Steganography Model using Lifting based DWT and Modified-LSB Method on FPGA

Mahesh A.A[1]
Associate Professor, Dept. of ECE
PESIT-South Campus, Bangalore, India

Dr.Raja K.B[2]
Professor, Dept. of ECE, University Visvesvaraya College of Engineering, Bangalore, India

***Abstract*—The data transmission with information hiding is a challenging task in today world. To protect the secret data or image from attackers, the steganography techniques are essential. The steganography is a process of hiding the information from one channel to another in data communication. In this research work, Design of an Efficient Steganography Model using Lifting Based DWT and Modified-LSB Method on FPGA is proposed. The stegano module includes DWT (Discrete Wavelet Transformation) with lifting scheme for the cover image and encryption with Bit mapping for a secret image, an embedded module using Modified Least Significant Bit (MLSB) Method, and Inverse DWT to generate the stegano image. The recovery module includes DWT, decoding module with pixel extraction and bit retrievals, and decryption to generate the recovered secret image. The steganography model is designed using Verilog-HDL on Xilinx platform and implemented with Artix-7 Field Programmable Gate Array (FPGA). The hardware resource constraints like Area, time, and power utilization of the proposed model results are tabulated. The performance analysis of the work is evaluated using Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE) Ratio for a different cover and secret images with better quality. The proposed steganography model operates at high speed, which improves communication performance.**

Keywords—Discrete Wavelet Transformation (DWT); steganography; Modified Least Significant Bit (MLSB) Method; XOR Method; FPGA; cover image; secret image; PSNR; MSE

I. INTRODUCTION

The steganography technique is essential to hide the information in most of the networking and computer applications. The steganography provides security over data alteration, data transmission over secret unsecure channel, and used in digital TV, audio-video synchronization. Steganography is a hiding communication and embeds the hidden content in the cover medium. In general, the stegano medium is the combination of cover medium, stegano key, and embedded message. The different techniques of steganography include text, audio, video, image, and network steganography. The steganography techniques are different from cryptography techniques, because the cryptography converts the overall structure of the data information, whereas in steganography doesn't change the overall structure of the data information [1-3]. There are different ways to classifying steganography methods. Most of the steganography methods hide the information in image files and are classified as spatial domain, spread spectrum, transform domain, statistical, and distortion methods. The Least Significant Bit (LSB) and Pixel Value Difference (PVD) methods are spatial domain methods in image steganography techniques. The spatial domain methods are simple to embed and extract the hidden information, but transformation methods complex compared to spatial domain methods [4-5] [6-7]. The steganography methods are designed and implemented using both software and hardware-based approaches.

Hardware-based approaches are having advantageous over software-based approaches in terms of constraints like less area, less power consumption, and less execution time. The hardware-based steganography approaches meet most of the real-time requirements and used in many applications [8]. The hardware-based approaches provide portability, capable of connecting with other devices, and with low processing speed. The General Purpose Processor (GPP), Digital Signal Processing (DSP), FPGA, and Application Specific Integrated Circuit (ASIC) platforms are available for suitable hardware based steganography approaches. Modern steganography uses FPGA and ASIC platforms; FPGAs are reconfigurable, flexible, and less expensive than ASICs. In this article, the hybrid combination of secured modified LSB and DWT approaches are used to hide the secret image in cover image to generate the stegano image and recover the secret image and also it is implemented on low-cost Artix-7 FPGA.

An efficient steganography technique with stegano and recover module using Lifting based DWT and modified LSB method is designed. Section II describes the review of the existing steganography methods for different applications followed by research gaps. The methodology of the proposed work is overviewed in Section III. The hardware architecture of the proposed stegano and a recovered module is described in Section IV. The resource utilization and performance evaluation concerning PSNR and MSE ratio for different images are represented in Section V. Finally, concludes the overall proposed work with improvements.

II. RELATED WORKS

This section discusses the exhaustive review of the existing steganography techniques with various approaches for different applications in recent years. Kumar et al. [9] presented color image steganography using LSB method with the help of frame deposition technique. The multiple frame video sequences are

used as color image inputs, and component division technique is used to extract the video frames. The architecture is sophisticated and a software-based approach is used for steganography. Deshmukh .P.U. and T. M. Pattewar [10] presented the LSB method for edge-based steganography. The data hiding and extraction process is done using the edge-based method and analyzes the performance between LSB and edge method. Data hiding is achieved on developed Particle-swarm-optimization (Dev.-PSO) Method using LSB approach by Shakur et al. [11]. The embedding the cover image using Dev.-PSO method and after reconstruct generate the stegano image. Apply the inverse of the Dev.-PSO method to a stegano image to extract the secret image. Odai et al. [12] presented the Modified LSB method for image steganography with random pixel selection. The hybrid combination of Modified LSB and image segmentation is used before embedding the secret images randomly. Similarly, Abbood et al. [13] presented the Developed LSB and random technique for text in image hiding. The secret text is hidden in the cover image using the random method and use the hash function to hide the secret text in a selected column to generate the stegano image. The visible watermarking is applied to the LSB method by Bhatt et al. [14] for image steganography to improve the image quality. Joshi et al. [15] presented the new software-based approach for image hiding and extraction using the 7th bit of pixel replacement by new temporary pixel and also analyze the performance metrics for different images with image quality improvements. Tulsidas et al. [16] present a new way of image steganography by using block division method. The block division method generates the maximum pixel value from each block as key and block wise, divide each pixel by maximum value and embedded with cover to generate the stegano image. Perform the average of stegano images to extract the secret image. The DWT based steganography method is designed by Sharma et al. [17] for data hiding. In this, hiding the information with a key using cryptographic substitution method and converted to secret image. Apply the cover image with secured secret image message to DWT method to generate the stegano image and perform the reverse process using DWT to generate the secret image and convert to text format to get the secret data. Similarly, Shet et al. [18] hide the color image using Integer wavelet transformation approach along with the LSB method. The Ardiansyah et al. [19] presented the hybrid approach with secured triple-DES in secret image and DWT along with LSB method in cover image to generate the secured stegano image. The digital watermarking application using image steganography is presented in Chandran et al. [20] using different approaches like Discrete Cosine Transform (DCT), DWT, and LSB methods. Most of the recent image steganography articles from [9-20] are software-based approaches. Almutairi et al. [21] presented the hardware-based steganography using secured LSB method with security, and similarly, the hybrid approach using Haar DWT and Modified LSB method for steganography is made by Simha et al. [22] on a hardware platform. The architecture is so complex and consumed more chip utilization.

Research Gap: After reviewing the existing works, finds the gaps and limitations in the steganography techniques. In that, most of the steganography based methods are based on the software approaches and won't meet the real-time requirements. Usage of inappropriate spatial or transformation domain usage, which causes computation complexity and leads to low-quality image outcomes. There are only few hardware-based architectures with hybrid approach are available. The proposed work overcomes these gaps with proper methodology and designs.

III. Proposed Methodology

The proposed efficient steganography module using Lifting based DWT and modified LSB method is designed using Verilog-HDL on Xilinx Platform and implemented on Artix-7 FPGA. The schematic flow of the proposed methodology is represented in Fig. 1. Matlab is used only for image representation and binary conversion. Consider the cover and secret image separately, extract the pixel information, and perform the image to binary conversion using Matlab and to generate the cover and secret text files in hex format. The FPGA design of steganography module receives the binary files via test-cases as inputs.

The secret image chosen with the 64x64 size is embedded to cover image of 128x128 size. The secret image data first encrypt using simple XOR method with 8-bit key, and the cover image is applied through lifting-based DWT to generate the high and low pass frequency components. The embedded module operates high pass and low coefficients with encrypted data using the modified LSB Method. Apply the Inverse-DWT to get the 128x128 stegano image, which is the embedded version of the cover image with hidden secret image.

The recovery of a secret image is a reverse work of the embedded process. In recover module, the stegano image data applied to Lifting based DWT and the generated high-pass component data is fed to decoding module, which extract the pixels and retrieves the bits using LSB method and performs the decryption with the same key for retrieved bits to get back the output text file. Moreover, apply Matlab to convert the text to an image to recover the secret image, which is having a 64x64 image size.

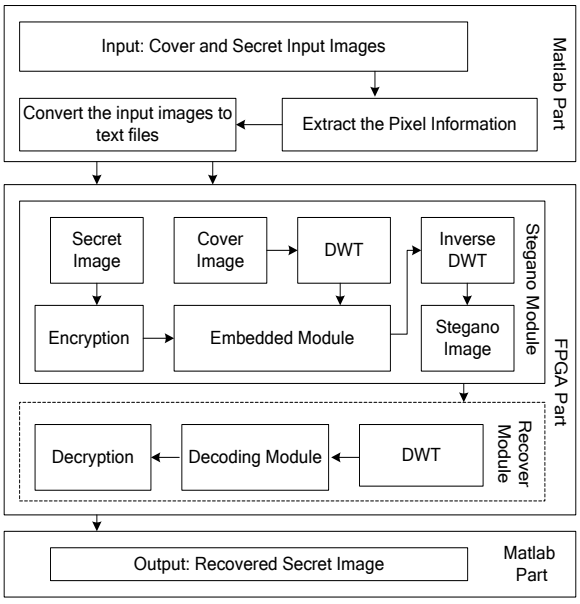


Fig. 1. Schematic Flow the Proposed Methodology.

IV. Proposed Steganography System

The Hybrid approach of steganography model includes mainly stegano module and recovery module. The Stegano module consists of Encryption, Bitmapping, splitting with Lifting based DWT, embedded module using the LSB method, and Inverse DWT Module. The Stegano module hardware architecture is represented in Fig. 2. The 128x128 size of cover image stores the pixel's data in 16384 memory locations, and each location is 8-bits. The splitting module receives the cover data and splits 8-bit even and odd based on the edge of the clock. The even and odd data of 8-bit size are fed to Lifting based DWT Module. The DWT Module uses the lifting based 9/7 filter coefficients on performing predict, update along with scaling and inverse scaling operations. The coefficients are named as alpha, beta, gamma, delta, scaling and inverse scaling. The DWT Module design uses 17-registers, 8-adders, and 4-multipliers for prediction and updating operations.

The prediction operation performs with even data, which is added with a delayed register; the results are multiplied with the filter coefficient (alpha) to generate the predicted data. The updating operation performs with odd data, which is added with predicted data; the results are multiplied with the filter coefficient (beta) to generate the updated data. The same process continues with other filter coefficients gamma and delta which are followed by scaling operation to obtain the 8-bit low-pass component (l) and inverse scaling operation to obtain the 8-bit High-pass component (h).

The 64x64 size of secret image uses 4096 memory locations, extract the 8-bit pixels serially to perform the encryption. The encryption operation is based on XOR operation for 8-bit secret data and 8-bit key, which is easy and provides basic security to the steganography model. The 8-bit encrypted data are input to the bit mapping module which is performed based on predefined memories. Consider four-memory modules M1, M2, M3, and M4 with defined values from 0-15. Each memory is having 4 locations with 8-bits in a 2x2 matrix format. The encrypted 8-bit data is divided into four parts as E [7:6], E [5:4], E [3:2] and E [1:0], each of 2-bit size and Mapped into one of the four Memory locations of Memory modules M1, M2, M3, M4 respectively. The mapping into one of the Memory location is based on whether encrypted 2 bits are 00, 01, 10 or 11 and generate mapped data of 4-bit size as b1, b2, b3, and b4 respectively from M1, M2, M3 and M4. The Embedded module receives the serially the High pass components as an 8-bit input along with four b1, b2, b3, and b4 mapped data. Four high pass components are taken one by one and their LSB 4-bits are replaced with b1, b2, b3 and b4 respectively one by one and then the cycle repeats and operation continues till the last high pass component.The inverse –DWT is a reverse process of DWT operation. The DWT output (l) as one of the input to Inverse DWT module as an even data, which performs the inverse scaling operation and other input from the embedded module (em) as odd data which performs the scaling operation. I have followed by updating with the delta coefficient and then prediction with the gamma coefficient. The updation and prediction will be followed with other filter coefficients beta and alpha, respectively. The final high pass (ih) and low-pass components are obtained to generate the 128x128 stegano image.The recovered module consists of splitting with Lifting based DWT, pixel extraction, and bit retrieval to retrieve mapped encrypted bits using LSB method and finally decryption Module. The Recovered module hardware architecture is represented in Fig. 3.

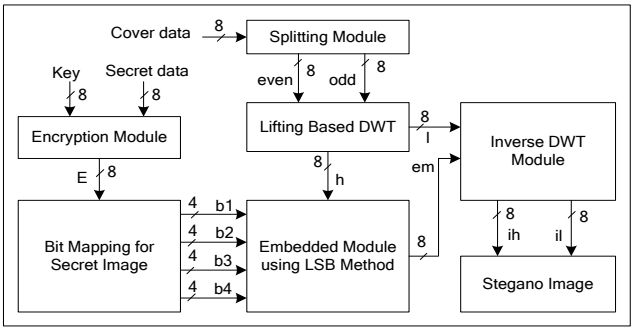


Fig. 2. Hardware Architecture of Stegano Module.

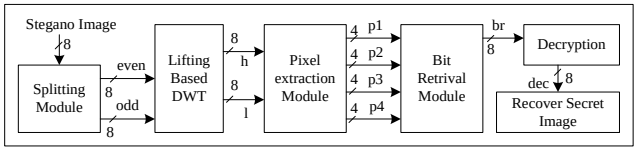


Fig. 3. Hardware Architecture of Recover Module.

The spitting module receives the stegano image data bits serially. After spitting, 8-bit even and odd data are generated. Perform the DWT Operation using even and odd data to generate low and high pass components. The operation of Spitting and lifting based DWT is the same as in the stegano module.

Consider the series of high-pass component to extract the pixels. The high-pass components are shifting serially one after other and use the first four high-pass components initially. Extract the 4-bit LSB data from the four high-pass components and store it as 4-bit p1, p2, p3, and p4. Perform the bit retrievals to extract the bits. Consider 4-bit p1, divide into 2-bit each, and perform XOR operation to generate the 2-bit data. Retrieve the same for other extracted bits like p2, p3, and p4 to generate 2-bit data for each. Finally, concatenate all the retrieved four 2-bits each other to form 8-bits and fed to the decryption module. Perform the XOR operation with the same 8-bit key to generate the recovered secret image. The next section evaluates the results and performance analysis of the proposed work.

V. Results and Performance Analysis

The proposed steganography model is designed using Verilog-HDL on Xilinx –ISE environment and implemented on Artix-7 FPGA. The simulation is performed using Modelsim 6.5c. The steganography model includes stegano and recovery module, and its resource constraints are tabulated in Table I. The area utilization in terms of Slice registers, Slice LUT's, and LUT-FF pairs are noted after synthesis of Stegano and recover modules. The timing utilization includes the minimum period (ns), and maximum operating frequency is tabulated for both the modules. Along with Power utilization is performed after the place and route operation using Xilinx X-power analyzer.

TABLE. I. SYNTHESIS RESULTS OF PROPOSED STEGANOGRAPHY TECHNIQUE ON ARTIX-7 FPGA

Resource Constraints	Stegano Module	Recover Module
Area Utilization		
Slice Registers	352	182
Slice LUTs	1272	435
LUT-FF pairs	179	69
Timing Utilization		
Minimum period (ns)	7.818	8.035
Maximum Frequency (MHz)	127.915	124.454
Power Utilization		
Total Power (W)	0.128	0.097
Dynamic Power (W)	0.046	0.014

The Graphical view of proposed design Synthesis results is represented in Fig. 4.

The stegano module utilizes 1272 slice LUT's because of DWT and IDWT operations, whereas the recover module utilizes 435 slice LUT's. The stegano and recover Module utilizes the 352 and 182 Slice Registers and 179 and 69 LUT-FF Pairs, respectively. The Maximum frequency of the stegano and recover module uses 127.915 MHz and 124.454MHz using Artix-7 FPGA device. The stegano module is operating faster than the recover Module, because of the parallel execution of bit mapping and embedding module using modified LSB technique. The stegano and recover module consume the total Power of 0.128W and 0.097W and also dynamic power of 0.046W and 0.014W, respectively.

The performance evaluation of the Steganography module is analyzed using PSNR and MSE for a different cover, and secret images are tabulated in Table II. These performance parameters are defined as

$$MSE = \frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}[f(i,j) - f'(i,2)]^2 \quad (1)$$

$$PSNR = 10\log_{10}\frac{255^2\,MN}{\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}[f(i,j)-f'(i,2)]^2} \quad (2)$$

The Steganography module, hardware results for different Images is resented in Fig. 5. The cover image has 128x128 image size in Fig. 5(a), the secret image is 64x64 image size in Fig. 5(b), apply the stegano module to generate the stegano image in Fig. 5(c). Also, apply the recovery module to recover the secret image in Fig. 5(d).

The different combination of different images for the cover and secret images are applied to the steganography module to analyze the performance. The Peppers + Lena as a cover and secret image gives the best PSNR of 29.0583dB and MSE ratio 326.3797. If the size of the cover images is increased, then the PSNR will be increased, and the MSR ratio will be decreased with better image quality.

The PSNR values are obtained for 5% and 10% noise is an average of 27.832dB and 26.424dB respectively. Similarly, for MSE Values are obtained for 5% and 10% noise is an average of 404.93 and 600.42 respectively. These values in comparison with Table II values show that there is a difference of 0.550 approximately.

The PSNR and MSR is calculated by adding the 5% and 10% salt and pepper noise to the obtained stegano image for below different image combinations and are tabulated in Table III.

The previous architecture [23] uses Haar DWT approaches and obtains the PSNR values for different images which is compared with proposed approaches for the same images with an improvements and are tabulated in Table IV.

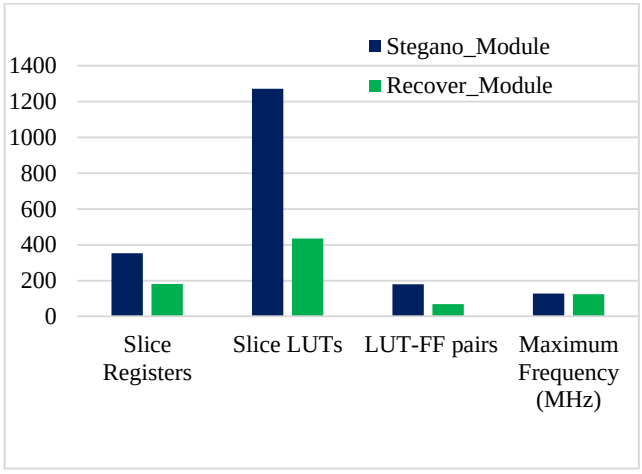


Fig. 4. Graphical Representation of Proposed Design Synthesis Results.

TABLE. II. PSNR AND MSE RATIO OF SECRET AND RETRIEVED SECRET IMAGES

Cover + secret Image	PSNR (DB)	MSE
Lena + Cameraman	27.8283	475.1156
Booban + Coins	27.9014	490.4397
Peppers + Lena	29.0583	326.3797
Cameraman + Booban	28.9508	256.4643
Average	28.434	387.099

TABLE. III. RETRIEVED SECRET IMAGES WITH 5% AND 10% SALT AND PEPPER NOISE

Cover + secret Image	5% -Noise		10%- Noise	
	PSNR (dB)	*MSE*	*PSNR (dB)*	*MSE*
Lena + Cameraman	27.191	492.68	25.7338	694.6458
Booban + Coins	27.1252	500.2755	25.7187	697.0546
Peppers + Lena	28.2588	349.7889	26.7112	554.6523
Cameraman + Booban	28.7544	277.0047	27.5338	455.3574
Average	27.832	404.93	26.424	600.42

TABLE. IV. COMPARISON OF PSNR VALUES WITH PREVIOUS APPROACH

Design	Technique Used	Cover + Secret image	
		Peppers + Lena	***Cameraman + Booban***
Previous [23]	Haar-DWT	25.2619	25.8955
Proposed	Lifting-DWT+MLSB	29.0583	28.9508

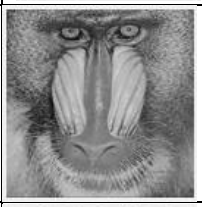
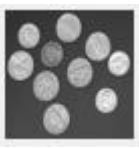
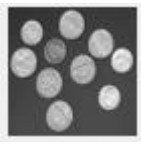
Image .No	Cover image	Secret Image	Stegano Image	Recover Secret Image
1				
2				
3				
4				
	5(a)	5(b)	5(c)	5(d)

Fig. 5. Steganography Technique Hardware Results for different Images.

The hardware architecture of previous approaches [24-25] uses Lifting based –DWT approaches on Spartan 3-EDK Processor, which consumes more chip area and operating frequency than the proposed method. Similarly, The Haar based –DWT approaches [22] using Spartan-6 FPGA device is compared with proposed method on the same FPGA device with chip area utilization improvement in Table V.

The proposed method of steganography is better compared to existing techniques for the following reasons:

- The hacker can't be reached to secret information as a two stage encryption is used.
- A 2 dimension LDWT is converted to 1 dimension LDWT.
- LSBs of high pass coefficients are embedded with encrypted data.

TABLE. V. HARDWARE ARCHITECTURE RESOURCE COMPARISON WITH PREVIOUS APPROACHES

Resources	**Previous [22]**	**Proposed**
Technique Used	Haar-DWT +MLSB	Lifting-DWT+MLSB
Device	Spartan-6	Spartan-6
Slice registers	514	507
Slice FF's	297	209
4-input LUT's used	2108	1706
Max. Frequency (MHz)	153.312	100.448

VI. CONCLUSION AND FUTURE WORK

In this research work, an efficient steganography approach with stegano and recover modules are designed using Lifting DWT based and modified LSB method. The stegano module embedded the cover image with a secret image hiding with a simple security. The recovery module extracts and retrieves the stegano image to generate the recovered secret image with quality. The proposed work is designed and implemented on Artix-7 FPGA. The resource utilization of the stegano and recover modules in terms of area, time, and power utilization are tabulated. The steganography model works an average of maximum operation frequency with 126.5 MHz to meet the real-time requirements with high speed. The performance analysis of the steganography work is evaluated using PSNR and MSE. For different cover and secret images with an average of 28.434dB and 387.099 MSE Ratio is noticed. The result obtained with noise introduced shows that there is small variation in PSNR of about 0.550; therefore, the proposed model is robust. In future, integrate the robust security algorithm with Dual Tree Complex Wavelet Transform to the steganography model to provide better secure communication.

REFERENCES

[1] S.Ashwin, S.Aravind Kumar,J.Ramesh and K.Gunavathi, "Novel and secure encoding and hiding techniques using image steganography: A survey," Emerging Trends in Electrical Engineering and Energy Management (ICETEEEM), pp 171-177, 2012.

[2] R. Mishra and P. Bhanodiya, "A review on Steganography and Cryptography," International Conference on Advances in Computer Engineering and Applications, Ghaziabad, pp. 119-122, 2015.

[3] Seo, Jun O., Sathiamoorthy Manoharan, and Aniket Mahanti. "A Discussion and Review of Network Steganography." IEEE 14th Int'l Conf on Dependable, Autonomic and Secure Computing, , International Conference on Pervasive Intelligence and Computing, Internationall Conference on Big Data Intelligence and Computing and Cyber Science and Technology Congress (DASC/ PiCom/ DataCom/ CyberSciTech), 2016.

[4] Sharma, Neha, and Usha Batra. "A Review on Spatial Domain Technique based on Image Steganography." IEEE International Conference on Computing and Communication Technologies for Smart Nation, pp 24-27, 2017.

[5] Qian, Tu, and Sathiamoorthy Manoharan. "A Comparative Review of Steganalysis Techniques." IEEE International Conference on Information Science and Security, 2015.

[6] Thangadurai, K., and G. Sudha Devi. "An Analysis of LSB based Image Steganography Techniques." IEEE International Conference on Computer Communication and Informatics, 2014.

[7] Maurya, Indu, and S. K. Gupta. "Secure Image Steganography through Pre-Processing."Soft Computing: Theories and Applications. Springer, pp 133-145, 2019.

[8] Debnath, Sanghamitra, Manashee Kalita, and Swanirbhar Majumder. "A Review on Hardware Implementation of Steganography."IEEE International Conference on Devices for Integrated Circuit, 2017. IEEE, 2017.

[9] Kumar Saket, Ajay Kumar Yadav, Ashutosh Gupta and Pradeep Kumar "RGB Iimage Steganography on Multiple Frame Video using LSB Technique." IEEE International Conference on Computer and Computational Sciences (ICCCS), pp 226-231., 2015.

[10] Deshmukh. P. U. and T. M. Pattewar. "A Novel Approach for Edge Adaptive Steganography on LSB Insertion Technique."IEEE International Conference on Information Communication and Embedded Systems (ICICES), 2014.

[11] Shukur, Wisam Abed, and Khalid Kadhim Jabbar. "Information Hiding using LSB Technique based On Developed PSO Algorithm." International Journal of Electrical and Computer Engineering (IJECE) ,Vol. 8, No. 2, pp 1156-1168, 2018.

[12] Al-Shatanawi, Odai M., and Nameer N. El Emam. "A new Image Steganography Algorithm based on MLSB Method with Random Pixels Selection." International Journal of Network Security and Its Applications Vol.7, No.2, pp 37-53, 2015.

[13] Abbood, Elaf Ali, Rusul Mohammed Neamah, and Shaymaa Abdulkadhm. "Text in Image Hiding Using Developed LSB and Random Method." International Journal of Electrical and Computer Engineering, Vol. 8, No. 4, pp. 2091-2097, 2018.

[14] Santhoshi Bhatt, Arghya Ray, Avishake Ghosh and Ananya Ray "Image Steganography and Visible Watermarking Using LSB Extraction Technique." IEEE International Conference on Intelligent Systems and Control, 2015.

[15] Joshi, Kamaldeep, Swati Gill, and Rajkumar Yadav. "A New Method of Image Steganography Using 7th Bit of a Pixel as Indicator by Introducing the Successive Temporary Pixel in the Gray Scale Image." Journal of Computer Networks and Communications, 2018.

[16] Tulasidasu, M., B. Lakshmi Sirisha, and K. Rasool Reddy. "Steganography Based Secret Image Sharing Using Block Division Technique." IEEE International Conference on Computational Intelligence and Communication Networks, pp 1173-1176, 2015.

[17] Sharma, Vijay Kumar, Pratistha Mathur, and Devesh Kumar Srivastava. "Highly Secure DWT Steganography Scheme for Encrypted Data Hiding." Information and Communication Technology for Intelligent Systems. Springer, Singapore, pp 665-673, 2019.

[18] Shet, K. Sathish, and A. R. Aswath. "Image Steganography using Integer Wavelet Transform Based on Color Space Approach." International Conference on Frontiers of Intelligent Computing: Theory and Applications, Springer, pp 839-848, 2015.

[19] Ardiansyah, Giovani, Christy Atika Sari, and Eko Hari Rachmawanto. "Hybrid Method Using 3-DES, DWT and LSB for Secure Image Steganography Algorithm." IEEE International conferences on Information Technology, Information Systems and Electrical Engineering, pp 249-254, 2017.

[20] S. Chandran and K. Bhattacharyya, "Performance Analysis of LSB, DCT, and DWT for Digital Watermarking Application Using Steganography," International Conference on Electrical, Electronics, Signals, Communication and Optimization (EESCO), pp. 1-5, 2015.

[21] Abdullah AlWatyan, Wesam Mater, Omar Almutairi, Mohammed Almutairi, Aisha Al-Noori and Sa'ed Abed "Security Approach for LSB Steganography based FPGA Implementation." IEEE International Conference on Modeling, Simulation, and Applied Optimization, 2017.

[22] Nikhil Simha H.N., Pradeep M. Prakash, Suraj S. Kashyap , Sayantam Sarkar "FPGA Implementation of Image Steganography Using Haar DWT and Modified LSB Techniques." IEEE International Conference on Advances in Computer Applications (ICACA), pp 26-31, 2016.

[23] Farahani, Mohammad Reza Dastjani, and Ali Pourmohammad. "A DWT based Perfect Secure and High Capacity Image Steganography method." International Conference on Parallel and Distributed Computing, Applications and Technologies, pp. 314-317, 2013.

[24] B. Vashanth Lakshmi and B. Vidya Raju, "FPGA Implementation of Lifting DWT based LSB Steganography using Micro-Blaze Processor", International Journal of Computer Trends and Technology, Vol. 6, No. 1, pp. 6-14, December 2013.

[25] Maya C S and Sabarinath G, "An Optimized FPGA Implementation of LSB Replacement Steganography using DWT", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 2, Special Issue. 1, pp. 586-593, December 2013.

Developing Agriculture Land Mapping using Rapid Application Development (RAD): A Case Study from Indonesia

Antonius Rachmat Chrismanto[1], Rosa Delima[4]
Program Studi Informatika
Universitas Kristen Duta Wacana
Yogyakarta, Indonesia

Halim Budi Santoso[2], Argo Wibowo[3]
Reinald Ariel Kristiawan[5]
Program Studi Sistem Informasi, Universitas Kristen Duta Wacana, Yogyakarta, Indonesia

***Abstract*—The use of Information and Communication Technology (ICT) in agriculture has become one of the steps to improve agricultural efficiency, effectiveness, productivity, and also expected to encourage the creation of Precision Agriculture. Precision agriculture has an impact on the efficiency of operational costs to increase margins in the production of agricultural products using ICTs. One of the problems that often arise in agriculture is related to the management of agricultural land in each farmer group area. This information is closely related to the needs of agricultural production facilities and infrastructure, such as the need for fertilizers, seeds, and other resources. Web Mapping System is one of the systems to assist in land or area mapping. In this study, the Web Mapping System is expected to be used to help at agricultural land mapping, owned by farmer members of farmer groups. The developed system will store spatial data from farmland members and farmer groups. The Web Mapping System was developed using the Rapid Application Development (RAD) method, where there are several iterative processes. The result of this study is the Web Mapping System for agricultural land. With this application, farmers can find out the status of the land being cultivated or owned. In addition, the Web Mapping System can record the status of the existing land in a farmer group and the need for agricultural production facilities and infrastructure. Further, the Web Mapping System also provides information in a dashboard that can help farmer groups to manage the land owned by each farmer who is a member of the group.**

Keywords*—Farmland; precision agriculture; land mapping system; dashboard; software development

I. INTRODUCTION

Agriculture is one of the focused fields of development in Indonesia. Various technologies in agriculture are developed to improve agricultural efficiency, effectiveness, and productivity. Information and communication technology (ICT) is used in the development of information systems for agriculture. Agricultural Information System (AIS) covers a variety of related systems, ranging from land preparation, systems for farmers' data collection, agricultural activities, systems for land management, agricultural activities, crop sales and purchase systems, learning systems for farmers and farmer groups. The development of AIS has done quite a lot in various regions in Indonesia, but most of the existing systems are local and not integrated.

The development of information systems in agriculture has been carried out by a development team from the Information Technology Faculty (FTI) of Duta Wacana Christian University (UKDW) since 2016. To conduct research related to the development and application of Information Technology in agriculture, a study is first carried out to see the readiness of the Indonesian agricultural community in the use of Information Technology [1] and several applications in agriculture that have been carried out [2]. After that, an integrated SIP blueprint was developed by developing Architecture Vision [3], Business Architecture [4], and defining integrated AIS stakeholders [5]. Besides, there are several systems developed, such as the Agricultural Portal [6], Farmer and Farmer Groups Information System [7], Farmers Activity Information System [8], and Information System of Agricultural Products' Purchases and Sales [9]. Three of the four systems developed are ready to be applied in the community. Three systems that have been developed can be accessed via the website at http://dutatani.id [6].

Along with the application of the three existing systems, the next stage of the research to be carried out is to develop a system for mapping of agricultural land and agricultural activities carried out by farmers. The development of this system was carried out because there were problems faced by farmer groups in processing land ownership data, seed requirements, and the estimated amount of agricultural productivity. The manual data processing makes it difficult for farmer groups to produce information related to land area, identification of needs, and level of agricultural production in their area. Indeed, information is needed for a variety of needs including agricultural quality assurance, preparing the needs of seeds, fertilizer, and other resources supporting the agricultural process.

To help farmer groups in overcoming the problem, a system for land mapping and data collection on agricultural activities was developed. This system is developed by Rapid Application Development (RAD) method and is intended to produce spatial information related to land use and agricultural activities that are being carried out. The system is able to integrate various data and display information in spatial form. Therefore it facilitates the analysis process and helps agricultural stakeholders to understand the data. The use of RAD is based on the suitability of sequential and iterative or

incremental model characteristics in the process of developing software prototypes. This method is also used in many studies, as in [10].

This paper specifically discusses the process of developing agricultural land mapping systems and dashboards as a user interface between agricultural stakeholders and the system. The paper consists of five parts, preceded by an introduction, followed by a literature review in section II. The application of the RAD method can be seen in Section III, followed by the results and discussion in section IV, and the paper is closed with the conclusion and future work in section V.

II. Literature Review

A. Precision Farming

Precision agriculture is one of the capabilities to handle various activities related to productivity on agricultural land and increase financial benefits, reduce residual production, and minimize impacts on the environment by using data collection, and utilizing the information for strategic decisions on agricultural management using information and communication technology [10]. The use of Information and Communication Technology (ICT) in precision agriculture supports the determination, analysis, and arrangement of changes in agriculture for optimal benefits, sustainability, and preservation for agriculture [11].

Precision agriculture has a good impact on the agriculture sector. Approaches using precision agriculture help to reduce costs and maximize yields [12]. Cost reduction and increased yields encourage increased profits for farmers. The application of precision agriculture also encourages agricultural operational efficiency, particularly for the use of fertilizers and pesticides [13]. This encourages the creation of environmental sustainability and reduces the adverse effects of the use of pesticides and fertilizers. The benefits above are also one of the driving forces that make actors, especially farmers, to implement precision agriculture [11].

B. Web Mapping System for Indonesian Land Mapping

One application of Information Technology for the agricultural sector is a system for mapping agricultural land. With the land mapping system, spatial data generated is needed for farmers to support the creation of precision agriculture [14]. This system is one step that can be used to map existing agricultural land. The mapping of agricultural land to support precision agriculture was started in 2002 to map fertilizer needs in each of the existing regions [15]. Using this system, fertilizer needs in each agricultural location can be identified more easily. This is certainly considered to support efficiency in managing fertilizer needs [15].

With the development of a mapping system website for agricultural land, there will be operational cost efficiency and also the effectiveness of costs incurred [16]. In addition, this land mapping system can also support land management and reduce neglected agricultural land [17]. Geospatial analysis and prediction models can also be produced by land mapping systems that can be used for agricultural land management [14]. By using a Land Mapping System (SPL) that has spatial data, the system can help to give farmers the ability to visualize their land and crops. The use of spatial data in agriculture can also help farmers to understand their agricultural land better and provide information that can support decision making [14].

C. Rapid Application Development (RAD) Methodology

According to Denis [18], RAD is a collection of methods developed to overcome the weaknesses of traditional development systems, such as the Waterfall model and its variants. Through a RAD process, organizations can reduce development and maintenance costs [19]. The method used in RAD cycles also provides good software quality compared to the traditional development method approach.

RAD was first introduced by James Martin in the 90s. James Martin believes that the RAD model is more flexible and adaptable to changing user demands and needs and ensures the quality of rapid development with minimal costs [20]. In its application, RAD emphasizes a short planning process by focusing on the software development process, which consists of the development, testing, and reciprocity [21]. The stages of developing a RAD – based system can be seen in Fig 1.

D. Convex Hull

A convex polygon, where each inner corner is less than or equal to 180 degrees, is a simple polygon whose interior is a convex set. This means that all vertices of the polygon will point outward, away from the interior of the field [22].

A subset S of a plane is called convex (Fig. 2) if and only if for each pair of points p, q ∈ S the line portion $\overline{pq}$ is contained entirely in S. More precisely, as illustrated in Figure. 3. convex hull is the meeting point of all convex sets containing S [23]. Besides, the convex hull can also be applied to 3D fields such as in Fig. 4 which shows the results.

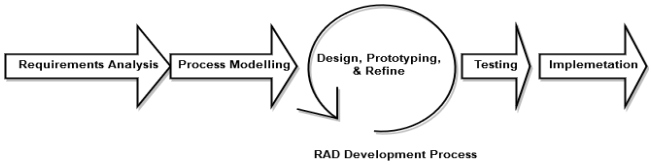


Fig. 1. RAD Development Process.

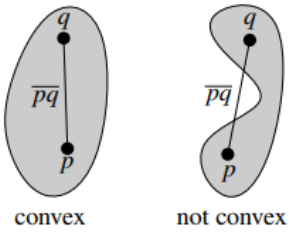


Fig. 2. Convex Example [23].

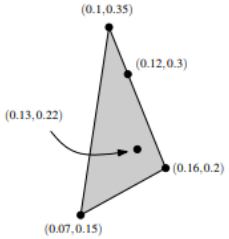


Fig. 3. Convex Hull 2D [23].

This research is funded by The Ministry of Research, Technology and Higher Education.

Fig. 4. Convex Hull 3D [23].

Calculating the convex hull is one of the problems in the calculation of geometry. According to Zhongliang Fu, et al. [24] , practically convex hull is widely used in recognizing patterns, image processing, statistics, and GIS. It also used to reconstruct geometric fields. The minimum convex hull of a set of points is a requirement of a GIS application (Fig. 5), such as dynamic area calculation, TIN, and area change.

E. Graham's Scan

The name Graham's Scan was given in a journal about efficient algorithms for the planar field case, which was published in 1972 by a mathematician named Ronald Lewis Graham. According to a book written by Cormet et al. [25]. The algorithm is a rotational sweep algorithm with good performance characteristics. Because of its speed, Graham's Scan is among the most popular in the search for the convex hull in the planar field.

The algorithm has several variations, but the original version runs in 3 phases:

1) Prepare a set of points as input.
2) Calculates the initial hull.
3) Sweeping to check one by one on the points in order and check whether it is included in the hull.

The first step in preparing a collection of input points is to choose a pivot point for the algorithm. This pivot is usually at the lowest point, then the leftmost in the collection. This point is definitely included in the convex hull [26]. All other points are then sorted by the pivot point as the center. Points that have identical angles are eliminated, the initial starting point from the pivot point is taken, which is the furthest point with the largest angle from the pivot point [25].

The starting hull is simply calculated starting from the pivot point and with 2 starting points that are in a collection of saved and sorted points (P1 and P2). The initial hull was considered as the current hull, which will be updated throughout the algorithm. The sweeping phase considers points in a set of points that have been sorted one by one. For each existing point, it will be determined whether adding this point to the current hull will result in a non-left turn. If the point causes a non-left turn or not, the last point will be removed, and the direction of the turn will be tested again. Turn points are illustrated as in Fig. 6. This continues until you get a left turn, the point will be entered into the current hull. This is repeated until the saved, and sorted points are finished (Fig. 7.) [25]. This figure is modeled Graham's Scan Process [27].

Fig. 5. Convex Hull Usage on Application.

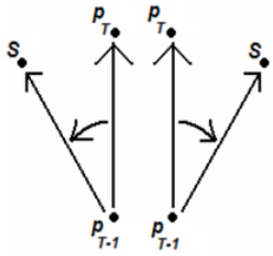


Fig. 6. Left Curve and Right Curve [28].

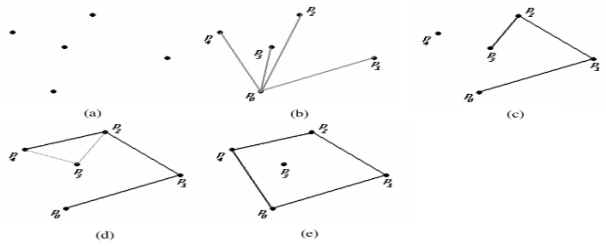


Fig. 7. Graham's Scan Process [27].

F. Google Maps API

Quoted from Google [28], the Google Map API is a free virtual world map service available online from Google. Google Maps can be opened at the following address https://www.google.com/maps. Google Maps has a feature that can display maps from all over the world, at various scales, and photos of the world from satellites for the whole world in the form of maps. There is also the Google Street View, which provides services to explore the streets with a series of photographs. In addition, it also provides location search and information from a place, travel route, measuring distance from one point to another, view traffic information, save certain places, and place ratings and reviews.

The online API map from Google provides variations to be added to the online map that will be displayed on a web page. As on the example, it can provide variations such as adding markers to a point on the map, which will later be used as a land pointer. The marker can also be added to events, such as if it's clicked, it will bring up the info window as an additional dialog box that points to the marker that was clicked. Then Google Maps also provides variations to make polyline to make lines, polygons to create fields that are formed with many points, other shape fields, and various other variations. The Polygon will be used to describe agricultural land.

III. Research Methodology

The research carried out applies the RAD software development model. The way to apply the RAD model is to combine sequential development techniques and prototyping systems. The dashboard development process is carried out through several stages, such as planning, analysis, design, and manufacture, system testing, and ending with the process of system integration into the dutatani portal. The stages of developing a Web Mapping System can be seen in Fig. 8.

In Fig. 8 it can be seen that in general, the process is divided into 2 stages, such as the sequential development stage, the initial process of planning, data collection, and user requirements analysis. After that, the application development process is continued by means of an iterative and incremental prototyping system. The prototyping system consists of design, coding, and testing activities. A system prototype was produced through this process. As a final activity, an evaluation of the system and integration of the system into the main Dutatani portal is carried out.

A. Planning

Planning is the initial stage in the system development process. This stage consists of planning the time and resources needed for system development. The system was developed with PHP and MySQL programming languages as the database with 5 people involved in this research.

B. Data Collection

The data in this study is used in the information system website and recording dashboard, including farmer data, farmer group data, land data, land detail data, species data, land planting data, farmer membership data, land ownership data, and user data and user category data. Most of the data obtained from the database of the main website Dutatani.id system. The data structure obtained from the Dutatani database is as follows: farmer data, farmer group data, farmer membership data, user data, user category data, category type data, plant species data, and regional data. Most of them already have data, but for user data, farmer data, farmer group data, membership data are obtained from Tani Harjo and Tani Rahayu farmer groups. Land data and data structures were obtained from data belonging to Tani Harjo and Tani Rahayu farmers groups.

Land data is also obtained from farmer groups. Using the data obtained, a data structure is created in the database that adjusts the data. Land data, land point data, land planting data, and land photo data are obtained. For land point data and land point detail, it is done by recording using the application directly in the rice fields in Gilangharjo, Pandak, Bantul, Special Region of Yogyakarta, guided by the committee of Tani Harjo farmer group to identify the land and match it with the Google Map online map in the system.

The data that has been obtained is then inputted into the system and then processed by the system to be displayed as a dashboard for calculating land recording and 2 main types of land mapping maps, such as a combined land map and a land distribution map.

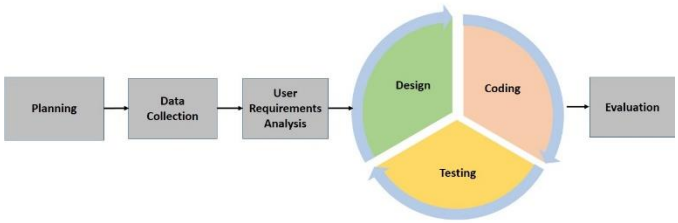


Fig. 8. Research Methodology.

C. User Requirements Analysis

The analysis phase is carried out to be able to understand the conditions that apply and identify the system requirements. Before conducting the analysis, the process begins with gathering needs. Techniques used for gathering needs include interviews, questionnaires, and surveys of land mapping systems that have been developed before. Interviews were conducted through small group discussions with system users. Interviews are intended to get the features and services needed by users. Interviews were conducted with farmer group coordinators and farmer group members of Tani Rahayu and Tani Harjo farmer groups. To get the characteristics of users, data collection is done through questionnaires. There were 36 respondents who participated in filling out the questionnaire.

After the data is collected, an analysis is carried out to formulate the functional requirements of the system. The analysis produces a description of the user's characteristics and a list of system requirements. Based on the collected data, the characteristics of the user of the system is obtained as follows.

1) The average age of farmers is 51 years with experience working on rice fields of approximately 25 years. This identifies that the farmer has been trained and has enough experience in managing agricultural land. The work of farmers becomes the main work. Only 15 respondents answered that their job as a farmer is as a side job.

2) Farmers in Gilangharjo manage an average land area of 2000 m2 per farmer. This land is mostly planted with rice types such as *mentik wangi* and *mentik susu* rice. In one year, farmers have 3 growing seasons, where 2 times are planted with rice and 1 time planted with corn, soybeans, beans, and others. This land is mostly privately-owned land with an income of less than 5 million rupiah.

3) Seen from their educational background indicates that almost 50% of farmers did not graduate from elementary school or only graduated from elementary school. This, of course, will also have an impact on the use and application of technology to assist production and management in this sector. It needs to build the system which is user friendly and easy to use.

D. Main Design

The main design for the development of the Web Mapping System is the development of use case diagrams based on the functional requirements of the Web Mapping System, as follows:

1) The Web Mapping System is capable of recording and managing land data, farmer data, and data of planting in that land.

2) The Web Mapping System has an online map provided through the API service by Google Maps, which will have farmers' land distribution points.

3) The Web Mapping System has info-graphics that display online maps and distribution data.

4) Web Mapping System has filters that can categorize data that will come out on maps and info-graphics.

5) The Web Mapping System can provide statistical calculations from existing land, agriculture, and planting data, which will then be displayed on an infographic dashboard.

The functional needs as the results of the design process are illustrated in the Use Case diagram, as shown in Fig. 9.

Fig. 9 explains the use case diagram of the Web Mapping System for farmland. There are 2 actors, such as the admin who is the representative or administrator of the farmer groups and farmers. The admin is actually a farmer who was appointed to be the committee of a farmer group. As an admin, there are several functional things that can be done, such as accessing land combined maps, accessing land distribution maps, managing land ownership, and accessing the dashboard of the existing system. Whereas farmers have the functions to make land arrangements, look at land lists, manage land point details, record/organize land planting, view land photos, and arrange land photos. To be able to run the features in the system, you need to log in first, either as farmer group's admin or farmer.

E. Detail Design

The detailed design of the system is done by using several diagrams, such as the Entity Relationship Diagram, Diagram, and Data Flow Diagram. The Entity Relationship Diagram in Fig. 10 explains the relationships between entities in the database used in this study. The schema of the relations in this diagram is used in the recording system and is used in determining simple calculations to be displayed in the Agricultural Land Web Mapping System.

Figure 10 shows the entity relations in the Web Mapping System. There are 17 tables in the ER Diagram. In carrying out land recording, the system will relate to the land ownership recorded in the system. It also relates the land with each detail point, planting, photos. Planting data also has a relation with saprotan (infrastructure for agricultural production) unit data to limit and find out what saprotan (infrastructure for agricultural production) units are available and can be used in recording land planting. In planting, it also records plant species that are related to the information of the plant species that have been stored previously in the main system.

Relationships between farmers and user accounts and categories are also interrelated to indicate the category of the user, whether he is a farmer or an admin who will differentiate his rights in the application. It also takes note of the membership of farmers in farmer groups by looking at the relationship between farmers and their registration in the farmer groups. In addition, there is also a relationship that shows the farmer who functions as a contact person of the farmer group.

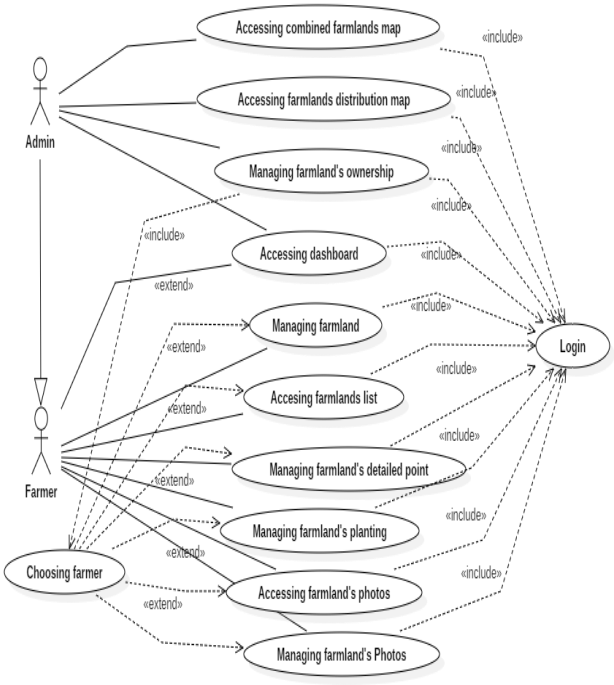


Fig. 9. Use Case Diagram.

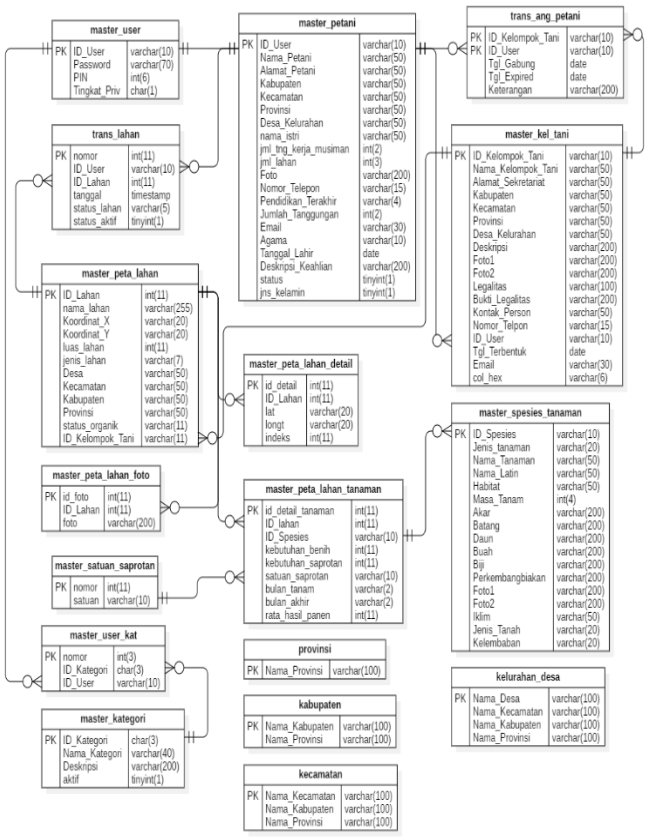


Fig. 10. Entity Relationship Diagram Web Mapping System.

F. Data Flow and Process Design

1) Overall process in the system: Fig. 11 explains Data Flow Diagram Level 0 (Context Diagram) from the Web Mapping System. Data flow diagram/DFD is used to describe the data flow in the system. The development of DFD starts from a context diagram to illustrate the system with entities outside the system/stakeholder. There are two outside entities, such as farmers and farmer admin.

Fig. 12 shows Data Flow Diagram Level 1. There are 2 main processes in this diagram, namely the agricultural land data processing and the process of displaying agricultural land information on the dashboard. The Level 0 process is divided into 2 so that the process is clearer. The processes are such as Recording Agricultural Land and Displaying Land Mapping Dashboard. Each of these processes can stand alone, but of course, the dashboard will have results if there has been a previous land recording before. The process of recording farmers' land will be explained in the next section.

2) Recording of farmer's land: Fig. 13 shows Data Flow Diagram Level 2 for the process of land data entry. The process at this level is a more detailed process than the process of recording farmer's land in DFD level 1. This level 2 diagram is illustrated in Fig. 13. All three stakeholders remain at this level. Farmers can carry out the process of adding land directly, while the Admin must make the process of selecting farmers before they can carry out the process of adding land. From the process of adding land, there will be 2 data outputs, such as land data and land ownership data. Then, to go to the process of adding detail to the point of land, adding land planting, and adding photos of land, farmers, and admins who have gone through the process of selecting farmers, must go through the process of selecting land first.

G. Coding and Testing

System development is done by implementing what already designed in the previous stage of RAD.

H. Evaluation

An evaluation is carried out to assess the performance of the system. Evaluation is carried out on the time and memory needed by the system as well as measuring the level of use and usability of the system.

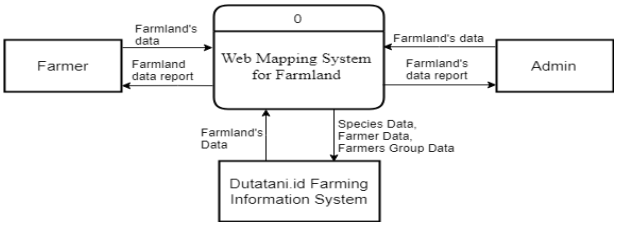


Fig. 11. Context Diagram Data Flow Diagram.

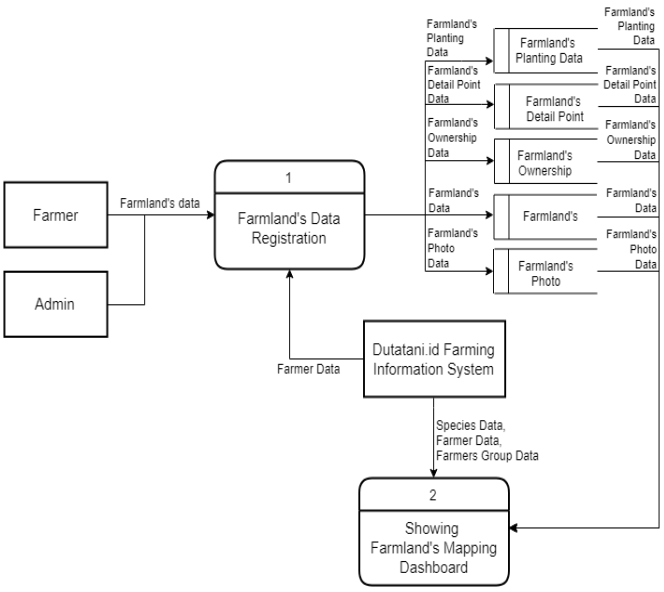


Fig. 12. Data Flow Diagram Level 1.

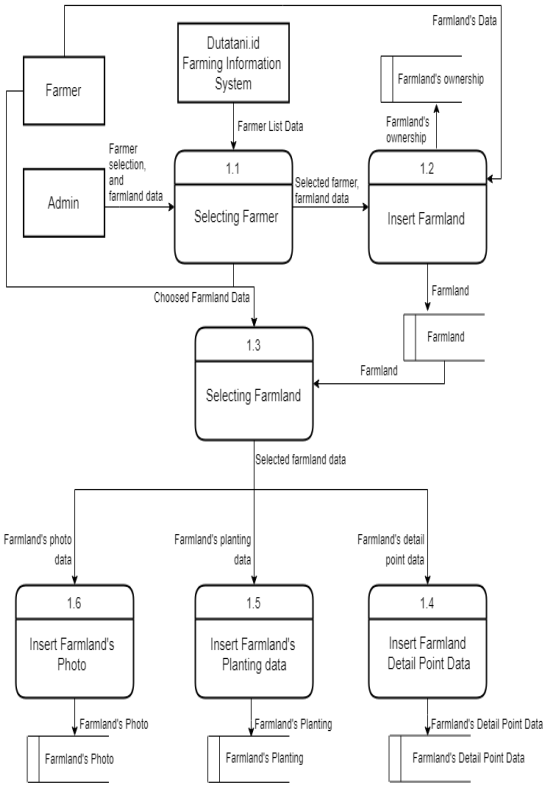


Fig. 13. Data Flow Diagram Level 2 for Land Data Entry.

IV. Results and Discussion

At this stage, the results of the application of the system will be explained, which includes an explanation of the process in the land recording information system and a land mapping dashboard, which will later be explained more clearly in each process. This system can be accessed via the URL http://dutatani.id/si_mapping. A description of the land recording information system will include an explanation of how to record the land and record additional data for lands

such as planting, ownership, and land photos. It is also how the system displays land data. In the mapping, the dashboard will explain how the system displays data. The discussion will include an explanation of the appearance, functions, and processes that occur in the system, accompanied by pictures to help explain the steps that occur in the system being applied.

A. Land Recording Information System

Land recording information system is part of the system used to register the land and additional information for the land. Additional information for the land is divided into four, such as the details of land points, details of land planting, land ownership, and land photo.

1) Land data recording: The first process in implementing this system is the process of land recording. This land recording process is important because the land data obtained will be used for processing and display in the information system and mapping dashboard on the website. As well as being used as a reference for recording additional land data such as land point details, land planting, land ownership, and land photos.

Fig. 14 shows the farmer data that has been entered into the Web Mapping System. The list of farmers can be accessed by selecting the Farmers Land List menu on the side menu. The page has filters based on the farmer group and the village where the farmer lives, as well as a search bar for farmers' name search. In addition, action options are provided for these farmers, such as adding land and a list of land owned by farmers. The add land button will immediately take the user to the land added form, while the Detail button will take the user to the farm register page of a farmer. In this system, based on the interview result, the land ownership status consists of 3 choices, i.e. owned, rented, and worked on.

2) Land details: The user can view details of the land that has been recorded on the detail page after it has been recorded. The page shows only the basic land data that has been recorded, while additional detail data is still displayed as not recorded. Only land ownership data that has been filled but later it can also be added because the land can be owned or rented or worked on by more than 1 farmer.

3) Land ownership recording: The next recording in the land recording information system is the recording of land ownership. Land ownership data is data that records land ownership transactions and ownership status of a farmer. Ownership status is divided into three, namely Owned, Rented, and Worked On. Ownership status is a status that indicates that the farmer is the owner of the land. TheRented Status is a status that indicates that the farmer is a land tenant, and the worked On Status shows that the farmer is only the worker of the land. This data recording is also important, it is necessary to store ownership transactions which also influence and are used in the process and output of the information system and land mapping dashboard. If this data is not recorded, the land would not appear in the list of land ownership list belongs to 1 farmer, and the land would not be found.

Fig. 15 shows the page for data entry on agricultural land ownership. One land can be recorded in an ownership transaction with more than 1 farmer. Of course, with a different status, because land tenants can be more than 1 per land.

4) Land planting recording: Detailed land planting data is additional data for land that records data on the annual cycle of land about what plants are planted on the land, the seed requirements for the land, the *saprotan* (infrastructure for agricultural production) requirements on the land, then the *saprotan* unit, then the planting month and the crop harvest month, and estimated yields from from one time planting with the data. Fig.16 shows the page for location data entry from farmland. Planting data can be added by the user as needed

5) Land photo recording: The next record in the system is the recording of land photographs. This recording records the land photo and saves the photo with the name specified by the system by combining the uploader's user id and the photo file name. Fig. 17 shows pages for images from each recorded land data. To set the land photo, the user can choose the photo detail button at the top of the land photo section. On this page, users can also upload photos and record data in a database. Also shown photos that have been uploaded, and the action to delete photos that can be done for each photo.

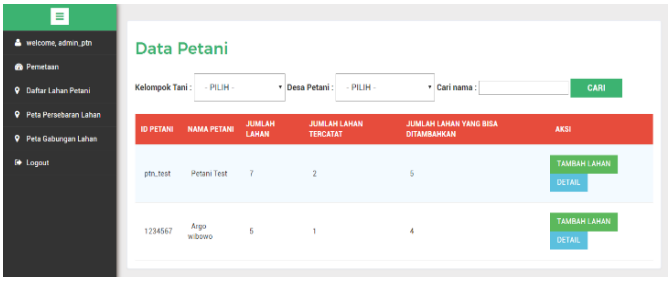


Fig. 14. Farmer Data.

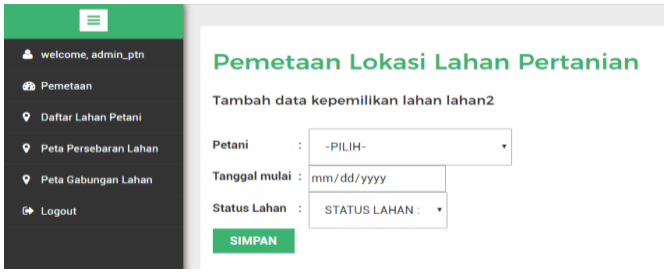


Fig. 15. Farm Land Ownership Data.

Fig. 16. Form Entry Farm Land Location.

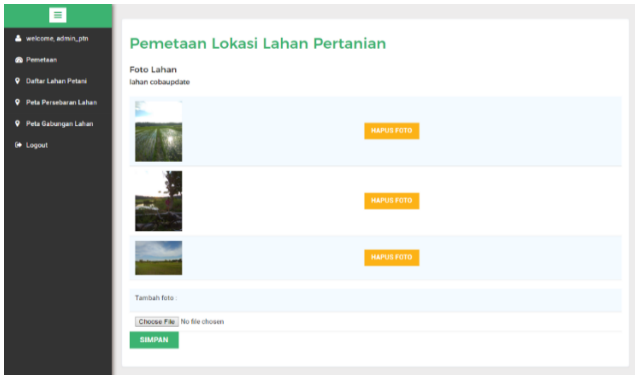


Fig. 17. Farm Land Picture.

6) Land point detail recording: Land point detail data is coordinate data stored to form fields that will be displayed through Google's online maps embedded on this website. The process of recording details of these land points is the second most important after land recording because the details of the points recorded will be used as landforms on the land mapping dashboard that shows the points and land plots on the online map.

Figure 18 shows the Farm Land Polygon. In recording the details of the land points, the user will be asked to select the detail points sequentially and not crossing diagonally between points, because the formation of the polygon fields is arranged sequentially in the order in which the points are recorded. The point detail of the land is used as a guide to form the outer point of the field, which was formed using the Polygon feature provided by Google, as in Fig. 18.

B. Land Mapping Dashboard

The second part of the system is a simple dashboard for mapping agricultural land which maps land from the existing data and is recorded in the system database and performs land calculations. This land mapping uses 3 types of land distribution maps, namely the Point of Farm Land Distribution Dashboard, which is the main page of this system, then the second is the Land Distribution Map, and finally, the Land Combination Map. Each map has 3 main parts, namely filters, maps, and land calculation information.

1) Map of land distribution point: Point of Farm Land Distribution Dashboard is a map displayed on the main page of the system, which is the distribution of the coordinates of the midpoints of each land, as in Fig. 19. The statistical calculation of land under the map is regulated following the available land data.

2) Map of farm land distribution: Fig. 20 shows a map of the distribution of agricultural land. The second type of map in this mapping dashboard is the Land Distribution Map, which will display all land that has detailed land points and can form fields on the map. Likewise, the calculations performed on this page. This condition is exemplified in Fig. 20.

3) Land combined map: The final type of map is the Land Combined Map. This Land Combined Map is a map that shows the resulting combined fields of land. The map is exemplified in Fig. 21, and Graham's Scan method implemented in the system uses a library to calculate and merge land points.

C. System Testing

In this study, a system test was also carried out using a test scenario. There are 16 test scenarios that categorized into three categories as seen in Requirement Traceability Matrix (RTM) in Table I.

Fig. 18. Farm Land Polygon.

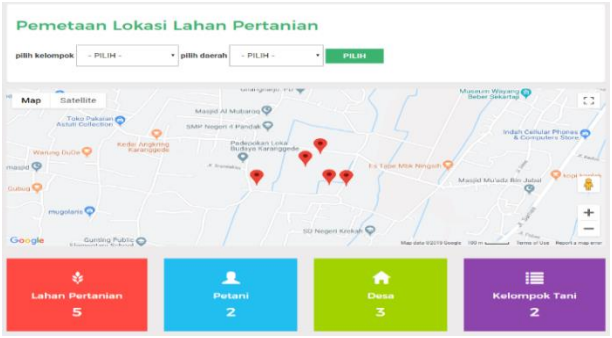


Fig. 19. Point of Farm Land Distribution Dashboard.

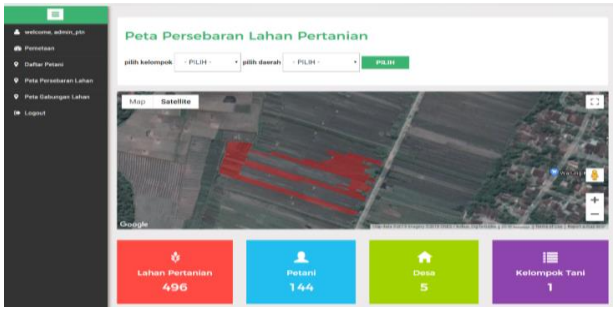


Fig. 20. Farm Land Distribution Map.

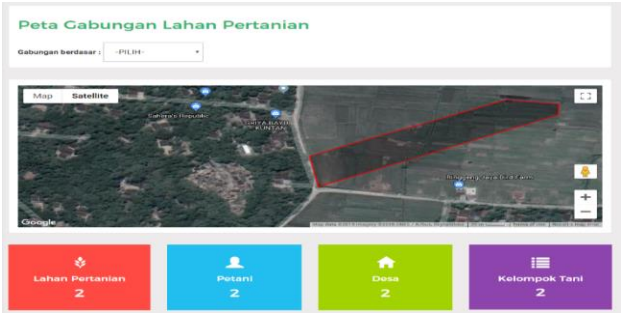


Fig. 21. Land Combined Map

TABLE. I. REQUIREMENT TRACEABILITYMATRIX

Req No	Req Desc	Test Case ID	Test Case Scenario
1	Login	TA01 TA02	Check Url http://dutatani.id/si_mapping Check Customer Login with invalid Data
2	Filtering Maps	TB01, TB02, TB03, TB04	Check Maps Filtering Features Change the Maps Mode Change back the Maps Mode Check Points Info
3	Manage Farmland Data	TC01, TC02, TC03, TC04, TC05, TC06, TC07, TC08, TC09, TC10	Check Menu *Daftar Lahan Petani* Add the Farmland Data Update the Farmland Data Delete the Farmland Data Add additional ownership data into a farmland Add additional planting data into a farmland Add farmland photos Add Farmland Points Update Farmland Points Remove Farmland Points

From testing to 30 users, it was found that the results were quite good with an average success rate of 74.375%. The results of this test can be seen in Table II and Figure 22.

TABLE. II. TESTING RESULT

Test Case ID	Test Case Scenario	Number Pass	Percentage %
TA01 TA02	Check Url http://dutatani.id/si_mapping Check Customer Login with invalid Data	27 22	90 73.33
TB01, TB02, TB03, TB04	Check Maps Filtering Features Change the Maps Mode Change back the Maps Mode Check Points Info	26 19 24 20	86.67 63.33 80 66.67
TC01, TC02, TC03, TC04, TC05, TC06, TC07, TC08, TC09, TC10	Check Menu *Daftar Lahan Petani* Add the Farmland Data Update the Farmland Data Delete the Farmland Data Add additional ownership data into a farmland Add additional planting data into a farmland Add farmland photos Add Farmland Points Update Farmland Points Remove Farmland Points	25 15 22 26 17 26 28 25 16 19	83.33 50 73.33 86.67 56.67 86.67 93.33 83.33 53.33 63.33

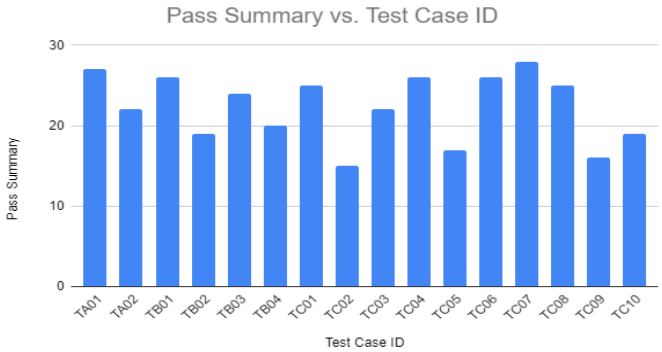


Fig. 22. Statistic of Scenario Testing.

Farm Land Web Mapping System that we developed has some strengths and weaknesses. This system provides information for farmers and management/representatives of farmer groups. This information will help farmers and farmer groups manage land ownership and land processing better. This information is shown on the dashboard that is provided in this system. The limitation of developing this system lies in the mapping of farmland filed formed on the Land Combined Map which covers areas that should not be included in agricultural areas. This is due to the use of Convex Hull Graham's Scan method on the online Google Maps which only detects the outermost point, while the inside will be missed. This can cause data to be biased.

This study gives some practical and academic contributions in terms of developing the Farm Land Web Mapping System. First, this system is built using the real data which got from Tani Harjo and Tani Rahayu Farmer Union. This is a new approach that researchers want to develop by understanding from the farmers what kind of data and information they need. If this system is successful to be built and implemented, researchers want to propose a local government to implement the Web Mapping System in order to help the farmer manage the land well. The developing of Web Mapping System using Rapid Application Development is an iterative and easy way to understand the needs of the user (farmers). Iterative development is needed since farmers do not understand a lot about Information Technology and some of them are digitally illiterate. By using Rapid Application Development, researchers want to understand the business process and farmer information needs Researchers are succeeded to gather the requirement from the farmers and farmer union.

V. CONCLUSION

From the results of research on the implementation of the system that has been done, it can be concluded that:

a) Application of Land Recording Information System can create a system for recording agricultural land so that the agricultural land data obtained is structured according to needs and stored in a database so that it can be used easily if needed.

b) The application can display data on a map in the dashboard using data that has been recorded in the database by calling data using the API service and from Google Maps as needed.

c) The application can do the calculation of farmland, farmers, regions and farmer groups to meet the calculation needs that are in the dashboard.

d) The Land Recording Information System application can also create and determine the relationships between farmers and farmland related to the farmers as needed by differentiating land ownership status.

The future works of this research is to measure the level of user acceptance and usability tests of the system. Both evaluations are conducted to get feedback for the final system product before it is implemented to the user. Further development will be built on a mobile-based application to facilitate user access to the system.

ACKNOWLEDGMENT

The research team would like to thank the Ministry of Research, Technology, and Higher Education for the funds that have been given to undertake this research with research contract number 227 / SP2H / LT / DRPM / 2019. The research team also thanked the Community Empowerment Research and Empowerment Institute Universitas Kristen Duta Wacana for its support so that this research could proceed well.

REFERENCES

[1] R. Delima, "Analisis Kondisi dan Kesiapan Masyarakat Tani di Daerah Istimewa Yogyakarta untuk Memanfaatkan TIK di Bidang Pertanian," Yogyakarta, 2016.

[2] R. Delima, H. B. Santoso and J. Purwadi, "Kajian Aplikasi Pertanian Yang Dikembangkan di Beberapa Negara Asia dan Afrika," in Seminar Nasional Aplikasi Teknologi Informasi, Yogyakarta, 2016.

[3] R. Delima, H. B. Santoso and J. Purwadi, "Architecture Vision for Indonesian Integrated Agriculture Information Systems Using TOGAF Framework," in International Conference on Informatics and Computing, Lombok, 2016.

[4] R. Delima, H. B. Santoso and J. Purwadi, "Business Architecture Development for Integrated Agriculture Information System (Iais) Using Togaf Framework," Researchers World, vol. VIII, no. 2(1), pp. 1 - 13, 2017.

[5] H. B. Santoso and R. Delima, "Stakeholder Definition for Indonesian Integrated Agriculture Information System (IAIS)," in The International Conference on Information Technology and Digital Applications, Yogyakarta, 2016.

[6] R. Delima, H. B. Santoso and J. Purwadi, "Development of Dutatani Website Using Rapid Application Development," International Journal of Information Technology and Electrical Engineering, vol. 1, no. 2, pp. 36-44, 2017.

[7] H. B. Santoso, C. Malvin and R. Delima, "Pengembangan Sistem Informasi Pendataan Petani dan Kelompok Tani," in Seminar Nasional Sistem Informasi Indonesia, Sanur, 2017.

[8] R. Delima, F. Galih and A. Wibowo, "Development of Crop and Farmer Activity Information System," Researchers World, vol. VIII, no. 4, pp. 180 - 189, October 2017.

[9] R. Delima, H. B. Santoso, N. Andriyanto and A. Wibowo, "Development of Purchasing Module for Agriculture e-Commerce using Dynamic System Development Model," International Journal of Advanced Computer Science and Applications, vol. 9, no. 10, pp. 86 - 96, 2018.

[10] S. M. A. El-kader and B. M. M. El-Basioni, "Precision farming solution in Egypt using the wireless," Egyptian Informatics Journal, vol. 14, pp. 221 - 233, 2013.

[11] S. T. Far and K. Rezaei-Moghaddam, "Impacts of the precision agricultural technologies in Iran: An analysis experts' perception & their determinants," Information Processing in Agriculture, vol. 5, pp. 173 - 184, 2018.

[12] M. Krishnan, C. A. Foster, R. P. Strosser and J. L. Glancey, "Adaptive modeling and control of a manure spreader for precision agriculture," Computers and Electronics in Agriculture, vol. 52, no. 1-2, pp. 1-10, 2006.

[13] D. Breazeale, "A Precision Agriculture Fertilization Program For Alfalfa Hay Production: Will it Pay for Itself," University of Nevada Cooperative Extension, 2006.

[14] M. R. Yousefi and A. M. Razdari, "Application of GIS and GPS in Precision Agriculture (a Review)," International Journal of Advanced Biological and Biomedical Research, vol. 3, no. 1, pp. 7-9, 2015.

[15] Z. Naiqian, W. Maohua and W. Ning, "Precision Agriculture Worldwide Overview," Computers and Electronics in Agriculture, vol. 36, pp. 113 - 132, 2002.

[16] G. Pulighe and F. Lupia, "Mapping Spatial Patterns of Urban Agriculture in Rome (Italy) using Google Earth and Web-Mapping Services," Land Use Policy, vol. 59, pp. 49-58, 2016.

[17] H. Yin, A. V. Prishchepov, T. Kuemmerle and B. Bleyhl, "Mapping Agricultural Land Abandonment From Spatial and Temporal Segmentation of Landsat Time Series," Remote Sensing of Environment, vol. 210, pp. 12-24, 2018.

[18] A. Dennis, B. H. Wilom and D. Tegarden, System Analysis and Design : An Object Oriented Approach with UML, United States of America: John Wiley & Sons, 2014.

[19] R. Naz, M. A. Khan, S. Zulkifar and A. R. Bhutto, "Rapid Application Development Techniques : A Critical Review," International Journal of Software Engineering and Its Application, vol. 9, no. 11, pp. 163-176, 2015.

[20] F. Fatima, M. Javed, F. Amjad and U. G. Khan, "An Approach to Enhance Quality of the Rad Model Using Agents," The International Journal of Science and Technoledge, vol. 2, no. 13, pp. 202 - 210, 2014.

[21] M. L. Despa, "Comparative Study on Software Development Methodologies," Database System Journal , vol. V, no. 3, pp. 37-56, 2014.

[22] Z. P. D. Zhu, Computational Geometry Algorithm Design and Analysis, Beijing: Tsinghua University Press, 2005.

[23] M. D. Berg, O. Cheong, M. V. Krevald and M. Ovemars, Computational Geometry Algorithms and Applications Third Edition, Springer, 2008.

[24] Z. Fu and Y. Lu, "An Efficient Algorithm for The Convex Hull of Planar Scattered Point Set," in International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences, Melbourne, 2012.

[25] T. H. Cormen, C. E. Leirson, R. L. Rivest and C. Stein, Introduction to Algorithms (Third Edition), The MIT Press, 2009.

[26] F. Lanzetta, A. Vaudrey and P. Baucour, "A New Method to Optimize Finite Dimensions Thermodynamic Models: application to an Irreversible Stirling Engine," International Journal of Ambient Energy, vol. DOI: 10.1080/01430750.2017.1310134, 2017.

[27] P. Novandi, "Analisis Kompleksitas Algoritma Pencarian Convex Hull Pada Bidang Planar," Institut Teknologi Bandung, Bandung, 2007.

[28] Google, "How To Use Google Maps," 18 November 2018. [Online]. Available: https://support.google.com/maps/answer/144349?hl=en&topic=1687350&visit_id=636779620492025610-3152190319&rd=2.

CREeLS: Crowdsourcing based Requirements Elicitation for eLearning Systems

Nancy M. Rizk[1], Mervat H. Gheith[2], Ahmed M. Zaki[3], Eman S. Nasr[4]
Business Information Systems Department, College of Management and Technology
Arab Academy for Science, Technology, and Maritime Transport (AASTMT), Egypt[1]
Faculty of Graduate Studies for Statistical Research, Cairo University, Egypt[2]
Independent Researchers, Egypt[3, 4]

***Abstract*—Crowdsourcing is the process of having a task performed by the crowd. Because of the Web evolution, recently crowdsourcing is being used in the field of Requirements Engineering to help in simplifying its activities. Among the information systems that were highly affected by the Web evolution are the eLearning Systems (eLS). eLS has special characteristics, such as the large number and diversity of users who could be geographically dispersed. To the best of our knowledge, there is little evidence that a crowdsourcing based requirements elicitation approach especially tailored for eLS that addresses their special characteristics exists. In this paper we attempt to fill in this gap. We present Crowdsourcing based Requirements Elicitation for eLS (CREeLS), which is made up of a framework of the necessary elements of crowdsourcing suggesting specific tools for each element, and a phased approach to implement the framework. We evaluated our approach through analyzing real-life users' reviews and extracted keywords that represent users' requirements by using topic modeling techniques. The reached results were then evaluated by manual text reviewing and the extracted features were found to be coherent. CREeLS has 0.66 *precision* and 0.79 *recall*. Hence we contend that CREeLS can help requirements engineers of eLS to analyze users' opinions and identify the most common users' requirements for better software evolution.**

Keywords*—Requirements engineering; requirements elicitation; crowdsourcing; eLearning systems

I. Introduction

Crowdsourcing is known to be the process of obtaining the needed services by outsourcing them to the crowd, which can be defined as a group of people with a common interest [1]. Crowdsourcing as a term was coined by Jeff Howe in Wired in June 2006. In his article "The Rise of Crowdsourcing" [2], he described how small businesses are getting successful from using "the power of the crowd", rather than the traditional professional ways, to cut their costs. He also proposed the use of crowdsourcing in research and development departments to get new ideas for new products or features from the crowd. Howe then wrote an article titled "Crowdsourcing: A Definition" [3] to make the term clearer and not to confuse it with other terms. He mentioned that crowdsourcing can be used at any time when needed in an organization.

The use of "the power of the crowd" to achieve specific tasks is gaining more and more ground every day. Because of the Web evolution, recently crowdsourcing is being used in the field of requirements engineering to help in simplifying the activity of requirements elicitation, which usually involves various stakeholders, e.g. [4] [5] [6] [7] [8]. According to Sommerville [8], requirements engineering activities are: requirements elicitation, requirements analysis, requirements specification and requirements validation. This paper will focus on the requirements elicitation activity only.

Requirements elicitation is an early software development activity within the requirements engineering phase. It is concerned with understanding and learning stakeholders' needs [9]. It is a very important activity for the success of a software development project, where detecting errors at the early stages of development can save money and time [10]. According to the Standish Group CHAOS Report [10], users' involvement is one of the critical success factors in any software development project and this is usually performed in the requirements elicitation activity. The narrow concept of stakeholders, the limited involvement of users with knowledge in requirements prioritization, and the bias of a requirements engineer who focus on certain types of requirements, in addition to the geographically dispersed stakeholders, and the uncertain technical and social environment are among the limitations and threats of the traditional requirements elicitation approaches [11] [12] [13] . Crowd-based requirements engineering, which was coined as a term by Groen et al., is a highly interactive approach; it can get user requirements in less time, helps in getting new ideas for software evolution, and has the potential to increase the quality of requirements elicitation [4].

Among the information systems that were highly affected by the Web evolution are the eLearning Systems (eLS). eLearning is well known to be the use of technology in the delivery of education, where in some cases the learning resources are accessed online anywhere and anytime [15], [16]. eLearning has different tools, types, and information systems, which are discussed and compared in [17]. eLS has two main types of management systems; Learning Management Systems (LMS) and Learning Content Management Systems (LCMS). LMSs are concerned with the administrative process of learning, such as scheduling, testing, billing and registering learners, e.g. Moodle, and Blackboard [18]. LCMSs combine the administrative processes of LMS with the authoring and content creation dimensions [19] [20]. Hence eLS can be defined to be the systems that are concerned with the administering or content authoring tools to help students, instructors and management in the learning process. eLS can

be used in an educational context or a corporate training context.

Among the characteristics of eLS are the large number and diversity of eLearning users in terms of background, geographical locations, and culture. Also, the high interactivity nature of the learning process, leads to an on-going demand of requirements that should be fulfilled for better improvement of the learning process and satisfaction of stakeholders. Limitations of the traditional requirements elicitation approaches are also exists when requirements elicitation are performed on eLS [21], [13]. Hence, we propose crowdsourcing too to be used in the eLearning context to handle the eLS characteristics and serve in the requirements elicitation activity. To the best of our knowledge, there is little evidence that a crowdsourcing based requirements elicitation approach especially tailored for eLS, that addresses their special characteristics exists. In this paper we attempt to fill in this gap to increase the quality of eLS' requirements elicitation and be able to get user requirements in less time, or get new ideas for software evolution by reaching greater number of stakeholders no matter their location or culture. We claim that crowdsourcing can use "the power of the crowd" through the power of Web 2.0 technologies to better elicit the stakeholders' requirements for eLS.

In this paper we present Crowdsourcing based Requirements Elicitation for eLS (CREeLS), which is made up of a general framework of the necessary elements of crowdsourcing suggesting specific tools for each element, and a phased approach to implement the framework in the requirements elicitation activity for eLS. We conducted an experimental study to evaluate the validity of our proposed approach. In addition, manual reviewing of user's requirements was used for the evaluation of the experimental study. CREeLS has 0.66 precision and 0.79 recall. Hence we contend that CREeLS can help requirements engineers of eLS to analyze users' opinions and identify the most common users' requirements for better software evolution.

The rest of this paper is organized as follows. Section 2 provides the literature survey of requirements elicitation for eLS, crowdsourcing-based requirements engineering, and the use of crowdsourcing in eLS as published in the literature. Section 3 presents CREeLS, our proposed framework and proposed approach, to attempt to fill in the identified gap in the literature. Section 4 explains and discusses the experimental study conducted using CREeLS. Section 5 discusses the evaluation of the experimental study, its results and limitations. Finally, Section 6 gives the conclusion and future work.

II. Literature Survey

This section gives the literature survey; it was conducted for three main fields of study. It first presents a brief survey about available publications of requirements elicitation for eLS. Second, it surveys the different crowdsourcing-based tools and approaches published in the requirements engineering literature. Third, and finally, it presents how crowdsourcing is used in general in the eLS literature.

A. Requirements Elicitation for eLS

In our attempt to make a survey to study the limitations of the traditional requirements elicitation approaches for eLS; we only found very little publications that address requirements elicitation for eLS in particular. AlKhuder and AlAli [21] presented the importance of requirements elicitation activity for the eLS development, mentioned some of eLS characteristics that challenge the requirements elicitation activity e.g. the on-going demand of requirements of learners, and the variability of stakeholders. They also proposeed some eLS requirements for different aspects of the system as an outcome of requirements elicitation activity. On the other hands, the authors were not clearly revealing the source or basis of eLS requirements presented in their paper.

Abdul Rahman and Sahibuddin [13] discussed the challenges of requirements engineering for eLS, one of these challenges was the lack of traditional requirements elicitation technique to get all of the stakeholders' requirements. They mentioned that the requirements engineers only focus on the technical requirements but not the social requirements of users. The paper suggested the need for an adequate requirements elicitation mechanism to detect and enhance users' social requirements to keep the users' sustainability of the eLS.

Tran and Anvari [22] highlighted the lack of the availability of a framework to address eliciting requirements of eLS' stakeholders, and confirmed the special nature of eLS because of the great number and diversity of stakeholders. The paper implied the need to open new insights in the perspectives of requirements elicitation by the software engineers, as well as the need for collaboration and communication in the requirements elicitation process. It focused on the questionnaire technique for corporate eLS in the context of Accounting Information Systems (AIS); a five-dimensional framework is proposed to guide the design of questionnaires that will be used in the requirements elicitation activity for eLS.

Ali and Lai [23] addressed the importance of communication and collaboration between stakeholders in the Global Software Development (GSD) context. We found that stakeholders in this context are comparable to stakeholders in eLS context, they are diverse in cultures, geographically dispersed, and there are times zones and language barriers, which made difficulties in engaging into an effective communication. Accordingly, there is a need of requirements elicitation approach to fulfill the collaborative needs and diverse context of stakeholders. The publication had presented a new method for requirements elicitation and analysis based on four stages involving some of the traditional requirements elicitation techniques e.g. use case, scenarios. Finally a preliminary evaluation was conducted through applying a case study on graduate students.

We can conclude that the surveyed papers confirms on the characteristics of the eLS and the need for new requirements elicitation approaches to overcome the limitations of the traditional ones in eLS context.

B. Crowdsourcing-Based Requirements Engineering

This section reviews and summarizes the use of crowdsourcing in requirements engineering, and presents the different crowdsourcing-based tools and approaches published in the requirements engineering literature. According to Hosseini [24], the four pillars of crowdsourcing are as follows, 1- The crowd: the people involved in a crowdsourcing action. 2- The crowdsourcer: the entity which looks for the power of the crowd for doing a task. 3- The crowdsourcing task: the activity or action in which the crowd participates. Finally, 4- The crowdsourcing platform: the system which a crowdsourcing task is accomplished within. Some platforms handle all of the software engineering phases; others handle specific phases. What is common between all platforms is that they all let a crowdsourcer find talents and benefit from reduced costs, solution diversity, creativity and problem solving [25]. There are many commercial platforms that are used in different research case studies or real-world projects in the field of software engineering, e.g. Upwork, TopCoder, Elance, Odesk, Utest, Amazon Mechanical Turk (AMT), IdeaScale, Stake Overflow [14].

Crowd-based requirements engineering as a term was coined by Groen et al. [4] to be a requirements engineering approach for acquiring and analyzing any kind of users' feedback from the crowd, with the aim of seeking validated user requirements. It was further elaborated by Groen and Koch [5] be "the combined set of techniques for analyzing data from the crowd using text and usage mining, motivational techniques for stimulating further generation of data, and crowdsourcing to validate requirements". Groen et al. [26] discussed the concept of crowd-based requirements engineering (CrowdRE) and its landscape and challenges to emphasize the use of it. The research mentioned the possible early return on investment from the use of crowdsourcing in requirements engineering; however there is a need for more empirical researches and case studies.

Crowdsourcing is used in requirements elicitation to help requirements engineering [27]. It assists in finding, detecting and involvement of different stakeholders who can outline software requirements. Crowdsourcing increases and improves the range of elicited requirements and, as a result, helps getting a whole idea of users' and other stakeholders' expectations from a software. Hosseini et al. [6] reported initial results in the use of crowdsourcing in requirements engineering after conducting two focus groups of experts to discover the crowdsourcing features and its quality attributes. The results showed that largeness, diversity, anonymous participation, volunteering and incentives lead to more correctness, and completeness of requirements gathering.

The use of crowdsourcing in requirements engineering is usually accompanied by a supported tool [4]. Groen et al. [4] presented a classification of the tools that were used to create a crowd-based requirements engineering approach: Social oriented collaboration tools, such as CrowdREquire. It was a platform that helped individuals and companies to find the best requirements specification for their proposed tasks and projects. It had a communication tool to connect requirements engineering professionals with the companies that request their services [28]. Srivastava and Sharma [12] proposed a crowdsourcing-based tool to a case study on MyERP software to extract software requirements across various and different geographical crowd. The tool succeeded in getting diverse opinions, requirements and lowering the cost of it. Snijders et al. proposed and evaluated a requirement engineering method based on gamification and crowdsourcing called Crowd-Centric requirements engineering [11]. They also proposed Refine, which was a game-based online platform for requirements elicitation and refinement; it allowed the involvement of a crowd of stakeholders [29]. Sharma and Sureka [7] proposed CRUISE which was a platform that had a comprehensive vision to be used as a crowd-based platform for all requirements engineering activities. The platform was validated through a preliminary experimental study to investigate the feasibility and capability of the platform. Lim et al. [30] had proposed a novel method called StakeRare that uses social networks analysis to identify and prioritize requirements in large software projects. The method was based on building a social network of stakeholders and their recommendations of other stakeholders to reach a list of requirements using applied SNA measures. The system was evaluated by applying it on large size software project. The case study applied confirmed that StakeRare predicted stakeholder needs accurately and correctly prioritized.

Web-based approaches with social network analysis or recommender systems: for example StakeSource. It was a Web-based tool that automated stakeholder analysis. It crowdsourced the stakeholders themselves for recommendations about other stakeholders and aggregated their answers using social network analysis [31].

Text mining tools: focus on analyzing available data without actively involving stakeholders. Thereby not supporting elicitation directly, rather, they determined the relevance and importance of a sentence or statement through natural language algorithms, usually based on app store reviews [32], [33], [34]. Hosseini et al. [35] surveyed experts to support the use of crowdsourcing for the help of requirements elicitation. In [35] CRAFT proposed, it is a technique that utilized the crowd power to enrich text mining by allowing the crowd to categorize and annotate feedback through a context menu. This, in turn, helped in better identifying user requirements within forums feedback. Guzman and Maalej [33] studied the use of NLP and sentiment analysis in the field of requirements engineering and specifically for the elicitation activity. They analyzed different users' reviews in the mobile applications industry; they used a collection of analysis methods to reach for fine grained extracted features. Finally, their approach was evaluated by comparing the results with manually extracted features they obtained a *precision* up to 91% with 59% in average. NLP had been tested for its efficiency in comparison to the manual analysis of users' reviews by Groen et al. [36] the results showed that automated NLP analysis were much faster. Table 1 Lists the crowd-based tools in requirements engineering found in literature; it gave the tool name, its corresponding requirements engineering phase, the supportive tools and the reference citation.

TABLE. I. LIST OF LIST OF THE CROWD-BASED TOOLS IN REQUIREMENTS ENGINEERING

Tool Name	Requirements Engineering Phase	Supportive Tool	Ref. No
CrowdREquire	Requirements Specification	-	[28]
---------	Requirements Elicitation	SNA	[12]
Refine	Requirements Elicitation	Gamification	[29]
CRUISE	Requirements Engineering Phases	-	[7]
StakeRare	Requirements Elicitation & Prioritization	SNA	[30]
----------	Requirements Evolution	NLP	[32], [33]
CRAFT	Requirements Elicitation	Expert Survey	[35]
StakeSource	Stakeholder Analysis	SNA	[31]
Requirements Bazaar	Requirements Elicitation & Prioritization	Social SW	[37]
CrowdCentricRE	Requirements Elicitation	Gamification	[11]

C. The use of Crowdsourcing in eLS

This section presents the current use of crowdsourcing in eLearning as available in the literature. In the eLS literature the use of crowdsourcing is concerned with the crowdsourcing of the creation of the learning content [38] and providing the learning service to a large number of users, e.g. Coursera that has classes with thousands of students [39], [40]. Although we are concerned with the use of crowdsourcing for requirements elicitation for eLS, we will present in this section how crowdsourcing were used in general in the eLS literature for completeness of coverage. Suhonjic et al. [41] proposed a crowdsourcing model that combines the collaborative learning and crowdsourcing mechanisms to implement it on learner-centered approach. The study aimed to enhance the participation and collaboration of learners as learning creators. The study was evaluated by case study applied on 74 students on Blgrade University. It showed an enhancement in user participation, and good quality of learning contents. Tarasowa et al. [42] presented Crowd-Learn which was the use of learning objects for structured eLS to support the system and to manage the learning objects (files, presentations). The model used the wiki style collaborative authoring, and crowdsourcing for the creation of learning contents of eLS. The system evaluated by case study applied on an information system lecture at Chemnitz Technical University. The Wiki slides are structured within the lecture and added questions for student self-assessment before the final exam. Tarasowa found that eLearning material when combined with crowd-sourcing and collaborative social approaches can help to cultivate innovation by collecting and expressing different individual's ideas.

Barbosa et al. [43] studied crowdsourcing for Massive Online Open Course (MOOC) and set dimensions to classify the types of crowdsourcing for eLearning tools, and identified many crowdsourcing tools for eLearning. The publication discussed and classified 22 crowdsourcing eLearning tools found in the Internet e.g. Coursera, Udacity and MIT OpenCourseW. The tools were varying from online universities to marketplaces for online courses. It built a framework to compare and group the tools, using a set of eleven dimensions. Collaboration is a key aspect, as in a class of thousands of students, it was virtually impossible for a teacher to give attention to every single student. The crowd must help itself to enable this approach, moreover, it offers learning in a natural way. The job of the teacher becomes more illustrative, and less evaluative.

Paulin & Haythornthwaite [40] addressed how the evolution of the Web changes how, where and with whom people learn, and the opportunities and challenges this rises for the future of educational practice. The publication focused on taking advantage of crowdsourcing to create and manage large-scale learning enterprises. MOOCs were the principal point for large-scale online learning. The power of the crowd was being leveraged to address many of the scale-related issues that arise in MOOCs. Elements suggested to be addressed by crowdsourcing were content, discussion, evaluation, behavior, practices, learning analytics, and assessment and feedback.

Karataev and Zadorozhny [38] studied the crowdsourcing of learning content to anyone. They introduced a novel framework for social learning that allows any person to author educational content as mini-lessons, learn lessons by use adaptive learning pathways to learn lessons, and interact with their peers. The system was evaluated through a number of classroom studies. The results showed that adaptive social learning can be utilized by collective learning experiences also they found that students with very high similarity tend to arrange groups.

We can conclude that literature survey ensures that there is a gap in the requirements elicitation activity for the eLS, there is a need for a new or enhanced approach to fill in this gap. Also, the literature survey gives a motivation and recommendation to use crowdsourcing in requirements engineering as an emerging approach, hence we present Crowdsourcing based Requirements Elicitation for eLS (CREeLS). The following section presents detailed overview of our proposed framework and approach CREeLS.

III. CREELS

This section presents CREeLS; our proposed automated approach for Crowdsourcing based Requirements Elicitation for eLS. It is made up of a framework, which presents the broad lines and the basic concepts, and an automated approach.

A. CREeLS' Framework

After reviewing the literature we came up with the recommended sources of crowd in the eLS context, and the supported tools that can utilize the crowd interactions or opinions needed in the requirements elicitation activity. We could form the proposed framework based on these sources and tools. The crowd sources are interactivity in the use of the power of social networking and applying text mining tool for the received feedback. The framework gives broad lines for achieving crowd-based requirements elicitation for eLS. The use of each suggested tool in crowdsourcing for requirements engineering is separately evaluated in the literature. The proposed framework is illustrated in Fig. 1.

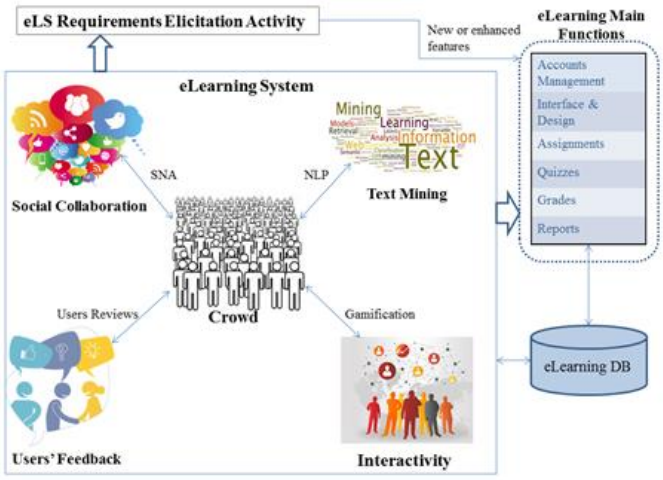


Fig. 1. The Proposed Framework of the Necessary Elements of CREeLS.

1) eLearning system: The proposed framework is operating in the context of eLS. The suggested elements of crowdsourcing requirements elicitation for eLS are established inside the eLS, as they are parts of the eLearning process as we will explain in the next sub-sections. Those elements are considered inputs for the eLS requirements elicitation activity, the results from the analysis of those elements can reveal new or enhanced features for the eLS functions.

2) The crowd: The crowd in crowdsourcing context is the group of people who engage and participate in the crowdsourcing activity. According to Hosseini et al. [24] crowd is characterized by: diversity, suitability, anonymity, largeness, and undefined-ness. Crowd in eLS are the eLS users from learners, instructors, administrators, management, or parents or learners. The framework can be applied on the context of crowdsourcing platforms. Crowdsourcing platform connects requesters with online workers [25].

3) Users' feedback: The target of the proposed framework is to minimize the gap between the development team and the eLS' stakeholders. Feedback is one source of getting what's in the users' minds without intentionally getting in direct interaction with them [44]. There must be different feedback methods from the interaction between the eLearning participants in the different forms of social collaborations that support eLS. Learning is a lifelong process that requires continuous feedback and adaptation. Feedbacks can be on the eLS itself, course and its material, or the instructor and management.

Users' comments or reviews are means of feedback that can be found in the eLS in its different modules. Users' comments and reviews can contain useful information for developers; they include good, bad, or recommended features [45]. Thus, the analysis of these reviews is important for the requirements engineering activities [46]. The proposed framework suggests the use of feedback analysis methods to gain the benefits from eLS users' comments and reviews in requirements elicitation activity while developing eLS.

4) Interactivity: Interactivity between the eLearning participants (Instructor, learner, course, and management) is important. Interactivity leads to better course results for learners [47], and to know the participants' opinions in the different modules of the eLS, e.g. course material, quizzes, assignments, scheduling, eLearning process, and participation between the different eLS users. Improving social interaction in eLS can improve user satisfaction. Social interactions involve more collaborative activities. Crowdsourcing in eLS not only increases the amount of educational content but also improves its quality [42].

The collaboration of a person's contribution with a larger, shared, cooperative work is a type of interaction, thus the act of crowdsourcing can be considered naturally interactive. Jinnifer and Brigid [48] identified three possible categories of interactive, crowdsourced works: Category 1: Linear/single-channel works created from multiple user contributions. Category 2: Interactive works created from unique individual contributions. Category 3: Interactive works created from multiple user contributions.

Category 3 is recommended to be the first to start with; as many stakeholders are involved in the requirements elicitation process. Under this category we suggest the use of gamification in the interactivity element of the framework. Gamification seeks of integrating the game process and techniques in a non-gaming process to be more attractive. Gamification seeks out for improvement of the user's performance, commitment, and motivation [49].

5) Text mining tools: Text mining is the process of analyzing unstructured text using data mining techniques. In the framework we use text mining in order to analyze eLearning participants' written interactions, which exist in the different modules in the eLS. It can be found in social networking applications attached to the eLS, discussion forums, comments spaces below blogs posts, or any other different posts. The use of text mining techniques will extract the hidden requirements. One method of text mining analysis is Natural Language Processing (NLP). Text mining can be used in requirements elicitation process for eLS to identify new, good, bad or need to be enhanced features [33].

6) Social collaboration: Social Network Sites (SNS) are an example of social software; they are used for communicating and connecting with others–anytime and anywhere. SNS allow the creation of social groups, where many people with similar interests are connected together and communicate in different forms. Studying the patterns of social collaborations in SNS is a method of getting the users requirements and knowing their behavior.

Social Network Analysis (SNA) is a method of understanding the relationships among the nodes of interactions and studies the patterns and effects of the relationships. Thus, SNA can help in requirements elicitation to identify eLS requirements.

B. CREeLS Automated Approach

The authors are encouraged to propose new requirements elicitation approach for eLS based on the crowdsourcing concept because of the following factors; eLS characteristics, the crowd-based requirements engineering definitions mentioned earlier, the findings from the literature review. in addition to, the proposed framework discussed in the previous section, the need of an automated approaches that combines both the social and technical aspects of software engineering in general and requirements elicitation in particular [50].

CREeLS approach has five phases, (1) Creating a channel for users to post their feedback, or show their interactions. (2) Extracting users' interactions or feedback. (3) Analyze users' interactions or feedback. (4) Evolve fine software requirements. (5) Categorize and consolidate the requirements. eLS stakeholders are CREeLS's crowd.

Phase 1: Creating (a) channel(s) for users to post their feedback or show their interactions. The approach starts by creating a channel(s) or a facility (ies) for users to post their feedback. The requirements engineer decides to select one, or more than one channel to be created. The recommended available channels are: a) allow users to post their feedback through posting reviews on the use of their eLS. This can take place through surveys, or evaluation buttons in the eLS applications. The paper will focus on this method. b) allow the use of social networking sites (SNS) within the eLS, or add social networks application to the eLS. c) create a gamified way to encourage users to post their experience of using the eLS. The use of gamification technique is promising in the requirements engineering field [11]. The use of incentives, collected points, and badges are different techniques of gamification. There is also one more hidden channel, which is creating different interactivity tools for the eLS users. The analysis of these interactions, eLS requirements can be extracted.

The previous channels are crowdsourcing the requirements elicitation task intentionally and unintentionally. Channel number one is considered as a direct channel where users know and intend to post their feedback. Channel two is considered an indirect way of extracting feedback as in the use of SNS; users post their feedback unintentionally through threads of discussions for socializing and communicating among different members or administrators. Channel three can be considered as both a direct and indirect way. It can be direct because users may know about the game purpose for collecting reviews, and intend to participate in it. On the other hand, for the users who like to be involved in games, they participate in it for the love of games, and unintentionally post their reviews. This phase allows eLS stakeholders to freely disclose their requirements on their way, no matter the number of feedback posts, geographical location, culture or background.

Phase 2: Extract users' interactions or feedback. Users' feedback posted in phase one should be collected and extracted in phase two. Users' feedbacks are stored in the eLS databases so the database administrator is involved in this phase to collect the stored feedback. The requirements engineer decides the data needed and ask the database administrator to prepare it and then send it to the text analyst to perform the analysis techniques.

Phase 3: Analyze Users' interactions or feedback. Analysis of users' feedback can be accomplished using different ways; text mining analysis is an example and it is under experimentation in this paper. The use of natural language processing in analyzing users' feedback; applying text preprocessing, then the feature extraction algorithms to extract users requirements.

Phase 4: Evolve fine software requirements. An optimization functions for natural language processing algorithms are applied to extract fine software requirements. Optimization functions intend to find the best values that achieve the highest coherence value and best collection of keywords and topics that represent the eLS requirements.

Phase 5: Categorize and consolidate the requirements. This phase is accomplished manually by the requirement engineer. Fine software requirements output from phase four are considered as input for this phase, requirements engineer classifies and categorizes software requirements then merge similar requirements together to have the final form of the eLS users' requirements.

IV. Experimental Study

This section presents our experimental study for CREeLS. According to Wohlin et al. [51], an experiment gives more control over the situation; it allows to compare the results when one variable is changing and the others are fixed. We wanted to analyze eLS users' feedback and evaluate whether this feedback was truly representing eLS requirements, then we will check whether the extracted requirements were similar and coherent as the manually extracted users' requirements. The experimental study reflects phase 3 in CREeLS approach, as we wanted to test whether CREeLS will succeed to extract keywords that reflect LMS users' requirements in less time than the manual extraction of requirements. Phases 1, 2, 4 and 5 will be skipped because of the following. Phase 1 requires programming development into the LMS to attach one of the suggested facilities tools, and this is out of the current research scope as we are focusing on LMS requirements extraction from users' reviews. Phase 2 is responsible for collecting and extracting the required reviews from the LMS database; we substituted this phase with the dataset we acquired from G2Crowd. Phases 4 and 5 will be left for future publication when we enhance CREeLS.

The experimental study started by data collection and went through the requirements extractions steps as detailed below. The only data we could be able to collect is LMS users' reviews from G2Crowd company; the data is on an Excel sheet. The reviews are for more than 20 products for both LMS for education purpose, e.g. universities and schools, and LMS for corporate purpose. The reviews are classified into reviews on features that users like, and reviews on features that users dislike. We used only one product for the current study which is 'Blackboard' with 5036 users' reviews. We followed the following steps for eLS feature extraction. The steps are illustrated in Fig 2. We should mention that it is an evolutionary approach in which the results are at a certain point in the requirements elicitation activity, because there is a continuous stream of information from an LMS.

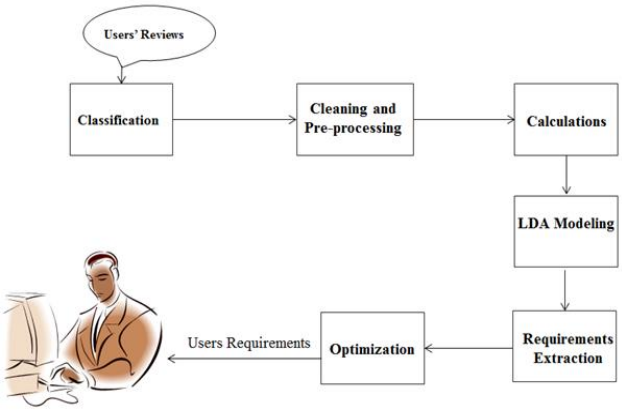


Fig. 2. Requirements Extraction Steps.

1) Classification. The dataset was classified according to the LMS type; features which users like, features that users dislike, and the role of the respondent, e.g. administrator, student, or instructor. In our study we selected first LMS products for educational purpose, because they have a larger number of reviews than corporate LMS. Second, we selected reviews about features which users dislike, because this will imply the users' needs and their requirements for the LMS. Third, role of users, this criterion we couldn't consider as most of the users were students and only few reviews were for administrators or instructor or management. Because text analysis needs a large amount of text for better results, we decided to include all the reviews with no classification according to users' roles.

2) Cleaning and Pre-processing. To perform the feature extraction, raw data should be prepared so that it can be easily analyzed and to get better results. Preparation of data should be performed in terms of: 1- cleaning or removing the special characters from the text e.g. commas, dashes, or semi colons, because these special characters were not needed in the extraction process. 2- Tokenization which is splitting the text into words, so that we can treat each word separately. The processes of cleaning and tokenizing text were performed together in one step using one function. 3- Stopwords removal: in computing, stop words are common words that has little value in the text [52] e.g. and, is, are. We used the standard list of stopwords provided by Gensim library and we added words that we found common in users' reviews, but weren't describing features e.g. "like", "dislike", "there", "easy". 4- Part of Speech Tagging (POS): it is tagging each word in the text as its corresponding grammatical part of speech [53]. We used the POS of wordnet in NLTK Package, in this step we defined and extracted the nouns, verbs, adjectives, and adverbs in the text. Because, it was important to understand what a text is about. 5- Stemming refers to a process that removes the ends of words to reduce it to its base or root form. 6- Lemmatization: aims to remove inflectional endings (are letters at the end of a word that change its meaning) and to return the word to its base or dictionary form.

3) Words calculations: We created a dictionary for each word used in the text. The output from this function was the minimum number each word has appeared in the text, and the maximum ratio of each word appeared in the text. We used the Gensim dictionary function in this step. TFIDF weight measurement was used for extracting features from the users' reviews. TF-IDF stands for Term Frequency-Inverse Document Frequency, the tf-idf weight is a statistical measure used to evaluate how important a word is to a document in a collection or corpus. The importance increased proportionally to the number of times a word appeared in the document but was offset by the frequency of the word in the corpus. Variations of the tf-idf weighting scheme are often used by search engines as a central tool in scoring and ranking a document's relevance given a user query [54]. Typically, the tf-idf weight is composed by two terms. The first term computes the normalized Term Frequency (TF); the number of times a word appears in a document, divided by the total number of words in that document. The second term is the Inverse Document Frequency (IDF), computed as the logarithm of the number of the documents in the corpus divided by the number of documents where the specific term appears.

4) Latent Drichlet Allocation (LDA) modeling: LDA is a topic modeling algorithm; it is a generative probabilistic algorithm for data collection, in our case is LMS users' reviews. In the context of topic modeling, each topic is considered as a group of topics [55]. This means that each user review can have more than one requirement (topic) associated; also, each requirement (topic) can have more than one keyword associated to it. In this step we used LDA algorithm to extract the top keywords in the text based on the calculations done in the step 3, which was calculating the weight of each word in each review and in the whole text. The result of applying LDA was the top feature keywords in the whole text.

5) Requirements extraction: Based on the top keywords in the text, we applied function that categorized these keywords into number of topics; these topics represented the users' requirements, and composed of number of the top keywords and its percentage of relevance to this requirement.

6) Optimization: We performed an optimization function, which specified the optimum number of requirements in the text. This function calculated the coherence value of the top keywords in text that composed a requirement and the distance between the requirements to reduce the overlapping between the requirements keywords. It also calculated the optimum value for keywords in terms of the minimum number each word appeared in the text, and the maximum ratio of this word appeared in the text. The results from the optimization function were 8 topics with keywords with minimum repetition in the text = 5 times, and maximum ratio to appear in the text is 40% with coherence value of 0.47. Each topic has dominant 10 keywords which indicated the system requirements. The topics distribution is illustrated in Fig. 3.

We noticed that the topics circles were not overlapped which means that the topics keywords were not overlapped, each topic represented its own keywords and topic. Circles with numbers represented the topics, the size of the circle indicated the dominance of this topic within the text, the keywords of the topic appeared in the text, and the highest frequency keyword appeared at the first. Table 2 illustrates the dominant keywords in each topic. We made some of these keywords bold to emphasize them, as we believe that they have higher tendency on indicating some of the eLS users' requirements.

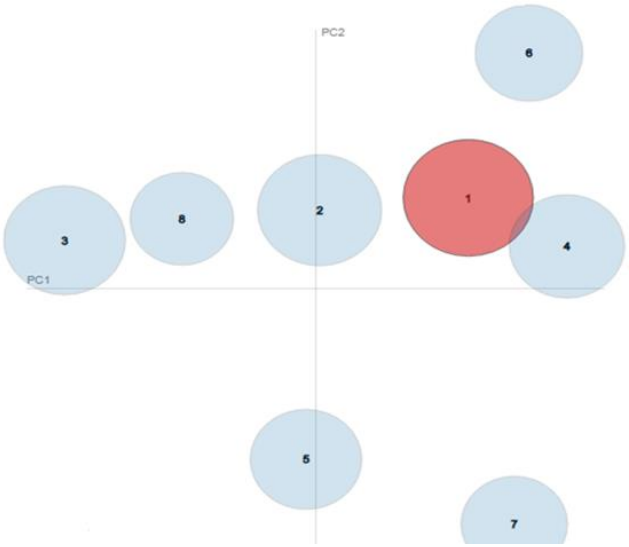


Fig. 3. Extracted Number of Topics.

TABLE. II. TOPICS AND KEYWORDS

Topic No.	Keywords
1	issue, content, **time**, **navigation**
2	**mobile**, **time**, **confuse**, **phone**
3	**Interface**, **grade**, **clunky**, **look**
4	**design**, **layout**, program, **difficult**
5	**assignment**, able, think, class
6	**time**, **maintenance**, fact, hour
7	know, **difficult**, product, specific
8	**buggy**, group, **calendar**, **glitch**

V. EXPERIMENTAL STUDY EVALUATION

In this section, the evaluation process of the experimental study is presented. Then a discussion of the results, its interpretations, limitations and threats to validity are discussed.

A. Results

There is no better way to accurately evaluate the topics generated from our approach, rather than manually, using human brain to revise the available users' reviews. We manually evaluated the approach by analyzing and reviewing each user's review for each LMS product to extract the user requirements for each review. Then we counted the number of reviews relevant to each requirement, and then we got the percentage of frequency for each requirement by dividing the number of reviews related to one requirement by the total number of reviews. This calculation was repeated for each manually extracted user requirement. The topics were sorted by importance from the highest percentage to lowest percentage. Finally, we compared it with the extracted topics. The process of manually extracting the users' requirements from the LMS reviews was accomplished by one person familiar with requirements engineering and extracting user requirements.

We evaluated the results of our automatic topic modeling by using *precision*, *recall*, and *F-measure*. According to Brownlee [56], *Precision* is how many selected items are relevant; it is computed by dividing the number of true positives by the sum of true positives and false positives. *Recall* is how many relevant items are selected; it is computed by dividing the number of true positives by the sum of true positives and false negatives. *F-measure* tests the experiment's accuracy; it's approximately the average of both *recall* and *precision*, the best value is 1 and the worst is 0. *F-measure* is calculated as follows:

$$F - measure = 2 * \frac{Precesion * Recall}{Precision + Recall}$$

True positive is the requirement that is both manually and automatically identified, false positive is the requirement that is automatically but not manually identified, and finally false negative is the requirement that is manually but not automatically identified from the approach. while working on the experimental study we considered a feature as true positive, if it was automatically extracted from a review and was also manually identified in that review. False positives are features that were automatically associated to a review in one of the topics, but were not identified manually in that review. Finally, false negative features were manually identified in a review but were not present in any of the extracted topics associated to the review. The results were as follows; *precision* 0.66, *recall* 0.77 and *F-measure* 0.71. In addition to *precision*, and *recall*, there is the *coherence* of topics which assesses how well the topics are logical and consistent and whether they share a common theme; its value reached up to 0.47. Those results were at certain points when running the approach; any changes in text reviews, or their number could affect the final results.

B. Results Interpretations

The quantitative results and the qualitative evaluation of the proposed approach were positive. CREeLS succeeded to extract an adequate number and good representation of topics, which are users' requirements of the LMS in a small time frame compared to the manual process. The qualitative evaluation showed coherent topics; most of the keywords represent LMS features, but not noise, and the topics' keywords were relevant to the LMS requirements. The results of the proposed approach can be manually adjusted for better users' requirements understanding. Synonym keywords and duplicate topics represented the importance of this topic as an LMS product requirement, e.g. *interface, design, look, clunky, and layout*, reflect the need for better and modern design for the LMS. The keyword '*time*' appeared in three topics but in different contexts; in topic 1 with the keyword navigation, it means that the navigation process takes time from the user. Also, in topic 2, the keyword *time* appeared with *mobile*, *phone*, and *confuse* means that the LMS version on the mobile takes more time. Finally, in topic 6 the keyword '*time*'

appeared with *maintenance* and *hour*, which means that the *maintenance time*, is not adequate with users. All of these interpretations for the different contexts of using the word *time* were supported by the manual evaluation of the results.

C. Limitations

This section gives some limitations of CREeLS. First, the features that are non-frequently mentioned in the reviews text are most probably not detected, as there is a minimum count for the keywords to appear in the reviews text. Second, the resulted topics keywords are not correlated. Third, LDA needs large number of reviews to perform better. These limitations could be improved by encouraging users to write their reviews, adding language patterns and the use of two connected keywords and not a single one only. This can allow the identification of low occurring keywords and add more correlation to the topics' keywords, and taking context into consideration.

D. Threats to Validity

The process of manually extracting the users' requirements from the LMS reviews was accomplished by one of the authors, and not an actual business analyst or requirements engineer. The author can have misunderstanding or incomplete information about real eLS. Also biased implications on the manual evaluation results can be present.

VI. Conclusion and Future work

This paper presented CREeLS, the crowdsourcing based requirements elicitation approach for eLS. CREeLS is made up of a framework for the necessary elements of crowdsourcing suggesting specific tools for each element, and a phased approach to implement the framework. The phased approach uses topic modeling techniques to extract requirements from eLS users' feedback. An experimental study was conducted to extract users' requirements from real-life LMS users' reviews. The results were evaluated by manually revising the user's reviews which showed coherence of topics up to 0.47, *recall* value 0.79, *precision* 0.66 and *f-measure* of 0.71. The results were very promising; therefore, we contend that CREeLS can help requirements engineers for eLS to analyze users' opinions and identify the most common users' requirements for better software evolution. For our future work we intend to continue improvement and validation of CREeLS through trying other topic modeling techniques that can combine two or three words to give more understandable results of the users' requirements. In addition, further experimental studies will be carried out on a greater number of text reviews for more than one LMS product, and will also include the corporate LMS products.

Acknowledgment

We are very grateful to G2Crowd Company for sharing with us its LMS' users' reviews data.

References

[1] [(2019, May) Cambridge English Dictionary. [Online]. https://dictionary.cambridge.org/dictionary/english/crowd.

[2] J.Howe. (2006, June) Wired "The Rise of Crowdsourcing". [Online]. http://archive.wired.com/wired/archive/14.06/crowds.html?pg=4&topic=crowds&topic_set=.

[3] J. Howe. (2006, June) Crowdsourcing: A Definition. http://crowdsourcing.typepad.com/cs/2006/06/crowdsourcing_a.html.

[4] E. C. Groen, J. Doerr, and S. Adam, "Towards Crowd-Based Requirements Engineering A Research Preview," in Requirements Engineering: Foundation for Software Quality, Samuel A. Fricker and Kurt Schneider, Eds.: Springer International Publishing, 2015, pp. 247-253.

[5] E. Groen and M. koch. (2016, June) How Requirements Engineering can Benefit from Crowd. re-magazine.ireb.org "Requirements Engineering Magazine".

[6] M. Hosseini, K. Phalp, J. Taylor, and R. Ali, "Toward Crowdsourcing for Requirements Elicitation: Results from Expert Survey," in Proceeding of The 20th International Working Conference on Requirements Engineering: Foundation for Software Quality, Essen,Germany, april,2014.

[7] R. Sharma and A. Sureka. (2017) CRUISE: A Platform for Crowdsourcing Requirements Elicitation and Evolution. [Online]. http://www.robo-paathshaala.in/ashish/IC3-2017-CRUISE-PAPER.pdf.

[8] K. Mao, L. Capra, M. Harman, and Y. Jia, "A Survey of the Use of Crowdsourcing in Software Engineering," Journal of Systems and Software, vol. 126, pp. 57-84, 2016.

[9] I. Sommerville, Software Engineering, 9th ed. USA: Pearson, 2011.

[10] D. Zowghi and C. Coulin, "Requirements Elicitation: A Survey of Techniques,Approaches, and Tools," in Engineering and Managing Software Requirements. Berlin: Springer, 2005, pp. 19-46.

[11] The Standish Group, "Chaos Report," The Standish group, 2018.

[12] R. Snijders, A. Ozum, S. Brinkkemper, and F. Dalpiaz, "Crowd-Centric Requirements Engineering: A Method Based On Crowdsourcing And Gamification," Utrecht University, Utrecht, The Netherlands, Technical Report ISSN: 0924-3275, 2015.

[13] P. K K. Srivastava and R. Sharma, "Crowdsourcing to Elicit Requirements for MyERP Application," in Proceeding of 1st International Workshop on Crowd-Based Requirements Engineering (CrowdRE), Ottawa, 2015, pp. 31-35.

[14] N. Abdul Rahman and S. Sahibuddin, "Challenges in E-learning: an Requirements Engineering Prespective," in Proceedings of the 3rd International Conference on Computing and Informatics, Bandung, Indonesia, 2011.

[15] Australian Flexible Learning framework, "Practical Guide to E-learning for Industry," Australian Flexible Learning framework, 2007.

[16] B. Holmes and J. Gardner, E-learning: Concepts and Practice.: Sage Publications, 2006.

[17] N. M. Rizk, E. S. Nasr, and M. H. Gheith, "Requirements' elicitation needs for eLearning Systems," in On Proceeding of The 12th International Computer Engineering Conference (ICENCO), Giza, Egypt, 2016.

[18] W. Horton and K. Horton, E-learning tools and techniques.: Wiley, 2003.

[19] G.l Gheorghiu. (2017, November) The Content in a Learning Content Management System (LCMS). SelectHub.

[20] S. Irlbeck and J. Mowat. (2007, January) Learning Content Management System (LCMS). http://www.herridgegroup.com/pdfs/LCMS_chptr_Aug29%202005_%20Final%20Sept%206%2005.pdf.

[21] S. B. AlKhuder and F. H. AlAli, "E-Learning Systems Requirements Elicitation: Perspectives and Considerations," International Journal of Virtual and Personal Learning Environments (IJVPLE), vol. 7, no. 1, pp. 44-55, January-June 2017.

[22] H. Minh Thi Tran and F. Anvari, "A Five-Dimensional Requirements Elicitation Framework for e-Learning Systems," International Journal of Information and Electronics Engineering, vol. 6, no. 3, pp. 185-191, 2016.

[23] N. Ali and R. Lai, "A method of requirements elicitation and analysis for Global Software Development," Journal of Software Evolution and Process, vol. 29, no. 4, pp. 1-27, 2017.

[24] M. Hosseini, K. Phalp, J. Taylor, and R. Ali, "The Four Pillars of Crowdsourcing: a Reference Model," in Proceedings of IEEE Eighth International Conference on Research Challenges in Information Science (RCIS), Marrakech, 2014, pp. 1-12.

[25] A. L. Zanatta, L. S. Machado, G. B. Pereira, R. Prikladnicki, and E. Carmel, "Software Crowdsourcing Platforms," IEEE Software, vol. 33, no. 6, pp. 112-116, November 2016.

[26] E. C. Groen et al., "The Crowd in Requirements Engineering: The Landscape and Challenges," IEEE Software, vol. 34, no. 2, pp. 44-52, march 2017.

[27] M. Hosseini, A. Shahri, and F. Dalpiaz, "Configuring Crowdsourcing for Requirements Elicitation," in In Proceeding f The IEEE Ninth International Conference on Research Challenges in Information Science, Greece, 2015.

[28] A. Adepetu, K. A. Ahmed, and Y. Al Ab, "CrowdREquire: A Requirements Engineering Crowdsourcing Platform," Association for the Advancement of Artificial Intelligence, Technical Report 2012.

[29] R. Snijders et al., "REfine: A Gamified Platform for Participatory Requirements Engineering," in IEEE 1st International Workshop on Crowd-Based Requirements Engineering (CrowdRE), Ottawa, Canada, 2015.

[30] S. L. Lim and A.y Finkelstein, "StakeRare: Using Social Networks and Collaborative Filtering for Large-Scale Requirements Elicitation," IEEE Transactions on Software Engineering, vol. 38, no. 3, pp. 707-735, 2012.

[31] S. L. Lim, D. Quercia, and A. Finkelstein, "StakeSource: Harnessing the Power of Crowdsourcing and Social Networks in Stakeholder Analysis," in In Proceedings of the IEEE 32nd International Conference on Software Engineering, 2010.

[32] T. D. D. Breaux and F. Schaub, "Scaling Requirements Extraction to the Crowd: Experiments with Privacy Policies," in On Proceeding of IEEE 22nd International Requirements Engineering Conference (RE) , Karlskrona, Sweden, 2014, pp. 163-172.

[33] E. Guzman and W. Maalej, "How Do Users Like This Feature? A Fine Grained Sentiment Analysis of App Reviews," in Proceeding of Requirements Engineering Conference (RE), 2014 IEEE 22nd International, Karlskrona, Sweden, 2014, pp. 153-162.

[34] C. Wang, M. Daneva, M. van Sinderen, and P. Liang, "A systematic mapping study on crowdsourced requirements engineering using user feedback," Journal of Software: Evolution & Process, pp. 1-20, July 2019.

[35] M. Hosseini, E. C. Groen, A. Shahri, and R. Ali, "CRAFT: A Crowd-Annotated Feedback Technique," in IEEE 25th International Requirements Engineering Conference Workshops, Lisbon, Portugal, 2017.

[36] E. C. Groen, J. Schowalter, S. Kopczynska, S. Polst, and S. Alvani, "Is there Really a Need for Using NLP to Elicit Requirements? A Benchmarking Study to Assess Scalability of Manual Analysis.," in REFSQ 2018 Joint Proceedings of the Co-Located EventsAt: Utrecht, The NetherlandsVolume: CEUR 2075, Utrecht, Netherlands, 2018.

[37] D. Renzel and R. Klamma, "Requirements Bazaar: Open-Source Large Scale Social Requirements Engineering in the Long Tail," IEEE Computer Society Special Technical Community on Social Networking E-Letter, vol. 2, no. 3, September 2014.

[38] E. Karataev and V. Zadorozhny, "Adaptive Social Learning Based on Crowdsourcing," IEEE Transactions on Learning Technologies, vol. 10, no. 2, pp. 128 - 139, April-June 2017.

[39] C.s E. Barbosa et al., "Conceptual Crowdsourcing Models for E-Learning," in On Proceeding of IEEE International Conference on Systems, Man, and Cybernetics, San Diego, 2014, pp. 1121-1127.

[40] D. Paulina and C. Haythornthwaiteb, "Crowdsourcing the curriculum: Redefining e-learning practices through peer-generated approaches," The Information Society, vol. 32, no. 2, pp. 130-142, 2016.

[41] A. Z. Suhonjić, M. Despotović-Zrakić, A. Labus, Z. Bogdanović, and D. Barać, "Fostering students' participation in creating," Interactive Learning Environments, vol. 27, no. 1, pp. 72-85, March 2019.

[42] D. Tarasowa, A. Khalili, S¨oren Auer, and J. Unbehauen, "CrowdLearn: Crowd-sourcing the Creation of Highly-structured E-Learning Content," International Journal of Engineering Pedagogy, vol. 5, no. 4, 2015.

[43] C. E. Barbosa, V. J. Epelbaum, M. Antelio, J. Oliveira, and J. M. Souza, "Crowdsourcing Environments in e-Learning Scenario: A classification based on educational and collaboration criteria," in on Proceeding of IEEE International Conference on Systems, Man, and Cybernetics, 2013, pp. 687-692.

[44] T.Wu. (2015, June) the Right State of Mind. Help Scout.

[45] D. Pagano and W. Maalej, "User FeedBack in Appstore an Empirical Study," in in Proceeding of Requirements Engineering Conference, Rio de Janeiro, 2013, pp. 125- 134.

[46] N. M. Rizk, A. Ebada, and E. S. Nasr, "Investigating Mobile Applications' Requirements Evolution Through Sentiment Analysis of Users' Reviews," in Proceeding of 11th International Computer Engineering Conference (ICENCO), Cairo, 2015, pp. 123-130.

[47] C. Palazuelos, D. García-Saiz, and M. Zorril, "Social Network Analysis and Data Mining: An Application to the E-Learning Context," in Computational Collective Intelligence. Technologies and Applications, Costin Bădică, Ngoc Thanh Nguyen, and Marius Brezovan, Eds. Craivo, Romania: Springer Berlin Heidelberg, 2013, pp. 651-660.

[48] J. Proctor and B.d Maher. (2013) Emotional Multiplicities in Multi-Sourced Work. http://dnaanthology.com/anvc/dna/emotional-multiplicities-in-multi-sourced-work.

[49] O. Pedreira , F. García , and N. Brisabo, "Gamification in software engineering – A systematic mapping," Information and Software Technology, vol. 57, pp. 157-168, 2015.

[50] G. Baxter and I. Sommerville, "Socio-technical systems: From design methods to systems engineering," Interacting with Computers, vol. 23, no. 1, pp. 4-17, January 2011.

[51] C. Wohlin et al., Experimentation in Software Engineering.: Springer, 2012.

[52] (2019, April) Stanford University. [Online]. https://nlp.stanford.edu/IR-book/html/htmledition/dropping-common-terms-stop-words-1.html

[53] (2019) Sketch Engine. [Online]. https://www.sketchengine.eu/pos-tags/

[54] TFIDF. [Online]. www.TFIDF.com.

[55] D. M. Blei, A. Y. NG, and M. I. Jordan , "Latent Dirichlet Allocation," Journal of Machine Learning Research , vol. 3, pp. 993–1022, March 2003.

[56] J. Brownlee. (2014, March) Classification Accuracy is Not Enough: More Performance Measures You Can Use. machinelearningmastery.com.

e-Learning Proposal Supported by Reasoning based on Instances of Learning Objects

Benjamin Maraza-Quispe[1], Olga Melina Alejandro-Oviedo[2], Walter Choquehuanca-Quispe[3]
Alejandra Hurtado-Mazeyra[4], Walter Fernandez-Gambarini[5]
Facultad de Ciencias de la Educación, Universidad Nacional de San Agustín, Arequipa-Perú

***Abstract*—In recent years, new research has appeared in the area of education, which has focused on the use of information technology and the Internet to promote online learning, breaking many barriers of traditional education such as space, time, quantity and coverage. However, we have found that these new proposals present problems such as linear access to content, patronized teaching structures, and non-flexible methods in the style of user learning. Therefore, we have proposed the use of an intelligent model of personalized learning management in a virtual simulation environment based on instances of learning objects, using a similarity function through the weighted multidimensional Euclidean distance. The results obtained by the proposed model show an efficiency of 99.5%; which is superior to other models such as Simple Logistic with 98.99% efficiency, Naive Bayes with 97.98% efficiency, Tree J48 with 96.98% efficiency, and Neural Networks with 94.97% efficiency. For this, we have designed and implemented the experimental platform MIGAP (Intelligent Model of Personalized Learning Management), which focuses on the assembly of mastery courses in Newtonian Mechanics. Additionally, the application of this model in other areas of knowledge will allow better identification of the best learning style of each student; with the objective of providing resources, activities and educational services that are flexible to the learning style of each student, improving the quality of current educational services.**

Keywords*—Learning; management; intelligence; styles; instances; objects; reasoning; model; personalized

I. Introduction

Artificial Intelligence (AI) in education is a highly researched field [1], which focuses primarily on the formulation and application of techniques for the development of systems that improve the teaching process through computer-assisted learning [2], with the goal of building more intelligent systems [3].

The term "intelligent" used in these systems is fundamentally determined by its capacity for continuous adaptation to the characteristics of learning and knowledge of different users [4].

For example, an article presents an approach that recognizes the relevant elements of the student profile seeking to meet their personal and academic needs by recovering reusable knowledge units with fine granularity stored in repositories of learning objects. The proposal is based on the technique of artificial intelligence, known as Case-Based Reasoning (CBR) [3].

For these reasons, we have decided to focus our research on developing dynamic methods for the search and identification of a student's best learning style. These methods are applied in real time, using Case-Based Reasoning CBR, through the similarity function, using the weighted multidimensional Euclidean distance.

Finally, the CBR will provide a method for personalizing learning according to the best learning strategy of each student. On the other hand, we have calculated the efficiency of our algorithm for the selection of learning styles via CBR, which has been compared with the results obtained by other learning styles selection algorithms such as Neural Networks, Naive Bayes, Tree J48 and Simple Logistic [5].

In this context, we have designed and implemented the MIGAP platform (Intelligent Model of Personalized Learning Management), with the aim of presenting learning contents, which can be adapted to the best learning style of each student according to the Honey-Alonso model.

The importance of our proposal is to adapt teaching to the specific needs of the student, giving flexibility and autonomy to the learning environment. For this we use artificial intelligence techniques such as Case Based Reasoning, whose efficiency is compared to other techniques or algorithms with RN, Naive Bayes, Tree J48 and Simple Logistic.

II. Theoretical Framework

A. Artificial Intelligence in Education

In the field of Artificial Intelligence applied to education, we have found research focused on the development of systems for education, based on aspects of knowledge [6]. Figure 1 shows the main AI techniques applied to education.

B. Learning Styles

1) Definition: Learning styles can be defined as cognitive, affective and physiological traits, which serve as indicators of how students perceive interactions and respond to their learning environments. [7].

Therefore, it can be determined that each person has a "fingerprint" of their own learning. Which each person develops and powers following different types of educational strategies (some learn through reading, others through practices, others through group work, others through individual work), however, we all have in different percentages some feature of different learning styles. [8].

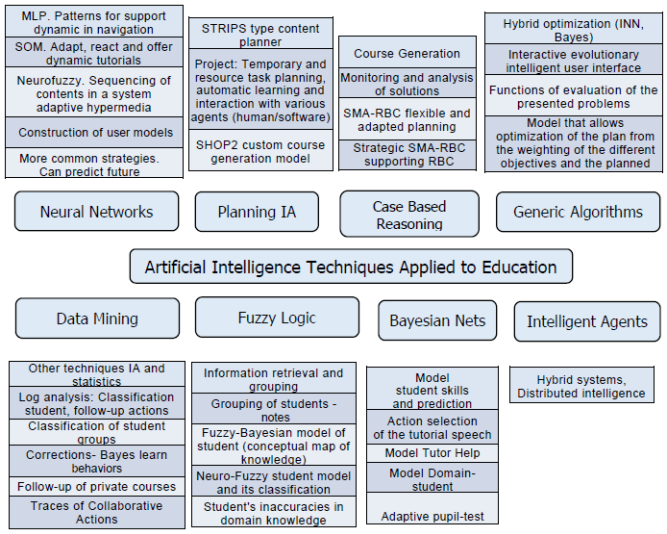


Fig. 1. Main AI Techniques Applied in Education.

2) Selected learning styles: To select a learning style show in Table I, it is necessary to first investigate what types of learning styles exist; we have found a model in which they use four styles of learning which are: [5].

- Active
- Theoretical
- Pragmatic
- Reflective

3) Artificial intelligence technique applied in the proposal: The technique of artificial intelligence that we have applied to the proposal is the Case-Based Reasoning, which first detects the student's learning style to determine the best learning strategy that best fits his learning style. CBR is the process of solving new problems based on solutions to previous problems. For example, an auto mechanic who repairs an engine because he remembered that another car had the same symptoms is using case-based reasoning [9]. An attorney who appeals to legal precedents to defend a case is using case-based reasoning.

Case-Based Reasoning: Case-Based Reasoning (CBR) is a set of concepts and techniques that address issues related to the representation of knowledge, reasoning and learning from experience [4]. The similarity is a concept that plays a fundamental role in CBR.

Case Definition: The case definition is also known as an instance, object or example. It can be defined as a piece of contextualized knowledge that represents a significant experience [10].

Stages of CBR: The main stages of CBR are four: Recovery, Reuse, Revision, and Retention. These four stages involve basic tasks such as case grouping and classification, case selection and generation, case learning and indexing, case similarity measurement, case recovery and inference, reasoning, adaptation rules, and data mining.

TABLE. I. CHARACTERISTICS OF EACH LEARNING STYLE [9]

Learning Styles	Main features
Active	Animator, Improviser, Discoverer, Risky.
Reflective	Weighted, Conscientious, Receptive, and Analytical.
Theoretical	Methodical, Logical, Objective, Critical, Structured
Pragmatic	Experiments, Practical, Direct, Efficacious, Realist

Life cycle of CBR: The life cycle of an RBC system for problem-solving consists of four states:

- Retrieve of similar cases from an experience base.
- Reuse of cases by copying or integrating solutions from recovered cases.
- Revise or adaptation of the recovered solutions to resolve the new problem.
- Retention of a new solution, once it has been confirmed or validated.

a) Functioning: Each case has predefined attributes. These are defined by a Name and a Datatype that can be String, MultiString, Float, Int, and Bool. The best case is found by the Euclidean distance, a technique that is similar to the Pythagorean Theorem in n dimensions. To find the best case, a similarity indicator (percentage) is used: [18].

$$M = \frac{100 \times (1 - D)}{\sqrt{\sum_{1}^{n} w}}$$

Where:

M = Best case percentage (between 0 and 100)

D = Distance

W = Weight

In addition, D is the distance between cases. It is a floating number between zero and one, which is calculated like this:

$$D = \sqrt{\sum_{1}^{n} Wn \times d(c - Cn)}$$

D = distance

W = Weight

d = Distance between the case "c" sought and the case *Cn* of the case base.

This floating value *D* means:

- 0 means exact accuracy (identical case).
- 1 means maximum distance (Not a similar case at all).

The weight W (weight n) is the weight for the attribute "n". It is an Integer > = 0, default = 5.

In addition, if an attribute for a case is not entered; the case is disqualified and does not enter the search.

b) Description of the proposed solution: A case-based system has three main components: a user interface, an

inference engine, and a case database. The case database contains descriptions of previously solved problems in the form of features (predictors and targets). Each case can describe a particular episode or a generalization of a set of related episodes.

The inference engine is the reasoning machine of the system, which compares the problem inserted with those stored in the case database and as a result infers a response, which has the greatest degree of similarity to the desired response. The user interface allows communication between the system and the user, giving the possibility of interacting with the case database, being able to raise new problems and consult the inferred results [11].

To solve the problems with the use of this technique, a similar case to the new one is recovered and the solution of the recovered problem is proposed as a potential solution for the new problem. This is derived from an adaptation process in which the old solution is adapted to the new situation. In this system, we have defined a series of steps and components that interact in a cycle of reasoning. Then from a new problem, the system recovers cases similar to the one entered, which go through an adaptation process with the aim of obtaining a response according to the proposed situation. Finally, if necessary and after its revision, the system decides whether or not to learn the given solution. All that we have mentioned is considered the cycle of reasoning based on cases as shown in figure 2.

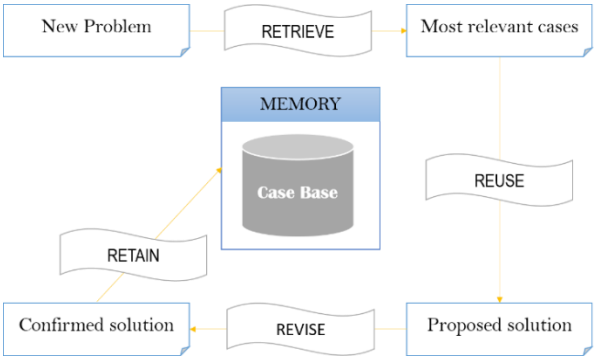


Fig. 2. Life Cycle of CBR [18].

III. Case Study

A. Architecture of the Proposed Model

Fig. 3 describes the proposed architecture, which is based on the general structure of an intelligent learning management system which considers student learning styles, integrating Case-Based Reasoning for the selection of teaching-learning strategies and Neural Networks for the identification of learning styles [12]. The architecture proposes innovations in the representation of the tutor module and the knowledge module. In particular, the tutor module incorporates the CBR technique, which will choose the contents considering the teaching strategies that support the learning styles of the student.

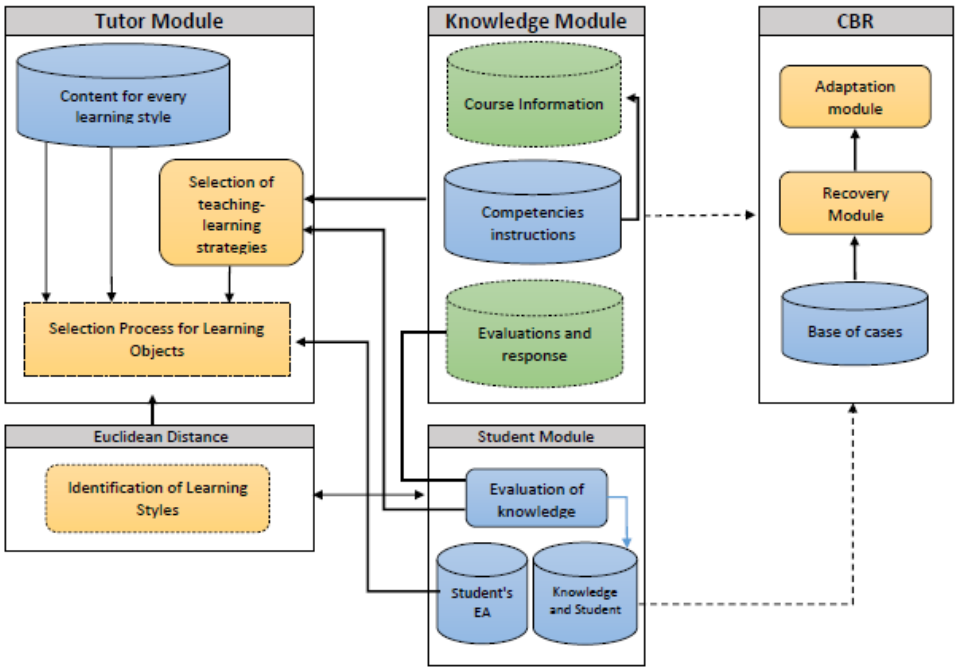


Fig. 3. General Architecture of the Proposed Model.

The knowledge module is influenced by the teaching strategies of the student's learning styles. These teaching strategies will be the link of the learning objects through the teaching-learning strategies applied to the design of the contents of the area [13].

The following is a description of the modifications made to the modules of the general architecture of the Intelligent Tutorial System (ITS).

a) Description of the model: The description of the model incorporates the classic architecture of an Intelligent Tutor System, a process of selection of learning objects (contents), influenced by the teaching strategies of the student's learning styles. [14].

The modifications made to the modules of the general ITS architecture are described.

The tutor module incorporates the teaching-learning strategies considered in the design of the themes of the different courses, as well as the redefinition of the teaching strategies according to the learning style of the student. It also incorporates a process to adapt the content to be presented:

- Identify learning styles through a test of learning styles [5].
- Select the topics to be shown to the student, linking their learning style with the teaching strategies used in the creation of the topics and thus promote their learning.
- In the knowledge module, a database is added that will store the competences of the subject. As well as the use of some metadata in the contents of the course to characterize the competences to be developed.
- The interface module will display the learning objects chosen by the tutor module selection process.
- The Case-Based Reasoning module is added, which is an approach that addresses new problems by reference to similar problems solved in the past. So similar problems have similar solutions.

A database of 199 students according to their learning styles is entered into the Case-Based Reasoning mechanism. This, prior to a case indexing process, which recovers cases using as a measure of similarity the Euclidean distance in n dimensions. Once the evaluation process is over, the winner is reviewed, returning the personalized content according to the learning style entered, if this case is significant it is retained; as can be seen in figure 4.

b) Customization of content according to the student's learning style: The experimentation was carried out in the Virtual Innovation Center, with a sample of 199 students who interacted with the MIGAP platform. In order to determine the predominant learning style, a questionnaire about the preferences of teaching strategies was applied. [15].

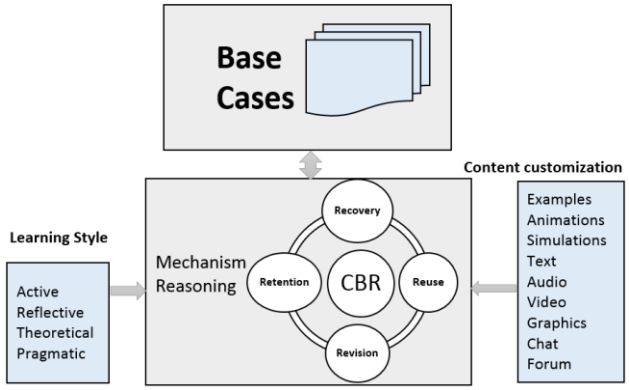


Fig. 4. CBR Proposal to Customize Content.

We also analyzed the frequencies of the learning styles detected in each of the students of each course, to know if these influenced the performance of the students. Figure 5 shows the graph corresponding to the learning styles, where a preponderance of reflexive and pragmatic learning styles can be observed. [16]

The following is a statistical summary of the learning styles detected in the 199 students, which were used as a sample to form the case base.

Fig. 5 shows that 37 students have the active learning style, 59 students have the reflective learning style, 44 students have the theoretical learning style and 59 students have the pragmatic learning style.

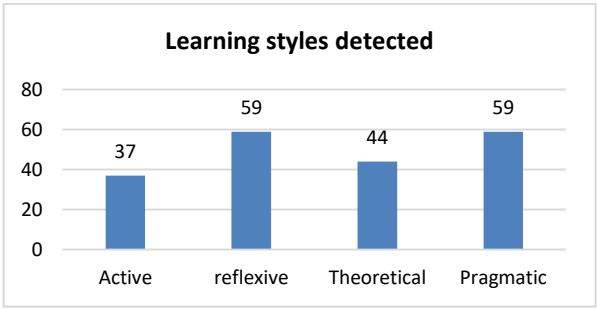


Fig. 5. Learning Styles Detected.

IV. Experimentation and Results

To carry out the evaluation of the proposal with other algorithms, we have used the cross validation technique that is a way to evaluate the results of a statistical analysis. That consists in repeating and calculating the arithmetic average obtained from the evaluation measures on different partitions [17].

It is used in environments where the main objective is a prediction, we have selected it since we want to estimate the accuracy of a model. It is a technique widely used in artificial intelligence projects to validate generated models.

The following graphs show a statistical analysis developed with the different Artificial Intelligence techniques used in the proposal. [10]

Table II shows that our proposal has a precision with a weighted average of 0.99 %. This is due to the fact that we were able to correctly classify a large number of positive instances with an average of 0.99% and classified few negative elements with an average of 0.007 %.

Table III shows that the Simple Logistic algorithm turned out to be the second best in the list; this is due to the fact that although I was able to correctly classify a large number of positive instances, I was also able to classify erroneously negative instances with an average of 0.003.

In the confusion matrix applying the naive Bayesian classifier (Probabilistic classifier) Table IV, based on the Bayes Theorem, we can observe that there is no good classification in learning styles since this Bayesian classifier uses some additional simplified hypotheses and because of these simplifications, which are usually summarized in the hypothesis of independence between predictor variables, is called Naive.

The Table IV shows that the Tree J48 algorithm turned out to be the fourth best classifier since it presents an accuracy with a weighted average of 0.97. This is due to the fact that it was able to classify correctly a positive instance with an average of 0.97 and classified few negative elements with an average of 0.01. We can observe that the TP Rate and Recall measures clearly and unequivocally reflect the number of successes in the classification of the positive instances.

The Table VI shows that the Neuronal Network was the fifth best classifier since it presents an accuracy with a weighted average of 0.95. This is due to the fact that it was able to classify correctly a positive instance with an average of 0.95 and classified few negative elements with an average of 0.018.

TABLE. II. CONFUSION MATRIX APPLYING CBR AND NEURAL NETWORKS

	Active	Reflective	Theoretical	Pragmatic	Facts	Accuracy	Errors
Active	37	0	0	0	37	37	0
Reflective	0	58	1	0	59	58	1
Theoretical	0	0	44	0	44	44	0
Pragmatic	0	0	0	59	59	59	0
						198	1
						99.50%	0.50%

TABLE. III. CONFUSION MATRIX APPLYING SIMPLE LOGISTIC ALGORITHM

	Active	Reflective	Theoretical	Pragmatic	Facts	Accuracy	Errors
Active	37	0	0	0	37	37	0
Reflective	0	57	2	0	59	57	2
Theoretical	0	0	44	0	44	44	0
Pragmatic	0	0	0	59	59	59	0
						197	2
						98.99%	1.005%

TABLE. IV. CONFUSION MATRIX APPLYING NAIVE BAYES ALGORITHM

	Active	Reflective	Theoretical	Pragmatic	Facts	Accuracy	Errors
Active	35	0	0	2	37	35	2
Reflective	0	58	1	0	59	58	1
Theoretical	0	0	44	0	44	44	0
Pragmatic	1	0	0	58	59	58	1
						195	4
						97.98%	2.01%

TABLE. V. CONFUSION MATRIX APPLYING TREE J48 ALGORITHM

	Active	Reflective	Theoretical	Pragmatic	Facts	Accuracy	Errors
Active	37	0	0	0	37	37	0
Reflective	0	54	4	1	59	54	5
Theoretical	0	1	43	0	44	43	1
Pragmatic	0	0	0	59	59	59	0
						193	6
						96.48%	3.01%

TABLE. VI. CONFUSION MATRIX APPLYING NEURAL NETWORKS

	Assets	Reflective	Theoretical	Pragmatic	Facts	Accuracy	Errors
Active	35	0	0	2	37	35	2
Reflective	0	55	4	0	59	55	4
Theoretical	0	4	40	0	44	40	4
Pragmatic	0	0	0	59	59	59	0
						189	10
						94.97%	5.02%

As a conclusion of the analysis developed, it can be observed that the greatest number of successes in the classification corresponds to the proposed technique of Case-Based Reasoning with 99.50% success and 0.5% error, as opposed to the use of the other techniques used that have a percentage of successes below the proposal. [18].

Fig. 6 shows that the greatest number of cases correctly classified 198, corresponds to the CBR with only one case incorrectly classified, with an average absolute error of 0.0279. After the comparisons with other classification algorithms were made, Simple Logistic followed second, Naive Bayes third, Tree J48 fourth, and Artificial Neural Networks fifth.

The Fig.7 shows the general average grades obtained by the students of each course, where it is observed that the average grades obtained by the students who took the personalized course are 60.5 points, while the average grades of the students who took the non-customized course are 39.5 points, which shows a very considerable difference of 21 points.

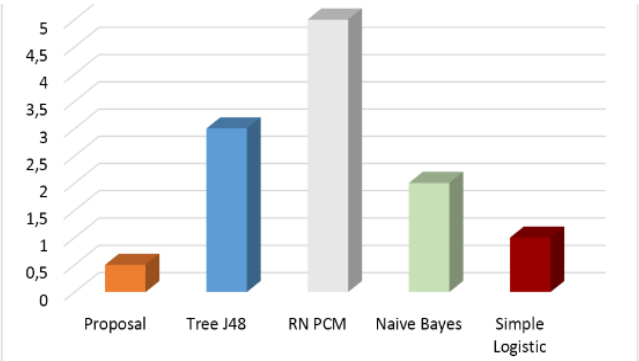


Fig. 6. Comparison of CBR Error Rate with other Techniques.

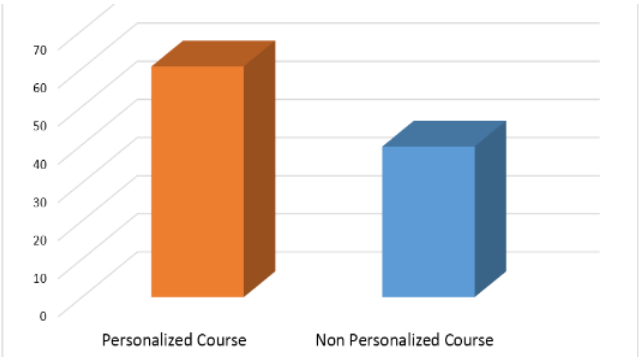


Fig. 7. Overall Grade Point Average Per Course.

V. CONCLUSIONS

- It has been possible to propose an Intelligent Personalized Learning Management Model based on instances of learning objects whose results show that the proposed model has an efficiency of 99.5%; above the models: Simple Logistic with 98.99%, Naive Bayes with 97.98%, Tree J48 with 96.98%, and Neural Networks with 94.97% success.
- A demonstration prototype can be seen at http://benjaminmaraza.my-place.us/ after proposing, experimenting, analysing and evaluating the Case-Based Reasoning, acceptable and significant behaviour is appreciated in the personalization of contents according to the learning style of the students.
- It has been possible to identify the problems in traditional systems as well as the theoretical foundations, determining the aspects that reduce the quality of learning management systems and proposing improvement strategies based on theory.
- A model has been developed that facilitates teaching-learning activities in e-Learning systems.
- The tests with this prototype show that the use of this e-Learning technology would directly affect the educational quality of the region. Allowing to optimize some elements of the learning process that are still traditional in our environment.
- It has been possible to Model the student in the Student Modeller Module attributing flexibility capabilities and personalization attributes provided by a Case Based Reasoning system based on the Euclidean distance in a N dimensional space.
- As future work is recommended the implementation of much more elaborate tests to give robustness to this proposal, since the tests are in the maturation phase and there is much research for the development of indicators to measure quality, flexibility, customization in an LMS system since it has to do with a neurological issue: Education.

REFERENCES

[1] J. Carbonell. (2014). “An Artificial Intelligence Approach to Computer assisted instruction” .CAI, vol. Vol 4, Nº 6.

[2] W. Murray. (2013). “Control for intelligent tutoring systems: A comparison of blackboard architecture and discourse management networks”. Research Report R-6267, FMC Corp.

[3] Moreno, R., Joyanes, L., Giraldo, L. M., Duque, n. d. y Tabares, V. (2018). Modelo para personalización de actividades educativas

aprovechando la técnica de Razonamiento basado en Casos (RBC). Campus Virtuales, Vol. IV, num. 1, pp. 118-127.

[4] E. Wenger. (2015). “Artificial intelligence and tutoring systems”.

[5] A. C. y. D. J. Honey, P. (2015). "Learning styles: diagnostic and improvement procedures." 2nd ed. Bilbao: Mensajero Editions, 1994. Pages. 104-116.

[6] R. Vicari; D. Ovalle. (2010). "ALLEGRO: Ambiente Multi-Agente de Apoyo a la Enseñanza-Aprendizaje utilizando Planificación Instruccional y Razonamiento Basado en Casos (CBR)". In Proceedings of XIII Congreso Iberoamericano de Educación superior en Computaci1th Latin-American Conference on Informatics CLEI, Medellin, Colombia.

[7] L. Zadeh. (2013). “Foreword of foundations of soft case-based reasoning”. Ediciones Berkely, CA.

[8] G. P. H. y. C. M. Alonso, Domingo J. (1994). "Learning styles: diagnostic procedures and improvement." 2nd ed. Mensajero, D.L. 1994. ISBN: 84-271-1914-3. Bilbao, Spain.

[9] B. Maraza. (2015). "Intelligent Model of Personalized Learning Management in a Virtual Simulation Environment Based on Instances of Learning Objects". Doctoral Thesis. National University of San Agustín. Peru.

[10] B. Collis. (2015). “Tele-learning in a digital world”.

[11] G. Verdejo, F. Davies, (1997). “Trends for higher education and training”.

[12] B. Expensive. (2013). "Estrategia de formación planificada de docentes," Ph.D. Thesis, Universidad de San Buenaventura, Universidad de San Buenaventura, Colombia.

[13] M. Urretavizcay-Loinaz and I. Fernandez de Castro. (2012). “Artificial intelligence and educacia ovierview”. In Conference on Advanced Information Systems Engineering www.upgrade-cepis.org/issues/2012/5 /upgrade_vIII-j.html.

[14] D. Cruz, R. Alexandre. (2013). "Technical Report Department of Information Technology and Automatics." University of Salamanca: Adison-Wesley Publishing Company, Inc.

[15] R. Dunn and K. Dunn. (2014). “Dunn and dunn learning style inventory department of educational and community programs”. Queens College, City University of New York.

[16] Hunt, P. (2017). “Community iswhat i think everyone is talking about, remedial and special education”. In ACM.

[17] C. Peña. (2014). “Intelligent agents to improve adaptivity in a web-based learning environment”. Universidad de Girona. España.

[18] Sankar K Pal and Simon K. Shiu. (2014). Foundation of soft Case-Based Reasoning. Indian Statistical Institute, Hong Kong Polytechnic University. By Jhon Wiley & Sons, Inc 2014.

Distance based Sweep Nearest Algorithm to Solve Capacitated Vehicle Routing Problem

Zahrul Jannat Peya[1], M. A. H. Akhand[2]
Tanzima Sultana[3]
Dept. of Computer Science and Engineering
Khulna University of Engineering & Technology
Khulna 9203, Bangladesh

M. M. Hafizur Rahman[4]
Dept. of Communication and Networks
College of Computer Science and Information Technology
King Faisal University, Al Hufūf, Al-Hasa
Saudi Arabia

***Abstract*—The Capacitated Vehicle Routing Problem (CVRP) is an optimization problem owing to find minimal travel distances to serve customers with homogeneous fleet of vehicles. Clustering customers and then assign individual vehicles is a widely-studied way, called cluster first and route second (CFRS) method, for solving CVRP. Cluster formation is important between two phases of CFRS for better CVRP solution. Sweep (SW) clustering is the pioneer one in CFRS method which solely depends on customers' polar angle: sort the customers according to polar angle; and a cluster starts with customer having smallest polar angle and completes it considering others according to polar angle. On the other hand, Sweep Nearest (SN) algorithm, an extension of Sweep, also considers smallest polar angle customer to initialize a cluster but inserts other customer(s) based on the nearest neighbor approach. This study investigates a different way of clustering based on nearest neighbor approach. The proposed Distance based Sweep Nearest (DSN) method starts clustering from the farthest customer point and continues for a cluster based on nearest neighbor concept. The proposed method does not rely on polar angle of the customers like SW and SN. To identify the effectiveness of the proposed approach, SW, SN and DSN have been implemented in this study for solving benchmark CVRPs. For route optimization of individual vehicles, Genetic Algorithm, Ant Colony Optimization and Particle Swarm Optimization are considered for clusters formation with SW, SN and DSN. The experimental results identified that proposed DSN outperformed SN and SW in most of the cases and DSN with PSO was the best suited method for CVRP.**

Keywords*—Capacitated vehicle routing problem; sweep algorithm; sweep nearest algorithm; genetic algorithm; ant colony optimization; particle swarm optimization

I. INTRODUCTION

The Vehicle Routing Problem (VRP) can be depicted as the issue of structuring ideal conveyance routes from one or a few warehouses to various geologically dissipated urban areas or clients while keeping up certain imperatives [1]. Capacitated VRP (CVRP) is one of the most studied variations of VRP with an extra limitation of fixed vehicle conveying limit [2]. In CVRP, all customers have predefined requests and fixed areas for the conveyance. The target of CVRP is to attenuate the overall traveling distance for all vehicles. Various ways are projected for solving CVRP; nearly all of them are heuristics. A heuristic approach doesn't explore the complete search area rather tries to search out associate in nursing optimum answer supported the accessible data of the matter. In solving CVRP, constructive and clustering methods are commonly used in the heuristic approaches to construct the routes. Constructive approach keeps the travelled distance optimum at the same time of route construction. There is no route improvement or optimization phase. Savings Algorithm [3], Matching Based Algorithm and Multi-route Improvement Heuristics [4] are the most popular constructive algorithms. On the other hand, the solution of a problem is divided into two phases in clustering methods. All the customers are gathered into different groups using a clustering algorithm and after that an optimization algorithm used to make route of individual clusters. Such 2-stage method is called cluster first and route second (CFRS) method. The well-known CFRS algorithms are Sweep [7], Fisher and Jaikumar [14], Petal [15] and Taillard's [16]. It is notable that appropriate clustering is important for optimal CVRP solution in any CFRS method.

Sweep is the pioneer one among CFRS algorithms and it creates clusters based on customers' angular position. The idea of the sweep was originated by Wren [5] and Wren and Holliday [6]. But Gillett and Miller [7] coined the name "the sweep algorithm." In the method, a cluster is made by sweeping the customers as per their polar angle (expanding or diminishing request). Sweeping stops when vehicle capacity is going to exceed and resumes grouping for another vehicle if customers remain. The algorithm was used in solving the CVRP for public vehicle [8]. Venkatesan et al. [9] solved Augerat benchmark CVRPs using Sweep algorithm. A number of studies also incorporated different techniques to improve Sweep clustering. K. Shin [10] introduced cluster adjustment approach in Sweep and route generated with Lin-Kernighan heuristic method. In [12], CVRP has been solved using Sweep algorithm jointly with Clark and Wright savings algorithm. Recently, Peya et al. [11] investigated an adaptive version of sweep algorithm for clustering customers.

An extension of Sweep (SW) algorithm, called Sweep Nearest algorithm, has been investigated and found to perform better than standard one. Sweep Nearest (SN) [13] combines the idea of Sweep and Nearest Neighbor concept. Like SW, SN also considers sorted polar angle of the customers and starts a cluster with the customer having smallest polar angle. But SN considers other customers to complete the cluster which are nearer to the already assigned customer(s). This

process repeats until all the customers are inserted into feasible clusters.

This study investigates a different way of clustering based on nearest neighbor approach. The proposed Distance based Sweep Nearest (DSN) method starts clustering from the farthest customer point and continue for a cluster based on nearest neighbor concept. The proposed method does not rely on polar angle of the customers like SW and SN. To identify the effectiveness of the proposed approach, SW, SN and DSN have been implemented in this investigation. For route optimization of individual vehicles, Genetic Algorithm, Ant Colony Optimization and Particle Swarm Optimization are considered for clusters formation with SW, SN and DSN. The test contemplates on a large number of benchmark CVRPs distinguished that proposed DSN outperformed SN and SW in most of the cases.

The rest of the paper is organized as follows. Section II explains proposed DSN method in detail. For better understanding it also explains SW and SN concisely. Section III briefly explains the optimization methods. Section IV is for exploratory examinations which presents trial results as well as compares the results of the techniques on benchmark CVRPs. Finally, Section V provides a concise conclusion of the paper.

II. Sweep Nearest and Distance based Sweep Nearest

The aim of this investigation is to present a distance-based sweep nearest algorithm that yields better solution than the existing ones. This portion first gives depiction of SW and SN for better understanding of DSN.

A. Sweep (SW) Algorithm

Sweep algorithm is least complex grouping strategy for CVRP. Cluster formation begins from 0^0 and therefore propels toward 360^0 to allot every one of the customers under various vehicles while keeping up capacity of a vehicle. This kind of sweeping is named as forward sweep. Clustering direction is clockwise which means however grouping begins 0^0 in backward sweep, at that point it progresses calculation from 360^0 to 0^0. The common recipe for computing polar angle of the customers with respect to warehouse is.

$$\theta = \tan^{-1}(y/x) \quad (1)$$

where $\theta =$ depot/customer, i.e., angle of a node; $x, y =$ Co-ordinates of customers. Algorithm 1 shows the steps of SW.

B. Sweep Nearest (SN) Algorithm

SN [13] combines the Nearest Neighbor algorithm with the classical SW. SW groups the customers exclusively by polar angle. On the off chance that the customers are generally isolated yet have less precise distinction, they might be assembled in a similar group. This diminishes the optimality of the solution cluster. To determine this issue, SN initially appoints to a vehicle the customer with the littlest polar angle among the rest of the customers and afterward finds the closest stop to those officially relegated and after that embeds that customer. Fig. 1 shows graphical representation of the clustering with SW and SN for a sample scenario of CVRP customer points [13]. In SW (Fig. 1(a)), points with relatively large distances are inserted into the same cluster due to closer polar angle. On the other hand, nearest customers have a place with a similar group in SN as shown in Fig. 1(b). For such case SN will give better CVRP solution than SW.

Algorithm 1: Sweep

Initialization:

1) Calculate the polar angle of each customer using Eq. (1).
2) Sort the customer according to their increasing order of polar angles.

Clustering:

1) Set $C = 1$.
2) Begin sweeping customers by expanding polar angle and allocate the customers to the present cluster.
3) Stop the sweep when including the following client would abuse the most extreme vehicle limit.
4) Set $C = C + 1$.
5) Repeat Steps 2-4 until every one of the customers have been allotted.

Algorithm 2 shows the steps of SN. The initialization of SN is same as SW. It also starts a cluster formation with the smallest polar angle customer from the unassigned customers like SW. Then the nearest customers with respect to the clustered customers are inserted. After a cluster finishes, the smallest angle customer among the remaining customers is chosen as starting for the next cluster.

Algorithm 2: Sweep Nearest

Initialization:

As of Sweep algorithm, i.e., Algorithm 1.

Clustering:

1) Set $C = 1$.
2) Select the smallest angle customer and assign to a cluster.
3) Select a customer which is nearest to the already inserted customers and insert it into the cluster. Continue clustering until vehicle capacity is not violated.
4) Set $C = C + 1$.
5) Repeat Steps 2-4 until every one of the customers have been allotted.

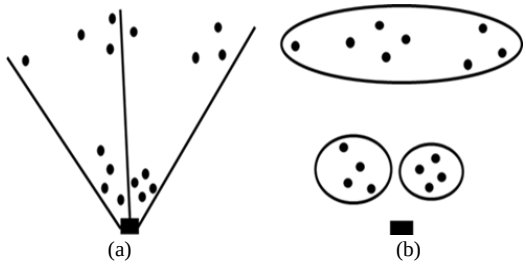


Fig. 1. Graphical Representation of (a) Sweep Clustering and (b) Sweep Nearest Clustering.

C. Distance based Sweep Nearest (DSN) Algorithm

This section describes proposed DSN clustering method mentioning difference from SW and SN. SW starts clustering with the customer having smallest polar angle. SN also starts clustering with the smallest angle customer but grow a cluster selecting its nearest ones. In both SW and SN, the distant customers from the origin may be inserted later. In such a case a cluster (i.e., new route) with remaining one or few far distance customer(s) incur relatively large CVRP cost. On the hand cluster formation starts from far distance customer is the alternate and better option. In such case, customer closer to depot may remain for new cluster. A new cluster with closer customers is cost effective. Moreover, remaining closer customers may be inserted into the existing clusters without increasing cost. On these motivations, the proposed DSN starts a cluster formation with the farthest customer from the depot and complete it as like nearest neighbor approach. When a cluster finishes, next cluster starts with the farthest among the remaining ones. DSN does not consider polar angles of the customers at all; it concerns only with Euclidean distance of the customers. Algorithm 3 shows the steps of DSN.

Algorithm 3: Distance based Sweep Nearest

Initialization:

1) Compute Euclidean distance of each customer from the depot.
2) Sort the customers according to the descending order of their distances.

Clustering:

1) Set C = 1.
2) Start formation for the cluster assigning farthest customer from the depot.
3) Select a customer which is nearest to the already inserted customers and insert it into the cluster. Continue clustering until vehicle capacity is not violated.
4) Set $C = C + 1$.
5) Repeat Steps 2-4 until all the customers have been assigned.

III. Route Generation of Individual Vehicles

Individual vehicles' route generation is the final step of any clustering based CFRS algorithm. Optimal route finding of a vehicle considering the nodes of a cluster is a traveling salesman problem (TSP); and any TSP method may use for this purpose. In this study, three prominent TSP methods have been considered which are Genetic Algorithm (GA), Ant Colony Optimization (ACO) and Particle Swarm Optimization (PSO). Short descriptions of the methods are as follows to make the paper self-contained.

GA is a pioneer optimization method based on Darwin's natural selection. The basic highlights of it for solving TSP are: permutation encoding to present solution cluster, tournament selection, and Enhanced Edge recombination crossover and swap mutation [17].

ACO is a well-known technique for TSP based on the behavior of ants seeking a path between their colony and a source of food. It starts placing different ants in different cities. Visibility heuristic (i.e., inverse of distance) and intensity of the pheromone on the path are considered by a particular ant to move one city to another one. Every ant lays some pheromone on the way based on the quality of the constructed tour. Pheromone evaporation of natural ant colony system is adopted by decreasing pheromone of all the links by a fixed rate; it allows artificial ants to forget links of bad choices. At long last, every one of the ants pursue the similar tour after certain cycles. Moderated description of ACO is available in [18].

PSO is the most popular optimization method mimicking social behavior of schools of fishes or flocks of birds. In PSO, each particle maintains a potential solution position and moves to a new position with the calculated velocity considering its previous best solution and the best one among all. The process continues for all the particles until the stopping criteria is meet. For solving TSP with PSO, each particle holds a complete tour and velocity is a measure to improve the tour. Velocity tentative PSO (VTPSO) [19], an improved PSO for TSP, is considered in this study. VTPSO introduced a measure, called partial search, to get better tour with the calculated velocity. The description of VTPSO is available in [19].

IV. Experimental Studies

This section first depicts the benchmark issues and exploratory arrangement for directing the investigation. Then it describes experimental results and analysis.

A. Benchmark Data and Experimental Setup

A suite of 27 benchmark problems from Augerat et al. (A-VRP) has been considered in this study. A problem incorporates number of customers, available vehicles and vehicle capacity. Coordinates and demand of individual customers are given in the datasets. Total vehicles are from 5 to 10 and capacity of each individual vehicle is 100. The number of customers differs from 32 to 80 and demand fluctuates from 407 to 932. The original data set is modified making the coordinate of the depot as (0, 0).

We considered a fair experimental methodology for the routine optimization with GA, ACO and PSO. The number of iterations was set at 100 for the algorithms. Same population size of 50 is considered for GA and PSO; whereas ants in ACO was equivalent to the of nodes in a cluster as it desired. The methods have been implemented using Visual C++ of Visual Studio 2013 on Windows 7 OS. A PC with Intel Core i5-3470 CPU @ 3.20 GHz CPU and 4GB RAM has been used to conduct the experiments.

B. Experimental Results and Analysis

This segment presents test results for the benchmark CVRPs utilizing SW, SN and DSN with route improvement with GA, ACO and PSO. Table I shows CVRP solution (i.e., optimized route cost) of individual benchmark problem. It also shows average for GA, ACO and PSO. The best (i.e., minimal CVRP cost) achieved among GA, ACO and PSO for a particular clustering is underlined and best one among the nine is showed in bold-face. In general, PSO is shown to

outperform GA and ACO. The latest version of PSO (i.e., VTPSO) has been employed in this study which is identified as a better TSP optimization technique. For SN and DSN, PSO is shown better than GA and ACO for all 27 cases and for SW, PSO is found worse than GA for only one case (i.e., A-n37-k5). The average CVRP costs with GA, ACO and PSO for SW are 1204.04 1227.67 and 1200.67, respectively. And the average with best among GA, ACO and PSO for SW is 1200.56 which is used compare with results of SN and DSN.

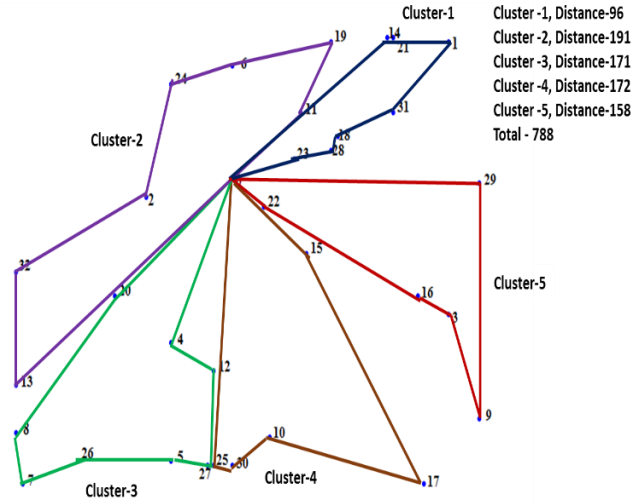
TABLE. I. BENCHMARK CVRP SOLUTIONS THROUGH CLUSTERING WITH SWEEP (SW), SWEEP NEAREST (SN) AND PROPOSED DISTANCE BASED SWEEP NEAREST (DSN) AND ROUTE OPTIMIZATION WITH GA, ACO AND PSO

SL.	Problem	SW			SN			DSN		
		GA	ACO	PSO	GA	ACO	PSO	GA	ACO	PSO
1	A-n32-k5	882	897	882	898	900	889	**870**	894	**870**
2	A-n33-k5	791	802	788	751	760	751	**720**	721	**720**
3	A-n33-k6	874	877	874	875	901	871	869	885	**867**
4	A-n34-k5	826	852	826	894	896	889	859	876	**859**
5	A-n36-k5	949	965	942	921	928	905	914	902	**887**
6	A-n37-k5	**822**	837	825	945	950	935	898	932	895
7	A-n37-k6	1141	1141	1131	**1033**	1043	**1033**	1084	1100	1077
8	A-n38-k5	876	907	874	914	917	913	866	870	**856**
9	A-n39-k5	881	918	**877**	1041	1037	1033	983	979	960
10	A-n39-k6	997	997	991	1084	1049	1048	900	906	**893**
11	A-n44-k6	1165	1230	1164	1065	1067	1065	1044	1048	**1037**
12	A-n45-k6	1115	1140	1115	1091	1091	1068	1053	1052	**1050**
13	A-n45-k7	1344	1364	1343	1251	1249	**1239**	1279	1276	1264
14	A-n46-k7	977	1010	**975**	1020	1042	1020	1087	1103	1087
15	A-n48-k7	1159	1166	**1152**	1299	1313	1297	1163	1195	1160
16	A-n53-k7	1183	1211	**1174**	1294	1304	1287	1306	1333	1293
17	A-n54-k7	1380	1374	1361	1378	1402	1378	1258	1275	**1248**
18	A-n55-k9	1201	1215	1201	1281	1284	1275	**1225**	1228	**1225**
19	A-n60-k9	1512	1562	1512	1613	1645	1609	1483	1494	**1482**
20	A-n61-k9	1225	1238	1219	1281	1290	1273	1182	1195	**1179**
21	A-n62-k8	1529	1554	1527	1498	1498	1484	1410	1428	**1403**
22	A-n63-k9	1824	1856	1823	1917	1947	1905	1783	1841	**1772**
23	A-n63-k10	1482	1532	**1481**	1511	1514	1509	1525	1513	1512
24	A-n64-k9	1607	1628	**1598**	1605	1607	1601	1674	1687	1654
25	A-n65-k9	1374	1399	1373	1360	1357	1351	1261	1258	**1254**
26	A-n69-k9	**1254**	1280	**1254**	1303	1294	1280	1342	1345	1330
27	A-n80-k10	2139	2195	2136	2140	2147	2122	1902	1927	**1890**
Average		1204.04	1227.67	1200.67	1231.96	1238.22	1223.33	1182.96	1194.93	**1174.96**
Average of best among GA, ACO and PSO		1200.56			1223.33			1174.96		
Best Count		8			2			17		
		Win / Draw / Loos Summary among SW, SN and DSN								
					SN			**DSN**		
	SW	-			10/0/17			19/0/8		
	SN				-			21/0/6		

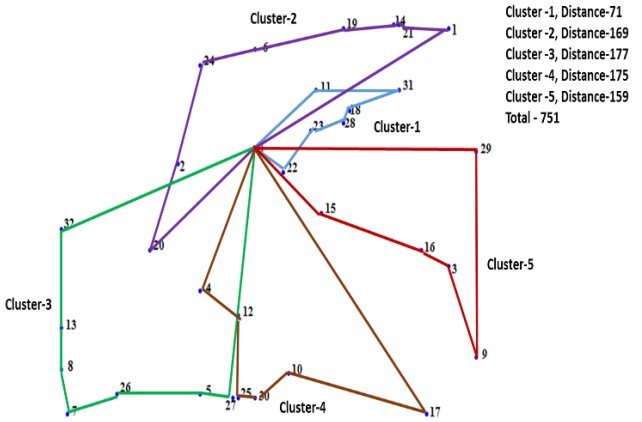
It is revealed from Table I that proposed DSN is better than SW and SN. SW is found best for 8 instances, SN for 2 instances and DSN for 17 instances out of 27. Pair wise Win / Draw / Loss summary is presented below the table for better understanding. DSN outperformed SW and SN for 19 and 21 cases, respectively, out of 27; and DSN was found inferior to SW and SN for rest several cases only. Between, SW and SN, SW outperformed SN for 17 cases and rest 10 case SN was found better than SW. It is notable that both anti-clockwise and clockwise (i.e., forward and backward) forms sweep have been considered in SW. On the other hand, SN is implemented for a smallest polar angle; SN with different angles outperformed SW but increased huge computational cost [13]. Finally, DSN + PSO (i.e., DSN with PSO) is revealed as a good CVRP solving method.

For better understanding, Fig. 2 shows graphical representation of the routes generated by the SW, SN and DSN algorithm with PSO for instance A-n33-k5. The figure also includes each individual cluster route cost and total CVRP cost. It is interesting to observe from the figure that routes for SN (i.e., Fig. 2(b)) and DSN (i.e., Fig. 2(c)) intersected but not for SW (i.e., Fig. 2(a))). Because formation advances in SW on the basis of customers' angle only either forward or backward. For SN, cluster 1 started with node 28 like SW and some nodes were common with SW. It is also remarkable for SN that earlier clusters are smaller in size and later ones are bigger. This is due to the fact that SN started clustering with the customer having smallest polar angle. On the other hand, clusters sizes for DSN are opposite of SN. DSN considered farthest point 7 in formation of first cluster and considered total seven nodes. For second cluster it started from node 17 which was the farthest among the remaining nodes after cluster 1. Therefore, earlier clusters are bigger in size as it starts clustering from the farthest customer from origin. The CVRP cost achieved for SW and SN were 788 and 751, respectively. For this case, achieved cost of DSN is 720 which is better than SN and SW.

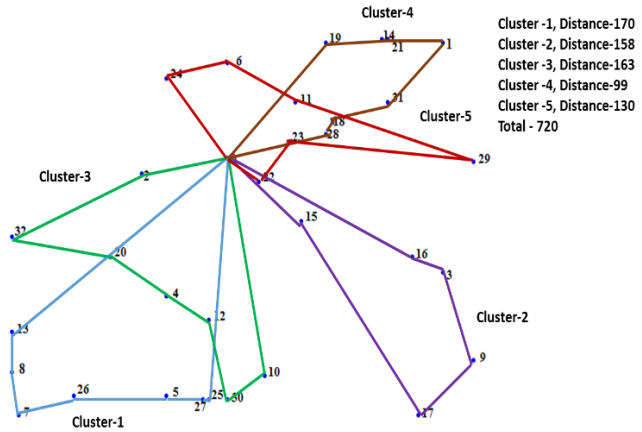
The experimental results presented in Table I and Fig. 2 were for fixed population and iteration in GA, ACO and PSO for route optimization with SW, SN and proposed DSN. The effects varying population and iteration in the route optimizing have also been investigated for proposed DSN based method. The population size was kept fixed while the generation numbered was varied and vice-versa. For fixed iteration 100, population changed from 5 to 100. On the other hand, for fixed population size 50, generation changed from 10 to 200. Fig. 3 presents CVRP cost of A-n80-k7 problem with proposed DSN clustering and varying population and iteration in PSO. It is observed from the figure that CVRP cost decreases rapidly for GA with the change of population and iteration. Changing population from 5 to 100, cost reduced from 2024 to 1902. GA also found sensitive to iteration variation. For ACO, population variation does not effective since it used total number of cities as population but cost changed slightly (from 1929 to 1927) for iteration variation. PSO also found mostly invariant with population and iteration variation. This result indicates that PSO is cost effective since it gives better outcome with small population and iteration.



(a) Solution with SW+PSO.

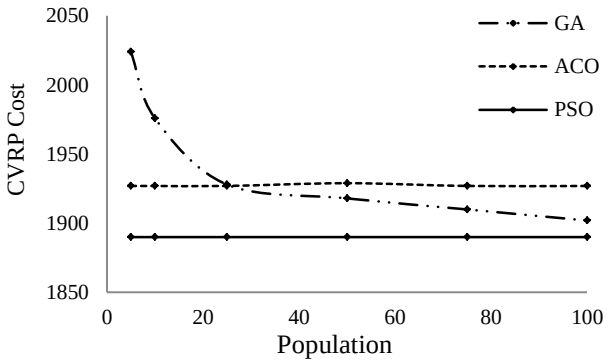


(b) Solution with SN+PSO.

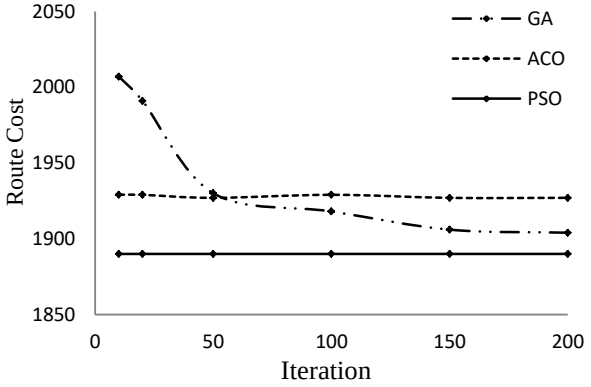


(c) Solution with DSN+PSO.

Fig. 2. Solution with Graphical Representation for A-n33-k5 using SW, SN and DSN Clustering and Route Optimizing with PSO.



(a) Effect of population size.



(b) Effect of iteration change.

Fig. 3. CVRP Cost of A-n80-k10 Problem with DSN Clustering and Varying Population and Iteration in GA, ACO and PSO.

V. CONCLUSIONS

CVRP is a popular optimization problem and different clustering-based methods are studied in recent years. Sweep algorithm is the simplest clustering algorithm to solve CVRP and Sweep Nearest is an extension of Sweep aiming to improve its performance. In this study, Distance based Sweep Nearest has been investigated. It started clustering from farthest distance node and conceived nearest neighbor method to consider nodes in the cluster. Experimental results reveal that the proposed method yields better solution than the existing ones for most of the cases. A potential future direction of the presentation study is to apply the idea for other real-life applications like metropolitan bus scheduling.

REFERENCES

[1] G. B. Dantzig and J. H. Ramser, 1959, "The Track Dispatching Problem," INFORMS, Management Science, vol. 6, no. 1 (Oct., 1959), pp. 80-91.

[2] Christofides N, Mingozzi A, Toth P. The vehicle routing problem. In: Christofides N, Mingozzi A, Toth P, Sandi C, editors. Combinatorial Optimization. Chichester: Wiley; 1958; 1979. p. 315–38.

[3] Clarke, G. & Wright, J.W., 1964, "Scheduling of Vehicles from a Central Depot to a Number of Delivery Points," Operations Research, vol. 12, pp. 568-581.

[4] Kemal Altinkemer, Bezalel Gavish, 1991, "Parallel Savings Based Heuristics for the Delivery Problem," Operations Research, vol. 39, no. 3, pp. 456-469.

[5] A. Wren. "Computers in Transport Planning and Operation". Ian Allan, London, 1971.

[6] A. Wren and A. Holliday. "Computer Scheduling of Vehicles from One or More Depots to a Number of Delivery Points". Operational Research Quarterly, vol. 23, pp. 333-344, 1972.

[7] B. E. Gillet and L. R. Miller. "A Heuristic Algorithm for the Vehicle Dispatch Problem," Operations Research, vol. 22, pp. 340-349, 1974.

[8] G. W. Nurcahyo, R. A. Alias, S. M. Shamsuddin and M. N. Md. Sap, "Sweep Algorithm in vehicle routing problem for public Transport," Journal Antarabangsa (Teknologi Maklumat), vol. 2, pp. 51-64, 2002.

[9] S. R. Venkatesan, D. Logendran, D. Chandramohan, "Optimization of Capacitated Vehicle Routing Problem using PSO," International Journal of Engineering Science and Technology (IJEST), vol 3, pp. 7469-7477, October 2011.

[10] K. Shin, "A Centroid-Based Heuristic Algorithm for the Capacitated Vehicle Routing Problem," Computing and Informatics, vol. 30, pp. 721–732, 2011.

[11] Z. J. Peya, M. A. H. Akhand and K. Murase, "Capacitated Vehicle Routing Problem Solving through Adaptive Sweep based Clustering plus Swarm Intelligence based Route Optimization," Orient. J. Comp. Sci. and Technol, vol.11, no. 2, pp. 88-102, 2018.

[12] M. Yousefikhoshbakht and E. Khorram, "Solving the vehicle routing problem by a hybrid meta-heuristic algorithm," Journal of Industrial Engineering International, vol. 8, id 11, pp. 1-9, 2011.

[13] Byungsoo Na, Yeowoon Jun & Byung-In Kim, "Some extensions to the sweep algorithm," Int J Adv Manuf Technol, vol. 56, pp. 1057–1067, 2011.

[14] M. L. Fisher and R. Jaikumar, "A Generalized Assignment Heuristic for Vehicle Routing," Networks, vol. 11, pp. 109-124, 1981.

[15] Jacques Renaud, Fayez F. Boctor, Gilbert Laporte, "An Improved Petal Heuristics for the Vehicle Routing Problem," Journal of the operational research society, vol. 47, pp. 329-336, 1996.

[16] E. Taillard, "Parallel Iterative Search Methods for Vehicle Routing Problems," Ecole Polytechnique Federale de Lausanne, Departement de Mathematiques, CH-1015 Lausanne, Switzerland, 1993.

[17] D. E. Goldberg, Genetic Algorithm in Search, Optimization and Machine Learning, New York: Addison – Wesley, 1989.

[18] T. Stutzle and M. Dorigo, "The Ant Colony Optimization Metaheuristic: Algorithms, Applications, and Advances," International Series in Operations Research and Management Science, Kluwer, 2001.

[19] M. A. H. Akhand, S. Akter, M. A. Rashid and S. B. Yaakob, "Velocity Tentative PSO: An Optimal Velocity Implementation based Particle Swarm Optimization to Solve Traveling Salesman Problem," IAENG International Journal of Computer Science, vol. 42, no.3, pp. 221-232, 2015.

Ontology Learning from Relational Databases: Transforming Recursive Relationships to OWL2 Components

Mohammed Reda CHBIHI LOUHDI[1]
Research Laboratory on computer science innovation (LRII)
Faculty of Science Aïn Chock Casablanca
Hassan II University, Casablanca, Morocco

Hicham BEHJA[2]
LRI - Laboratory
ENSEM, Hassan II University
Casablanca, Morocco

***Abstract*—Relational databases (RDB) are widely used as a backend for information systems, and contain interesting structured data (schema and data). In the case of ontology learning, RDB can be used as knowledge source. Multiple approaches exist for building ontologies from RDB. They mainly use schema mapping to transform RDB components to ontologies. Most existing approaches do not deal with recursive relationships that can encapsulate good semantics. In this paper, two technics are proposed for transforming recursive relationships to OWL2 components: (1) Transitivity mechanism and (2) Concept Hierarchy. The main objective of this work is to build richer ontologies with deep taxonomies from RDB.**

***Keywords*—Relational databases; ontologies; OWL2; recursive relationship; transitivity; concept hierarchy**

I. Introduction

A relational database is a digital database based on the relational model of data, as proposed by Codd in 1970 [1]. RDB use many components (tables, constraints, etc.) to manage data in a structured way. These databases are usually created on the basis of a conceptual model which is established by designers after a deep analysis of an information system.

However, RDBs are considered "semantically poor" because of the nature of the used components that are structure-oriented. Indeed, the schema of a RDB is composed by a set of tables related by foreign key constraints. This limitation makes the use of RDB for semantic purposes very difficult. Transforming the RDB to an ontology can lift the limitation.

According to Tom Gruber, "an ontology defines a set of representational primitives with which to model a domain of knowledge or discourse. The representational primitives are typically classes (or sets), attributes (or properties), and relationships (or relations among class members). The definitions of the representational primitives include information about their meaning and constraints on their logically consistent application" [2].

There are many ways to represent ontologies. The choice of the representation to use depends on the ontology operationalization. The Web Ontology Language is one of the most used languages to represent ontologies on the Web. It is an ontology language for the Semantic Web with formally defined meaning. OWL 2 (latest version of the language) ontologies provide classes, properties, individuals, and data values and are stored as Semantic Web documents [3].

There are many approaches that transform a RDB to an ontology. Three main techniques are used: (1) Reverse Engineering, to convert the relational model to the conceptual model (which is considered as semantically richer than the relational model) or to retrieve lost information during the transformation of the conceptual model to the relational model, (2) Schema Mapping, to convert relational model components to ontology components, through the use of transformation rules and (3) Data Mining to analyze stored data in order to enrich the ontology.

The majority of the existing techniques for transforming RDBs to ontologies do not deal with the specific case of Recursive Relationships that are simply transformed to a property with domain and range that belongs to the same class.

This work is supported by the project "Knowledge Management for Development in the Context of OCP Group (KM4Dev – OCP Group)" granted by OCP Group – Morocco.

This paper will discuss how we can extract richer semantics from Recursive Relationships by the use of OWL2 components. The rest of this paper is organized as follows: In the 2nd Section, present the previous works of the authors in the case of transforming RDBs to OWL ontologies. The Section 3 gives an overview of related works for transforming Recursive Relationships in RDBs to ontologies. Section 4 discusses Recursive Relationships in RDBs. Section 5 deals with Recursive Properties in OWL2 ontologies. In the 6th Section, a proposal for transforming Recursive Relationships in RDBs to OWL2 components is tackled. Finally, the last Section will include concluding remarks and some topics for further works.

II. Previous Work

In the case of building OWL ontologies from relational databases (RDBs), authors have conducted several researches. In [4], a set of transformation rules was proposed for building OWL ontologies from RDBs. It allows transforming all possible cases in RDBs (one-to-many relations, many-to-many relations, n-ary relations and inheritance) into ontological constructs. After that, a hybrid method for automatic ontology building from a RDB was proposed [5]. That hybrid method

combines reverse engineering, schema mapping and data analysis techniques. The extracted ontology is refined by renaming the components whose names do not reflect their real meaning. This method allows (1) recovering lost tables during the mapping of ER-Model components to the relational model, by using reverse engineering technique for the generalization and specialization cases; (2) transforming, in the schema mapping phase, the different constructs and cases such as multiple inheritance, n-ary relations, etc.; (3) analyzing stored data to detect disjointness and totalness (or Completeness) constraints in hierarchies, and calculating the participation level of tables in n-ary relations. This method begins with recovering the database schemata, after that, a set of proposed algorithms are applied to detect generalized and specialized tables in order to enrich the ontology taxonomy. In the next step, a set of transformation rules is applied on the schema to convert the database components to ontology components. At the end, a manual refinement phase is conducted to rename components (classes and properties) having automatic generated names. In [6], an enhancement for the previously proposed algorithms for reverse engineering was presented. The main objective of the enhancement is to detect the lost entities in the multi-level inheritance for the generalization and specialization cases. Indeed, the proposed algorithms in [5] deals with only one-level inheritance.

In the previous works, recursive relationships in relational databases was not correctly transformed. This kind of relations contains semantics that can be used to build richer OWL2 ontologies rather than transforming it to a simple property. In the next section, related works to this case will be discussed.

III. Related Works

In the case of transforming recursive relationships from relational databases to ontologies, there are many works (generally irrelevant to that case). In [7], authors suggest a mapping method to map the two types of recursive relationships to the resource description framework schema (RDFS) [8]. One type of recursive relationship is generated during the integration process with different entities at different levels in a hierarchical structure while the other is generated at the hierarchical structure between the instances of an attribute in an entity. The transformed RDFS, including the class, subclasses, and sub-properties minimizes the loss of data meaning and enables the process of the inference function to be used with RDB data. In paper [9], authors give some proof case studies and propose a model to upgrade the semantics of the relational model, before the ontology learning. They argue that without an explicit model of the domain semantics in the relational model, the automatic learning of ontology risks to infer incorrect semantics. Recursive relationships are transformed into two mutually inverse object properties having domain and range referencing the same class. In [10], the author presents ERD (Entity-Relation Diagram) to OWL-DL ontology transformation rules at a concrete level. These rules facilitate an easy and understandable transformation from ERD to OWL. To transform recursive relationships, the author creates a new class representing the recursive association, resulting on an existential quantification restriction (some Values From restriction in OWL) on the class corresponding to the table having the recursive relationship. In [11], authors propose a method that is consisted of two main phases: building ontology from an RDB schema and the generation of ontology instances from an RDB data automatically. In the first phase, they study different cases of RDB schema to be mapped into the ontology represented in RDF(S)-OWL, while in the second phase, the mapping rules are used to transform RDB data to the ontological instances represented in RDF triples. Rules 15 and 16, are applied to transform recursive relationships into a Transitive or a Symmetric Property. Transitivity can be applied in most cases. But Symmetry can only be applied if and only if each row of the table (having a recursive relationship) references (through a foreign key constraint) another row in the same table and vice versa (one row references the other in both ways).

IV. Recursive Relationships in Relational Databases

The conceptual data model is a structured business view of the data required to support business processes, record business events, and track related performance measures. This model focuses on identifying the data used in the business but not its processing flow or physical characteristics. This model's perspective is independent of any underlying business applications [12]. The conceptual data model represents the overall structure of data required to support the business requirements independent of any software or data storage structure. It is an important phase before building the database.

Entity-Relationship (ER) modeling is a logical design modeling technique. After the business requirements and data requirements are gathered and the business rules understood, we can start developing the logical data model. An ER model is often referred to as a 3NF (third normal form), or sometimes just a normalized model for short. It is also sometimes referred to as a relational model, which is incorrect. Although it is implemented in a relational database, it is not the sole data modeling technique that could be used in a relational database [12].

The ER modeling concepts are sufficient for representing many database schemas for traditional database applications, which include many data-processing applications in business and industry. However, designers of database applications have tried to design more accurate database schemas that reflect more precisely the data properties and constraints. This led to the development of additional semantic data modeling concepts that were incorporated into conceptual data models, such as the ER model. Various semantic data models have been proposed in the literature. Among them, we find the EER Model (Enhanced Entity-Relationship Model) that incorporates a set of new concepts (class/subclass relationships and type inheritance into the ER model, specialization and generalization, various types of constraints on specialization/generalization, etc.) [13].

One of the most difficult relationships to express is a recursive relationship. This is a non-identifying, non-mandatory relationship in which the same entity is both the parent and the child [12]. Each migrating primary key attribute must be given a role name to clarify the attribute's foreign key role. In figure 1, to express the fact that an Employee can supervise another one, a recursive relationship can be used.

The *Emp_SSN* column in relational model represents the supervisor identifier.

However, variations in relationships can be masked in such a model when a dependency exists between relationships or between a relationship and an attribute [14]. For example, in figure 1, some employees manage other employees, while other employees aren't managed (they don't have a supervisor).

Another usage case for recursive relationships is the organization of categories of articles in inventory management systems (each article is belonging to a category). Usually, categories in such a system, are organized in a hierarchical way (a category contains multiple categories which contains others and so on). The figure 2 shows the ER Model representing this case and the corresponding Relational Model. The *Parent_Category_id* column in relational model represents the parent category identifier.

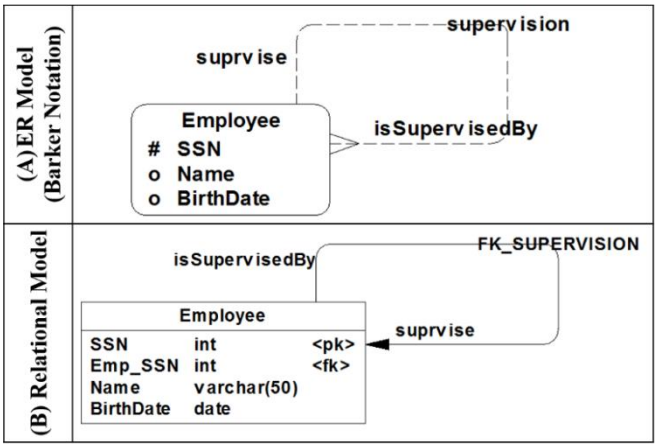


Fig. 1. Example of a Recursive Relationship in ER Model and Relational Model.

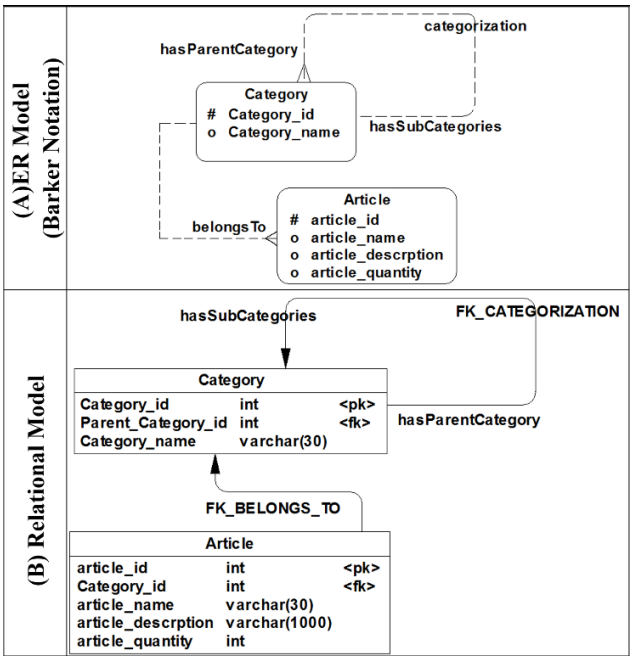


Fig. 2. Using Recursive Relationship to Categorize other Entities.

V. Recursive Relations in OWL2 Ontologies

The Web Ontology Language, informally OWL2, is an ontology language for the Semantic Web with formally defined meaning. OWL2 ontologies provide classes, properties, individuals, and data values and are stored as Semantic Web documents [3]. There is no specific way to express recursive properties in OWL2. It is simply represented as an Object Property having domain and range referencing the same class. In the example of figure 3, a Person has as parent another Person. The corresponding code using OWL Functional syntax (which will be used in all following examples) is presented below.

However, the OWL2 recommendation defines multiple characteristics that can be assigned to recursive properties: (A)Symmetry, (IR)Reflexivity and Transitivity.

A. Symmerty

An object property (SOP) is considered as symmetric, if an individual x is connected by SOP to an individual y, then y is also connected by SOP to x. In the example of figure 4, a Woman has as sister another Woman.

B. Asymmerty

An object property (AOP) is considered as asymmetric, if an individual x is connected by AOP to an individual y; then y cannot be connected by AOP to x. In the example of figure 5, a Person has as parent another Person, the property is not valid in both directions.

C. Reflexivity

An object property (ROP) is considered as reflexive, if an individual x is connected by ROP to itself. In the example of figure 6, a Person knows himself.

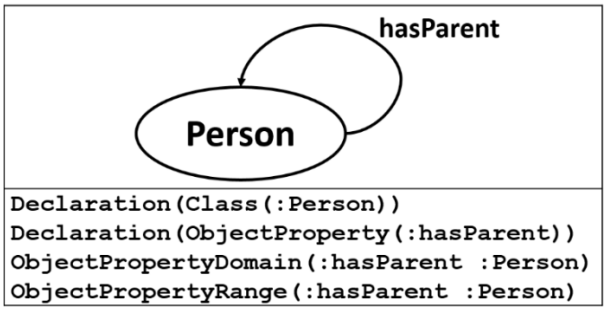


Fig. 3. Example of a Recursive Property.

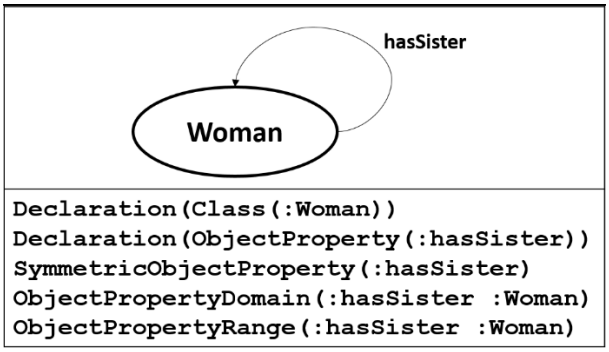


Fig. 4. Example of a Symmetric Property.

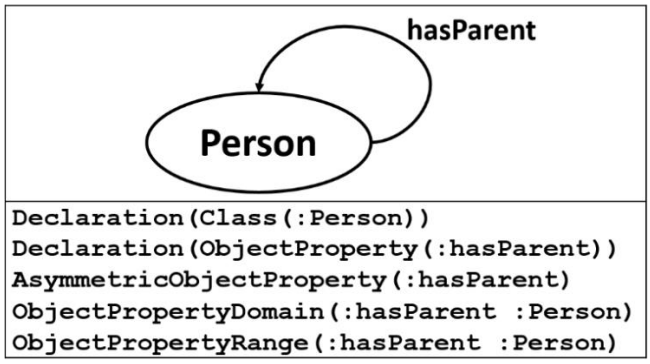


Fig. 5. Example of an Asymmetric Property.

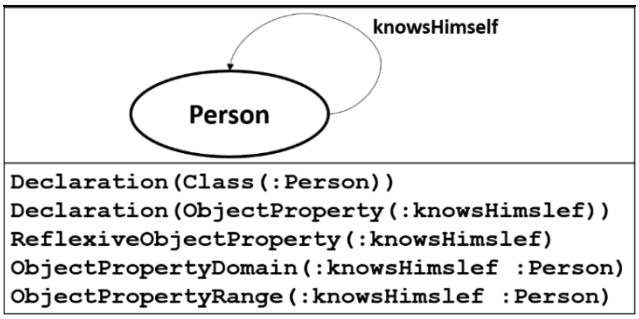


Fig. 6. Example of a Reflexive Property.

D. Irreflexivity

An object property (IOP) is considered as irreflexive, if an individual x cannot be connected by IOP to itself. In the example of figure 7, a Person is the child of another person, but cannot be the child of himself.

E. Transitivity

An object property (TOP) is considered as transitive, if an individual x is connected by TOP to an individual y, which is connected to another individual z, then x is also connected to z. In the example of figure 8, a Region is included in another Region (if a Region r1 is included in a Region r2, that is included in a Region r3, then r1 is included in r3).

In the next section, two ways to transform recursive relationships from relational model to OWL2 components will be proposed.

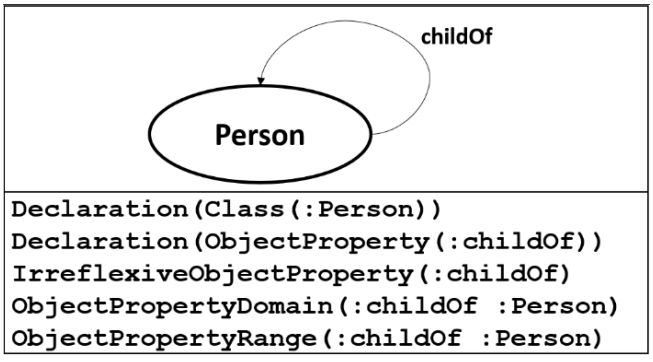


Fig. 7. Example of an Irreflexive Property.

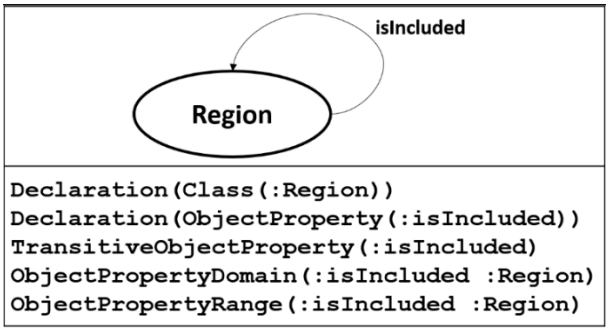


Fig. 8. Example of a Transitive Property.

VI. Proposed Transformations for Recursive Relationships

This section discusses and compares two different transformations for recursive relationships in relational model. The first one is to use Transitivity mechanism and the second one through the use of concept hierarchy.

A. Transitivity Mechanism

For the first proposal, two mutually inverse object properties are created (each one is the inverse of the other) with domains and ranges referencing the same class (corresponding to the table having the recursive relationship). These properties are also declared as Transitive figure 9.

In the example of figure 1, an Employee is supervised by another Employee. Inversely, an Employee supervises another one. The transformation of this case will produce, a class representing an "Employee", and two mutually inverse Object Properties "*isSupervisedBy*" and "*supervises*" having domains and ranges referencing the "*Employee*" class. The figure below presents the obtained results.

B. Concept Hierarchy

In some cases, recursive relationships in the relational model are used to classify, in a hierarchical way, the occurrences, of other entities. In the example of figure 2, Articles are categorized in categories that are organized hierarchically using a recursive relationship.

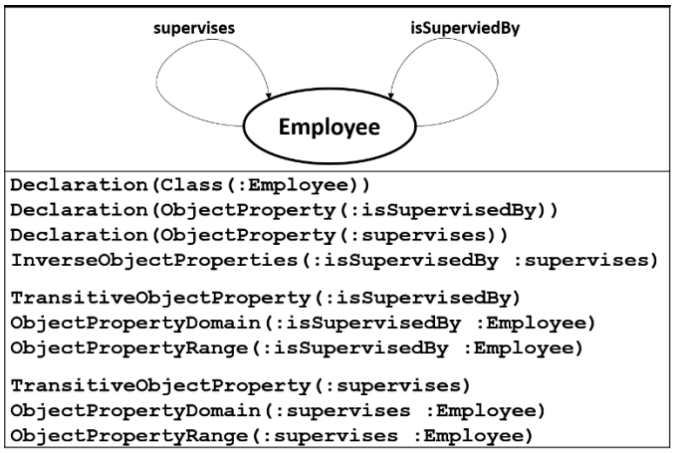


Fig. 9. Transformation Example using Transitivity Mechanism.

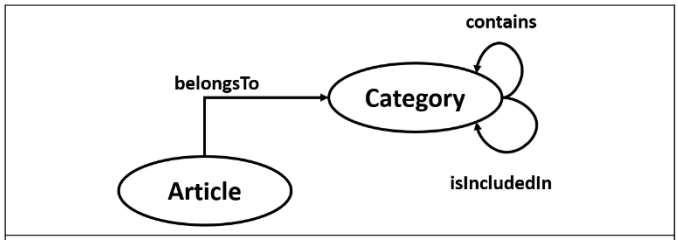
Transforming the example of figure 2 can be achieved using Transitivity. As result, two classes will be obtained, corresponding to the entities "*Article*" and "*Category*", linked with an Object Property "*belongsTo*". Two other mutually inverse Object Properties ("*contains*" and "*isIncludedIn*") will be created having domains and ranges referencing the class "*Category*". These two Properties are also declared as Transitive. The figure 10, shows the obtained transformation.

A better result can be obtained through the use of the Concept Hierarchy, which is a type of background knowledge (an approach for guiding the knowledge discovery process, and for evaluating the patterns found [15]) which expresses the structure of the concept from low-level to a more general concept. The use of the concept hierarchies as background knowledge allows expressing the discovered knowledge in a higher abstraction level, more concise and usually in a more interesting format [16].

The proposed solution is to create a class hierarchy from the occurrences of the entity having the recursive relationship. Each class of the hierarchy will be formed as Disjoint Union of all its subclasses.

As an alternative to the solution proposed in figure 10, a class hierarchy will be created from the occurrences of the table "Category". Each class in the hierarchy correspond to an existing category (occurrence) and is related to other categories by an "is-a" relation.

To explain this proposal, the database of the Inventory Management system of Cadi Ayyad University of Marrakech (named SyGeS : *Système de Gestion de Stock)* will be used. The "*Category*" table is used to categorize articles (each Article belongs to a Category). Figure 11 shows the hierarchical organization of categories in the system.




```
Declaration(Class(:Article))
Declaration(Class(:Category))
Declaration(ObjectProperty(:belongsTo))
Declaration(ObjectProperty(:contains))
Declaration(ObjectProperty(:isIncludedIn))

ObjectPropertyDomain(:belongsTo :Article)
ObjectPropertyRange(:belongsTo :Category)

InverseObjectProperties(:contains :isIncludedIn)
TransitiveObjectProperty(:contains)
ObjectPropertyDomain(:contains :Category)
ObjectPropertyRange(:contains :Category)

TransitiveObjectProperty(:isIncludedIn)
ObjectPropertyDomain(:isIncludedIn :Category)
ObjectPropertyRange(:isIncludedIn :Category)
```

Fig. 10. Transformation of Example of Figure 2 using Transitivity Mechanism.

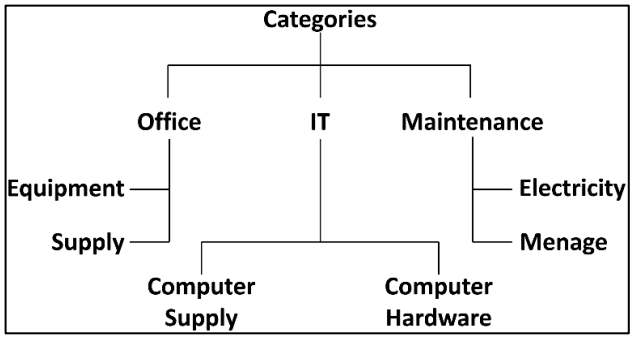
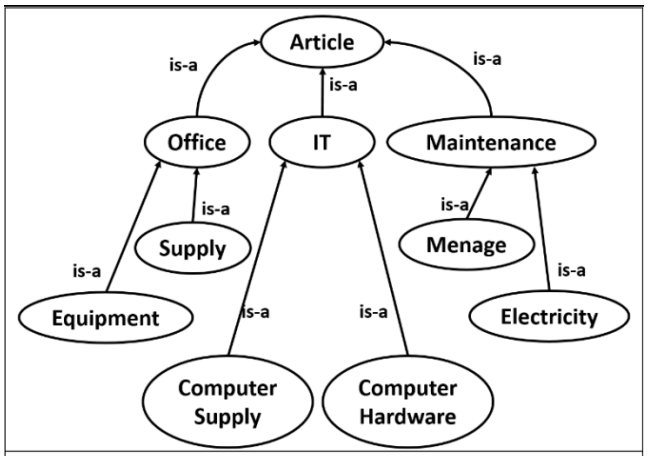


Fig. 11. Article' Categories in SyGeS System.

As result of the transformation (applying Concept Hierarchy) of this case, the categories (occurrences of the table "*Category*") will be declared as classes and organized in a hierarchical way, by detecting the parent of each category (through the recursive relationship). The detected root categories (categories without a parent: null value on foreign key column) will be declared as subclasses of the "Article" class. The figure 12 presents the obtained transformation.




```
Declaration(Class(:Article))
Declaration(Class(:ComputerHardware))
Declaration(Class(:ComputerSupply))
Declaration(Class(:Electricity))
Declaration(Class(:Equipment))
Declaration(Class(:IT))
Declaration(Class(:Maintenance))
Declaration(Class(:Menage))
Declaration(Class(:Office))
Declaration(Class(:Supply))

SubClassOf(:IT :Article)
SubClassOf(:Maintenance :Article)
SubClassOf(:Office :Article)
SubClassOf(:ComputerHardware :IT)
SubClassOf(:ComputerSupply :IT)
SubClassOf(:Electricity :Maintenance)
SubClassOf(:Menage :Maintenance)
SubClassOf(:Equipment :Office)
SubClassOf(:Supply :Office)

DisjointUnion(:Article :IT :Maintenance :Office)
DisjointUnion(:IT :ComputerHardware :ComputerSupply)
DisjointUnion(:Maintenance :Electricity :Menage)
DisjointUnion(:Office :Equipment :Supply)
```

Fig. 12. Transformation of Example of Figure 2 using Concept Hierarchy.

At the end, the occurrences of table "*Article*" are transformed to individuals of the class corresponding to their category in the ontology. For example, an article "*Laptop*" will be declared as an individual of the class "*ComputerHardeware*".

VII. Conclusion and Future Work

This paper proposes two manners for transforming recursive relationships from relational databases to OWL2 ontologies' components. In the first one, Transitivity mechanism is applied as a characteristic for the created object properties representing the recursive relationship. In the second one, Concept Hierarchy is used to build a taxonomy of classes from the occurrences in the table having the recursive relationship. This proposal is an enhancement of the proposed transformation rules in [4][5].

The main objective of this work is learning OWL2 ontology from relational databases to extract richer semantics. As future work, the tables' occurrences will be analyzed in order to extract deeper taxonomies. Some existing approaches tries to do that, like in [17] where the author combines a classical analysis of the database schema with a task specifically dedicated to the identification of categorization patterns in the data. Another improvement clue is to enhance the developed tool in [5] by integrating all recent researches.

Acknowledgment

This work is supported by the project "Knowledge Management for Development in the Context of OCP Group (KM4Dev – OCP Group)" granted by OCP Group – Morocco.

Thanks to Mr. ETTKIRITA Youness, manager of the Stock Management System at the University of Cadi Ayyad–Marrakech, for providing a part of the database of their system to validate our proposal.

References

[1] G. Eason, B. Codd, E. F., "A Relational Model of Data for Large Shared Data Banks". Communications of the ACM. 13 (6): 377–387, 1970.

[2] Gruber, T., "Ontology". The Encyclopedia of Database Systems, Ling Liu and M. Tamer Özsu (Eds.), Springer-Verlag, 2009.

[3] W3C, "OWL 2 Web Ontology Language : Structural Specification and Functional-Style Syntax (Second Edition)", W3C Recommendation. Available at: https://www.w3.org/TR/owl2-syntax, 2012.

[4] Chbihi Louhdi, M. R., Behja, H., & Ouatik El Alaoui, S., "Transformation Rules for Building OWL Ontologies from Relational Databases". In the proceeding of the Second Conference of Data Mining & Knowledge Management Process. Dubai, 2013.

[5] Chbihi Louhdi, M.R., Behja, H., & Ouatik El Alaoui, S., "Hybrid Method for Automatic Ontology Building from Relational Database". International Review on Computers and Software, vol. 8(8), pp. 1801-1813, 2013.

[6] Sbai, S., Chbihi Louhdi, M.R., Behja, H., Zemmouri, E., & Chakhmoune, R., "Using Reverse Engineering for Building Ontologies with Deeper Taxonomies from Relational Databases". Journal of Software, Vol. 14(3), pp.138-145, 2019.

[7] Choi, M., Moon, C., Baik, D., Wie, Y., & Park, J., "The RDFS mapping for recursive relationship of relational data model". The IEEE International Conference on Service-Oriented Computing and Applications (pp. 1-6), Perth, WA, 2010.

[8] W3C, "RDF Schema 1.1, W3C Recommendation". Available at: https://www.w3.org/TR/rdf-schema, 2014.

[9] Idrissi, B.E., Baina, S., Baina, K., "Upgrading the semantics of the relational model for rich OWL 2 ontology learning". Journal of Theoretical and Applied Information Technology, vol. 68(1), pp. 138-148, 2014.

[10] Fahad, M., "ER2OWL: Generating OWL Ontology from ER Diagram". In: Shi Z., Mercier-Laurent E., Leake D. (eds) Intelligent Information Processing IV. IIP. IFIP – The International Federation for Information Processing, vol 288. Springer, Boston, MA, 2008.

[11] Hazber, M.A.G., Li, R., Gu, X., & Xu, G., "Integration Mapping Rules: Transforming Relational Database to Semantic Web Ontology". International Journal of Applied Mathematics & Information Sciences, vol. 10(3), pp. 881-901, 2016.

[12] Elmasri, R., & Navathe, S.B., "Fundamentals of Database Systems (7th Edition)", Pearson, 2016.

[13] Sherman, R., "Business Intelligence Guidebook From Data Integration to Analytics". In Foundational Data Modeling, pp. 173-195, Elseiver, 2015.

[14] Burton-Jones, A. Lazarenko, K., & Weber, R., "Problems with recursive relationships and relationships with attributes in ER models". In Proceedings of the 10th AIS SIGSAND Symposium, Bloomington, Indiana, USA, 2011.

[15] Han, J., Kamber, M., & Pei, J., "Data Mining: Concept and Techniques, Morgan Kaufmann", Elseiver, 2011.

[16] Di Beneditto M.E.M., & de Barros L.N., "Using Concept Hierarchies in Knowledge Discovery". In: Bazzan A.L.C., Labidi S. (eds) Advances in Artificial Intelligence – SBIA 2004. Lecture Notes in Computer Science, vol 3171. Springer, Berlin, Heidelberg, 2004.

[17] Cerbah, F., "Mining the Content of Relational Databases to Learn Ontologies with Deeper Taxonomies". In Proceedings of the IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology (pp. 553-557). Sydney, NSW, 2008.

Hyperspectral Image Classification using Support Vector Machine with Guided Image Filter

Shambulinga M[1], G. Sadashivappa[2]
Dept of Telecommunication Engineering, RV College of Engineering, Bengaluru

***Abstract*—Hyperspectral images are used to identify and detect the objects on the earth's surface. Classifying of these hyperspectral images is becoming a difficult task, due to more number of spectral bands. These high dimensionality problems are addressed using feature reduction and extraction techniques. However, there are many challenges involved in the classification of data with accuracy and computational time. Hence in this paper, a method has been proposed for hyperspectral image classification based on support vector machine (SVM) along with guided image filter and principal component analysis (PCA). In this work, PCA is used for the extraction and reduction of spectral features in hyperspectral data. These extracted spectral features are classified using SVM like vegetation fields, building, etc., with different kernels. The experimental results show that SVM with Radial Basis Functions (RBF) kernel will give better classification accuracy compared to other kernels. Moreover, classification accuracy is further improved with a guided image filter by incorporating spatial features.**

***Keywords*—Support Vector Machine (SVM); hyperspectral images; guided image filter; Principal Component Analysis (PCA)**

I. Introduction

Remote Sensing is the study of collecting the earth's surface data and information by measuring the reflected signal form objects at long distances. The data collected in the form of images are classified and identified for different objects on the earth's surface. The major applications of remote sensing are urban planning and management, forestry, environmental monitoring, agriculture, Highway, Resource monitoring, and flood management. Remote sensing techniques are divided into two types, namely infrared and optical remote sensing. In optical remote sensing, an optical sensor in the satellite is used to detect targets by measuring the reflected or scattered solar radiated signal from the earth objects. In infrared remote sensing, the infrared sensor in the satellite is utilized to identify the infrared radiated signal emitted from the earth's surface.

Optical remote sensing satellite makes use of electromagnetic waves sensor of different wavelength ranging from visible to infrared region in forming images. Solar radiation from the earth surface reflects and absorb at different wavelength band for different materials to form a spectral signature of targets. Depending upon the number of spectral bands utilized in an imaging system, satellite images are classified into three types, panchromatic image, multispectral image, and hyperspectral image. The panchromatic imaging system has a single spectral band with a broad wavelength. Multispectral imaging has few spectral bands contains both brightness and color information of the targets. The hyperspectral imaging system captures the image in more than 100 spectral bands. This hyperspectral image contains the exact spectral information which has better characterization and detection of the objects in the image.

The problems in the classification of hyperspectral images are high dimension which results in the Hughes phenomenon [1]. In the Hughes phenomenon, the accuracy of the supervised classification method decreases as the data dimensionality increases, with fixed training samples and labels. High dimensionality problem in the classification of a hyperspectral image can be overcome by feature selection and extraction techniques. The researchers have developed various feature extraction techniques, for example, Principal component analysis (PCA) [2], Independent component analysis (ICA) [3], and linear discriminant analysis (LDA) [4].

PCA and ICA are unsupervised methods do not require labels and LDA is the supervised method requires labels for extraction of a feature vector. These feature extraction techniques preserve the spectral signature information of different class by projecting a feature vector with more dimension vector to less dimension vector. Among these feature extraction methods, the PCA method will preserve most of the spectral information of a hyperspectral image in a small amount of principal components. The feature selection technique tries to find out the best spectral bands in hyperspectral images to achieve the highest class separability. Different types of methods developed based on distance and information theory [5] for the spectral band selection in hyperspectral images. Experimental results of these feature selection methods have shown better performances, but these methods have some theoretical difficult in finding the best subset combination of features for classification.

More number of pixel-wise classifiers was proposed for the classification and identifying targets in a hyperspectral data such as random forests [6], neural networks [7], Adaboost, SVM with various kernels, sparse representation [9] and active learning [10]. SVM is the better pixel-wise classifier compare to other classifiers and also shown better performance in terms of the overall accuracy of classification. SVM requires less number of training samples and labels to obtain good classification accuracy and it is also robust to spectral dimensions in hyperspectral images. Furthermore, many researchers have tried to enhance the performance of the classification by considering the spectral and spatial feature classification techniques [11], which includes spatial information to the pixel-wise classifier. Some image fusion techniques [12] are utilized to enhance the spectral and spatial information.

In addition to spatial feature extraction, another spectral and spatial classification method has been developed based on image segmentation [13]. In this, segmentation of the hyperspectral image is performed based on similarity and homogeneity of spectral information, so that all pixels in the region are considered as the same class. Various segmentation techniques have been developed for hyperspectral images such as watershed [15], partitional clustering [14], minimum spanning forest [17] and hierarchical segmentation [16]. However, the classification of these methods depends on the performance of the segmentation. Most of the advanced segmentation algorithms are time-consuming.

Recently, a guided image filter [18] is used as edge-preserving filter for most of the applications such as enhancing and denoising the images and high dynamic imaging. This guided image filter can be used to enhance the SVM classification accuracy [8] of the hyperspectral images by considering spatial features.

Hyperspectral image classification based on SVM with a guided image filter and PCA is proposed in this paper. Here PCA is used as a dimensionality reduction algorithm for reducing the feature vectors and also the first principal component of spectral features are used as a guidance image for guided image filter.

This paper is organized as follows: Section II introduces the theory of PCA for feature reduction. Section III gives the basic idea of SVM with different kernels for classification. Section IV describes the theory of guided image filter to improve the performance of classification. Section V describes the methodology of hyperspectral classification. Section VI and VII discusses the experimental results of hyperspectral classification and conclusion.

II. Principal Component Analysis

PCA is the dimensionality reduction algorithm for the hyperspectral images in which bands are highly correlated and convey similar information. The original data bands are analyzed and transformed to remove the correlation in the bands. Statistics properties are used in PCA to remove the correlated bands. The basic principle used in PCA is the eigenvalue decomposition of the covariance matrix. The detailed steps of PCA for a hyperspectral image are as follows.

Consider the hyperspectral image has N bands. Each pixel of the image is defined by a vector

$$X_i = [x_1, x_2, x_3 \dots \dots x_N] \quad (1)$$

where x_1, x_2, x_3…..x_N are the data number of the respective bands. In hyperspectral image has m rows and n columns which leads to a total of M=m*n such vectors. The mean value for each vector defined in (1) is calculated by using (2).

$$m = \frac{1}{M}\sum_{1=1}^{M}[x_1, x_2, \dots \dots x_N]_i^T \quad (2)$$

The covariance matrix is calculated by using (3)

$$C_X = \frac{1}{M}\sum_{i=1}^{M}(X_i - m)(X_i - m)^T \quad (3)$$

PCA is based on the eigenvalue decomposition of the covariance matrix which is given in (4)

$$C_X = ADA^T \quad (4)$$

where,

$$D = diag(\lambda_1, \lambda_2, \dots \dots \lambda_N) \quad (5)$$

D is the diagonal matrix contains the eigenvalues of the covariance matrix and A is the orthonormal matrix of N dimension eigenvector a_k of C_X

$$A = (a_1, a_2, \dots \dots a_N) \quad (6)$$

Linear transformation Y_i is the PCA pixel vector given by (7)

$$Y_i = A^T x_i \quad (7)$$

Pixel vectors in (7) are PCA bands of the original hyperspectral image.

Let eigenvector and eigenvalues are arranged in descending order, say, $\lambda_1 > \lambda_2 > \lambda_3\ \lambda_4 > \dots > \lambda_N$, first K rows of matrix A^T in equation (7) can be used to calculate the approximation of the original images as mentioned in (8)

$$z_i = \begin{bmatrix} z_1 \\ z_2 \\ \vdots \\ z_k \end{bmatrix}_i = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1K} & \dots & a_{1N} \\ a_{21} & a_{22} & \cdots & a_{2K} & \dots & a_{2N} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{K1} & a_{K2} & \cdots & a_{KK} & \dots & a_{KN} \end{bmatrix} \cdot \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_K \\ \vdots \\ x_N \end{bmatrix}_i \quad (8)$$

Pixel vector z_i is the first K bands of PCA images. These PCA image has the highest contrast or variance in the first band and lowest contrast or variance in the last band. Thus PCA contains a majority of information in the first few bands of the hyperspectral images.

III. Support Vector Machine

SVM is derived based on the decision planes that determine decision boundaries. A decision plane sorts out between a set of objects having various class memberships. SVM classifier separates the data into a training set and testing set. Each instance in the training set is assigned to one target value. Let X be the input data set and Y be the output dataset. Training set be $\{(x_1, y_1), (x_2, y_2), \dots\dots. (x_m, y_m)\}$. Try to find out the suitable value of $y \in Y$ from the previously seen value $x \in X$. SVM model can be generated by the equation

$$Y = f(x, \alpha) \quad (9)$$

here, α are the parameters of the kernel function that needs to be fine-tuned for accurate classification. SVM classifier has various types of kernel functions such as polynomial, linear, and radial basis functions. SVM methodology with a linear kernel is shown in Fig. 1. Here, H is the optimal hyperplane and it should have a maximum margin value to separate the two classes. The SVM decision function is given by (10)

$$f(x) = \sum_{i \epsilon S} \alpha_i\, y_i K(x_i, x_j) + b \quad (10)$$

$K(x_i, x_j)$ is the kernel function and S is training sample subsets.

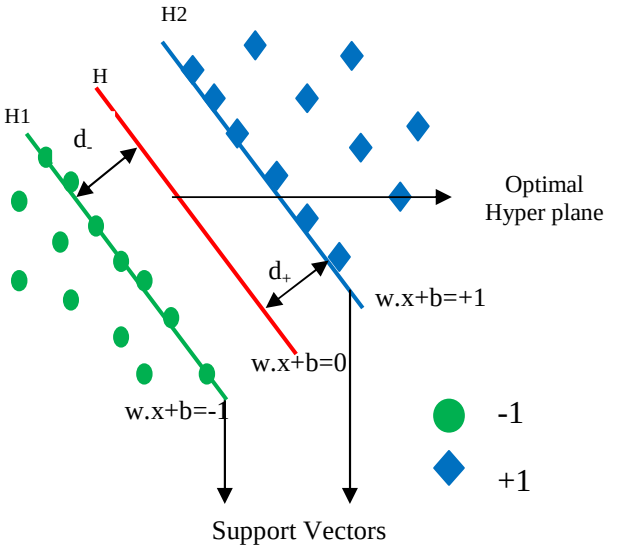


Fig. 1. Linear SVM Methodology.

Some of the commonly used kernels are:

Linear:

$$K(x_i, x_j) = \langle x_i, x_j \rangle$$

Polynomial:

$$K(x_i, x_j) = (\gamma \langle x_i, x_j \rangle + c)^d$$

Radial basis function:

$$K(x_i, x_j) = exp\left\{-\frac{\|x_i - x_j\|^2}{2\sigma^2}\right\}$$

Sigmoid:

$$K(x_i, x_j) = tanh(\gamma \langle x_i, x_j \rangle + c)$$

IV. Guided Image Filter

Guided Image filter is an Edge preserving filter that defines a linear translations variant filtering process, contains guidance image I and input image p. Depending on the application, guidance image can be same as the input or any other image. Guided image filter output q_i as defined in (11) is a linear transform of a guided image in a window ω_K of particular size centered at pixel k

$$q_i = a_k I_i + b_k, \forall\, i \in \omega_k \quad (11)$$

a_k and b_k are the linear coefficients determined by minimizing cost function between the filter output q and filter input p

$$E(a_k, b_k) = \sum_{i \in \omega_k} ((a_k I_i + b_k - p_i)^2 + \epsilon {a_k}^2) \quad (12)$$

ϵ is the regularization parameter and solution to equation (12) is given by linear regression

$$a_k = \frac{\frac{1}{|\omega|}\sum_{i \in \omega_k} I_i p_i - \mu_k \overline{p}_k}{\sigma_k^2 + \epsilon} \quad (13)$$

$$b_k = \bar{p}_k - a_k \mu_k \quad (14)$$

here, μ_k is the mean and σ_k^2 is the variance of I in ω_k, $|\omega|$ is the total number of pixel in ω_k.

Apply a linear model to every local window in an image and filter output is computed by equation (15).

$$q_i = \frac{1}{|\omega|}\sum_{k:i \in \omega_k} (a_k I_k + b_k) = \overline{a}_i I_i + \overline{b}_i \quad (15)$$

Where

$$\bar{a}_i = \frac{1}{|\omega|}\sum_{k \in \omega_i} a_k \text{ and } \bar{b}_i = \frac{1}{|\omega|}\sum_{k \in \omega_i} b_k$$

V. Methodology

The implementation of hyperspectral image classification using the SVM classifier technique is shown in Fig. 2. In the implementation, a hyperspectral image data with 224 spectral bands of different wavelengths are considered. The estimated size of the image data is three dimensional because the image is captured at different wavelengths. Convert the three-dimensional data to two-dimensional data for SVM classification. Since the spectral information in the image data contains more dimensions which consume more time for classification, so the dimensions of the data are reduced using PCA as shown in Fig. 3. The supervised classification requires training samples and training labels. In the given set of data samples, randomly select and normalize the training samples and testing samples with labels associated to the respective sample.

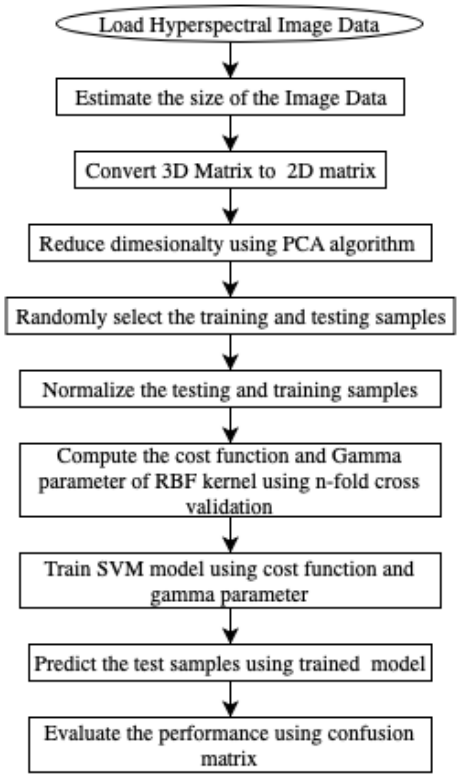


Fig. 2. Flow Chart of Hyperspectral Image Classification.

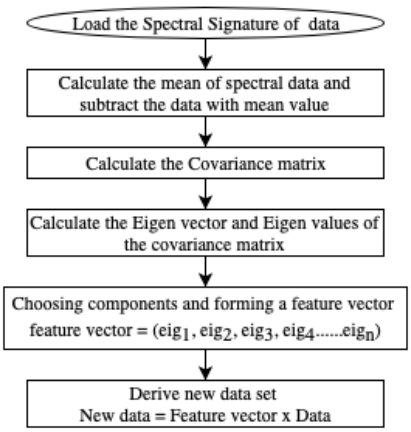


Fig. 3. Flow Chart of PCA Implementation.

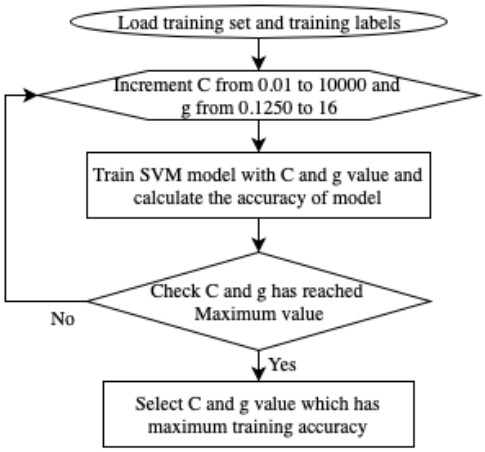


Fig. 4. Flow Chart of n-fold Cross Validation.

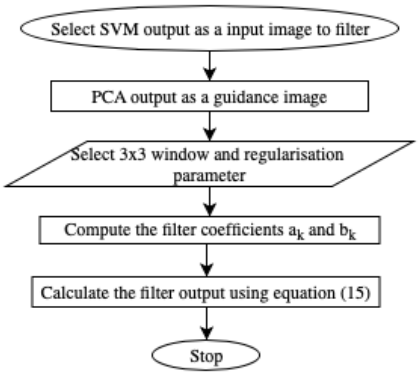


Fig. 5. Flow Chart of Guided Image Filter Implementation.

Using training samples SVM model is developed with a different kernels. Cost function and gamma parameter for RBF kernel are calculated using the n-fold cross-validation approach as shown in Fig. 4. This approach tries to find the best cost function and gamma parameter which has the highest training accuracy. The developed SVM model with different kernel parameters is utilized to predict the different classes of various test samples of the hyperspectral dataset. Evaluate the performance of the model by computing a confusion matrix to find the classification accuracy and computational time. Guided image filter, as shown in Fig. 5, is used to improve the training accuracy by averaging the misclassified data with nearby classified data using regularization parameters and the first component of PCA as a guidance image.

VI. Experimental Results and Discussions

A. Experimental Setup

Hyperspectral Data Sets: The Indian pines image dataset has been used to analyze the performance of the proposed approach. This hyperspectral dataset captured through the Airborne Visible/ Infrared Imaging Spectrometer (AVIRIS) sensor at the Indian test site of North-Western Indiana. These data sets contain the spectral information of 220 bands with a spectral wavelength of 0.4 to 2.5μm of size 145 x 145 pixels.

The spatial resolution of the Indian pines dataset is 20 m per pixel. The image dataset has 16 classes of different agriculture, vegetation, and forest information. The number of spectral bands in an image dataset is reduced to 200 by removing unnecessary spectral band covered with the water absorption region. The Three band color composite and its ground truth data of various classes of the Indian Pines image are shown in Fig. 6.

Performance parameters: The performance parameters used to analyze the performance of the proposed classification method are overall accuracy (OA), the average accuracy (AA), and the Kappa coefficient. OA is the ratio of a number of pixel samples classified to accurate class to the total number of pixel samples in the dataset. AA is the mean classification accuracy of various classes that is present in the dataset. The Kappa coefficient is a performance parameter of classification that gives the percentage of data samples classified accurately to the respective classes of a hyperspectral dataset, corrected by the number of arguments.

B. Classification Results

Indian Pines image dataset is classified using SVM with different kernels and guided image filter by considering the 10% of training samples of various classes. The results of the SVM classification accuracy of different kernels and guided image filter are shown in Table I and Table II, respectively.

The results infers that the SVM classifier with RBF kernel has the highest overall classification accuracy of 81.15 %. The classified image of different vegetation fields is shown in Fig. 7. Guided image filter is used after SVM classification to improve the overall accuracy from 81.15 to 94.22 % for RBF kernel. The classified image of different vegetation fields with a guided image filter is shown in Fig. 8. The computation time required for the complete process is 155 seconds.

The computation time required for the SVM is reduced by considering the PCA and removing the unnecessary spectral information of the hyperspectral image. These reduced principal components are used as a feature vector to classify the image using SVM and Guided image filter. Fig. 9 and 10 demonstrate SVM classification accuracy and computational time required for classification with respect to the number of principal components. Fig. 9 shows that SVM with 20 principal components will give the classification accuracy of 79 % with a computation time of 38 seconds. Classification accuracy is improved to 89 % after using the guided image filter.

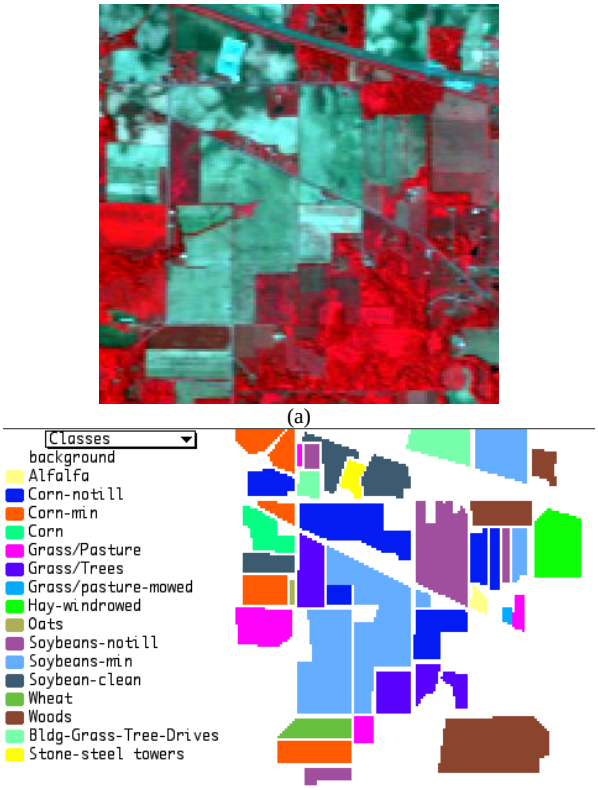


Fig. 6. Indian Pines Image (a) Three Band Color Composite (b) Ground Truth Data.

TABLE I. RESULTS OF SVM CLASSIFICATION

Kernel	RBF	Linear	Polynomial	Sigmoid
OA	81.15	74.28	76.52	18.06
AA	79.77	73.92	76.47	18.90
Kappa coefficient	0.78	0.70	0.73	0.9
Alfalfa	70.00	67.65	64.71	0.54
Corn-notill	75.95	66.16	69.62	16.47
Corn-mintill	64.71	55.71	66.71	9.57
Corn	63.43	41.74	51.29	3.61
Grass-pasture	88.71	85.65	79.29	28.15
Grass-trees	92.40	94.53	95.83	31.63
Grass-pasture-mowed	86.67	70.00	87.50	0.00
Hay-windrowed	100.00	98.50	99.51	87.76
Oats	52.63	62.50	60.00	0.00
Soybean-notill	73.15	60.04	65.57	16.92
Soybean-mintill	82.18	77.58	78.58	16.84
Soybean-clean	78.37	72.22	70.44	18.18
Wheat	97.16	92.57	86.08	0.00
Woods	95.28	96.76	94.94	33.39
Buildings-Grass-Trees-Drives	68.90	59.69	56.03	34.09
Stone-Steel-Towers	86.79	81.48	97.37	5.24

TABLE II. RESULTS OF SVM WITH GUIDED IMAGE FILTER

Kernel	RBF	Linear	Polynomial	Sigmoid
OA	94.22	90.16	93.14	19.72
AA	94.78	91.90	94.20	19.32
Kappa coefficient	0.93	0.88	0.92	0.10
Alfalfa	100.00	100.00	100.00	0.00
Corn-notill	92.67	76.02	92.25	15.69
Corn-mintill	95.90	95.56	98.25	8.88
Corn	77.52	61.51	81.07	0.00
Grass-pasture	98.98	97.26	98.09	40.19
Grass-trees	95.33	97.75	98.49	0.00
Grass-pasture-mowed	100.00	100.00	100.00	0.00
Hay-windrowed	100.00	100.00	100.00	100.00
Oats	100.00	100.00	100.00	0.00
Soybean-notill	85.55	89.69	90.71	0.00
Soybean-mintill	95.87	94.73	91.88	0.00
Soybean-clean	95.72	88.99	89.44	0.00
Wheat	100.00	100.00	100.00	0.00
Woods	99.39	99.54	98.64	36.16
Buildings-Grass-Trees-Drives	83.73	75.69	72.81	100.00
Stone-Steel-Towers	95.83	93.62	95.65	8.18

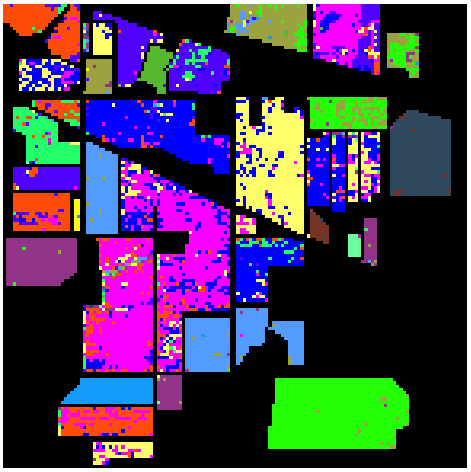


Fig. 7. Classified Image using SVM with RBF Kernel.

Fig. 8. Classified Image using SVM with RBF Kernel and Guided Image Filter.

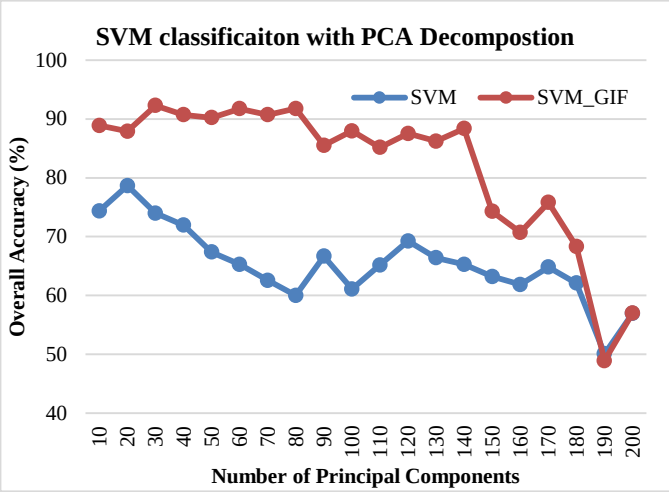


Fig. 9. Variation of OA in SVM with Number of Principal Components.

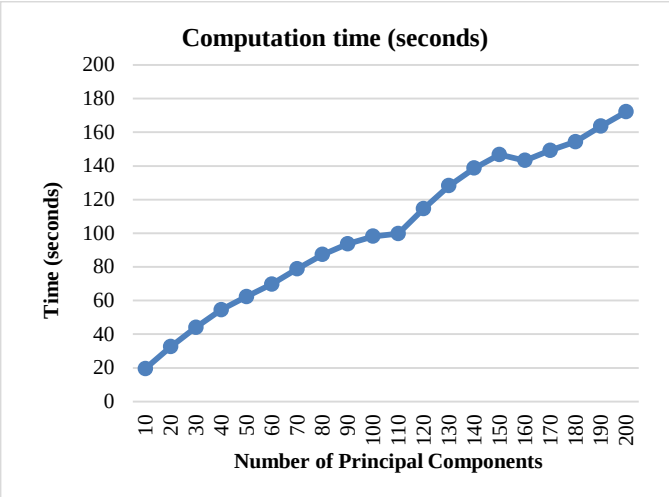


Fig. 10. Variation of Computation Time with Respect to Number of Principal Components Considred in SVM.

VII. Conclusions

In this paper, a spectral and spatial classification method was developed for the hyperspectral image classification. The proposed approach uses the SVM classifier with kernels for the classification. The results shows that the RBF kernel will have the highest overall accuracy. Hyperspectral image contains many numbers of bands so more computational time is required to compute the kernel parameters and classification maps. In order to minimize the computational time, spectral features are reduced using PCA and only a few principal components are used for the classification. Furthermore, the classification accuracy of the SVM is increased by using the guided image filter with the first principal component has a guided image. From the experimental results it can be inferred that overall accuracy is improved from 81.15% of SVM to 94.22% for RBF kernel with the same training samples. In the future scope, computational time of the classification can be further reduces by employing supervised dimensionally reduction algorithm.

References

[1] G. Hughes, “On the mean accuracy of statistical pattern recognizers,” IEEE Transactions Information Theory, vol. IT-14(1), pp. 55–63, 1968.

[2] S. Prasad and L. M. Bruce, “Limitations of principal components analysis for hyperspectral target recognition,” IEEE Geoscience Remote Sensing Letter., vol. 5(4), pp. 625–629, 2008.

[3] A. Villa, J. A. Benediktsson, J. Chanussot, and C. Jutten, “Hyperspectral image classification with independent component discriminant analysis,” IEEE Transactions Geoscience Remote Sensing, vol. 49(12), pp. 4865–4876, 2011.

[4] W. Li, S. Prasad, J. E. Fowler, and L. M. Bruce, “Locality-preserving dimensionality reduction and classification for hyperspectral image analysis,” IEEE Transactions Geoscience Remote Sensing., vol. 50(4), pp. 1185–1198, 2012.

[5] B. Guo, S. R. Gunn, R. I. Damper, and J. D. B. Nelson, “Band selection for hyperspectral image classification using mutual information,” IEEE Geoscience Remote Sensing Letters., vol. 3(4), pp. 522–526, 2006.

[6] M. Dalponte, H. O. Orka, T. Gobakken, D. Gianelle, and E. Nasset, “Tree species classification in boreal forests with hyperspectral data,” IEEE Transactions Geoscience Remote Sensing, vol. 51(5), pp. 2632–2645, 2013.

[7] Y. Zhong and L. Zhang, “An adaptive artificial immune network for supervised classification of multi-/hyperspectral remote sensing imagery,” IEEE Transactions Geoscience Remote Sensing, vol. 50(3), pp. 894–909, 2012.

[8] T. Dundar and T. Ince, "Sparse Representation-Based Hyperspectral Image Classification Using Multiscale Superpixels and Guided Filter," in IEEE Geoscience and Remote Sensing Letters, vol. 16(2), pp. 246-250, 2019.

[9] Y. Chen, N. M. Nasrabadi, and T. Tran, “Hyperspectral image classification via kernel sparse representation,” IEEE Transactions Geoscience Remote Sensing., vol. 51(1), pp. 217–231, Jan. 2013.

[10] J. Li, J. M. Bioucas-Dias, and A. Plaza, “Spectral–spatial classification of hyperspectral data using loopy belief propagation and active learning,” IEEE Transactions Geoscience Remote Sensing., vol. 51(2), pp. 844–856, Feb. 2013.

[11] A. Mughees and L. Tao, "Multiple deep-belief-network-based spectral-spatial classification of hyperspectral images," in Tsinghua Science and Technology, vol. 24(2), pp. 183-194, 2019.

[12] K. Suchitha, B.S. Premananda and A.K. Singh, "High spatial resolution hyperspectral image using fusion technique," International Conference on Trends in Electronics and Informatics, pp. 348-353, 2017.

[13] A. Datta and A. Chakravorty, "Hyperspectral Image Segmentation using Multi-dimensional Histogram over Principal Component Images," International Conference on Advances in Computing, Communication Control and Networking, pp. 857-862, 2018.

[14] Y. Tarabalka, J. A. Benediktsson, and J. Chanussot, “Spectral–spatial classification of hyperspectral imagery based on partitional clustering techniques,” IEEE Transactions Geoscience Remote Sensing., vol. 47(8), pp. 2973– 2987, 2009.

[15] R. Gaetano, G. Masi, G. Poggi, L. Verdoliva and G. Scarpa, "Marker-Controlled Watershed-Based Segmentation of Multiresolution Remote Sensing Images," in IEEE Transactions on Geoscience and Remote Sensing, vol. 53(6), pp. 2987-3004, 2015.

[16] A. M. Braga, R. C. P. Marques, F. A. A. Rodrigues and F. N. S. Medeiros, "A Median Regularized Level Set for Hierarchical Segmentation of SAR Images," in IEEE Geoscience and Remote Sensing Letters, vol. 14(7), pp. 1171-1175, 2017.

[17] F. Poorahangaryan and H. Ghassemian, "Spectral-spatial hyperspectral classification with spatial filtering and minimum spanning forest," 9th Iranian Conference on Machine Vision and Image Processing, pp. 49-52 2015.

[18] X. Kang, S. Li, and J. A. Benediktsson, “Spectral–spatial hyperspectral image classification with edge-preserving filtering,” IEEE Transactions Geoscience Remote Sensing., vol. 52(5), pp. 2666–2677, 2014.

Modeling Ant Colony Optimization for Multi-Agent based Intelligent Transportation System

Shamim Akhter[1], Md. Nurul Ahsan[2]
Applied Intelligent System and Information Processing Lab
Dept. of Computer Science and Engineering
International University of Business Agriculture and Technology (IUBAT), Dhaka, Bangladesh

Shah Jafor Sadeek Quaderi[3]
Applied Computing,
Faculty of Computer Science, and Information Technology
University of Malaya
Kuala Lumpur, Malaysia

***Abstract*—This paper focuses on Sumo Urban Mobility Simulation (SUMO) and real-time Traffic Management System (TMS) simulation for evaluation, management, and design of Intelligent Transportation Systems (ITS). Such simulations are expected to offer the prediction and on-the-fly feedback for better decision-making. In these regards, a new Intelligent Traffic Management System (ITMS) was proposed and implemented - where a path from source to destination was selected by Dijkstra algorithm, and the road segment weights were calculated using real-time analyses (Deep-Neuro-Fuzzy framework) of data collected from infrastructure systems, mobile, distributed technologies, and socially-build systems. We aim to simulate the ITMS in pragmatic style with micro traffic, open-source traffic simulation model (SUMO), and discuss the challenges related to modeling and simulation for ITMS. Also, we expose a new model- Ant Colony Optimization (ACO) in SUMO tool to support a multi-agent-based collaborative decision-making environment for ITMS. Beside we evaluate ACO model performance with exiting built-in optimum route-finding SUMO models (Contraction Hierarchies Wrapper) -CHWrapper, A-star (A*), and Dijkstra) for optimum route choice. The results highlight that ACO performs better than other algorithms.**

Keywords—Intelligent Traffic Management System (ITMS); Simulation of Urban Mobility (SUMO); traffic simulation; Contraction Hierarchies Wrapper (CHWrapper); Dijkstra; A-star (A*); Deep-Neuro-Fuzzy Classification

I. Introduction

A new intelligence traffic management system (ITMS) [8] [11] [20] [21] [22] [30] was proposed and implemented to find an optimum route from source to destination. Each route is segmented and called as road segment. We investigate environmental, vehicles and road related information for each road segment and generate a road weight for this particular road segment using Deep-Neuro-Fuzzy model [8][20][21][22]. However, ITMS needs some simulation or emulation to provide that the system works accurately. In this paper, we are proposing a traffic simulation environment by integrating Sumo Urban Mobility Simulation (SUMO) tool and a real-time Intelligent Traffic Management System (ITMS) [8] [11] [20] [21] [22]. Such simulations are expected to offer the prediction and on-the-fly feedback for better decision-making on complex traffic managerial issues and corporate them to the end-user applications. Simulation or emulation based ITMS implementation can explore an opportunity to expose the model and proof the workability of the model. In our simulation environment, the full simulation is modeled into a sample map. Sample map can be drawn by SUMO NETEDIT software or modified manually for all roads, vehicle speeds, and path directions. The real map of Gulshan, Dhaka is collected from the internet as ".osm" format, edited it according to the road segments, and then placed it for simulation. A new Graphical User Interface (GUI) is developed to control the simulation. This GUI accesses the value of the attributes and takes input from the user. User can set random values to the decision attributes, or IoT tool collects attributes values directly from the environment and vehicles. Deep-Neuro-Fuzzy framework [8] is used to classify those values and to formulate a weight for a mapped road segment. We expose a multi-agent-based optimum route-finding algorithm- ACO based System into SUMO simulator tool to make the ITMS more robust and self-adaptive. Thus, we need to modify and adjust the ACO according to our ITMS and SUMO implementation. We consider road segments as edges or links and road speeds are trails or pheromone levels. In our implementation, ACO model is analyzed by changing internal parameters including pheromone density, pheromone trail, visibility, and optimum setting for control parameters (α, β) to route more vehicles from source to destination within a certain period. After that, we compare the performance of ACO with existing SUMO based route finding algorithms including CHWrapper, A*, and Dijkstra. The results highlight that the ACO model performs better than other existing models.

The remainder of the work is organized as follows: Section II introduces the related works and state-of-the-art technologies. Section III gives the implementation details of the proposed simulation model. Section IV shows the result analysis and performance comparison between different routing algorithms. Section V discusses the challenges face to achieve the problems and their solutions. Finally, the conclusion is presented in the final section.

II. Related Works

Machine learning techniques are used in [1] [14] [15] to reduce transportation time by optimizing travel options or paths. On the other hand, communication with sharing traffic information is also helped to solve the transportation constraints [2][3] and improve travel quality in both time and speed domains. In this regard, Google developed a traffic condition detection mapping technique [13] using GPS enable

Google Map API and crowed sourcing [16] to collect metadata from user devices anonymously. However, it violates user privacy during Street View Mapping project by scooping personal information, including passwords and e-mail related metadata. Thus, another Traffic Management System (TMS), with optimum route prediction, but exclusive of the privacy violation is required. We proposed an ITMS and implemented it in a piecewise fashion. Besides, the model does not have any empirical evidence of working the whole model. Therefore, the proposed ITMS needs some comprehensive analysis, other means some simulation or emulation, etc., to provide that the hypothesis is valid.

SUMO [4][5] is a simulation framework that is used for microscopic and continuous road traffic simulation package designed to handle large road networks. It applies to develop different applications, including online traffic monitoring system [17], traffic light games [18], and etc. Two different modules Sumo-net-convert and Sumo-route, and they are added to get the best routing decision. NS2[19] is another network simulation tool but usually used for network simulation purpose mainly in node to node connection in different topologies. It also has lacked on the user interface for visual traffic simulation. Thus, SUMO is chosen for implementing our proposed Traffic Management System (TMS). Four (4) optimum route-finding algorithms Dijkstra [9], A*[9], and CHWrapper [9] are already used as built-in API and integrated with SUMO software.

A significant number of researches are conducted using ACO for path detections and routing decisions. For instance, strategy for optimal truss design [23], solution of TSP (Travelling Salesman Problem) [24], optimization for the asymmetric travelling system [25], and Dynamic Vehicle Routing Problem analysis [26] [27]. Previously, our ITMS system was used to find optimum routes using the Dijkstra algorithm, and there was no real-time simulation to visualize the optimum path. Thus, SUMO based simulation will help to simulate the vehicle routing paths and proofs the workability of the model. Besides, SUMO can port the Vehicle Ad-hoc Network with different machine learning algorithms including ACO, fuzzy logic, and etc. and expose a comparative route-finding environment for ITMS. In these regards, this is the first attempt to integrate ACO with SUMO and ITMS, and open an opportunity to compare ITMS performance with existing SUMO built-in route-finding models.

III. SUMO Simulator Setup for ITMS

Sumo Urban Mobility Simulator (SUMO) provides an opportunity to explore the ITMS in realistic style with a significant focus on traffic related issues including route choice, simulate traffic light, vehicular communication, and etc.

A. Implementing Road Maps in Sumo

A certain part of Dhaka city map is downloaded from the internet (openstreetmap.org) as .osm format (Fig- 1). At first, ITMS simulation is implemented in a prototype map (Fig- 2) which is selected from the real map (Fig- 1). After that, the whole simulation is implemented on the real map of Dhaka city. Sumo needs to convert the map files to XML format for generating optimum route and traffic system. DOS command script "start-command-line.bat" and "netconvert" commands are used to convert the map. osm files to map.net.xml files. Additional necessary elements including road name, traffic light timing, etc. are added using Sumo Neteditor. For vehicle simulation on SUMO needs to configure the configuration file on "map.sumocfg", and the environmental interface of SUMO can be changed in "gui-setting.cfg" file [10]. Using Sumo GUI software, we simulate both maps and observe the vehicle simulation at the initial stage (Fig- 3 and Fig- 4).

Fig. 1. Map of Gulshan, Dhaka (Real Map).

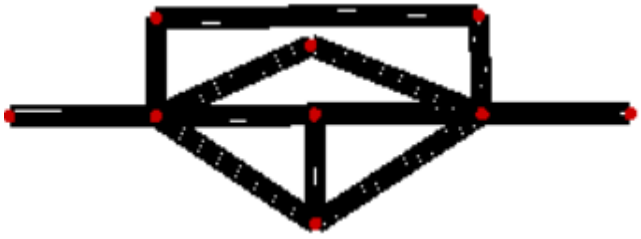


Fig. 2. Sample Map.

Fig. 3. Initial Simulation Result for Real Map.

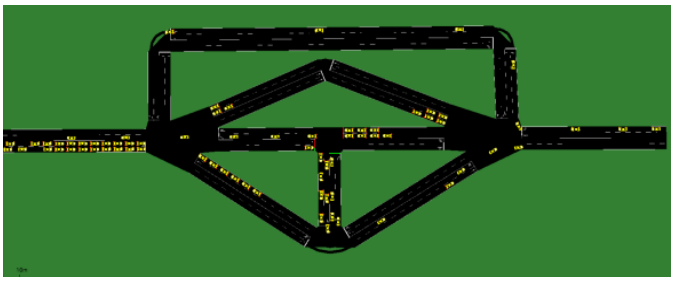


Fig. 4. Initial Simulation Result for Sample Map.

B. Integrating Road Weight Module

A new GUI is developed (Fig- 5) in C# to make the simulation process interactive and user-friendly. This GUI helps to enhance the testing process by changing different weights to the system and thus control the overall traffic flow simulation. Weight calculation depends on eight (8) different attributes including humidity, peak hour, rainfall, temperature, wind, road status, road construction and road accident. All these attributes are combined with varying ranges, as presented in Table I. The selected attributes from GUI are placed to generate the weight value by C-means clustering and Deep-Neuro-Fuzzy software [8]. The weight output range is 0-10. "0" is the lowest weight value that means the natural and road conditions are in the best situation; for that reason, the roads get the maximum speed to ensuring faster vehicle passing. "10" is highest weight value, which means the nature, or road, or both are in an odd situation, for that reasons the roads (or lanes on-road) get the lowest speed value and vehicle passing would be stopped or reduced their speed. Fig- 6 presents the relationship chart between weight and speed. Using Deep-Neuro-Fuzzy tool, we get weight values for each road segment and can be set for specific roads/ a single road/ a single lane. The sample of input data and their corresponding weights and speeds are presented in Table II.

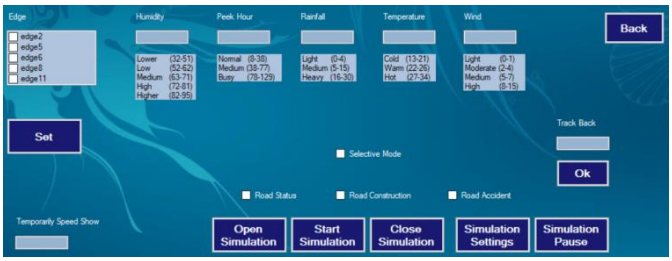


Fig. 5. GUI for Attributes Value Inputting.

TABLE. I. RANGE OF ATTRIBUTES

Attributes	Range	Value Named As
Humidity	32-95	
Peak Hour	8-129	
Rainfall	0-30	
Temperature	13-34	
Wind	0-15	
Road Status	0,1	normal
Road Construction	0,1,2	low, medium, high
Road Accident	0,1	no, yes

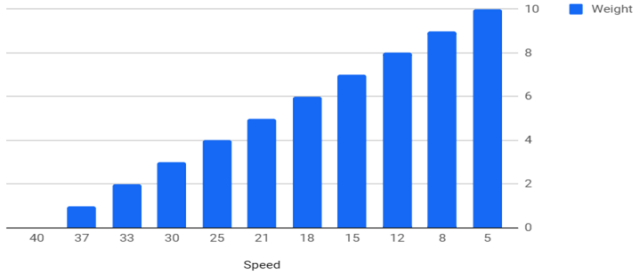


Fig. 6. Weight vs Speed.

TABLE. II. WEIGHT AND SPEED VALUES (FEW SAMPLES)

Attributes								Calculated Weight	Speed Across Weight
Humidity	Peak Hour	Rainfall	Temperature	Wind	Road Status	Road Construction	Road Accident		
80	15	4	21	5	0	0	0	3	30
70	40	0	28	2	0	0	0	7	15
60	78	0	24	1	0	1	0	9	8
65	10	0	20	4	0	0	1	10	5

C. Modeling Ant Colony Optimization (ACO)

ACO was proposed by Macro Dorigo in 1992 [24]. It is used to search for an excellent solution to a given optimization problem. In ACO, a set of software agents called artificial ants or simply ants and they work together to construct a solution by moving on the problem graph but biased by a pheromone model. Ants use the amount of pheromone (a set of parameters is associated with graph edges) to determine the path for gathering their food and caring them back to the nests through an optimum way. Especially they follow that path which has the highest density of pheromone, and after a certain period the amount of pheromone will be vaporized, and then ants may choose another route to reach the destination. Thus, ant pheromone is the key to make ACO adaptive as well as self-learning technique and it can be calculated as:

$$\Delta\tau_{i,j}^{k} = \begin{cases} \frac{1}{L_{i,j}}^{k} & K^{th}\ ant\ travel\ on\ edge\ (i,j) \\ 0 & Otherwise \end{cases} \quad (1)$$

Where i and j are the two (2) nodes of edge (i, j) and k is the particular ant number. $\Delta\tau_{i,j}^{k}$ is the amount of pheromone that is created by the k[th] ant in (i, j) edge. L is the length between (i, j).

The total amount of pheromone in a particular edge (i, j) will be the summation of all amount of pheromones are created by all ants (m) travel through link (i, j) and represented as:

$$\tau_{i,j}^{k} = \sum_{k=1}^{m} \Delta\tau_{i,j}^{k}\ \ Without\ vaporization \quad (2)$$

However, pheromone can be evaporated during time. Thus, the above equation transforms to:

$$\tau_{i,j}^{k} = (1-\rho)\tau_{i,j} + \sum_{k=1}^{m} \Delta\tau_{i,j}^{k}\ \ With\ vaporization \quad (3)$$

Where ρ is the evaporation rate, and $\rho = 0$ means no evaporation and then the amount of pheromone in an edge/link old, and new pheromone $\rho = 1$ means all old pheromones are evaporated. Thus, the current pheromone will be equal amount to the new pheromone.

$$P_{i,j} = \frac{(\tau_{i,j})^{\alpha}(\eta_{i,j})^{\beta}}{\Sigma((\tau_{i,j})^{\alpha}(\eta_{i,j})^{\beta})} \quad (4)$$
$$where\ \eta_{i,j} = \frac{1}{L_{i,j}}$$

$P_{i,j}$ is the transition probability from i to j for k^{th} ant. α and β are parameters that control the importance pheromone trail (lots of traffic and it is highly desirable) or visibility (close town should be chosen with a higher probability).

Using the above ACO concept, we develop the simulation environment with our prototype map with some modification in road segments. We consider road segments as edges or links and road speeds are trails or pheromone levels. When the road is busy, weight is being higher, speed is lower, and vehicles simultaneously avoid that path and vice versa. Meanwhile the nearby roads weight may be lower, or speed may be higher, and vehicles select those paths to avoid that congestion, and this road may also get busy after some time (due to passing more vehicles to the road segment, weight becomes higher, or speed becomes lower). Then again vehicles select other low weighted, high speed road segments and this procedure will continue. Thus, we are using both pheromone trail and visibility to generate the transition probability $P_{i,j}$. Visibility is decided by the value of $\eta_{i,j}$ and it is the inverse of distance ($L_{i,j}$) between two road segments.

D. Implementing ACO in SUMO

This work is the first and foremost attempt to implement ACO in SUMO environment. SUMO is not initially designed for simulating automated vehicles, and we present an interface for exchanging the road weights generated by the Deep-Neuro-Fuzzy software model between ITMS to SUMO environment. Besides, SUMO is not directly computable with algorithms that require dynamic runtime event to change SUMO's internal environmental state. We apply an indirect approach-restart method to hold that dynamicity.

SUMO needs to make a starting call with its local built-in modules to execute any external user-defined modules (e.g., ACO). Thus, we choose A* algorithm to initialize traffic simulation, and after a certain period, the whole simulation restarts from the last saved state with ACO algorithm. The following code segments are used to initialize SUMO environment and make the starting call to run the A* algorithm.

```
process_timer.StartInfo.FileName="cmd.exe";
process_timer.StandardInput.WriteLine("sumo-
gui --routing-algorithm astar --start -c
test7.sumocfg");
```

After completing the initial stage, the simulation system needs to restart and generates several .xml files during simulation where each record contains the state of the simulation process. Thus, the last file contains the most updated state of the simulation and is required for successive simulations.

SUMO needs to be stopped before restarting the next phase execution with loading the previous phase's last saved state (last output file) information. Now the question is –what will be the suitable time duration of an execution phase of the simulation model? We experimented and traced that SUMO takes 2/3 seconds for each restart. Thus, 10 seconds duration in each execution phase cannot demonstrate the simulation impact properly. However, 30/40 seconds duration takes longer time to demonstrate. 20 seconds seems enough to balance the above mentioned constrains. In addition, this time duration also add constrains to data collection and processing interval to 20 seconds.

Since the system needs to take multiple times of restarting for applying ACO (because the speed of road segment may need to be changed after a certain period of time), a timer function is implemented, the interval time is 20 seconds for restarting:

```
processTimer.Tick+=newEventHandler(processTime
r_Tick);
processTimer.Interval=20*1000;
```

Usually, ACO directs the vehicle to the best optimum route, and chooses the same direction, until the timer stops the simulation. Our ACO implementation can handle uncertain situations including heavy rainfall, peak hour, road construction, or accident. During the precarious conditions, the weight of the road segment will be changed and also changed the road speed. Then, other road segments will get the best road speed and continue the vehicle flow. The situation is adequately explained in Fig- 7 and 9. Fig- 7 shows the normal position, a smooth vehicle flow in the system. After a little moment, a road accident is occurred (created by GUI in Fig- 8) in the road segment named edge2.

Our simulation model will detect the occurrence road accident and determine the road segment attribute values accordingly and input them to the Deep-Neuro-Fuzzy model to generate a corresponding weight value of the road segment. Thus, the road segment weight will be adjusted according to accident and reduce the vehicle flow on that particular road segment. Vehicle flow will transfer to the next available route/road segment chosen by the ACO algorithm (in Fig- 9). It will almost reduce all vehicle congestion in the road network as well.

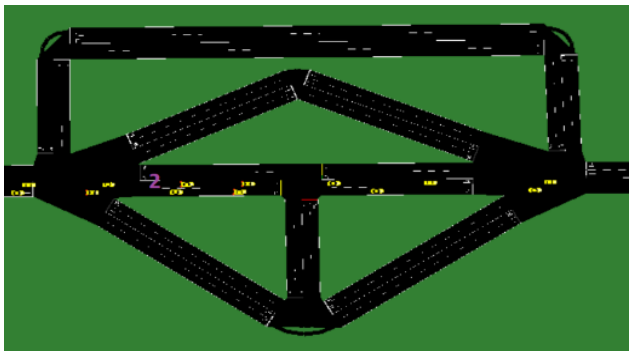


Fig. 7. Smooth Vehicle Flow.

Fig. 8. Selecting Road Accident in Edge2.

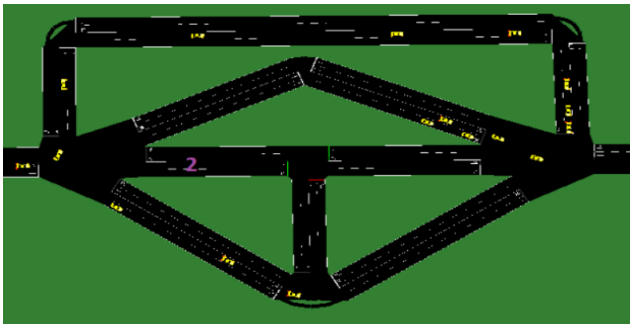


Fig. 9. ACO Chosses Alternate Paths and Transfer Vehicle Flow.

IV. Result Analysis

A. Experiments on ACO Parameters

As we mentioned earlier, $P_{i,j}$ is the transition probability from i to j for k^{th} ant/car, road speed reflects to trails or pheromone levels and directly proportional to $P_{i,j}$. Thus, intuitively high road speed (low weight) segment will be chosen for routing. However, cars will follow the high road speed segments and increase the pheromone level according to ACO algorithm. Certainly, after a period of times the road segment will be congested. Then our ITMS automatically change the road segment weight to higher means low pheromone level will be in that road segment. Thus, we do not need to create any vaporization effect in our ACO implementation. Nonetheless, the road segment weight will not be changed during the 20 seconds simulation periods. Because, the restart method needs 20 seconds duration to update the next road weights and creates effect in the simulation. Thus, α and β parameters values will play an important role within the 20 seconds simulation periods to produce the real effect of ACO. α and β control the road segment probability according to pheromone trail or visibility. Choosing higher α value means choosing denser pheromone trail and it reflects to lot of traffics. Other side, choosing higher β means choosing closer road segments. There are two (2) concerning issues in this regard.

1) fixed α and β will choose a road segment with highest probability and it will continuously be chosen according to the ACO algorithm except the vaporization occurs or weight/speed is going to be readjusted due to the external effects. After a certain period of times the traffic on this road segment will be increased and congestion will occur. We experimented in SUMO with α=0.1 and β=0.1 fixed value to simulate 200 vehicles with ACO algorithm. Thus, $P_{i,j}$ will be increased in a particular road segment and vehicle flow will also be increased. Due to the fixed value in α and β path/road segment will not be changed. The situation is clearly stated in Fig- 10. Where the vehicles are choosing same road segment continuously and congestion situation may arrive soon. To avoid such circumstances, we need to decrease the vehicle speed automatically after a certain period of times. Thus, we need to reduce α value so that alternate path can be selected to avoid such situation in our ITMS.

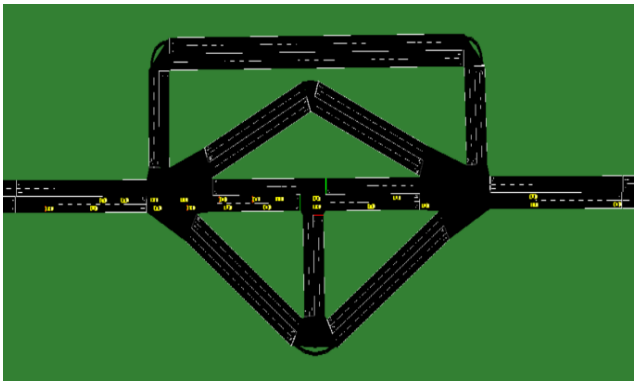


Fig. 10. ACO is Chossing Same Road Segment with Fixed α and β Values.

2) Dynamic changing in α and β values during execution of ACO is required. We also need to find out the changing techniques/steps of α and β, and trace their optimum conditions.

Thus, we do grid search on α and β values in SUMO and trace the optimum situation for ACO algorithm to route 200 vehicles in a shorter period of times. Table III presents the grid search results, and according to the result setting β=1- α value almost find the optimum time. To avoid starvation or congestion in our ACO implementation, in each step, we decrease α value to 0.05 to the highest $P_{i,j}$ road segment, and increase α value to 0.05 to other nearby road segments. The above situation is implemented with our proposed ACO, and the congestion situation is by passed and simulated more vehicles during a fixed period of times. Fig- 11 presents snapshot of the updated simulation.

B. Performance Evaluation of ACO with Built-in Route-Finding Algorithms (Dijkstra, A*, CHWrapper)

We develop an experimental setting with our SUMO based ACO implementation and other three (3) built-in SUMO route finding algorithms (Dijkstra, A*, CHWrapper) on our sample maps. The objective of this experimental setup is to evaluate the performance of all algorithms to simulate/schedule 500 vehicles from source to destination (one way only). Table IV presents the performance of those algorithms in time unit (seconds). The time unit can be represented as second, Nano seconds, mile seconds etc. Depending on the computer specification, the simulation time unit will be varied. Among the built-in algorithms in Sumo environment Dijkstra performs poorer than others. However, it is a simple algorithm and easy to implement. That is why it has been chosen as the default path finding algorithm in SUMO environment. Contraction Hierarchies Wrapper (CHWrapper) is a preprocessing-based routing algorithm. As expected, it performs better than other two (2) A* and Dijkstra implementations. However, comparing ACO with CHWrapper, ACO performs better than CHWrapper in most of the test cases. ACO takes 1580 unit of time on average of 100 simulations with α values between 0.1-0.9 and β=1- α values. Overall, we can conclude that ACO performance is better than all other algorithms for vehicle routing.

TABLE. III. GRID SEARCH ON α AND β VALUES

α	β	Time (Second)	α	β	Time (Second)	α	β	Time (Second)
0.1	0.1	707	0.4	0.1	721	0.7	0.1	730
0.1	0.2	702	0.4	0.2	711	0.7	0.2	735
0.1	0.3	698	0.4	0.3	713	0.7	0.3	727
0.1	0.4	699	0.4	0.4	716	0.7	0.4	739
0.1	0.5	686	0.4	0.5	705	0.7	0.5	732
0.1	0.6	653	0.4	0.6	701	0.7	0.6	728
0.1	0.7	634	0.4	0.7	699	0.7	0.7	740
0.1	0.8	621	0.4	0.8	708	0.7	0.8	736
0.1	0.9	616	0.4	0.9	704	0.7	0.9	734
0.2	0.1	714	0.5	0.1	722	0.8	0.1	720
0.2	0.2	713	0.5	0.2	731	0.8	0.2	714
0.2	0.3	699	0.5	0.3	729	0.8	0.3	703
0.2	0.4	687	0.5	0.4	725	0.8	0.4	701
0.2	0.5	650	0.5	0.5	730	0.8	0.5	710
0.2	0.6	644	0.5	0.6	719	0.8	0.6	722
0.2	0.7	640	0.5	0.7	713	0.8	0.7	738
0.2	0.8	642	0.5	0.8	720	0.8	0.8	753
0.2	0.9	651	0.5	0.9	707	0.8	0.9	744
0.3	0.1	715	0.6	0.1	720	0.9	0.1	730
0.3	0.2	104	0.6	0.2	725	0.9	0.2	714
0.3	0.3	721	0.6	0.3	718	0.9	0.3	722
0.3	0.4	718	0.6	0.4	716	0.9	0.4	734
0.3	0.5	692	0.6	0.5	727	0.9	0.5	728
0.3	0.6	701	0.6	0.6	735	0.9	0.6	731
0.3	0.7	695	0.6	0.7	731	0.9	0.7	737
0.3	0.8	710	0.6	0.8	728	0.9	0.8	742
0.3	0.9	705	0.6	0.9	730	0.9	0.9	749

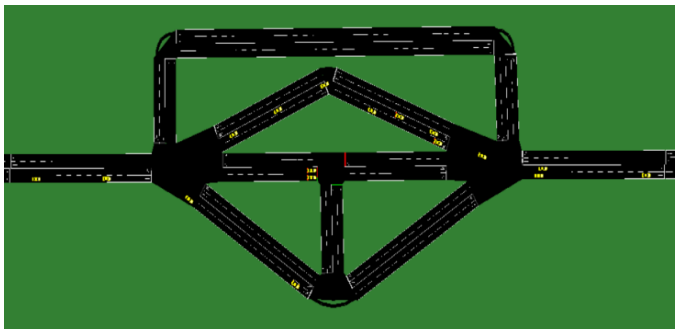


Fig. 11. ACO with Dynamic α and β Values.

TABLE. IV. PERFORMANCE COMPARISON OF DIJKSTRA, A*, CHWRAPPER AND ACO ALGORITHMS

Algorithms	Time (Seconds) For 500 vehicles
Dijkstra	1840
A*	1675
CHWrapper	1630
Ant Colony	1580

V. DISCUSSION

A novel Deep-Neuro-Fuzzy classification model [7] [8] was implemented in python language with TensorFlow library support to solve the weight overlapping problems, to remove the data outliers, and to avoid the overfitting problems and 98.63% classification accuracy. We used the Deep-Neuro-Fuzzy model to calculate dynamic road weights using environmental, road and vehicle-related decision attributes. However, the model did not have any empirical evidence of working in the traffic system. Simulation or emulation-based implementation can explore an opportunity to expose the model and proof the hypothesis. On these regards, SUMO open-source tool was used to simulate the total ITMS.

In addition, a new model- Ant Colony Optimization (ACO) was implemented with SUMO tool to support multi-agent based collaborative decision-making environment for ITMS. We also compared the performance of the proposed ACO model with other built-in simulation models (CHWrapper, A*, and Dijkstra) in SUMO simulation environment and tested the model work abilities. Our results highlighted ACO for its better performance than others.

Although SUMO is an open source simulation framework, however, it has a complex design and architecture, and does not support any upgradation or modification into its internal built-in route findings modules. Thus, our first and foremost challenge is to implement a new algorithm module (ACO model) into the SUMO environment. We solved the problem using C# base scripts to execute the ACO module explicitly then port our algorithm into SUMO.

The second challenge we faced to incorporate the ACO into our ITMS system, especially with Deep-Neuro-Fuzzy model. We solved the problem by considering road segments as edges and road speed or road weight as pheromone level. Thus, we simulated the ITMS in pragmatic style with a micro traffic, open source traffic simulation model (SUMO), and solved the challenges related to modeling and simulation for ITMS. Article in [6] also present a similar approach to solve the traffic management problem. However, they used fuzzy logic and ACO on one attribute (# of vehicles on a road segment) only to detect congestion amount of a particular road segment. They did not focus other relevant attributes including weather, road or vehicle. In addition, counting # of vehicles in a segment is easy to find in simulation environment but difficult in real scenarios. Because the process requires instantaneous congestion detection method, which is not discussed in [6]. We also did a comparative study with other methods and implemented a low-cost but flexible ITMS method in [20][21][22]. Our Deep-Neuro-Fuzzy model [7][8] uses multivariate and multi-attributes data and simulates properly in SUMO environment. Our IoT based embedded sensor system helps the ITMS to collect the real-time environment, road and vehicle related information with low cost, less bandwidth, but flexible environment. However, the complete ITMS or even the Deep-Neuro-Fuzzy model is not yet been implemented in a real test bed with real traffic scenarios and their workability is still unproved in real road networks.

In addition, a central server approach (for data uploading, processing, and sending results back to the server) was proposed in [6] and all our previous works [11][12][20][21][22][30]. However, central server approach will create great pressure on the network for large number of sensors or IoT devices and massive data processing situations. Thus, edge and fog computing [28] [29] will provide a novel approach in this research domain and support a load balancing, power balancing, and mobile communication network for our ITMS.

VI. Conclusion

ITMS is successfully implemented in SUMO with traffic related issues including route choice, traffic light simulation or vehicular communication and etc. The road weight generate module- Deep-Neuro-Fuzzy tool was suffering for an interface to provide input data to the ITMS. SUMO based ITMS supports a GUI for Deep-Neuro-Fuzzy tool and is capable to change the weight according to road and vehicle related attributes and helps to improve route situation.

ACO is successfully implemented as an external SUMO module and compare its performance with other built-in route-finding modules. Three (3) different parameters including road speed, α and β are explored and investigated in vehicle routing. ACO takes 1580 unit of time on average of 100 simulations with α values between 0.1-0.9 and β=1- α values. ACO based ITMS performs better and suggest for future use.

VII. Future Works

In future, route finding algorithms can be explored with reinforce learning (Q-learning) algorithm and evaluated performance in our ITMS. IoT based input devices will be connected directly to take different real time weather and vehicle related data from different road segments. In near future we will try to implement the full ITMS in Dhaka City, Bangladesh. VANET (Vehicular Ad-Hoc Network) can also be another option to incorporate in our proposed system where vehicles will communicate among themselves to share road status, road accident using wireless connection. Integrating ACO algorithm and VANET into vehicles and manage them through our ITMS is the future goal of our research.

Acknowledgment

This research is supported and funded by the Information and Communication Technology (ICT) Division, Government of the People's Republic of Bangladesh. The authors would also like to show their gratitude International University of Business Agriculture and Technology (IUBAT), Sector-10, Uttara Model Town, Dhaka, Bangladesh for their necessary supports.

References

[1] P. Yousefi and R. Zamani, “The optimal routing of cars in the car navigation system by taking the combination of divide w Journal of Machine Learning and Computing (IJMLC), Vol. 3, Issue 1,February 2013, pp. 44–48,.

[2] S. Inoue, Y. Taoda and Y. Kakuda, “An Alleviating Traffic Congestion Scheme Based on VANET with a Function to Dynamically Change Size of Area for Traffic Information in Urban Transportations,” 10th International Symposium on Autonomous Decentralized Systems (ISADS), 2011, pp. 299-302.

[3] M. Kimura, S. Inoue, Y. Taoda, T. Dohi and Y. Kakuda, “A Novel Method Based on VANET for Alleviating Traffic Congestion in Urban Transportations,” IEEE Eleventh International Symposium on Autonomous Decentralized Systems (ISADS), 2013, pp. 1-7.

[4] D. Krajzewicz, J. Erdmann, M. Behrisch, and L. Bieker,” Recent Development and Applications of SUMO- Simulation of Urban Mobility”, International Journal on Advances in Systems and Measurements, vol 5 no 3 & 4, year 2012,pp.128-138.

[5] Krajzewicz, Daniel & Hertkorn, Georg & Feld, Christian & Wagner, Peter. “SUMO (Simulation of Urban MObility); An open-source traffic simulation”. 4th Middle East Symposium on Simulation and Modelling (MESM2002),2002,pp.183-187.

[6] F. Khodadadi, S. J. Mirabedini, A. Harounabadi, “Improve Traffic Management in the Vehicular Ad Hoc Networks by Combining Ant Colony Algorithm and Fuzzy System”, International Journal of Advanced Computer Science and Applications(IJACSA), vol. 7, No. 4, 2016,pp. 44-53.

[7] S. Akhter, S. Sumit, M. R. Rahman “Design and Implementation of an Intelligent Traffic Management System- A Neural Approach”, In book: Exploring Critical Approaches of Evolutionary Computation, Chapter: 4, page 58-79, Publisher: IGI Global, 10.4018/978-1-5225-5832-3.ch004,2018,pp.58-79.

[8] S.H. Sumit and S.Akhter, “C-Means Clustering and Deep-Neuro-Fuzzy Classification for road weight measurement in traffic management system”, Soft Computing, Springer, Vol 23, Issue 12, june-2019, pp 4329–4340. https://doi.org/10.1007/s00500-018-3086-0.

[9] V. T. Nha , S. Djahel, & J. Murphy. “A comparative study of vehicles routing algorithms for route planning in smart cities”. 2012 First International Workshop on Vehicular Traffic Management for Smart Cities (VTM) 2002.

[10] Çelikoğlu, Hilmi & Dobrowiecki, Tadeusz & Alms, Robert & Klischat, Moritz & Krol, Jakub & Chraibi, Mohcine & Saivichit, Chaiyachet & Banijamali, Ahmad & Hafner, Alexander & Behrisch, Michael & Bieker-Walz, Laura & Bonne, Jean-Benoît & Vullings, Erik & Schott, Benedikt & Härri, Jérôme & Weber, Thomas & Erdmann, Jakob & Flötteröd, Yun-Pang & Grigoropoulos, Georgios & Wesemeyer, Daniel. (2019). SUMO User Conference 2019.

[11] S.Akhter, M. R, Rahman & A. Islam. “Neural Network (NN) Based Route Weight Computation for Bi-Directional Traffic Management System”. International Journal of Applied Evolutionary Computation. Vol. 7, issue 4, 2016, pp.45-59.

[12] M. A. A. Forhad, M. Nadim, M. R. Rahman and S. Akhter , “Cloud IoT based Mobile Agent Framework for real-time traffic information acquisition, storage and retrieval, "Smart Devices, Applications, and Protocols for the IoT", Chapter-II, 2019 PP 14-32, IGI Global publisher.

[13] B.W. Dekock, K. L.Russell, R. J.Qian.US6466862B1-Method and apparatus for automatic traffic conditions data collection using a distributed automotive computing system:Oct.15,2002.

[14] P. Chhatpar, N. Doolani, S. Shahani, & R. Priya. “Machine Learning Solutions to Vehicular Traffic Congestion”. *2018 International Conference on Smart City and Emerging Technology (ICSCET)*. doi:10.1109/icscet.2018.8537260.

[15] A. Elfar, A. Talebpour, and H.S. Mahmassani, “Machine Learning Approach to Short-Term Traffic Congestion Prediction in a Connected Environment”, Transportation Research Record: Journal of the Transportation Research Board, vol 2672, Issue 45, 2018, pp. 185-195. doi:10.1177/0361198118795010.

[16] L. Estes, D. McRitchie, J. Choi, S. R. Debats, T. Evans, W. Guthe, K. Caylor, “A platform for crowdsourcing the creation of representative, accurate landcover maps”, Vol 80, June 2015, pp. 41-53.

[17] M. Krumnow, A. Kretschmer, “Real-Time Simulations Based on Live Detector Data – Experiences of Using SUMO in a Traffic Management System”, Simulation of Urban Mobility Lecture Notes in Computer Science,vol. 8594, 2013, pp. 136-145. doi:10.1007/978-3-662-45079-6_10.

[18] Y. Xu, D. Li, Y. Xi, S. Lin,”Game-Based Traffic Signal Control with Adaptive Routing via V2I”, 21st International Conference on Intelligent Transportation Systems (ITSC), 2018. doi:10.1109/itsc.2018.8569587.

[19] A. Gupta, H. Bedi, M. D. B., V. Shashidhar (2010). Simulation to track 3D location in GSM through NS2 and real life. International Journal on Applications of Graph Theory In Wireless Ad Hoc Networks And Sensor Networks,vol 2 issue1, 2010, pp. 18-29.

[20] M.R. Rahman and S. Akhter, “Real time bi-directional traffic management support system with GPS and websocket”, In: Proc. of the 15th IEEE International Conference on Computer and Information Technology (CIT2015), Liverpool. UK,2015.

[21] M.R. Rahman and S. Akhter, “Bidirectional traffic management with multiple data feeds for dynamic route computation and prediction system”, International Journal of Intelligent Computing Research (IJICR), Special Issue. Vol. 7, Issue 2, 2015, PP. 720-727.

[22] M. R. Rahman and S. Akhter, “Bi-directional traffic management support system with decision tree based dynamic routing”, In: Proc. of 10th International Conference for Internet Technology and Secured Transactions, ICITST, 2015, London. United Kingdom.

[23] S. Christodoulou, “Optimal truss design using ant colony optimization”, In: Proc. of 5th GRACM International Congress on Computational Mechanics, Limassol, 2005.

[24] M. Dorigo, L. Gambardella,”Ant colony system: A cooperative learning approach to the traveling salesman problem”, IEEE Transactions on Evolutionary Computation, Vol. 1, Issue 1, 1997, PP. 53-66. doi:10.1109/4235.585892.

[25] M. Dorigo, V. Maniezzo and A. Colorni, “Ant system: Optimization by a colony of cooperating agents”, IEEE Trans. Syst., Man, and Bybern, Part B. Vol. 26, 2002, PP. 29-41.

[26] X. Haitao, P. Pan and D. Feng., “Dynamic Vehicle Routing Problems with Enhanced Ant Colony Optimization”. Discrete Dynamics in Nature and Society, 2018, PP. 1-13. 10.1155/2018/1295485.

[27] D. Coltorti, and A.E. Rizzoli, “Ant colony optimization for real-world vehicle routing problems”. ACM SIGEVOlution, vol. 2 issue. 2, 2017,pp. 2-9. doi:10.1145/1329465.1329466.

[28] W. Yu, F. Liang, X. He, W. G. Hatcher, C. Lu, J. Lin and X. Yang, “A survey on the Edge Computing for the Internet of Things”, IEEE Access, vol. 6, Mar 9, 2018, pp. 6900-6919. doi: 10.1109/ACCESS.2017.2778504.

[29] Y. Jararweh, A. Doulat, O. AlQudah, E. A., M. Al-Ayyoub, and E. Benkhelifa, “The Future of Mobile Cloud Computing: Integrating Cloudlets and Mobile Edge Computing”, 23rd International Conference on Telecommunications, 16-18 May, Greece, 2016.

[30] S. Nawrin, M. R. Rahman and S. Akhter, “Exploreing k-means with internal validity indexes for data clustering in traffic management system” Thomson Reuters Master Journal List and ISI index. International Journal of Advanced Computer Science and Applications (IJACSA), Vol. 8, No. 3, March 2017, pp. 264-272.

Palm Vein Verification System based on Nonsubsampled Contourlet Transform

Amira Oueslati[1], Kamel Hamrouni[2]
University of Tunis ELManar, National Engineering School of Tunis, LR-SITI Signal Image and Technologie of information Tunis, Tunisia

Nadia Feddaoui[3]
ISD, Manouba University, Tunisia
LR-SITI Signal Image and Technologie of information Tunis, Tunisia

Safya Belghith[4]
University of Tunis ELManar, National Engineering School of Tunis
Laboratory of Robotics, Computing and Complex System

***Abstract*—This document presents a new approach in verification system to verify the identity of person by his intrinsic characteristics "Palm vein" which is unique, universal and easy to captured. The first step in this system is to extract the region of interest (ROI) which represent the most informative region of palm, then coding step based on nonsubsampled contourlet transform (NSCT) is presented to produce a binary vector for each ROI, next a matching step of different representative vectors is given and finally a decision is made for both identification and verification mode. This approach is tested on CASIA multispectral database; the experimentations have proved the effectiveness of this coding system in verification modes to gives 0.19% of Equal Error Rate (EER).**

***Keywords*—Verification; palm-vein; nonsubsampled contourlet transform; region of interest; equal error rate**

I. Introduction

Biometrics is referring to the recognition of individual using his intrinsic characteristics no longer limited to the fingerprint's modality, and many modalities are used for access control applications to premises or personal items. Many modalities can be mention like the face, the voice, the signature, the iris.

Those modalities represent some problems such as lack of individuality and sensitivity to attacks for example fingerprints can be reproduced using silicone so to overcome that limits a new modality which is the palm vein has been used. Human palm vein biometrics represents one of the ambitious numerically biometric systems, this is due to the special characteristic of palm-vein texture among different persons and its unique and measurable intrinsic characteristics used to identify a person.

Some stringent pre-processing steps have been used to extract a stable region of interest (ROI) that has a fixed-size to minimize some translational and rotational variations in the palm vein image. Then, the texture of the ROI has been analyzed by the Non-Subsampled Contourlet Transform (NSCT), which is a shift-invariant, multi-directional and multi-scale transform, to capture significant veins features along all directions of the ROI image. The remainder of this paper is organized as follows: In Section two, existing methods in literature are briefly reviewed. In Section three, palm vein texture description is presented, the proposed palm veins feature extraction method is presented in section four. In section five, experimental results of the proposed method are given. Finally, conclusion is drawn in section six.

II. Literature Review

An image represents a set of details which appear at different resolutions. For that, multi-resolution decomposition is significant to analyze different type of image's structure in each resolution.

Several techniques in literature based on multi-resolution decomposition are proposed like the method based on Gabor filter in the work of '[1]' who measured the similarity between two-bit string representations called VeinCodes using hamming distance, and the work of '[2]'who used a Fisher Discriminated Analysis (FDA) to reduce the dimension of the features vector and the nearest neighbor's method for matching. Those techniques have been shown a satisfying efficiency in terms of recognition rate and execution.

There are many works in literature based on Curvelet transform like the work of '[3]'which applied Principal Component Analysis (PCA) on curvelet-decomposed images for dimensionality reduction and a simple distance-based classifier like the nearest-neighbor (NN) for matching, and the work of '[4]' which have used the curvelet transform to extract curve-like features from vein patterns and provides excellent sparse representations of the patterns.

Recently, multi-resolution transform codes are deemed to be the most promising methods, since the multi-resolution transform feature contains more discriminative power than other features and is more robust for illumination changes.

Therefore, this paper has also presented recognition performance from multi-resolution approach based on Non-Subsampled Contourlet Transform (NSCT) and tested on CASIA Multispectral Palmprint database. (http://biometrics.idealtest.org/dbDetailForUser.do?id=6).

III. Palm Vein Texture Description

The palm vein map represents several particularities since it had a structured pattern, homogeneous, directional, fine, rich, linear details that are interconnected.

When the hand is illuminated with infrared light, the venous network appears in black. It is enrolled as an "identity card" in a database and can be used as a comparison during recognition.

There are two types of "photography"; the first method, which is the most effective, is the "reflective" method and the second is the method of transmission (capture of light passing through the hand). Indeed, when it is cold, the veins contract and the contrast is not visible by the method of transmission while the reflected light is not changed.

Two types of texture can be found; the first is Macro-textures (or structured textures) which is easy to extract visually the basic pattern and the laws of assembling the primitives together. The second is Micro-textures (or random textures) that have a more chaotic appearance and more disorganized, but whose visual impression remains globally homogeneous. Palm vein represent a macrotexture type.

IV. ROI Extraction

ROI extraction should be extremely efficiency due to its importance in the following steps, the performance of the following steps in palm-vein verification systems is highly dependent on the results of the ROI extraction algorithm. In our research there are four stages to get the region of interest:

1) Straighten the palm Vein image with misalignments of the hand '[5]'.

2) Separate the form from the bottom that is not useful to the verification: Binarizing the input image by apply Ost'u thresholding algorithm that gives perfect results faster, directly and simply and that complies with the texture nature of our image.

3) Trace along the outline of the hand to find the possible locations of the valley: Locate the boundary of the palm using an edge detection algorithm which is sobel filter.

4) Detect the key points using competitive hand valley detection algorithm (CHVD) with our new algorithm which Making the perpendicular line passed by each key point previously founded, the perpendicular line is indeed for each point "Pi" which verifies the three preceding conditions, the following pixel is immediately taking on the skin of the hand "Pi + 1" and trace an infinitesimal segment [m1, m2] which passes through the two points (Pi) and (Pi + 1) (m1 is the point Pi and m2 is the point Pi + 1), then the pixel (mj) is located according to the following two conditions:

- The distance between (m1, mj) = c, where c = 1 pixel.
- The angle (m1m2, m1mj) = 90°.

And we repeat its two conditions by increasing the distance m1mj by one pixel each time and keeping the same angle until reaching the edge of the image as illustrated in 'Fig.1'.

5) Extract the region of interest by Making a square around the region of interest (ROI) using the process describe in fig 2. the general process of our ROI extraction method.

The fifth step describes a new effective algorithm to determine a square that characterizes and delimits the region of interest (ROI):

1) 1. Align the second valley point V2 and the fourth valley point V4 (trace the segment [V2, V4]).

2) Calculate the average distance Dm between [V2, V4].

3) Locate points A1 and A2 that meet the following conditions:

- The distance V2A1 = V4A2 = Dm / 4.
- The point A1 is on the perpendicular which goes through V2 and which verifies that the angle (V2V4 ^ V2A1) = -π / 2.

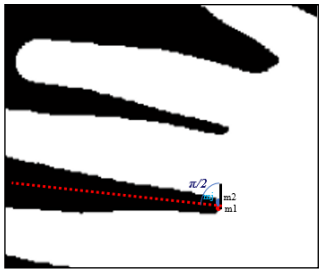


Fig. 1. Perpendicular Line Passed by a Valley.

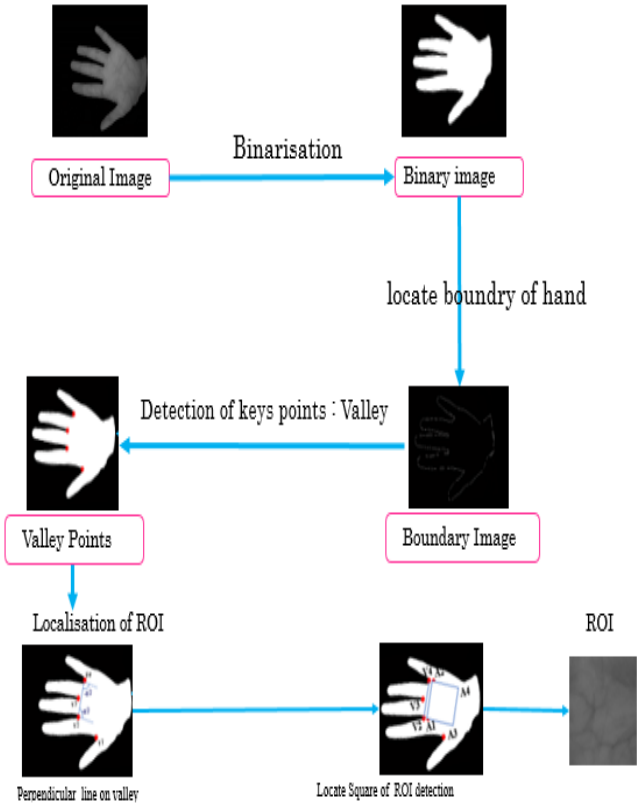


Fig. 2. General Process of ROI Extraction Model using Palm Veins Pattern.

Point A2 is on the perpendicular that goes through V4 and verifies that the angle (V4V2 ^ V4A2) = -π / 2

4) Finally, a side square A1A2 is located on the palm of the hand and the region of interest of the original image is obtained.

V. Palm Vein Feature Extraction

1) General Process: In order to extract the most discriminating information in palm vein texture, the following steps are used:

a) Filtering input images using NSCT on N levels and on L directional subbands.

b) Calculate the phase response information on the NSCT coefficients in each directional subbands.

c) Divide the resulting images into local regions

d) Calculate statistical descriptors for each region in different subbands and directions resulting from the phase response of the NSCT coefficient matrix.

e) From the statistical descriptors obtained, determine a binary code based on the descriptor signs in the resulting directional subbands.

NonSubsampled Contourlet Transform which provides an excellent representation of information in space and spatial frequency is applied.

The input image (ROI) undergoes the first NSCT undoped pyramidal filter and returns an image of single-scale high-pass subbands. It only allows the robust information to be transmitted at the directional NSCT filter. the NSCT coefficient phase response has been chosen since it is the most suitable for palm vein maps because it presents well the orientation of the vein line and has a linear relationship with the dominant orientation angle in a subband.

Let ROI decomposed by the pyramidal and directional filters of the NSCT with J scales and K orientations by scale, and let $S_{jk}(i,j)$ be the coefficient of the subband at position (i, j) at the scale j and the orientation k, where j = 1, 2, ..., J and k = 1, 2, ..., K. as shown in 'Fig. 3' when J = 3 and K = 8, the process is presented in fig. 4.

Phase information (P) at a sub-band at (i, j) is defined as the difference between the coefficient phase at this point and at the next coefficient. Specifically, the P at the spatial location (i, j) of a subband is given by:

$$Pjk(i,j) = \begin{cases} \angle S_{jk}(i,j) - \angle S_{jk}(i,j+1) si 1 \le k \le \frac{K}{2} \\ \angle S_{jk}(i,j) - \angle S_{jk}(i+1,j) si \frac{K}{2} \le k \le K \end{cases} \quad (1)$$

Where ∠ denotes the phase.

Then a binary signature which represent the palm vein texture description would be extracted. A size of 64*64 ROI is considered so the size of the characteristic vector obtained is 32768 bits. What is considered very important and will increase the overall computation time for recognition system. To reduce the size of the characteristic vector, we proposed to subdivide the phase response image into blocks of (8*8), then a statistical descriptor such as the standard deviation STD, the mean or the mean absolute deviation AAD is calculated in each block. Then, a coding of the characteristic vector is necessary to generate a binary signature. Inspired by the work of '[6]', the matrix of statistical characteristics is linearized and then compared the values of the blocks, each value is compared with the previous one and coded by 1 if it is greater or 0 otherwise. In this way, a binary Vector is obtained with 512 bits of size.

2) Similarity comparison: The verification and identification processes require the comparison between two images by quantifying the similarity rate between their signatures using hamming distance '[7]'seen that a binary vector is obtained as a result of the previous step, this distance is calculated by:

$$HD = \frac{1}{XY} \sum_{x=1,y=1}^{XY} V^1(x,y) \oplus V^2(x,y) \quad (2)$$

With $V^1$and V^2 represent the binary vector of two different images and (x, y) represents the coordinates of the pixel in the X × Y subband image.

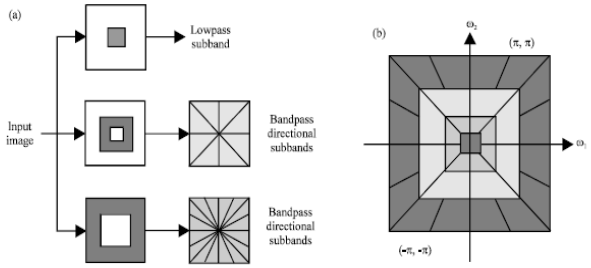


Fig. 3. Nonsubsampled Contourlet Transform: (a) NSCT Structure and its Decomposition Process, (b) Idealized Schematic Diagram of Frequency Resolutions.

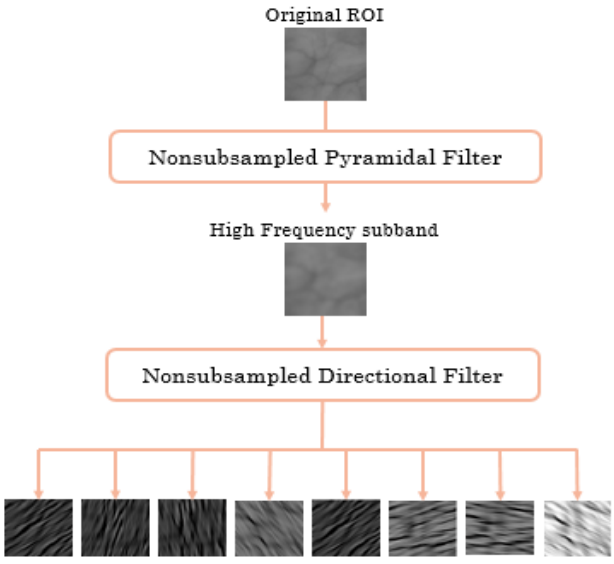


Fig. 4. Palm Vein Decomposition using NSCT.

VI. Experimental Results

In verification mode: When checking, all images are considered in comparison. The performance of this approach is measured through: intra-class and inter-class curves, Detection error tradeoff (DET curve), equal error rate (EER), decidability and degree of freedom.

During the experiments, Hamming distances is calculated and characterize "one to one" comparisons and determine the distribution of similar (genuines) vectors represented by the intra-class curve and the distribution of non-similar vectors (impostors) represented by the inter-class curves as shown in 'Fig 5'.

The total number of operations is 35,9400, distributed as follows: 3,000 authentic and 716,400 imposters.

The overlap corresponding to a zone of doubt means that false acceptances and false rejected whose rates depend on the separation threshold from which any candidate is considered as impostor.

The value of the threshold is varied between 0 and 1 by looking at the overlap area delimited by a range of Hamming distances between 0.13 and 0.14 and each time, the corresponding FAR and FRR in calculated. This work has been repeated for several illuminator wavelength values and their curves have grouped in , which finally allowed to obtain the DET curve shown in 'Fig.6' which shows that the performance of the system clearly depends on the value of the illuminator wavelength that is an optimal ERR equal to 0.19% for 940 nm.

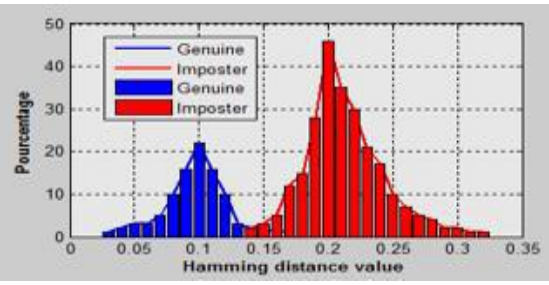


Fig. 5. Illustration of Intra-Class and Inter-Class Distributions.

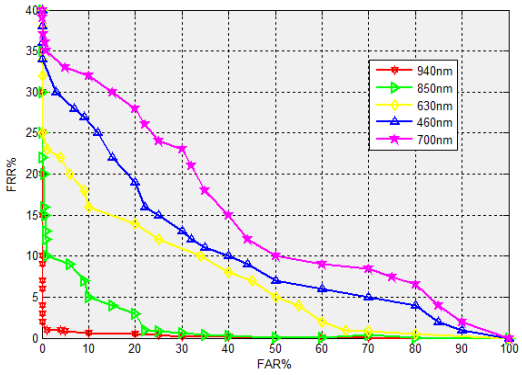


Fig. 6. DET Curves: Illustration of the Evolution of the FAR According to the FRR.

VII. Comparison and Discussion

In order to validate the performance of the presented approach in verification mode, results are compared with others obtained by the methods of: Derived from the Gaussian filter of '[8]', Wavelets of '[9]' and Gabor Wavelet Filter of '[10]' on the same database "CASIA multispectral Database". The DET curves in 'Fig.7' illustrating the evolution of the FAR according to the FRR, allow us to perform a graphical comparison in verification mode between the different methods. In fact, the red curve relating to our method coincides with the ordinate axis, which is not the case for the representative curves of the Wavelet and Gabor wavelet filter methods.

Table 1 summarizes the analytical results of the EERs obtained from the DET curves for the different methods studied. The proposed approach minimized the error of 2.69% compared to the Gaussian filter derivative method, 0.67% compared to the Gabor Wavelet Filter method and 0.3% compared to the method of wavelets.

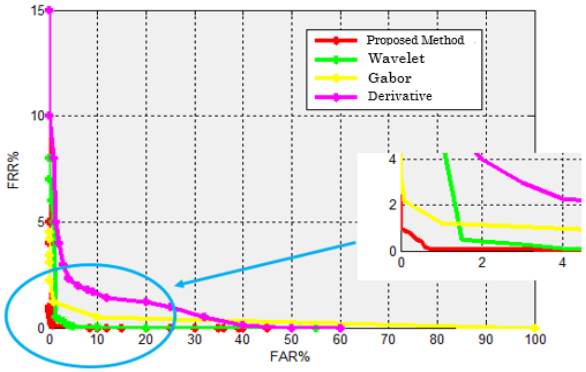


Fig. 7. DET Curves: Comparison of different Methods.

TABLE. I. EER Comparison of different Approaches

Method	EER %
NSCT	0,19
Derivative of Gaussian Filter	2.88
Gabor	0.86
Wavelet Filter	0.49

VIII. Conclusion

A palm vein characterization approach is proposed, in which invariant, multi-scale and multidirectional NSCT coefficients are used as effective characteristics of the venous card. The region of interest of the palmar vein image is used as the input of the NSCT and the phase response information of the NSCT coefficients in each directional subband is used to extract the characteristics. An encoding technique is provided to generate 512 bytes of binary signature.

Finally, the similarity between the models is estimated by the calculation of the Hamming distance. The NSCT transformation is a truly two-dimensional transformation that captures the intrinsic geometric structures of the image.

In this paper results in verification mode are presented, in a future work the performance of biometric system on identification mode will be studied.

ACKNOWLEDGMENTS

The authors would like to acknowledge the National Laboratory of Pattern Recognition, Institute of Automation, Chinese Academy of Sciences for their supply of Casia Multi-Spectral Palm print image database.

REFERENCES

[1] Han W.Y., Lee J. Ch., B., "Palm vein recognition using adaptive Gabor filter", Expert Systems with Applications, vol. 40, 2013.

[2] Al-juboori A.M. et al., "Palm vein verification using Gabor filter," International Journal of Computer Science Issues, vol. 10, no. 1, pp. 678–684,2013.

[3] Feng Y. et al., "Real-time ROI Acquisition for Unsupervised and Touch-less Palmprint", World Academy of Science, Engineering and Technology,2011 p54.

[4] Qiang L. et al.," Curvelet-based palm vein biometric recognition", OSA Publishing, Chinese Optics Letters, 2010, Vol 8, Issue 6, pp 577.

[5] Method for Correcting Palm Vein Pattern Image Rotation by Middle Finger Orientation Checking.

[6] Feddaoui N., and Hamrouni K.," Iris recognition based on multi-block Gabor statistical features encoding". SoCPaR, 2010 pp. 99-104.

[7] J. Daugman, "Biometric personal identification system based on iris analysis". US Patent, no. 5291560, 1994.

[8] X. Wu, "Palmprint texture analysis using derivative of gaussian filters" International Conference Computational Intelligence and Security, 2006.

[9] A.K. Kong, D. Zhang, "Competitive coding scheme for palmprint verification". International Conference on Pattern Recognition, Cambridge UK, August 2004.

[10] Z. Sun, "Ordinal palmprint representation for personal identification", In Proc. Computer Vision and Pattern Recognition. IEEE, pp. 279–284, 2005.

An Enhanced Weighted Associative Classification Algorithm Without Preassigned Weight based on Ranking Hubs

Siddique Ibrahim S P[1]
Research Scholar
School of Computing Science and Engineering
VIT University, Chennai, India

Dr. Sivabalakrishnan M[2]
Associate Professor
School of Computing Science and Engineering
VIT University, Chennai, India

***Abstract*—Heart disease is the preeminent reasons for death worldwide and in excess of 17 million individuals were kicked the bucket from heart disease in the past years and the mortality rate will be increased in upcoming years revealed by WHO. It is very tough to diagnose the heart problem by just observing the patient. There is a high demand in developing an efficient classifier model to help the physician to predict such threatening disease to recover the human life. Now a day, many researchers have focused novel classifier model based on Associative Classification (AC). But most of the AC algorithm does not consider the consequence of the attribute in the database and treat every itemsets equally. Moreover, weighted AC ignores the significance of the itemsets and suffering the rule evaluation due to support measure. In this proposed method we have introduced attribute weight, which does not require manual assignment of weight instead the weight would be calculated from link based model. Finally, the performance of the proposed algorithm is verified on different medical datasets from UCI repository with classical associative classification.**

***Keywords*—Association rule mining; hub weight; classification; heart disease; attribute weight; associative classification**

I. INTRODUCTION

Heart disease is also called as Cardio Vascular Disease (CVD) that occurs by various factors like high blood pressure, obesity, high cholesterol in the blood, high sugar level, and food habits. These conditions lead to formation of plaque in the blood path that slow down the blood flow to the heart muscle results in heart failure. One in four persons dies from heart disease in developed countries and the count will more in low and middle income countries throughout the world [1, 2]. Every day medical industries will generate large amount of patient's treatment data. This data can be analyzed to prevent the risky condition of heart disease by providing prediction at early stage and this will reduce the death rate. The data mining has applications in many fields, like education, production, inventory and bio medical which use techniques such as Regression, Clustering, Classification, Prediction, and Associative Classification (AC) plays a vital role in identifying the hidden knowledge for precautionary decision making. This motivated the researchers to develop computer aided heart disease prediction system to reduce the risk factors of the deadly disease.

Data mining is the process of learning new knowledge in terms of pattern from wide availability of database and help the information industries to make better decision on data which is based on the variety of techniques. It has wide variety of applications including banking, education, retail, e-commerce, bioinformatics, insurance and communication. Association Rule Mining (ARM) [3] is a data mining method that helps to find the frequent pattern between two or more items. It discovers a correlation among data repositories from datasets that satisfy the minimum support and confidence threshold using simple if then statements which is very easy to understand by normal users.

Classification technique is another widely used method in data mining technique. The important role of classification algorithm predict categorical class label for each given instance after construction of model in the database. For example, a classification build a model used to identify the potential customers of loan application risk level such as low, medium, and high. Several models have been projected by different researchers over the years to exactly guess the intention class. This task includes statistical [4], neural networks [5], divide and- conquer [6], decision tree [7, 8], PART [9], PRISM [10] and Naïve Bayes [7]. Association Classification (AC) has been successfully integrates association rules for classification that yield specific subset association rule whose consequent will be a class label [11]. Classification construct classifier from which new class label could be assigned to new records. A new Class based Association Rule (CBA) that enhances the learning phase to provide future data samples. Thus, the AC technique is the hybrid version of the association rule mining. For example, as the class rule R: AT1, AT2 -> class is inferred as follows: If the itemsets combination occurs together in a particular instance with Ci, then the right hand side Ci can be inferred as class label then AT1, AT2 are attribute values. Two basic metrics are in place to help each class association rules namely support and confidence user specified constraints. For an instance, the support of CBA A1, A2 ->C1 is described as number of occurrence that itemsets rule A1, A2 matches belongs to a class C1 in dataset D.

The paper is organized as follows: next section describes the preliminaries done for the proposed work. In Section 3 represent proposed weighted associative classification method which is explained along with sample computation. In

Section 4 presents with different analysis on heart disease and other medical and non-medical datasets. The final section concludes our work followed by future work.

II. Related Work

Liu et al. [11] was introduced Class Association Rule (CBA) the first algorithm that incorporate the well-known Apriori algorithm [12] for class rule generation. It has rule generation stage uses well-known that scan multiple times in dataset to bring the frequent Class Association Rules (CARs). After rule generation the CBA uses minconf measure for selecting the best rules for classifier construction. Finally, the algorithm performs prediction in order to guess the unknown instance.

Wenmin et al. [13] introduced the concept of producing FP-tree based CAR. This method was attained maximum precision than CBA algorithm. Cowling et al. [14] was proposed multi-class and, multi-label algorithm to solve multiple scanning issue by introduced three different measures for evaluating the algorithm efficiency. The authors have used 28 different UCI datasets shows that MMAC performed better than traditional CBA algorithm.

The problem of generating Multi-Class Association Rule (MCAR) was proposed by Thabtah et al. [15] that maintains item occurrence position during the rule generation phase instead of rules. The author proved that the MCAR has limited number of rule generation in the initial stage.

Alwidian et al. [16] developed statistical ranking measure for enhancing the accuracy of CBA algorithm. Various algorithms were compared in performance evaluation section that showed the ECBA algorithm could provide better performance in terms of accuracy. Hadi et al. [17] developed fast associative classification based on Diffset method to improve the class rule generation. This algorithm used sorted order rule evaluation using confidence and support measure. Moreover, this algorithm formed rule based cluster from which the rule matching has been performed. The author showed the better result with other traditional AC algorithms.

Over the past few years, many researchers have been focused to finding efficient solution for heart disease prediction. Anbarasi et al. [18] executed the decision tree method of popular data mining techniques to obtain trusted value of accuracy in diagnosis of patients. Similarly, this was acquired previously by more number of attributes. The author uses genetic algorithm that plays a major contribution towards the diagnosis of heart disease by determining the correct attributes which will help both patients as well as physicians to reduce the number of test taken for diagnosing the disease. By using local search algorithm the author have reduced to 6 attributes from 13 attributes used in traditional algorithms.

Harleen et al. [19] inspired the important and essential part of classification technique such as Artificial Neural Network (ANN), Rule induction and decision tree to diagnosing the patient's health. Automated prediction system was proposed by Srinivas et al. [20] to enhance the diagnosis system and to reduce the medical expenses by implementing decision tree, Naive Bayes and neural network.

Latha et al. [21] developed a prototype for heart disease prediction system based on neuro-fuzzy system combined with Genetic Algorithm (GA) that were improved the prediction. Nidhi et al. [22] described decision tree algorithm that contains only 4 attributes for heart disease prediction. Here the author converted all the data into categorized form in order to reduce mean absolute error. Pethalakshmi et al. [23] projected the genetic algorithm with few numbers of features to increase classification accuracy. The author projected the fuzzy logic method that reducing the execution time and improving accuracy.

Alladoumbaye et al. [24] model an intelligent heart disease prediction system using data mining techniques to predict heart disease from real datasets with 14 clinical features. This algorithm achieved 91.42% accuracy over SVM algorithm. Ankita et al. [25] used improved k-means and ANN algorithms to attained greater accuracy of 99%. Mohamed et al [26] had applied different data mining algorithm to predict medical diseases using five different algorithms, namely, C4.5, SVM, logistic regression, Neural network and Naive Bayes.

A. Weighted Association Rule Mining (WARM)

First we have discussed WARM in this section, further we explained the proposed EWAC using Ranking Hubs with suitable illustrations.

The traditional frequent itemset mining methods do not consider the importance of the individual items in the data set. The mining process is based on the count of its itemset in a database. But various real applications such as the business market and the clickstream require the significance of itemsets in the database. Various algorithms were presented in recent years to describe the quantitative aspects representing the knowledge for the itemset in a given database. Few among them are discussed below.

Wang et al. [27] proposed the WAR algorithm. They introduced weighted_support which represents the significance of the item in the database. Here, domain experts assign weights to every individual item and mining interesting rules form weighted_ support measure. Cai et al. [28] break the traditional downward closure property by introducing distinct weight property. But this method consumes more time and expensive when the database is outsized. Wang et al. [29] eliminated the concept of assigning weights to the items by human experts. The author proposed a link-based ranking model that represents the association rules. The major drawback of this algorithm is, it finds only the rank and it does not attempt to calculate any measure like weighted_support to evaluate the mining process.

This is impressive as the domain expert assigns a higher weight to an uninteresting item in the transaction. But sometimes it leads to provide incorrect knowledge and misses the valuable itemsets. Moreover, it is impractical to manually assign the weights to the items when the dataset has a massive number of items with different fields. Hence, it becomes necessary to introduce a method to overcome the above drawbacks. Based on the above reasons, we proposed the enhanced weight calculation strategy which does not require domain expert interaction on datasets. It derives the weights

completely from the internal structure of the database and based on the assumption of good items consisting of higher weights.

III. Proposed Ewacrh Algorithm

A. Enhanced Weighted Associative Classification with Ranking Hubs (EWACRH)

In this section, at first we describe the weighted associative classification and its significance followed by details of Hub based weighted scheme of HITS Model. Consider the Fig. 1 shows the proposed architecture.

B. Problem Definition

Let consider a database D= {At1, At2, At3……An, C} be a list of attributes and C is a class label in the database. If a rule states that A2 -> C1, while A2 is attribute value then C1 is the class attribute.

Algorithm: Enhanced Weighted Associative Classification

Dataset D with n Instances

Divide T {Traning_data T, Test_data T1}

Training_data T

{

S1=Empty_set, F1=Empty_set

K=1

Do{

For all transaction Ɛ T

Initialize auth(i) to 1

Hub(t)=

Auth(i)= hub(t)

S1=Generate all candidate k itemset rule(Training data T, n, min_support

Weighted_support)

For each Itemset r1 in s1

Support(r1)=supportcount(r1)->class/N

weight_support=Authority_weight(r1)+support/k

If weighted_support(r1) min weighted_support

F1=S1+r

End if

Find all combination ruleset(rk)

End for

K=k+1

}

While Sk

Return F1'

}

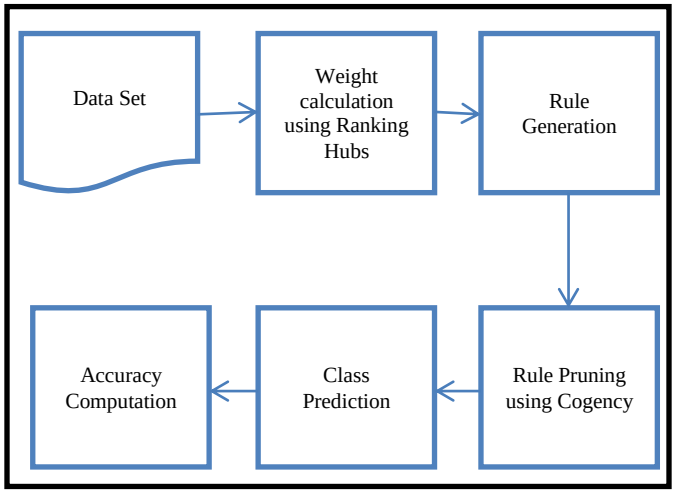


Fig. 1. Generating Enhanced Weighted Associative Classification using Ranking Hubs.

Example 1. Let consider a sample Heart Disease data description shown in below Table I.

C. Hub-based Weighting Scheme

The proposed Hub based weighting scheme constructs a bipartite graph from the values of the data set. It is known that the bipartite graph consists of two disjoint, independent set of vertices. These two sets are interconnected with the edges. In the proposed scheme, the unique row values (V) and all possible instances of attributes (U) form the two independent vertices. An edge is placed between any two vertices belonging to these subsets of vertices V and U, if and only if Ui c Vi. The degree of the vertices in set U is considered as the authority weight

This bipartite graph gives us an idea of applying link based approach for classification attributes. Here the AC takes the support values proportional to its degree of appearance in the database. Classical CBA [11] algorithm does not consider these different transaction significance during the support calculation. Moreover, the proposed method invoking the concept of hub and authority while calculating the itemset weight. The below equations are applied to the bipartite graph for computing authority weight in each iteration. In Fig. 2 presented the bipartite graph equivalent of Table I.

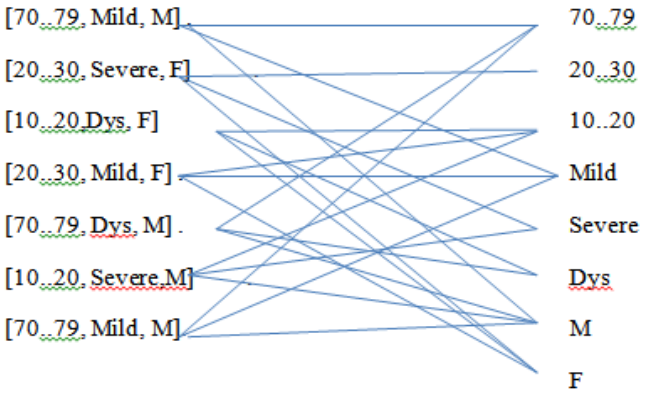


Fig. 2. Bipartite Graph.

TABLE. I. SAMPLE HEART DISEASE DATASET

Age	Restwm	Sex	Recurrence_Event
70..79	Mild	M	Yes
20..30	Severe	F	No
10..20	Dys	F	Yes
20..30	Mild	F	Yes
70..79	Dys	M	Yes
10..20	Severe	M	No
70..79	Mild	M	No

$$auth(i) = \sum_{T:i\in T}^{n} \text{hub(T)} \quad (1)$$

$$hub(T) = \sum_{i:i\in T}^{n} \text{auth(i)} \quad (2)$$

Example 2. Let consider the Table II for automated weight calculation using HITS model. The authority weight is listed for corresponding to the itemset.

TABLE. II. AUTHORITY WEIGHT OF THE EXAMPLE DATASET

Sl.No.	Attribute	Authority Weight
1	70..79	3
2	20..30	2
3	10..20	2
4	Mild	3
5	Severe	2
6	Dys	2
7	M	4
8	F	3

D. Weighted_Support Calculation

The following section illustrates how the weighted AC works based on automated HITS algorithm in step by step manner. Here, the weight does not assign by the subject experts.

S1. Generate single candidate weight

Computing support count and weighted_support of each itemset rules we will generate candidate single itemset in Table III. Here the min. weighted_support =4. Min. weighted_ support is a predefined parameter for selecting active rulesets. Assigning larger value of this parameter leads to move restriction number of rule generation. One of the main advantages of the proposed methodology is to control the number of rule generation in AC by increasing min_weight parameter in each iteration. The following example shows the evaluation of weighted_support for ruleset r1.

$$\text{Weighted\_support} = \frac{Authority\_weight(r1)*Support}{K} \quad (3)$$

$$\text{Weight (r1)} = \frac{Authority\_weight(r1)}{K} \quad (4)$$

For sample calculation: Let us consider first rule in Table XIII:

Weight (70..79)->yes) =3/1

Weighted_support (70..79 ->yes) = 3/1 * 2 =6

TABLE. III. SINGLE CANDIDATE RULESET

No. of Rules	Single Itemset	Support	Weighted_support
1	70..79->yes	2	3*2=6
2	70..79->no	1	3*1=3
3	20..30->yes	1	2*1=2
4	20..30->no	1	2*=2
5	10..20->yes	1	2*1=2
6	10..20->no	1	2*1=2
7	Mild->yes	2	3*2=6
8	Mild->no	1	3*1=3
9	Severe->yes	0	2*0=0
10	Severe->no	2	2*2=4
11	Dys->yes	2	2*2=4
12	Dys->no	0	2*0=0
13	M->yes	2	4*2=8
14	M->no	2	4*2=8
15	F->yes	2	3*=6
16	F->no	1	3*1=3

S2. Frequent single class ruleset will be generated which contains the ruleset has a weighted_support greater than or equal to the specified minimum weighted_support as given in Table IV.

S3. Find the two candidate itemset based on the support and weighted_support as shown in below Table V. The frequent itemset for data's in Table V is given in Table VI.

TABLE. IV. FREQUENT SINGLE RULESET

No. of Rules	Frequent Single Itemset	Weighted support
1	70..79->yes	6
2	Mild->yes	6
3	Severe->no	4
4	Dys->yes	4
5	M->yes	8
6	M->no	8
7	F->yes	6

TABLE. V. TWO CANDIDATE ITEMSET

No. of Rules	Two Itemset rules	Support	Weighted support
1	70..79, Mild->yes	1	3*1=3
2	70..79, Dys->yes	1	3*1=3
3	70..79, M->yes	2	4*2=8
4	70..79, F->yes	0	3*0=0
5	Mild, Dys->yes	1	3*1=3
6	Mild, M->yes	1	4*1=4
7	Mild, F->yes	1	3*1=3
8	Dys, M->yes	1	3*1=3
9	Dys, F->yes	1	3*1=3
10	M, F->yes	0	Ignore same instances
11	Severe, M->no	1	3*1=3

TABLE. VI. FREQUENT TWO ITEMSET

1	70..79, Mild->yes	1	3*1=3
2	70..79, Dys->yes	1	3*1=3

S4. Find the three candidate itemset based on the min_support and weighted_support as shown in Table VII.

In the above Table VII there is no ruleset has sufficient support count that satisfy the min_ weighted_support. Hence the ruleset process is stops by the algorithm and start for preparing useful ruleset.

S5. Find the useful ruleset based on minimum confidence (i.e >=0.5) in the frequent CAR and remove all other ruleset as shown in Table VIII.

Cogency is posteriori based mathematics [30, 31] that conclude the confabulation if the assume facts being true.

S6. For sample cogency computation: Let consider the first rule in the below Table IX.

(70..79->yes)

1* weighted_support * confidence/ count of yes

1*6*0.67/4 =1

TABLE. VII. THREE CANDIDATE ITEMSET

No. of Rules	Frequent Two Itemset rules	Support	Weighted support
1	70..79, Mild, M->yes	1	3*1=3

TABLE. VIII. RULESET SATISFY THE CONFIDENCE MEASURE

No. of Rules	Itemset rules	Support	Confidence
1	70..79->yes	2	0.67
2	Mild->yes	2	0.67
3	Severe->no	2	0.5
4	Dys->yes	2	0.5
5	M->yes	2	2
6	M->no	2	2
7	F->yes	2	0.67
8	70..79->yes	2	0.67
9	Mild->yes	1	0.5

TABLE. IX. COGENCY COMPUTATION

No. of Rules	Frequent Two Itemset rules	Confidence	Weighted support	Cogency
1	70..79->yes	0.67	6	1
2	Mild->yes	0.67	6	1
3	Severe->no	0.5	4	0.66
4	Dys->yes	0.5	4	0.5
5	M->yes	2	8	4
6	M->no	2	8	5.33
7	F->yes	0.67	6	1
8	70..79, M->yes	0.67	8	1.34
9	Mild, M->yes	0.5	4	0.5

TABLE. X. SORTED RULESET

No. of Rules	Frequent Two Itemset rules	Confidence	Weighted support	Cogency	Rank
1	M->no	2	8	5.33	1
2	M->yes	2	8	4	2
3	70..79, M->yes	0.67	8	1.34	3
4	70..79->yes	0.67	6	1	4
5	Mild->yes	0.67	6	1	5
6	F->yes	0.67	6	1	6
7	Severe->no	0.5	4	0.66	7
8	Dys->yes	0.5	4	0.5	8
9	Mild, M->yes	0.5	4	0.5	9

S7. Table X shows the sorted CAR rules based on cogency measure. If more than one rule has the same cogency value then the rule will be sorted based on confidence measure. If both the rules have the same cogency and confidence then considers the rules weighted_support followed by length of the rule for further decision.

S8. Suppose one can predict the class of unknown rule with following values {70..79, Mild, Y}. The new rules selects based on cogency of (Ri) > Rj elseif conf (ri)>conf(Rj) or conf(Ri) = conf (Rj) and w.sup(Ri) > w.sup(Rj) or conf(Ri)=conf(Rj) and w.sup(ri)=w.sup(Rj) and sup(Ri)>sup(Rj) [22]. The algorithm have found the following potential rules for given new instances: 70..79->yes, Mild->yes, Y->yes. Hence the rule can be assigned with 'yes' class.

IV. EVALUATION OF WEIGHTED ASSOCIATIVE CLASSIFICATION

The proposed system was tested using heart disease dataset and several benchmark UCI repository [32] data sets and brief description is presented in Table XI. The performance of the proposed hub based weighted AC algorithm was evaluated by comparing with three well known algorithms are CBA, CMAR, and MCAR. All the datasets were implemented using JAVA programming. All the experiments were carried out on a computer with Windows 7 OS 64 bit, AMD A4-3330 with clock rate of 2.40GHz with 8GB Physical memory. In the dataset, Holdout approach [33] was used 70% of the datasets were used as training data and the remaining 30% of the datasets were used as testing data. The system performance was examined by different metrics such as accuracy, precision and recall for heart disease and other datasets. The dynamic minimum threshold set for weighted support and confidence parameters were used for testing all the algorithms. Tables XIII and XIV representing the results of precision and recall on heart disease dataset. Tables XV and XVI shows the accuracy for the different medical datasets and non-medical datasets using our proposed approach.

The proposed algorithm is applied to the heart disease dataset and obtained the results. From results in Tables XII, XIIII and XIV, it is inferred that the proposed algorithm, EWACRH outperformed the other with an accuracy of 97%, precision of 95%, and recall of 93% respectively.

TABLE. XI. DATASET DESCRIPTION

Dataset	No. of Transaction	No. of Classes
Heart Disease	303	2
Breast Cancer	286	2
Breast -W	699	2
Diabetes	768	2

TABLE. XII. ACCURACY OF HEART DISEASE DATASET

Algorithm	Accuracy
CBA	87
CMAR	88
MCAR	91
EWACRH	97

TABLE. XIII. PRECISION OF HEART DISEASE DATASET

Algorithm	Precision
CBA	83
CMAR	82
MCAR	87
EWACRH	**95**

TABLE. XIV. RECALL OF HEART DISEASE DATASET

Algorithm	Recall
CBA	80
CMAR	81
MCAR	85
EWACRH	**93**

TABLE. XV. ACCURACY OF MEDICAL DATASET

Datasets	CBA	CMAR	MCAR	EWACRH
Heart Disease	87	88	91	97
Breast Cancer	77	75	80	91
Breast-w	80	77	75	90
Diabetes	78	77	79	94
Avg. Accuracy	**81**	**79**	**81**	**93**

TABLE. XVI. ACCURACY OF DATASETS (NON-MEDICAL)

Data Sets	CBA	CMAR	MCAR	EMACRH
Wine	71	71	72	90
Iris	86	89	89	99
Car	73	75	75	95
Bank	71	76	84	89
Avg. Accuracy	**75**	**78**	**80**	**93**

The Hub based weighting scheme proposed in this paper aids the EWACRH algorithm in getting a better result. Due to this scheme, the attributes influencing the decision get higher priority, which leads to an accurate decision. In heart disease dataset, age, sex, chest pain, restecg, heart muscle condition, and resting blood pressure are the decision influencing attributes. Another notable advantage of the proposed algorithm is, it considers the unassociated items also in its decision. From the obtained results, rules are framed. The cogency measure [30] used in this paper helps to prune the rules.

A. Accuracy Computation

Accuracy can be distinct as the amount of uncertainty in a measurement with respect to an absolute standard. It means the proportion of correct results that a classifier achieved. If the classifier can correctly predict the class label of half of the given datasets, then the accuracy is 50%. We used the following metrics:

True Positive (TP): Number of positive samples, labeled as positive

False Positive (FP): Number of negative samples, labeled as positive

True Negative (TN): Number of negative samples, labeled as positive

False Negative (FN): Number of positive samples, labeled as negative

We can calculate the accuracy as follows:

$$Accuracy = \frac{(TP+TN)}{(TP+TN+FP+FN)} \quad (5)$$

Fig. 3 and 6 shows the graphical representation of proposed algorithm accuracy for heart disease and other medical datasets. Also, Fig. 4 and 5 shows the precision and recall results of our proposed algorithm on heart disease dataset. The prediction accuracy of our proposed algorithm for different non-medical datasets, compared with those of some existing models is presented in Fig. 7.

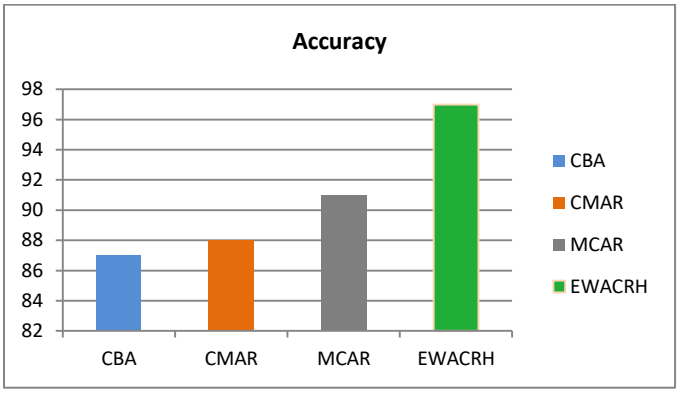


Fig. 3. Comparisons of different Rule mining Algorithms on Heart Disease Dataset.

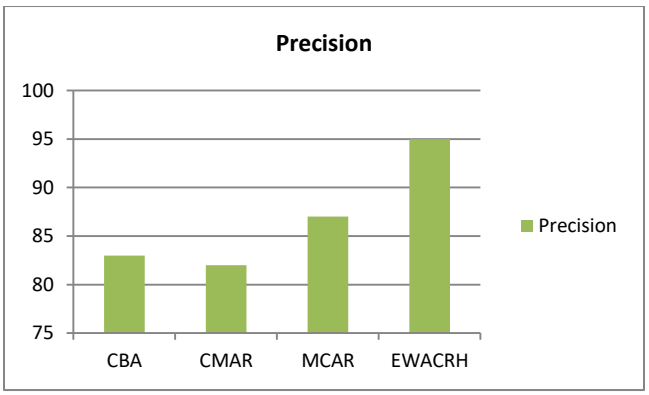


Fig. 4. Precision of Heart Disease Dataset.

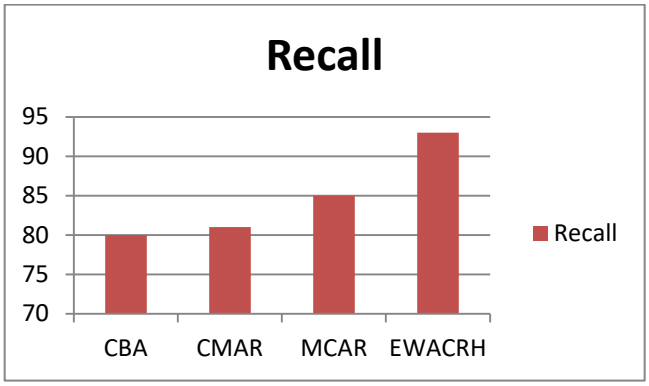


Fig. 5. Recall of Heart Disease Dataset.

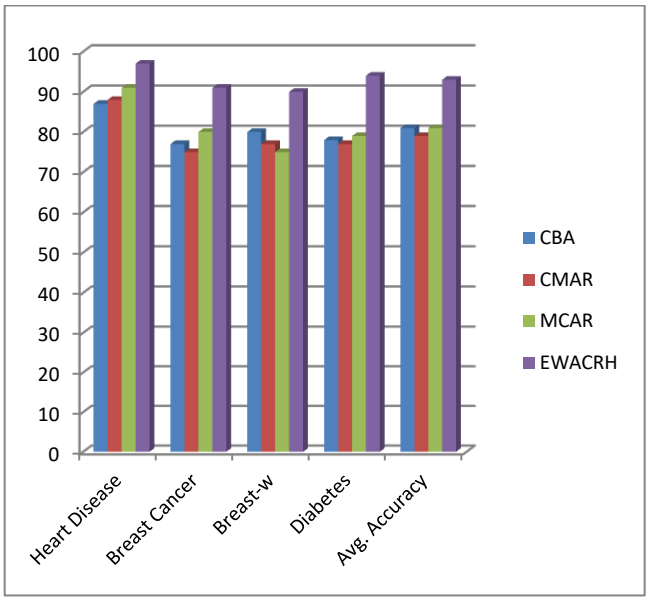


Fig. 6. Comparisons of different rule Mining Algorithms on Medical Datasets.

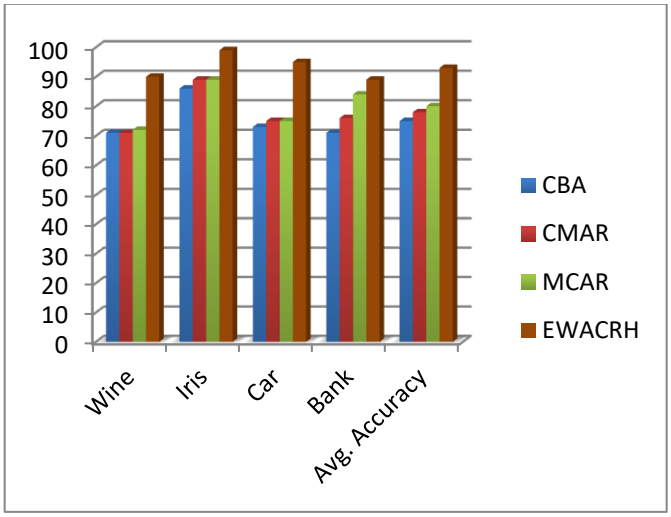


Fig. 7. Comparisons of different rule Mining Algorithms on Non-Medical Datasets.

V. Conclusion

In this paper, we proposed an enhanced weight measure scheme for heart disease prediction. This proposed algorithm uses hub ranking and the cogency measure to improve the performance. The weighted AC algorithm has applied the weight on each fields in the database to prioritize the ruleset from the least important one based on Hub ranking. In the future, this algorithm EWACRH can be evaluated by applying it to different domain data sets. It is also planned to use the memetic algorithm for investigating different weighting, pruning, and ranking.

VI. Data Availability

https://archive.ics.uci.edu/ml/datasets/Heart+Disease

https://archive.ics.uci.edu/ml/datasets/Breast+Cancer

https://archive.ics.uci.edu/ml/datasets/Breast+Cancer+Wisconsin+%28Original%29

https://archive.ics.uci.edu/ml/datasets/Diabetes

https://archive.ics.uci.edu/ml/datasets/Wine+Quality

https://archive.ics.uci.edu/ml/datasets/Iris

https://archive.ics.uci.edu/ml/datasets/Car+Evaluation

https://archive.ics.uci.edu/ml/datasets/Bank+Marketing

References

[1] https://medlineplus.gov/heartdiseases.html.

[2] Heart Disease and Woman : www.womenshealth.gov/files/images/hds-heart-disease-and-women-1.jpg

[3] Rakesh A, and Tomasz I., “Mining Association Rules between sets of Items in large databases” Proceed. of the ACM SIGMOD conference, USA, 1993.

[4] Kumar V, and Wu “Top 10 algorithms in data mining” KIS(2008), Springer series, 2007.

[5] Yeh Ivy and Che-Hui Lien., “Cosmetics purchasing behavior-An analysis using association reasoning neural networks” Elsevier., volume.37, No. 10, PP.7219-7226, Oct. 2010.

[6] Johannes F., “Separate and Conquer Rule Learning”, Kluwer Academic publisher, PP. 3-52, 1999.

[7] Ross Quinlan J., “C4.5: programs for Machine Learning” Artificial Intelligence – Springer, Morgan Kaufmann Publisher, 1994.

[8] George John H, and Langlay P., “Estimating Continuous Distributions in Bayesian Classifiers” Machine Learning, PP. 338-345, Feb 2003.

[9] EFrank E and Ian H., “Generating accurate rule sets without global optimization” - Proceeding of the Inter. Conference on machine learning (ICML 98), PP. 144-151. July 1998.

[10] Jadzia C., “PRISM: An Algorithm for inducing modular rules” Int. journal of Man-Machine Studies, PP. 349-370, vol.27, 1987.

[11] Bing Liu, and Hsu W., “Integrating Classification and association rule mining” (KDD), 1998.

[12] Rakesh A, and Ramakrishnan S., “Fast Algorithms for mining association rule” Proceed. of the twentieth Int. conference on VLDB, PP. 487-499. 1994.

[13] Wenmin Li, Jiawei H and Jilan P., “CMAR: Accurate and Efficient Classification based on Multiple-class Association Rule” IEEE Int. conference on data Mining, PP. 360-368. 2001.

[14] Fadi G, Peter Cowling and Yonghon P., “MMAC: A New Multi-Class, Multi-Label Associative Classification Approach” IEEE Int. conference on data Mining, 2004.

[15] Fadi T, and Peter I. "Multi-Class Classification based on Association Rule" IEEE Int. conference on Computer systems and Applications (AICCSA), PP. 33-40, 2005.

[16] Jaber A, and Bassam H., "Enhanced CBA algorithm based on Apriori Optimization and statistical Ranking Measure", 28th Int. conference on vision 2020 (IBIMA), Nov. 2016.

[17] Waai Hadi, and Faisal A., "A new fast associative classification algorithm for detecting phishing websites", vol. 48, No. 16, PP. 729-734, Nov. 2016.

[18] Ambarasi M., "Enhanced Prediction of Heart Disease with Feature Subset Selection using Genetic Algorithm, IJESI, Vol. 2, 2010.

[19] Harleen K, Siri K., "Empirical study on applications of data mining techniques in healthcare", Int. journal of computer science, PP.194-200, 2006.

[20] Srinivas K, and Kavitha R., "Applications of data mining techniques in health care and prediction of heart attack", Int. Journal of Computer Sci. and Engg, vol.02, pp.250-255, 2010.

[21] Latha Parthiban, Subramanian R., "Intelligent heart disease prediction system using CANFIS and genetic algorithm", Int. journal of medical and health sciences, Vol.01, No:05, PP.278-281, 2007.

[22] Nidhi B, and Kiran J., "An analysis of heart disease prediction using different data mining techniques", IJET, Vol. 1, PP. 1-4, Oct. 2012.

[23] Pethalakshmi A., "Effective feature selection via featuristic genetic on heart data", Int. journal of computer science and engineering, Vol. 7, June 2012.

[24] Alladombaye N, and Lin Lei., "Comparative Study of Datamining Techniques on Heart Disease Prediction System: "Republic of chad" " Int. Journal Of Sci. and Research (IJSR), PP. 6-391, May 2016.

[25] Ankita R., "Heart disease prediction using ANN and improved k-means" IJET, Vol.19, PP. 3081-3085, Sep 2017.

[26] Basker M., "An intelligent and electronic system based classification and prediction for heart disease diagnosis", Int. Journal of Emerging Trends and Technology(IJETT) in Computer Science, May 2016.

[27] Wei W, and Jiong Y., "Efficient Mining of Weighted Association Rules (WAR)" Sixth Int. conference of ACM SIGKDD, PP. 270-274, Aug. 2000.

[28] Cai CH, and AWC Fu., "Mining Association rules with weighted items", Proc. IDEAS 98, July 1998.

[29] Wang Ke., "Item selection by "hub-authority" profit ranking", Int conference on KDD 2002, PP. 652.657.

[30] Robert., "Confabulation Theory"Artificial Intelligence Springer Series. pp. 419-426. 2006.

[31] Robert Hecht., "Cogent Confabulation" Neural Network in Elsevier, vol. 18, Issue. 2, PP. 111-115, 2005.

[32] Machine-learning-databases/heart-disease UCI: https://archive.ics.uci.edu/ml/machine-learning-databases/heart-disease/

[33] Reitermanova Z., "Data Splitting" proceeding of Contributed Papers WDS-10, Part 1, PP. 31-36, 2010.

Security Issues in Software Defined Networking (SDN): Risks, Challenges and Potential Solutions

Maham Iqbal[1], Farwa Iqbal[2], Fatima Mohsin[3], Dr. Muhammad Rizwan[4], Dr. Fahad Ahmad[5]
Department of Computer Science
Kinnaird College for Women, Lahore, Pakistan

***Abstract*—SDN (Software Defined Networking) is an architecture that aims to improve the control of network and flexibility. It is mainly connected with open flow protocol and ODIN V2 for wireless communication. Its architecture is central, agile and programmatically configured. This paper presents a security analysis that enforces the protection of GUI by requiring authentication, SSL/TLS integration and logging/security audit services. The role based authorization FortNOX and ciphers like AES and DES will be used for encryption of data and improving the security of SDN environment. These techniques are useful for enhancing the security framework of the controller.**

Keywords*—SDN; wireless SDN; security threats; AES; DES; FortNOX; TLS

I. Introduction

SDN has emerged as a flexible, secure and well-managed network. The architecture of SDN provides a central network control and its management via controller [1]. It segregates the data forwarding functions from the control plane of network. The control is transferred to a centralized controller to take decisions related to routing and then communicate those decisions to the data-forwarding plane [2]. Despite of all its features and functions, security of SDN is still considered to be a major concern. The configuration errors can lead to serious consequences as well as the aspects of programmability makes it vulnerable to attacks. The authentication, security and integrity of the network are severely affected. The architecture of SDN can be exploited to improve network security by providing security monitoring, analysis and response system [3]. The basic architecture has been shown in Fig. 1. SDN is cost-effective, dynamic, manageable and adaptable. Initially, it was being used for wired networks but with swift increase in the use of devices including smartphones and tablets has led to a great increase in data traffic in these devices. WLANs are used in homes, businesses and in public environments. There is a one-to-one mapping between a client and a light virtual access point with a unique and different BSSID. The client can switch control from one AP to another without any notification that connection was reestablished. There is no delay in communication or hardware as one device can move LVAP form one device or AP to another. This paper focuses on the security issues of SDNs. It presents some specific design issues of securing SDN. Subsequently, this paper also analyzes the state of software-defined security in order to improve the security properties which are confidentiality, integrity and availability [4]. The remaining paper is organized as follows. Section II provides a detailed literature review on SDN Section III contains problem statement, security issues in SDN. Section IV explains proposed methods and solutions, whereas Section V explains the results and further conclusions are drawn in Section VI.

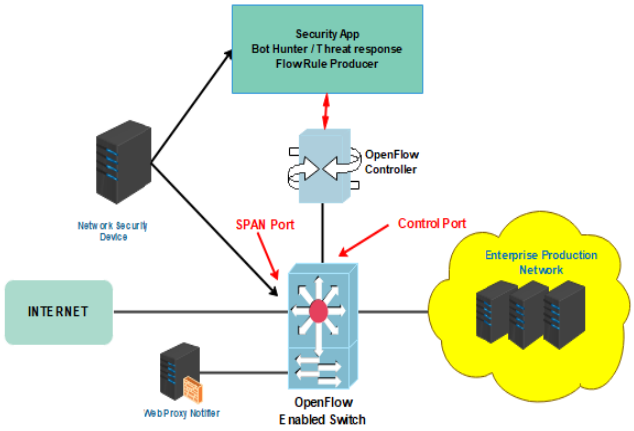


Fig. 1. SDN Structure.

II. Literature Reveiw

A. Security Issues in SDN

These are the main issues related to SDN

Forwarding Device Attack: The network traffic can be disturbed by access points or switches, which results in malicious users launching denial of service (DoS) attack that can result in network failure or disruption.

Threats in Control Plane: Due to the use of central controller, any problem arising in the network results in the failure of the central controller. The approach that is being used to solve this problem is to use either horizontal or hierarchical controller distributions.

Vulnerability of Communication Channel: SDN southbound API's such as Open Flow protocol uses TLS for data-control channel communication security but it is often disabled administratively and is prone to man-in-the middle attacks thus not suitable for implementation of channel security.

Fake Traffic Flows: A non-malicious faulty device or an attacker can launch this or DoS attack to dissipate the resources in forwarding devices or controllers.

Authenticity: It refers to the property that entities in networks are actually the ones they claim to be. The issue of

authenticity for forwarding devices in SDWN networks is similar to that in traditional networks; it can result as hindrance in network performance [2], [4].

Confidentiality: it prevents from the expose of information to unauthorized users, if not ensured can lead unauthorized users to access network information or data [5].

Availability: It means that authorized users can access data, devices, and services whenever they need.

Open Programmable API: The open nature of API makes the vulnerabilities more transparent to attackers.

Man-in-the-Middle-Monitors: The switches and the controllers are not directly connected for the transmission of information, which "man-in-the-middle" monitors can steal or misuse the information without being caught thus leading to black hole attack. Some of threats in SDN and their impact are shown in Table I.

B. Securing Wireless Software Defined Networks

SDN is decoupling the data plane form control plane thus providing efficient network management, thus replacing traditional networks. The present paper reviews the hard work and challenges required to enforce security in software defined networks. Distributed SDN network remains a concern for dependent networks at architecture level, as wireless SDN with wired SDN is discovering applications in multiple fields to provide centralized network and traffic engineering. Wireless SDN inherits both pros and cons of wired SDN with added concerns like large number of threats due to high monitoring overhead, multiple operator and users of network, security and compatibility [1] [6]. Here are some concerns related to wireless SDN.

- The network traffic can be disturbed by switches or access points and denial of service (DoS) attack can be launched by unauthorized users.
- Any problem in SDN controller can create problems in whole network as central controller is used.
- SDN API is susceptible to man-in-the middle attacks so is not suitable for implementation of channel security.
- Authentication and security is required in servers and compromise in this can put whole network operation in risk and danger.
- Authentication, integrity, security, efficient event detection, data and control plane consistency are very important in wireless networking and can be easily endangered.

Wireless SDN amidst all these concerns provide great opportunity for improving network security through global monitoring, real-time programmability. SDN's centralized control network provides with the facility of tracking and alleviating security threats. Central controller functionality can be easily distributed in different servers on network. Global network visibility provide a great view to check real-time network, statistics of traffic and help to fulfill the changing network security requirements.

TABLE. I. THREATS IN SDN

Attack	**Effected SDN Layer**	**Affected Security Aspect**		
		Availability	Confidentiality	Integrity
Distributed DoS Attack	Control, Data	×		
DoS Attack	Control, Data	×		
Hijacked Controllers	Control, Data, App	×	×	×
Malevolent Applications	App		×	×
Man-in-the-Middle	Control, Data, Link between control and data		×	×
Black Hole	Control, Link between control and data	×	×	
Eavesdropping	App, Control, Data		×	

C. Securing Software Defined Wireless Networks

Securing network is important requirement for any network whether it is SDN or traditional networks. SDWN physically separates the data and control planes of various elements in the wireless structure, and have a central controller for controlling the overall functions of network [7]. However, the centralized and fine-grained control that comes with SDWN introduces a greater risk of outages due to errors made by network administrators. In this paper, security threats in SDN and issues in architecture to make it secure and their counterparts are discussed. SDWNs bring the benefits of network programmability and logically centralized control, it is exactly these benefits that expose SDWNs to new threats or those treats that are harder to exploit in traditional networks. SDWN networking is responsible for providing effective network management, but unfortunately turn out to be more weak to attacks than traditional networks where authenticity, confidentiality, integrity, availability, consistency, control traffic of network is affected due to attacks on forwarding devices, controllers thus leading network vulnerable to security attacks and issues. The security issues in SDN can be controlled by using some approaches that are:

- The problem of forged attacks can be solved by an authentication mechanism.
- Applications require security model to separate data forwarding and network management resources thus role-based authorization like FortNOX can be used.
- Attacks by hackers or unauthorized person can be reduced by using security technology like TLS.
- Communication between controller and forwarding device can be encrypted to ensure confidentiality.
- Dos attacks can be mitigated by rate-limiting mechanisms and redundant controllers.

- Flow timeouts can be adjusted to decrease the effects of DoS attacks.
- Flow timeouts can be randomized to introduce unpredictable behavior, so the attacker cannot view states of network.

D. Security Analysis for SDN Environment

Software defined networks are replacing the traditional networking systems due to its centralized control approach. The privacy, integrity and confidentiality of the system may get affected due to the attacks on the system's vulnerabilities which ultimately reduce the performance and efficiency of the network [8]. This paper provides a security analysis to enforce security within SDN through attack graph and alert correlation model to lessen the false positive alerts. The security challenges to SDN include open programmable API in which the open nature of the API's makes the vulnerabilities more visible to the attackers. An unauthorized access to the central controller may cause a huge damage to the information and inject malicious codes into the system. More attacks faced by SDN consist of application layer attacks, control layer attacks and infrastructure layer attacks.

Application layer attacks include:

- **Rules insertion:** creating and implementing security rules for SDN in different domains lead to various conflicts.
- **Malicious Code:** injecting different programs lead to various attacks where attackers inject malicious code which leads to the corruption or loss of data.

Control layer includes the following attacks:

- **Denial of Service Attacks:** these attacks can occur at channel, controllers or between the controller and the switches.
- **Attacks from Applications:** the attacker who gets illegal access from the application layer gets the sensitive data about the network which leads to attacks against control layer.

Infrastructure layer attacks:

- **Dos Attack:** An attacker can dowse the buffer flow and the flow table by transmitting frequent large mysterious packets, which will generate new rules to be inserted into flow tables.
- **Man-in-the-middle Attack**: The switches and controllers are not directly connected for the transfer of information so the "man-in-the-middle" monitors can intercept important information without being detected ad can result in eavesdropping and black hole attack.

Security is analyzed through attack graph and alert correlation model. Attack graph measures the ability to overcome the attacks whereas the alert correlation model classifies the alerts.

E. SDN Architecture Impact on Network Security

The architecture of SDN separates the data plane from the control plane. It provides decisions for forwarding the datasets. The protocol being used for communication between SDB controller and network data is Open Flow. This paper discusses the features of SDN that can be used for improving the security of the network [3]. The automatic exposure of threats can be handles by reconfiguring flow tables in switches. An amalgam approach is based on the local and universal study of the traffic pattern. One of the methods for detecting the threats is called frequent set. The local frequent set analyzer is placed on SDN switch for the detection of threats. In this way, the malicious activities can be detected locally, and an appropriate action is executed in response. Along with it Global Frequent Analyzer is also used which is placed on the SDN controller. LFSA inserts new rules into the flow tables that plunge the packets which contain malicious data resulting in the reduction of attacks, protection from DoS attacks. These attacks are controlled more accurately in the access switch rather than the aggregation switch. The anticipated DFSA system that makes use of features of SDN network, can be used for effective and unswerving detection of numerous network attacks that are observed nowadays in IP networks.

F. Securing Software Defined Networks

In this paper, many exterior and interior threats are being explored in the architecture of SDN. As the integrity and security of SDN is still not proven in terms of the functionality management settlement in a single central server. Cyber-attacks which are launched throughout SDN have bigger destructive effects as compared to simple networks [9].

Every layer of SDN architecture has its separate requirements of security such as the configuration errors. If these requirements are not provided, they may result in various categories of security threats and attacks. The communication flooding attack linking the switch and the controller will have an effect on all the corresponding three layers. The upper three layers can be affected from the policy enforcement security attacks. Authorization attacks may result in prohibited access to the controller.

For a safe SDN environment, it is necessary to make sure that every component of SDN is secured. The primary task is to ensure that the SDN controller is secured as it controls the complete management of the network. The operating system should also be secured. If the SDN controller gets compromised, it will cause the failure of the whole network. The flow model of SDN should be secured by encrypting the flows so that the injection of malicious flows is avoided. An SDN agent constitutes the environment therefore its security is very essential. The installation of identity management modification techniques and threat isolation is the main requirement. IPS, IDS, and firewalls should be dynamically updated. The communication channel must be protected between each layer. Secure coding, digital signing of the code and deployment of integrity checks are the security measures taken for this purpose.

G. Critical Analysis

Approximately 64% of the false positive alerts are reduced by the alert correlation when compared with the original false positive alert. Security analysis is performed by the combined use of the attack graph and alert correlation method [8]. TLS uses better algorithms for providing security between control plane and data plane as compared to SSL but unfortunately many implementations of TLS/SSL undergo man-in-the-middle attacks. Hence, TSL may not be the optimal choice because it may fail to handle the future security issues [1]. Role based authorization, FortNOX, is a potential solution for the authorization and authentication concerns of network resources. It resolves the situation for the controller to handle inconsistent flow rules from the two different applications. Nevertheless, role-based authorization is not sufficient to deal with the complexity of SDWN to isolate applications or resources [7]. The conflicts in an SDN firewall are resolved by checking firewall authorization. The conflict resolving strategies differ from the processes which are involved in the flow entries and flow rules. The effectiveness and efficiency of the proposed approach is examined using header space analysis [9] [10].

III. Problem Statement

Applying SDN to improve performance, scalability of network is being widely used in industry for some years, for both wired and wireless connections. One of the challenges of SDN is to ensure the quality of service for various functions of network by resisting against intrusions, malicious attacks and liabilities, how to develop an authentication between a control plane and a data plane and how the sufficient security services can be provided in networks in future in an economic way [5].

IV. Proposed Solution

A hybrid approach including the data link layer, control link layer and encryption would be used for ensuring a much better security of SDN.

A. Security of Control Plane in Network

FortNOX is a security enforcement kernel responsible for implementing role-based verification to regulate the authorization of each OF applications [11]. The major work is to secure the programming and it directly impacts the application and control layer and on communication between these layers. Another t contribution of FortNOX is to conflict rules from different applications in network thus resolving issues in control layer and north and south bound interfaces. It uses the controller to define three standard authorization roles among the flow rule producers

1) OF Operator Role–define imposing the policy of security

2) OF Security Role-flow constraints are added to fight against live threat activity

3) OF Application Role–authorization of OF Applications

The basic architecture of FortNOX is shown in Fig. 2.

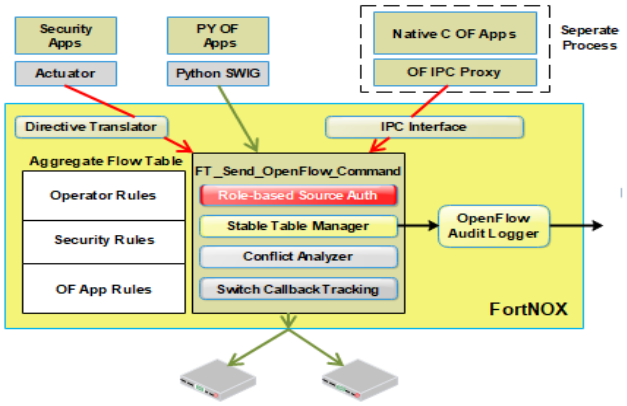


Fig. 2. Architecture of FortNOX.

B. Transport Lyer Security Protocol

The use of Transport Layer protocol for ensuring the security of SDN aims to protect the privacy of information communicated over the internet between the data and the control plane [10] [12]. For managing the authentication, the server has to prove its identity to the client and the client needs to prove its identity to the server by using the private keys. These keys are created using the cypher suites for encrypting the information. The message authentication code (MAC) is applied to the outgoing messages and are verified at the receiving end. The basic working of TLS is shown in Fig. 3.

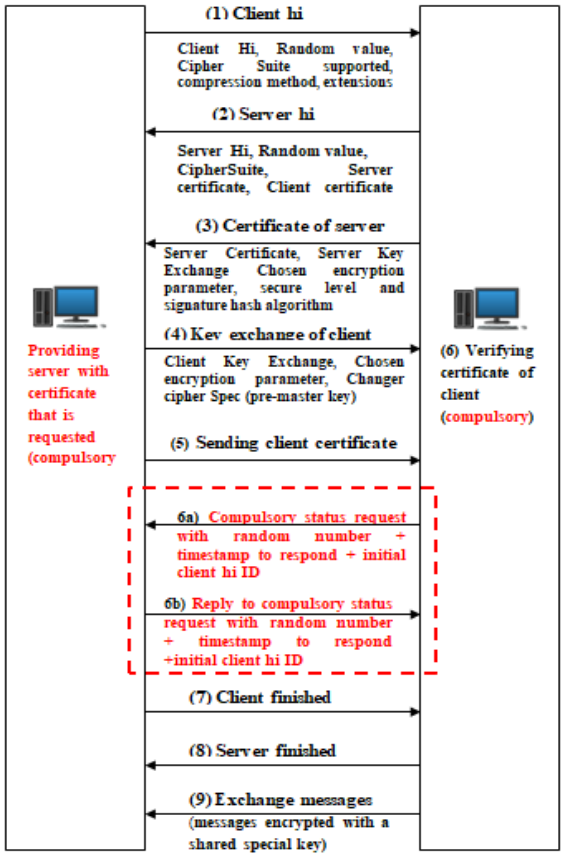


Fig. 3. Working of TLS.

C. Encryption of Data

a) Advantages of Encryption: Encryption is used to attain complete security. Data is most defenseless when it is being transmitted from one location to another. Encryption works during data transmission, in order to shield delicate data, including personal information for individuals. Encrypted data maintains integrity of data by informing the recipients of the data to detect the corruption or cyber-attack. It aids in ensuring privacy and decreasing chances for surveillance by both government agencies and criminals.

Advanced Encryption Standard: AES is a symmetric block cipher used for the protection of classified information by the encryption and decryption of sensitive data. By encryption data is changed into cipher text while decryption transforms cipher text into text form of data, it is applied in hardware and software to protect digital information in several forms data, audio, video etc. from unauthorized users. As it is a security protocol, therefore it is commonly used for wide range of applications such as wireless communication, financial transactions, e-business, encrypted data storage etc. However, AES is difficult to implement in software as it takes both performance and security into considerations since every block is always encrypted in the same way. The basic working of AES is shown in Fig. 4.

b) Data Encryption Standard: Data Encryption Standard or DES is a symmetric block cipher. It takes 64-bit plain text and 56-bit key as input and produces 64-bit cipher text as output. In DES, encryption and decryption uses the same algorithm. The key is taken in opposite order.. An attack on a 56-bit key in encryption is impractical. However, DES is insecure beacuse the 56-bit key size being too small. DES is a very slow algorithm such that Triple DES (3DES) [12] [13].

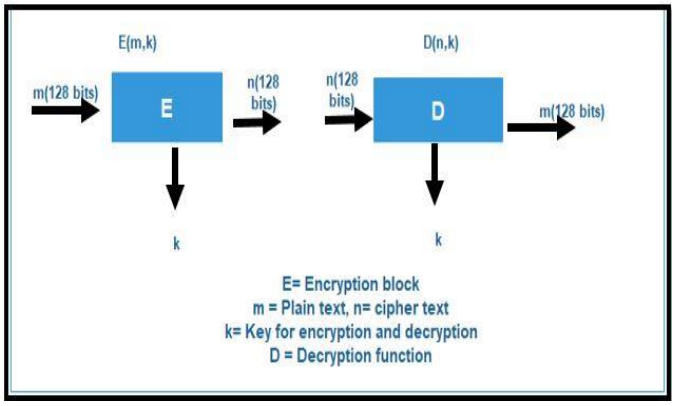


Fig. 4. Working of AES.

V. Result Discussion

The TLS protocol is used to provide encryption, authentication, and data integrity. TLS provides particular alerts about problems with a session and documents when these certain alerts are sent. Transport layer Security is divided into two layers Record and handshake and uses public key cryptography to ensure a secured communication. Client sends requests to server who respond with information that is required for its authentication, both, client and server exchanges several keys and client's authentication key is stored. The use of extended security system of TLS protocol provides a more secure data communication between the client and the server. It protects the loss of data by man-in-the-middle attacks. An additional feature of time stamp indicates the entry of each packet in the network. The time stamp measures the delay and packet loss thus reducing the loss of data as no exchange of metadata occurs between the switches. Once the authentication block is over, and client's authentication is given a CA certificate secured communication is established, but it just ensures secure delivery of data but does not secure data for which encryption of data is necessary which is done through AES and DES ciphers. DES uses cryptographic key for block of a code, it converts the message into 64-bit blocks. These blocks are then encrypted into key whereas decryption in it is done by using the encryption process in reverse, whereas AES uses same key to encrypt and decrypt [14] [15]. FortNOX – A new security enforcement kernel for OF networks is used in SDN to ensure secure data communication. It assigns a key to the devices in network and stores that key or rule. It checks the key of devices that make a request for information, if key does not match it generates an error otherwise access to information is given.

VI. Conclusion

The emergence of the Software-defined network has overcome the requirement and need of secure, trustworthy, flexible and well-managed networks. However, due to the separation of the two planes, SDN is vulnerable to more attack vectors than traditional networks. This means that the availability, consistency, authenticity, confidentiality, and integrity of network and control traffic could be rigorously affected. This paper highlights some of the basic threats to the SDN and discusses various solutions which have been suggested. WSDN also suffers security concerns which are much similar to the framework of wireless SDN along with the issues that arises by using wireless medium. Moreover, in spite of risks or issues, the security benefits in a centralized SDN framework are being exploited by research efforts, which are real-time programmability and global traffic monitoring capability.

REFERENCES

[1] T. Bakhshi, "Securing Wireless Software Defined Networks: Appraising Threats, Defenses & Research Challenges," in In 2018 International Conference on Advancements in Computational Sciences (ICACS), 2018.

[2] C. W, L. A and W. P, "A roadmap for traffic engineering in SDN-OpenFlow networks. Computer Networks," pp. 1-30, 2014.

[3] C. K., W. J. and K. S. , "SDN Architecture Impact on Network Security," in Federated Conference on Computer Science and Information Systems, 2014.

[4] K. D, R. F. and V. P. , "Towards secure and dependable software-defined networks," in Proceedings of the second ACM SIGCOMM workshop on "Hot topics in software defined networking, 2013.

[5] Y. Zheng and P. Zhang, "A security and trust framework for virtualized networks and software-defined networking," Security and communication networks, pp. 3059-3069, 2016.

[6] R. . M. F. and K. D, "Software-Defined Networking: A Comprehensive Survey," in Proceedings of the IEEE, 2015.

[7] H. Daojing , . S. Chan and M. Guizani, "Securing software defined wireless networks," IEEE Communications Magazine, pp. 20-25, 2016.

[8] El Moussaid, T. N and El Azhari, "Security Analysis as Software-defined Security for SDN Environment," in Fourth International Conference on IEEE, 2017.

[9] A. A, A. E and G. A, "Securing Software Defined Networks: Taxonomy, Requirements, and Open Issues," IEEE Communications Magazine, vol. 53(4), pp. 36-44, 2015.

[10] Belema Agborubere and Erika Sanchez-Velazquez, "OpenFlow Communications and TLS Security in Software-Defined Networks," in IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData), 2017.

[11] Phillip Porras, Seungwon Shin and Martin Fong, "A Security Enforcement Kernel for OpenFlow Networks," in Proceedings of the first workshop on Hot topics in software defined networks, 2012.

[12] A. e. a. S, "A Survey of securing Networks Using Software Defined Networking," in IEEE Trans. Reliability, 2015.

[13] K. K and S. F, "Distributed Attack Graph Generation," in IEEE Transactions on Dependable and Secure Computing, 2016.

[14] S.-H. S and S. S, "A survey of security in software defined networks," in IEEE Communications Surveys & Tutorials, 2016.

[15] H. J., "Taxonomic Modeling of Security Threats in Software Defined Networking," in In BlackHat Conference, 2015.

MVC Frameworks Modernization Approach

Adding MVC Concepts to KDM Metamodel

Amine Moutaouakkil[1], Samir Mbarki[2]
MISC Laboratory. Faculty of Science
Ibn Tofail University
Kenitra, Morocco

***Abstract*—The use of web development frameworks has grown significantly, specially the Model-View-Controller (MVC) based frameworks. The ability to immigrate web applications between different frameworks available becomes more and more relevant. The automation of the migration through transformations avoid the necessity to rewrite the code entirely. Architecture Driven Modernization (ADM) is the most successful approach that standardizes and automates the reengineering process. In this paper, we define an ADM approach to generate MVC web applications models in the highest level of abstraction from Struts 2 and Codeignitter Models. To do this, we add the MVC concepts to the KDM metamodel and then we specify a set of transformations to generate MVC KDM models. This proposal is validated through the use of our approach to transform CRUD (Create, Read, Update and Delete) applications models from MVC frameworks to MVC KDM.**

Keywords*—Framework; Architecture-Driven Modernization (ADM); Knowledge Discovery Model (KDM); Model-View-Controller (MVC)

I. Introduction

Web technology systems are the most used IT solutions in Business management.

More web applications are made with the use of MVC frameworks, these frameworks are constantly evolving, and new frameworks are available. The frameworks: CodeIgniter for PHP language and Struts 2 for Java language are very used. The need to immigrate both from and to these frameworks is increasing.

The existence of a standardized and automatic process of reengineering will minimize time and costs.

Object Management Group (OMG) [1] has proposed the Architecture-driven Modernization (ADM) [2] initiative to enhance the classical reverse engineering processes by introducing the Model-driven Architecture (MDA) [3] concepts. Like the MDA approach which gives the models leading role, the ADM approach formalizes the RE [4] processes by introducing models based concepts.

It is necessary to realize methods for migrating MVC Frameworks based Web applications and define a way to represent the MVC information at a higher abstraction level. But currently there are no relied ADM based approach making it.

We defined an ADM based approach to represent MVC web systems in form of KDM models. This approach takes advantage of the potential of the Architecture Driven Modernization (ADM) to modeling the knowledge which will be extracted from the source code.

In this paper, we describe the generation of models to represent MVC web systems at the highest level of abstraction. The rest of this paper is organized as follows: Section 2 describes the process based on the ADM approach and describes their different phases. In Section 3, we illustrate our proposed approach by a case study and make the analysis of the process result. Then, we list some interesting related works. Finally, Section 4 concludes the work and presents the perspectives.

II. Research Method

A. MDRE

MDRE [5] is the application of Model Driven Engineering (MDE) principles and techniques to RE in order to get model based views from legacy systems. The MDRE is based on two main phases: Model Discovery which is extracting information from source code by using parsers, and then represents this information in form of models. And Model Understanding which is applying Model to Model transformations on extracted information to get a higher abstraction level presentation of the information.

B. ADM

Architecture Driven Modernization (ADM) is an initiative proposed by OMG to standardize and automate the reengineering process. ADM is based on three standards meta-models to represent the information involved in a software reengineering process. In the current study, only Knowledge Discovery Meta-Model (KDM) is useful for the purpose. KDM [6] allows defining models at a higher abstraction level representing semantic information about a software system.

C. Model Understanding

Model understanding consists in the transformation of models to get higher abstract models. In our study, we need to make two transformations:

Apply model to model transformation on the PSM Struts 2 model to get PIM MVC KDM model.

Apply model to model transformation on the PSM CodeIgniter model to get PIM MVC KDM model.

D. QVT Transformation Standard

QVT (Query/View/Transformation) [7] is a standard set of languages for model transformation defined by the OMG.

The QVT standard defines three model transformation languages. All of them operate on models which conform to Meta-Object Facility (MOF) 2.0 metamodels; the transformation states which metamodels are used.

QVT-Operational which we use, it is an imperative language designed for writing unidirectional transformations.

Model Extraction Process is shown in "Fig. 1".

E. Related Works

More and more research projects use the mechanisms offered by the MDA, in among these projects include, e.g.:

- ADM-Based Hybrid Model Transformation for Obtaining UML Models from PHP Code [8].
- Validation of ATL Transformation to Generate a Reliable MVC2 Web Models [9].
- A Model Driven Approach for Modeling and Generating PHP CodeIgniter based Applications [10].
- MoDisco Project [11].
- Reverse Engineering Applied to CMS-Based Web Applications Coded in PHP: A Proposal of Migration [12].

ADM-Based Hybrid Model Transformation for Obtaining UML Models from PHP Code (2019): This paper defines a model transformation process which performs reverse engineering of PHP web-based applications. The model transformation is expressed in ATL [13] (Atlas Transformation Language). The obtained models are expressed in UML.

Validation of ATL Transformation to Generate a Reliable MVC2 Web Models (2017): This paper defines an ADM-based method to generate automatically an MVC2 web model at PSM level which respects the architecture of MVC2 pattern. In This method, a mapping between PSM and PIM metamodels is defined then the transformation script from Struts2 to UML is written In ATL transformation language.

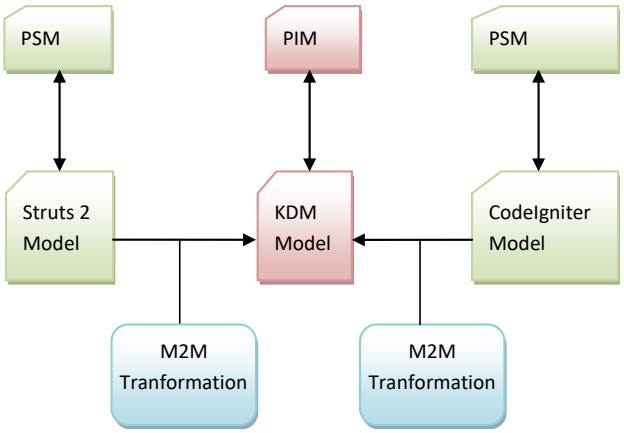


Fig. 1. Models Extraction Process.

A Model Driven Approach for Modeling and Generating PHP CodeIgniter based Applications (2017): This paper defines a Model Driven approach to model the CodeIgniter PHP framework and generate CRUD applications based on this framework. This method uses model transformations.

MoDisco Project (2014): Modisco provides the capability of extracting information from Java software artifacts, The model resulting will conform to meta-model included in Modisco. KDM Models can be extracted using Modisco. KDM allows representing the entire software system and all its entities at both structural and behavioral levels. Modisco is one of rare tools that apply the ADM principles in real. Unfortunately, the current Modisco version does not include any specific support for MVC architecture.

Reverse Engineering Applied to CMS-Based Web Applications Coded in PHP: A Proposal of Migration (2013): This paper defines an ADM-based method for migrating open-source PHP CMS-based Web applications. In the reverse engineering phase, ASTM models are extracted from the PHP code by text-to-model (T2M) transformation made by a source code parser, then KDM models are obtained from ASTM models by model-to-model (M2M) transformation. Finaly CMS model is obtained by using M2M transformations. All M2M transformations are implemented using ATL Transformation Language.

According to the related works we can conclude that ADM approaches that handle MVC structure are inexistent. "Modisco" approach does not offer any support for MVC. The approach "Reverse Engineering Applied to CMS-Based Web Applications Coded in PHP: A Proposal of Migration" uses a CMS metamodel to represent the CMS concepts of a CMS based web system. This logic is avoided in our approach because creating a specific metamodel to represent CMS based web systems or MVC based web systems in our case will contradict the abstraction logic that we want to set, instead of this the use of a metamodel such as KDM that is standardized by OMG is more convenient. In "Modisco Project", "Reverse Engineering Applied to CMS-Based Web Applications Coded in PHP: A Proposal of Migration" as well as "Validation of ATL Transformation to Generate a Reliable MVC2 Web Models" approaches ATL language is used to realize M2M transformations, instead of ATL, our approach uses the QVT language, which is newer and OMG standardized language.

F. The Method Principle

The main idea of our approach is the use of the QVT transformation language to perform Model to Model transformation from MVC web frameworks models to MVC KDM models. Two tasks that the approach will make: The Adaptation of the KDM metamodel by adding MVC concepts, then mapping MVC web frameworks metamodels elements to MVC KDM metamodel elements and then use the mapping to write the QVT transformation script.

G. Struts 2 Framework Metamodel

Apache Struts 2 [14] is an open-source, MVC framework for creating Java web applications. Struts 2 extend the Java Servlet API.

Based on [15], a Struts 2 Framework meta-model “Fig. 2” is defined. This metamodel “Fig. 3” will be useful in our approach.

H. Codeignitter Framework Metamodel

CodeIgniter [16] is a PHP MVC pattern based open-source framework. The MVC pattern structures the development by separating the application logic and the presentation layer. Compared to other PHP frameworks, Codeigniter is known to be fast and light.

Based on [17], a CodeIgniter Framework meta-model “Fig. 4” is defined. This metamodel “Fig. 5” will be useful in our approach.

I. KDM

KDM is a standard defined by OMG for the representation of software systems. This is a meta-model “Fig. 7” allows to represent systems artifacts in a high level of abstraction.

The KDM specification consists of 12 packages that are arranged into the following four layers “Fig. 6” [18]:

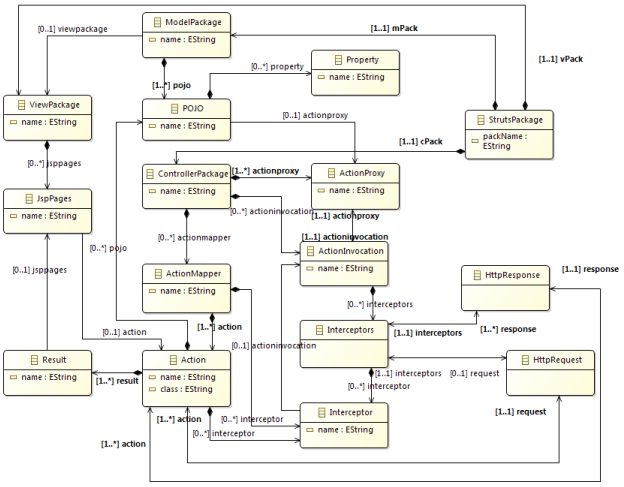


Fig. 2. Struts 2 Meta-Model.

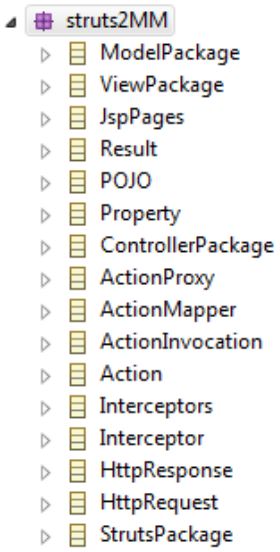


Fig. 3. Struts 2 Ecore Meta-Model.

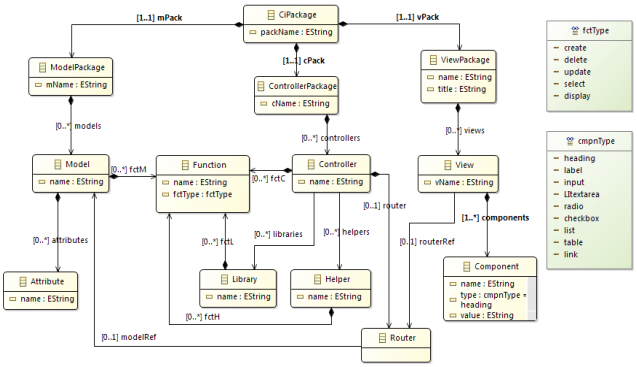


Fig. 4. CodeIgniter Meta-Model.

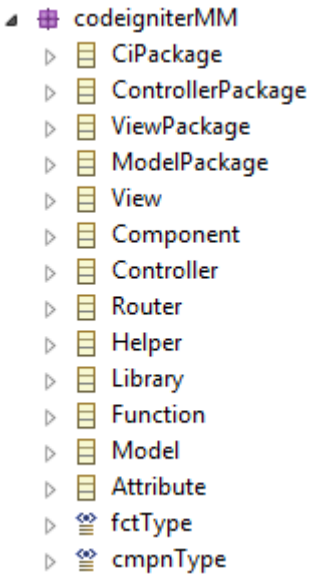


Fig. 5. CodeIgniter Ecore Meta-Model.

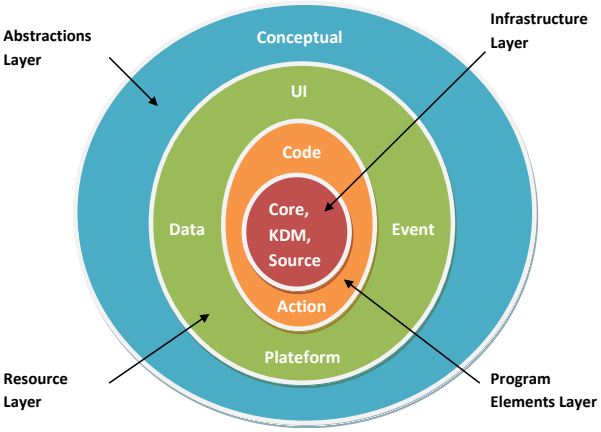


Fig. 6. KDM Meta-Model Layers

We can notice that the KDM metamodel does not give a representation of MVC architecture elements.

J. KDM MVC Package

In our approach we add a MVC package “Fig. 8”. The MVC package represents MVC architecture elements as: models, view and controller.

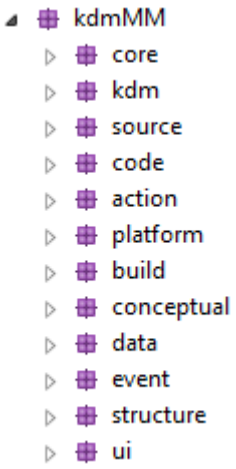


Fig. 7. KDM Ecore Meta-Model Provided by OMG.

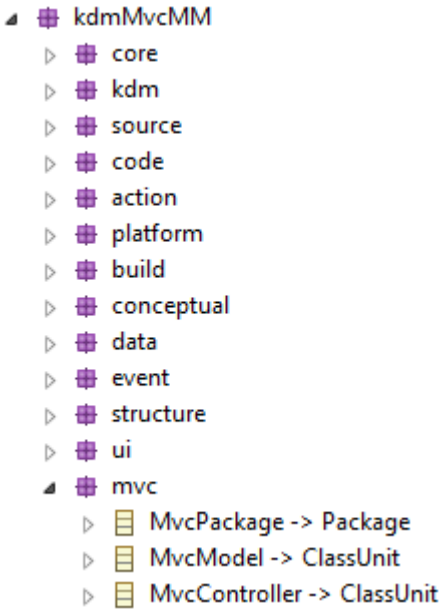


Fig. 8. MVC KDM Ecore Meta-Model.

K. Struts 2 to KDM QVT-O Transformation Script

We have defined a mapping table "Table I" between Struts 2 model elements and KDM model elements.

TABLE. I. STRUTS 2 ELEMENTS TO KDM MVC ELEMENTS MAPPING

Struts 2 element	MVC KDM element
StrutsPackage	code::CodeModel
ModelPackage	mvc::MvcPackage
POJO	mvc::MvcModel
ControllerPackage	mvc::MvcPackage
ActionMapper	mvc::MvcController
ViewPackage	mvc::MvcPackage
JspPages	code::ClassUnit
Property	code::StorableUnit
Action	code::MethodUnit

Based on the mapping table, we have written a QVT-O transformation script to map Struts 2 model elements to MVC KDM model elements.

```
modeltype STR uses 'http://struts2MM';
modeltype KDM uses 'http://kdmMvcMM';
transformation struts2kdmmvc(in str : STR, out
KDM);

main() {
 str.rootObjects()[STR::StrutsPackage]->map R00();
}

mapping STR::StrutsPackage::R00() :
KDM::kdm::Segment {
       model += self.map R0();
}

mapping STR::StrutsPackage::R0() :
KDM::code::CodeModel {
  codeElement += self.getModelPackage()->map R1();
  codeElement += self.getControllerPackage()->map
                        R2();
  codeElement += self.getViewPackage()->map R3();
              result.name := self.packName;
}

mapping STR::ModelPackage::R1() :
KDM::mvc::MvcPackage {
       name := self.name;
       type := "Model";
        codeElement += self.getModels()->map R11();
}

mapping STR::POJO::R11() : KDM::mvc::MvcModel {
 name := self.name;
 codeElement += self.getMdlProperties()->map R4();
                        }
mapping STR::Property::R4() :
KDM::code::StorableUnit {
       name := self.name;
}

query STR::StrutsPackage::getModelPackage() :
OrderedSet(STR::ModelPackage) {
       return
self.subobjects()[STR::ModelPackage]-
>asOrderedSet()
                        }
query STR::ModelPackage::getModels() :
OrderedSet(STR::POJO) {
       return self.subobjects()[STR::POJO]-
>asOrderedSet()
                        }
query STR::POJO::getMdlProperties() :
OrderedSet(STR::Property) {
       return self.subobjects()[STR::Property]-
>asOrderedSet()
}
…
```

L. Codeigneitter to KDM QVT-O Transformation Script

We have defined a mapping table "Table II" between CodeIgniter model elements and MVC KDM model elements.

Based on the mapping table, we have written a QVT-O transformation script to map CodeIgniter model elements to KDM model elements.

```
modeltype CI uses 'http://codeigniterMM';
modeltype KDM uses 'http://kdmMvcMM';
transformation codeigniter2kdmmvc(in ci : CI, out
KDM);

main() {
        ci.rootObjects()[CI::CiPackage]->map R00();
}

mapping CI::CiPackage::R00() : KDM::kdm::Segment {
        model += self.map R0();
}

mapping CI::CiPackage::R0() : KDM::code::CodeModel {
  codeElement += self.getModelPackage()->map R1();
  codeElement += self.getControllerPackage()->map
R2();
  codeElement += self.getViewPackage()->map R3();
  result.name := self.packName;
}

mapping CI::ModelPackage::R1() : KDM::mvc::MvcPackage
{
        name := self.mName;
        type := "Model";
        codeElement += self.getModels()->map R11();
}

mapping CI::Model::R11() : KDM::mvc::MvcModel {
 name := self.name;
 codeElement += self.getMdlAttributes()->map R4();
}

…

mapping CI::Attribute::R4() : KDM::code::StorableUnit
{
        name := self.name;
}

query CI::CiPackage::getModelPackage() :
OrderedSet(CI::ModelPackage) {
        return self.subobjects()[CI::ModelPackage]-
>asOrderedSet()
}

query CI::ModelPackage::getModels() :
OrderedSet(CI::Model) {
        return self.subobjects()[CI::Model]-
>asOrderedSet()
}

query CI::Model::getMdlAttributes() :
OrderedSet(CI::Attribute) {
        return self.subobjects()[CI::Attribute]-
>asOrderedSet()
}
```

TABLE. II. CODEIGNITER ELEMENTS TO KDM MVC ELEMENTS MAPPING

CodeIgniter element	MVC KDM element
CiPackage	code::CodeModel
ModelPackage	mvc::MvcPackage
Model	mvc::MvcModel
ControllerPackage	mvc::MvcPackage
Controller	mvc::MvcController
ViewPackage	mvc::MvcPackage
View	code::ClassUnit
Attribute	code::StorableUnit
Function	code::MethodUnit

III. DISCUSSION

In the ADM approach, KDM is very important. This meta-model allows representing the structural and semantic aspect of the software systems artifacts in the higher possible level of abstraction.

Being represented in form of KDM model, thanks to its high level abstraction, the immigration of an MVC web system to another platform becomes easier. Adding MVC concepts to KDM metamodel will also enlarge its domain of application and allows to more systems to be modeled in a higher level of abstraction. Obtained results correspond to our aim goal which was to represent MVC web systems in a high level abstract way.

IV. RESULTS

A. Case Study Example

Both of CodeIgniter and Struts 2 give the possibility to manage basic CRUD operations through their predefined structures. So, our approach, takes a basic CRUD example as a case study.

1) Struts 2 model "Fig. 9":

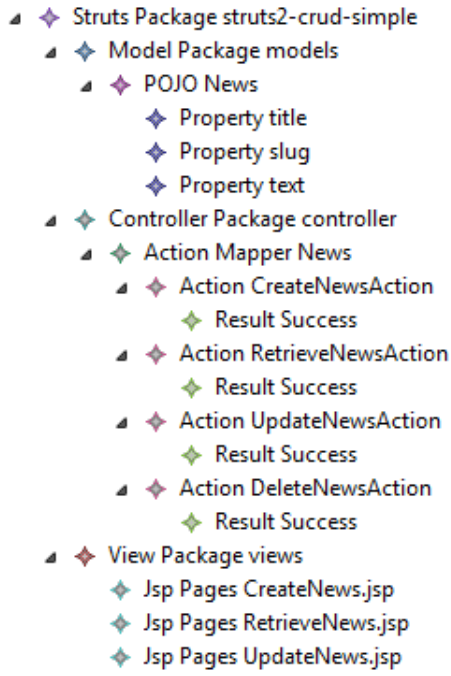


Fig. 9. Stuts2 CRUD Example.

2) CodeIgniter model "Fig. 10"

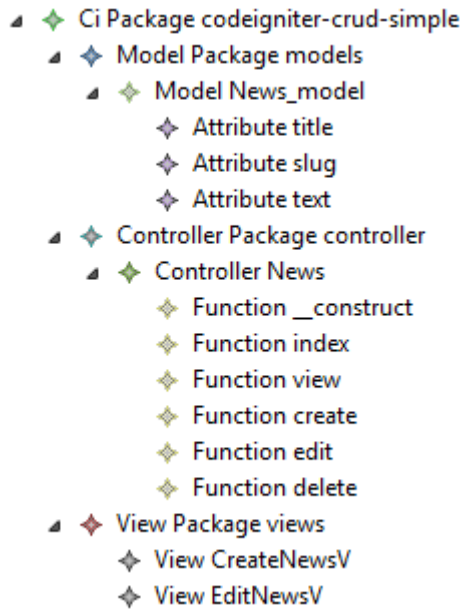


Fig. 10. Codeignitter CRUD Model Example.

B. Results

1) MVC KDM model obtained from Struts 2 models "Fig. 11".

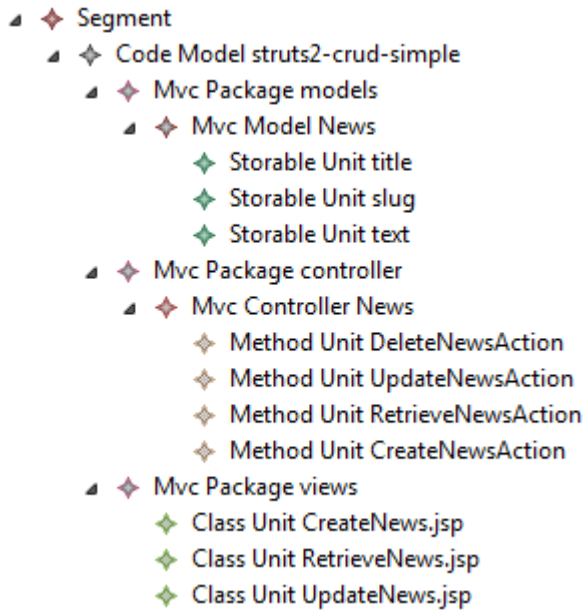


Fig. 11. MVC KDM Model Obtained from Struts2 CRUD Model.

2) MVC KDM model obtained from CodeIgniter models "Fig. 12"

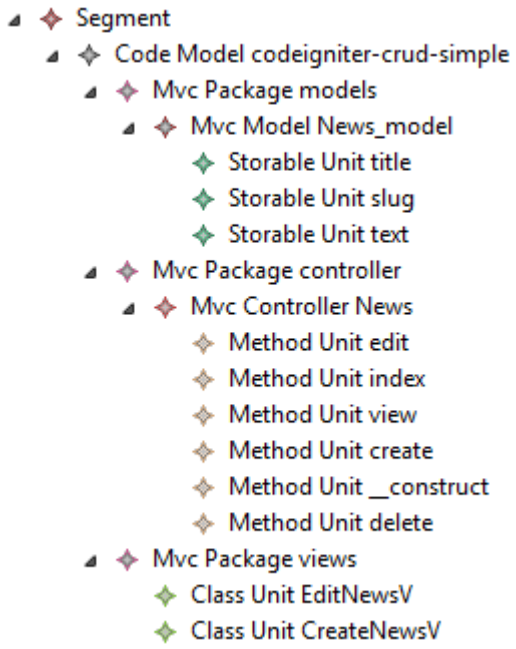


Fig. 12. MVC KDM Model Obtained from CodeIgniter CRUD Model.

V. Conclusion

This paper presented an ADM based approach that Adds MVC Concepts to KDM metamodel.

This approach is composed of two phases: 1) adding MVC main concepts to the KDM metamodel, 2) Generation of KDM models, KDM models are generated from Struts 2 and CodeIgniter models by means of M2M transformations. For the implementation of the Generation of KDM models phase we have implemented transformation rules using QVT-Operational language.

The major contribution is the adding of the MVC concepts to the KDM metamodel and the use of the QVT transformation language defined by the OMG to realize transformations between platforms. Using this approach reduces the necessary time to migrate the MVC web applications. As a future work, we will perform similar approach to other MVC platforms and we will realize the reverse way which is the generation of a specific MVC web system from KDM abstract models.

References

[1] Object Management Object (OMG) . [Online]. Available: http://www.omg.org/.

[2] Architecture Driven Modernization (ADM) . [Online]. Available: http://adm.omg.org/.

[3] A. Kleppe, J. Warmer, W. Bast, "MDA Explained: The Model Driven Architecture: Practice and Promise". Addison-Wesley Professional. January 2003.

[4] E. J. Chikofsky, J. H. Cross II, "Reverse engineering and design recovery: A taxonomy," IEEE Software. vol 7, issue 1 , pp. 13-17, January 1990.

[5] C. Raibulet, F. Arcelli Fontana, M. Zanoni, "Model-Driven Reverse Engineering Approaches : A Systematic Literature Review," IEEE Access. vol 5 , pp. 14516-14542, December 2017.

[6] Knowledge Discovery Meta-Model specification of the OMG. [Online]. Available: http://www.omg.org/spec/KDM/1.3.

[7] I.Arrassen, A.Meziane, R.Sbai, M.Erramdani, "QVT transformation by modeling : From UML Model to MD Model," International Journal of Advanced Computer Science and Applications (IJACSA). vol 2, issue 5, pp. 7-14, January 2011.

[8] A. Elmounadi, N. Berbiche, N. Sefiani, N. El Moukhi, "ADM-Based Hybrid Model Transformation for Obtaining UML Models from PHP Code," International Journal of Embedded Systems (IJES). vol 7, issue 1, pp. 32-41, January 2019.

[9] S. Mbarki, M. Rahmouni, "Validation of ATL Transformation to Generate a Reliable MVC2 Web Models," International Journal of Engineering and Applied Computer Science (IJEACS). vol 2, issue 3, pp. 83-91, March 2017.

[10] K. Arrhioui, S. Mbarki, O. Betari, S. Roubi and M. Erramdani, "A Model Driven Approach for Modeling and Generating PHP CodeIgniter based Applications," Transactions on Machine Learning and Artificial Intelligence (TMLAI). vol 5, issue 4, pp. 259-266, August 2017.

[11] H. Brunelière, J. Cabota, G. Dupé, F. Madiot, "MoDisco: a Model Driven Reverse Engineering Framework," Information and Software Technology, Elsevier, vol 56, issue 8, pp. 1012-1032, April 2014.

[12] FF. Trias, V. de Castro, M. López-Sanz, and E. Marcos, "Reverse Engineering Applied to CMS-Based Web Applications Coded in PHP: A Proposal of Migration. Evaluation of Novel Approaches to Software Engineering," 8th International Conference (ENASE). Angers. pp. 241-256, July 2013.

[13] M. Rahmouni, S. Mbarki, "MDA-Based ATL Transformation to Generate MVC 2 Web Models," Int. J. Comput. Sci. Inf. Technol., vol 3, issue 4, pp. 57–70, August 2011.

[14] Apache Struts Framework. [Online]. Available: https://struts.apache.org/.

[15] S. Mbarki, M. Rahmouni, "Validation of ATL Transformation to Generate a Reliable MVC2 Web Models," International Journal of Engineering and Applied Computer Science (IJEACS). vol 2, issue 3, pp. 83-91, March 2017.

[16] Codeigniter Web Framework. [Online]. Available: https://www.codeigniter.com/.

[17] K. Arrhioui, S. Mbarki, O. Betari, S. Roubi and M. Erramdani, "A Model Driven Approach for Modeling and Generating PHP CodeIgniter based Applications," Transactions on Machine Learning and Artificial Intelligence (TMLAI). vol 5, issue 4, pp. 259-266, August 2017.

[18] KDM Technical Overview from KDM Analytics. [Online]. Available: http://kdmanalytics.com/resources/standards/kdm/technical-overview/

Validation Policy Statement on the Digital Evidence Storage using First Applicable Algorithm

Achmad Syauqi[1]
Department of Information System
Universitas Peradaban
Brebes, Indonesia

Imam Riadi[2]
Department of Information System
Universitas Ahmad Dahlan
Yogyakarta, Indonesia

Yudi Prayudi[3]
Department of Informatics
Universitas Islam Indonesia
Yogyakarta, Indonesia

***Abstract*—Digital Evidence Storage is placed to store digital evidence files. Digital evidence is very vulnerable to damage. Therefore, making digital evidence storage need access control. Access control has several models, one of them is ABAC (Attribute-Based Access Control). ABAC is a new access control model. ABAC model has a flexible function, allows intersect with many attributes. This will be very complex and causing inconsistency and incompleteness. Access control testing is a must before access control is implemented because it is the main key in the security of a system. Especially in digital evidence storage because the data in it is very vulnerable to damage either intentionally or not. The type of access control that is widely used is ABAC because this ABAC model has a flexible function. This ABAC model intersects with many attributes, it is necessary to test the policy statement. This test is carried out to avoid inconsistencies and incompleteness in the policy statement. An example tool for testing policy statements is ACPT (Access Control Policy Testing). At ACPT there are various algorithms for creating and testing policy statements. This study uses the first applicable algorithm to test policy statements in digital evidence storage. This research has successfully tested the policy statement properly and found no inconsistencies and incompleteness.**

Keywords*—Testing; policy statement; rule; ABAC; digital evidence

I. Introduction

Storing a file is important and has rules. [1] ne example is digital evidence. Digital evidence is very vulnerable to damage and very possible data changes [2]. A system must be safe, especially from attacks [3] and avoid cybercrime [4]. Therefore, to making digital evidence storage (DES), special security is needed. The digital evidence contained within them will be guaranteed safety with security. [5] Redfield has researched the process of recording and storing digital evidence. They introduced the Gringgotts scheme to a system to maintaining integrity in the recording process, transfer and data storage with the digital signatures as data security from the digital evidence file. The digital evidence file is guaranteed authenticity and can be accounted for before the court.

DES must be made to make it easier for users. data storage, a web-based graphical user interface, and an API endpoint so practitioners can analysis the schedule actions on clients and view and process data. [6].

Digital evidence cannot be accessed by any user, so the DES needs to be added with access control. Access control has several models, one of them is ABAC (Attribute-Based Access Control). ABAC is a new access control model. ABAC model has a flexible function. So ABAC is used as an access control model that is widely used in security systems now and for years to come.

ABAC model has a flexible function, allows intersect with many attributes. This will be very complex and causing inconsistency and incompleteness. ABAC model is possible for a user who should have permit access rights to change to deny, and vice versa. Therefore the implementation of ABAC must be supported by appropriate policies and validated properly in order to the security in DES runs well.

There are many models for validating ABAC, one of them is model checking. This model while discussing the elements in the system to the errors can be identified easily. There are many tools for validating policy statements, one of them is Access Control Policy Testing (ACPT). ACPT has various methods for creating and testing policy statements [7]. As well as being complete ACPT is widely used for ABAC validation research that has been done before. ACPT has several algorithms that used to test policy statements.

II. Literature Review

Literature review takes reference based on studies that have been done first. The literature review can be seen in Table I.

TABLE. I. LITERATURE REVIEW

Main paper	application	Validation model used	Data used	Tools
Catherine MS Redfield, Hiroyuki Date (2014) [5]	Digital evidence storage	Skema Gringgot	Digital evidence	-
Dianxiang Xu, Yunpeng Zhang (2014) [8]	Application content	Model checking	Policy	ACPT
Ang Li, Qinghua Li, Vincent C Hu, Jia Di (2015) [9]	Database system	Model Checking	Policy	ACPT
Nariman Ammar, Zaki Malik, Abdelmounaam Rezgui, Elisa Bertino (2016) [10]	Data Repository	Dinamic privacy management	Policy	SunXACML
Nuo Li, JeeHyun Hwang, Tao Xie (2008) [11]	Web application	-	Policy	SunXACML
Muhammad Aqib, Riaz Ahmed Shaikh (2015) [12]	-	Formal methods, Model checking methods, matrix based approaches, mining technique, mutation testing technique, others	Policy	-
M Fadly Panende, Imam Riadi, Yudi Prayudi (2017) [13]	Digital evidence storage	-	Policy	UMU
Research				
Solution	Digital evidence storage	Model Checking	Policy	ACPT

III. THEORY

Access control has several types of models that used from the first to the lastest. Access control models are MAC, DAC, RBAC, and ABAC:

1) MAC (Mandatory Access Control): MAC giving access depends on the document owner.

2) DAC (Discretionary Access Control): The DAC will restrict access to objects based on the identity of the subject.

3) RBAC (Role-Based Access Control): RBAC is an approach that limits access to a system for users who have authority in the system.

4) ABAC (Attribute-Based Access Control): ABAC is one of model access control that applies policies.

According to Dianxiang Xu and Yunpeng Zhang [8], the latest generation of access control models is the ABAC model because this model has better features than the previous generation access control model. These features are:

1) ABAC can provide grant access control trought the attributes of authorization elements such as subject, resources, actions, and environment into an access control decision. This also allows the subject to access the widest possible resources without the existence of individual relationships between each subject.

2) ABAC can facilitate the administration of collaborative policies in large organizations. This policy can be prepared by policymakers from various departments.

3) ABAC can also facilitate the decoupling of access control from certain application business logic.

How to work from ABAC according to Hu et al. [3] can be illustrated in Fig. 1:

From the picture it can be explained that there are three main steps in implementing ABAC, namely:

1) Subject accept request from object

2) Give a decision given through an evaluation mechanism for (a) Rules, (b) Subject Attributes, (c) Object Attributes and (d) environmental conditions.

3) The subject is given a decision: reject or allow access to the object.

ABAC is an access control method in which subjects will only make requests to perform operations on objects based on the attributes that have been pinned on the subject, object, environmental conditions, and some policies, included in the attributes and conditions. The authorization element In the ABAC model is defined in the attribute. According to Shandu [14] there are 4 aspects of attributes in ABAC, namely:

1) Subject: The subject is a user, whether human or not (eg device or software) requesting an access request. Examples of this subject include name, address, position, etc. While requests can use subject attributes with unique properties.

2) Resources: Resources are protected targets such as devices, networks, files, applications, etc.

3) Operation: An operation is the implementation of a function that requests a subject for resources.

4) Environment attribute: Is an operational and situational characteristic, such as current time, ip address, etc

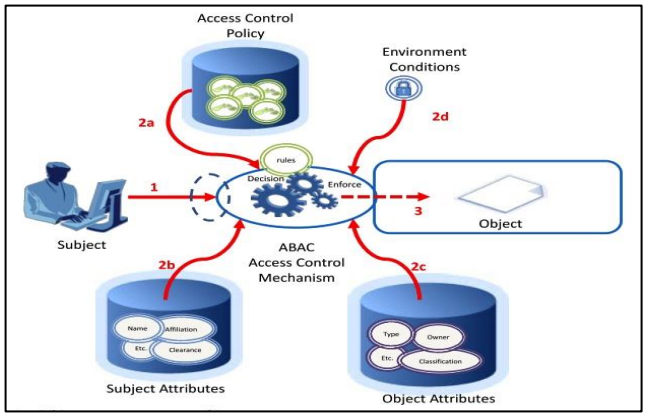


Fig. 1. How to Work from ABAC.

Attributes can be determined through identifiers (variables), data types, and domains where finite sets containing the value of the data type are given. Data types of attributes can be used in computer systems such as integers, strings, and booleans. Data types or domain attributes in ABAC can be specified explicitly or implicitly.

ABAC policy is a function representation that determines whether access requests are permitted based on the given attribute value. Formally the ABAC policy will contain three (X, Y, f). where:

- X is the finite set of attributes with domain D1 ... Dn
- Y is the finite set of access control decisions (for example: permit, deny, undefined)

F:= D1 x D2 x … Dn → Y; this is an access control function

The ABAC policy is said to be complete if and only if f is a total function, where for the value given by each attribute then f always produces deterministic decisions. In this case, a different ABAC system will use a different set of access control decisions, for example {permit, deny, undefined*}* *or* *{*permit, deny, NotApplicable, Intermediate*}*. According to Aqib [12], there are two problems faced in implementing access control solution, namely.

1) Inconsistency: Inconsistency it is a condition where there are 2 rules that give the result of contradiction. If S, O and A is Subject, Object and Actions. If given $a \in$ A, $s \in S$, $o \in O$, then given $d \in D$ namely set Decision D = { permitted, denied, undefined} and $r \in R$ in the form of a three tuple rule (s,o,a) → d. A policy is said to inconsistency if for every two rules r_i and $r_j \in R$, where $i \neq j$ then $r_i \rightarrow d_i$ and $r_j \rightarrow d_j$ where $i \neq j$ then r_i and r_j will give the results of contradictory decisions.

2) Incompleteness: It is a condition where there are rules that have not been accommodated in a set of rules that have been previously set. That is, there is r for a condition where r ∉ R.

The purpose of validating access control policies is to make sure that the inconsistency and incompleteness system was not happening. If the problem still exists, the security system becomes invalid or not safe. Accordance with Aqib [12] to validate the access control policy with the ensure that there are no incidents and incompleteness. There are 5 methods to do validation namely: Mining technique, model checking technique, formal methods, matrix-based approaches, mutation testing, and other technique.The method in this study can be summarized as in Fig. 2:

Based on the summary of the access control validation method from Aqib [12] the author tries to apply an examination model for validating digital evidence access. Model-checking method is a method that uses Linear Temporal Logic (LTL) to describe the nature and model of SPIN examiners to be used in the verification and validation of existing policies. The checking model checks the components in a system, in this case, a policy statement. The policy statement in the DES will be checked one by one so that if there are differences in policy, the errors will be known and can be corrected again.

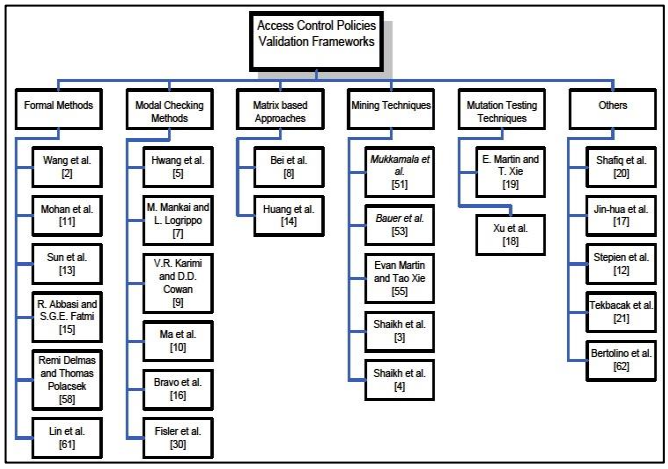


Fig. 2. Summary of Validation Access Control Methods.

There are many tools for making ABAC policies, one good tool is ACPT [7]. Some previous studies used ACPT to create and test ABAC access control. ACPT provides 3 main functions, namely:

1) Help find and combine policies based on what is already known by the existing policy model.

2) ACPT analyzes and converts policies (based on policy models) into formats that can be run like XACML.

3) To ensure that the policy is correct, ACPT conducts static and dynamic verification of a policy.

ACPT has several algorithms for creating and testing ABAC access control, namely:

1) First applicable: First applicable is the condition when the policy statement that has been compiled and given access rights becomes the first effect. While policy statements that have not been granted access rights will be given other access rights.

2) Deny overrides: Deny overrides is an algorithm that combines decisions in such a way that if there is a missing decision. Then the decision will win.

3) Permit Overrides: Permit Overrides are the opposite of deny overrides, an algorithm that combines decisions in such a way that if there is a permit decision. Then the decision will win.

This study uses the first applicable algorithm because it is more suitable for making and testing ABAC access control for DES.

IV. METHODOLOGY

1) Policy Statement: The policy statement in this study takes the example of a policy statement in the DES [13].

2) Software: The software used to test the policy statement is ACPT (Access Control Policy Testing).

3) Model: The model used used for this study is a checking model with methods provided by ACPT, namely, first applicable.

V. Result and Analisys

A. DES Policy Statement

The policy statement in this research takes the example of a policy statement in the DES [13], the policy statements namely:

1) First responder: The First Responder has the task of processing the scene to find evidence and obtain electronic evidence and upload digital evidence to DES. So that the DES has permission to access rights, namely: upload digital evidence, create a cabinet, create a rack, create a bag, input data evidence. In addition to the access rights granted, First Responder is not permitted to access it.

2) Examiner: The Examiner has the task of processing digital evidence so that the DES has permission to access rights, namely: download digital evidence, input data case. In addition to the access rights granted, Examiner is not permitted to access it.

3) Officer: The officer has the task of managing everything in the DES so that he has permission, namely: create a username, create a password, create a signature, delete digital evidence, validate digital evidence, validate data evidence, validate data case, create form COC, download form COC. In addition to the access rights granted, Officer is not permitted to access it.

4) External: Externals are parties that go beyond official participation. Which includes external in the DES, namely lawyers and external examiners. Externals who are given access rights namely: download digital evidence and download form COC. In addition to the access rights granted, External is not permitted to access it.

Rules for DES-based on the policy statement above are divided into four, namely, rules for first responders, rules for testers, rules for officers and final rules for external. The rule for the first responder on DES can be seen in Table II.

The rule for examiner on DES can be seen in Table III.

The rule for an officer on DES can be seen in Table IV.

The rule for external on DES can be seen in Table V:

TABLE. II. Rule for First Responder on DES

Subject	Resource	Action	Environment	Decision
First Responder	Digital Evidence	Upload	Fulfilled	Permit
	Cabinet	Create	Fulfilled	Permit
	Rack	Create	Fulfilled	Permit
	Bag	Create	Fulfilled	Permit
	Data Evidence	Input	Fulfilled	Permit

TABLE. III. The Rule for Examiner on DES

Subject	Resource	Action	Environment	Decision
Examiner	Digital Evidence	Download	Fulfilled	Permit
	Data Case	Input	Fulfilled	Permit

TABLE. IV. Rule for Officer on DES

Subject	Resource	Action	Environment	Decision
Officer	Username	Create	Fulfilled	Permit
	Password	Create	Fulfilled	Permit
	Signature	Create	Fulfilled	Permit
	Digital Evidence	Delete	Fulfilled	Permit
	Digital Evidence	Validate	Fulfilled	Permit
	Data Case	Validate	Fulfilled	Permit
	Form COC	Create	Fulfilled	Permit
	Form COC	Download	Fulfilled	Permit

TABLE. V. Rule for External on DES

Subject	Resource	Action	Environment	Decision
External	Form COC	Download	Fulfilled	Permit
	Digital Evidence	Download	Fulfilled	Permit

B. Testing Policy Statement

Test the policy statement using the ACPT tool and use a combination of the first applicable algorithm. This test is done 30 times because in statistics 30 is the minimum sample for a large population. In one test, there were 60 different policy statement combinations. This combination resulted in two decisions, namely, permission and rejection. The complete results of this test can be seen in Table VI.

This study has the main objective to examine the policy statement in DES to avoid inconsistencies and incompleteness and by the rules that have been prepared previously with the checking model. This inspection model checks the elements in the policy statement in DES whether the policy statement complies with the rules or not and there are no inconsistencies and incompleteness.

TABLE. VI. Test Result

Testing to	Test Result		Testing to	Test Result	
	Decision Permit	**Decision Deny**		**Decision Permit**	**Decision Deny**
1	3	57	**16**	1	59
2	2	58	**17**	2	58
3	1	59	**18**	1	59
4	2	58	**19**	2	58
5	2	58	**20**	2	58
6	3	57	**21**	4	56
7	3	57	**22**	1	59
8	3	57	**23**	2	58
9	3	57	**24**	1	59
10	2	58	**25**	3	57
11	1	59	**26**	1	59
12	1	59	**27**	1	59
13	4	56	**28**	5	55
14	3	57	**29**	1	59
15	2	58	**30**	2	58

1) Inconsistency: Inconsistency it is a condition where there are 2 rules that give the result of contradiction. If S, O and A is Subject, Object and Actions. If given $a \in$ A, $s \in S$, $o \in O$, then given $d \in D$ namely set Decision D = { permitted, denied, undefined} and $r \in R$ in the form of a three tuple rule (s,o,a) → d. A policy is said to inconsistency if for every two rules r_i and $r_j \in R$, where $i \neq j$ then $r_i \rightarrow d_i$ and $r_j \rightarrow d_j$ where $i \neq j$ then r_i and r_j will give the results of contradictory decisions. Examples of inconsistencies from this study are if the first responder is the subject, digital evidence as an object, upload as action and allow as a decision. However, in rule 1 and other rules, the decision of the subject of the first responder must be permitted but has a decision deny.

This study found no inconsistencies in the policy statement for the DES after testing using the model checking. Policy statements are prepared by existing rules.

2) Incompleteness: It is a condition where there are rules that have not been accommodated in a set of rules that have been previously set. That is, there is r for a condition where r $\notin$ R. An example of the incompleteness of this study is that the subject of the first responder must have 5 rules, but in preparation, there are only 4 rules so that there is still 1 rule that has not been accommodated in the rules set for the first responder subject.

This policy statement in DES after testing with the checking model did not find any rules that had not been accommodated from the set of rules that had been made. The rules in the DES policy statement have been accommodated properly without being incomplete.

VI. Conclusion

Security in a system is the main thing in making the system itself. Especially systems that have very important and easily damaged data such as DES. These problems form the basis of the DES system which must be equipped with access control. Access control is what restricts users from accessing the entire system. The access control model that is widely used today is the ABAC model. Developing an ABAC model of access control for DESs must also consider policy statements and rules to be made and tested as a final step before access control is applied to the DES system. Testing models for testing access control now vary. This study uses the ACPT tool and a combination of the first applicable algorithm in compiling and testing DES policy statements. The tests conducted in this study did not find inconsistency and incompleteness problems. The combination of policy statements from the test results runs according to the rules that have been prepared previously.

References

[1] F. Albanna dan I. Riadi, "Forensic Analysis of Frozen Hard Drive Using Static Forensics Method," International Journal of Computer Science and Information Security (IJCSIS), Vol. %1 dari %2Vol. 15, No. 1, 2017.

[2] R. Umar, I. Riadi dan G. M. Zamroni, "A Comparative Study of Forensic Tools for WhatsApp Analysis using NIST Measurements," (IJACSA) International Journal of Advanced Computer Science and Applications , Vol. %1 dari %2Vol. 8, No. 12, 2017.

[3] A. Yudhana, I. Riadi dan F. Ridho, "DDoS Classification Using Neural Network and Naïve Bayes Methods for Network Forensics," (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. %1 dari %2Vol. 9, No. 11, 2018.

[4] I. Riadi, A. Fadlil dan A. Fauzan, "A Study of Mobile Forensic Tools Evaluation on Android-Based LINE Messenger," (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. %1 dari %2Vol. 9, No. 10, 2018.

[5] C. M. Redfield dan H. Date, "Gringotts: Securing Data for Digital Evidence," IEEE Security and Privacy Workshops, 2014.

[6] S. Sunardi, I. Riadi dan A. Sugandi, "Forensic Analysis of Docker Swarm Cluster using Grr Rapid Response Framework," (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. %1 dari %2Vol. 10, No. 2, 2019.

[7] J. Hwang, T. Xie, V. Hu dan M. Altunay, "ACPT: A Tool for Modeling and Verifying Access Control Policies," IEEE International Symposium on Policies for Distributed Systems and Networks, 2010.

[8] D. Xu dan Y. Zhang, "Specification and Analysis of Attribute-Based Access Control Policies: An Overview," Eighth International Conference on Software Security and Reliability - Companion, 2014.

[9] A. Li, Q. Li, V. C. Hu dan J. Di, "Evaluating the Capability and Performance of Access Control Policy Verification Tools," IEEE Military Communications Conference, 2015.

[10] N. Ammar, Z. Malik, A. Rezgui dan E. Bertino, "XACML Policy Evaluation with Dynamic Context Handling," IEEE Transactions on Knowledge and Data Engineering, 2016.

[11] N. Li, J. Hwang dan T. Xie, "Multiple-Implementation Testing for XACML Implementations," TAV-WEB '08 Proceedings of the 2008 workshop on Testing, analysis, and verification of web services and applications , 2008.

[12] M. Aqib dan R. A. Shaikh, "Analysis and Comparison of Access Control Policies Validation Mechanisms," I.J. Computer Network and Information Security, 2015.

[13] M. F. Panende, I. Riadi dan Y. Prayudi, Model ABAC pada Lemari Penyimpanan Bukti Digital, Yogyakarta: Universitas Islam Indonesia, 2018.

[14] R. Sandhu, Security Models: Past, Present and Future, San Antonio: Institute for Cyber SecurityUniversity of Texas at San Antonio, 2009.

Selection of Sensitive Buses using the Firefly Algorithm for Optimal Multiple Types of Distributed Generations Allocation

Yuli Asmi Rahman[1]
Department of Electrical Engineering
Tadulako University
Palu, Indonesia

Salama Manjang[2], Yusran[3]
Department of Electrical Engineering
Hasanuddin University
Makassar, Indonesia

Amil Ahmad Ilham[4]
Department of Informatics
Hasanuddin University
Makassar, Indonesia

***Abstract*—Power loss is one aspect of an electric power system performance indicator. Loss of power can have an impact on poor voltage performance at the receiving end. DG integration in the network has become one of the more powerful methods. To get the maximum benefit from synchronizing the system with DG, it is necessary to ascertain the size, location, and type of DG. This study aims to determine the capacity and location of DG connections for DG type I and type II. To address the aim of this paper, a metaheuristic solution based on a firefly algorithm is used. FA can cover up the lack of metaheuristic algorithms that require a long computational time. To ensure that the load bus location solution is selected as the best DG connection location, the input of the load bus candidate has been filtered based on stability sensitivity. The proposed method is tested on IEEE 30 buses. The optimization results show a decrease in power loss and an increase in bus voltage, which affects an increase in system stability by integrating three DG units. FA validation of the evolution-based algorithm shows a significant reduction in computational time.**

***Keywords*—Firefly algorithm; time computation; real power loss index; voltage profile index; multi-type DG**

I. INTRODUCTION

The use of distributed generators (DG) on a scale of capacity and various types of innovation is becoming increasingly prevalent used in electric power systems. Technically, the benefits obtained from DG integration have been mentioned in previous studies, including reducing power losses, increasing reliability, improving stability, and improving the voltage profile [1]-[4].

However, the implementation of the addition of DG to the existing system will cause a new problem that is synchronizing the work between the old generating system and the new generating system. Therefore it is essential to do a thorough analysis of the technical factors related to the placement of DG, including the size, location of the connection, and the resulting impact. DG units can inject and absorb active and reactive power in the distribution network. They can maintain and enhance the voltage profile at different power factors. The power factor is a factor determining the type of DG that governs the type and size of the injected power. Based on the kind of power injected, DG is divided into four classes which are presented in Table I [5].

The maximum result of DG integration is achieved by the size and installed location of DG. Therefore, further analysis is needed regarding this matter. Previous research has examined various DG allocation techniques, precisely Analytical techniques developed by becoming techniques based on artificial intelligence.

Analytical technique is a form of mathematical settlement in the form of numerical equations that are expressed as objective functions. This analytical technique represents the target to be achieved after DG placement. Some goals that generally want to be performed are the minimization of power losses, and increasing the voltage profile, achieving system stability [6]-[8]. In [7], the DG optimization process uses a combination of genetic algorithms with analytical techniques. DG optimization is done to reduce power losses in the system. In line with research [7], reference [8] has proposed a method for determining the location and size of DG type combinations using the efficient analytical method (EA) integrated power flow study. The target function is only to prioritize the power loss function, which is described by the real power loss (RPL) formula without assessing the bus voltage value after DG placement.

Artificial intelligence techniques using metaheuristics now also dominate DG research [9]-[13]. This is due to metaheuristic success to resolve cases in an extensive system range. Metaheuristic algorithms mimic natural processes in matters such as biological systems and chemical processes. Met[[aheuristics can be divided into search points, namely one point search and population search. Population-based algorithms have the advantage of being able to explore effectively in the search space, making it suitable for global search. This is due to the ability of local exploitation and comprehensive exploration to avoid convergent locality. One approach using population metaheuristics is the firefly algorithm.

In this study, using techniques developed by Dr. Xin-She Yang named the firefly algorithm (FA)[14]. FA imitated the information of fireflies in solving problems where in previous studies have been proven to resolve technical issues by solving global solutions [15]-[16]. The flash produced by fireflies is formulated based on objective functions. The brightest firefly determined as the most optimal solution.

TABLE. I. CLASSIFICATION OF DG BASED POWER INJECTION

DG Type	Power Injecting DG	Power Factor (pf)
Tipe I (DG-1)	Real power (P+)	Unity (1)
Tipe II (DG-2)	Real power (P+) and reactive power (Q+)	leading
Tipe III (DG-3)	Real power (P) but absorbing reactive power (P+Q-)	lagging
Tipe IV (DG-4)	Reactive power (Q+)	Zero

In a generation, there will undoubtedly be losses along the transmission and distribution lines. With the integration of DG, learning is done to minimize losses that occur on a line by using voltage control in a system that has been assumed, as illustrated in Fig. 1.

There is a trend towards a reduction in power loss in line with the increase in DG capacity. But there is a point where the trend reverses to increase again. This indicates the need for proper techniques to obtain the optimal level of DG capacity.

DG applications at the distribution and transmission levels show that usage on DG-1 and DG-2 is quite high. Photovoltaics, microturbines, fuel cells assisted by converters, and inverters can be used as good examples for Type 1. Type 2 can be DG generating units based on synchronous engines such as cogeneration, gas turbines, and others. The utilization of DG-1 and DG-2 is increasingly widespread so that it becomes the reason for the choice of DG type.

This paper presents research results on the placement of DG-1 and DG-2 in varying units using FA approximations. FA, as a type of metaheuristic-based algorithm, has advantages in exploitation and exploitation in the search process and short computing time. This paper exists to address the shortcomings of using metaheuristic algorithms that require a long time in the execution process [9], [10]. Due to this reason, the FA election to resolve the DG case in this study.

The clustering of load buses based on the sensitivity level by bus stability level has been carried out to ensure the placement of DG buses as the best location. This indeed ensures that the selected bus is the best bus for DG placement that fulfills the objective function.

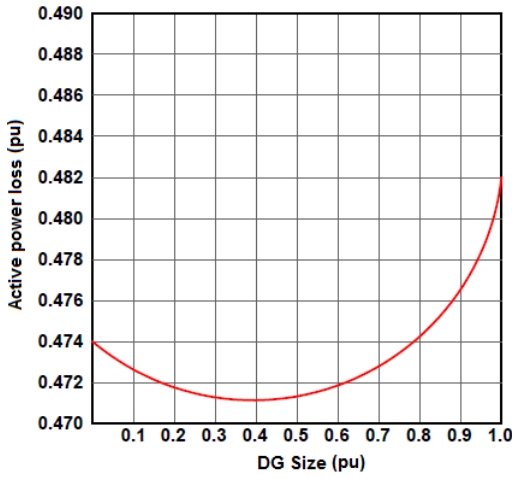


Fig. 1. Effect of DG Size on Active Power Loss [17].

The structure of the article is divided into five parts. Section 1 explains the background and linkages with previous research. Section 2 provides an analytical explanation of power flow studies for multi type DG placement. Section 3 describes the stages of solving optimization problems using FA. Sections 4 and 5 each explain the results of optimizing the placement of the both DG types and conclusions.

II. MULTI-TYPE DG OPTIMAL POWER FLOW

A. Objective Function

In this study, DG optimization consists of DG placement location and how much power is injected by DG. Calculation of DG power injection is determined based on power losses in the power system network, which are stated as objective functions. The objective function in this study is the minimization of the power loss function expressed by the exact loss formula [18] or written as (1).

$$F_{objective} = \text{Min } P_L$$
$$= Min \sum_{i=1}^{NB} \sum_{j=1}^{NB} [a_{ij}(P_i P_j + Q_i Q_j) + b_{ij}(Q_i P_j - P_i Q_j)] \quad (1)$$

Where,

$$\alpha_{ij} = \frac{r_{ij}}{V_i V_j} \cos(\delta_i - \delta_j) \qquad \beta_{ij} \frac{(r_{ij})}{V_i V_j} \sin(\delta_i - \delta_j);$$

V_i , δ_i = voltage and phase angle of bus-i ;

$r_{ij} + jx_{ij}$ = Zij are components of impedance Z bus matrix;

P_i and Q_i= real and reactive power injections of i^{th} bus

P_j and Q_j= real and reactive power injections of j^{th} bus

DG optimization strategies provide limits that must be met active power and reactive power of DG as shown in equations (2) and (3).

$$0.001 < P_{DGi} < 10 \text{ MW}, i = 1,2,....N_{DG} \quad (2)$$

$$0.001 < Q_{DGi} < 2\text{MVAr}, i = 1,2,....N_{DG} \quad (3)$$

where : N_{DG} is unit DG, P_{Dgi} and Q_{Dgi} are active power and reactive power of DG, respectively.

After DG integration, the voltage on bus-i (VDgi) must be controlled at the value specified in equation (4).

$$1.05pu < V_{DGi} < 0.95MW, i = 1,2,....N_B \quad (4)$$

The voltage limit refers to IEEE Std 45-2002 [19]. In this study, NB is limited to 30 according to the plant used, IEEE bus 30.

B. Determining Size of DG

Based on Table I, the DG type indicates the type of power injected into the system. Active power and reactive power that is injected must be following the needs to function optimally. The proposed power loss is the elaboration of the exact loss formula given in (1).

Since active and reactive power injected by DG on the bus i^{th} are:

$$P_i = P_{DG\,i} - P_{D\,i} \quad (5)$$

$$Q_i = Q_{DG_i} - Q_{D_i} \quad (6)$$

From equations (1), (5), and (6), active power losses are expressed by:

$$P_L = \sum_{i=1}^{N}\sum_{j=1}^{N}\begin{bmatrix} \alpha_{ij}\,[(P_{DG_i} - P_{D_i})P_j + (\,a\,P_{DG_i} - Q_{D_i}) & Q_j] + \\ +\,\beta_{ij}\,[\,(a\,P_{DG\,i} - Q_{D_i})P_j - (P_{DG_i} - P_{D_i}) & Q_j \end{bmatrix} \quad (7)$$

differentiating (7) w.r.t to get minimum value $: \frac{\partial P_L}{\partial P_{DG_i}} = 0$

$$\frac{\partial P_L}{\partial P_{DG_i}} = 2\sum_{j=1}^{N}[\,\alpha_{ij}\,(P_j + aQ_j) + \beta_{ij}(aP_j - Q_j) \quad (8)$$

By solving (8) in a matrix (7), a solution (9) is obtained as the optimal value of DG size on the bus i:

$$P_{DG1}=(\alpha_{ii}(P_{D1}+\alpha Q_{D1})+\beta_{ii}(P_{D1}-\alpha Q_{D1})-X_i-\alpha Y_i)/\alpha^2\alpha_{ii}+\alpha_{ii}$$

$$P_{DG_1} = \frac{\alpha_{ii}(P_{D_1}+aQ_{D_1})+\beta_{ii}(aP_{D_i}-Q_{D_i})-X_i-aY_i}{a^2\alpha_{ii}+\alpha_{ii}} \quad (9)$$

Assume a = (*sign*) tan ($\cos^{-1}$ (pfDG))$\cos^{-1}$ (pf_{DG}),

DG reactive power can be defined as given (10)

$$Q_{DGi} = a\,P_{Dgi} \quad (10)$$

where

Sign = +1: DG reactive power injection;

Sign = +1: DG absorbs reactive power;

pf DG is the DG power factor

The relationship between power factor (pfDG) and variable a_1 on the bus i th is expressed by (11):

$$pf_{DG} = \cos\left(\tan^{-1}\left(\frac{\alpha_{ij}Q_{Di}-Y_i}{\alpha_{ij}P_{Di}-X_i}\right)\right) \quad (11)$$

where

$$X_i=\sum_{\substack{j=1\\ j\neq i}}^{n} \alpha_{ij}P_j-\beta_{ij}Q_j \quad \text{and} \quad Y_i=\sum_{\substack{j=1\\ j\neq i}}^{n} \alpha_{ij}Q_j-\beta_{ij}P_j$$

The DG types used in this research simulation are DG-1 and DG-2. In DG-1, the value (pfDG = 1, a = 0) so that the optimal DG-1 on each bus is expressed in (12):

$$P_{DG_1} = P_{D_1} - \frac{1}{\alpha_{ii}}\,[\beta_{ii}\,Q_{D_1} + \sum_{\substack{j=1\\ j\neq i}}^{N}(\alpha_{ij}\,P_j - \beta_{ij}Q_j)] \quad (12)$$

For DG-2, the PF is in the range of values 0 <pfDG <1, the sign is '+', and 'a' is constant.

III. Implementation of the FA OPF in Determining Optimal DG

As discussed in the introduction, that the working principle of the FA's work follows the principle of fireflies in dealing with mating partners and potential prey. The working principle of the OPF FA algorithm embraces three social behaviors of fireflies.

1) All fireflies are unisex.

2) The movement of fireflies always looking for fireflies that have a higher brightness than their flocks.

3) The movements of the fireflies are always random until they find brighter fireflies.

In the FA OPF process, mathematical calculations follow the social behavior of fireflies, including distance calculation, brightness level calculation, and attraction calculation. These calculations are shown in (13), (14), and (15), respectively [14].

$$A(d) = A_0 * \exp(-\gamma\, d^m) \quad \text{with } m>>1 \quad (13)$$

where d= distance between firefly

A_0 = attractiveness of firefly at d=0

γ= coefficient of absorption

As distance increases, the attraction of fireflies will decrease due to absorption factors. The process of calculating the brightest firefly distance from the first firefly (i-firefly) is formulated in (13).

$$\boldsymbol{d_{ij} = \sqrt{\left((x_i - x_j)^2 + (y_i - y_j)^2\right)}} \quad (14)$$

The distance and attractiveness of fireflies determine the process of moving fireflies in a brighter direction. It is given by (14).

$$\boldsymbol{x_i^{k+1} = x_i^k + A_0 * \exp(-d^2) * (x_i^k - x_i^k + a * rand_i^k)} \quad (15)$$

where x^i_k = base position of firefly i

$a*rand^i_k$= random movement of fireflies i^{th}

The fireflies move randomly and will continue to repeat until the convergence criteria are reached. This process called safe iteration; the last iteration is called the optimal solution. The brightest position of the fireflies is predicted as the location and the optimal size of DG. The procedure above is shown through the power flow picture in Fig. 2.

The FA approach to this problem used the parameters that have been used in the calculation of power flow as follows number of firefly=40, α=0.5, β_0=1, β_{min}=0.2, γ=1, $Iter_{max}$ =100 [16].

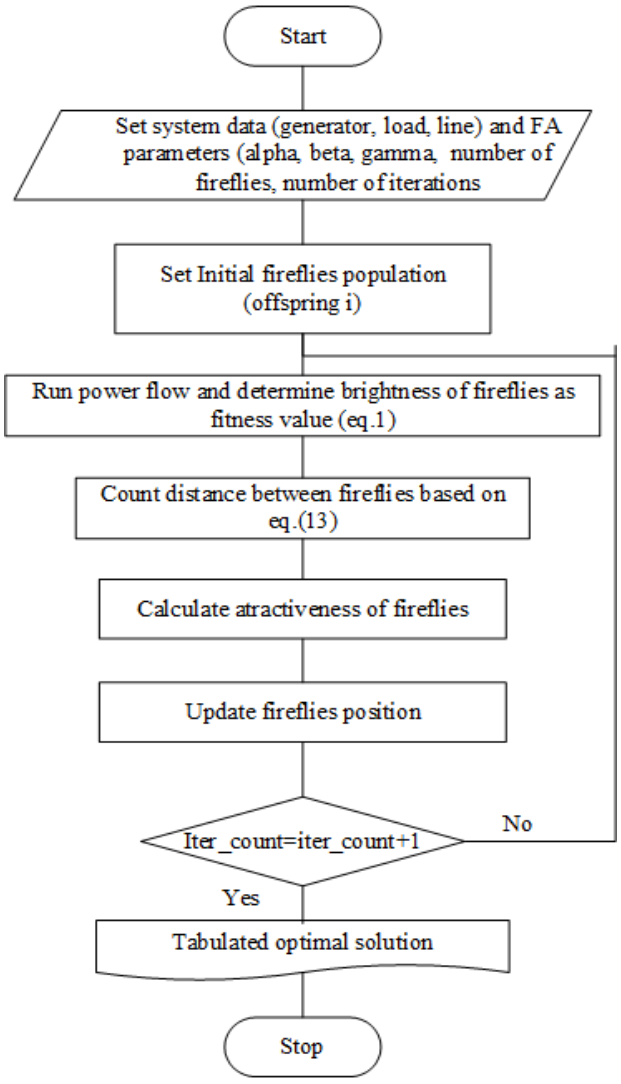


Fig. 2. Flowchart of FA OPF DG.

The proposed algorithm has been tested in Matlab 2016a. As a comparison validation, the computational time indicator and the power loss indicator are used as a fitness function.

IV. Result and Discussion

Implementation of FA on the problem of DG placement optimally performed on IEEE 30 bus system. The IEEE 30 bus system consists of six generator bus, and 41transmission lines that serve a total load 283.4 MW + j 126.2 MVAr load spread over 24 load bus. IEEE 30 bus system load and line data refer to previous research [20].

A. Exploration and Exploitation of FA

The combination of DG size and location that has been raised has two dimensions, namely dimension -i and dimension -j. The number of dimensions -i is determined by the number of fireflies population, which is the number of desired candidate candidates (DG number) while the value of the candidate solutions determines the number of dimensions j. The population raised is an array to represent the size of the DG and the location of the DG.

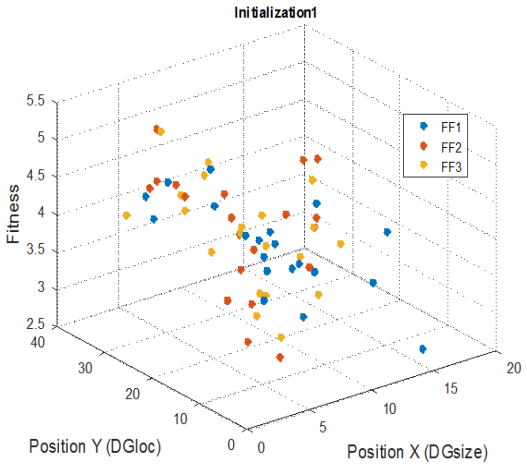


Fig. 3. Initialization Process.

Evaluate each component of DG size and location to position the first fireflies, as shown in Fig. 3. All processes in the FA stage are carried out in the form of functions that require different computational time.

As validation, the computational time of the proposed method is compared with the GA method that has been done in previous studies [10]. Comparison of the computational time of both methods are shown in Fig. 4. Compared to evolution-based search techniques, FA techniques have the advantage of faster computing time. The total execution time of FA is shorter 16.645 s compared to GA [10].

The time is due to the process of searching in the FA less starting from the process of generating population, evaluating, calculating the distance of fireflies, attractiveness, and movement. The function of FA affects the matrix operation formed. Compared to GA, matrix operations are built a lot because it matches the stages in the process of finding a solution. Self-time is the time spent in a function, not including the time spent in other sub-functions. In the process of optimizing the load flow sub-function, it is crucial to determine the solution obtained because the function produces an output of a power loss value and a voltage value. These parameters will be evaluated in the fitness function.

B. Optimal Multiple of Multi-Type DG

Performance of the firefly algorithm is measured using the Real Power Loss Index (RPLI) [21], Voltage Profile Index (VPI) [22], and Voltage Sensitivity Index (VSI) [23]. The equation of each index is shown in (16), (17), and (18).

$$RPLI = (P_{loss} \text{ after DG}/P_{loss} \text{ without DG}) \quad (16)$$

where,

P_{loss} is active power loss of power system,

RPLI <1 shows DG integration is successful in reducing active power loss,

RPLI = 1 DG indicates that DG integration has no impact on the reduction in active power loss,

RPLI> 1 DG indicates that DG integration has not been successful in reducing power loss.

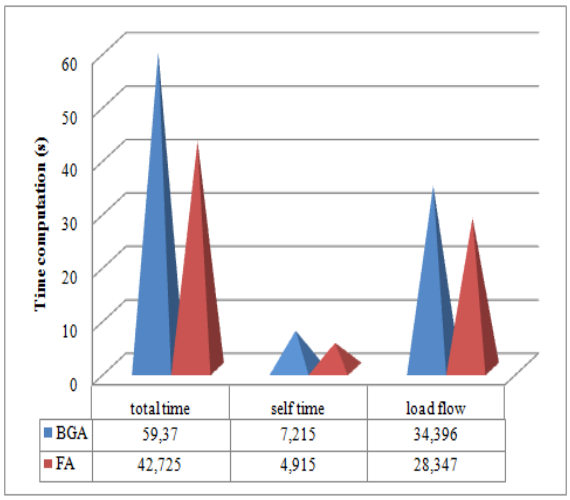


Fig. 4. Comparison of Time Computation.

$$VPI_{(i)} = (V_i - V_{min})*(V_{max} - V_i)/(V_{nom} - V_{min})*(V_{max} - V_{nom}) \quad (17)$$

where, $VP_{(i)}$ is the voltage profile of i^{th} bus, V_{min} and V_{max} are the minimum and maximum allowable voltages of the system and V_{nom} is the nominal bus voltage (1.0 pu).

$$VSI_{(i)} = \sqrt{\frac{\sum_{k=1}^{n}(1 - V_k)^2}{n}} \quad (18)$$

where, V_i is voltage on i^{th} bus and n is total number of bus.

Placement of multiple DG-1 units is shown in Table II.

The clustering process is carried out by the FA to get candidates for DG placement locations. The resulting bus candidates are sensitive buses referring to (18), namely buses 7, 10, 23, 26, 29, and 30 with VSI values of 0.3857, 0.4476, 0.4253, 0.7978, 0.4322 and 0.4688, respectively. The most likely bus candidate as a DG placement location is the bus.

The results of this cluster become a reference for applying the combination process with DG size as specified in (2), (3), and (4). In this test case, the best solutions for placing multiple DG-1 units are shown in Table II.

The placement of one DG-1 unit of 9 MW on bus 30 generates RPLI 0.914. The placement of DG-1 has an impact on reducing power loss by 8.64% so that the system power loss becomes 16.657 MW. The installation of the two DG-1 units on bus 26 and bus 30 was 8.4 MW and 9.4 MW, respectively, resulting in a real power loss reduction of 15.87%.

In addition to reducing power loss, DG-1 integration also has an impact on improving the voltage profile. The addition of one DG-1 unit reduces the voltage deviation from 4.1% to 1.4% or 0.986 pu while the addition of two DG-1 units decreases the minimum voltage deviation by 4.1% to 1.3% or the minimum voltage by 0.987 pu. Concerning the RPLI with a minimum value of 0.78259, the optimal location of DG-1 is on buses 7, 30, and 26, with sizes of 8.9 MW, 8.9 MW, and 9.4 MW, respectively.

TABLE. II. RESULT OF OPTIMAL MULTIPLE DG-1 PLACEMENT

DG Unit	Optimal DG	Index	
		RPLI	*VPI* ($VP_{with\ DG}/VP_{withoutDG}$)
1	Bus 30 (9 MW)	0.9136	1.223
2	Bus 26 (8.4 MW)	0.8412	1.312
	Bus 30 (9.4 MW)		
3	Bus 7 (8.9 MW)	0.7825	1.334
	Bus 30 (8.9 MW)		
	Bus 26 (9.4 MW)		

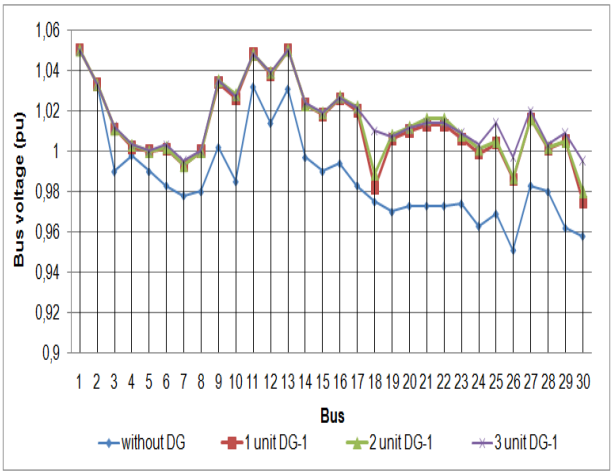


Fig. 5. Voltage Profile after DG-1 Placement.

The real power loss for this solution decreased by 22.37% of the power loss before the DG-1 placement or 14.402 MW. Integration of the DG units into the network improved the voltage profile of the system. Placement of three DG-1 units gives the best results by adjusting the voltage profile from a deviation of 4.1% to 0.3% or a minimum voltage of 0.997 pu on bus 26. Comparison of the DG-1 placement voltage profile with the number of units one, two, and three can be seen in Fig. 5. From the results of the power flow shows that the addition of three DG units causes the voltage magnitude of all buses not to violate the voltage limit function. However, when the number of DG units increases to four DG units, voltage limit function violations will occur.

Multiple DG-2 placements is shown in Table III.

The placement of one DG-2 unit on bus 30 with a capacity of 9.70 MW + j1.30 MVAr gives an RPLI value of 0.898. The installation of DG-2 has the effect of reducing active and reactive power losses by 10.16% and 35.86%, respectively.

The integration of two DG-2 units on bus 23 with a capacity of 9.90MW + j0.9 MVAr and on bus 30 with a capacity of 9.80MW + j1.5 MVAr were able to reduce real power losses by 17.4% from 18.403 MW (without DG) to 15.207 MW. RPLI of 0.8263 indicates these benefits.

The reactive power loss was also reduced by 56.53% so that the system's reactive power loss was 12.66 MVAr. In addition to reducing power loss, DG-2 integration also has an impact on improving the voltage profile. The addition of one DG-2 unit decreases the voltage deviation from 4.1% to 1% or equal to 0.990 pu on bus 26.

TABLE. III. RESULT OF OPTIMAL MULTIPLE DG-2 PLACEMENT

DG Unit	Optimal DG	Index	
		RPLI	*VPI* ($VP_{with\ DG}/VP_{withoutDG}$)
1	Bus 30 (9.70 MW+j 1.30MVAr)	0.898	1.218
2	Bus 30 (9.80 MW + j1.5 MVAr)	0.8263	1.268
	Bus 23 (9.80MW+j0.9MVAr)		
3	Bus 30 (8.6 MW +j0.7 MVAr)	0.76521	1.320
	Bus 7 (9.6 MW +j0.05 MVAr)		
	Bus 10 (9.1 MW +j1.9 MVAr)		

While the addition of two DG-2 units reduces the minimum voltage deviation by 3.3% so that the minimum system voltage is maintained at 0.994 pu on bus 7.

Concerning the RPLI, the minimum value of 0.765201 refers to the DG-2 optimal location on three buses 7, 30 and 10, with a total size of 27.3MW + j2.65 MVar. The actual power loss and reactive power for this solution decreased by 23.48% and 69.9% of the power loss before DG-2 or 14.082MW - j8.753 MVar, respectively. The integration of DG-2 on three different buses also had a positive impact on decreasing the minimum voltage deviation of 2.9%. Where the minimum system voltage is maintained at 0.998 pu on bus 7. Overall, from the DG2 placement scenario, it can be concluded that the placement of three DG-2 units gives better results on the voltage improvement, as shown in Fig. 6.

After the addition of DG-1 and DG-2 into the power system, line loss reduced. Because of DG has supplied the current flowing in the small line due to part of the load. DG acts as a negative load which causes the load on the system to be reduced so that the current flowing is diminished.

In this study, the test system is in a balanced condition scenario, so it needs further analysis for unbalanced conditions with variable load, bearing in mind that this is the main problem in the distribution system. For further studies, implementation in a real plant needs to be considered where there is a study that is in sync with the geographical conditions of natural resources in the form of geographic information systems (GIS).

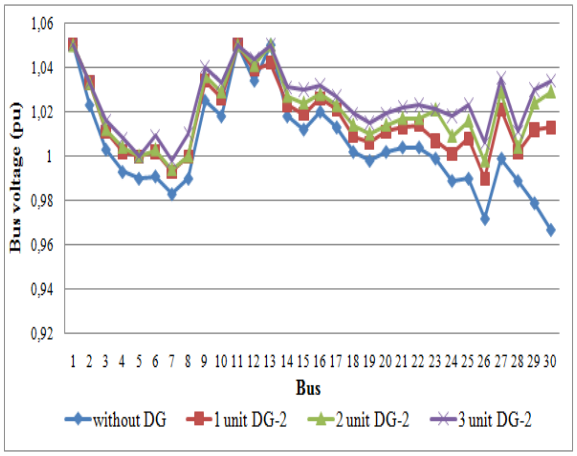


Fig. 6. Voltage Profile after DG-2 Placement.

V. CONCLUSION

The FA optimization method succeeded in solving locating the location of the generator deployed faster than searching using an evolution-based algorithm. The FA's clustering process based on the bus sensitivity factor results in a combination of location and DG size, which effectively reduces power loss and improves the voltage profile. The effectivity measured through the smaller RPLI indicator and the increasing VPI after integrated DG.The power loss and voltage profile obtained when DG-2 penetration is smaller than DG-1.

REFERENCES

[1] T. Ackermann, Andersson, Göran, & Söder, Lennart, "Distributed generation: a definition," Electric power systems research, 57(3), 195-204, 2001.

[2] Y. A. Rahman, S. Manjang, Yusran, and A. A. Ilham, "Evaluating the effect placement capacitor and distributed photovoltaic generation for power system losses minimization in the radial distribution system," AIP Conference Proceedings, vol. 1941, p. 020027, 2018.

[3] Pesaran H.A, Mahmoud, Huy, Phung Dang, & Ramachandaramurthy, Vigna K.," A review of the optimal allocation of distributed generation: Objectives, constraints, methods, and algorithms," Renewable and Sustainable Energy Reviews, 75, 293-312, 2017.

[4] Ahmad, Sanaullah, Sardar, Babar ul Asar, Sana Noor, " Impact of distributed generation on the reliability of local distribution system, ", International Journal of Advanced Computer Science & Applications, Vol.8, issue 6, 2017.

[5] El-Fergany, Attia," Multi-objective allocation of multi-type distributed generators along distribution networks using backtracking search algorithm and fuzzy expert rules,"Electric Power Components and Systems, 44(3), 252-267, 2016.

[6] S. Kaur, G. Kumbhar, J.A. Sharma, " A MINLP technique for optimal placement of multiple DG units in distribution systems," International Journal of Electrical Power & Energy Systems, Vol 32, issue 6, 609-617, 2014.

[7] M. Vatani, GB. Gharehpetian, MJ. Sanjari, A. D Solati, "Multiple distributed generation units allocation in distribution network for loss reduction based on a combination of analytical and genetic algorithm methods, " IET Generation, Transmission &Distribution, vol. 10, pp.66-72, 2016.

[8] K. Mahmoud, N Yorino, and A. Ahmed, "Optimal distributed generation allocation in distribution systems for loss minimization,," IEEE transaction on power systems, vol.31, no. 2, pp. 960-969, 2016.

[9] Yusran, Ashari, Mochamad, & Soeprijanto, Adi. (2013). Optimization scheme of distributed generation installation growth considering network power quality. Journal of Theoretical & Applied Information Technology, 53(1).

[10] Y. A. Rahman, S. Manjang, Yusran, and A. A. Ilham, "Distributed generation's integration planning involving growth load models by means of a genetic algorithm," Archives of Electrical Engineering, 67, 2018.

[11] Bohre, Aashish Kumar, Agnihotri, Ganga, & Dubey, Manisha. (2016). Optimal sizing and sitting of DG with load models using soft computing techniques in practical distribution system. IET Generation, Transmission & Distribution, 10(11), 2606-2621.

[12] Ahmad, Sanaullah, Sardar, Sana Noor, Babar ul Asar, Azzam, "Analyzing distributed generation impact on the reliability of electric distribution network, International Journal of Advanced Computer Science & Applications, "Vol.1, issue 7, pp 217-221, 2016.

[13] C. K. Das, O. Bass, G. Kothapalli, T. S. Mahmoud, and D. Habibi, "Optimal placement of distributed energy storage systems in distribution networks using artificial bee colony algorithm," Applied energy, vol. 232, pp. 212-228, 2018.

[14] X.-S. Yang, "Firefly algorithms for multimodal optimization," in International Symposium on stochastic algorithms, pp. 169-178, 2009.

[15] Sarbazfard, S Jafarian, “A hybrid algorithm based on firefly algorithm and differential evolution for global optimization, International Journal Advanced Computer and Science Application, “Vol 7, issue 6, 95-106, 2016.

[16] A. Tazi, Z. Sabiri, N. Belbounaguia, K. El Mkaddem, & M. Bezza, “Firefly Algorithm for Solving Load Flow Problem,” In 2018 Renewable Energies, Power Systems & Green Inclusive Economy (REPS-GIE) (pp. 1-5). IEEE.

[17] S. Essallah, A. Bouallegue and A. Khedher,” Optimal Placement of PV-Distributed Generation units in radial distribution system based on sensitivity approaches,” 16th international conference on Sciences and Techniques of Automatic control & computer engineering - STA'2015, Monastir, Tunisia, December 21-23, 2015.

[18] Satish Kansal*, B.B.R. Sai, Barjeev Tyagi, Vishal Kumar,”Optimal placement of distributed generation in distributed network,”International Journal of Engineering, Science, andTechnology Vol 3, no 3, 2011,pp.47-55.

[19] M.M. Aman, G.B Jasmon, A.H. A. Bakar, H. Mokhlas, “A new approach for optimum simaultaneous multi-DG distributed generation units placement and sizing based on maximization of system loadability using HPSO (hybrid particle swarm optimization algorithm),” Energy, vol.66, pp 202-215, 2014.

[20] R. Christie, I. Dabbagchi, Christie, R., & I. Dabbagchi, “ 30 bus power flow test case,” 1993.

[21] Injeti, S. Kumar, and Navuri P. Kumar. "Optimal planning of distributed generation for improved voltage stability and loss reduction." International Journal of Computer Applications 15.1 (2011): 40-46.

[22] Iyer, H., S. Ray, and R. Ramakumar. "Voltage profile improvement with distributed generation." IEEE Power Engineering Society General Meeting, 2005. IEEE, 2005.

[23] Lof, P-A., et al. "Fast calculation of a voltage stability index." IEEE Transactions on Power Systems 7.1 (1992): 54-64.

An Evaluation of User Awareness for the Detection of Phishing Emails

Mohammed I Alwanain
Department of Computer Science,
College of Science and Humanities in Alghat
Majmaah University
Saudi Arabia

***Abstract*—Phishing attacks are among the most serious Internet criminal activities. They aim to make Internet users believe that they are using a trusted entity, for the purpose of stealing sensitive information, such as bank account or credit card information. Phishing costs Internet users millions of dollars each year. An effective method that can prevent such attacks is improving the security awareness of Internet users, especially in light of the significant growth of online services. This paper discusses a real-world experiment, which aims to analyze and monitor the phishing awareness of an organization's users in order to improve their awareness. The experiments have been targeting 1500 users in the education sector. The results of the experiment reveal that phishing awareness has a significant positive effect on users' ability to distinguish phishing emails and websites, thereby avoiding attacks.**

Keywords*—Anti-phishing countermeasures; online fraud; evaluation experiments

I. INTRODUCTION

E-commerce and online services make our lives more comfortable and manageable, wherever we may be and at any time of day. However, this ubiquity of service carries with it a critical security threat, which can cost Internet users dearly. One such threat is posed by phishing, whereby a criminal (phisher) will attempt to steal a user's sensitive information (such as credit and debit card details, bank account details, and address) using fake emails, fake websites, or both [1]. Therefore, phishing attacks have become one of the most serious types of threat to businesses and the public in recent years [2]. According to the Canadian Center for Cyber Security [3], the number of reported phishing attacks is around 156 million emails per day, and the number of victims reaches around 80,000 per day. Alsadoon [4] stated that the target of these attacks is the financial sector, which received 70% of the reported attacks in the third quarter of 2018 [5]. For instance, in 2005, the Bank of America lost 1.2 million usernames and social security numbers (SSNs) belonging to its customers, which led to the loss of millions of dollars. In 2011, the details of 10 million credit cards belonging to users were stolen from Sony Entertainments, which cost approximately two billion dollars, making it the most expensive cyber-hack in history [2]. The FBI's Internet Crime Report for 2017 counts phishing attacks amongst the top three types of crime cited by victims of Internet crime, with losses of approximately 30 million dollars being recorded for that year. In fact, this number is likely to be much higher because not all attacks are reported.

The financial sector is not the only target for phishers; a Malcovery report for the last quarter of 2013 showed that the top five organizations targeted by phishers were Facebook, WhatsApp, UPS, Wells Fargo, and Companies House (UK) [6], indicating that phishing attacks target people's social lives as well as their financial interests. Consequently, both industry and academia are working hard to develop solutions to the phishing threat. It is therefore of paramount importance that organizations pay attention to end user awareness when attempting to prevent phishing.

Phishing is a very hard security issue to prevent for two main reasons. First, it is very easy for the phisher to design an identical website that represents a bank or famous brand and looks very convincing to users, so that a significant percentage of users are unable to recognize a phishing attack. Second, most phishing attacks are currently hosted on websites that have HTTPS and SSL certificates.

Recently, a number of technical solutions have been proposed to mitigate the problem of phishing, such as SpoofStick, Netcraft, and SpoofGuard. However, these tools are not the only means developed to prevent attacks [7]. For instance, Dhamija et al. [8] conducted a phishing experiment, with results that revealed how 23% of the study participants never looked at the address bar or status bar when receiving a link by email and did not even understand the anti-phishing tool indicators. This led them to making mistakes in the experiment 40% of the time and these mistakes were the main reasons for phishing attacks. That study demonstrated that anti-phishing training for end users should be mandatory for any technical solution proposed. According to Symantec[9], users' awareness is central to changing their behavior and preventing online scams. A higher level of awareness will reduce the number of mistakes made by users when dealing with phishing emails and websites.

In [10], we conducted two phishing experiments, each was written in a different language (English and Arabic). We found that the number of participants who failed to detect the phishing email in the first experiment was sharply reduced in the second experiment, for two reasons. The first reason was the improvement in the participants' phishing awareness, due to phishing information that we provided to the victims when they clicked the link. The second reason was the language of the email. Although the majority of the participants were non-English speakers, the second experiment was conducted in

English. Consequently, we found that the language of the email also has a significant effect on the results of experiments. In this paper, we conducted a phishing experiment, Which is an extension of the experiments in [10]. The aim of this experiment is to evaluate the improvement on user's awareness when the email is written in two different languages (Arabic and English in this experiment) and to compare the result of this experiment with the experiments presented in [10], both of which have been carried out in the same environment. Moreover, the experiment in this paper has been conducted in real-world environment. The sample in this experiment consists of the victims who clicked on the phishing link in both experiments mentioned above (which was presented in a previous paper [10]), as well as a new group of participants. Furthermore, the new experiment was conducted in an educational context, with the aim of studying the outcomes produced by participants who comprised computer science specialists and faculty members with a PhD in computer security. The results of the experiments outlined in this paper strongly support the assumption presented above: that technical solutions cannot prevent phishing attacks without user awareness.

The remainder of this paper is organized as follows. Section two presents the background literature on anti-phishing approaches. In section three, the research hypotheses are described, while the fourth section explains the research methodology. The fifth section defines the evaluation method implemented. In the sixth section, the results of the experiment are presented, and the paper is then concluded with a discussion of the findings and recommendations for future work.

II. Related Work

Security issues in technology have been recognized since technology became very significant in all aspects of human life. For instance, in 1960, access controls and encryption approaches were developed to protect passwords from a security threat known as "phone phreaking." At the time, phone phreaking referred to the use of an electronic device called a "blue box," which was capable of emitting the frequencies used by telephone companies, thereby making it possible to make free calls. The "ph" in "phishing" is derived from this term, with "ph" replacing the "f" in "fishing" [1].

The term "phishing" was first used in 1996, when hackers stole users' confidential information from America On-line (AOL) [1], [2]. In that incident, the hackers contacted AOL users via fake emails and asked them to verify their passwords for security purposes. As a result, many users provided passwords to the hackers, who were then able to make purchases from their accounts. This ultimately cost millions of dollars at the expense of legitimate users. According to [11], the main domains targeted by hackers for phishing are .com, at 41%, followed by .net at 7%, .org at 5%, and .br at 3%.

In recent years, there have been numerous attempts to reduce the incidence of phishing: for example, through the introduction of anti-phishing toolbars, which are Web browser plug-ins that warn users when they access a suspected phishing site [12]. Additionally, many financial, commercial, private, and government institutions (for example, eBay and HSBC) offer guidance on how to prevent phishing. The aim of these tips is to train users to look for signs of phishing in emails and websites, thereby enabling them to identify phishing attempts more effectively. In general, however, ordinary users do not read the online material intended as anti-phishing training, even though this can be effective if applied [13].

In contrast, Sheng et al. [14] proposed an online game to teach users good habits, helping them to avoid phishing attacks. Kumaraguru et al. [15] also considered training users to identify and deal with phishing emails during their everyday email use. Their aim was to teach users to look for phishing clues in their emails. They found that this training approach works better than the current practice of sending anti-phishing tips by email. However, the above approach did not include teaching users how to avoid phishing websites.

There are various ways in which phishing sites may be accessed, such as in online advertisements. Alnajim and Munro [16] proposed an anti-phishing strategy in the form of a training intervention. This is designed to help users ascertain whether a website is legitimate. It provides information for end users and helps them as soon as they make a mistake. The above authors found a positive effect of using their approach, compared with the earlier strategy of sending anti-phishing tips by email.

The approaches of Kumaraguru et al. [15] and Sheng et al. [14] were evaluated in studies involving participants who had been recruited on the basis of their technical background. Prospective participants were classified as either "expert" and "non-expert" users, based on pre-study screening questions. Their technical background was judged according to whether they had ever changed preferences or settings in their Web browsers, created a Web page, or helped someone to resolve a computer problem. Any participant who answered 'No' to at least two of the screening questions was selected to take part in the experiments. This assessment of technical background was therefore used to recruit non-experts. However, these apparent non-experts in the use of the relevant technology may have already been aware of phishing and how to detect attacks, before taking part in the evaluation experiments, leading to biased results. This is because participants with prior knowledge of phishing may have applied their existing knowledge, rather than the anti-phishing approaches being taught in the experiment.

Fettel et al. [17] proposed machine learning methods to detect a phishing attack. These approaches assessed the properties of URLs contained within an email (for example, the number of dots in the URL, the age of the linked domains, and the number of links in the email) to flag emails as phishing emails. These techniques are helpful in filtering phishing emails but still cannot prevent the attacks without an improvement in the user's knowledge of phishing.

Downs et al. [18] studied whether there was any correlation between a level of experience of the Web environment and susceptibility to phishing. They found that users who correctly answered a question about the definition of phishing (that is, phishing-aware users) were significantly less likely to be deceived by phishing emails.

A similar approach has been proposed by Alnajim [19]. The model presented was mainly a prototype of an automated analyzer for users' anti-phishing behavior within a LAN. This analyzer automatically performs ongoing analysis of users' behavior in response to phishing attacks. Based on the results of this analysis, the analyzer decides whether users require training in the detection and avoidance of phishing. However, this approach goes beyond that by adding an advanced setting that fully automates the training without the human intervention. This approach has been implemented and evaluated in a real-world context.

In [10], we conducted two different phishing experiments, targeting active users who were randomly selected from different specialties and who had different levels of knowledge. In the first experiment (Experiment 1), a phishing email (in Arabic) was sent from an unofficial domain to 1500 active users, who used email regularly in the education sector. This email was written in Arabic because most Internet users at the university (87%) were Arabic speakers. The sample included managers, faculty staff, and general employees. The phishing email was designed to resemble a legitimate email, requesting users to update their passwords immediately via a website link. The hyperlink directed the users to a website that informed the users that they had been targeted by a phishing email. The website consisted of information about phishing and the most common phishing scenarios, with the aim of improving users' knowledge and thereby avoiding any future phishing attacks. In the second experiment (Experiment 2), an English version of the same email was sent to a sample of the same size, consisting of users who had failed to detect the phishing email in Experiment 1, as well as some new participants who had not participated in the first experiment. The email in the second experiment was in English, to evaluate the awareness of non-Arabic speaking participants and the curiosity of non-English speaking participants. The results revealed that a significant improvement was identified in the phishing awareness of those who had participated in the first experiment: only five participants from Experiment 1 clicked on the link. In this paper, we continue examining participant awareness by conducting an experiment evaluating the user's awareness when the email written in two different languages that can be understand by all the users. The following sections describe this technique in detail.

III. Research Hypotheses

With this approach, the research hypotheses can be expressed as follows:

Hypothesis 1: There is no significant impact of the language of the email in recognizing and detecting Phishing email.

Hypothesis 2: The time of sending the phishing email has a significant impact. The majority of the victims are always affected by phishing on the first day, but the rate dropped sharply over subsequent days.

An evaluation and analysis of these hypotheses are presented in following sections.

IV. Implementation

A. Objective

Many public and private sector organizations, such as companies and universities, have many users in their local network. Those users use the organization's network to perform their required tasks, such as serving the public or students. Such tasks may require them to connect to the Internet to provide the organization's services online or to communicate with others. They may be exposed to phishing attacks because they are connected to the Internet. Consequently, improving the users' awareness of phishing attacks is a significant step toward preventing it.

B. Development

The website used in the experiment has been implemented in PHP Laravel, which is operated and stored on a local machine and run by an Apache server. The Domain Name System (DNS) host files in the Windows operating system were modified, so that the Web browsers displayed the URL of the actual phishing websites. When a user click on the corresponding link, the website would store information of importance to the experiment, such as the user's position, department, specialty, gender, IP address (to see if he or she was accessing the site from within or outside the domain), date, and time. All this information was stored in the local database, so that a statistical analysis could be carried out.

V. Methodology

The experiment presented in this paper has been conducted in a real-world context, to produce results that are close to reality which was the main goal of the approach.

In this experiment, the phishing email was written in Arabic and English, and was sent from an unofficial domain to 1500 active users who used email regularly in the education sector. The sample included managers, faculty staff, and general employees. However, students fell outside the scope of this study. The sample also included the victims who had clicked the phishing link in Experiments 1 and 2 of [10].

The phishing email was designed to resemble a legitimate email, informing the users that their mailboxes had reached the limit and encouraging them to increase the size by clicking on a given link.

The hyperlink attached to the button directed the users to a website, which informed the users that they had been targeted by a phishing email. The website consisted of information about phishing and the most common phishing scenarios, with the aim of improving users' knowledge and thereby avoiding any future phishing attacks. In this paper, it was assumed that a participant clicking on the hyperlink would become a phishing victim.

VI. Results

Once the experiments had been completed, a statistical analysis was carried out using IBM SPSS Statistics. In the experiment, the emails were sent to local active users. This involved filtering the users and eliminating those who had not used their email accounts for at least a month. This kind of filtering was very useful for determining the accuracy of the

results, ensuring that only active users were involved in the study. In the experiments, we analyzed the results with respect to the users' confidentiality and privacy. The following sections describe these experiments in detail.

A. Experiment

In the experiment, the email was sent to 900 (60 %) male users and 600 (40%) female users over a period of three days: from December 5–8, 2018. As mentioned above, the email was in Arabic and English, to cover both Arabic and non-Arabic participants. The results of the experiment showed that the total number of users who opened the email amounted to 580: 287 female and 293 male.

192 participants clicked on the link. Similar to the previous experiments, the highest rate at which participants became victims happened on December 5 (57.3%) and the lowest rate was 0.5%, which happened at the end of the experiment. As mentioned in [10], this was because of some users who were more aware, users with a technical background, and the first victims to suffer attacks warning other users about the phishing emails via social media, such as WhatsApp.

In terms of gender, 63% male and 37% female participated, where only 36 of the males and 14 females were PhD holders. The majority of participants (68.8%) were employees, followed by faculty (26.6%), managers (4.2%), and deans (0.5%) (see Table I).

Further analysis was carried out to determine the relationship between gender, position, PhD status, and date (see Table II). The results show a weak negative correlation between date and position (r=-0.157, N=192, P=0.030) and between date and PhD status (r=-0.158, N=192, P=0.029), which indicate that people with high position and PhD holders were less likely to become victims.

B. Results Comparison

This section discusses and compares the results found in the new experiment (which we call Experiment 3) and the results of the experiments conducted in [10]. The total number of victims in Experiment 3 was 192 during three days, compared with 79 victims in Experiment 1 and 127 victims in Experiment 2 (see Table III). It was noticed from the three experiments that the number of the victims increased.

TABLE. I. DISTRIBUTION OF SAMPLE ACCORDING TO PHD STATUS AND JOB LEVEL

Gender	**PhD holder**			
	No		**Yes**	
	Position		**Position**	
	Employee	**Manager**	**Dean**	**Faculty**
Female	54	1	0	14
Male	77	7	1	35
Total	131	8	1	49

TABLE. II. PEARSON CORRELATION MATRIX.

		Gender	**Date**	**position**	**PhD holder**
Gender	Pearson Correlation	1	.007	.092	.119
	Sig.(2tailed)	.000	.920	.202	.101
	N	192	192	192	192
Date	Pearson Correlation	.007	1	-.157-[a]	-.158-[a]
	Sig.(2tailed)	.920	.000	.030	.029
	N	192	192	192	192
position	Pearson Correlation	.092	-.157-[a]	1	.947[b]
	Sig.(2tailed)	.202	.030	.000	.000
	N	192	192	192	192
PhD holder	Pearson Correlation	.119	-.158-[a]	.947[b]	1
	Sig.(2tailed)	.101	.029	.000	0
	N	192	192	192	192

[a] Correlation is significant at the 0.05 level (2-tailed).

[b] Correlation is significant at the 0.01 level (2-tailed).

TABLE. III. DISTRIBUTION OF SAMPLES ACCORDING TO THE EXPERIMENT, AND WHETHER A SPECIALIST OR PHD HOLDER

					PhD holder			
					No		**Yes**	
					Employee	**manager**	**Dean**	**faculty**
Group	Experiment1	female	Specialist	No	11	0	0	1
				Yes	1	2	0	0
		male	Specialist	No	35	3	1	12
				Yes	8	3	2	0
	Total				79			
	Experiment2	female	Specialist	No	17	0	1	12
				Yes	2	0	0	2
		male	Specialist	No	43	3	2	37
				Yes	7	0	1	0
	Total				127			
	Experiment3	female	Specialist	No	53	0	0	14
				Yes	1	1	0	0
		male	Specialist	No	72	5	1	35
				Yes	5	2	0	0
	Total				192			

This is because, in each experiment, a new phishing email was sent using a different email style, and it was also written in different languages. However, the number of users who failed to detect the phishing email decreased from 79 victims in Experiment 1 to five victims in Experiment 2. In addition, the victims of Experiments 1 and 2 were involved in Experiment 3 and the results show that only 12 users out of 84 (the sum of the victims of Experiments 1 and 2) clicked on the link, as Fig. 1 shows.

The third experiment has the largest number of victims. This is because the email was written in English and Arabic, so both Arabic and non-Arabic speakers were among the participants because they understand the content of the email. In Experiment 3 there was a weak negative correlation between date and position of message opening (r=-0.157, N=192, P=0.030), compared with a non-significant correlation between date and position in the result of Experiment 1 and Experiment 2, as Table II shows.

VII. Discussion

From the experiments presented in this paper and in [10], the results clearly showed a high and significant effect on users' phishing awareness, demonstrated by users correctly identifying a phishing email and thereby avoiding a phishing attack. As a result, this led to a higher rate of phishing avoidance amongst phishing-aware users, compared with the less aware users. This appeared in a comparison between the results of the three experiments presented in the previous section, with the difference between them indicating a significant positive effect of phishing awareness, as compared with low phishing awareness. Consequently, it would appear that the awareness of phishing has a significant positive effect on users' ability to detect and therefore prevent phishing.

In addition, it was clear from the experiments that having a technical background had little effect on users' ability to distinguish between phishing and legitimate emails. However, this study demonstrated that, in comparison with users who had less awareness of phishing, there was a significant positive effect of phishing awareness on phishing detection.

The results also show that the language of the email has a significant impact. For instance, the experiment presented above has a larger number of victims than the experiments presented in [10]. Consequently, Hypothesis 1 is rejected. This is because the email used in the third experiment was written in Arabic and English, so both Arabic and non-Arabic speakers can participate.

Another significant finding was that the majority of the victims were affected by phishing on the first day of each experiment, but the rate dropped sharply over subsequent days. Hypothesis 2 is therefore accepted, because of some users who were more aware, users with a technical background, and the first victims to suffer attacks warning other users about the phishing emails via social media networks, such as WhatsApp.

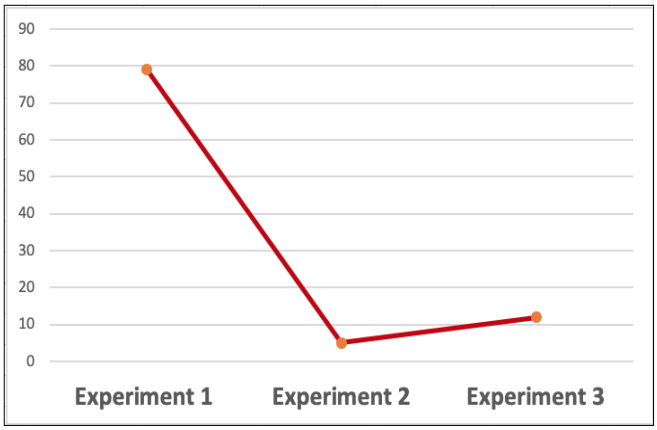


Fig. 1. Victims who Clicked on the Link in Two or All Experiments.

Additionally, Fig. 1 shows that the number of the victims who failed to detect the phishing email in Experiment 1 was reduced sharply in Experiment 2 and Experiment 3. This is because user awareness improved, and the users were able to detect the phishing email.

VIII. Conclusion

The aim of this paper was to demonstrate a phishing experiment which aimed to simulate, analyze and monitor the phishing awareness of users to improve it. This experiment was conducted on a sample of users in a real environment, and the results were reported and interpreted. Significant positive effects were found, with regard to the ability of users to determine whether emails were legitimate or designed solely for the purpose of phishing. The paper also presented a comparison between the result of the experiment conducted in this paper and the related results presented in [10]. Furthermore, the experiments revealed a pressing need for practical training to enhance phishing awareness.

Future work will involve a phishing experiment on students of Computer Science, with a particular focus on security students. The aim being to evaluate the impact of modules dedicated to the topic of security, on the student' own security awareness.

Acknowledgment

The author would like to thank Deanship of Scientific Research, Majmaah University (Grant no. R-1441-5) for funding this work.

References

[1] Gupta, N. Arachchilage, and K. Psannis, "Defending against phishing attacks: taxonomy of methods, current issues and future directions," Telecommun. Syst., vol. 67, no. 2, pp. 247–267, 2018.

[2] A. K. Jain and B. B. Gupta, "Phishing detection: analysis of visual similarity based approaches," Secur. Commun. Networks, vol. 2017, no. 5421046, 2017.

[3] Canadian Centre for Cyber Security, "Phishing: How many take the bait," 2015. [Online]. Available: https://www.getcybersafe.gc.ca/cnt/rsrcs/nfgrphcs/nfgrphcs-2012-10-11-en.aspx.

[4] I. Alseadoon, "The impact of users' characteristics on their ability to detect phishing emails," Queensland University of Technology, 2014.

[5] Anti-Phishing Working Group, "Phishing Activity Trends Report. 3rd Quarter 2018," 2018.

[6] S. Ragan, "Senior executives blamed for a majority of undisclosed security incidents," 2013. [Online]. Available: http://www.networkworld .com/article/2171678/data-center/senior-executives-blamed-for-a-majority-ofundisclosed-%0Dsecurity-incidents.html.

[7] A. Alnajim, "A country based model towards phishing detection enhancement," Int. J. Innov. Technol. Explor. Eng., vol. 5, no. 1, pp. 52–57, 2015.

[8] R. Dhamija, J. D. Tygar, and M. Hearst, "Why phishing works," in the SIGCHI conference on Human Factors in computing systems, 2006, pp. 581–590.

[9] "Symantec, Mitigating Online Fraud: Customer Confidence, Brand Protection, and Loss Minimization.," 2004. [Online]. Available: http://www.antiphishing.org/sponsors_technical_papers/symantec_online_fraud.pdf.

[10] M. Alwanain, "Effects of User-Awareness on the Detection of Phishing Emails: A Case Study," Int. J. Innov. Technol. Explor. Eng., vol. 8, no. 4, pp. 480–484, 2019.

[11] IID, "eCrime Trends Report." [Online]. Available: http://internetidentity .com/resources.

[12] L. F. Cranor, S. Egelman, J. I. Hong, and Y. Zhang, "Phinding Phish: An Evaluation of Anti-Phishing Toolbars," 2006.

[13] A. Alnajim and M. Munro, "An evaluation of users' tips effectiveness for Phishing websites detection," in The third IEEE International Conference on Digital Information Management ICDIM, 2008, pp. 63–68.

[14] S. Sheng, B. Magnien, A. Kumaraguru, Ponnurangam Acquisti, L. F. Cranor, and J. Hong, and E. Nunge, "Anti-phishing phil: the design and evaluation of a game that teaches people not to fall for phish," in The 3rd symposium on usable privacy and security SOUPS '07, 2007, pp. 88 – 99.

[15] P. Kumaraguru, Y. Rhee, A. Acquisti, L. F. Cranor, J. Hong, and E. Nunge, "Protecting people from phishing: the design and evaluation of an embedded training email system," in The SIGCHI conference on Human factors in computing systems, 2007, pp. 905 – 914.

[16] A. Alnajim and M. Munro, "An anti-phishing approach that uses training intervention for phishing websites detection," in the 6th IEEE International Conference on Information Technology - New Generations (ITNG), 2009, pp. 405–410.

[17] I. Fette, N. Sadeh, and A. Tomasic, "Learning to detect phishing emails," in Proceedings of the 16th international conference on World Wide Web, 2007, pp. 649–656.

[18] J. S. Downs, M. Holbrook, and L. F. Cranor, "Behavioral response to phishing risk," in the anti-phishing working groups 2nd annual eCrime researchers summit, 2007, pp. 37 – 44.

[19] A. Alnajim, "An Automated Analyzer for Users' Anti-Phishing Behaviour within a LAN," Int. J. Soft Comput. Eng., vol. 5, no. 3, pp. 115–119, 2015.

Lexicon-based Bot-aware Public Emotion Mining and Sentiment Analysis of the Nigerian 2019 Presidential Election on Twitter

Temitayo Matthew Fagbola[1], Surendra Colin Thakur[2]
Department of Computer Science, Federal University, Oye-Ekiti, PMB 373, Ekiti State, Nigeria[1]
e-Skills coLab, Durban University of Technology, Durban 4000, South Africa[1, 2]

***Abstract*—Online social networks have been widely engaged as rich potential platforms to predict election outcomes' in several countries of the world. The vast amount of readily-available data on such platforms, coupled with the emerging power of natural language processing algorithms and tools, have made it possible to mine and generate foresight into the possible directions of elections' outcome. In this paper, lexicon-based public emotion mining and sentiment analysis were conducted to predict win in the 2019 presidential election in Nigeria. 224,500 tweets, associated with the two most prominent political parties in Nigeria, People's Democratic Party (PDP) and All Progressive Congress (APC), and the two most prominent presidential candidates that represented these parties in the 2019 elections, Atiku Abubakar and Muhammadu Buhari, were collected between 9th October 2018 and 17th December 2018 via the Twitter's streaming API. *tm* and *NRC* libraries, defined in the '*R*' integrated development environment, were used for data cleaning and preprocessing purposes. Botometer was introduced to detect the presence of automated bots in the preprocessed data while NRC Word Emotion Association Lexicon (EmoLex) was used to generate distributions of subjective public sentiments and emotions that surround the Nigerian 2019 presidential election. Emotions were grouped into eight categories (sadness, trust, anger, fear, joy, anticipation, disgust, surprise) while sentiments were grouped into two (negative and positive) based on Plutchik's emotion wheel. Results obtained indicate a higher positive and a lower negative sentiment for APC than was observed with PDP. Similarly, for the presidential aspirants, Atiku has a slightly higher positive and a slightly lower negative sentiment than was observed with Buhari. These results show that APC is the predicted winning party and Atiku as the most preferred winner of the 2019 presidential election. These predictions were corroborated by the actual election results as APC emerged as the winning party while Buhari and Atiku shared very close vote margin in the election. Hence, this research is an indication that twitter data can be appropriately used to predict election outcomes and other offline future events. Future research could investigate spatiotemporal dimensions of the prediction.**

Keywords*—Nigeria; 2019 presidential_election; bots-awareness; EmoLex; lexicon_analysis; public_opinion; emotion_mining; sentiment_analysis; twitter; APC; PDP; win_prediction; muhammadu_buhari; atiku_abubaka

I. Introduction

The online social networks, being a medium for communicating and sharing opinions, have provided us with a large and rich variety of facts, interests and opinions which can be accessed and mined, by leveraging on the strong predictive power of learning algorithms, to generate useful patterns about offline events [1] [2]. Examples of such platforms include Twitter, Facebook, Instagram, YouTube among others. David and Francesco [3] defined opinion mining as a sub-discipline of computational linguistics that major on extracting people's opinion on social platforms. In recent years social media platforms have expanded massively thereby encouraging users to participate, contribute, and give opinions regarding different kind of issues, debates, and election prediction. Social platforms such as Twitter and Facebook provide researchers with a large significant data to be processed and mined due to the massive user-generated content which has widen the application scope of public opinion mining tools, and are becoming highly available to majority of the public [4]. Several works have adopted and utilized the readily-available data on social media platforms such as Twitter as a relatively cheaper and less-time consuming means for mining public opinions [5]. Public opinion mining comes handy and cogent in studies such as election predictions [6], crime analysis [7], Stock market analysis [8], consumers' behaviour [9], the outbreak of disease [10], public health [11] and so on.

In elections, opinion polls have been the intermediary between the opinion of the voters and politicians. However, the desire to predict an election outcome via twitter is to create an alternative to current polls with the minimal cost but still maintaining the standard in terms of precision, accuracy and reliability. Examples of elections forecasted via the use of online social networks include the 2018 Brazilian presidential elections [12], 2016 United States presidential election [13-16], Indian 2015 election [17], 2014 Brazil presidential election [18], Pakistan Election 2013 [19] and United States presidential election 2012 [20] among others. However, most of these works did not take into cognizance, the presence of software bots in online social networks. Software bots are automated accounts usually deployed by a third party to

pollute the content, manipulate and influence public sentiment in online social networks and performing human-associated activities like tweeting, retweeting and liking among others [21-22]. Zi, Steven, Haining and Sushil [23] revealed that Twitter accounts originating from human, cyborg and bot, follow an estimated 5:4:1 ratio distribution, respectively. Hence, the need for bots detection and removal from Twitter data as crucial preprocessing steps cannot be overemphasized.

Currently, the Nigeria 2019 presidential election is topical and of great interest to the public as it attracts diverse opinions that could be mined and analyzed to infer public preference in comparison with the actual outcomes of the election. In this paper, a bot-aware public emotion mining on Twitter is conducted to predict winner of the Nigeria's 2019 presidential election. This prediction leverages on the NRC Word Emotion Association Lexicon (EmoLex) [24] and an enhanced Sentiment Polarity Lexicon Model (SPLM) [25] to detect and analyze the distribution of sentiments (positive and negative) and emotions (happy, sadness, trust, anger, anticipation, fear, joy, surprise, disgust), as defined in the Plutchik's wheel of emotions [26], which are associated with the public opinions expressed on Twitter. The rest of the paper is organized as follows: Section 2 presents some related works regarding the use of online social networks for predicting presidential elections' results; Section 3 presents the materials and methods used to conduct the study; Section 4 presents the results of the analyses and predictions of the winner of the presidential election while the conclusion is presented in Section 5.

II. Related Works

Sri, Arash and Christine [27] analyzed the public sentiments of over 200,000 tweets associated with the two major candidates in the United States' 2016 Presidential Election in terms of positive, negative, anger, trust, anticipation, disgust, joy, fear, sadness and surprise. Results reported indicate a significant difference in positive sentiment and emotions including fear, joy, disgust, surprise, trust while negative sentiment and anticipation, anger and sadness emotions were reported insignificant. Brian, Joseph and Taghi [28] employed spatial information, positive sentiment and tweet volume features extracted from around 3 million tweets collected from twenty-one states between 22nd September 2016 and 8th November 2016 to predict the winner of the U.S. 2016 Presidential Election between the two prominent candidates "Donald Trump" and "Hillary Clinton". Budiharto and Meiliana [29] conducted a sentiment analysis and counting of tweets gathered between March 2018 and July 2018 with regards to the Presidential Candidates of Indonesia (Jokowi and Prabowo) to predict Indonesian Presidential election result. Andranik *et al.* [30] conducted a sentiment analysis of the 2009 federal election of the national parliament in Germany with over 100,000 tweets related to either a political party or a politician. The study affirmed that microblogging is able to provide extensive public opinion about offline events including politics. Gayatri and Nilesh [31] employed Naïve-Bayes and *k*-means algorithm to conduct a sentiment analysis about the public political orientation regarding the Maharashtra state assembly election by leveraging on the tweet contents and the associated twitter user-based features. Pritee and Sachin [32] adopted a lexicon-based approach integrated with Naïve-Bayes algorithm to detect and predict emotions in tweets using Gujarat Election data. Emotions of interest were tentativeness, sadness, anxiety, anger, work, certainty and achievement, as well as positive and negative sentiments. However, majority of the Candidates had more tweets expressing joy than any other emotion. However, the candidate Amit had the highest positive sentiment score, followed by Ahmed and Smriti in that order. Elvyna and Yustinus [33] applied Naïve-Bayes algorithm to predict the 2016 U.S. Presidential election with 371,264 tweets gathered between December 16, 2015 and February 29, 2016 using Twitter Streaming API on Tweepy. The system achieved a 95.8% accuracy over a 10-fold cross validation and also predicted Ted Cruz and Bernie Sanders as Republican and Democratic nominee respectively. Kassraie, Modirshanechi and Aghajan [34] developed a Gaussian process regression model to predict the 2016 US Election from 370,000 tweets via an estimation of the candidates' vote shares.

Adam and Alan [35] combined sentiment analysis with volume-based metrics to model political sentiment of the 2011 Irish General Election using data obtained from Twitter. The developed integrated method was evaluated against the conventional election polls and the final election result. Results obtained reveal that the developed method is predictive and capable of revealing public opinions about elections via social media data. Oikonomou and Tjortjis [36] employed Twitter data to predict the winner of the 2016 USA presidential elections in Ohio, Florida and North Carolina. To achieve this, the study conducted a sentiment analysis on the two major candidates "Donald J. Trump" and "Hillary Clinton" to predict the winner. Kellyton *et al.* [12] identified the correlation between social media and the final outcome of the 2018 Brazilian presidential elections for the thirteen (13) candidates using 291 million social media users' interactions and over 41,000 posts obtained from Instagram, Twitter and Facebook between January 2018 and October 2018. Features of interest adopted include social media profiles, users' posts and number of followers and the posts from the presidential candidates. The study established a strong correlation between the followers of candidates and votes received. Similarly, there was a recorded higher rate of discussions via posts and followers on Instagram than were recorded on both Facebook and Twitter.

Omaima, Suhem and Bravim [37] employed location information from 650,000 tweets collected from Twitter within a period of 5 days to identify patterns and trends in a bid to predict the winner of the Indian general elections 2014. The study used sentiment analysis and Naïve-Bayes algorithm for prediction and classification purposes. Jayakumar *et al.* [38] adopted a Long Short Term Memory (LSTM) deep learning model to predict wins in Indian elections by leveraging on users' opinions in twitter. Barkha and Sangeet [39] developed a Hybrid Topic Based Sentiment Analysis (HTBSA) that leveraged on biterm topic model and geotagging to extract latent topics and capture word relations and co-occurences in more than 300,000 tweets collected between 1st February 2017 and 20th February 2017 to predict

win in Uttar Pradesh legislative elections. Manish, Anoop and Amit [40] predicted the winner of the three presidential elections held in Latin America during the months of February through April, 2013 by leveraging on the popularity of the candidate on Twitter. Vinay and Shishir [41] developed an intelligent model based on dynamic keywords and topic modeling to predict win in elections with respect to the sentiments of users and volume of tweets. Chaitanya [42] conducted a predictive sentiment analysis of the Karnataka State Elections with tweets fetched obtained from Twitter using Tweepy. Zhang [43] employed regression analysis to develop a model to forecast the results of Taiwanese elections using data obtained from candidates' Facebook posts and their Like Ratio and daily average page views on each candidate's Wikipedia page. Bruno *et al.* [44] developed a spatio-temporal sentiment framework aided with a Support Vector Machine to analyze the Brazilian presidential elections using data obtained from Twitter. Di-Fatta *et al.* [45] conducted a political sentiment analysis of the 56th United Kingdom Parliament general elections with over 28 million tweets collected between 1st March 2015 and 31st May, 2015.

III. Materials and Method

In this section, the profiles of the political parties and that of the candidates, the description of the data collected and the Lexicon-based bot-aware election prediction workflow used for the predictive analysis are presented.

A. Materials

The Political Parties: The two (2) political particles are the All Progressive Congress (APC) and the People's Democratic Party (PDP).

1) Profiles of the political parties

a) APC: APC became the largest political party in Nigeria by toppling the PDP after an emphatic win at the national level in the 2015 Presidential election which brought in President Muhammadu Buhari. Apart from the presidency, APC has 22 states in its coffers as well as the president of the senate and the speaker of the House of Representatives. The leader of the party is Senator Bola Ahmed Tinubu.

b) PDP: PDP is the second biggest political party in Nigeria after losing the 2015 presidential election to the All Progressive Congress (APC). But it is still the most formidable opposition party to the ruling party. PDP still has about 12 states in its control as well as the deputy senate president and a handful of senators and honorable members.

2) Profiles of the presidential candidates: The profile of the two prominent Nigerian 2019 presidential candidates is presented in Table I.

3) Inferring public voting intentions and preference from tweets: A modified SPLM developed by Davidov, Tsur and Rappoport [25] is an excellent tool to infer and estimate public sentiment in online social networks about objects and/or offline social events. In this paper, SPLM is used to evaluate actual public voting preference regarding the political parties and the presidential candidates in the Nigerian 2019 presidential elections as presented in equations (1 and 2).

$$(P_1) = \frac{Pos(P_1)+Neg(P_2)}{Pos(P_1)+Neg(P_1)+Pos(P_2)+Neg(P_2)} \quad (1)$$

$$(P_2) = \frac{Pos(P_2)+Neg(P_1)}{Pos(P_1)+Neg(P_1)+Pos(P_2)+Neg(P_2)} \quad (2)$$

where P_1 *and* P_2 are the political parties, $Pos(P_1)$ depicts the positive sentiment score for P_1, $Pos(P_2)$ depicts the positive sentiment score for P_2, $Neg(P_1)$ depicts the negative sentiment score for P_1 while $Neg(P_2)$ depicts the negative sentiment score for P_2.

B. Lexicon-based Bot-aware Election Prediction Workflow

The workflow is comprised of four steps including data acquisition, data cleaning, preprocessing, tweet analysis and output visualization as presented in Fig. 1.

1) Data acquisition: 224,500 tweets associated with some leading political hashtags like #PDP2019, #APC2019, #Buhari2019, #Atiku2019, #MBuhari2019, #AtikuObi and #Atikulated2019 were fetched from Twitter via the Twitter REST API between 9th October 2018 and 17th December 2018. An example of the code snippet used to generate tweets from twitter for #Buhari2019 is as follows:

$Buhari <- searchTwitter("\#Buhari2019", n = 20000)$ where n represents the number of Tweets to be returned. Sample tweets collected are presented in Fig. 2. The data was collected into an Excel spreadsheet and saved as a CSV (comma separated values) format as shown Fig. 3. Different files were used to store tweets of each unique party and presidential candidate.

TABLE. I. Information Regarding the Presidential Candidates

S/N	Full Name	Age (Years)	Position held
1.	Muhammadu Buhari	75	Incumbent President of the Federal Republic of Nigeria, he was also the Military Head of State from 1983 – 1985
2.	Abubakar Atiku	71	Former vice president of Nigeria

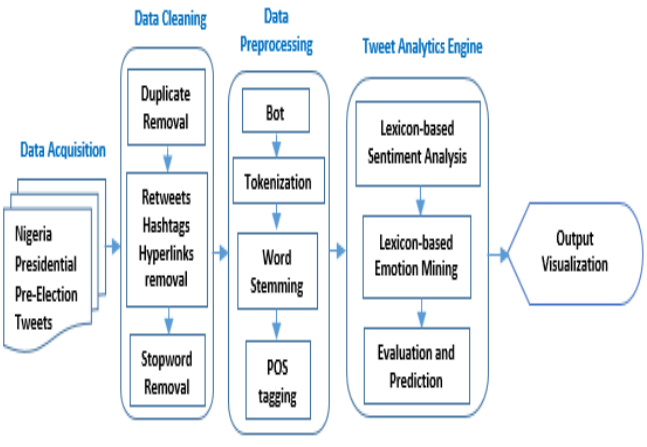


Fig. 1. Our Lexicon-based Bot-aware Election Prediction Architecture.

RT @senatorsolace: If MUSA can score 2 goals in 2nd half, that means BUHARI can do better in 2nd term
@fkeyamo There is nothing distasteful in this, Keyamo is doing a great job, he is really giving opposition sleeples...
RT @BornoYoung: @MBuhari & @ProfOsinbajo will win the 2019 election wether you like it or not. #Buhari2
@MBuhari & @ProfOsinbajo will win the 2019 election wether you like it or not. #Buhari2019 C16
@APCNigeria Asiwaju, is a collosal personality and politician. Buhari2019...
@APCNigeria He's a Wise Choice. Man Of The People. Buhari2019...
@APCNigeria Cheerful News Please Do More. Buhari2019...

Fig. 2. Sample Tweets Collected Mentioning #Buhari2019.

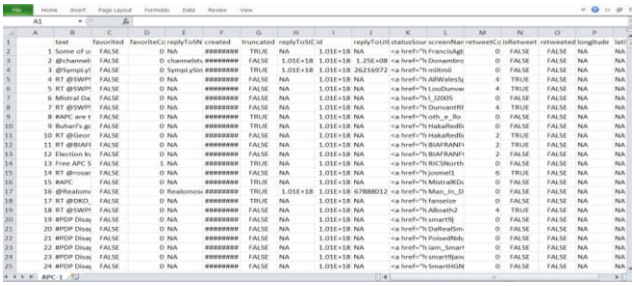


Fig. 3. Cross-Section of the Tweets Collected in Microsoft Excel Spreadsheet.

2) Data cleaning: Data cleaning is an important step to reduce the noise in the dataset. Duplicate hashtags, punctuations, tweets, retweet entities, upper to lower case conversion, hyperlinks, numbers, stopwords, emojis, empty spaces, special and repeated characters in a text and HTML twitter handles were removed by introducing appropriate arguments into the "*gsub* ()" and the "*grep* ()" functions defined in the "*nrc*" documentation. Out of the 224,500 tweets fetched, 10,523 tweets/retweets were found to be duplicates and so removed. Sample '*R*' code snippet used to process tweets collected from twitter is as follows:

$$removeURL <- function(x)\ gsub\ ("http[^[:space:]]*","",x))$$

3) Data pre-processing: Data preprocessing steps include bot removal, tokenization, word stemming and part of speech tagging. The Botometer [46] was used to check for likely presence of bots in the remaining 213,977 tweets. However, 45,244 tweets, with bot scores above 0.6, were detected to have originated from bot accounts and hitherto removed. After bot removal, the remaining tweets were tokenized into a set of unigram words using the *get_tokens* () function defined in the Syuzhet library in '*R*'. Furthermore, each unigram is reduced to its shortest possible form using the *stemDocuments* () function defined in the "*tm*" library in *R*. For example, "voted" becomes "vote". Moreover, POS tagging was conducted to disambiguate the meaning of the unigrams and their lexical categories. Tables II and III present the common hashtags used by the two (2) presidential candidates and the two (2) dominating political parties on Twitter alongside their respective number of remaining after preprocessing.

TABLE. II. 2019 NIGERIAN PRESIDENTIAL ELECTION'S CANDIDATES, HASHTAGS AND TWEETS AFTER PREPROCESSING

Candidates	Search Keywords (Hashtags)	# tweets
Muhammadu Buhari	#Buhari2019, #MBuhari2019	24,897
Abubakar Atiku	#Atiku2019, #AtikuObi2019, #Atikulated2019	26,354

TABLE. III. 2019 NIGERIAN PRESIDENTIAL ELECTION'S PARTIES, HASHTAGS AND TWEETS AFTER PREPROCESSING

Parties	Search Keywords (Hashtags)	# tweets
All Progressive Congress	#APC2019, #BuhariOsinbajo2019	86,659
People's Democratic Party	#PDP2019, #AtikuObi2019	30,823

4) Tweet analytics engine: The analytics engine employs the Syuzhet library functions defined within the '*R*' documentation and the NRC Word Emotion Association Lexicon (EmoLex) dictionary to estimate the scores of the eight (8) Plutchik's emotion distributions (sadness, trust, anger, fear, joy, anticipation, disgust, surprise) and the two (2) sentiments (negative and positive), associated with the tweets. However, a modified SPLM was used to infer and estimate public voting intention and win prediction by leveraging on the public sentiment scores.

IV. RESULTS

In this section, the public emotion distribution across political parties and the presidential candidates are presented. Similarly, results of public voting intention and preference analysis from the tweets are also presented.

A. Results of Public Emotion Distribution by Political Parties

1) All progressive congress: As presented in Fig. 4, the public emotion scores of APC towards the Nigerian 2019 Presidential election are 6077, 9836, 3150, 8487, 5039, 4906, 3087, 14316, 11527 and 20234 for "Anger", "Anticipation", "Disgust", "Fear", "Joy", "Sadness", "Surprise", "Trust", "Negative sentiment" and "Positive sentiment", respectively. Pictorially as shown in Fig. 5, it can be seen that most of the tweets conveyed "Positive" sentiment which accounted for about 23% of the entire NRC emotions distribution. "Trust" is the second most conveyed emotion and accounts for 16% of the overall emotions. "Negative" sentiment is the third most significant expression with a 13% distribution among other emotions. "Anticipation" (11%), "Fear" (10%), "Anger" (7%), "Joy" and "Sadness" (6%) while "Disgust" and "Surprise" has the least distribution with about 4% of the entire NRC emotions.

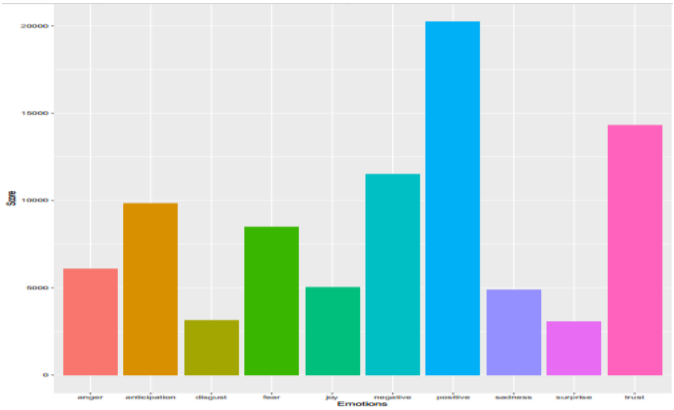


Fig. 4. Chart Showing Public Emotion and Sentiment Scores for APC2019.

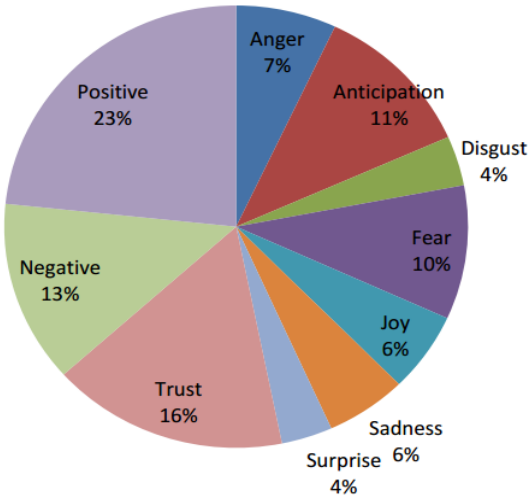


Fig. 5. Chart Showing % Public Emotion and Sentiment Distribution for APC2019.

2) People's democratic party: As presented in Fig. 6, the public emotion scores of PDP towards the Nigerian 2019 Presidential election are 2236, 2944, 1521, 2587, 2291, 2166, 1334, 4737, 4753 and 6254, for "Anger", "Anticipation", "Disgust", "Fear", "Joy", "Sadness", "Surprise", "Trust", "Negative sentiment" and "Positive sentiment", respectively. The frequency of unique tweets depicted in percentage as presented in the pie chart of Fig. 7 shows that most of the tweets conveyed the "Positive sentiment" which accounted for about 20% of the overall distribution of the emotions, followed by "Negative sentiment" (16%), "Trust" (13%), "Anticipation" (10%), "Joy" (8%), "Fear" (8%), "Anger" (7%), "Sadness" (7%), "Disgust" (5%) and "Surprise" (4%) in decreasing order of public expression.

B. Results of Public Emotion Distribution by Presidential Candidates

1) #Buhari2019: The public emotion scores of "Buhari" towards the Nigerian 2019 Presidential election are 1672, 2405, 1104, 1958, 1842, 1717, 1086, 4099, 3682 and 5332 for "Anger", "Anticipation", "Disgust", "Fear", "Joy", "Sadness", "Surprise", "Trust", "Negative sentiment" and "Positive sentiment", respectively as presented in Fig. 8. A pie chart showing the percentage distribution of each of these emotions is presented in Fig. 9. It is observed that most of the tweets conveyed the "Positive sentiment" which accounted for about 21% of the overall distribution of the emotions, followed by "Trust" (17%), "Negative sentiment" (15%), "Anticipation" (10%), "Fear" (8%), "Anger" (7%), "Sadness" (7%), "Joy" (7%), "Disgust" (4%) and "Surprise" (4%) in decreasing order of public expression.

2) #Atiku2019: The public emotion scores of "Atiku" towards the Nigerian 2019 Presidential election are 1734, 2595, 1090, 1976, 2067, 1759, 1271, 4288, 3584 and 5990 for "Anger", "Anticipation", "Disgust", "Fear", "Joy", "Sadness", "Surprise", "Trust", "Negative sentiment" and "Positive sentiment", respectively as presented in Fig. 10. A pie chart showing the percentage distribution of each of these emotions is presented in Fig. 11. It is observed that most of the tweets conveyed the "Positive sentiment" which accounted for about 23% of the overall distribution of the emotions, followed by "Trust" (16%), "Negative sentiment" (14%), "Anticipation" (10%), "Joy" (8%), "Fear" (7%), "Sadness" (7%), "Anger" (6%), "Surprise" (5%) and "Disgust" (4%) in decreasing order of public expression.

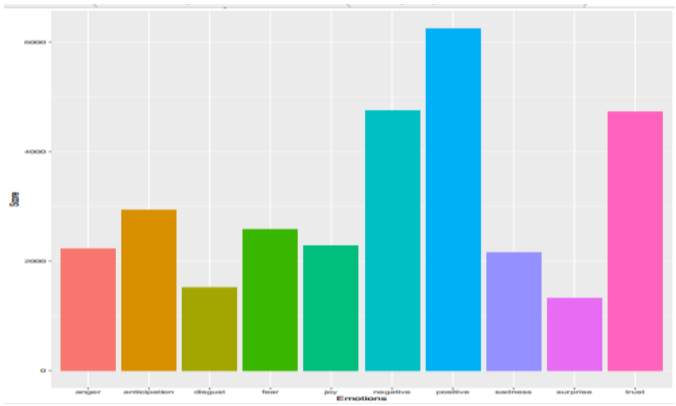


Fig. 6. Chart Showing Public Emotion and Sentiment Scores for PDP2019.

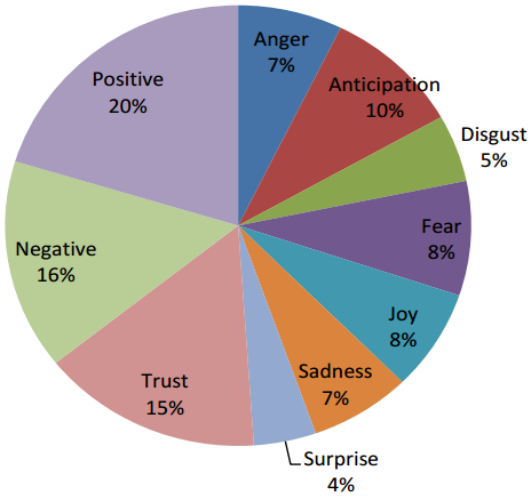


Fig. 7. Chart Showing % Public Emotion Distribution for PDP2019.

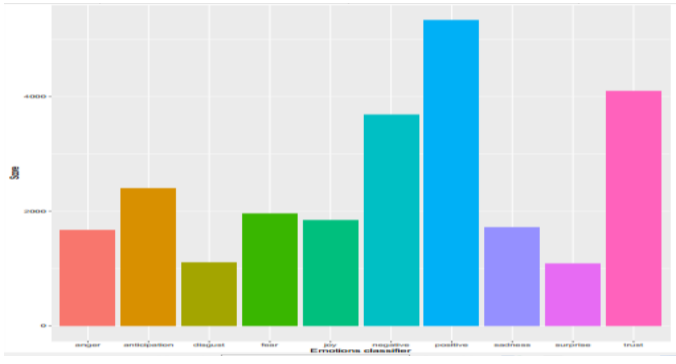


Fig. 8. Chart Showing Public Emotion and Sentiment Scores for Buhari2019.

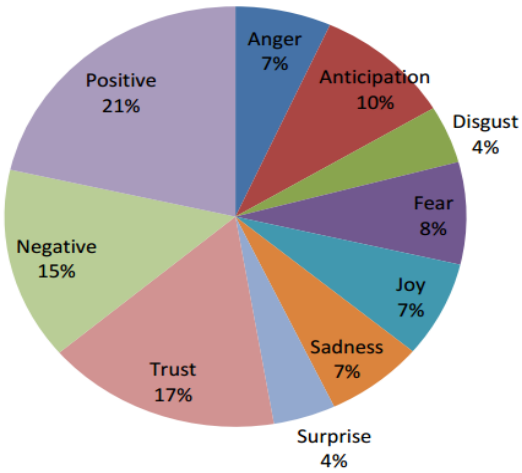


Fig. 9. Chart Showing % Public Emotion Distribution for Buhari2019.

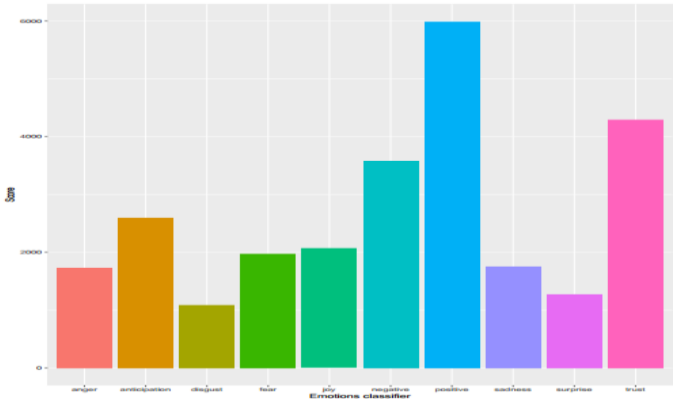


Fig. 10. Chart Showing Public Emotion and Sentiment Scores for Atiku2019.

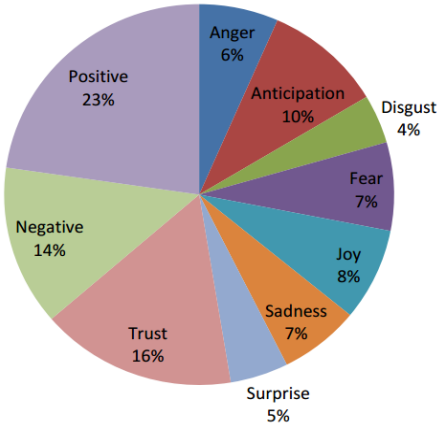


Fig. 11. Chart Showing % Public Emotion Distribution for Atiku2019.

3) Inferring public voting intention and preference from the tweets: The public voting preference for the political parties and the presidential aspirants from the analysis of the associated tweets is presented in this section.

4) Public opinion estimation of preferred political party: This was conducted to estimate the public preference towards a political party of choice in the 2019 Nigeria presidential election using a modified SPLM based on the party-based sentiment polarity scores obtained and presented in Table IV.

TABLE. IV. PARTY-BASED SENTIMENT POLARITY SCORES

Description	Values
P_1	Party 1 (APC)
P_2	Party 2 (PDP)
$Pos(P_1)$	20234
$Pos(P_2)$	6254
$Neg(P_1)$	11527
$Neg(P_2)$	4753

Hence, owing to equations (1 and 2),

$$P(\text{APC}) = \frac{20234 + 4753}{20234 + 11527 + 6254 + 4753} = \frac{24987}{42768} = 0.58$$

$$\text{P(PDP)} = \frac{6254 + 11527}{20234 + 11527 + 6254 + 4753} = \frac{17781}{42768} = 0.42$$

Therefore, the public opinion as revealed by this analysis indicates that APC and PDP had a 58% and a 42% probability of win, respectively.

5) Public opinion estimation of preferred presidential candidate: The public opinion estimation of most preferred presidential candidate in the Nigerian 2019 presidential election was conducted for the two most dominant presidential candidates, (Atiku Abubakar and Muhammadu Buhari), using a modified SPLM that leverages on the sentiment polarity scores of the public expressed about the candidates as presented in Table V.

With respect to equations (1 and 2),

$$P(\text{Atiku}) = \frac{5990 + 3682}{5990 + 3584 + 5332 + 3682} = \frac{9672}{18588} = 0.52$$

$$P(\text{Buhari}) = \frac{5332 + 3584}{5990 + 3584 + 5332 + 3682} = \frac{8916}{18588} = 0.48$$

These results indicate that 52% of the public opinions expressed support for Atiku to emerge as the president of Nigeria while the remaining 48% goes to Buhari. Overall, the results of the party-based and the candidate-based sentiment analyses indicate that the public prefers APC to emerge as the ruling party but with some level of distastefulness for Buhari. The public had shown more interest in Atiku and not in PDP, his party. However, the outcome of the actual election held on the 23 February 2019, as reported by a widely-read newspaper, "The Guardian", with the headline "Muhammadu Buhari wins Nigerian election with 56% of the vote", declared Buhari as the presidential winner with 15.2 million votes over PDP's Atiku with 11.3 million votes. It was further stated that Buhari won in 19 out of the 26 states in Nigeria while Atiku won in the remaining 17 states. [1] These actual outcomes corroborate our predictions strongly as summarized in Table VI. These results have shown that online social networks is a veritable and effective tool for reliable

[1] www.theguardian.com/world/2019/feb/26/muhammadu-buhari-to-claim-victory-in-nigerias-presidential-election

assessment of public opinion regarding political issues and any other real-life events regardless of the domain of application. Furthermore, public opinion mining and sentiment analysis could help to evaluate public opinion and preference about an event and help make improved decisions.

TABLE. V. CANDIDATE-BASED SENTIMENT POLARITY SCORES

Description	Values
C_1	Candidate 1 (Atiku)
C_2	Candidate 2 (Buhari)
$Pos(C_1)$	5990
$Pos(C_2)$	5332
$Neg(C_1)$	3584
$Neg(C_2)$	3682

TABLE. VI. PREDICTED VERSUS ACTUAL WIN OUTCOMES IN THE NIGERIAN 2019 PRESIDENTIAL ELECTION

Parties / Candidates	Predicted Values (%)	Actual Outcomes (%)
APC / Buhari	58 / 42	56
PDP / Atiku	42 / 58	44

V. CONCLUSION

In this paper, a bot-aware, lexicon-based emotion mining and sentiment analysis of public opinions on Twitter were conducted to predict winner of the Nigeria's 2019 presidential election. 224,500 tweets, associated with the two most prominent political parties (PDP and APC) and the presidential candidates (Atiku Abubakar and Muhammadu Buhari), were collected between 9th October 2018 and 17th December 2018 via the Twitter's streaming API. *tm* and *NRC* libraries were used for data cleaning and preprocessing purposes. Botometer was introduced to detect the presence of automated bots in the preprocessed data while NRC Word Emotion Association Lexicon (EmoLex) was used to generate distributions of subjective public sentiments and emotions that surround the Nigerian 2019 presidential election based on the Plutchik's emotion wheel. Results obtained indicate a higher positive and a lower negative sentiment for APC than was observed with PDP, and as further corroborated by the actual election results. This strongly indicate that Twitter is a great resource for predicting offline social events. Future works could be directed towards incorporating both time and location metadata information from the tweets in the prediction.

REFERENCES

[1] R. Shah, and B. Patel, "Procedure of Opinion Mining and Sentiment Analysis," International Journal of Current Engineering and Technology, 4, pp. 4086-4090, 2014.

[2] C. Andrea, C. Luigi, I. Stefano, and P. Giuseppe, "Every tweet counts? How sentiment analysis of social media can improve our knowledge of citizens' political preferences with an application to Italy and France," New Media & Society, vol. 16, pp. 340-358, 2013.

[3] O. David, and M. Francesco, "Research challenge on Opinion mining and sentiment analysis," Australian Journal of Public Administration, 64, pp. 3–13, 2012.

[4] N. Burns, Y. Bi, H. Wang, and T. Anderson, "Sentiment Analysis of Customer Reviews: Balanced versus Unbalanced Datasets," Knowledge-Based and Intelligent Information and Engineering Systems. Lecture Notes in Computer Science, vol. 6881(1), pp. 20-29, 2011.

[5] A. Karami, L. Bennett, and X. He, "Mining Public Opinion about Economic Issues: Twitter and the U.S. Presidential Election," International, IGI Global, vol. 9(1), pp. 18-28, 2018.

[6] N. Dwi, and C. Hauff, "Twitter-based Election Prediction in the Developing World," HT 15, Proceedings of the 26th ACM Conference on Hypertext & Social Media, pp. 149-158, 2015.

[7] W. Xiaofeng, G. Matthew, and B. Donald, "Automatic Crime Prediction Using Events Extracted from Twitter Posts," International Conference on Social Computing, Behavioral-Cultural Modeling, and Prediction, 7227, pp. 231-238, 2012.

[8] B. Johan, M. Huina, and Z. Xiao-Jun, "Twitter mood predict the stock market," Journal of Computational science, 2(1), pp. 1-8, 2011.

[9] K. Evangelos, K. Areti, T. Efthimios, and T. Konstantinos, "Applying brand equity theory to understand consumer opinion in social media," Journal of Universal Computer Science, 22(5), pp. 709–734, 2016.

[10] R. Joshua, O. Miles, and K. Ewan, "Using prediction markets and Twitter to predict a swine flu pandemic," In Proceedings of the 1st International Workshop of Mining Social Media, pp. 9-17, 2009.

[11] M. Jonathan, "Internet Search Data and Issue Salience: The Properties of Google Trends as a Measure of Issue Salience," Journal of Elections, Public Opinion & Parties, vol. 24(1), pp. 45-72, 2014.

[12] K. Brito, N. Paula, M. Fernandes, and S. Meira, "Social Media and Presidential Campaigns – Preliminary Results of the 2018 Brazilian Presidential Election," 20th Annual International Conference on Digital Government Research, DOI:10.2245/3325112.3325252, 2019.

[13] V. Ignasi, T. Tina, and X. Wei, "Characterizing the 2016 U.S. Presidential Campaign using Twitter Data," International Journal of Advanced Computer Science and Applications, vol. 7(10), pp. 12–19, 2016.

[14] C. Delenn, Z. Anna, and Z. Jessica, "Analyzing Twitter Sentiment of the 2016 Presidential Candidates," SIAM Journal on Scientific Computing, vol. 38(4) pp.1-12, 2016.

[15] P. Burckhardt, "Tweet as a Tool for Election Forecast : UK 2015 General Election as an Example," IEEE Transactions on Knowledge and Data Engineering, pp. 1–47, 2016.

[16] J. Kazem, and M. Yumi, "The Predictive Power of Social Media: On the Predictability of U.S. Presidential Elections using Twitter," IEEE Transactions on Knowledge and Data Engineering, pp. 11-49, 2014.

[17] W. Gayatri, and A. Nilesh, "Indian election using Twitter," Advances in Intelligent Systems and Computing, vol. 468 (22), pp. 251–261, 2017.

[18] C. M. Carvalho, H. Nagano, and A. K. Barros, "A Comparative Study for Sentiment Analysis on Election Brazilian News," Proceedings of Symposium in Information and Human Language Technology, Uberlandia, MG, Brazil, October 2-5, 2017.

[19] R. M. Asif, Q. A. Mustafa, and B. H. Syed, "Prediction and Analysis of Pakistan Election 2013 based on Sentiment Analysis," ASONAM 2014 - Proceedings of the 2014 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining, (December), pp. 700–703, 2014.

[20] S. Amith, A. Jadhav, P. Kapanipathi, C. Lu, H. Purohit, G. A. Smith, and W. Wang, "Twitris: A System for Collective Social Intelligence," In: Alhajj R., Rokne J. (eds) Encyclopedia of Social Network Analysis and Mining, Springer-Verlag New York, vol. 1, pp. 2240-2253, 2014.

[21] C. Shao, G. L. Ciampaglia, O. Varol, K. Yang, A. Flammini, and F. Menczer, "The Spread of Low-credibility by Social Bots," Nature Communications, 9, vol. 4787, pp. 1-9, 2018.

[22] O. Varol, E. Ferrara, C. A. Davis, F. Menczer, and A. Flammini, "Online Human-Bot Interactions: Detection, Estimation, and Characterization," Proceedings of the Eleventh International AAAI Conference on Web and Social Media. arXiv preprint arXiv:1703.03107, 2017.

[23] C. Zi, G. Steven, W. Haining, and J. Sushil, "Detecting automation of twitter accounts: Are you a human, bot, or cyborg?," IEEE Transactions on Dependable and Secure Computing, vol. 9(6), pp. 811-824, 2012.

[24] S. M. Mohammad, and D. P. Turney, "Crowdsourcing a Word-Emotion Association Lexicon," Computational intelligence, vol. 29(3), pp. 1-25, 2013.

[25] D. Davidov, O. Tsur, and A. Rappoport, "Enhanced Sentiment Learning using Twitter Hashtags and Smileys," COLING '10 Proceedings of the 23rd International Conference on Computational Linguistics: pp. 241-249, 2010.

[26] R. Plutchik, "The Psychology and Biology of Emotion," New York: Harper Collins, 1994.

[27] H. D. K. Sri, N. Arash, and W. Christine, "Identifying Trending Sentiments in the 2016 U.S. Presidential Election: A Case Study of Twitter Analytics," Issues in Information Systems, 18(2), pp. 80-86, 2017.

[28] H. Brian, D. P. Joseph, and M. K. Taghi, "Location-Based Twitter Sentiment Analysis for Predicting the U.S. 2016 Presidential Election," The Thirty-First International Florida Artificial Intelligence Research Society Conference (FLAIRS-31), pp. 265-270., 2018.

[29] W. Budiharto, and M. Meiliana, "Prediction and Analysis of Indonesia Presidential Election from Twitter using Sentiment Analysis," Journal of Big Data, vol. (5)51, pp. 1-10, 2018.

[30] T. Andranik, O. S. Timm, G. S. Philipp, and M. W. Isabell, "Election Forecasts With Twitter: How 140 Characters Reflect the Political Landscape," Social Science Computer Review, vol. 29(4), 402-418, 2011.

[31] P. W. Gayatri, and V. A. Nilesh, "Analysis of Indian Election using Twitter," International Journal of Computer Applications, vol. 121(22), pp. 37-41, 2015.

[32] S. Pritee, and D. Sachin, "Twitter Based Election Prediction and Analysis," International Research Journal of Engineering and Technology, vol. 4(10), pp. 539-544, 2017.

[33] T. Elvyna, and E. S. Yustinus, "And the Winner is ...: Bayesian Twitter-based Prediction on 2016 U.S. Presidential Election," IC3INA 2016 Conference, 3-5 Oct. 2016.

[34] P. Kassraie, A. Modirshanechi, and H. Aghajan, "Election Vote Share Prediction using a Sentiment-based Fusion of Twitter Data with Google Trends and Online Polls," In Proceedings of the 6th International Conference on Data Science, Technology and Applications (DATA 2017), pp. 363-370, 2017.

[35] B. Adam, and F. S. Alan, "On Using Twitter to Monitor Political Sentiment and Predict Election Results," Proceedings of the Workshop on Sentiment Analysis where AI meets Psychology, IJCNLP 2011, pp. 2-10, 2011.

[36] L. Oikonomou, and C. Tjortjis, "A Method for Predicting the Winner of the USA Presidential Elections using Data extracted from Twitter. In the Proceedings of the 2018 South-Eastern European Design Automation, Computer Engineering, Computer Networks and Social Media Conference (SEEDA-CECNSM), pp. 1-8, vol. 2017.

[37] A. Omaima, P. Suhem, and C. Bravim, "Application of Location-Based Sentiment Analysis Using Twitter for Identifying Trends towards Indian General Elections 2014," IMCOM '15, January 08 - 10 2015, BALI, Indonesia.

[38] S. JayaKumar, P. Priyank, K. S. Rajat, and P. Akkshansh, "Election Result Prediction Using Deep Learning Techniques," International Journal of Engineering and Advanced Technology, vol. 8(4), pp. 74-77, 2019.

[39] B. Barkha, and S. Sangeet, "On Predicting Elections with Hybrid Topic based Sentiment Analysis of Tweets," 3rd International Conference on Computer Science and Computational Intelligence, Procedia Computer Science, pp. 346-353, 2018.

[40] G. Manish, K. Anoop, S. Amit, and B. Raytheon, "Leveraging Candidate Popularity on Twitter to Predict Election Outcome. ACM SNA-KDD '13 Chicago, Illinois, USA, pp. 1-8. 2013.

[41] K. J. Vinay, and K. Shishir, "Towards Prediction of Election Outcomes Using Social Media," I.J. Intelligent Systems and Applications, vol. 12, pp. 20-28, 2017.

[42] A. Chaitanya, "Predicting the results of the 15th Karnataka Legislative Assembly Elections using Twitter," International Journal of Scientific Development and Research, vol. 3(10), pp. 105-109, 2018.

[43] X. Zhang, "Social media popularity and election results: A study of the 2016 Taiwanese general election," PLoS ONE, vol. 13(11), 2018.

[44] J. G. P. Bruno, P. C. L. João, P. A. M. João, L. L. Fabio, T. Rafael, and B. P. Juliano, "Spatio-Temporal Trend Analysis of the Brazilian Elections based on Twitter Data," IEEE International Conference on Data Mining Workshops, pp.1355-1360, 2018.

[45] F. Di-Fatta, J. Reade, S. Jaworska, and A. Nanda, "Big social data and political sentiment: the tweet stream during the UK General Election 2015 campaign," In: The 8th IEEE International Conference on Social Computing and Networking (SocialCom 2015), Dec. 1921, 2015, Chengdu, China.

[46] N. Chavoshi, H. Hamooni and A. Mueen, "DeBot: Twitter Bot Detection via Warped Correlation," in ICDM, pp. 817-822, 2016.

Towards Understanding Internet of Things Security and its Empirical Vulnerabilities: A Survey

Salim El Bouanani[1], Omar Achbarou[2], My Ahmed Kiram[3], Aissam Outchakoucht[4]
Computer Science Dept, Cadi Ayyad University, Marrakesh, Morocco[1, 2, 3]
LISER laboratory, Hassan II University, Casablanca, Morocco[4]

***Abstract*—The Internet of things is no longer a concept; it is a reality already changing our lives. It aims to interconnect almost all daily used devices to help them exchange contextualized data in order to offer services adequately. Based on the existing Internet, IoT suffers indisputably from security issues that could threaten its evolution and its users' interests. Starting from this fact, we try to define the main security threats for the IoT perimeter and propose some pertinent solutions. To do so, we first establish a state of the art concerning the IoT definition, protocols, environment, architecture and security. Then, we expose a case study of a standard IoT platform to illustrate the impact of security on all IoT layers. Furthermore, the paper presents the results of a security audit on our implemented platform. Finally, based on our evaluation, we highlight many solutions as well as possible directions for future research.**

Keywords*—*Internet of things; IoT security; security audit; IoT architecture; IoT protocols

I. Introduction

After Ashton introduced the internet of things (IoT) for the first time [1], the concept really took shape with the MIT Auto-ID [2] and their presentation of the IoT vision. In the IoT world, any daily device can be transformed to a "smart thing" or "smart device" if it could be equipped by an IP address [3], thus accessible like any other connected computer. According to Cisco Internet Business Solutions Group [4], IoT is simply defined as the point in time when more "things" were connected to the Internet than people. In fact, IoT connects humans and a huge number of devices as never before, basically sensors and actuators. In this sense, the group predicts that there will be 50 billion connected devices by 2020. This great number of "things" tends to transform the three dimensions related to information processing [5], namely "location, time and manner", since information can be processed by people, devices or services.

This democratization (i.e. openly available to almost everyone) and interconnectivity helps provide processes with precise data to make optimal decisions. From this point, we notice that several new realities emerged such as smart grids, smart homes, smart cities, etc. "Smart environments" are made possible thanks to the IoT paradigm which helped the emergence of communication protocols, embedded sensors, and smart physical objects that collect and process data in real time. In this context, the Internet with billions of connected devices gathering contextualized data and having actuating ability can be considered as sensory, which means that it provides the ability to become more proactive thanks to their ubiquitous connectivity to the Internet.

However, this evolution doesn't remain without weaknesses; the pervasive paradigm established by the IoT can be seen as a huge, complex and risky zone where the previously cited advantages can quickly become drawbacks. Actually, this technology is facing serious challenges [6] such as heterogeneity, security, privacy, access control, IPv6 transition, power supply, massive data storage and processing, etc.

This paper mainly answers the following fundamental questions:

- What are the most significant IoT security challenges to address?
- To what extent the usual audit techniques can be used in IoT environments?

To the best of our knowledge, there is no paper that answered these questions from a practical perspective. This article is implementing an IoT based platform, on which we performed an audit to come up with empirical solutions.

Focusing on security issues in the IoT, we can assert that they are not only related to threat diversity, but are also the results of the various vulnerabilities. To secure IoT environments, many studies have to be led in order to enumerate risks that have to be covered. In fact, many researches were focused on tracking not only the vulnerabilities of IoT devices but also the potential threats that can exploit them [7, 8, 9, 10] and the conclusions of these researches were alarming.

The pervasive aspect of the IoT environments make them present everywhere with many interconnected devices whose security and privacy issues could have a significant impact in our daily life.

In the following sections, we will define the IoT, then we will focus on detailing the IoT environments and security. Moreover, we choose a case study of a generic IoT infrastructure on which we will apply a security audit, a risk analysis and several attacks to finally come out with solutions and recommendations as a concrete and logical result to ameliorate IoT security.

II. Overview of the Internet of Things

Day after day, the Internet is getting larger due to thousands of newly connected "smart objects". In this section, we take a deep look at this paradigm, its standards, protocols and application domains, all from a security perspective.

A. The Internet of Things Paradigm

There is no unique accepted definition for IoT. In this paper, we tried to propose a definition that seems relevant and global, based on literature review [5, 11, 12, 13] we define IoT as a global infrastructure of networked physical and virtual objects. These intelligent electronic devices ("smart things") should have a unique identity as well as the ability to transfer/receive data over networks using interoperable technologies offered by Internet protocols. The IoT as a ubiquitous network is founded on four major pillars namely sensing, communicating, processing and actuating.

In the next subsection, we will explore how IoT will be present almost everywhere in our daily life: smart cars, smart cities and E-Health applications, etc.

B. Application Domains

One aspect of the Internet transformation is that it benefits from sensory abilities that help it become more proactive. This goal is achieved through the cooperation of many sensors – measuring temperature, motion, pressure, etc. – and actuators that perform the right tasks according to the situations – turning on an air conditioner, ringing an alarm, weight sorting, etc.

In Table I, we modified three mostly used application domains categories [5] into four by adding "Healthcare" to "Industry", "Environment" and "Society". The importance of this category is due to the growing interest in healthcare applications based on huge investments to develop objects that take care of people's health.

Given the intersections between IoT and all these diverse domains, several protocols and standards were proposed to facilitate and simplify their implementations. Below, we focus on some commonly used ones.

C. Protocols and Standards

It is known that most IoT devices are constrained devices, these latter will require energy saving, less computations and a minimum of network connectivity, thus, using HTTP protocol [12] is no longer convenient since its request needs at least nine TCP packets, even more when we consider packet loss from poor connectivity. HTTP is not the only protocol that can no longer be used in IoT environments.

In Fig. 1, we present some protocols and standards IoT oriented that can replace traditional network protocols organized following the TCP/IP Layers.

TABLE. I. IOT CATEGORIES AND SUB CATEGORY DOMAINS

Category	Application domains
Industry	Retail, transportations, manufacturing, logistics, industrial control, telecommunications
Healthcare	Smart Health, e-Health, activity monitors
Environment	Smart environment, smart agriculture, smart animal farming, domestic automation
Society	Smart cities, security and emergencies, social networking

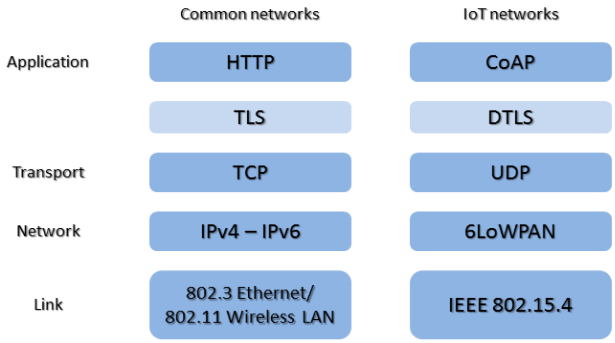


Fig. 1. Difference between Traditional and IoT Networks.

Depending on the need, both TCP and UDP could be used in the transport layer; however, we recall that UDP is simpler and faster than TCP. Consequently, using UDP is advantageous in the environments where reliability is not a priority; nevertheless, there are numerous situations where TCP is mandatory. Also, we mention that both TCP and UDP segments are not encrypted so it is strongly recommended to use TLS/DTLS for communication security (Note that DTLS is a TLS-like protocol, but unlike this latter, DTLS is based on UDP).

In the application layer, many IoT-oriented protocols are available; e.g. CoAP for Constrained Application Protocol [14] as an alternative to HTTP in IoT environments, or MQTT for Message Queuing Telemetry Transport [15] that can replace HTTP too when TCP is required. Here is an overview of these two widely used protocols:

CoAP [16]: It is a web transfer protocol for resource constrained devices and networks. It is built on top of UDP and follows the REST paradigm. There exist many implementations of this extremely lightweight protocol, each of these with its own particular features and requirements.

MQTT [17]: It is a publish/subscribe messaging protocol based on a client/server model where a broker (server), receives messages from all the other nodes. Its resulting flexibility and simplicity enable the connection of embedded devices to middleware and applications.

At the network layer level, there is the 6LoWPAN standard for IPv6 Low Power Wireless Personal Area Network [18] and we find the IEEE 802.15.4 standard [19] in the link layer. The increasing number of objects can no longer be managed by the IPv4's address ranges, also the IoT devices (sensors, actuators and constrained objects) need an internet protocol that could manage low-power devices with limited processing capabilities. That is why the transition to IPv6 is an evidence. The importance of 6LoWPAN as an application reside in allowing IPv6 packets to be sent and received over IEEE 802.15.4 based networks.

Hereafter in Table II, the previous cited protocols and standards with their security options.

Undoubtedly, IoT systems could be built over familiar web technologies, though the result would not be as efficient as the newer protocols and standards that are adapted to the IoT.

TABLE. II. IOT PROTOCOLS AND STANDARDS

Protocol & Standard	Description	Security
MQTT	- Simple and lightweight messaging protocol - Publish/subscribe architecture - Relies on TCP as transport protocol - Use broker - More mature and stable	- No encryption by default - Username and password are required for authentication - TCP connection may be encrypted with SSL/TLS
CoAP	- RESTful application protocol for constrained nodes and networks - Client / server architecture - UDP-based transport protocol - Still evolving	- No encryption by default - SSL/TLS are not available to provide security - Use Datagram Transport Layer Security (DTLS) for encryption - DTLS permit CoAP devices to support RSA and AES or ECC and AES
6LoWPAN	- Allow transmission of IPv6 Packets over IEEE 802.15.4 Networks - Guarantee the encapsulation and compression of IPv6 packets.	- Security of 6LoWPAN is defined at the link layer by IEEE 802.15.4. -Unlike in IPv6, IPsec is not suitable to use in IoT/6LoWPAN environments given their constraints.
IEEE 802.15.4	- Communication protocol for low rate wireless personal area networks (LR-WPAN) - Used by many implementations based on proprietary protocols such as ZigBee or 6LoWPAN. - Its architecture is defined in terms of layers; each layer is responsible for a part of the standard and offers services to the higher layers.	- The 802.15.4 specification provides security functions at the link layer: access Control, messages integrity, messages privacy and protection against replay attacks. These elements are set at the security-enabled field in the MAC frames. We can enable one, several or all the functions, based on encryption algorithms AES.

III. INTERNET OF THINGS ENVIRONMENTS

The IoT relies on open architecture to maximize interoperability among heterogeneous systems and distributed resources. This architecture has to fulfil some security requirements, especially confidentiality, integrity and availability. In this section, we present the basic IoT architectures as shown in Fig. 2:

A. Internet of Things Architectures

In IoT environments, three main IoT architectures are frequently adopted [20]:

Centralized architecture (Fig. 2(a)): where end devices pass through gateways (more powerful nodes) for every communication whether with other objects or with the Cloud.

Decentralized architecture (Fig. 2(b)): every end device is autonomous; it is fully capable of managing its communications without any intermediate device.

Hybrid architecture (Fig. 2(c)): combines the two previous ones [21], gateways manage some features (i.e. security mechanisms) while the end device deals with the rest.

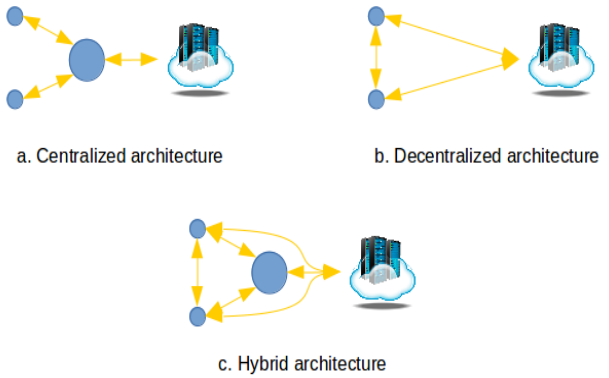


Fig. 2. IoT Architectures.

B. Standard Internet of Things Architecture

On the basis of conducted literature review, hybrid architecture is used in the case study that we are presenting in this paper. This architecture provides more flexibility, reliability and availability, which are mandatory requirements for reliable platforms. Fig. 3 details the various components of this architecture [22], which are the cloud, the mobile and the IoT devices.

Actually, in the cloud component, four layers are defined. First, the application layer then the repository layer for files; next we find the middleware to manage communications and finally the link layer where communication protocols are used.

For the gateway sensor, it was pertinent to add a device API layer below the middleware, where sensor and actuator protocols will be defined, and the optional embedded OS layer. Finally, the link layer hosts several protocols and standards such as Bluetooth, Wi-Fi, IEEE 802.15.4 for constrained devices/networks, etc.

It is worth noting that BT, BT LE (Bluetooth Low Energy), Zigbee, and NFC are lightweight standards and protocols.

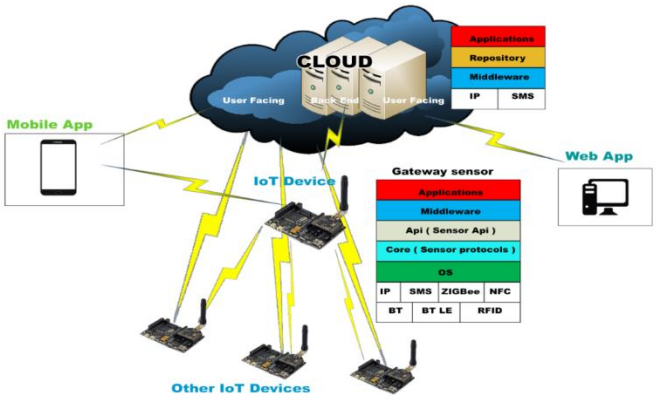


Fig. 3. Internet of Things Standard Architecture in Detail.

C. Internet of Things Security

Jointly to the IoT exponential evolution, threats in IoT remain critical and various. Indeed, many security issues have to be solved in network protocols, data and identity management, user privacy, access control models, etc. These vulnerabilities are mainly due to the fact that connected devices are designed to be easily and quickly deployed (reducing the Time-to-Market) and accessed by users who are little informed on the IoT risks. Hence, reducing the costs of research and development on security makes this domain an accessory where it should be a priority.

Recently, academic research targeting the privacy and security for IoT environments has gained more momentum. The survey papers [23], [24], [25], [26], and [27] evaluate the possible threats to IoT systems according to the layers and the available countermeasures. The present paper focus on IoT security with a more methodical and formal tools beginning with the proposition of a standard IoT architecture suitable for security needs, then by conducting a security audit covering the whole environment and finally by the reputed EBIOS risk analysis. Up to our knowledge, there is no paper that has adopted this procedure to evaluate and recommend solutions to IoT security issues in such a holistic manner.

In order to discuss security issues, we introduce the CIA model, which relies on three pillars "Confidentiality, Integrity & Availability" [10] briefly explained hereafter:

Confidentiality refers to the ability to protect data from unauthorized parties.

Integrity refers to the ability to prevent our data from being changed or deleted in an unauthorized or undesirable manner.

Availability: It is the ability to access our data when and where it's needed.

Concretely, we will distinguish three main areas in the IoT environment to facilitate our security audit, namely:

- The IoT device (e.g. sensor, actuator, smartphone, people)
- The Network (e.g. LAN, Internet)
- The Cloud: platform for storing, treating and analyzing data.

IV. Case Study of a Standard Internet of Things Platform

To be more concrete, and without losing generality, we decide to focus on one (generic) scenario and to work methodically to explore its security requirements.

In Fig. 4, we expose the fundamental components of our standard IoT environment. We tried to have a generic IoT platform with basic operations very similar to the majority of existing platforms to be able to have global results. For our case, our platform can be considered as a temperature detection platform with actuating and notifying abilities.

We have objects collecting temperatures continuously – unavailability is not tolerated, in addition to the cloud platform responsible for managing and analyzing collected data and sending notifications when temperatures exceed some thresholds. To increase availability, we placed a central less-constrained node allowing us to have hybrid architecture. More components are added to the architecture to enrich it – smartphones, PCs, a router etc.

A. Environment Architecture

We opted for the standard IoT architecture as mentioned in the subsection B.2 due to its availability and flexibility advantages. Indeed, if the cloud platform fails, the external entity (a minimum level of service) will be guaranteed by the nodes, in order not to paralyze the whole IoT environment. Also, we can use the central node, more powerful than other IoT devices, for tasks that require more computing and to orchestrate our environment.

We used ThingSpeak as an IoT cloud platform. It helps us to visualize the behavior of temperature data, to use various mobile applications in order to control our objects (e.g. Blynk), and to view data behavior (e.g. ThingView on Android).

B. The Components

During the implementation of the platform, we made some technical choices that are shown in Fig. 5. This latter presents a sample of the IoT constrained nodes, IoT less constrained ones, sensors and actuators that we actually implemented in our architecture:

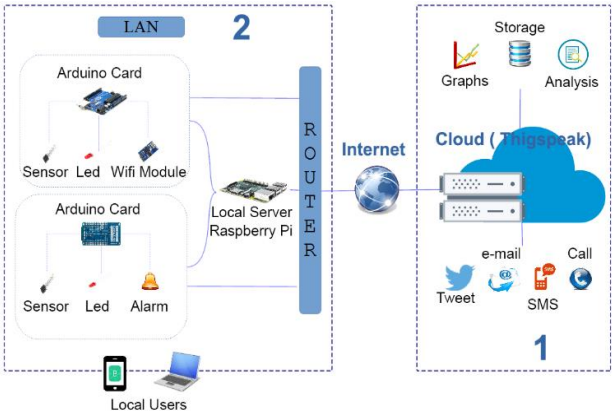


Fig. 4. Environment Architecture of the Case Study.

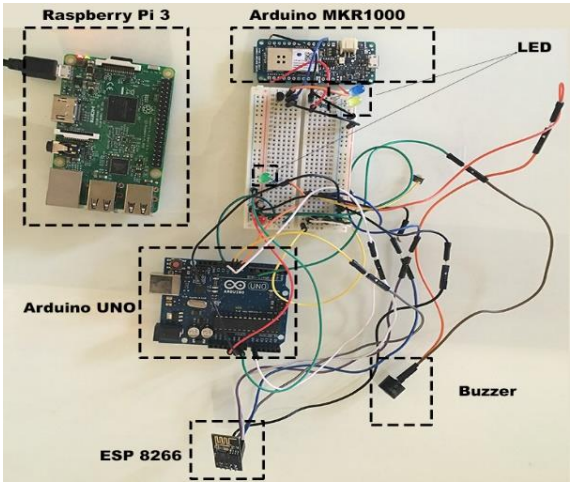


Fig. 5. Our IoT Environment Components.

1) The micro-controllers: They are integrated circuits that gather the essential elements of a computer: processor, memory, peripheral units and input-output interfaces. Micro-controllers are characterized by a high degree of integration, lower power consumption, lower operating speed and reduced cost compared to microprocessors used in personal computers. We opted for Arduinos.

2) The central node: The Raspberry Pi is a nano-computer board that allows the execution of several operating systems GNU/Linux and compatible software. The operating system used in our case study is the Raspbian. In the Raspberry, we installed our local server that will be discussed in following subsections. In Table III, we expose a brief comparison between the investigated nodes and a smartphone as reference, in terms of performances and capabilities. It shows clearly that the Raspberry has similar computational capabilities, which is the reason why it is a central node in our architecture, as a device that can be considered less constrained compared to the Arduinos or microcontrollers.

C. The Organogram

In this section, we present how the whole IoT environment works in (see Fig. 6). We can identify three sections in our system:

1) Object-level: An internal process within the IoT node determines if the temperature exceeds the threshold value; if so, the alarm sounds and a red LED light up.

2) Central node level: The data sink collects information, then applies some availability and integrity verification functions. An SMS is sent to the administrator in an error context.

TABLE. III. COMPONENT PERFORMANCES IN COMPARISON TO A SMARTPHONE

Objects	RAM	CPU
Arduino UNO	2KB	16 MHz | 8-bit architecture
Arduino MKR1000	32KB	48MHz | 32-bit architecture
Raspberry Pi	1GB	Quad-core | 1.2 GHz | 64-bit architecture
iPhone 6	1GB	Dual-core | 1.4 GHz | 64-bit architecture

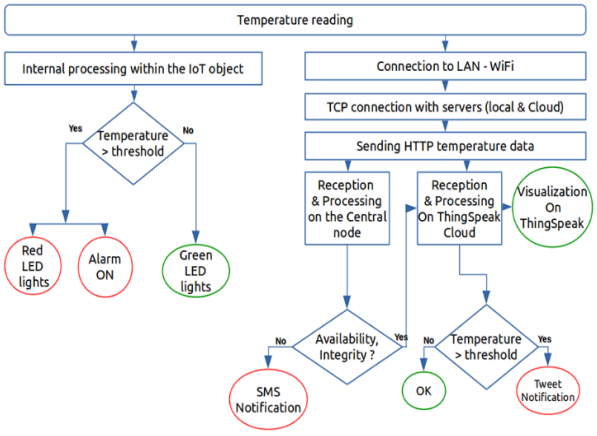


Fig. 6. Organizational Chart of the Case Study.

3) Cloud: On ThingSpeak cloud platform, we also configured actions of sending tweets to the accounts dedicated to our IoT environment, the manager will be tagged in the tweet mentioning that the temperature exceeds the threshold.

You can refer to our repository in GitHub [28] for the code of this implementation and other technical details.

V. SECURITY AUDIT AND RISK ANALYSIS

In this section, we introduce and lead a security audit jointly with a risk analysis on our case study. This approach will provide us with a transparent exploration of the IoT environment security.

A. Importance of the Security Audit

In the IT domain, people always pretend that their systems are secure; however, one of the most effective ways to determine whether this is true is by performing a thorough audit of the whole system. Thus, audit and information security should work together synergistically. The information security designs, implements and applies various procedures and protocols to protect the organization's information resources, while audit provides periodic feedback and suggestions in order to improve that security.

Symantec considers that security audits do not take place in a vacuum [29]; they are part of the on-going process [30] of defining and maintaining effective security policies. Otherwise, security audits provide such a tool as a fair and measurable way to examine how secure an “IT system” really is. These audits become more exigent when these systems are much more complex and interact with various other domains opening larger surface vulnerabilities, which is the case for our IoT environments.

B. Risk Analysis

It is hard to study and manage the systems’ security without using a risk management methodology. In fact, security measures are not able to assure 100% protection against all threats. Therefore, risk analysis, which is the process of evaluating system vulnerabilities and the threats facing it [31], is an essential part of security management as it provides concrete results based on a scientifically approved approach.

In our study, we opted for EBIOS (Expression of Needs and Identification of Security Objectives) methodology since it provides a global and consistent view of information systems security. Moreover, EBIOS [32] has a uniform vocabulary and concepts; it also allows exhaustive coverage with determination of suitable security objectives and requirements. It is a method for analyzing, evaluating and acting on risks relating to information systems. It generates a security policy adapted to the needs of an organization and includes the five following steps:

The first step handles the context establishment, the relationship between the business context and the IS, contribution to business goals, boundary, decomposition, etc. Then, security requirements are determined based on the feared security events. Next, a risk study is conducted in order to identify and analyze threat scenarios. In the fourth step, information from the previous phases is used to identify risks and describe the necessary and sufficient security goals relating

to these risks. Finally, the essential security requirements are determined as well as the exhibition of the perfect coverage of security objectives. These steps are described according to our platform in the next subsections:

C. Context Study

As mentioned before, our case study consists in setting up an environment, which includes all the elements taking part in an IoT ecosystem. First, it is necessary to identify the sensitive elements and the zones presenting security. The environment defines a hybrid architecture where smart objects are connected to each other, to a local central node and to a Cloud platform. The communication protocol used for sending the temperature values to the Raspberry Pi and ThingSpeak is HTTP. Smart devices can be controlled by smartphones and the system can autonomously trigger actions in an emergency context: alarms, SMS, Tweets. This environment is considered critical, so no unavailability or alteration is tolerated.

1) Expression of security needs: The target system being identified, we will express here the security needs. This step contributes to risk estimation and definition of risk criteria; it is based on the development and use of a needs scale as well as the identification of unacceptable impacts on the system.

In our study we treated confidentiality, integrity and availability as security criteria. For the first, we defined four levels (public, restricted, reserved and secret), then we opted for an integrity scale of three levels (no need for integrity, mastered and integrated). For the availability scale, we fixed four levels (no need for availability less than 72 hours, less than one hour and a real-time availability). In order to evaluate the risks, we have defined a 4-level gravity scale (negligible, limited, important and critical) and another for the probability (minimal, significant, strong and maximum).

We have divided our perimeter to six surfaces, which we evaluate according to the three security criteria fixed above, making 18 feared events with three criteria for each surface, namely:

The IoT object (1), information collection (2), local storage/treatment (3), information transfer (4), storage and processing of information on the Cloud (5) and actions (6). One of the first observations in this assessment is the criticality of the unavailability and alteration in most of the studied surfaces compared to confidentiality. This latter does not have a significant weight given the nature of the information exchanged (temperature) in our case.

2) Threat study: We estimated that threat scenarios will affect the following sub perimeters:

- IoT devices: consists of an Arduino board equipped with a temperature sensor, an actuator (LED / alarm) and a wireless module.
- Central Node: Raspberry board which hosts an apache web server.
- The staff: represents those who have access to the company buildings, namely the director, employees and trainees.
- The Wi-Fi LAN.
- Location: the location of the objects.
- Internet.
- Mobile applications: thanks to which the client can act on the object and where it will receive notifications describing the behavior of temperature values.
- The platform (ThingSpeak) that stores and analyses data and sends notifications by SMS, e-mail or Tweet.

Our evaluation allowed us to reach the most probable sources of the threats on our IoT environment, namely the mobile, LAN, staff and Cloud.

3) Risk analysis: We have established a list of 18 risks of unwanted events and previously appreciated threat scenarios. 12 unacceptable risks, 4 significant and 2 negligible. Risks previously analyzed (identified and estimated) are shown in Table IV. The risk matches those reduced by existing security measures, like use of surveillance cameras, use of WPA2, etc.

4) Determination of security requirements: Many security measures may be recommended, we cite the most relevant here: access control for IoT objects, passwords policy, encrypted protocols (HTTPS, CoAPS…), IDS/IPS and firewalls on LAN, updates, upgrades, choice of a Cloud platform, awareness, and qualifications and training of information security staff.

Once applied, we estimate that the risk levels will decrease in a considerable way, so that no unacceptable risk will remain. 14 will become negligible and only four significant risks remain, namely, the risk related to the modification of transferred information, which must stay unmodifiable; risk related to the modification of information in storage and treatment, which must stay unmodifiable; risk related to the modification of the IoT device, which must stay unmodifiable; and risk related to the unavailability of actions in real time.

5) IoT attack perimeters: Based on the OWASP's report, we were able to gather and limit these surfaces to four as shown in Fig. 7.

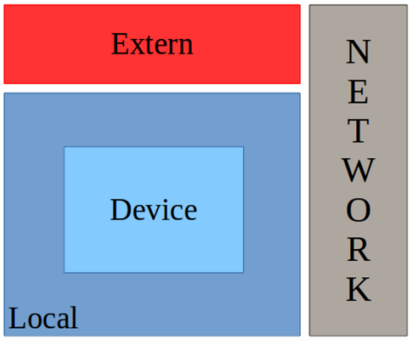


Fig. 7. IoT Attack Surfaces.

TABLE. IV. RISK EVALUATION

GRAVITY	4. CRITICAL		- Risk related to the unavailability of the IoT device in real-time. - Risk related to the modification of the central node. -Risk related to the modification of transferred information. - Risk related to the modification of information in storage and treatment. - Risk related to the modification of the action.	- Risk related to the unavailability of the IoT device in real time. - Risk related to the modification of the IoT device. - Risk related to the unavailability of captured information in real time. - Risk related the modification of captured information. - Risk related to the modification of the central node. - Risk related to the unavailability of the information transferred in real time. - Risk related to the modification of the information transferred. - Risk related to the modification of the information in storage and treatment - Risk related to the unavailability of actions in real time.	
	3. IMP		- Risk related to disclosure of secret central node contents. - Risk related to disclosure of reserved transferred information.	- Risk related to disclosure of reserved transferred information. - Risk related to the unavailability of the central node more than 1 hour. - Risk related to the unavailability of the information in storage and treatment, more than 1 hour.	
	2. LIMITED		- Risk related to disclosure of limited information in Cloud storage and treatment.	- Risk related to disclosure of public captured information. - Risk related to disclosure of limited information in Cloud storage and treatment.	- Risk related to disclosure of the IoT device beyond the stuff and the device owner. - Risk related to disclosure of public captured information.
	1. Neg.				- Risk related to disclosure of public actions.
		1. Min	2. Significant	3. Strong	4. Maximal
		Probability			
Negligible risks				Significant risks	Intolerable risks

Neg. stands for negligible; Imp. for important; *Min*. for minimum.

The Device: the key of any IoT architecture and its weak link, this surface regroups device memory, its physical/web interfaces, its firmware and its network services.

Local treatment: includes local storage, treatment and control.

Network: all communication traffic whether in LAN, MAN or WAN including ad-hoc networks and internet.

External treatment: includes all services that are traded outside the local network, especially Cloud and Third-party APIs, web-services, remote access and applications.

D. Security Attacks

Table V exposes the four IoT security layers summarized in the previous subsection. For each layer, we listed some well-known attacks, their impacts and then our recommendations to improve the security of the IoT environment related to these layers.

E. Security Solutions

Due to the generic aspect of our platform, we come up in Table VI with concrete suggestions and tangible recommendations towards a more secure IoT system. The implementation of these recommendations will satisfy the security goals of the whole IoT environment according to the CIA triad. The recommendations are categorized by their impact on one or more of these three pillars: confidentiality, integrity and availability.

Other solutions and best practices could be added [33,34] from the application of security standards as PCI-DSS, ISO/IEC 15408 and 2700x, etc. if the IoT environment is part of an information system already governed by established standards.

In addition to these recommendations, IoT environments should have an Information Technology Security Evaluation to ensure that their platform and things go through a formal security evaluation process, such as Common Criteria. An evaluation from a certified lab could enable the manufacturers of the IoT products to obtain an international security certificate.

TABLE. V. IOT ATTACKS BY LAYERS

Layers	Attacks	Impacts	Recommendations
Device layer	- IoT object theft / USB access - Disconnect the power - Run malicious software during the initial start-up process - Side channel attacks - Reverse engineering	- Malfunction of the smart object - Get hold of critical information - Sending incorrect information	- Implement secure booting so that the system only runs trusted software during the initial start-up process - Implement physical anti-theft solution (locks, cameras…) - Secure storage / tamper resistance
OS layer	- Break simple passwords - Privilege escalation - Buffer overflows - OS fingerprinting	- Uninstalling the system - Critical configuration changes	- Eliminate as many known vulnerabilities as possible (e.g. error configuration, simple passwords, improperly obtained higher permissions, buffer overflow) to minimize external intrusions to the system
App. layer	- DoS, DDoS - Backdoor / SQL injections - XSS - Virus / Trojan horses - Logic bombs / Worm	- Paralyze the whole system - Unauthorized access - Information steal - Sending false information	- Design security as part of the product, not separately - Apply secure coding principles, which minimize security vulnerabilities - Port optimization / firewall
Net-work layer	- Man in The Middle - Break simple passwords - Sniffing / Spoofing - DoS, DDoS/replication attacks - Routing attacks	- Critical information disclosure - Information alteration during transfer - Power cut - Use the identity of a legitimate user maliciously	- Integrate authentication and secure network access - Incorporate authentication and secure communications to prevent eavesdropping and ensure trusted communications between connected devices

TABLE. VI. SUGGESTED SOLUTIONS

Solutions	C	I	A
Access control to devices, network and Cloud	*	*	*
Security by design	*	*	*
Validation by a certified third-party trough evaluation process, such as Common Criteria	*	*	*
Encryption SSL/TLS, DTLS, ...	*	*	
Long, complex and periodically changeable passwords	*	*	*
Principle of least privilege	*	*	*
Internet protocol security (IPsec) and digital signature (e.g. ElGamal).	*	*	
Firewall, IDS/IPS and router control			*
Apply secure coding principles to avoid XSS, SQLI, buffer overflow…	*	*	*
Secure local network: WPA2 activation	*	*	*
Redundancy			*
Logging		*	
Hybrid architecture			*
Updates and upgrades	*	*	*
Choosing a secure Cloud platform	*	*	*
Disabling physical input-output: USB, SSD Cards …	*	*	*
Secure company building: authentication, cameras, fire protection devices			*
Administrator machine security	*	*	*
User and administrator awareness	*	*	*

VI. Conclusions and Perspectives

The IoT paradigm is certainly a big part of Internet evolution. Its main vision is to interconnect physical and virtual things based on evolving interoperable technologies. Nowadays, IoT is developing much faster than ever before; it will bring us opportunities in everyday aspects of life. However, it has also raised several new challenging issues, especially security problems that will slow down this evolution until we find the right solutions.

In this paper, we first presented the concept of the IoT paradigm, its application domains, protocols and standards. Then we detailed the main IoT architectures. After that, and to illustrate the impact of security in IoT environment, we opted for a standard case study on which we applied a security audit followed by a risk analysis as well as several attacks in order to provide adapted solutions to improve IoT security.

In our future work, we will explore the access control in IoT environments; first by analyzing the existing AC models and eventually we will propose a new one focusing on IoT context.

References

[1] K. Ashton, "That 'Internet of Things' thing in the real world, things matter more than ideas," RFID Journal, 2009.

[2] MIT AUTO-ID Center, "Vision, Technology, Applications, " Retrieved May 21, 2019, from http://web.mit.edu/supplychain/www/sp-iscm/repository/auto-id_103001.pdf, 2001.

[3] R. Want, S. Dustdar, "Activating the Internet of Things [Guest editors' introduction]," Computer (Long. Beach. Calif), 2015.

[4] D. Evans, "How the Next Evolution of the Internet Is Changing Everything," Cisco Internet Bus. Solut. Gr., 2011.

[5] H. Sundmaeker, P. Guillemin, P. Friess, Sylvie Woelfflé, "Vision and Challenges for Realising the Internet of Things," Cluster of Europ. Research Projects on the Internet of things, 2010.

[6] O. Salman, I. Elhajj, A. Chehab, A. Kayssi, "IoT survey: An SDN and fog computing perspective," Computer Networks, 2018.

[7] R. A. Rahman, B. Shah, "Security analysis of IoT protocols: A focus in CoAP," ICBDSC, 2016 [The 3rd MEC International Conference on Big Data and Smart City].

[8] HP Fortify, "Internet of Things Security Study : Smartwatches," Hp, 2015.

[9] Cisco, "IoT Threat Environment," with risk-based Secur. Progr. Recomm. A White Pap. , 2015.

[10] K. Michael, "The Basics of Information Security: Understanding the Fundamentals of InfoSec in Theory and Practice," Comput. Secur. , 2012.

[11] S. El Bouanani, M. A. El Kiram, O. Achbarou, A. Outchakoucht, "Pervasive-Based Access Control Model for IoT Environments," IEEE Access, vol. 7, pp. 54575–54585, 2019.

[12] R. Minerva, A. Biru, D. Rotondi, "Towards a definition of the Internet of Things (IoT)," IEEE IoT Initiative white paper, 2015.

[13] M. Gyu Lee, "The Internet of Things - Concept and Problem Statement," 2012.

[14] C. Bormann, "Block-Wise Transfers in the Constrained Application Protocol (CoAP)," 2016.

[15] OASIS (Organization for the Advancement of Structured Information Standards), "MQTT Version 3.1.1," 2014.

[16] M. Iglesias-Urkia, A. Orive, A. Urbieta, D. Casado-Mansilla, "Analysis of CoAP implementations for industrial Internet of Things: a survey," Journal of Ambient Intelligence and Humanized Computing, 2018.

[17] M. A. Prada, P. Reguera, S. Alonso, A. Morán, J. J. Fuertes, M. Domínguez, "Communication with resource-constrained devices through MQTT for control education," IFAC-PapersOnLine, 2016.

[18] N. Kushalnagar, G. Montenegro, C. Schumacher, "IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs): Overview, Assumptions, Problem Statement, and Goals," 2007.

[19] IEEE P802.15 Working Group, "IEEE 802.15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs)," 2011.

[20] R. Roman, J. Zhou, and J. Lopez, "On the features and challenges of security and privacy in distributed internet of things," Comput. Networks, 2013.

[21] I. Bouij-Pasquier, A. A. Ouahman, A. A. El Kalam,M. O. de Montfort, "SmartOrBAC Security and Privacy in the Internet of Things," 2015.

[22] P. Friess, "The Internet of things: Converging Technologies for Smart Environments and Integrated Ecosystems," 2013.

[23] M. binti Mohamad Noor, W. H. Hassan, "Current research on Internet of Things (IoT) security: A survey," Comput. Networks, 2019.

[24] F. A. Alaba, M. Othman, I. Abaker, T. Hashem, F. Alotaibi, "Author's Accepted Manuscript Internet of things Security: A Survey," J. Netw. Comput. Appl., 2017.

[25] A. Tewari, B. B. Gupta, "Security, privacy and trust of different layers in Internet-of-Things (IoTs) framework," Future Generation Computer Systems, 2018.

[26] A. Riahi Sfar, E. Natalizio, Y. Challal, Z. Chtourou, "A roadmap for security challenges in the Internet of Things," Digit. Commun. Networks, 2018.

[27] J. Lin, W. Yu, N. Zhang, X. Yang, H. Zhang, W. Zhao, "A Survey on Internet of Things: Architecture, Enabling Technologies, Security and Privacy, and Applications," IEEE Internet Things J., 2017.

[28] S. El Bouanani, https://github.com/esalim/IOT-STANDARD-PLATFORM, last visit 26-08-2019.

[29] R. Garrett, "INSECURITY in IoT," Supply Demand Chain Exec., 2016.

[30] B. Hayes, "Conducting a security audit: an introductory overview," Symantec Connect, 2003.

[31] B. D. Romero M, H. M. Haddad, "Asset assessment in web applications," ITNG2010, 2010, [7th International Conference on Information Technology: New Generations].

[32] ANSSI agency, "EBIOS risk management methodology, " p. 13, 2010.

[33] M. Hossain, R. Hasan, A. Skjellum, "Securing the Internet of Things: A Meta-Study of Challenges, Approaches, and Open Problems," ICDCSW, 2017 [IEEE 37th International Conference on Distributed Computing Systems Workshops].

[34] Cisco, "The Internet of Things : Reduce Security Risks with Automated Policies," 2015.

Model for Time Series Imputation based on Average of Historical Vectors, Fitting and Smoothing

Anibal Flores[1], Hugo Tito[2]
E.P. Ingeniería de Sistemas e Informática
Universidad Nacional de Moquegua, Moquegua, Perú

Deymor Centty[3]
E.P. Ingeniería Ambiental
Universidad Nacional de Moquegua, Moquegua, Perú

***Abstract*—This paper presents a novel model for univariate time series imputation of meteorological data based on three algorithms: The first of them AHV (Average of Historical Vectors) estimates the set of NA values from historical vectors classified by seasonality; the second iNN (Interpolation to Nearest Neighbors) adjusts the curve predicted by AHV in such a way that it adequately fits to the prior and next value of the NAs gap; The third LANNf allows smoothing the curve interpolated by iNN in such a way that the accuracy of the predicted data can be improved. The results achieved by the model are very good, surpassing in several cases different algorithms with which it was compared.**

***Keywords*—Univariate time series imputation; average of historical vectors; interpolation to nearest neighbors**

I. Introduction

The prediction of climate change and similar events requires increasingly precise predictive models, currently the most accurate prediction models require large amounts of data, however, in the field of meteorology, most historical time series present missing values or NA values for multiple reasons, and this means that a large amount of data cannot be used in prediction processes.

This paper presents a new model for imputation of missing data in meteorological time series. Missing data or NA values in weather series are presented in different sizes, small-gaps, medium-gaps and big-gaps [1]; accuracy in completing this data is very important to carry out successful forecasting or prediction processes.

The proposal model is based on three algorithms: AHV, iNN and LANNf which are briefly described below:

AHV approach is inspired by CBRi and CBRm that to complete a set of NA values use the prior value and the next value to the block of NA values and based on this, all historical values that are between these two values are searched and averaged.

However, implementing CBRi or CBRm for big-gaps is a bit complicated, since it is difficult to find intermediate data between 11 and 30 cosecutive NAs in a historical time series, and using the similarity could introduce bias in the synthetic data. That is why obtaining historical vectors considering just the prior value to the block of NAs was chosen.

Average of Historical Vectors (AHV) is a simple algorithm that uses historical vectors to calculate an average vector, historical vectors are classified into two groups and in each group they are identified by a key value that corresponds to their prior value. In addition, in the first group we find the historical vectors for the fall and winter stations and in a second group we find the historical vectors for the spring and summer stations, taking into account that the first group temperatures tend to fall and in the second group temperatures tend to rise.

In general, the algorithms for estimating missing values or NA values perform a horizontal analysis of time series considering the values before or after a group of NA values, such as LANN [1], LANN++ [1], SMA [2][3], LWMA [2][3], EWMA [2][3], ARIMA [3], etc. In CBRi "in press" [4] and CBRm [5] for NA calculation it is proposed to use only two horizontal values prior and next, and the rest of the data is vertical. Fig. 1 shows the difference between traditional approaches (horizontals) and new approaches (verticals). In this work, AHV uses a vertical approach using one of the most traditional and basic imputation techniques, the mean.

Interpolation to Nearest Neighbors (iNN) is an interpolation or fitting algorithm that allows adjusting a predicted curve to two values. In an imputation process, these two values would correspond to the prior and next values in a time series with NA values. See Fig. 2.

The adjustment problem arises in AHV predictions since in some cases no historical vectors are found for the prior value of a gap of NAs and vectors of a key value or other prior similar to the current prior are used.

Once the curve of imputed values is adjusted, it is important to carry out smoothing, since the imputed and interpolated data are usually not. It has been observed in Deep Learning algorithms such as Long Short-Term Memory (LSTM) [6], Gate Recurrent Unit [7], and others such as Prophet [8] that the estimated or predicted values are very smoothed, hence the present work apply smoothing to the predicted and interpolated vector in such a way that the accuracy of the model is improved. LANNf is used for this process which is inspired by the LANN [1] imputation algorithm.

For the experiment in this work, medium-gaps and big-gaps are considered. For the first case the performance of known imputation techniques such as SMA [9], LWMA [10], EWMA [2] [11], Kalman ARIMA, etc is analyzed. For the second case, very known prediction techniques such as ARIMA, LSTM, GRU and Prophet are analyzed.

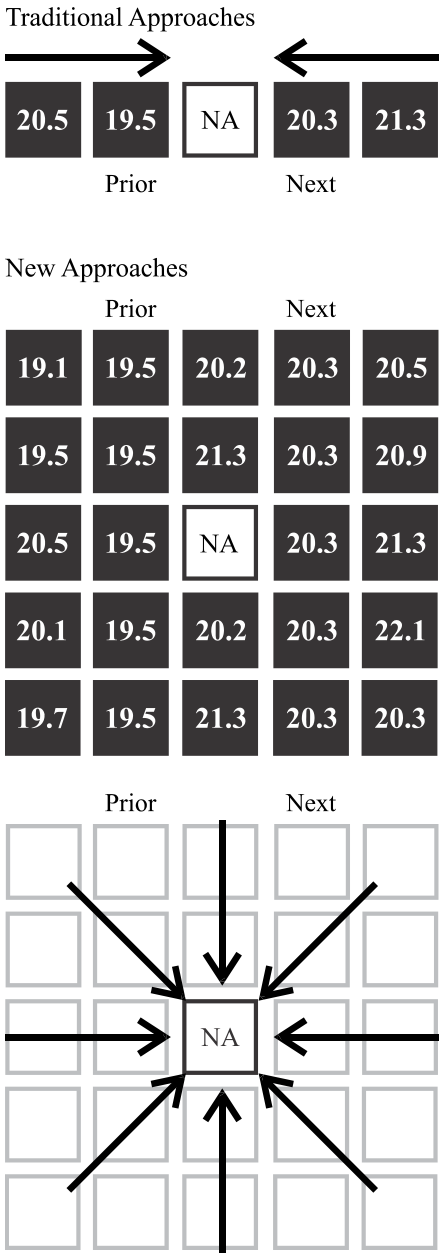


Fig. 1. Horizontal vs Vertical Approaches.

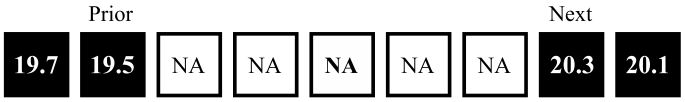


Fig. 2. Prior and Next Values.

This paper has been organized as follows: a summary of related work on univariate time series imputation is shown in the second section. In the third section some concepts are developed that will allow a better understanding of the proposal made at work. The fourth section describes the proposal model and each of its elements and algorithms implemented. The fifth section shows the results achieved and a comparison with several techniques. In the sixth section, the conclusions reached at the end of the present work are shown, finally some weaknesses of the proposed model are described and that could be overcome in future works.

II. Related Work

This section shows the reviewing results of different techniques or algorithms for univariate time series imputation which is detailed next.

Traditionally, quite simple techniques have been used for imputation of time series; these include the mean, median and mode, which currently are not recommended due to the risk of introducing bias to the time series.

Last Observed Carried Forward (LOCF) [12] is also a fairly simple technique, which involves replacing an NA value with the last observed value of the time series [13].

Baseline Observation Carried Forward (BOCF) [14] is similar to the LOCF; it replaces NA values with the non-missing baseline observation of the time series.

Hot-deck [15] [16], is an algorithm that replaces an NA value with an existing value of time series randomly. For example, if time series have ten values with an NA value, hot-deck, randomly select a value from the existing nine values and replace the NA value. For comparative analysis in this work VIM R package is used to implement hot-deck imputation.

Another set of imputation techniques that have been used frequently are those based on moving averages [3], among them Simple Moving Average (SMA) [3] [9], Linear Weighted Moving Average (LWMA) [3] [9] and Exponential Weighted Moving Average (EWMA) [3] [9] [11]. All of them use a parameter k that establishes the number of elements to calculate the average that replaces the NA value. In the case of SMA, the average is calculated considering only the elements established in parameter k without assigning any weight. In the case of LWMA, a linear weight is assigned to each element that will be used to calculate the average. And in the case of EWMA, the weight is assigned exponentially to each element used to calculate the average. For comparative analysis, moving average based algorithms are implemented using the imputeTS package of R language.

Kalman filter [17], also known as Linear Quadratic Estimation (LQE), is an algorithm that uses a series of measurements observed over time, which contains statistical noise and other inaccuracies, and produces estimates of unknown variables that tend to be more accurate than those based on a single measurement. Autoregressive Integrated Moving Average (ARIMA) [18] [19]integrated with Kalman filter produces good results in regression processes. Also, impute TS package of R language implements Kalman ARIMA imputation with a special setting called auto.arima [9] that produces optimal results.

LANN and LANN+ [1], they are two fairly simple algorithms based on moving averages that produce good results in the imputation of short-gaps (1 or 2 consecutive NAs). In this work, these are just compared and evaluated for the study cases corresponding to medium-gaps (3 to 10 consecutive NAs).

CBRi "in press" [4] and CBRm [5] are algorithms inspired by Case Based Reasoning and instead of taking advantage of the horizontal characteristics of a time series, these exploit the historical vertical values between the prior and next value in a block of NA values. Both are analyzed and compared in médium-gaps study cases.

For big-gaps, prediction algorithms that use large amounts of historical data are usually used, in this case algorithms such as ARIMA [3], PROPHET [8], LSTM [6] [20] and GRU [7] [21] will be implemented for analysis. Python language with keras and tensorflow libraries is used.

III. Theoretical Background

A. Time Series

A time series is the result of observing the values of an X variable over time. For example: the minimum daily temperature of the city of Lima, The total monthly sales of a given product, the number of visits per hour of a website, etc.

A common use of time series is its analysis for prediction and forecasting. Time series are studied in different areas such as signal processing, econometrics, statistics, biology, etc. Some features or characteristics of time series are: trends, cycles of seasonality and non-seasonality, pulses and steps, and outliers.

B. Missing Data

Depending on what causes missing data, the gaps will have a certain distribution. Understanding this distribution may be helpful in two ways [2]. First, this knowledge can be used to select the most appropriate imputation algorithm to complete the NA values. Second, this knowledge can help implement an imputation model with a set of training data and a set of test data to determine the RMSE to replace known NA values of the same time series; once the model is evaluated, it must be decided whether it is suitable for the imputation process of unknown NA values.

Missing data is classified into three categories: Missing Completely at Random (MCAR), Missing at Random (MAR) and Not Missing at Random (NMAR). The process of completing NA-gaps in time series is sometimes complicated, since the underlying mechanisms are unknown [2].

C. Univariate Time Series

This term refers to a time series that consists of single observations recorded sequentially over successive time periods. Although a univariate time series is usually considered as one column of observations, time is in fact an implicit variable [2]. Traditional techniques such as SMA, LWMA, EWMA, ARIMA and others usually just work with time series values, instead another forecasting techniques such as Prophet, LSTM, GRU in addition to the time series values they use the recording date, this undoubtedly makes their accuracy much better than moving average techniques.

IV. Proposal Model

The proposal model has four modules: Time Series, NA Calculation, Fitting - Smoothing, and Testing. Fig. 3 shows a graphical view of the proposal model and every module of this is described below.

A. Time Series

This module contains several functions that allow the pre-processing of the time series from which the historical vectors will be implemented. For the present study, the same time series was chosen as in [1], "in press" [4] and [5] so that the comparison of results is more appropriate.

Also, this module contains a getVectors() function which allows to extract historical vectors from the chosen time series.

Two vectors were considered for the vector base: The first Q1, contains time series extracted from March 23 to September 22 (Fall and Winter seasons in Peru). The second Q2, contains time series extracted from September 23 to March 22 (Spring and Summer seasons in Peru). Table I shows the algorithms used in Time Series Module.

TABLE. I. Algorithms for Retrieving Historical Vectors

```
function initTemp()
{   t=15.0;
    for(i=0;i<=200;i++)
    {   temv.push(parseFloat(t.toFixed(1)));
        t+=0.1;
    }
}
function initBase(ts,idx)
{   Q1=new Array(200);
    Q2=new Array(200);
    getVectors(ts,idx);
}
function getVectors(ts,idx)
{   nQ=Q1.length;
    nts=ts.length;
    total=30;
    for(i=0;i<nQ;i++)
    {   value=parseFloat(temv[i]);
        cad1="";//fall-winter
        cad2="";//spring-summer
        finj=nts-total;
        for(j=0;j<finj;j++)
        {   if(value==parseFloat(ts[j]))
            {   ini=j+2;
                fin=j+total;
                if(idx[j]<184)
                {   cad1+=ts[j+1];
                    for(k=ini;k<=fin;k++)
                        cad1+="*"+ts[k];
                    cad1+="/";
                }
                else
                {   cad2+=ts[j+1];
                    for(k=ini;k<=fin;k++)
                        cad2+="*"+ts[k];
                    cad2+="/";
                }
            }
        }
        Q1[i]=cad1;
        Q2[i]=cad2;
    }
}
```

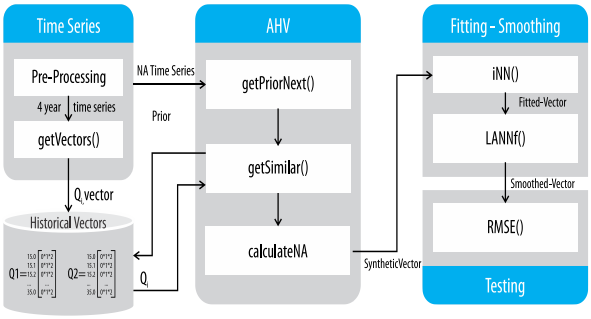


Fig. 3. Proposal Model.

B. Average of Historical Vectors (AHV)

This module was implemented through a function called AHV that uses several functions that will allow to calculate the NA values, among these functions we have getPriorNext (), getSimilar() and calculateNA(), which are described below:

getPriorNext() is a function that allows to calculate the prior and next values from the time series with NA values.

getSimilar () is a function that allows to obtain the historical vectors of 30 days having the prior value as a key value.

The data returned by the getSimilar() function is converted in vectors and then into a matrix M whose columns will be averaged to obtain the average vector with the estimated NA values. Equation (1) is used to calculate NA values.

$$NAs = \sum_{j=0}^{m-1}(\sum_{i=0}^{n-1} Mij)/n \quad (1)$$

TABLE. II. AHV ALGORITHM

```
function AHV(prior,ix)
{
    totalf=30;
    posf=ts.length-1;
    i=0;
    index=ix+1;
    avector=new Array();
    while(i<totalf)
    {   data=getSimilar(prior,ix);
        dat=data.split("/");
        ndat=dat.length-1;
        M=new Array();
        for(j=0;j<ndat;j++)
        {    da=dat[j].split("*");
             M.push(da);
        }
        nda=20;
        ix+=nda;
        if(ix>=365)
             ix=0;
        for(jj=0;jj<nda;jj++)
        {    s=0.0;
             for(ii=0;ii<ndat;ii++)
                  s+=parseFloat(M[ii][jj]);
             mean=s/ndat;
             avector.push(mean.toFixed(4));
        }
        current=mean.toFixed(1);
        i+=nda;
        posf=ts.length-1;
    }
    return avector;
}
```

The code corresponding to the AHV algorithm is shown in Table II.

C. Fitting - Smoothing

This module allows improving the accuracy of the estimated vector by AHV algorithm using two algorithms, the first is iNN (interpolation to Nearest Neighbors) and the second is LANNf, which are described below.

- Interpolation to Nearest Neighbors (iNN). It is an algorithm that approximates an estimated vector of NA values towards the prior and next values of a block of NA values.

This approach consists of:

1) Calculate the difference *d* between prior and next values, through equation (2).

$$d = (prior - next) \quad (2)$$

2) Determine the *t* factor from equation (3).

$$t = d/nna \quad (3)$$

Where *nna* is the gap-size. The *t* factor is used to calculate the values of the first NA and Last NA. See Fig. 4.

The *t* factor is subtracted or added according to the value of *d*, which determines the trend of the curve.

3) Once the first fitted NA and last fitted NA values are calculated, the differences between these values and those estimated in the NA Calculation block are determined using equation (4) and equation (5).

$$d1 = first\_NA - first\_fitted\_NA \quad (4)$$

$$d2 = last\_NA - last\_fitted\_NA \quad (5)$$

4) Based on the differences *d1* and *d2*, the *k* factor is calculated using equation (6).

$$k = |\frac{d1-d2}{nna-1}| \quad (6)$$

The k factor is used to adjust the non-adjusted NA values. An adder *s* is initialized on *d1* and each non-adjusted NA element is iterated. If *d1<d2* the adder *s* increases in *k*, otherwise if *d1>d2* the adder *s* decreases in *k*.

Fig. 5 shows an example of an estimated 30-day curve fitted with iNN.

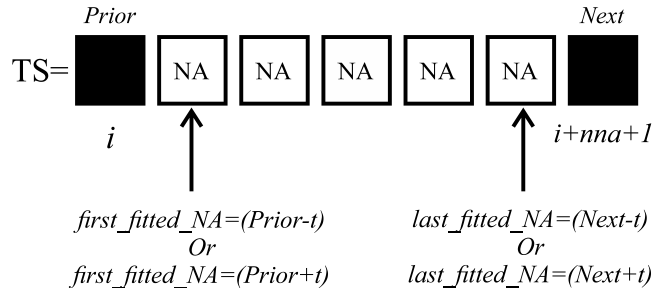


Fig. 4. First and Last NA Re-Calculation.

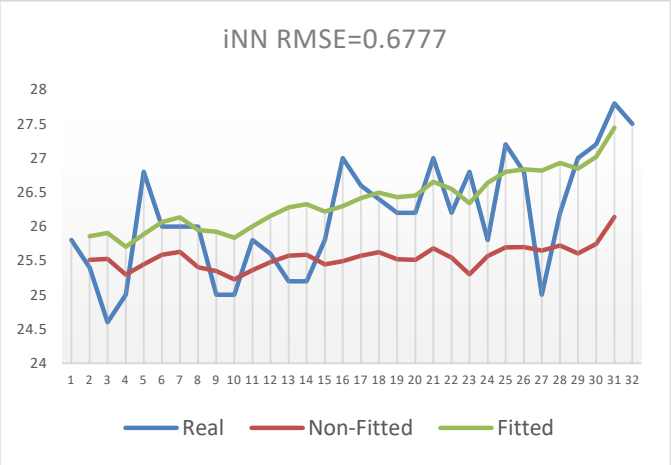


Fig. 5. Comparison of Non-Fitted Curve vs Fitted Curve.

The iNN algorithm is shown in Table III, which it receives as inputs:

- ts the time series to interpolate or adjust
- prr the prior value
- nxt the next value
- nna the number of NA values

TABLE. III. iNN ALGORITHM

```
function iNN(ts,prr,nxt,nna)
{   first=0;
    last=nna-1;
    d=prr-next;
    t=Math.abs(d/nna);
    if(d>0)
    {   prr1=prr-t;
        nxt1=nxt+t;
    }
    else
    {   prr1=prr+t;
        nxt1=nxt-t;
    }
    d1=ts[first]-prr1;
    d2=ts[last]-nxt1;
    dd=d1-d2;
    k=Math.abs(dd/(nna-1));
    predi=new Array();
    predi.push(prr1);
    s=d1;
    for(z=1;z<last;z++)
    {
        if(d1>d2)
            s-=k;
        else
            s+=k;
        fllw=parseFloat(ts[z])-s;
        predi.push(fllw);
    }
    predi.push(nxt1);
    return predi;
}
```

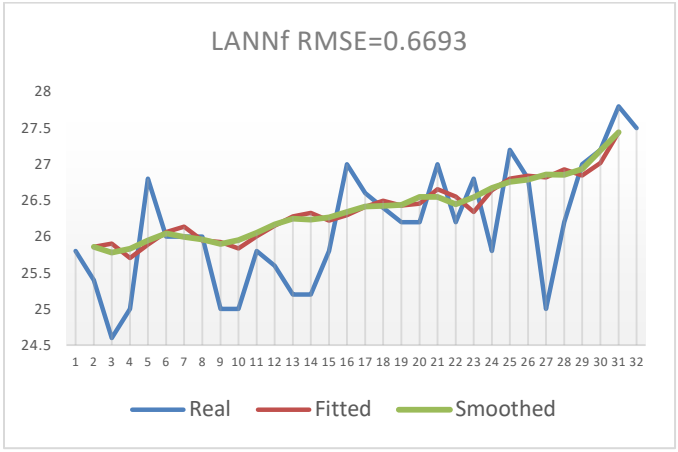


Fig. 6. Comparison of Fitted Curve vs Smoothed Curve.

- Local Average of Nearest Neighbors Filter (LANNf). It is an algorithm inspired by LANN [1] that allows smoothing a curve, for each estimate it uses three values of the vector to be smoothed, recalculating the intermediate or second value with the average of the first and third. Fig. 6. Shows a comparison between a fitted curve versus a smoothed curve using LANNf.

D. Testing

This module implements a RMSE function that calculates the Root Mean Squared Error to estimate the performance and accuracy of the proposal model. RMSE is calculated with Equation (7).

$$RMSE = \sqrt{\frac{\sum_{i=0}^{n-1}(Pi-Ri)^2}{n}} \quad (7)$$

The LANNf algorithm is shown in Table IV.

TABLE. IV. LANNF ALGORITHM

```
function LANNf(ts)
{   nts=ts.length-1;
    i=1;
    while(i<nts)
    {   prr=parseFloat(ts[i-1]);
        nxt=parseFloat(ts[i+1]);
        ts[i]=((prr+nxt)/2).toFixed(4);
        i+=1;
    }
    return ts;
}
```

V. RESULTS AND DISCUSSION

In this section, the accuracy of the proposal model is compared with different techniques described in Related Work section; the comparative results show the performance of the proposal on medium and big gaps.

Table V and Fig. 7 show the results achieved by the proposal model compared to other well-known techniques. As it can be seen, the proposal model is always among the best ones.

TABLE. V. COMPARISON WITH OTHER UNIVARIATE IMPUTATION TECHNIQUES (90-DAYS) IN MEDIUM-GAPS

Technique	RMSE (NAs 80%)	RMSE (NAs 65.55%)	RMSE (NAs 54.44%)
AHV, iNN & LANNf	**0.7038**	**0.7251**	**0.8381**
CBRm	**0.6844**	0.8050	0.8968
CBRi	0.8086	0.8112	0.8905
LANN	0.8422	0.8198	0.9053
LANN+	0.8276	0.7339	0.8608
Hotdeck	1.4337	1.6323	1.4996
SMA (k=1)	0.8324	**0.7035**	**0.8403**
LWMA (k=4)	**0.7673**	**0.7083**	**0.8106**
EWMA (k=4)	0.7682	0.7456	0.8535
ARIMA Kalman	5.4275	6.7383	2.6836

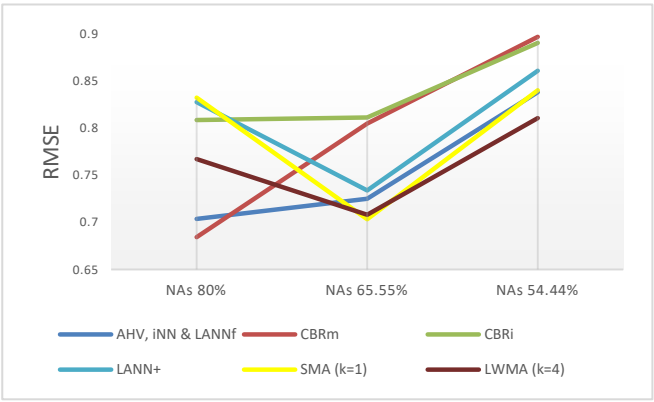


Fig. 7. Comparison with other Techniques (Medium-Gaps).

According to Table VI and Fig. 8, it can be seen that the proposal model, like the case of medium-gaps, for big-gaps is also among the best.

TABLE. VI. COMPARING WITH OTHER UNIVARIATE IMPUTATION TECHNIQUES IN BIG-GAPS

Technique	RMSE GAP-SIZE:11	RMSE GAP-SIZE: 21	RMSE GAP-SIZE: 30
AHV, iNN & LANNf	0.6175	0.6783	**0.6693**
ARIMA	0.6748	1.0424	1.4165
Prophet	**0.5991**	**0.6477**	0.7652
LSTM	0.6156	0.6820	0.7579
GRU	0.6749	0.6503	0.7262

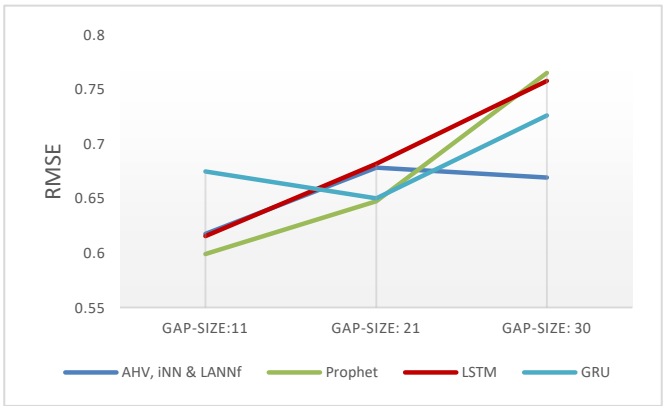


Fig. 8. Comparison with other Techniques (Big-Gaps).

VI. CONCLUSION

In imputation processes of máximum temperature time series with medium-gaps (from 3 to 10 consecutive NAs), of the three proposed problems and among 10 techniques, the proposal model was among the best: in one problem it was third and in the other two it was second.

For big-gaps imputation, in three different problems the proposed model was always among the three best, in two cases it was third and in one case it was the best.

Therefore, according to the results achieved, the proposed model is highly recommended for imputation processes of medium and big-gaps.

VII. FUTURE WORK

There are several improvements that can be implemented in this work; some of them are mentioned below:

AHV only uses historical data to estimate NAs vertically; it could be complemented with the traditional horizontal mode. In addition, the vertical imputation technique could be any of the known SMA, LWMA, EWMA, ARIMA, KALMAN, etc., since as the average is known, it is one of the most basic and risky techniques due to the bias that can be inserted in time series.

Also, instead of working with only two stations, the 4 known stations could be included for this type of time series.

REFERENCES

[1] Flores, H. Tito, C. Silva, "Local average of nearest neighbors: Univariate time series imputation," International Journal of Advanced Computer Science and Applications, vol. 10, nº 8, pp. 45-50, 2019.

[2] S. Moritz, A. Sardá, T. Bartz-Beielstein, M. Zaefferer, J. Stork, "Comparison of different Methods for Univariate Time Series Imputation in R," arxiv.org, 2015.

[3] S. Moritz, "Package ImputeTS," cran.r-project.org, 2019.

[4] A. Flores, H. Tito, C. Silva, "CBRi: A Case Based Reasoning-Inspired Approach for Univariate Time Series Imputation. In Press," de IEEE Latin American Conference on Computational Intelligence, Guayaquil, Ecuador, 2019.

[5] A. Flores, H. Tito, C. Silva, "CBRm: Case based Reasoning Approach for Imputation of Medium Gaps," International Journal of Advanced Computer Sciences and Applications, vol. 10, nº 9, pp. 376-382, 2019.

[6] S. Hochreiter, J. Schmidhuber, "Long short-term memory," Neural computation, vol. 9, nº 8, pp. 1735-1780, 1997.

[7] C. Kyunghyun, V. Bart, C. Caglar, B. Dzmitry, B. Fethi, S. Holger, B. Yoshua, "Learning phrase representations using RNN encoder-decoder for statistical machine translation," arXiv, 2014.

[8] S. Taylor, B. Letham, "Forecasting at scale," PeerJ Preprints, 2017.

[9] S. Moritz, T. Bartz-Beielstein, "imputeTS: Time Series Missing Value Imputation in R," The R Journal, vol. 9, nº 1, pp. 207-2018, 2017.

[10] S. Moritz, A.Sardá, T. Bartz-Beielstein, M. Zaeffer, J, Stork, "Comparison of different methods for univariate time series imputation in R," arxiv.org, 2015.

[11] E. Rantou, "Missing Data in Time Series and Imputation Methods," University of the Aegean, Samos, 2017.

[12] N. Bokde, M. Beck, F. Martinez, K. Kulat, "A novel imputation methodology for time series based on pattern sequence forecasting," Pattern Recognition Letters, 2018.

[13] A. Zeileis, G. Grothendieck, "zoo: S3 infrastructure for regular and irregular time series," Journal of Statistical Software, vol. 14, nº 6, 2005.

[14] K. Kaiser, O. Affuso, T, Beasley, D. Allison, "Getting carried away: A note showing baseline observation carried forward (BOCF) results can

be calculated from published complete-cases results," PMC US National Library of Medicine, 2012.

[15] A. Kowarick, M. Templ, "Imputation with the R package VIM," Journa of Statistical Software, vol. 74, nº 7, 2016.

[16] T. Aljuaid, S. Sasi, "Proper imputation techniques for missing values in data sets," de International Conference on Data Science and Engineering (ICDSE), Cochin, India, 2016.

[17] P. Zarchan, H. Musoff, Fundamentals of kalman filtering, American Institute of Aeronautics and astronautics, 2000.

[18] Z. Wang, Y. Lou, "Hydrological time series forecast model based on wavelet de-noising and ARIMA-LSTM," de IEEE 3rd Information Technology, Networking, Electronic and Automation Control Conference (ITNEC), Chengdu, China, 2019.

[19] Y. Du, "Application and analysis of forecasting stock price index based on combination of ARIMA model and BP neural network," de Chinese Control and Decision Conference (CCDC), Shenyang, China, 2018.

[20] S. Kumar, L. Hussain, S. Banarjee, M. Reza, "Energy load forecasting using deep learning approach-LSTM and GRU in spark cluster," de IEEE, Kolkata, India, 2018.

[21] J. Chung, C. Gulcere, K. Cho, Y. Bengio, "Empirical evaluation of gated recurrent neural networks on sequence modeling," arxiv.org, 2014.

Enhanced, Modified and Secured RSA Cryptosystem based on *n* Prime Numbers and Offline Storage for Medical Data Transmission via Mobile Phone

Achi Harrisson Thiziers[1*], Haba Cisse Théodore[2], Jérémie T. Zoueu[3], Babri Michel[4]
Instrumentation, Imaging and Spectroscopy Laboratory (L2IS)
Institut National Polytechnique-Houphouët Boigny (INP-HB)
DFR-GEE, Yamoussoukro, Côte d'Ivoire[1,2,3]
Computer Science and Telecoms Networks Laboratory (LARIT)
INP-HB Abidjan, Côte d'Ivoire[4]

***Abstract*—The transmission of medical data by mobile telephony is an innovation that constitutes the m-health or more generally e-health. This telemedicine handles personal data of patients who deserve to be protected when they are transmitted via the operator or private network, so that malicious people do not have access to them. This is where cryptography comes in to secure the medical data transmitted, while preserving their confidentiality, integrity and authenticity. In this field of personal data security, public key cryptography or asymmetric cryptography is becoming increasingly prevalent, as it provides a public key to encrypt the transmitted message and a second private key, linked to the first by formal mathematics, that only the final recipient has to decrypt the message. The RSA algorithm of River and Shamir provides this asymmetric cryptography based on a public key and a private key, on two prime numbers. However, the factorization of these two prime numbers to give the variable *N* of RSA can be discovered by a hacker and thus make the security of medical data vulnerable. In this article, we propose a more secured RSA algorithm with *n* primes and offline storage of the essential parameters of the RSA algorithm. We performed a triple encryption-decryption with these *n* prime numbers, which made it more difficult to break the factorization of the variable *N*. Thus, the key generation time is longer than that of traditional RSA.**

Keywords*—*e-Health; medical data transmission; asymmetric cryptography; RSA algorithm; first numbers

I. INTRODUCTION

Transmitting medical data via interconnection technologies such as mobile telephony is an operation that requires the highest level of security, in order to preserve their private and personal nature. This subject, as well as the algorithm of River and Shamir [1], have been the topic of several studies in the literature and continue to fascinate many researchers. D. Sathya and al. [2] worked on a secure remote monitoring system, combining a symmetric algorithm and attribute-based encryption, to secure data transmission and the medical sensor network access control system. J. Heurix and al. [3] have worked on storage that preserves privacy and access to medical data through pseudonymization and encryption. Mohammed L. and al. [4] worked on remote supervision of e-health that preserves privacy, through a process of prior patient approval, before any transmission to the Health Centre. M. Milutinovic and al. [5] spoke about the management of privacy-preserving data in an e-health system, developing a protocol based on new e-health architecture.

We note from these works that data encryption aims to make medical data inaccessible to unauthorized persons. Thus, the confidentiality, integrity and availability of this data are preserved [6]. There are two main types of cryptography. Symmetric key cryptography, with a unique public key that is shared between the sender who sends the encrypted message and the receiver who receives it and decrypts the full text. Among the symmetric algorithms are DES, 3DES, AES, IDEA, and BLOWFISH [7]. We also have asymmetric cryptography with two distinct keys: a public key that the sender uses to encrypt his message and another private key mathematically linked to the first that is used to decrypt the original message. We can mention here the RSA algorithm which factors two prime numbers to give a large integer number 'N' [8]. The simple principle that drives RSA is to be able to perform easy mathematical calculations, but whose reverse operation is difficult, in the absence of additional information, according to M. A. Islam and al. [9].

In general, RSA uses two primes "p" and "q" to obtain the factorization of the large integer "N". The attack on RSA can occur at this level, when the hacker succeeds in discovering the factorization of the large number "N", thus preventing the generation of the private key from the public key.

Our contribution, in this article, is an amelioration of the security of RSA, by accentuating key generation time, during the factorization of the large number *N*. We used, like M. A. Islam, four prime numbers, instead of two, in the original RSA model; this makes the factorization more robust with a large number of the exponent used for encryption. Instead of the double encryption-decryption he performed, we made a triple encryption-decryption to make RSA even stronger, therefore more secured than the original RSA of Shamir and MSRSA from Muhammad. To speed up encryption-decryption, we stored offline the essential key generation and factorization parameters.

The first part of this article, constituted by the introduction, is followed by the second part which relates the state of the art,

*Corresponding Author

in terms of cryptosystems based on the modification of the RSA Algorithm. In the third part, we present the method and material of our research. The original RSA algorithm, Muhammad Ariful's Modified and Secured RSA algorithm and our reinforced, modified and secured RSA Algorithm are presented in Parts Four and Five respectively. Part Six presents the implementation and results. As for the fifth part, it gives a conclusion and suggests avenues for our future works.

II. Related Works

Several research studies in doctoral theses and scientific journals [32-36], have shown that it is possible to improve the security of encryption and decryption of personal and private data. Concerning the RSA algorithm, this work is abundant, and in this literature review, we present a non-exhaustive table of this work. H. Ali and al. [10] proposed an amendment to RSA called timing attack prospect for RSA cryptanalysts using genetic algorithm technique. This article proposes the use of a genetic algorithm to measure the time required to attack the crypto RSA system. B. Kumar and al. [11] proposed a hybridization of the AES and RSA algorithm for clouds. A. Bhardwaja and al. [12] presented security algorithms for cloud computing. B. Swamia and al. [13] proposed an algorithm based on a double modulo at the RSA algorithm using the Jordan-Totient function. Dr. P. Mahajan and al. [14] reviewed the literature on encryption based on AES, DES and RSA algorithms for data security. D. Preuveneersa and al. [15] wrote an article on the future of mobile telephone-based e-health application development, examining HTML5 for diabetes management in an intelligent environment. M. Kethari and al. [16] produced a literature review on the transmission of medical data for e-health in terms of web platform security. V. Kapoor and al. [17] have produced a new hybrid cryptography technique to consolidate network security. K. G. Kadam and al. [18] also produced a hybrid algorithm using both RSA-AES encryption for web services. K. Rege and al. [19] also used the hybridization of AES and RSA algorithms to secure Bluetooth communication. R. Raj and al. [20] worked on the modification of the crypto RSA system. S. Patel and al. [21] have implemented a new encryption method using a modification of the RSA algorithm and the Chinese recall theorem. A. Gupta and al. [22] examined a double modification of the modulo of the RSA algorithm and tested it with a brute force attack. B. Yüksel and al. [23] have produced research on privacy and security of electronic services. S. Bhuyan and al. [24] wrote an article on privacy and security issues in mobile health: Current research and future directions. H. S. G. Pussewalage and al. [25] published on privacy mechanisms for enforcing security and privacy requirements in e-health solutions. Y. Li and al. [26] worked on the design and implementation of an improved RSA algorithm. S. Sharma and al. [27] produced a new variant of the RSA subset-sum cryptosystem. Amare Anagaw Ayele and al. [28] have implemented a modified RSA encryption technique based on multiple public keys. H. Huang and al. [29] wrote an article on the transmission and analysis of private and secure medical data for a wireless health care system with detection. B. P. U. Ivy and al. [30] published an article on a modified RSA encryption system based on 'n' prime numbers.

All these works have shown that it is possible to improve the safety of the RSA Algorithm by modifying it and enhancing its safety, and even more so by making it faster. Indeed, one of the weaknesses of RSA is the relatively long time for the execution of the algorithm. Our research consists in strengthening the generation of the private key, by using several prime numbers, and by proceeding with triple encryption-decryption. This increases security, as the generation of the private key takes more time and makes it more difficult to factorize the large number of 'N', which the Hacker will have difficulty breaking easily. To make the algorithm run faster, in addition to the triple encryption-decryption, we stored in a database the essential parameters for generating the private key.

III. Materials and Method

The data to be secured are the ones transmitted by mobile phone to a cloud, to enable e-health, protecting patients' private data, as shown in Fig. 1. Our device is a multi-sensor called "6 in 1 Health monitor" that allowed us to acquire directly on the patients, 6 health constants: Infrared temperature, blood pressure, blood sugar, blood oxygen saturation level SpO2, ECG electrocardiogram, and heart rate. These constants are then transmitted to the mobile application by Bluetooth, and then, the tablet transmits them via the mobile application we have developed, on the telephone network, to a special doctor who can interpret them and give the necessary recommendations.

To achieve this objective, we propose, as in the work of Muhammad and al. a modification of RSA. However, unlike the pair of random numbers he used, we use a four random numbers, with their inverse multiplication module, to further increase the security of RSA. We have obtained a greater generation time of the private key for MRSA of Muhammad and therefore also for the original RSA. The encryption and decryption time is much longer than that of the original RSA, but we were able to obtain that, despite the triple encryption and decryption, the encryption and decryption time of our EMSRSA is almost equal to that of MSRA, by storing offline the key parameters for generating the private key in a database. This results in faster execution of encryption and decryption. Better than Muhammad and al., we implemented a real simulation interface, which we called 'RSA GENERATOR', to achieve performance tests. This interface has been implemented in a JAVA environment; we have used, like Muhammad and al., the functions of the same large integer library. As Muhammad and al. said, this library offers several functions such as modular arithmetic, calculation of the highest common denominator, primacy test, prime number generation, bit manipulation and many other operations. For EMSRSA, Via 'RSA GENERATOR', based on our reference article, the user has the possibility to choose prime numbers or to choose the size of the bits in order to automatically generate the prime numbers. Subsequently, a comparison of the execution times of the private key generation time, the encryption time and the decryption time is made between the original RSA, MSRA and EMSRSA.

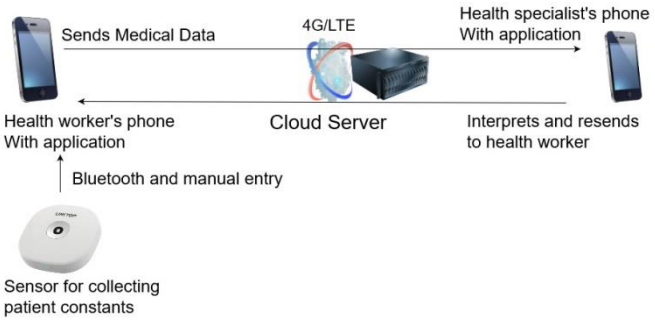


Fig. 1. Overview of our Mobile Cloud Computing for Secure Transmission of Medical Data.

A. Functionning of the original RSA Algorithm of Shamir and al.

Private Key generation

a) Select p and q, both prime numbers, p being different from q.

b) Calculate

$$n = p * q \quad (1)$$

c) Calculate the Euler phi value of n

$$Ø(n) = (p\ -1) * (q\text{-}1) \quad (2)$$

d) Randomly select an integer *e* that satisfies the following conditions

$$\text{PGCD}\ (Ø\ (n), e) = 1 \quad (3)$$

Where

$$1 < e < Ø(n) \quad (4)$$

e) Calculate a random number d such that:

$$d = e\text{-}1\ (\text{mod}\ Ø\ (n)) \quad (5)$$

Or

$$d * e \equiv 1\ (\text{mod}\ Ø\ (n)) \quad (6)$$

f) Public Key

$$PUK = \{e, n\} \quad (7)$$

g) Private Key

$$PRK = \{d, n\} \quad (8)$$

Encryption

ncryption is done using the public key: {*e*, *n*}

a) The full text - Message (M)

b) The encrypted text:

$$C = M^e \bmod n \quad (9)$$

Decryption

The decryption is done by the private key: {*d*, *n*}

a) Encrypted text - C

b) Full text

$$M = C^d \bmod n \quad (10)$$

Where *M* is the original message, *p* and *q* being prime numbers; *n* is their common modulo, *e* and *d* being respectively the public and private key.

B. Functioning of the MSRSA Algorithm of Muhammad Islam and al.

Private Key generation

a) Select *p* and *q*, *r*, *s*, all four of the prime numbers, *p*, *q*, *r*, *s* being different.

b) Calculate:

$$n = p * q * r * s \quad (11)$$

c) Calculate the Euler phi value of n:

$$Ø(n) = (p\ -1) * (q\text{-}1) * (r\text{-}1) * (s\text{-}1) \quad (12)$$

d) Randomly select two integers *e* and *f* that meet the following conditions.

$$\text{PGCD}\ (Ø\ (n), e) = 1 \quad (13)$$

Where

$$1 < e < Ø(n) \quad (14)$$

$$\text{PGCD}\ (Ø\ (n), f) = 1 \quad (15)$$

Where

$$1 < f < Ø(n) \quad (16)$$

e) Calculate a random number *d* such that:

$$d = e\ \text{-}1\ (\text{mod}\ Ø\ (n)) \quad (17)$$

Or

$$d * e \equiv 1\ (\text{mod}\ Ø\ (n)) \quad (18)$$

Calculate another random number *g* so that:

$$f * g \equiv 1\ (\text{mod}\ Ø\ (n)) \quad (19)$$

f) Public Key

$$PUK = \{e, f, n\} \quad (20)$$

g) Private Key

$$PRK = \{d, g, n\} \quad (21)$$

Encryption

Encryption is done by public key: {*e*, *f*, *n*}

a) Encrypted text - C

b) Full text:

$$C = ((M^e \bmod n)^f) \bmod n) \quad (22)$$

Where M is the original message, *p* and *q*, *r*, *s* being prime numbers. 'n' is their common modulo, (*e*, *f*) and (*d*, *g*) being respectively the public and private key.

Decryption

The decryption is done by the private key: {*d*, *g*, *n*}

a) Encrypted text - C

b) Full text:

$$M = ((C^g \bmod n)^d) \bmod n) \quad (23)$$

Where M is the original message, p and q, r, s being prime numbers. 'n' is their common modulo.

C. Functioning of our Proposed EMSRSA Algorithm

Private Key generation

a) Select p and q, r, s, all four of the prime numbers, p, q, r, s being different.

b) Calculate:

$$n = p * q * r * s \quad (24)$$

c) Calculate the Euler phi value of n:

$$Ø(n) = (p-1) * (q-1) * (r-1) * (s-1) \quad (25)$$

d) Randomly select integers e, f, h, i that meet the following conditions:

$$\text{PGCD}(Ø(n), e) = 1 \quad (26)$$

Where

$$1 < e < Ø(n) \quad (27)$$

$$\text{PGCD}(Ø(n), f) = 1 \quad (28)$$

Where

$$1 < f < Ø(n) \quad (29)$$

$$\text{PGCD}(Ø(n), h) = 1 \quad (30)$$

Where

$$1 < h < Ø(n) \quad (31)$$

e) Calculate a random number d such that:

$$d = e^{-1} \pmod{Ø(n)} \quad (32)$$

Or

$$d * e \equiv 1 \pmod{Ø(n)} \quad (33)$$

Calculate two other random numbers g and i, so that:

$$(f * g) * (h * i) \equiv 1 \pmod{Ø(n)} \quad (34)$$

f) Public Key:

$$PUK = \{e, f, h, n\} \quad (35)$$

g) Private Key

$$PRK = \{d, g, i, n\} \quad (36)$$

Encryption.

Encryption is done by public key: $\{e, f, h, n\}$

a) Encrypted text - C

b) Full text

$$M = ((((M^{e} \bmod n)^{f}) \bmod n)^{h}) \bmod n) \quad (37)$$

Where M is the original message, p and q, r, s being prime numbers. 'n' is their common modulo, (e, f, h) and (d, g, i) being respectively the public and private key.

Decryption.

The decryption is done by the private key: $\{d, g, i, n\}$

a) Encrypted text - C

b) Full text

$$M = ((((C^{g} \bmod n)^{d}) \bmod n)^{i}) \bmod n) \quad (38)$$

Where M is the original message, p and q, r, s being prime numbers; 'n' is their common modulo.

Fig. 2 shows a flow diagram of our Enhanced Modified and Secured RSA (EMSRSA) algorithm. Like M. Islam and al., we used four prime numbers to calculate n and Ø(n). This time, a triplet of numbers (e, f and h) obtained at random is used in the range $1 < e < Ø(n)$, $1 < f < Ø(n)$ and $1 < h < Ø(n)$ as exponent of the public key. Subsequently, the inverse modulo multiplication of these random numbers (d, g and i) is calculated to serve as a private key exponent. Encryption and decryption are carried out by the exponents of this public and private key.

(MRSA) of M. A. Islam and al.

As with Muhammad's article, let's look at a concrete example using, this time, our EMSRSA.

Let's take four prime numbers: $p = 53$, $q = 41$, $r = 43$, $s = 47$.

We Calculate:

$n = p*q*r*s$

$n = 53*41*43*47 = 4391633$

We compute Euler phi value of n:

$Ø(n) = (p-1) * (q-1) * (r-1) * (s-1)$

$Ø(n) = (53-1) * (41-1) * (43-1) * (47-1) = 4018560$

We randomly select two integers e and h that meet the following conditions.

$\text{PGCD}(Ø(n), e) = 1$ and $1 < e < Ø(n)$ give $e = 41$

$\text{PGCD}(Ø(n), h) = 1$ and $1 < h < Ø(n)$ give $h = 53$

We randomly select an integer d that meets the following conditions.

$d * e \equiv 1 \bmod Ø(n)$

We deduce

$d = 294041$.

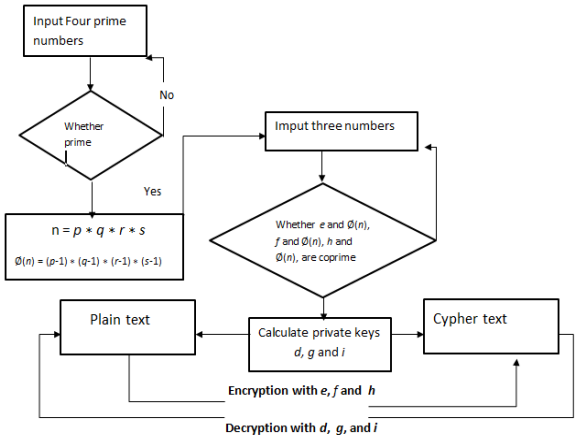


Fig. 2. Flow Diagram of our Algorithm (EMSRSA), Inspired by.

We randomly select another integer f that meets the following conditions

PGCD ($Ø(n)$, f) = 1 and $1 < f < Ø(n)$ give $f = 97$.

We randomly compute an integer g that meets the following conditions

$g * f \equiv 1 \bmod Ø(n)$

We deduce

$g = 455713$

We randomly select an integer i that meets the following conditions

$(i * h) \equiv 1 \bmod Ø(n)$

And

$(g * f) * (i * h) \equiv 1 \bmod Ø(n)$

Input Message is M=12321

Let's Encrypt the Message

$C = ((((M^e \bmod n)^f) \bmod n)^h) \bmod n) = 3475386$

We then decrypt the crypted Message C

$M= ((((C^g \bmod n)^d) \bmod n)^i) \bmod n) = 12321$

D. Implementation

Our algorithm implementation was done in JAVA version OXYGEN environment on a Lenovo computer, Intel® Core TM i5 CPU M520 (2.40 GHz)*(2.40 GHz), with 8 GB of RAM. The security challenge of the RSA Algorithm and other modified algorithms such as Muhammad's is to consolidate the factorization of the 'n' number in order to increase the difficulty of detecting the key by a hacker.

IV. Results and Discussion

A. Performance Analysis

To compare the primary key generation times, encryption and decryption times of the three algorithms, we used the same bit sizes in our RSA Generator interface. Table I, Table II and Table III give performance of the RSA, MRSA and our EMSRSA Algorithms.

Fig. 3 shows our developed interface called 'RSA GENERATOR'. We used it to test both, RSA, MRSA and our EMSRSA performance.

Fig. 4 is the graph of Key generation time comparison for the three algorithms.

Fig. 5 and Fig. 6 following are respectively the graph of encryption time comparison and the graph of decryption time comparison for the three algorithms.

For prime number entries for the 2048 size bit, our key generation time is 21.220416 ms compared to 11.668641 ms for Muhammad's MRSA. This proves that our enhanced EMSRA is stronger than MRSA and RSA. Our encryption time is longer with our method (1285.051478 ms) compared to 16.20906 ms for MRSA, but our decryption time is shorter (2699.154794 ms) than (2809.571451 ms) for MRSA.

B. Complexity Analysis

Complexity of the RSA algorithm

As Muhammad showed for RSA, the complexity of the two randomly selected numbers is.
O ($s* (\log2p)^2 *\ln p$) and O ($s* (\log2q)^2 *\ln q$), due to MILLER RABIN complexity.
The complexity of randomly finding the variable 'e' being
O $((\log2(\log2p-1) * (\log2q-1))^2+1)$.
Similarly for our EMSRSA, as for the MRSA of Muhammad, the complexity to find the prime numbers p, q, r, s that we will note for the occasion w, x, y, z is respectively:
O ($s* (\log2w)^4 *\ln w$), O ($s* (\log2x)^4 *\ln x$),
O ($s* (\log2y)^4 *\ln y$) et O ($s* (\log2z)^4 *\ln z$).
The complexity for the hacker to find the numbers at random e, f, and h being the same:
O $((\log2(\log2w-1)*(\log2x-1)*(\log2y-1)*(\log2z-1))^4+1)$.

We can see that the EMSRSA Algorithm is more complex than the RSA algorithm.

TABLE. I. Original RSA Performance

Length of p, q (byte)	Key Generation time (in ms)	Encryption time (in ms)	Decryption time (in ms
100	0,487619	0,059883	4,845822
128	0,397367	0,0586	0,257925
256	0,536381	0,102229	0,873438
512	0,583859	0,151419	3,477494
1024	1,022289	0,962406	24,465223
2048	1,878189	2,863266	167,77436
4096	6,547785	10,178836	1464,092836

TABLE. II. Performance of MRSA

Length of p, q,r,s (byte)	Key Generation time (in ms)	Encryption time (in ms)	Decryption time (in ms
100	1,150182	0,155696	1,250701
128	0,948718	0,169812	1,941494
256	2,089063	0,506868	15,558901
512	3,352168	1,804191	53,716385
1024	3,724298	4,027991	337,387986
2048	11,668641	16,20906	2809,571451
4096	43,781358	87,732529	20253,26726

TABLE. III. Performance of Our Proposed EMSRSA

Length of p, q,r,s (byte)	Key Generation time (in ms)	Encryption time (in ms)	Decryption time (in ms
100	2,262297	0,71603	1,193811
128	1,846109	0,747683	1,176702
256	3,756807	10,668167	14,275265
512	7,11368	33,898088	51,301388
1024	12,052748	199,573975	377,112268
2048	21,220416	1285,051478	2699,154794
4096	65,98343	10237,78236	20158,48051

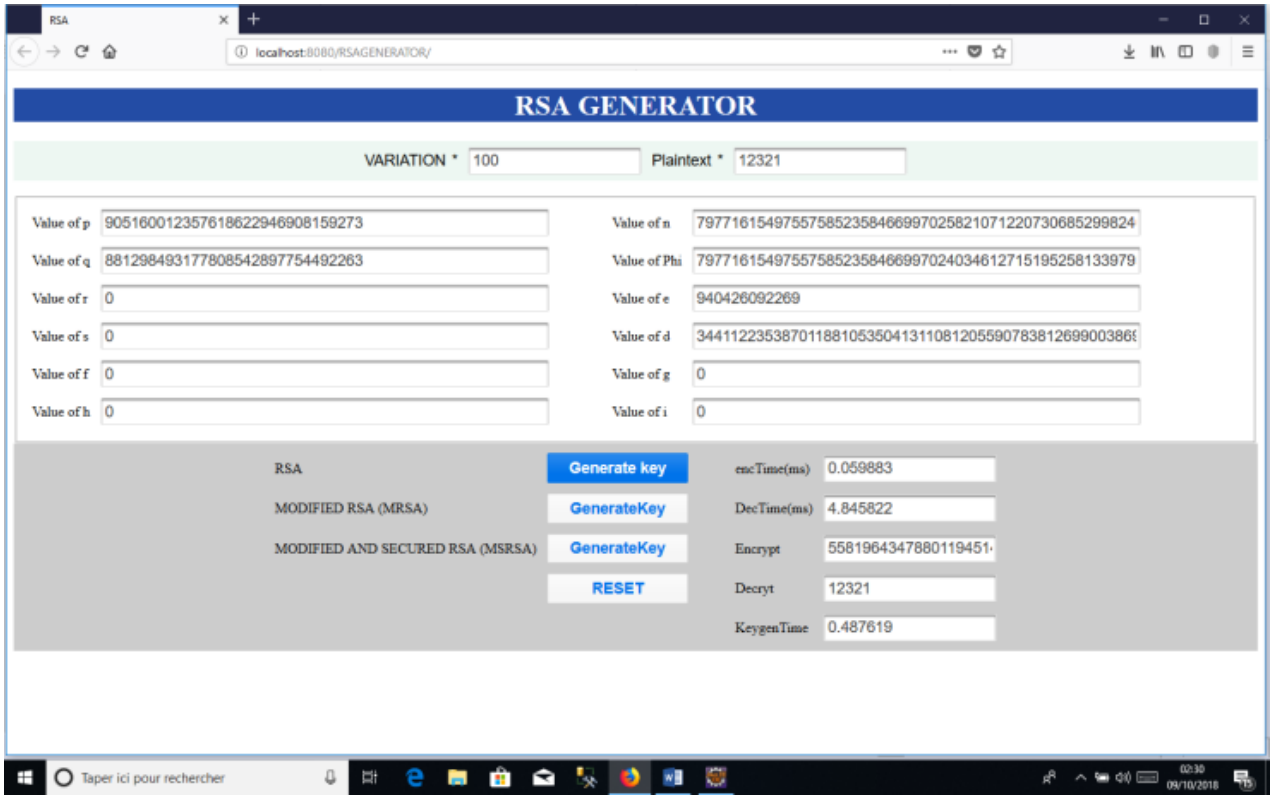


Fig. 3. JAVA Interface 'RSA GENERATOR' for a Size bit Set to 100.

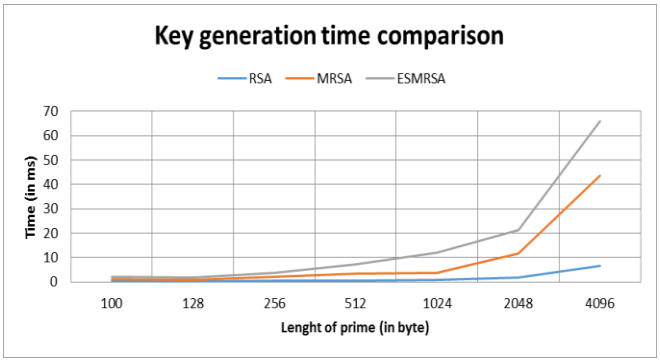


Fig. 4. Key Generation Time Comparison.

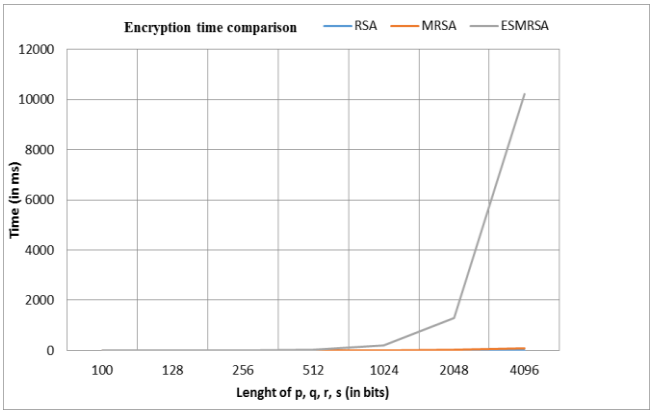


Fig. 5. Encryption Time Comparison.

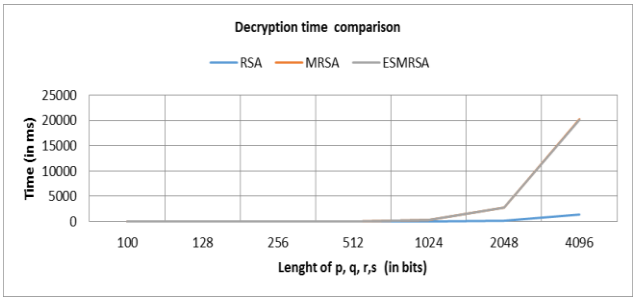


Fig. 6. Decryption Time Comparison.

C. Security Analysis

Similarly, as Muhammad explained, the factorization technique can be used to find 'w', 'x', 'y', 'z', the four prime numbers p, q, r, s that we renamed for the circumstance, but not to find 'e', 'f', 'g'. Indeed for them, you have to use the brute force attack. Thus, the simplest attack on a number is the brute force attack. In this attack, an attacker simply tries to decrypt the message with each possible secret key and checks the decryption result to see if it makes sense. With enough time and computer resources, this attack is guaranteed to work since the real secret key must be found in all possible secret keys and the attacker will eventually try it and (hopefully) realize that the resulting plain text is the right one [31].

$$\Omega_{system1} = \Omega_{w,x,y,z} + \Omega_{bruteforce1} \quad (39)$$

For our EMSRSA

$$\Omega_{system2} = \Omega_{x,y} + \Omega_{bruteforce2} \quad (40)$$

With RSA original

Ω_{system}= Time required to break the system.

$\Omega_{w,x,y,z}$= Time required to find w, x, y, z using, for example, the methods of modern factorization algorithms GNFS (General Number Field Sieve) and ECM (Elliptic Curve Method).

$\Omega_{x,y}$= Time required to find x, y, using, for example, the methods of modern factorization algorithms GNFS (General Number Field Sieve) and ECM (Elliptic Curve Method).

$\Omega_{bruteforce1}$= Time required for the brute force attack that would allow to find the prime numbers ad random *e*, *f* and *h*.

$\Omega_{bruteforce2}$= Time required for the brute force attack that would allow the first number e to be found at $\emptyset(n)$.

We have just demonstrated that $\Omega_{w,x,y,z}$ is higher than $\Omega_{x,y}$.

(Key generation time)

Similarly, $\Omega_{bruteforce1} > \Omega_{bruteforce2}$, because it takes more time for brute force to find ad random three prime numbers (*e*, *f*, and *h*) than is required in the original RSA method.

Let's take a demonstrative example: if we use the site https://howsecureismypassword.net/, a tool for checking cryptanalysis online password, it takes at least 34,0000 years to get to the end of a password like Binl_ose1***. The longer and more complex the password, the longer it takes to crack it. We also know that there are at least (62)x possibilities to crack by brute force a key of length x. If we have the length x= 5 characters, this gives us 3844000000000000000 possibilities to find in a time $\Omega_{bruteforce}$, depending on the performance of the attack server.

This confirms that $\Omega_{bruteforce1} > \Omega_{bruteforce2}$, because instead of working as an input with the two prime numbers taken at random, you have to find four.

We deduce that $\Omega_{system1} > \Omega_{system2}$. The hacker will necessarily take longer to crack our improved EMSRSA than to do it with the original RSA.

The security of our EMSRSA algorithm is therefore stronger than RSA, because it is already stronger than Muhammad's MRSA, because the hacker has to find four prime numbers instead of two, then it takes him a longer time to generate the primary key related to the factorization of the large prime number 'N'. However, our decoding time is shorter than that of MRSA from large bits. The interest of our work is that RSA is used only for the exchange of private keys, as the public key passes through the mobile medical data transmission network. For the transmission of this data, a symmetrical algorithm such as AES, for example, would be more appropriate. In this context, private key security is important, and the generation time of the primary key is very important, and this is what we have obtained by our method, by improving the security of RSA.

V. Conclusion and Future Work

The security of the transmission of our medical data depends on the encryption we apply. We chose RSA, which we modified and which uses the factorization of large numbers. Our work, similar to that of Muhammad Ariful, consisted of 'n' prime numbers instead of two. The triple encryption-decryption we have done has made it more difficult to break the factorized number 'N' on which all the encryption depends. The time required to break it in our case is much longer than that of the MRSA of Muhammad, and RSA. The encryption time is much longer than RSA and MRSA, but through our offline storage, we have been able to improve decryption time, better than Muhammad Ariful, especially when the input bits are larger. We therefore intend, in our future work, to improve the time of encryption by applying the AES algorithm at this level, which would result in an asymmetric combination of AES and EMSRSA, to increase the performance of our new cryptosystem algorithm.

References

[1] R. Rivest, A. Shamir, and L. Adleman, “A Method for Obtaining Digital Signatures and Public-Key Cryptosystems”, Vol.21, 1978, pp. 120–126.

[2] D. Sathya, P. G. Kumar, “Secured remote health monitoring system”, Healthcare Technology Letters, Vol. 4, Iss. 6, 2017, pp. 228–232.

[3] J. Heurix and T. Neubauer, “Privacy-preserving storage and access of medical data through pseudonymization and encryption”, Institute of Software Technology and Interactive Systems, Austria, 2011, pp. 1–12.

[4] M. Layouni, K. Verslype, M. T. Sandıkkaya, B. De Decker, and H. Vangheluwe, “Privacy-preserving telemonitoring for eHealth”, IFIP International Federation for Information Processing 2009, Data and applications security, LNCS 5645, 2009, pp. 95–110.

[5] M. Milutinovic, B. De Decker, “Privacy-preserving data management in eHealth systems”, Conference on enterprise information systems / HCIST–International Conference on Health and Social Care Information Systems and Technologies, 2013, pp. 1085–1092.

[6] Sun, H.M., M.E.,Ting, W.C. and Hinek, M.J., “Dual RSA and its security Analysis”. IEEE Transactions on information Theory,53, 2007, pp. 2922–2933.

[7] S. K. Abd and S.A.R Al-Haddad, F. Hashim and A. Abdullah, “A review of cloud security based on cryptographic mechanisms”, International Symposium on Biometrices and Security Technologies (ISBAST), 2014, pp.106–111.

[8] Ms. R. Patidar, Mrs. R. Bhartiya, “Implementation of modified RSA cryptosystem based on offline storage and prime number”, International Journal of Computing and Technology, Volume 1, Issue 2, (IJCAT), ISSN: 2348-6090, 2014, pp. 205–209.

[9] M. A. Islam, Md. As. Islam, N. Islam, B. Shabnam, “A modified and secured RSA public key cryptosystem based on ‘n’ prime numbers”, Journal of Computer and Communication, 6, 2018, pp.78–90.

[10] H. Ali, M. Al-Salami, “Timing attack prospect for RSA cryptanalysts using genetic algorithm technique” Computer science department, Zarka Private University, Jordan, The International Arab Journal of Information Technology, Vol. 1, No. 1, 2004, pp. 80–84.

[11] B. Kumar, J. Boaddh and L. Mahawar, “A hybrid security approach based on AES and RSA for cloud data”, International Journal of Advanced Technology and Engineering Exploration, Vol 3(17), 2016, pp. 43–49.

[12] A. Bhardwaja, G. Subrahmanyamb, V. Avasthic, H. Sastryd, “Security algorithms for cloud computing”, Procedia Computer Science, 85, 2016, pp.535–542.

[13] B. Swamia, R. Singhb, S. Choudharyc, “Dual modulus RSA based on Jordan-Totient function”, International Conference on Emerging Trends in Engineering, Science and Technology (ICETEST), 2015, pp. 1581–1586.

[14] Dr. P. Mahajan and A. Sachdeva, “A study of encryption algorithms AES”, DES and RSA for Security, Global Journals Inc.(US), vol 13, 2013, pp. 8807 –8811.

[15] D. Preuveneersa, Y. Berbersa, W. Joosena , “The future of mobile e-health application development: exploring HTML5 for context-aware diabetes monitoring”, Procedia Computer Science, 21, 2013, pp. 351–359.

[16] M. Kethari, Prof. L. Desai, "A survey on secure web based medical data transmission for eHealth", International Journal of New Innovations in Engineering and Technology, Volume 6 Issue 3, ISSN : 2319-6319, 2016, pp. 18–20.

[17] V. Kapoor and R. Yadav, "A hybrid cryptography technique for improving network security", International Journal of Computer Applications (0975 – 8887) Volume 141 – No.11, 2016, pp. 25–30.

[18] K. G. Kadam and Prof. V. Khairnar, "Hybrid RSA-AES Encryption For Web Services", International Journal of Technical Research and Applications e-ISSN: 2320-8163, 31, 2015, pp.51–56.

[19] K. Rege, N. Goenka, P. Bhutada, S. Mane, "Bluetooth communication using hybrid encryption algorithm based on AES and RSA", International Journal of Computer Applications (0975-8887) Volume 71-No.22, 2013, pp. 10–13.

[20] R. Raj, Y. S. Solunke, "A modified RSA cryptosystems and analysis", Published By: Blue Eyes Intelligence Engineering & Sciences Publication Pvt. Ltd, 2015, pp. 1–3.

[21] S. Patel, P. P. Nayak, "A novel method of encryption using modified RSA algorithm and chinese remainder theorem", Department of Electronics and Communication Engineering National Institute of Technology, 2009, pp. 1–44.

[22] A. Gupta and V. Sharma, "Modified double Mod RSA tested with brute force attack", International Journal of Innovative Research & Development, 2014, pp. 1–4.

[23] B. Yüksel, A. K., Ö. Özkasap, "Research issues for privacy and security of electronic health services", Future Generation Computer Systems,68, 2017, pp.1–13.

[24] S. Bhuyan, H. Kim, O. O. Isehunwa, N. Kumar, J. Bhatt, D. K. Wyant, S. Kedia, C. F. Chang, D. Dasgupta, "Privacy and security issues in mobile health: current research and future directions", The University of Memphis School of Public Health 135 Robison Hall, 2017, pp. 188–191. https://doi.org/10.1016/j.hlpt.2017.01.004

[25] H. S. G. Pussewalage, V. A. Oleshchuk, "Privacy preserving mechanisms for enforcing security and privacy requirements in e-health solutions", International journal of Information Management,36, 2016, pp.1161–1173.

[26] Y. Li, Q. Liu, T. Li, "Design and implementation of an improved RSA algorithm", International Conference on e-Health Networking, Digital Ecosystems and Technologies, 2010, pp. 390–393.

[27] S. Sharma, S. Hiranwal, P. Sharma, "A new variant of subset-sum cryptosystem over RSA", International Journal of Advances in Engineering & Technology, 2012, pp. 90–97.

[28] A. A. Ayele, Dr. V. Sreenivasarao, "A modified RSA encryption technique based on multiple public keys", International Journal of Innovative Research in Computer and Communication Engineering Vol. 1, Issue 4, 2013, pp. 859–864.

[29] H. Huang, T. Gong, N. Ye, R. Wang and Y. Dou, "Private and secured medical data transmission and analysis for wireless sensing healthcare system", 1551-3203, (c) IEEE, 2016, pp. 1227–1237.

[30] B. P. U. Ivy, P. Mandiwa and M. Kumar, "A modified RSA cryptosystem based on 'n' prime numbers", International Journal Of Engineering And Computer Science ISSN:2319-7242 Volume1 Issue 2, 2012, pp.63–66.

[31] https://www.commonlounge.com/discussion/4c8ace459d1840 408e487a673cca255d, accessed July 16th, at 11:36.

[32] Shambavhi, Dr. S. Sharma, "Enhanced RSA Algorithm for data security in cloud", Iconic Research and Engineering (IRE) journals, volume1, Issue 9, 2018, pp. 64–67.

[33] A. Nag, V. K. Jain, "Implementation of Modified RSA in Matlab", Volume 3 Issue 13, 2014, pp. 382–384.

[34] H. R. Hashim, "A New Modification of RSA Cryptosystem Based on the Number of the Private Keys", American Scientific Research Journal for Engineering, Technology, and Sciences (ARSJETS), Volume 24, No 1, 2016, pp 270–279.

[35] E. S. I. Harba, "Secure Data Encryption Through a Combination of AES, RSA and HMAC", Engineering, Technology & Applied Science Research Vol. 7, No. 4, 2017, pp. 1781–1785.

[36] A. H. Mansour, "Analysis of RSA Digital Signature Key Generation using Strong Prime", International Journal of Computer (IJC), Volume 24, No 1, 2017, pp. 28–36.

Developing an Algorithm for Securing the Biometric Data Template in the Database

Taban Habibu*[1], Edith Talina Luhanga[2], Anael Elikana Sam[3]
School of Computational and Communication Sciences and Engineering (CoCSE)
The Nelson Mandela African Institution of Science and Technology (NM-AIST), Arusha, Tanzania[1,2,3]

***Abstract*—In the current technology advancement, biometric template provides a dependable solution to the problem of user verification in an identity control system. The template is saved in the database during the enrollment and compared with query information in the verification stage. Serious security and privacy concerns can arise, if raw, unprotected data template is saved in the database. An attacker can hack the template information in the database to gain illicit access. A novel approach of encryption-decryption algorithm utilizing a design pattern of Model View Template (MVT) is developed to secure the biometric data template. The model manages information logically, the view shows the visualization of the data, and the template addresses the data migration into pattern object. The established algorithm is based on the cryptographic module of the Fernet key instance. The Fernet keys are combined to generate a multiFernet key to produce two encrypted files (byte and text file). These files are incorporated with Twilio message and securely preserved in the database. In the event where an attacker tries to access the biometric data template in the database, the system alerts the user and stops the attacker from unauthorized access, and cross-verify the impersonator based on the validation of the ownership. Thus, helps inform the users and the authority of, how secure the individual biometric data template is, and provided a high level of the security pertaining the individual data privacy.**

***Keywords*—Biometric template; template-database; multiFernet; encryption-algorithm; decryption-algorithm; Twilio SMS**

I. Introduction

The biometric template is a digital sample of a distinct feature obtained from a biometric trait stored in the database, aimed at authenticating and recognizing an individual [1], [2]. The template is built on something you have (fingerprint, facial, iris and voice) as opposite to something you know, such as passwords or Personal Identification Number (PIN). It compares the individual's characteristic extracted to make a match score, the match score is computed, so that the resultant value is in the range (0, 1), where 0 means not matching and 1 means perfect match. If the matching fails, the person can repeat the verification attempt for the second time.

Numerous kinds of algorithmic methods are introduced by different scholars to transform the biometric traits into a template, for instance, the bio-hashing and concealable biometric [3]. The bio-hashing extracts, for example the fingerprint (minutiae point) and convert it into the mathematical file know as a biometric template. The template is then transformed and stored in the database, where matching is performed directly. However, despite the advantages of the biometric data template in verifying and authenticating the individual access, the storage template database can lead to high risk, such as template abuse, modification of the existing template, addition of a new template into the database, and stolen templates in the database [4], [5]. The stored template information can be substituted by an attackers pattern; the impostor can create the physical spoofing from the original pattern to gain unlawful access to legitimate individual's information i.e. Medical records, which may result in false accept or false reject, depending on the motive of the impostor or mount a denial-of-service (DoS) and counterfeit document. The impostor can inject or hijack the characters of the lawful person's template directly into the storage database and replace the original template with the fake template.

Lately, different approaches have been put in place to improve the protection of biometric templates, for instance, the hardware-based and software-based accesses. The hardware-based contain a closed recognition system such as the smart card or handheld device, where the template is securely laid in. The card or device makes up only the template information and the matcher scores (Match-on-card), that aid in mitigating an occurrence on the biometric templates. The software-based solution stores a revised template that do not disclose data about the original biometric traits. It ensures that the biometric data stored in the templates are coded (using a secret key) and practically infeasible to discover the encryption key or regenerate the original fingerprints of a user.

The purpose of this study is to identify the known attacks against the biometric data template in the database from the review of the literature and propose a solution to effectively protect the biometric data template in the database. The suggested solution is established on an encryption-decryption algorithm with a design pattern of model view template (MVT). The algorithm is based on the cryptographic module integrated with Fernet key instance, where two Fernet keys are combined to generate a multiFernet key (K) for the encryption. The Fernet keys guaranteed that, a template data encrypted can't be revealed or read without the secret key, making it unmanageable for an attacker to circumvent or breakthrough into the database server. The cryptographic module included the security tools such as Jinja2, Wtforms, SQLAlchemy [6]. Thus, securely prevented unauthorized access to sensitive template information in the database.

*Corresponding Author

The study, therefore, provided a useful insight on the current biometric technology vulnerability attacks and the mechanism to protect the biometric data template in the database for the everyday government or private registration application system.

It helps inform the users and the authority of, how secure the individual biometric data template in the database is, and provided a high level of the security pertaining the individual data privacy and integrity. Because any attempt in the database can inform the two parties. The key contribution of this article is:

- Providing insight of the possible vulnerability attacks on the biometric data template in the database.
- Implementation of the various sets of security tools and standards that facilitate the safety of the biometric data template in the database.
- The proposed framework architecture model of the encryption- decryption algorithm integrating the key management in securing the biometric data template information in the database.
- The Integrated biometric data template with the Twilio message in the database for security purposes.

Based on the above contributions, this article provides a simple mechanism to reduce the attackers from violating individual biometric data template in the database. The simple mechanism alleviates the database security performance as this paper does not require a complex computer algorithm for the biometric deployment, thus, minimizing overheads and costs.

II. Related Work

This section discusses about some previous works related to the attacks of the biometric data template in the database, and proposed techniques to secure the biometric data template. This is useful to map this paper with the current research trend about the biometric data template safety measure alongside the template database.

A. Vulnerabilities Attacks of Biometric Template in the Database

The vulnerability attacks of the biometric template in the database have evoke fears among the users of biometric applications. This is because of a person's privacy, public liberties infringements and trustworthiness [7], [8]. For instance, an impostors intention to corrupt and interchange a genuine template with a fake template, the deliberate alteration of an enrolled template by an impostors pattern or biometric operator, has deterred user's trustworthiness and fear in the technology itself [9].

The most vulnerability attacks of the biometric technology occur in the template database (see Table I). This is because the template database is responsible for comparing the individual's characteristic extracted to make a match score. Thus, a potential target of the attack. The attacker aims to pull out information related to the quality used in the encoding algorithm either directly or indirectly via an externally compromised system (if the server is online). The taken template can be used to attempt a man-in-the-middle attack, such as a replay attack or delete the stored templates to mount a denial-of-service attack [9], [10].

According to Arjunwadkar et al. [11] the impostor can intervene the stored template to compromise the biometric traits, breaks the security loopholes to replace, change or edit the existing template of the legitimate person [12]. Gobi and Kannan argued that the templates are tempered by adding the new user template or fake template to the database, altering the current template in the storage and deleting the existing genuine one [13]. Bindha et al. [14] indicated that the template data can be substituted by an attacker's template to attain illegitimate access to a system. Study of Mwema et al and Raju et al. [15], [16] observed that spoofing at the template database is the most determined epidemics experienced in biometric technology.

Manvjeet et al. [17] presented that the cross-matching is the possible exploitation of biometric templates, because the template data are used for extra aim than the proposed aim. Thus deprived of the individual's permission, for instance, fingerprint pattern taken from a bank's record can be used to search for an unlawful fingerprint database for criminal investigation [18]. In Uganda, the 15,277 million voters' fingerprint intended for National Identity Cards (NIC) was extracted from NIRA database, this provoked a serious concern of the citizens [19]. Yet, when a person's template is stolen, it is stolen forever and not easy to revoke, since every individual has (one face, ten fingers, two eyes etc.). In traditional password-based authentication systems, once a password is compromised, the new one is reissued [18]. If the biometric data is compromised, it can result into four vulnerabilities:

- The template being substituted or replaced by an attacker's template to gain illegal access.
- Physical spoofing being produced or generated from the template to gain illegal access to the organization as well as other schemes that employ similar biometric feature.
- The template being taken or reiterated to the matcher to acquire illegal access.
- If not correctly insured, the template can be used for cross-matching across different database records to covertly track an individual deprived of their consent.

Li and Kot [20] suggested a privacy safety (hiding scheme) for the weak-thinned fingerprint template. In their study, the user's identity is concealed in the thinned fingerprint image during enrollment and a fingerprint template stored in an online database for authentication. They claimed that applying such a system, it is impracticable for the attacker to expose the individuality of the user from stealing the template collected from a compromised online template database [21].

TABLE. I. POSSIBLE ATTACKS ON THE BIOMETRIC DATA TEMPLATE IN THE DATABASET

Targeted position	Possible attacks	Countermeasures	References
Data collection	Spoofing	Liveness detection, Challenge/response	[49],[50]
Raw data extraction and transmission	Eavesdropping	Data Transmitted over an encrypted path/secure channel Challenge/response	[51]–[54]
	Replay attacks	Communally authenticate/use symmetric key or asymmetric key; Digitally sign data; Utilize Timestamp (TTL) tag	[53]–[55]
	Man-in-the-middle	Bind biometric to PKI certificate; Data Transmitted over an encrypted path	[56]
Data processing, transmission	Brute force	Timeout/lock out policies	[51],[53],[54]
	Eavesdropping	Data Transmitted over an encrypted path/secure	[51]–[54]
	Replay attacks	Communally authenticate/use symmetric key or asymmetric key; Digitally sign data; Utilize Timestamp (TTL) tag	[53]–[55]
	Man-in-the-middle	Bind biometric to PKI certificate; Data Transmitted over an encrypted path	[56]
Template retrieval	Brute force	Timeout/lock out policies	[51],[53],[54]
	Eavesdropping	Data Transmitted over an encrypted path/secure	[51]–[54]
	Replay attacks	Communally authenticate/use symmetric key or asymmetric key; Digitally sign data; Utilize Timestamp (TTL) tag	[53]–[55]
	Man-in-the-middle	Bind biometric to PKI certificate; Data Transmitted over an encrypted path	[56]
Storage	Database compromise (reading template, replacing template(s))	Hardened server DB access controls; Sign and store encrypted templates; Store template on smart cards or other device.	[51],[53]
Matching scores transmission	Hill climbs	Trusted sensor (Mutual authentication); Secure channel	[53],[54],[57]
	Manipulation of match score	Secure channel; Communal authentication between matcher and decision components	[53]
	Component replacement (“yes machine”)	Significant components	[53]
Decision	Hill climbs	Communal Authentication; Secure channel	[53],[54],[57]
Communication to application	Eavesdropping	Data Transmitted over an encrypted path/secure	[51]–[54]
	Manipulation of match decision	Data Transmitted over an encrypted path	[53]

Liu et al. [22] considered a cryptographic technique of secret transmission encryption to encode a plaintext for multi recipients and hide the recipients’ identities. They suggested the cancellable biometrics and biometric cryptosystem to protect the template. In cancellable biometrics, instead of applying the original biometric data, a partial form is kept in the database, in this manner, an intruder cannot gain access to the unique pattern from the database. In biometric cryptosystem, the biometric data is encrypted before storing it in the database; this makes it rather hard for the attacker to decode the data and stealing the genuine template from the database.

Elkamchouchi et al. [23] suggested method of cryptography which uses the image as an open key and arbitrary integers as a private key to compute the image [24]. Jain et al. [25], suggested a steganography to hide biometric data (fingerprint minutiae) in multitude images (face), whose function is to transmit the data. The carrier image can be an artificial fingerprint image, a face image or any arbitrary image. The suggestion is useful in a distributed system, where the raw biometric data are transmitted over an insecure communication channel and prevented a skimmer from reading sensitive information. They also discussed a novel application wherein, the facial feature of a user (eigencoefficient) is embedded in a host fingerprint image of the user to increase the security, then stored them on a smart card. The fingerprint of the person is compared to the fingerprint on the smart card. The false information hidden in the fingerprint is recovered and used as an additional basis of validity either mechanically or by a humanoid in a controlled biometric application.

Emmanuel et al. [26] proposed the concealable biometric method to protect the template database. The cancellable biometrics involved repeatable distortion of an original biometric pattern intentionally based on a chosen non-invertible transform, to enroll and authentication the system from the stored template. This reduced the template compromise and resolved the legitimate substitution of a privacy-related issue for matching against transformed vector and prevented the system from storing the new biometric traits of the user.

Pratiba and Shobha [27] proposed a watermarking technique. The watermarking information on the biometric template data in the database allowed the legitimacy of the biometric contents to be verified, when retrieved for matching. The pixel value is used to hide the watermark information [28].

In case an impostor tried to replace or forge the secured biometric template, the system notifies the database manager signifying something is wrong with the biometric template in the database [29]. Although, the watermark information prevented invader from altering the template, there is a small alteration in the genuine template as well as insufficient changes in the pixel. Hence, resulted in insecure template database protection.

Nandakumar and Jain [30] proposed the fuzzy vault pattern using fingerprint and Iris. The study revealed that, multi biometric vault on thumbprints and irises achieved a Greater Accept Rate (GAR) of 98.2% at FAR of 0.01%. The matching GAR value of the person's irises and thumbprint vaults are 88% and 78.8% respectively. The safety of the system is at 41 bits and that of the thumbprint and irises offered 49 bits [31], [32]. In conclusion, the biometric vault provided improved recognition presentation and highest safety of the biometric data template.

Ashish et al. [33] suggested the usage of string re-arrangement to ease the protection of the template database. The biometric data is encrypted and discarded after constructing the comfortable template. During the verification, the stored data is deciphered using the secret key and matched against the captured query. The obstacle to the encryption-based policy is the unprotected key control that exposed the decryption secret to the machine for each authentication. The advantage is the matching process hired for maintaining the matching accuracy [34].

Rathgeb et al. [35] proposed an alignment free iris key-binding scheme with concealable transforms. They adopted Indexing-First-One (IFO) hashing to achieve non-invertible and cancelable transformation for biometrics and the cryptographic key-binding. The key-binding is separated into four levels cryptographic key generation, genuine and synthetic permutation, key-binding, hashed code generation and computer memory. The findings showed that the highest GAR of 96.37% at zero FAR with storage, record equal to 1.90 kB was achieved. They further proposed useful key retrieval metric KRR for implementing the security analysis. The proposed embraces the flexibility while maintaining significant accuracy, public presentation and protection layer. The quality preservation of the accuracy performance at higher security levels is achieved and the method requires no re-enrollment and storage [36].

Yang and Martiri [37] proposed honey template-based template protection scheme to detect the biometric template database leakage. In the protection scheme, machine learning based classification algorithms is utilized to produce the sugar and honey templates applied in face [38].

Hine et al. [39] introduced a zero-leakage biometric cryptosystem to measure the performance reachable when fusing the data from the four available fingers of each field at feature and score levels, utilizing the inverse of both L1 and L2 distance metrics as matching scores. The four classifiers give an equal error rate (EER) of 0:67%. The proposed system guarantees no information leakage and it allows achieving a trade-off between privacy and credit rates.

Dwivedi et al. [40] proposed a secrecy-protective cancelable irises template encoding and a new cancelable iris template on arbitrarily look-up table drawing. The method uses a number vector created from a changing-invariant character vector using 1-D Log Gabor filter usable to the iris picture. The experimentation is carried away on several iris databases to support the efficiency of the proposed attack. Equal Error Rate (EER) of 0.37%, 0.43% and 0.79% for CASIA-V 1.0, CASIA-V3-Interval and ICE 2005 iris databases are achieved [41].

Prasad et al. [42] applied a novel approach based on modulo operation. The method utilizes consistent bit vector generated from pre-aligned IrisCodes. These IrisCodes are created by applying 1-D Log Gabor filter on the iris images using different iris datasets. Equal Error Rate of 0.54% and 0.86% for CASIA-V 1.0 and CASIA-V3-Interval iris datasets are achieved. The method satisfies revocability, unlikability and irreversibility criteria and it is difficult to regenerate original IrisCode [43].

Lai et al. [44] proposed a novel cancellable iris system, coined as IFO hashing inspired from the Min-hashing. Two new mechanisms, namely Hadamard product code and modulo thresholding function are inserted to further enhance the system. The IFO hashing scheme endures numerous security and privacy attacks such as a single hash attack, multi-hash attack, attack via record multiplicity and pre-image attack. Thus, enjoys fast similarity search property inherited from Min-hashing and can potentially be drawn out to identification task and other binary biometric features [45].

Zhao et al. [46] proposed an iris template protection method based on local ranking. It is established from the resolutions that the method is able to give 0.57% EER value for CASIA-V 1.0 and 0.79% EER value for CASIA-V3-Interval and also cover all the security and revocable issues. Furthermore, Zhou and Ren [47] proposed a user-centric biometric validation system (PassBio) that allows end-users to encode personal patterns with light-weighted encryption scheme. The findings prove that no critical information of the templates can be revealed under both passive and dynamic approaches. It guarantees that only the comparison result is discovered and no key information about x and y can be memorized. It can be widely used in many interesting applications such as searching over encrypted data while assuring information protection and seclusion.

Mai et al. [48] presented an acceleration of the guessing entropy, which reflects the expected number of guessing trials in attacking the binary template in the biometric application. The results revealed that, rushing has more than 6x, 20x, and 200x speed upward lacking down the approximation accuracy in dissimilar system settings.

In conclusion, no single biometric system is enough to protect the biometric template database to its fullest. Thus, the study, suggested the encryption-decryption algorithm based on the cryptographic module incorporating the Fernet key instance. The cryptographic module integrated the biometric traits (fingerprint, and face image) with persons biodata, to produce an encrypted byte and a text file, these files are securely kept in the database incorporated with Twilio

message. The approach is more secure and harder for an impostor to guess the key mixtures and suitable for use in many biometric software applications.

III. Materials and Method

This section explained the security tools and approach deployed in safeguarding the biometric data template in the database. The security tools installed are Jinja2, Wtforms, SQLAlchemy, Cryptography, Twilio programmable Short Message Service (SMS) and the encryption-decryption algorithm approach [58], [59].

The python flash is used as the development platform, because it contains inbuilt development server that provided simplicity, flexibility and fine-grained control, as considerably as a faster debugger to the network application. It allowed one to add security mechanisms to the application such as session-based certification, function management, password hashing, basic hypertext transfer protocol (HTTP), and token-based certification.

IV. Proposed Framework

In this section, the proposed framework is presented and classified into three. The first is the Model View Template (MVT) incorporating Helper Utilities File system (HUF), useful in controlling the models function for securing the biometric data template. The second is the encryption algorithm for encoding the biometric features and biodata. The third is the decryption algorithm for decoding the encrypted ciphertext.

A. The MVT-HUF Framework Architecture

The Model View Template (MVT), a modification of the Model View Controller (MVC) for securing the template database is used as the design implementation pattern. The model is an object that controls, data logically, the view signifies the imagining of the information a model contains, execute the business lucidity and relate with a model to transmit data and renders a template. The template controls the information movement into model entity and keeps the view and the model differently.

Fig. 1(a) and 1(b) shows the proposed framework architecture of the MVT-HUF System and the functional intent of the ePassport. The MVT is slightly modified to cater for security issues. For instance, the Wtforms was introduced for CSRF prevention, and helper, introduced to handle heavy processing between model and View. The biometric passport was used as an object acted as a model integrating fingerprint and facial image at the feature level with person's biodata, to derive a two byte and text file as a template. This template is securely kept in the database incorporated with the Twilio SMS. The encryption- decryption algorithm based cryptographic key management is applied to ensure the security of the template database. The algorithm accounted for the acceptable disparities in the biometric input. An impostor whose sample biometric is different from the enrolled biometric features, cannot break or recreate the private key. The biometric features encrypted stored a hashed value of the key as a template byte and text file and releases it only if the hashed value obtained for verification is the same. The hashed version can be functioned as a cryptographic key. With this invention, an attacker cannot obtain the original key outside the encoding scheme.

In Fig. 1(b), it's realizing that the encrypted fingerprint and face image is kept in the file system (including the ciphertext of second key). Meanwhile, user biodata is stored in relational tables. It is a significant to recognize that the computer memory in a file system is implemented using random integers (IDs) that hold less meaning to the user at presentation layers as the presentation level IDs are computed from helpers other than coming from the database.

B. The Encryption Algorithm

In encryption process, the users enter the credentials. The username and password are compared with a copy that is kept in the database. If the details do not match, he/she is requested to re-enter either a new username or password, else if it matches an authentication code (AC) is produced and sent to the user via SMS. Upon the user receiving the authentication code, he/she is requested to enter the received authentication code. The authentication code is matched with a copy that is kept in the database. If the authentication code does not match with the copy stored in the database, the user is guided back to login interface. If it matches, the database generates two Fernet keys (K_1 and K_2).

The Fernet keys are secret key of asymmetric implementation based on cryptography that supports key rotation in the form of byte key. The two keys are combined to further generate a multiFernet key (K) for encryption. The MultiFernet key (K) is integrated with biometric features (Face, Fingerprint) and biodata passing through the encryption algorithm to produce the biometric template as byte file and a text file. The two files are securely kept in the database. Fig. 2 summarized the proposed implementation of the encryption algorithm.

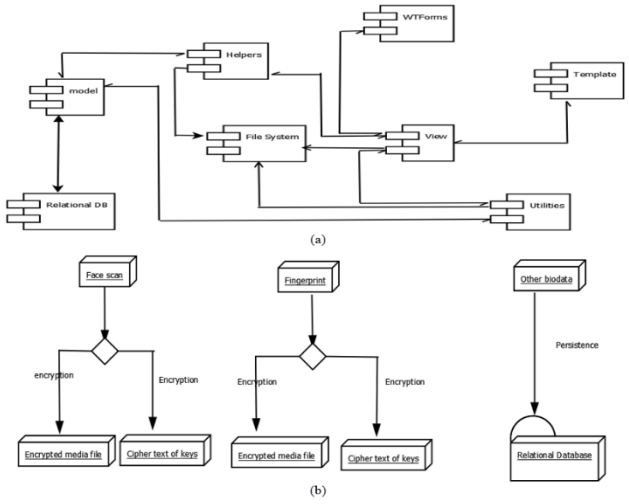


Fig. 1. (a) Overview of the Proposed Model of MVT-HUF System. (b) The Function Design of the E-Passport.

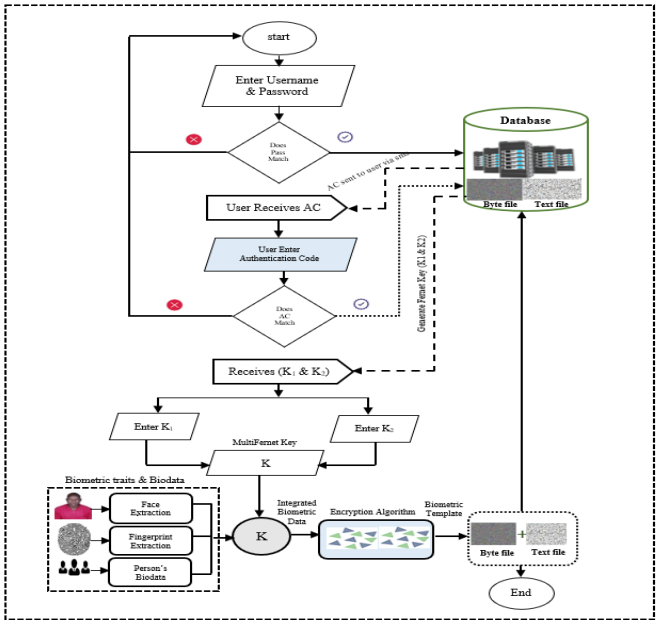


Fig. 2. Proposed Framework of the Encryption Algorithm.

C. The Decryption Algorithm

In decryption process, the administrator is requested to enter the credentials. The username and password are compared with a copy that is kept in the database. If the information does not tally, the administrator is requested to re-enter either a new username or password, else if it matches an authentication code is produced and sent to the administrator via SMS. Upon receiving the authentication code, the administrator is asked to enter the received authentication code. The authentication code that the administrator entered is matched with a copy that is kept in the database. If the authentication code does not match with the copy stored in the database, the administrator is led back to login interface. If it matches, the database generates two Fernet keys (K_1 and K_2). The two keys are combined to further generate a multiFernet key (K) for decryption. The MultiFernet key (K) is integrated with biometric template (byte file and a text file) passing through the decryption algorithm to produce the plain text. Fig. 3 summarized the proposed implementation of the decryption algorithm.

In case an attacker tries to access the biometric data template in the database, the system blocks the attacker from unauthorized access. Because the system cross-verify the user based on two dissimilar kinds of identification such as the knowledge base (something the user knows) and the possession factor (something the user owns) such as authentication code (AC). This is really important in securing up the biometric template information in the database. Even if the perpetrators are able to discover a user's password, they nevertheless lack the second kind of identification required to login to the application. Fig. 4 presented the suggested security measures in the encryption algorithm.

D. Database models

The SQLite3 is used as the proposed model for the development process, and the database switched to PostgreSQL, because of the object relational mapper (SQLAlchemy) for security purpose. The PostgreSQL has multi-value fields (aka arrays, aka nested tables) which can reduce the need for joins. Dramatically increase the performance of storing and retrieving the multi-dimensional data structures, and making it possible to write stored procedures in other programming languages such as C, Perl, Python and JavaScript V8 engine [60].

E. Comparison of the Current System

The proposed framework and the encryption-decryption algorithm based on the cryptographic module in the multiFernet key instance performed better. User data template in the database is securely protected. The imposter cannot easily break into the system or read or re-generate a key. Therefore, using the proposed approach, prevented data being compromised by an impostor, hence provided higher security of individual privacy data.

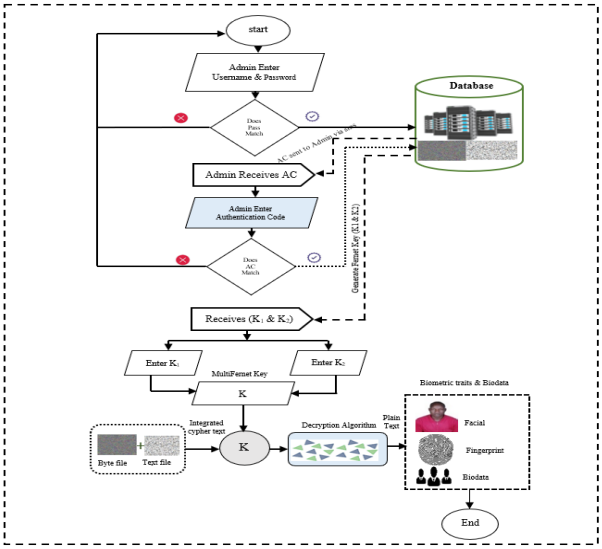


Fig. 3. Proposed Framework of the Decryption Algorithm.

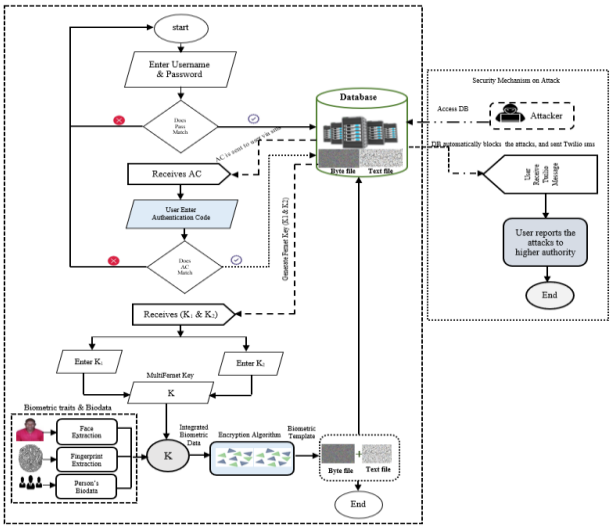


Fig. 4. Proposed Framework of the Security Mechanism in the Encryption Algorithm.

V. The Implementation Design

This section discusses the security tools deployed for the implementation of the proposed encryption-decryption algorithm.

A. Jinja2 Implementation

Jinja2 is used as template engine containing variables and tags to direct the logic of the template. It provided a protected basis for mechanization of sampling the application and helped avoid cross-site scripting (XSS) occurrence through its powerful automatic Hypertext Markup Language (HTML) escaping system. The cross-site scripting (XSS) enabled the invaders to insert client-side scripts into web application sighted by different users. Fig. 5 presented the implementation code for Jinja2. Note that {%… %} is used to represent statements and {{…}} used to print the data.

The primary function of a template engine is to sort out the logic from the horizon. Thus, the template engines considered obeys the following principles:

1) A restricted set of command structures: such as Loop i.e. for, loop or while; Condition i.e. If, if else and else; Filter3 i.e. {{Variable filter}}; Setting of variables and Printing of a variable.

2) A mechanism to include other templates, to use inheritance of templates or to use macros, written entirely in the restricted instructions from above.

3) No way to write pure code in the language that is used for the backing (i.e. PHP, Python or Java) within the template.

B. Wtforms

Wtforms generates applicant's passport forms, rather than coding Hypertext Markup Language (HTML). This helped protect the system from Cross Site Reference Forgery (CSRF) module. The CSRF implementation is pivoted around the exceptional token, put in a varied field on the form named csrf_token, rendered in the template, and passed from the browser back to the interface. The cryptography hashed function against the data enabled the attacker not to form the template database. Note that CSRF is a character of malicious exploitation of a website where unauthorized commands are transported from a user that the web application trusts. Through the Wtforms, the cross-site request forgery attack is prevented.

Notice that, when carrying out the web page form using Wtforms and python, the contours are represented as class representatives. This allowed clearer backend validations before data proceeds to the database, meaning in case the front-end is tempered with, the Wtforms validations can be capable to manage the authentication. Fig. 6 presented the implementation coding for the applicant detail on the template side using Wtforms.

C. SQLAlchemy

The object relational mapper (SQLAlchemy) is applied to create database models instead of database drivers directly. The security advantage is to prevent the SQL- injection attack, zero-day attack for various databases plus other database exploited through the application, because the coercion is first practiced on every database transaction. With SQLAlchemy the user doesn't write SQL statements, instead make the class representative and the SQLAlchemy figures out the optimum and attack free SQL statement equivalence. The SQL Expressions can be applied independently of the ORM. When using the ORM, the SQL Expression language remains part of the public face API as it is used within object-relational configurations and queries. Notice that SQL injection is the location of malicious code in SQL statements via the web page input [60]. Fig. 7 presented a model of SQLAlchemy dependency layers. The SQLAlchemy helped in mapping this class to the corresponding table.

Fig. 5. Implementation of 'The Confirms Details' Template using Jinja2.

Fig. 6. Implementation Code in the Template Side using Wtforms.

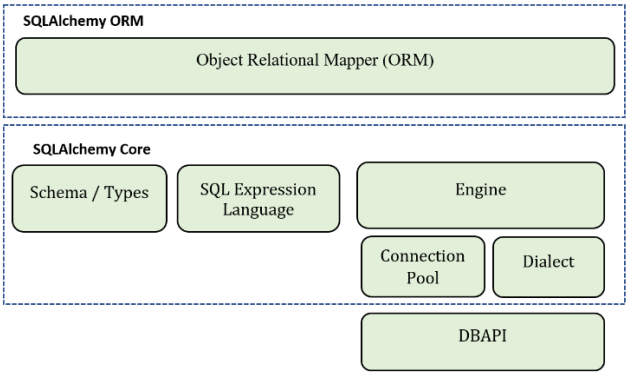


Fig. 7. SQLAlchemy Dependencies Layers.

D. Cryptography

In cryptography, plain text is encoded into coded text with the help of encryption algorithm, the coded text is decoded to plain text with the help of decryption algorithm. In both operations, the cryptographic key played a significant part. It limited the admission of the coded data so that the possessor of the key could decrypt cipher text properly. In this technique, it was expected that only the sincere user knows the decryption key. Therefore, cryptography, as a powerful tool in biometric technology, depends on the secrecy of cryptographic key and the key needed an efficient key management technique. The key management technique included the process of key generation, key modification and key sharing [61].

The cryptographic module encrypted the fingerprint and the face image based on a Fernet instance key. The key is categorized into two smaller keys: a 128-bit AES encryption key and a 128-bit SHA256 HMAC signing key. These keys are retained in a central source that keystone passes in a library to handle the encryption and decoding process. The Fernet key guaranteed that the message encrypted cannot be read missing the key. It involved the application of symmetric (secret key) authentication, that support Fernet key alternation via multiFernet key (class cryptography. fernet. Fernet(key)).

The multiFernet performed the cipher code using first key in the list of Fernet instance. Then decrypt each key in turn. The key alternation replaced the old key to add a new key Infront of the list. The new message was encrypted to discard the old key. The Token rotation was offered by meth (multiFernet. rotate) as a primary key to prevent mutilation and decreases the trouble of attack. Hence, preserved the timestamp originally saved with the token. The successful rotated token was returned while unsuccessful rotated token returned an exception error such as (cryptography. Fernet. InvalidToken). Token rotation as offered by MultiFernet, is the best practice and the manner of cryptographic hygiene, designed to fix damage in case of an undetected event and to increase the difficulty of attacks [58].

E. The Twilio Programmable SMS

The Twilio SMS is utilized to signal users and authority over SMS messages about unlawful entry to the system account and the database template. In case they are not the one accessing the record, then be able to identify. Twilio is a cloud communiqué system that offers SMS services to its users. The Twilio source fetches the logs for any outbound messages from the narrative, like the Sent folder in the email client. Utilize this data to update the customer relationship management (CRM) whenever a client gets a text message from the application. Or to see the recipients of an SMS message before it sends, to ensure they don't receive it before. It brings in any inbound messages to any of the Twilio numbers. This is like the email inbox.

If you apply a single Twilio number to commit many types of messages, it can route the responses to the necessary people, founded along the sentiment score of the consistency of the message, who mailed it. Or what time it arrived in. It also sent lots of SMS messages while Parabola flow runs. This permitted one to send out custom or generic SMS messages to a list of recipients at scheduled times. Use the destination to send the weekly performance, remind occurrence of an event and threats coming up in the system, or constantly ping your details to remind you of any approval privileges to allow admittance to your certification. Once an approval of applicants is performed, the SMS confirmation message for biometrics scan is automatically sent to the applicant for the achievement. Fig. 8(a) and 8(b) illustrates the Twilio SMS sent to applicant for verification and biometric scan process.

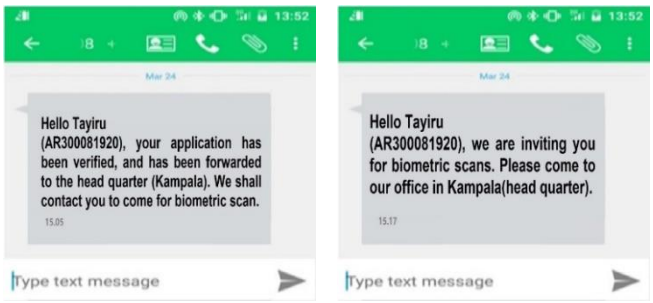
With the Twilio SMS, the system is non-traceable by the impostor, it also comprises safety mechanisms to circumvent hacking and despicable attacks to compromise the user's information and individual rights to secrecy during the personal information transmission.

F. The Cryptographic Fernet Keys

The cryptographic Fernet key is built on three criteria. The advanced encryption standard (AES) in coded block chaining (CBC) mode with a 128-bit key for encryption using the PKCS7 padding. The Hash-based Message Authentication Code (HMAC) uses the Secure Hash Algorithm (SHA) 256 for authentication. The Initialization vector to generate a random secret number using os. urandom () [58]. The AES provides advantages such as high-level security and implementation ability that does not expose unauthenticated bytes. It encrypts the data that easily fits in the memory.

It uses the parameter such as secret keys (byte) either in 128,192 or 256 bits long and the CBC mode using the padding for block ciphers. The parameters rest on the IV and secret key. The IV is a unique public information, randomly unpredictable at the encryption time to prevent data repetition, making it hard for a hack to get patterns to crack into the template database. It ensured that, information is not leaked by the cipher text itself and prevented identical plaintexts from producing identical cipher text. The secret key protected the encrypted information.

The HMAC is used to calculate the communication, validation using cryptographic hash functions, paired off with a private key. For example, class cryptography. hazmat. primitives.hmac.HMAC (key, algorithm, backend). This hashed algorithm randomly generated the bytes equal in duration to the digest_size of the secret hashed function kept.



(a) (b)

Fig. 8. (a) Twilio Verification Message (b) Twilio Message for the Biometric.

G. Key Management for the Encryption Algorithm

The encryption algorithm used is based on the combination of two Fernet keys, i.e. the first key (K_1) and the second key (K_2). User inputs original biometric features Image (I) and K_2 to generate K_1-encoded (byte key). The K_1-encoded is further applied to generate K_1 decoded (string key) using K_2.

The K_1 encoded is combined with K_2 to generate multiFernet keys (K). The K is used in encrypting the Image (I) to realize the encrypted image file (I_0). In order to guarantee the safekeeping of the biometric data in the database, the encrypted image (I_0) is further re-encrypted with multiFernet key (K) to produce an encrypted byte and a text file (K_{10}). The two files are securely stored in the database as a template.

The encoding is the operation of transforming information (plaintext) into something that appears to be random and meaningless (ciphertext) so that it is unclear to anyone but to the intended receiver. Fig. 9 summarized the stepwise process for the key management of the encryption algorithm.

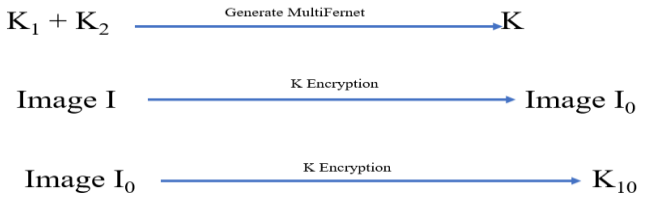
Presented below are the key management using encryption algorithm with multiFernet key.

H. Key Management for the Decryption Algorithm

In order to acquire the original image (I) from the encrypted byte and text file (K_{10}), the decryption process is simply the reversed engineering of the encryption step. K_{10} is decrypted using the multiFernet key (K) to realize the encrypted image (I_0). The K is generated from a combination of Fernet keys (K_1 & K_2). The multiFernet key (K) is further employed to decode the encrypted Image (I_0) to produce the original image (I). If the formatted token is successfully decoded, the original plain text (I) is received as the result, otherwise an exception error can be produced.

The decryption is the operation of changing encrypted information (secret code text) back to readable plaintext so that it is understandable again. Fig. 10 summarized the stepwise process for the key management of the decoding algorithm.

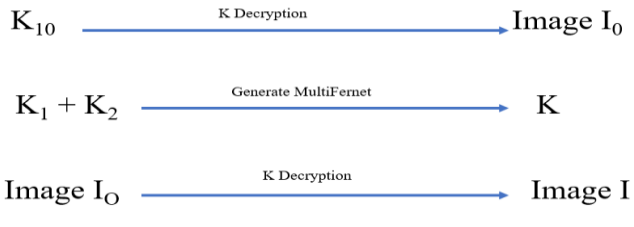
Given is the key management of the decryption algorithm with multiFernet key.



Such that

i. **K_1:** First Fernet Key
ii. **K_2:** Second Fernet Key
iii. **K:** multiFernet key
iv. **Image I:** Original face scan image or fingerprint Image
v. **Image I_0:** Encrypted biometric image
vi. **K_{10}:** Encrypted byte file and text file

Fig. 9. Key Management of the Encryption Algorithm.



Such that

i. **K_{10}:** Encrypted byte file and text file
ii. **K_1:** First Fernet Key
iii. **K_2:** Second Fernet Key
iv. **K:** multiFernet key
v. **Image I_0:** Encrypted biometric image
vi. **Image I:** Original face image or fingerprint Image

Fig. 10. Key Management of the Decryption Algorithm.

VI. Discussion of Results

The Twilio SMS is implemented for the validation over unlawful access to the system account and the template database. In case an attacker attempts to access the biometric data template in the database, the system blocks the attacker from unauthorized access. Because the system cross-verify the user based on something the user owns such as authentication code (AC). The Twilio fetches the login for any outbound messages from the report as well as any inbound messages to any of the Twilio numbers.

The Ubuntu 18.04 is used as a client server to provide an interface and allowed users to call for the services. Users are situated at workstations or on personal computers, while servers are located in the regional centers of the immigration offices, controlled in the powerful machines at the headquarter for the request and the response. The users and the server each have distinct jobs to perform. For example, in the biometric passport data processing unit, a user machine runs an application program, while the server mainframe runs another program that handles the database. Fig. 11 summarized the client-server architecture of the application system.

The results are tested with user's biometric traits, containing 50 fingerprints and 50 face image templates incorporated with the personal biodata. The image size of fingerprint template extracted is 256X256 and resolution set to 72 dpi. The face image is uniformly illuminated and captured from the right mind with no rotation or tilting, no apparitions, with a plain background colour. The end product of the image is set to 600dpi with 120 pixels as the standard, recommended by ISO/IEC [62], [63]. The encrypted byte and text files are incorporated with Twilio programmable SMS. The Twilio SMS message is auto-generated directly from the database, to alert users in case an attacker tries to access the database. The text message is one of the security mechanisms successfully implemented. It helps inform the users and the authority of, how secure is the individual biometric data template in the database. How the users are indirectly involved in awarding or refusing access to the exercise of their biometric template information. Because any attempt in the database can inform the two parties.

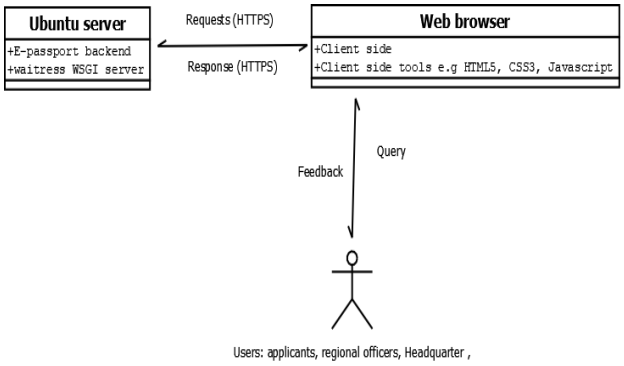


Fig. 11. Client-Server Architecture.

VII. Conclusions

In this article, various attacks against a biometric template database are highlighted and the techniques used to secure the contents of the biometric data template in the database are discussed. Since securing the biometric information in the database is one of the studies focuses, encryption-decryption algorithm approach is suggested based on the cryptographic module with the security tools such as Jinja2, Wtforms, SQLAlchemy and Twilio SMS.

The encryption-decryption algorithm is developed to encrypt the biometric data in the database. Two encrypted byte file and text file are generated, incorporated with Twilio message, securely stored in the database server. The database has security features that warn against any impostor attack alongside with persons information. The system can block the attacker from unauthorized access. This is really important in the security of privacy of the biometric template information in the database. Even if the perpetrators are able to discover a user's password, they nevertheless lack the second kind of identification required to login to the application.

Living by the proposed framework in Fig. 2 and 4, the same conclusion can be drawn near the model. It can be well-known that no biometric system is optimal. The decision as to which biometric is to be used can be prepared from the foundation of the kind of application and the degree of protection required. Therefore, the policymaker needs to design security-policies based on lawful ideologies and should include the input of various players to defend against the vulnerability of users' information. Because individual's data exist in every place online. Further experimental research on ways, to facilitate the database server with additional safety coding like hash functions and two factor authentications to prohibit data requests transmission and setting out principles and alertness session to all mediators at the start of the engagement before being granted access to personal information.

Acknowledgments

The authors would like to acknowledge Nelson Mandela African Institution of Science and Technology, Arusha-Tanzania, and Muni University Arua-Uganda, for the financial support and research resources to carry out this research.

References

[1] MacHado S, D'Silva P, D'Mello S, Solaskar S, Chaudhari P. Securing ATM Pins and Passwords Using Fingerprint Based Fuzzy Vault System. Proc - 2018 4th Int Conf Comput Commun Control Autom ICCUBEA 2018. 2018;1–6.

[2] MM A. Biometric: fingerprints protection. Biometrics Biostat Int J. 2018;7(2):156–61.

[3] Mm A, Gr S. Biometric Template Protection. J Biostat Biometric Appl. 2017;1(2):1–8.

[4] Riaz N, Riaz A, Khan SA. Biometric template security: an overview. Sens Rev. 2018;38(1):120–7.

[5] Ghouzali S, Lafkih M, Abdul W, Mikram M, El Haziti M, Aboutajdine D. Trace attack against biometric mobile applications. Mob Inf Syst. 2016;2016.

[6] Dey S, Ghosh R. A review of cryptographic properties of S-boxes with Generation and Analysis of crypto secure S-boxes . PeerJ-Preprints. 2018.

[7] Group UKBW. Biometric security concerns. Technical Report, CESG, September 2003, http://www. cesg. gov. uk/site/ast …; 2003.

[8] Habibu T, Luhanga ET, Sam AE. Evaluation of Users ' Knowledge and Concerns of Biometric Passport Systems. Data [Internet]. 2019;4(April):1–17. Available from: www.mdpi.com/journal/data.

[9] Ambalakat P. Security of biometric authentication systems. In: 21st Computer Science Seminar. Citeseer; 2005. p. 1.

[10] Habibu T, Sam AE. Assessment of vulnerabilities of the biometric template protection mechanism. Int J Adv Technol Eng Explor. 2018;5(45):243–54.

[11] Arjunwadkar M, Kulkarni R V, Shahu C. Biometric Device Assistant Tool: Intelligent Agent for Intrusion Detection at Biometric Device using JESS. Int J Comput Sci Issues. 2012;9(6):366–70.

[12] Poongodi P, Betty P. A Study on Biometric Template Protection Techniques. Int J Eng Trends Technol. 2014;7(4).

[13] Xi K, Hu J. Bio-Cryptography. Handb Inf Commun Secur [Internet]. 2010;129–57. Available from: http://www.springerlink.com/index/T28595L71117713Q.pdf

[14] Brindha VE, Natarajan AM. Multi-modal biometric template security: Fingerprint and palmprint based fuzzy vault. J Biometrics Biostat. 2012;3(3):100–50.

[15] Mwema J, Kimwele M, Kimani S. A simple review of biometric template protection schemes used in preventing adversary attacks on biometric fingerprint templates. Int J Comput Trends Technol. 2015;20(1):12–8.

[16] Raju S V, Vidyasree P, Madhavi G. Enhancing Security Of Stored Biometric Template in Cloud Compuuting Using FEC. Int J Adv Comput Eng Netw. 2014;2(2):35–9.

[17] Manvjeet Kaur, Sanjeev sofat DS. Template and Database Security in Biometrics Systems : A Challenging Task. Int J Comput Appl. 2010;4(5):2–6.

[18] Prabhakar S, Pankanti S, Jain AK. Biometric recognition: security and privacy concerns. IEEE Secur Priv Mag [Internet]. 2003;1(2):33–42. Available from: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=1193209.

[19] Rindai Vava Chipfunde. Biometric voter registration : Lessons from Ugandan polls. 2016.

[20] Li S, Kot AC. Privacy protection of fingerprint database. IEEE Signal Process Lett. 2011;18(2):115–8.

[21] Yang W, Wang S, Hu J, Zheng G. SS symmetry Security and Accuracy of Fingerprint-Based Biometrics : A Review. Symmetry (Basel). 2019.

[22] Liu L, Li Y, Cao Z, Chen Z. One Private Broadcast Encryption Scheme Revisited. Int J Electron Inf Eng. 2017;7(2):88–95.

[23] Elkamchouchi HM. A New Image Encryption Algorithm Combining the Meaning of Location with Output Feedback Mode. In 2018.

[24] Nita SL, Mihailescu MI, Pau VC. Security and Cryptographic Challenges for Authentication Based on Biometrics Data. Cryptogr Artic. 2018.

[25] Jain AK, Ross A, Uludag U. Biometric template security: Challenges and solutions. In: Signal Processing Conference, 2005 13th European. Citeseer; 2005. p. 1–4.

[26] Emmanuel E, Edebatu D, Catherine N, Ngozi A. Vulnerability of Biometric Authentication System. Int J Innov Res Sci Eng Technol. 2016;2742–9.

[27] Pratiba D, Shobha G. A Novel approach for securing biometric template. Int J Adv Res Comput Sci Softw Eng. 2013;3(6):974–9.

[28] Malhotra S, Kant C. A Novel approach for securing biometric template. Int J Adv Res Comput Sci Softw Eng. 2013;3(5).

[29] Anitha P, Rao KN, Rajasekhar V, Krishna CH. Security for Biometrics Protection between Watermarking and Visual Cryptography. SSRG Int J Electron Commun Eng. 2017;(March):64–71.

[30] Nandakumar K, Jain AK. Biometric template protection: Bridging the performance gap between theory and practice. IEEE Signal Process Mag. 2015;32(5):88–100.

[31] Gomez-Barrero M, Maiorana E, Galbally J, Campisi P, Fierrez J. Multi-biometric template protection based on homomorphic encryption. Pattern Recognit. 2017;67:149–63.

[32] Khan SH, Akbar MA, Shahzad F, Farooq M, Khan Z. Secure biometric template generation for multi-factor authentication. Pattern Recognit. 2015;48(2):458–72.

[33] Ashish MM, Sinha GR. Biometric Template Protection. J Biostat Biometric App. 2016;1(2):202.

[34] Simoens K, Bringer J, Security HC-… F and, 2012 U. A framework for analyzing template security and privacy in biometric authentication systems. IEEE Trans Inf Forensics Secur [Internet]. 2012 [cited 2017 Dec 12]; Available from: http://ieeexplore.ieee.org/abstract/document /6129504/.

[35] Rathgeb C, Gomez-Barrero M, Busch C, Galbally J, Fierrez J. Towards cancelable multi-biometrics based on bloom filters: a case study on feature level fusion of face and iris. In: Biometrics and Forensics (IWBF), 2015 International Workshop on. IEEE; 2015. p. 1–6.

[36] Gomez-Barrero M, Maiorana E, Galbally J, Campisi P, Fierrez J. Multi-biometric template protection based on Homomorphic Encryption. Pattern Recognit [Internet]. 2017;67:149–63. Available from: http://dx.doi.org/10.1016/j.patcog.2017.01.024.

[37] Yang B, Martiri E. Using honey templates to augment hash based biometric template protection. Proc - Int Comput Softw Appl Conf. 2015;3:312–6.

[38] Martiri E, Gomez-Barrero M, Yang B, Busch C. Biometric template protection based on Bloom filters and honey templates. IET Biometrics. 2016;6(1):19–26.

[39] Hine GE, Maiorana E, Campisi P. A Zero-Leakage Fuzzy Embedder from the Theoretical Formulation to Real Data. IEEE Trans Inf Forensics Secur. 2017;12(7):1724–34.

[40] Dwivedi R, Dey S, Singh R, Prasad A. A privacy-preserving cancelable iris template generation scheme using decimal encoding and look-up table mapping. Comput Secur [Internet]. 2017;65:373–86. Available from: http://dx.doi.org/10.1016/j.cose.2016.10.004.

[41] Kumar MM, Prasad MVNK, Raju USN. Iris Template Protection using Discrete Logarithm. 2018;43–9.

[42] Prasad MVNK, Jyothi A, Lasya K. Cancelable iris template generation using modulo operation. Proc - 13th Int Conf Signal-Image Technol Internet-Based Syst SITIS 2017. 2018;2018-Janua:210–7.

[43] Rathgeb C, Breitinger F, Busch C. Alignment-free cancelable iris biometric templates based on adaptive bloom filters. Proc - 2013 Int Conf Biometrics, ICB 2013. 2013.

[44] Lai YL, Jin Z, Jin Teoh AB, Goi BM, Yap WS, Chai TY, et al. Cancellable iris template generation based on Indexing-First-One hashing. Pattern Recognit [Internet]. 2017;64(August 2016):105–17. Available from: http://dx.doi.org/10.1016/j.patcog.2016.10.035.

[45] Li C, Hu J, Pieprzyk J, Susilo W. A New Biocryptosystem-Oriented Security Analysis Framework and Implementation of Multibiometric Cryptosystems Based on Decision Level Fusion. IEEE Trans Inf Forensics Secur. 2015;10(6):1193–206.

[46] Zhao D, Fang S, Xiang J, Tian J, Xiong S. Iris Template Protection Based on Local Ranking. Secur Commun Networks. 2018;2018.

[47] Zhou K, Ren J. PassBio: Privacy-preserving user-centric biometric authentication. IEEE Trans Inf Forensics Secur. 2018;13(12):3050–63.

[48] Mai G, Lim MH, Yuen PC. On the guessability of binary biometric templates: A practical guessing entropy based approach. IEEE Int Jt Conf Biometrics, IJCB 2017. 2018;2018-Janua:367–74.

[49] Marasco E, Ross A. A survey on antispoofing schemes for fingerprint recognition systems. ACM Comput Surv. 2015;47(2):28.

[50] Hadid A, Evans N, Marcel S, Fierrez J. Biometrics systems under spoofing attack: an evaluation methodology and lessons learned. IEEE Signal Process Mag. 2015;32(5):20–30.

[51] Nandakumar K, Jain AK. Multibiometric template security using fuzzy vault. In: Biometrics: Theory, Applications and Systems, 2008 BTAS 2008 2nd IEEE International Conference on. IEEE; 2008. p. 1–6.

[52] Ross AA, Shah J, Jain AK. Toward reconstructing fingerprints from minutiae points. In: Biometric Technology for Human Identification II. International Society for Optics and Photonics; 2005. p. 68–80.

[53] Dürmuth M, Oswald D, Pastewka N. Side-Channel Attacks on Fingerprint Matching Algorithms. In: Proceedings of the 6th International Workshop on Trustworthy Embedded Devices. ACM; 2016. p. 3–13.

[54] Boult TE, Scheirer WJ, Woodworth R. Revocable fingerprint biotokens: Accuracy and security analysis. In: 2007 IEEE Conference on Computer Vision and Pattern Recognition. IEEE; 2007. p. 1–8.

[55] Shelton J, Bryant K, Abrams S, Small L, Adams J, Leflore D, et al. Genetic & evolutionary biometric security: Disposable feature extractors for mitigating biometric replay attacks. Procedia Comput Sci. 2012;8:351–60.

[56] Lancelot Miltgen C, Popovič A, Oliveira T. Determinants of end-user acceptance of biometrics: Integrating the 'big 3' of technology acceptance with privacy context. Decis Support Syst. 2013;56(1):103–14.

[57] Miltgen CL, Popovič A, Oliveira T. Determinants of end-user acceptance of biometrics: Integrating the "Big 3" of technology acceptance with privacy context. Decis Support Syst. 2013;56:103–14.

[58] Contributors I. Cryptography Documentation. 2019.

[59] Chaudhary S. An Approach to Secure Database Templates in Multimodal Biometric Systems. IJCSC. 2013;4(2):268–73.

[60] Bayer M. SQLAlchemy Documentation [Internet]. SQLAlchemy Documentation Release 0.7.10. 2016. Available from: papers3://publication/uuid/5E97B936-E845-4995-92F5-EB7F0C39672B

[61] Stallings W. Cryptography and network security: principles and practice. Pearson Upper Saddle River; 2017.

[62] Griffin P, Ph D. Understanding The Face Image Format Standards. 2005.

[63] Sang J, Lei Z, Li SZ. Advances in Biometrics. Springer-Verlag [Internet]. 2009;5558(May 2014). Available from: http://link.springer .com/10.1007/978-3-642-01793-3.

A Robust Method for Diagnostic Energetic System with Bond Graph

Belgacem Hamdouni[1], Dhafer Mezghani[2], Jamel Riahi[3], Abdelkader Mami[4]
UR-LAPER, Faculty of Sciences of Tunis, University of Tunis ElManar
Tunis, Tunisia

***Abstract*—Surveillance and supervision systems have a major role in insuring the safety and availability of industrial equipments and installations. Default detection and diagnosis is highly important to facilitate the planning and implementation of curative and preventive actions. Industrial systems are usually governed by different physical phenomena's and diverse technological components. Bond graph, being a powerful tool based on energetic and multi-physical analysis can be a well-adapted tool in default detection. The resulting Bond Graph model, allows to apply model based diagnosis methods to detect and eventually isolate defaults. In this paper, energetic systems diagnosis problems are discussed by detailing existing diagnosis methods. The proposed modeling tool is then introduced with illustration of different use cases and applications examples. Diagnosis methods based on Bond Graph model are presented, as well as the extension of these methods with uncertain parameters models. Finally, the studied diagnosis method is applied for default detection and isolation using the study case of asynchrony motor.**

Keywords*—Bond graph; diagnostic; fault detection; energy systems

I. Introduction

Any failure of a process is harmful in an environment where performance is paramount. It is, therefore, necessary to ensure permanently the functioning vis-à-vis process goals that have been assigned. The information to translate the behavior of a system is given by the actions of one variable. The quality of measurements is essential to allow monitoring and evaluation of the performance of a process. The quality of information can be increased by improving the precision instrumentation and multiplying the number of sensors. For technical or financial reasons, this solution in which the same quantity is measured by several sensors is for high-tech industries or those with high technological risks. Furthermore, this hardware redundancy does not protect against a failure of some common elements of the electrode: several sensors measuring the same size are generally geographically neighboring and powered by the same electric network; a power failure causes a stop of the whole measurement system.

Exploiting a priori models accurate linking different measured variables is another way to check the reliability of the measurements. The analytical redundancy has the advantage of not increasing the cost of the installation and to disengage from material constraints. In the field of diagnostics, methods based on the concept of redundancy of information have been developed.

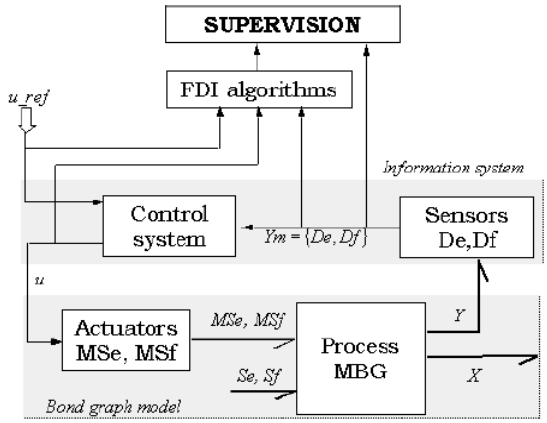


Fig. 1. Bond Graph Representation of a Monitoring System.

The mathematical process, analytical redundancy methods, therefore, require a model of the system being monitored. This model includes several parameters whose values are assumed to be known during normal operation. The comparison between the actual system behavior and the expected behavior given by the model provides a quantity called residue, which will be used to determine if the system is in a failed state or not and specify if any part or component failing system. Diagnoses of operation of a system are to detect and locate the internal defects (affecting the process itself), external faults (affecting actuators, sensors), abnormal operation, then to estimate the main characteristics of the highlighted defects (their amplitudes).

The modeling of the different sections of the pumping system that we will describe its diagnostic in this work was presented and investigated in [1].

II. Diagnostic System's Description

The systems designed and manufactured by man (vehicles, aircraft, telecommunications networks, factories) are becoming more complex. This complexity is due to a large number of components making up these systems. Despite the high-security requirements, reducing operating costs and control of equipment availability, these systems are not immune to failure. This is why monitoring, diagnosis (detection, location, identification of failures), repairing or reconfiguration is very important. These activities help to detect and locate faults, minimize repair time and provide a reliable and easy interpret diagnosis despite the complexity of the equipment. Nowadays, the implementation of automated systems requires the establishment of important tools for the

diagnosis and monitoring to help companies in their constant search for better functioning of their lower-cost systems. In this context, many approaches have been developed for fault detection and diagnosis by different auto research communities. These approaches can be classified generally as methods based models, pattern recognition basis, based on Bayesian networks, base case, and methods based decision tree. The model-based methods consider a behavioral model based on fundamental physical principles. These models can be of the quantitative type expressed as mathematical equations (constraints) or qualitative type, expressed for example in the form of logical relationships. The methods for pattern recognition basic aim to identify an area of values that correspond to failed states. The methods based on Bayesian networks are probabilistic methods that allow making the diagnosis. The methods based on the tree decision can build a tree in successive issues. Depending on the response, this tree can be built and allows the diagnosis. The case-based methods include recording in a knowledge base effects observed defects that have occurred in the past and then, when acting occurs abnormal.

1) Terminology: As a step towards unified terminology, the Technical Committee of International Federation of Automatic Control "(IFAC) SAFEPROCESS suggested definitions in the field of fault diagnosis.

- Structural analysis: Analysis of the structural properties of models, i.e. properties that are independent of the actual values of the parameter.

- Failure: A permanent interruption of the ability of the system to perform a function required under specified operating conditions.

- Default: An unlicensed deviation of at least one structural property or characteristic parameter of the system in relation to the nominal behavior (usual or acceptable).

- Default detection: The determination of the presence of defects and the moment of their occurrences.

- Insulation of fault: The determination of the type, location and time of occurrence of a defect.

- Identification: The determination of the size and temporal behavior of a defect.

- Diagnostic: Determination of type, size, location and time of occurrence a defect; it tracks the detection of defects and includes isolation and identification.

- Failure effect: The consequence of a failure mode on the operation, function, or status of a variable.

- Qualitative model: A system model describing behavior with relationships between variables and system parameters in heuristic terms such as causalities or rules.

- Quantitative model: A system model describing behavior with relationships between variables and system parameters in analytic terms such as equations differences or differences.

- Modeling of the defect: Determination of a mathematical model to describe a specific effect of the defect.

- Re setup: Change of the structure and parameters of the controller. The original goal of Command is reached although execution may be degraded.

- Analytical redundancy: Determining a variable by measuring or using a mathematical model of the process under consideration.

- Residue: Signals carrying information, based on the difference between measurements and calculations based on the model.

- Threshold: The limit value of the deviation of a residual with the zero, so if it is exceeded, a defect is declared as detected.

2) Methods of diagnosis: The diagnostic strategy and the form in which knowledge is available to determine the methods used to design the monitoring algorithms. The main criterion for classification of monitoring methods is based on the type of knowledge; there are two types of approaches methods: the methods using operating models and those using diagnostic models (often known as the methods with or without model).

3) Methods without models: Described by several realization modes, methods without a model as the name implies, have no operating model. Otherwise, no model is describing normal behavior and delinquent the behavior of the system. The methods are then called learning processes and pattern recognition [2] or artificial intelligence. [3] The model without method is used in the case of complex systems dealing with very varied data (analog, digital) or imprecise (noise measurement). The goal of pattern recognition is to automatically classify shapes in modes (classes) known a priori. Therefore, these techniques must know a priori at all operating states (normal and default).

Analysis Phase: This phase involves the gathering of all existing information on the data process from the various sensors, models of devices, history, and experience. From this phase, we must get a precise definition of the parameters that will observe or represent the operating modes. A series of observations of the same model is not a single point but occupies an area of the observation space. This is due to the noise inherent in the various measures. It is therefore associated with each observed form of a mode or class. After representing the modes by significant parameters, we try to have as much data on each observable mode; this is the learning phase.

The phase of selection of a detection system: The boundaries between the classes are defined in this phase. A decision system capable to decide the membership or not of a new observation to existing classes is created. Many solutions used to define the decision system can be retained. [2] Cites a non-exhaustive methods of parametric discrimination with rejection (assume full knowledge of probability laws governing observations and applied under the Gaussian assumption with parameter estimation), methods of nonparametric discrimination (laws probability in each class are unknown but can be estimated by the method of Parzen or

the nearest neighbor), Operating phase. It is the implementation phase of the diagnostic system to propose a decision for any new observation made. The system must adapt its decision rule based on new classes detected.

4) Methods this second family of models: (Which is also our study) is based on the existence of material or analytical redundancy to characterize the operation mode or the system status. The principle of redundancy is to determine the value of variables in different ways and to analyze whether the results coincide. Physical redundancy consists of using multiple sensors for measuring the same variable. These sensors indicate the normal operation of the same value of noise and inaccuracies of close measurement. The duplication of the sensors is necessary to detect single faults. However, the location of the failure requires a minimum of three sensors, we will proceed to a majority vote. This method has been widely used in industry because it is easy to apply and very reliable, however, it is very heavy and expensive. Furthermore, it is not always applicable for architectural and material reasons and its scope is limited to only sensors failures. Unlike hardware redundancy, analytical redundancy allows finding the relationships between the known variables of the system (inputs and outputs). Many works are devoted to them, including the summaries found in [4], [5], [6] and the teaching manual [7] for linear systems. In this case, the generation of waste can be achieved by different approaches:

5) Approach parameter estimation: The input and output signal systems are used to estimate the different values of the analytical model parameters. The system parameters are estimated using identification procedures. The differences between the estimated values and the reference values are the residues. When the nominal values are not known, another approach is consisting to replace them with earlier estimates. In this case, the gap residues concerning zero are the result of parameter variations. These differences are then analyzed by the decision theory [4], [8].

The approach of state estimation: This is the dual approach to the estimation of parameters. The state estimation techniques use the raw database to estimate the state of the system x (t) and consequently its output y (t). These are compared with the actual outputs: any deviation between the measured value of the output and the actual value is a residue. There are two classes of approaches, the first one estimates the state vector (Luenberger observer [9] Kalman filter [10] and deduces the estimated output by applying the measurement equation. the other approach uses the observers who feel directly outputs, or more generally any combination of the state variables including the theoretical behavior is known in normal operation. [11].

The approach of parity space: This approach led to a rewriting of the equations of state and measurement, in which only known variables (commands and outputs) are allowed to appear. In the linear case, these equations are known by the parity equations and analytical redundancy relations (RRA) in the most general case.

III. Robust Diagnosis by Bond Graph Approach

The diagnosis systems by Bond Graph approach is one of the methods that are based on the use of a mathematical model of the system. Analytical methods rely on a knowledge of the system established by the explicit formulation of an analytical model of the monitored system. The basic principle of this approach is based on the acquisition of information through sensors on the monitoring process. The comparison between the actual behavior of the process and the behavior predicted by the model provides the information in a set of signals indicative of defects (residues). Analysis (time or frequency) of these signals can detect and optionally interpret any abnormal behavior of the system and locate its origin. From a representation by a bond graph approach, a monitoring system can be illustrated in Fig. 1. There are essentially two parts: one for the transfer of power and energy (formed by the process and all of the actuators), while the second shows the signals (information system is the sensors and the control system).

The bond graph model represents the energy of the system. The process is generally modeled by the usual elements of bond graphs (R, C, I, and the junctions). The actuators (pump, heat source,) are modeled by the sources (stress and/or flow). The sources can be simple (Se, Sf) or modulated (MSe, MSf), which is controlled by an external signal provided by a controller or operator. The sensors and the control system form the information system. In the first system (energy), the exchanged power is represented by a half-arrow (a power link) led the effort and the flow variables. In the second system (information system) the exchanged power is negligible, it is then represented by an information link (arrow) which is the same used in the classic block diagrams.

Monitoring algorithms (IDF detection and fault isolation) receive online information from the sensors (sensors of effort and flow) and withdraw the supervision system alarms. The information on the status of faulty elements is transmitted to the maintenance service. In the following sections, the different approaches to a bond graph by IDF are presented. There are two main approaches to bond graph process monitoring: the quantitative approach and the qualitative approach. Monitoring algorithms (IDF detection and fault isolation) receive online information from the sensors (sensors of effort and flow) and withdraw the supervision system alarms.

1) The qualitative approach for diagnosis using the bond graph: This approach does not require a very precise model. Unlike conventional representations of knowledge that describe the structure of the system and its status through various tools (block diagram, differential equations, etc.), the qualitative leap graphs explicitly describe the location of the system components and their interconnections. Thereafter, the based surveillance modeling qualitative bond graph is simpler in comparison with quantitative methods because it does not require a specific model. These qualitative models are built without consideration of system parameters. They are based on qualitative values (instead of numerical values) defined by the set {[1] [+] [0] [-] [-1] [?]} Representing the quality of the deviation in the space measures compared to the normal

operation. Operators are thus qualitative, they can be defined using the operators of real numbers {+, -, x, ÷, =} [12].

We then solve a system of qualitative equations to determine the cause of failures. Other studies use temporal causal graphs to isolate failures taking into account the dynamics (and the order) of occurrence of the fault. [12] Other authors use qualitative analysis of linear equations of state to determine possible causes of failure. [13] The advantage of this approach is that it does not require a deep knowledge of the system structure or numerical magnitudes of the parameters. However, this approach becomes a complicated process for multi-energy and has other drawbacks such as non-fault detection sensors and the difficulty of determining the lower and upper limits of the deviations [14].

2) The quantitative approach for diagnosis using the bond graph: The principle of this approach is to compare the normal behavior of the process with the digital model. Unlike the qualitative approach, the quantitative approach is based on physical laws and requires a deep knowledge of the system structure and the numerical values of the parameters. Models whatever their forms (transfer function, equations of state,) are obtained based on physical laws (first principles laws) [15] or the basis of a statistical parameter identification [16], [5]. In the remainder of this section, we will outline the methods of diagnosis based models using the Bond Graph approach.

3) Observers to enter unknown: An observer is defined as an unknown input because the estimation error of the state vector tends to zero asymptotically without taking into account the unknown input (for example, a disturbance) in the system [17]. The following LTI system:

$$x\left(t\right) = Ax\left(t\right) + Bu\left(t\right) + D\nu\left(t\right),\ y\left(t\right) = Cx\left(t\right) \quad (1)$$

Where $x\left(t\right) \in Rn$ is the state vector, $u\left(t\right) \in Rm$ is the measurable input vector, $\nu\left(t\right) \in Rq$ of the unknown input vector, $y\left(t\right) \in Rp$ is the output vector. The observer unknown input of this system is:

$$z\left(t\right) = Nz\left(t\right) + Ly\left(t\right) + Gu\left(t\right),\quad x0\left(t\right) = z\left(t\right) - Ey\left(t\right) \quad (2)$$

Where $z\left(t\right) \in Rn$ is the state vector, the matrices $N, L, G\ E$ and have suitable dimensions and are determined such that $x0\left(t\right)$ converges asymptotically to $x\left(t\right)$ the dynamics of the error is given by:

$$e\left(t\right) = x\left(t\right) - x0\left(t\right)\ e\left(t\right) = x\left(t\right) - X0\left(t\right) =$$
$$Ax\left(t\right) + Bu\left(t\right) + D\nu\left(t\right) - Z\left(t\right) + ey\left(t\right) =$$
$$Ax\left(t\right) + Bu\left(t\right) + D\nu\left(t\right) - Nz\left(t\right) - Ly\left(t\right) -$$
$$Gu\left(t\right) + EC\left(Ax\left(t\right) + Bu\left(t\right) + D\nu\left(t\right)\right) =$$
$$Ax\left(t\right) + Bu\left(t\right) + D\nu\left(t\right) - nx0\left(t\right) + Ney\left(t\right) - Ly\left(t\right)$$
$$- Gu\left(t\right) + EC\left(Ax\left(t\right) + Bu\left(t\right) + D\nu\left(t\right)\right) =$$
$$Nx\left(t\right) - nx0\left(t\right) - \left(NP + LC - PA\right) x\left(t\right)$$
$$- \left(G - PB\right) u\left(t\right) + P\,D\nu\left(t\ \right) =$$
$$Ne\left(t\right) - \left(LC + NP - PA\right) x\left(t\right) -$$
$$\left(G - PB\right) u\left(t\right) + P\,D\nu\left(t\right) \quad (3)$$

Where $P = I + EC\ I \in Rn * n$ and unit matrix. The error converges to zero if:

$$PD = D + EDC = 0 \quad (4)$$

$$NP + LC - PA = 0 \quad (5)$$

$$G - PB = 0 \quad (6)$$

The solution of equation (66) for E can be written as:

$$E = D\left(CD\right) + Y\left(Ip - \left(CD\right)\left(CD\right) +\right) \quad (7)$$

Wherein $\left(CD\right) +$

is the generalized inverse of CD, $Ip \in Rp * p$ the unit, Y is an arbitrary matrix of appropriate size. The G matrix may be derived from equation (57) as follows:

$$G = PB = B + ECB \quad (8)$$

The state error converges to zero as the poles N are stable. Let K us:

$$N = PA - KC \quad (9)$$

The equation is true iff :

$$K = L + DO \quad (10)$$

$$N = PA - KC = PA - \left(L + N\right) C =$$
$$PA - LC - NEC\ NEC$$
$$+ \Rightarrow N = PA - LC\ or\ N\left(I + EC\right) =$$
$$NP = PA - LC$$

And as P is known, the poles N can be placed carefully choosing the matrix K (eq. (11)).

The closed-loop gains of the observer are:

$$L = K - K = NE - \left(PA - KC\right) E = K\left(I + EC\right) - P\,AE \quad (11)$$

Calculation of matrix N, G, and L complete the construction of the observer unknown complete order entry. To isolate the fault, the disturbances must be redefined 52 equation system as follows:

$$x\,(t) = Ax\,(t) + Bu\,(t) + EDD\,(t) + Ef\,f\,(t),\ y\,(t) = Cx\,(t) + Gdd\,(t)\ Gf + f\,(t) \quad (12)$$

where x (t) is the state vector, y (t) is the output vector, u (t) is the known input vector, d (t) is the unknown input vector (disturbance), f (t) is the defects vector, the matrices A, B, C, D, Ed, Ef, Gd and Gf are constant. An observer unknown input with its waste generator is defined by:

$$x0\,(t) = Hxx0\,(t) + Huu\,(t) + Hyy\,(t),\quad r\,(t) = Mxx0\,(t) + Myy\,(t) \quad (13)$$

Where $Hx\ Hu, Hy, Mx\ My$ and have appropriate dimensions. Either the error defined by $e\,(t) = x0\,(t) - T\,x\,(t)$, where T is a transformation matrix. The estimation error can be written as follows:

$$\begin{aligned} &E\,(t) = X0\,(t) - Tx\,(t) = \\ &Hxx0\,(t) + Huu\,(t) + Hyy\,(t) \\ &- T\,Ax\,(t) - t\,Bu\,(t) - \\ &T\,EDD\,(t) - T\,Ef\,f\,(t) = \\ &Hxx0\,(t) - HXT\,x\,(t) + HXT\,x\,(t) \\ &+ Huu\,(t) + Hy\,(C\,(t) + Gdd\,(t) + Gf\,f\,(t)) - \\ &T\,Ax\,(t) - t\,Bu\,(t) - T\,EDD\,(t) - T\,Ef\,f\,(t) = \\ &Hx\,(x0\,(t) - T\,x\,(t)) + (HXT + HyC - TA)\,x\,(t) \\ &+ (Hu - TB)\,u\,(t) + (HyGd - T\,Ed)\,d\,(t) + \\ &(HyGf - T\,Ef)\,f\,(t) = \\ &HXE\,(t) + (HXT + HyC - TA)\,x\,(t) \\ &+ (Hu - TB)\,u\,(t) + \\ &(HyGd - T\,Ed)\,d\,(t) + (HyGf - T\,Ef)\,f\,(t). \end{aligned} \quad (14)$$

The residue vector is given by:

$$r(t) = M_X E(t) + (MyC - MxT)\,x\,(t) + MyGdd\,(t) + MyGf\,f\,(t) \quad (15)$$

The asymptotic convergence of the error and the decoupling of the disturbances are verified with the following conditions: Hx is stable,

$$TA = -(HXT + HyC),\ TB = Hu,\ HyGd - T\,Ed = 0,\ MyC - MxT = 0,\ MyGd = 0, \quad (16)$$

The estimation error and the residues are defined by:

$$E\,(t) = HXE\,(t) + (HyGf - T\,Ef)\,f\,(t),\quad r\,(t) = MXE\,(t) + MyGf\,f\,(t) \quad (17)$$

And as Hx is stable in healthy cases (without defects) $e\,(t) \to 0\ and\ r\,(t) \to 0\ as\ t \to \infty$.

a) Application with the Bond Graph approach: At this stage, we consider the system treated in section (Fig. 2).

The model in the state space is given by:

$$\begin{Bmatrix} \dot{Q}_2 \\ \dot{Q}_7 \end{Bmatrix} = \begin{bmatrix} -\frac{1}{C_{T1}R_{vb}} & \frac{1}{C_{T2}R_{vb}} \\ \frac{1}{C1R_{vb}} & -\frac{1}{C_{T2}R_{vb}} - \frac{1}{C_{T2}R_{vo}} \end{bmatrix} \begin{Bmatrix} Q_2 \\ Q_7 \end{Bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} Q_P \quad (18)$$

Consider the elements $C : C_{T1}$, $R : R_{vb}$ $C : C_{T2}$ and $R : R_{vo}$; candidate defects, which are reflected by leaks in tanks and leakage/blockage in the valve. If the fault is in the R-element: R_{vb} while Fig. 2(b) shows that this component gives the flow to the system. This element can be therefore replaced by a stream source (Fig. 3(a)). Thereafter we proceed to the construction of an observer unknown entry (taking into account the new source of flow disturbance like), then the residue takes a zero value if and only if the element $R :\ R_{vb}$ is in default. By following the same steps, one can construct the observer for the other combinations of defects (Fig. 3(a), (b) and (c)).

For Fig. 3(a) model in the state space is:

$$\begin{Bmatrix} \dot{Q}_2 \\ \dot{Q}_7 \end{Bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & -\frac{1}{C_{T2}R_{vo}} \end{bmatrix} \begin{Bmatrix} Q_2 \\ Q_7 \end{Bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} Q_P + \begin{bmatrix} -1 \\ 1 \end{bmatrix} V(t) \quad (19)$$

For the model in Fig. 3(b):

$$\begin{Bmatrix} \dot{Q}_2 \\ \dot{Q}_7 \end{Bmatrix} = \begin{bmatrix} -\frac{1}{C_{T1}R_{vb}} & 0 \\ \frac{1}{C1Rb} & 0 \end{bmatrix} \begin{Bmatrix} Q_2 \\ Q_7 \end{Bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} Q_P + \begin{bmatrix} -\frac{1}{R_{vb}} \\ -\frac{1}{R_{vb}} \end{bmatrix} V(t) \quad (20)$$

Finally, Fig. 3© gives:

$$\begin{Bmatrix} \dot{Q}_2 \\ \dot{Q}_7 \end{Bmatrix} = \begin{bmatrix} -\frac{1}{C_{T1}R_{vb}} & \frac{1}{C_{T2}R_{vb}} \\ \frac{1}{C1R_{vb}} & -\frac{1}{C_{T2}R_{vb}} \end{bmatrix} \begin{Bmatrix} Q_2 \\ Q_7 \end{Bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} Q_P + \begin{bmatrix} 0 \\ -1 \end{bmatrix} V(t) \quad (21)$$

We note that the matrix A in equation (16) is different from those found in equations (15), (16), (17), in each case, we must build a corresponding observer. In the case of a fault in the element R: RVO, 14 the equation can be rewritten as follows:

$$\begin{Bmatrix} \dot{Q}_2 \\ \dot{Q}_7 \end{Bmatrix} = \begin{bmatrix} -\frac{1}{C_{T1}R_{vb}} & \frac{1}{C_{T2}R_{vb}} \\ \frac{1}{C1R_{vb}} & -\frac{1}{C_{T2}R_{vb}} - \frac{1}{C_{T2}R_{vo} + \Delta R_{vo}} \end{bmatrix} \begin{Bmatrix} Q_2 \\ Q_7 \end{Bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} Q_P \quad (22)$$

Or

$$\dot{x(t)} = Ax(t) + Bu(t) + \Delta Ax(t) = Ax(t) + Bu(t) + Dv(t) \quad (23)$$

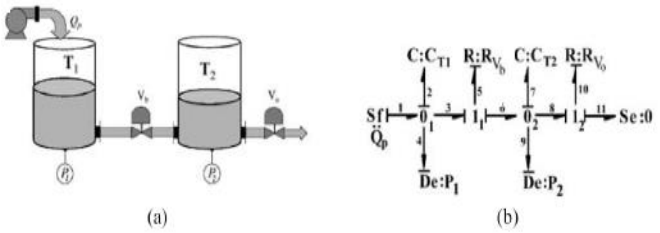


Fig. 2. System 2 Tanks (a) Bond Graph Equivalent (b).

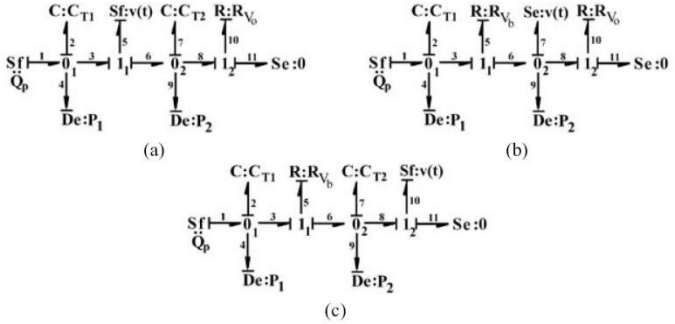


Fig. 3. Different Cases of unknown Input Assumptions Considered for Defects.

Where, dA represented the change in matrix A due to a parametric failure, its effect results in an unknown input. The formulation presented in equation (23) can be implemented in the model Bond Graph by the appropriate addition of stress sources and flows. The model Bond Graph modified to a defect in R: Rgb and C: CT2 respectively are shown in Fig. 4(a) and (b).

b) Discussions: The representation of the unknown inputs in a bond graph model does not generalize the method to design observers to unknown entries in a direct way (from the bond graph model). Construction observers must necessarily go through the step of writing the state equations from the model. Under these conditions, the use of the Bond Graph approach is not practical. In the remainder of this article, we will introduce other approaches for diagnosis based on the bond graph model.

4) Residues in the parity area outside: Consider the following LTI system:

$$\dot{X}(t) = Ax(t) + Bu(t) + E_d d(t) + E_f f(t)$$
$$Y(t) = Cx(t) + Du(t) + G_d d(t) + G_f f(t) \quad (24)$$

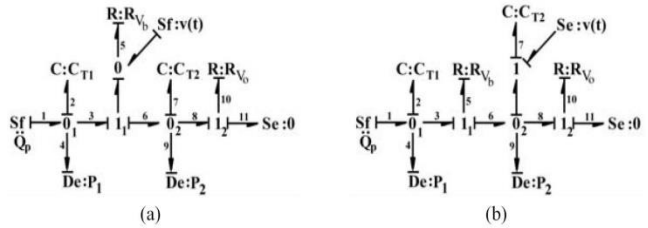


Fig. 4. Bond Graph with unknown Grafted.

In normal operation f (t) = 0 ∀ t. It is assumed initially that (d (t) = 0, f (t) = 0).

$$Y(t) = Cx(t) + Du(t)$$
$$\dot{Y}(t) = C\dot{x}(t) + D\dot{u}(t) \quad (25)$$

Substituting x = Ax (t) + Bu (t) in equation (27) and deriving up to the order m:

$$\dot{Y}(t) = CAx(t) + CBu(t) + D\dot{u}(t)$$
$$\ddot{Y}(t) = CA^2x(t) + CABu(t) + CB\dot{u}(t) + D\ddot{u}(t)$$
$$\vdots$$
$$Y^m(t) = CA^mx(t) + CA^{m-1}Bu(t) + \ldots + CBu^{m-1}(t) + Du^m(t) \quad (26)$$

If the matrix is full rank, then you can apply the theorem Caley Hamilton (Each matrix satisfies its characteristic equation that is to say):

$$\phi(A) = 0$$

Such that:

$$\phi(s) = |sI - A| = sn + an-1s\,n-1 + \ldots + a0 + A1S)$$

Then:

$$Y^n(t) = CA^nx(t) + CA^{n-1}Bu(t) + \ldots + CBu^{n-1}(t) + Du^n(t)$$
$$= a_{n-1}CA^{n-1}x(t) - a_{n-2}CA^{n-2}x(t) - \ldots - a_1CAx(t)$$
$$-a_0Cx(t) + CA^{n-1}Bu(t) + \ldots + CBu^{n-1}(t) + Du^n(t)$$
$$= -a_{n-1}(y^{n-1}(t) - CA^{n-2}Bu(t) - \ldots - CBu^{n-2} - Du^{n-1}(t)$$
$$-a_{n-2}(y^{n-2}(t) - CA^{n-3}Bu(t) - \ldots - CBu^{n-3}(t) - Du^{n-1}(t)$$
$$-\ldots$$
$$-a_0(y(t) - Du(t))$$
$$+CA^{n-1}Bu(t) + \ldots + CBu^{n-1}(t) + Du^n(t) \quad (27)$$

Or:

$$\phi_{ARR}((y(t),u(t)),(\dot{y}(t),\dot{u}(t)),\ldots,(y^n(t),u^n(t))) = 0 \quad (28)$$

Equation (27) defines a set of constraints between the inputs/outputs, which are by definition the Analytical Redundancy Relations.

a) Sample Application: Consider the mass-spring-damper system and its bond graph model represented by Fig. 5(a) and (b).

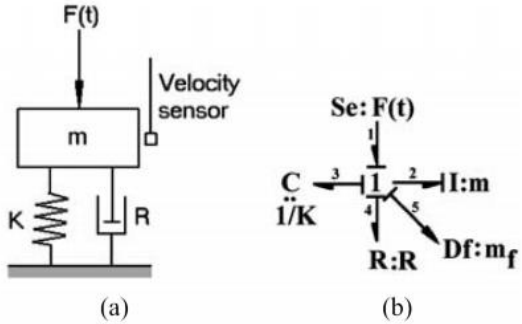


Fig. 5. Bond Graph Model of a System Mass-Spring-Damper.

From the link graph model, the equations of the state space are as follows:

$$\begin{Bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{Bmatrix} = \begin{bmatrix} -\frac{R}{m} & -K \\ \frac{1}{m} & 0 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u(t)$$

$$\{y_1\} = \begin{bmatrix} \frac{1}{m} & 0 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} \quad (29)$$

Where $x1 = P2$, $x2 = Q3$, $u\ (t) = F\ (t)$ and y1 is the output of the speed sensor. By applying several derived from y1:

$$\dot{y}_1 = \frac{\dot{x}_1}{m} = -\left(\frac{R}{m^2}\right) x_1 - \left(\frac{K}{m}\right) x_2 + \frac{u(t)}{m}$$
$$= -\left(\frac{R}{m}\right) y_1 - \left(\frac{K}{m}\right) x_2 + \frac{u(t)}{m},$$
$$\ddot{y}_1 = -\left(\frac{R}{m}\right) \dot{y}_1 - \left(\frac{K}{m}\right) \dot{x}_2 + \frac{\dot{u}(t)}{m}$$
$$= -\left(\frac{R}{m}\right) \dot{y}_1 - \left(\frac{K}{m^2}\right) x_1 + \frac{\dot{u}(t)}{m} \quad (30)$$

We thus obtain an RRA (Relationship Analytical Redundancy)

$$m\ddot{y}_1 + R\dot{y}_1 + Ky_1 - \dot{u}(t) = 0 \quad (31)$$

If we add a vertical displacement sensor (y2):

$$\begin{Bmatrix} y_1 \\ y_2 \end{Bmatrix} = \begin{bmatrix} \frac{1}{m} & 0 \\ 0 & 1 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} \quad (32)$$

We then get the following RRA:

$$m\dot{y}_1 + Ry_1 + Ky_2 - u(t) = 0,$$
$$y_1 - \dot{y}_2 = 0, \quad (33)$$

As a conclusion, we can note from the previous example that, the maximum degree spin in the RRA is "1". The first analytical redundancy relationship RRA1 is responsive to a static shift concerning the valuesy1 and y2, the second RRA2 is responsive to a static lag y1. If RRA is written with a higher-order derivative, the detection of the shift in the sensors will not be possible. Superior derived from a noise signal will also cause problems in the decision step.

5) Analytical redundancy relations generation:

a) Graphical representation systems: Before presenting the algorithm for generating the RRAS, we first wanted to highlight some graphical representations of dynamical systems. For this, we have chosen to proceed with a simple example shown in Fig. 6.

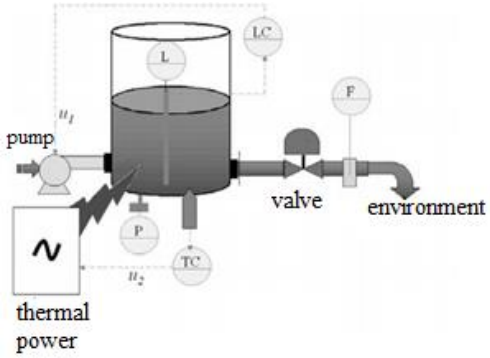


Fig. 6. Tank Supplied with Water by a Pump.

b) Representation by a structural model: It is shown in [18] that, from a structural standpoint, the dynamic model of any physical system may be represented by the pair [C, Z], with Z = {z1, z2 ... zn} represents the set variables and the system parameters, and C = {c1, c2, cn} represents the set of constraints. Then, the structural representation will express the relationship between the variables and the constraints of the process. The advantage of this representation is that it can represent any system regardless of its model (qualitative, quantitative, static, dynamic, rules, tables, etc.). Thus, the analytical form of the system model is not necessarily required. By applying the description given in [18], the constraints corresponding to the hydraulic part of the system of Fig. 6 are given in Table I. Where M (t) is the total mass in the tank, qi (t) is the input flow, qo (t) is the output rate, u (t) is the control of the level controller, the coefficient Cd discharge valve, and the A section of the tank and ΦPi the function corresponding to the level controller. In addition to these relationships, an eighth constraint can be added by introducing the derivative of the variable M (t): qo (t) output rate, u (t) the control of the level controller, the discharge coefficient Cd of the valve, the section A of the tank and ΦPi the function corresponding to the level controller. In addition to these relationships, an eighth constraint can be added by introducing the derivative of the variable M (t):

TABLE. I. STRUCTURAL MODEL OF THE HYDRAULIC PART

Component	Constraint	Model
Tank	C_1	$M(t) = q_i(t) - q_0(t)$
Pump	C_2	$q_i(t) = \alpha u(t)$
Valve	C_3	$q_0(t) = C_d.\sqrt{M(t)}$
level sensor	C_4	$L(t) = \frac{M(t)}{\rho A}$
Pressure sensor	C_5	$P(t) = M(t).\frac{\rho}{A}$
flow sensor	C_6	$F(t) = q_0(t)$
level regulator	C_7	$u(t) = \phi_{PI}(M(t))$

$$c_8 : \dot{M}(t) = \frac{dM(t)}{dt}$$

The set of constraints C and all Z variables of the physical system are therefore determined as follows:

$$C = \{c_1, c_2, c_3, c_4, c_5, c_6, c_7, c_8\}$$
$$Z = \{M(t), M(t), q_i(t), q_0(t), u(t), L(t), P(t), F(t)\} \quad (34)$$

Note that the structural model is used to determine the structural properties of the systems (observability, controllability, surveillabilité, and reconfigurability) independently of numerical values of the parameters.

Representation by a digraph

Consider the model of the example in Fig. 6 in the form of the following state equations:

$$\dot{x}(t)\, f(x(t), u(t)) = -C_d . \sqrt{x(t)} + \alpha . u(t),$$
$$y(t) = g(x(t), u(t)) = \begin{pmatrix} y_1(t) \\ y_2(t) \\ y_3(t) \end{pmatrix} = \begin{pmatrix} \frac{1}{\rho^A} . x(t) \\ \frac{2}{A} . x(t) \\ C_d . \sqrt{x(t)} \end{pmatrix} \quad (35)$$

The digraph corresponding to the system of equation (35) is a graph in which the vertices are the inputs, the outputs and the states of the system; and the links between the vertices are defined by the following rules:

- There exists a link xk top (respectively top ul) to the vertex xi if and only if the state variable xk (respectively ul input variable) appears in the function fi.

- There is a link to the top xk yi higher if and only if the state variable xk appears in the function gj.

The digraph associated with equation (35) is given in Fig. 7.

The representation by the digraph is an abstraction of the dynamic model of the moment that the tops can be interpreted as a mutual influence between the variables of the system.

The disadvantage of this form of representation is that it does not represent the algebraic constraints of the model.

Representation by bond graph: The bond graph model, derived causality, corresponding to the hydraulic part of the physical system of Fig. 6 is shown in Fig. 8.

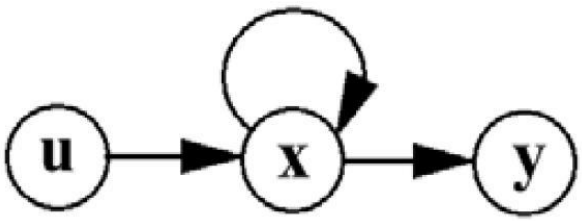


Fig. 7. A Logging the Equations Corresponding to 35.

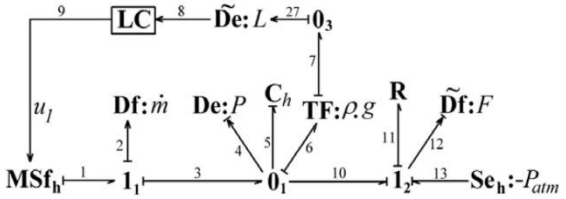


Fig. 8. Bond Graph Model of the Example in Fig. 6.

Using the bond graph representation, the set of variables Z (known and unknown K X) and the set of constraints C can be deducted directly from the bond graph model of the process.

c) Generation RRAS using the bond graph: The purpose of using the graphical representation of links is to use a single tool for modeling, the RRAS generation, the structural analysis, and the monitoring and sensor placement. A bond graph monitoring system can be represented by the diagram shown in Fig. 1. There are essentially two parts: the bond graph model and the information system. The bond graph model represents the energy of the physical process. It includes the process and all the actuators which are modeled by the sources (effort or flow). The sources may be single: Se, Sf (pump, heating, supply pressure, etc.) or modulated MSe, MSf (sources controlled by an external signal provided by a controller or a user). The sensors and the control system (PID, T R, etc.) form the information system. In the first system (energy), the power exchanged is represented by a half-arrow (link) that translates the power of variables (effort and flow). In the second system (information system) the power exchanged is negligible; it is represented by an information link.

The generation of RRAS through the bond graph methodology is based on the same principles as in the bipartite graph, namely the elimination of unknowns in an overdetermined and observable subsystem. On a bond graph model, the observability can be checked using the structural properties developed in [19]. The known variables K are those of the detectors and the sources while the unknown variables X are those of the links of powers in the elements C, I and R. The elimination of unknown variables is routinely on the bond graph model with a causal property and a course of causal paths. In the following, the developed approach consists of generating an algorithmic and systematic way of the RRAS corresponding to the residues and the failure's signature matrix. In a bond graph representation, the relationship on $f(K) = 0$ the definition of an RRA becomes:

$$f(D_e, D_f, S_e, S_f, MSe, MSf, \theta_m) = 0 \quad (36)$$

With .theta..sub.m represents all the measured or estimated system parameters. The algorithm presented here allows generating all the possible RRAS from a bond graph model of a given system. The model is first set preferably on the derived causality (with inversion of the detectors if possible). This avoids the initial conditions of the state and considers the sources and detectors as inputs of the model. The RRAS, in differential form, is then directly deduced from the expressions of the laws of junction 0 and 1 of the leap in the model graph causally derived.

RRAS generation algorithm by bond graph: The following algorithm can generate RRAS systematically from a bond graph model. Here, in order, the steps to follow:

1) Put the bond graph model causality preferably derived (by reversing the causal sensors if possible).

2) Write the equations of the resulting model: behavior FB, Junctions FJ to measured FY, sources FAT and control FC.

3) For any junction equation 0 and 1 containing at least one detector:

a) eliminate unknown variables by browsing the causal paths on the bond graph,

b) for any detector whose causality is reversed an RRA is deducted,

c) for any detector whose causality cannot be reversed an RRA is deduced by making equal its output with the output of another sensor of the same type (hardware redundancy).

4) RRA is obtained from each controller by comparing the measured output with output predicted by the control algorithm.

5) Repeat steps 3 and 4:

a) if the RRAS obtained are strictly different from those already obtained then keep, otherwise continue until all equations junctions and those Regulators are explored. Now apply this algorithm on our example application given to Fig. 3.

6) The bond graph model causality derivative corresponding to the hydraulic part the system is given to Fig. 8. The different analytical constraints model is given by equations (25), (27), (29), (31) and (32). Moreover, it is Important, in this algorithm, to consider that the outputs of sources and regulators are known (measured). Step 3 the algorithm is to eliminate the unknown variables of each equation junction. Choose as the first equation corresponding to junction 01.

So we have:

$$f_6 = f_3 - f_4 - f_5 - f_{10} \quad (37)$$

In this equation, the subset of unknown variables is X = f6, f3, f4, f5, f10. These variables can be eliminated by browsing the causal paths on the bond graph model in Fig. 8. f4 and f6 correspond to variable flow pressure sensors by P and level L and therefore their values are zero (f6 = f4 = 0). f3 can be determined from the causal path MSfh: Φpump (U1) → → f1 f3 (see Fig. 8), since the output of the actuator is considered in this case as being known (MSf pump = Φ (u1)). We can write:

$$f_3 = \phi_{pump}(u_1)$$

The causal path Df: F → → f12 f10 f10 determines the variable:

$$f_{10} = F$$

While f5 variable is calculated from the constitutive relationship of the element C_h:

$$f_5 = C_h \frac{de_5}{dx}$$

Where Ch is given and e5 is determined by traversing the causal path from:

$$e27\ L \rightarrow \rightarrow \rightarrow e7\ e6 \rightarrow e5\ e5 = \Rightarrow \rho.gL$$

Was thus:

$$f_5 = \frac{A}{g}\rho g \frac{dL}{dt} = A\rho\dot{L}$$

All unknown variables in equation (40) are eliminated, the first following analytical redundancy relationship is then obtained:

$$RRA_1 : \phi_{pump}(u_1) - \rho A\dot{L} - F = 0 \quad (38)$$

Proceeding in the same way as in equation (39), a second RRA may be generated from the equation of junction 01. In this equation, e12 = 0 since it corresponds to the variable force of a flow detector (Df: F). We can write:

$$e_{12} = e_{10} - e_{11} + e_{13} \Rightarrow e_{10} - e_{11} + e_{13} = 0 \quad (39)$$

From the causal path:

$$e_{27}\ L \rightarrow \rightarrow \rightarrow e_7\ e_6 \rightarrow e_{10},$$

e_{10} calculates e_{13} Variable represents the atmospheric pressure of the ambient environment, while e_{11} can be obtained from the constitutive relation of the element R:

$$e_{10} = \rho gL$$

$$e_{13} = -P_{atm}$$

$$e_{11} = \phi_R(f_{11}) = \phi_R(F)$$

The second RRA which is structurally independent of the first is

$$RRA_2 = \rho gL - \phi_R(F) - P_{atm} = 0 \quad (40)$$

The Prior RRAS (Eq. (39) and Eq. (41)) are both obtained from the junction corresponding to the hydraulic phenomena of the process.

Failures signature Matrix: The RRAS form the structure of a binary matrix Sji which provides the information on the sensitivity of the residues to the failures component of the physical process (sensors, actuators, controllers, physical elements). The matrix elements are defined as follows:

$$S_{ji} = \begin{cases} S_{ji} = 1, if\ the\ i^{th}\ RRA\ contains\ variables\ of\ j^{th} component \\ 0, else \end{cases} \quad (41)$$

The Sji matrix is called a failure signature matrix that provides the logic for the location errors detected during the system operation. The purpose of the localization (isolation) procedure is to provide the operator with a list of failed components. Each component has a signature represented by a vector line of the matrix and does not take into account the values assigned to the variables Db (detectability) and Ib (isolability). Component failure is detected if the variable associated with the component is present in at least one RRA (or the corresponding r residue). This failure is localizable if its signature is unique, that is to say, different from the signatures of the other components. From the specifications requested, we can fix the list of components to be monitored. Obviously, the performance of the monitoring system (about isolabilité) depends on the number of items to be monitored and to the differences in their failure signatures. To build the matrix of the signatures, some components are removed from the matrix since they are considered infallible.

How detection and fault isolation? Once the failures generated by the analytic redundancy relationships and the signature matrix have been obtained, the decision process is the next step in designing a monitoring system. It consists of making the detection and location of faults robust, reliable and efficient. In general, the logic used to determine whether or not a failure has occurred depends on the type of knowledge available about the process, the method used and treated as failures. A wide range of decision algorithms is given in [20].

The decision procedure is applied to all R residues $r - f(K) = 0$ to generate a binary coherent vector V = [v1 v2 ... vn], which indicates whether a failure is present or not in the process. Each element vi of V is obtained by applying the corresponding decision procedure i (n), ie vi = Φi (n). Thus, an alarm is generated when vi = 1 ⇒ V / = [00 ... 0].

Theoretically, if the system works, the value of each residue ri (i = 1, .., n) must be equal to zero. But in practice and in the simplest case, | ΨΔT (ri) | is limited by a small amount i with pretreatment ΨΔT on each residue (i.e., a running average over a time interval ΔT). The parameter i is a fixed threshold (by experience, for example). Indeed, in practice, the residual values in normal operation are never zero. This is due to modeling errors and noise measurements. To decide the presence of a failure, each treated residue is compared with a threshold value i set as a priori. In the simplest case, each element vi of V is obtained by using the following condition:

$$v_i = \begin{cases} S_{ji} = 1, if\ |\psi_{\Delta T}(r_i)| > \epsilon_i \\ 0, else \end{cases} \quad (42)$$

6) Robust Diagnostic Bond Graph approach6

a) Representation LFT: Linear Fractional Transformations (LFTs) are very generic objects used in the modeling of uncertain systems. The universality of LFT is because any regular expression can be written in this form. [21] This form of representation is used for the synthesis of an uncertain system of law control according to the principle of μ analysis. It consists of separating the nominal part of a model from its uncertain part, as shown in Fig. 9. The nominal values are grouped in an augmented matrix denoted M, supposedly clean, and an uncertainty whatever their type (parametric uncertainties, structured and unstructured model uncertainty, measurement noise, etc.) is connected in a matrix structure diagonal Δ.

b) Modeling of Bond Graph uncertain elements: The BG deterministic models of a physical element R of the causality resistance and the conductance are shown respectively in Fig. 10 (a) and (b).

Bond Graph element with additive uncertainty.

By introducing an uncertainty additively on the element R in causal resistance are obtained:

$$e_R = (R_n + \Delta R)\, f_R = R_n f_R + \Delta R f_R = e_n + e_{inc} \quad (43)$$

R_n With the nominal value of the element R ΔR and the additive uncertainty parameter. ΔR And f_R are respectively the effort and flow in the element in R. Rn.fR = and = EINC ΔR.fR represent respectively the effort made by the nominal setting and effort introduced by the additive uncertainty. Equation (42), clearly shows that the effort introduced by. Δ R additive uncertainty is independent of the nominal value of the parameter Rn. This form of representation is valid for linear systems with constant parameters. The bond graph equivalent model to the mathematical model of equation (42) is given by Fig. 11(a) and Fig. 11(b) shows the bond graph model of the element R in causal conductance. The bond graph approach can anticipate problems simulation and generation of robust RRAS.

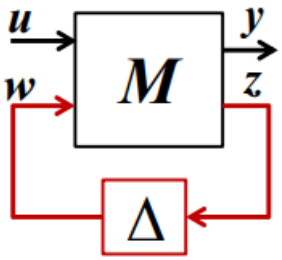


Fig. 9. LFT Representation.

Fig. 10. The Deterministic Elements of Causal in the Resistance R (a) and the Causal Conductance (b).

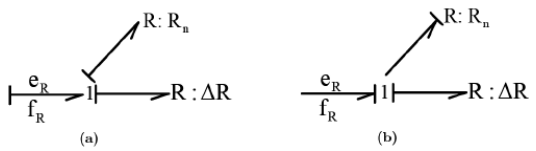


Fig. 11. Element R Causality Resistance with Additive uncertainty (a). In Causal Conductance (b).

Indeed, in the case where the uncertainty is introduced additively as a BG member (Bond Graph), the structural properties of the uncertain model prevent the automatic generation of the robust RRAS and generate the errors in the simulated model. To illustrate this feature, the analysis of the BG models and the C and I elements with integral causality are derived in Fig. 12 and 13.

The BG models of C and I in the integral causality presented in Fig. 12(a) and 13(a) show that the uncertainty represented by a link graph element is causally related to the nominal parameter with no link of causality with the rest of the model. This situation creates a differential between the nominal loop element and the uncertainty. Thus, for complex models, where the number of uncertainties parametric is important, the dynamic simulation model is practically impossible because of the algebraic differential loops. When BG models C and I elements are derived by causality (Fig. 12(b), 13 and (b)), the nominal parameter (C_n and I_n) pass through the causal derivative and the parameter corresponding to the uncertainty (ΔC and ΔI) pass through the integral causality, but the differential loop is still present.

BG-LFT element with a multiplicative uncertainty

The introduction of a multiplicative uncertainty on the element R in resistance causality gives:

$$e_R = R_n(1+\delta_R) f_R = R_n f_R + \delta_R R_n f_R = e_n + \delta_R e_n = e_n + e_{inc} \quad (44)$$

R_n with the nominal value of the element R and ΔR Multiplicative uncertainty parameter. e_R and f_R are respectively the effort and flow in the parameter R = $\delta_R R_n f_R$ e_{inc} $R_n f_R$ and represent the effort made by the nominal setting and effort introduced by the multiplicative uncertainty. Unlike the effort introduced by an additive uncertainty concerning the parameter (eq. (45), the effort made by a multiplicative uncertainty (eq. (47, 45)) is a function of the effort made by the nominal setting.

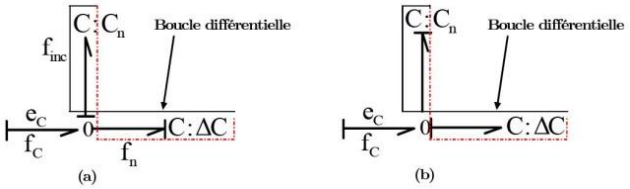


Fig. 12. The C Element in the Integral Causality with the Additive uncertainty (a). The Causally Derivative (b).

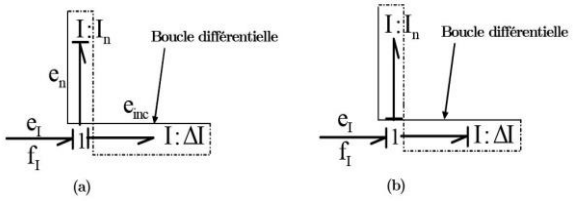


Fig. 13. Element I in Integral Causality with Additive uncertainty (a). Causally Derivative (b).

With 47 is:

$$q(t) = \int^t f(t)dt = q_0 + \int_{t_0}^t f(t)dt \quad (45)$$

The introduction of a multiplicative uncertainty element R in conductance causality gives:

$$f_R = \frac{1}{R_n}\left(1+\delta_{\frac{1}{R}}\right)e_R = \frac{1}{R_n}e_R + \delta_{\frac{1}{R}}\frac{1}{R_n}e_R$$
$$= f_n + \delta_{\frac{1}{R}} f_n = f_n + f_{inc} \quad (46)$$

The multiplicative uncertainty on the element R in causal conductance. e_R and f_R are respectively the force and the flux in the element R in causal conductance.

$$f_n = \frac{1}{R_n}e_R \quad \text{et} \quad f_{inc} = \delta_{\frac{1}{R}}\frac{1}{R_n}e_R$$

Represent respectively the flow provided by the nominal parameter and the flow introduced by the multiplicative uncertainty. The equivalent models of the synoptic scheme of the equations (43) and (45) are respectively given in Fig. (14)(a) and (b).

From equations (45) and (47), we can construct the jump graph model in Fig. 15(a) and (b). Passing by a deterministic BG model in a form of uncertain LFT model, therefore, consists in introducing the modulated sources of effort or flux, which are respectively added to the junctions 1 or 0. Thus, the model is correct and its structurally causal properties are not modified (controllability, observability, etc.). Moreover, these modulated sources have a causal link with the rest of the model, in which the energy supply is spread in the form of effort or flux and is added to the energetic balance at the junctions. This standard form is suitable for diagnosing systems with uncertain parameters [22].

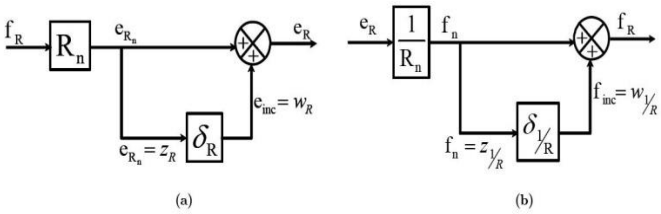


Fig. 14. LFT Block Diagram Model of a Resistance Element R Causally with Multiplicative uncertainty (a). Causality Conductance (b).

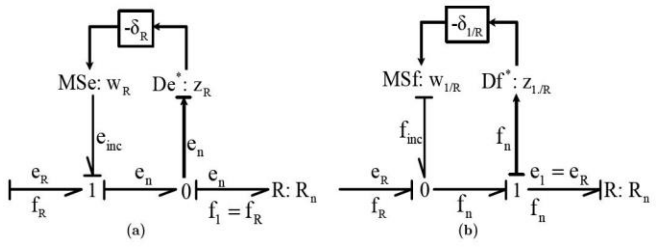


Fig. 15. The BG-LFT Model and the Causality R Resistance Element with the Multiplicative uncertainty (a) .in Causal Conductance (b).

c) Construction of a BG-LFT model: This method consists of replacing each element with its uncertain BG-LFT. Full BG-LFT can then be represented by the diagram of Fig. 16 when the standard structure of Fig. 9 appears. On a link graph model, each element corresponds to a specific hardware component or physical phenomenon, thus facilitating the identification of the numerical values of the parameters and uncertainties, and the transition to the LFT form is done by a simple addition modulated sources in the effort and in the model data flow. The state variables of a bond graph model are related to the dynamic elements I and C, and the causal and structural aspects of the model allow the automatic generation of an uncertain state model in the standard 9 format.

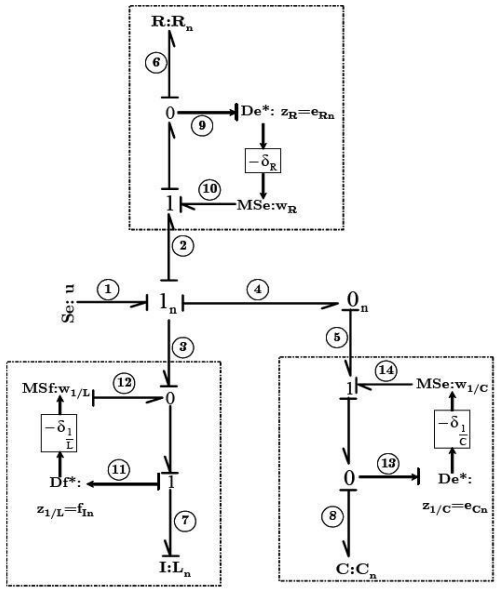


Fig. 16. Representation of a BG-LFT.

Example: Given the RC circuit, I Next (Fig. 17).

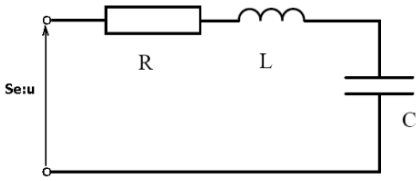


Fig. 17. Electrical Circuit R, C, I.

The deterministic bond graph model of the system is given in Fig. 18.

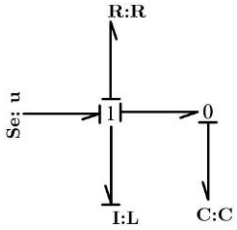


Fig. 18. Deterministic Model BG Integral Causality of a Circuit R, C, I.

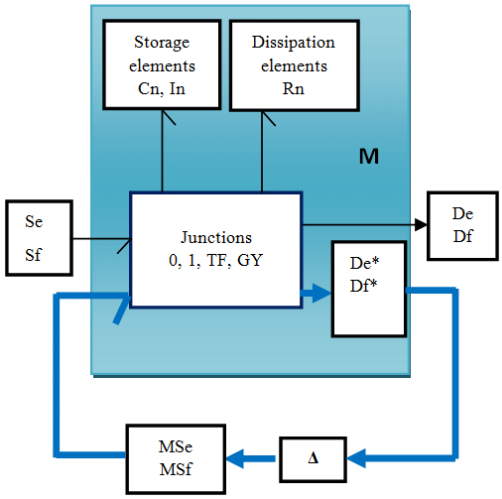


Fig. 19. BG-LFT Model in Integral Causality of a Circuit R, C, I.

The bond graph model uncertain as LFT is obtained by replacing each element by its uncertain BG-LFT model; we obtain the BG-LFT model of Fig. 19. Parametric uncertainties ΔR , δ 1 R, 1 δ C corresponds to specific hardware components. Interactions efforts (or flows) introduced by the nominal parameters and uncertainties are performed by the causal and structural constraints of the model; efforts (or flux) are propagated along causal paths and are added to a junction 1 (or a junction 0).

7) Generating robust residues:

a) The general form of the uncertain RRA: Generating robust analytic connections redundancy from clean, observable and over determined link graph models is summarized by the following steps:

- Step 1: Verifying the state of coupling with the deterministic causal model of the preferential derivative link graph; if the system is over determined, then, continue the following steps.

- Step 2: The link graph model is formed in LFT.

- Step 3: The symbolic expression of the RRA is deduced from the equation junctions. The first form will be expressed by:

$$\sum b_i f_{i_n} + \sum Sf + \sum \omega_i = 0 \qquad (47)$$

For a junction 0:

$$\sum b_i e_{i_n} + \sum Se + \sum \omega_i = 0 \qquad (48)$$

For a junction ΣSf 1: With the sum of the sources flows due to the junction 0, ΣSe the sum of the sources flows to the junction 1, and b = ± 1 depending on whether the half-arrow into or out of the junction. The unknown variables and ein end.

- Step 4: The unknown variables are eliminated by browsing causal paths between the sensors or sources and unknown variables.

- Step 5: After removal of the unknown variables, the uncertain RRAS is in the form:

$$RRA: \phi(\sum Se, \sum Sf, De, Df, \tilde{De}, \tilde{Df}, \sum \omega_i, R_n, C_n, I_n, TF_n, GY_N) = 0 \quad (49)$$

Where, TFn and Gyn are respectively the nominal values of the moduli of TF and GY elements. Rn, Cn and In are the nominal values of the components R, C and I. Σwi is the sum of the modulated inputs corresponding to the uncertainties on the junction-related items.

b) Generation of adaptive thresholds: The generated RRAS consists of two separated parts by the use of the LFT model, a nominal part denoted r:

$$r = \phi(\sum Se, \sum Sf, De, Df, \tilde{De}, \tilde{Df}, \sum \omega_i, R_n, C_n, I_n, TF_n, GY_N) \quad (50)$$

and uncertain part denoted with

$$b = \sum \omega_i :$$

$$\omega_i = \phi(De, Df, \tilde{De}, \tilde{Df}, R_n, C_n, I_n, TF_n, GY_n, \delta_R, \delta_I, \delta_C, \delta_{TF}, \delta_{GY}) \quad (51)$$

Where, ΔR dI, Ac, δTF, δGY are respectively the values of multiplicative uncertainty on the elements R, I, C, TF and GY, the uncertain portion of the RRA used for generating the adaptive thresholds of normal operation as an envelope that contains the residue in the absence of the defects. A parametric uncertainty can be defined as a slight deviation of the parameter from its nominal value, with no effect on the proper functioning of the system. It can be constant or variable and may vary randomly in a positive sense and in a negative direction. Given this kind of uncertainty parameters, and by using the properties of the absolute value of a real:

$$|\omega_i| = |\delta_i e_{in}|$$

$$|\omega_i| = |\delta_i f_{in}|$$

Indeed starting RRA of equation (50), r and substituting its value (eq. (53)) in the RRA are obtained:

$$r + \sum \omega_i = 0 \Rightarrow r = -\sum \omega_i$$

While asking

$$a = \sum |\omega_i|$$

We then

$$r \leq a$$

Since the variation of the residue is the image of the variation of the uncertainties in the absence of defects, it can vary in a positive direction and a negative direction. It is, therefore, necessary to generate a lower (negative) threshold - a noted.

$$-a \leq r \leq a$$

In this part, we presented the diagnostic methods according to the Bond Graph approach, the use of observers with unknown inputs does not provide a representation of the fault deduced directly from the model of the link graph. The analytic redundancy relationships generated using the parity space method depends on knowing the degree of diversion to be applied. The benefits of using this latter method consist of the simplicity of understanding the (RRAS) because they correspond to the relationships and the variables displayed by the bond graph model, then the transition to the LFT form by simply adding the data source. The effort and the flow modulated the image of the physical process.

IV. Application and Simulation Results

The previous sections have presented the diagnostic methods based on the link graph models. In this section, we will illustrate some examples of technical applications based on the generation of analytic redundancy relationships. The system in Fig. 20 represents the diagnostic techniques of academic platform tests. It consists of 3 tanks, 3 valves and a flow source.

The jump pattern corresponding to the graph is given in Fig. 21.

The analytical redundancy relations generated from the model in Fig. 21 are given by:

$$ARR_1 = s_f - \phi c_{T1}(P) - \phi_{R_{V1}}(P_1, P_2) = 0 \quad (52)$$

With

$$\phi c_{T1}(P_1) = \frac{A_1}{g}\frac{dP_1}{dt}$$

$$\phi_{R_{V1}}(P_1, P_2) = C_{db}.sign(P_1 - P_2)\sqrt{|P_1 - P_2|}$$

$$ARR_2 = \phi_{R_{V1}}(P_1, P_2) - \phi c_{T2}(P_2) - \phi_{R_{V2}}(P_2, P_3) = 0 \quad (53)$$

With

$$\phi c_{T2}(P_2) = \frac{A_2}{g}\frac{dP_2}{dt}$$

$$\phi_{R_{V2}}(P_2, P_3) = C_{db}.sign(P_2 - P_3)\sqrt{|P_2 - P_3|}$$

$$ARR_3 = \phi_{R_{V2}}(P_2, P_3) - \phi c_{T3}(P_3) - \phi_{R_{V3}}(P_3) = 0 \quad (54)$$

With

$$\phi c_{T3}(P_3) = \frac{A_3}{g}\frac{dP_3}{dt}$$

$$\phi_{R_{V3}}(P_3) = C_{do}.sign(P_3)\sqrt{|P_3|}$$

The three residues represented in Fig. 22 are the result of the introduction of a fault type "leak" t = 0.25 t = 0.75 at the No. 1 tank.

The introduction of the same type of defect in No. 2 tank gives the results in Fig. 23

The same fault as the previous two results is introduced into vessel 3, giving the residues represented by Fig. 24:

The result of a combined defect of the three tanks at the same time is given in Fig. 25.

The response of the system in the presence of three simultaneous faults is shown in Fig. 26.

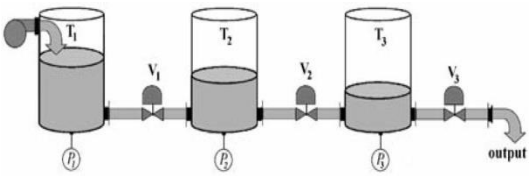


Fig. 20. Hydraulic System 3 Tanks.

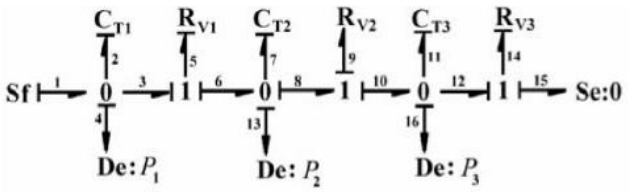


Fig. 21. Hydraulic System Model Bond Graph 3 Tanks.

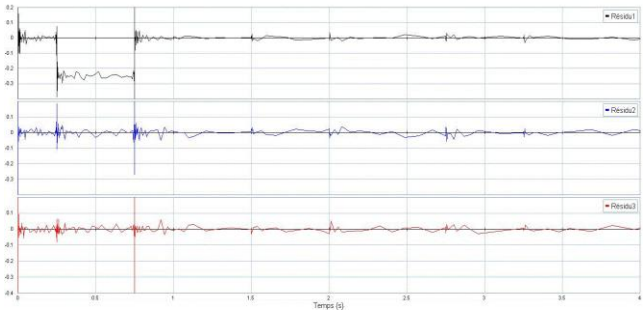


Fig. 22. Residues Resulting from a Defect Leakage on Tank 1.

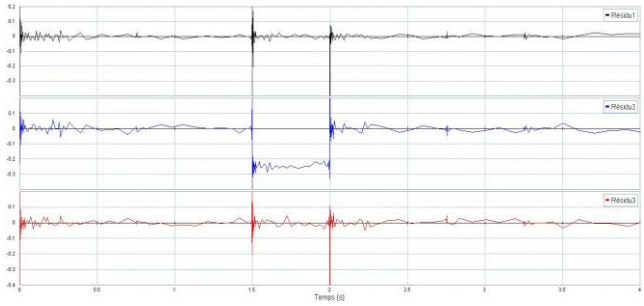


Fig. 23. Residues Resulting from a Defect Leakage on the Tank 2.

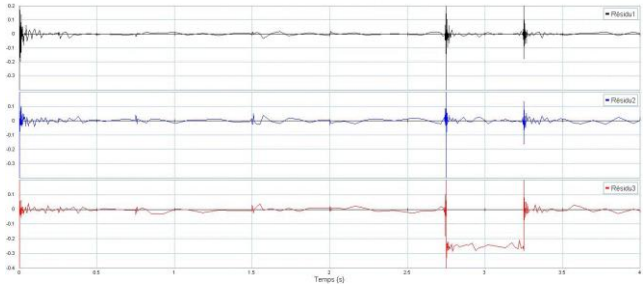


Fig. 24. Residues Resulting from a Defect Leakage on the Tank 3.

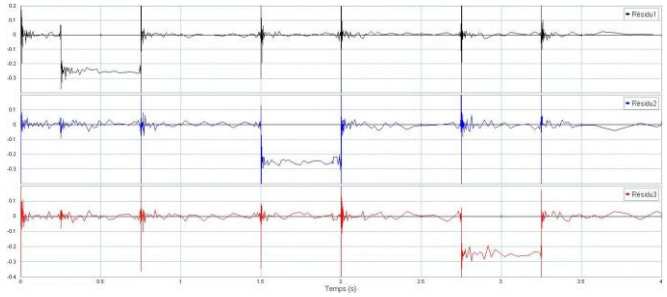


Fig. 25. Bottoms Combined Defects on the Tank 1.2 and 3.

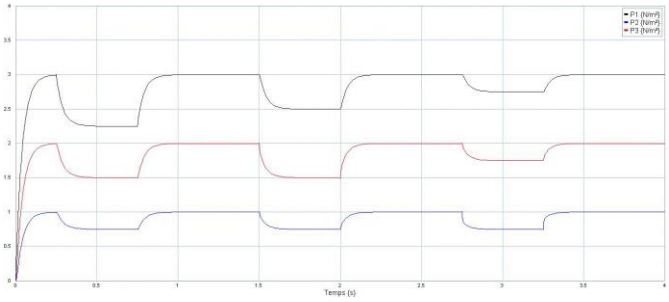


Fig. 26. Response System to Three Defects Combined on the Tanks 1, 2 and 3.

V. Discussions

The results of the application of the basic diagnostic method to the bond graph model proved the effectiveness of the technique in detecting the insulation defects in a single system.

– For the detection: the residue is zero as long as there is no fault in the system, the introduction of a default passed the residue to a non-zero value.

– For the isolation: the passage of the residue at a non-zero value (or exceeds the threshold) is the result of a defect in the corresponding tank.

1) Case study of an asynchronous motor

a) Bond Graph Model of the asynchronous motor: The bond graph model of the asynchronous squirrel-cage motor is given by Fig. 27.

The simulation model presented above shows the obtained results (ias, ibs, ics and angular velocity) (Fig. 28).

The load torque absence is shown in Fig. 29:

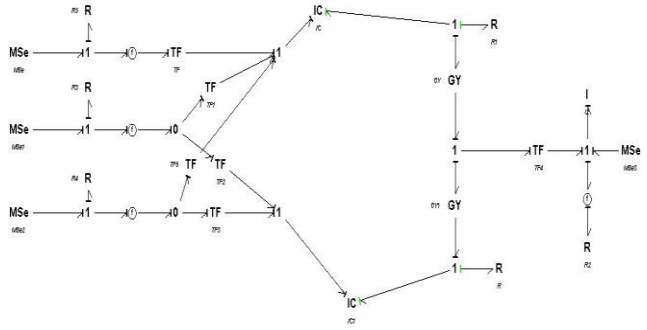


Fig. 27. Bond Graph Model of the Asynchronous Motor with Cage.

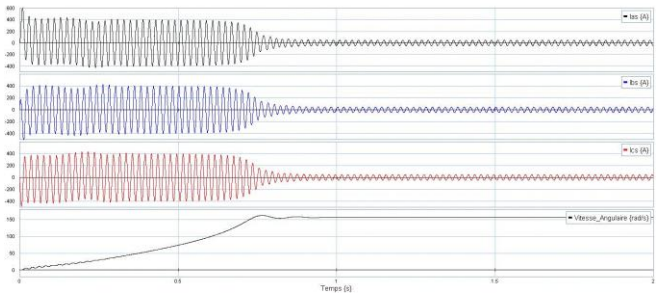


Fig. 28. The Stator Currents and the Angular Velocity of the MAS.

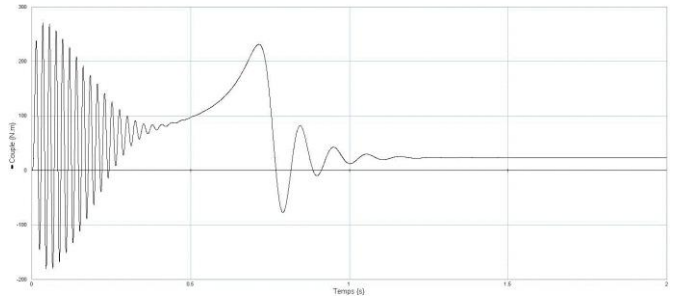


Fig. 29. The Couple Absence Charge.

The torque as a function of the angular velocity is illustrated in Fig. 30.

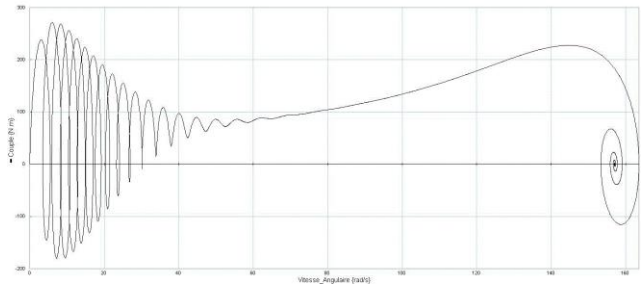


Fig. 30. The Torque Depending on the Angular Velocity of Load Absence.

The development of the asynchronous motor modeling step is detailed in [23].

However, to introduce the defects in the rotor of the asynchronous motor, it is necessary to represent the expression of the currents in each bar. The link graph model presented in the following section will allow us to apply the diagnostic methods studied in the previous sections

b) BG model of an asynchronous motor with cage for the diagnosis: The bond graph model presented in Fig. 31 will allows us to introduce the defects (bar Break, shorted turns in a coil, ...) in the asynchronous motor. (The modeling step is detailed in [23], [24] and [25]).

The stator currents in the two-phase mark are:

$$\begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} = \begin{bmatrix} \frac{\sqrt{2}}{\sqrt{3}} & -\frac{1}{\sqrt{6}} & -\frac{1}{\sqrt{6}} \\ 0 & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \end{bmatrix} \begin{bmatrix} i_{sa} \\ i_{sb} \\ i_{sc} \end{bmatrix} = \begin{bmatrix} \frac{1}{m_1} & \frac{1}{m_2} & \frac{1}{m_3} \\ 0 & \frac{1}{m_4} & -\frac{1}{m_5} \end{bmatrix} \begin{bmatrix} i_{sa} \\ i_{sb} \\ i_{sc} \end{bmatrix} \quad (55)$$

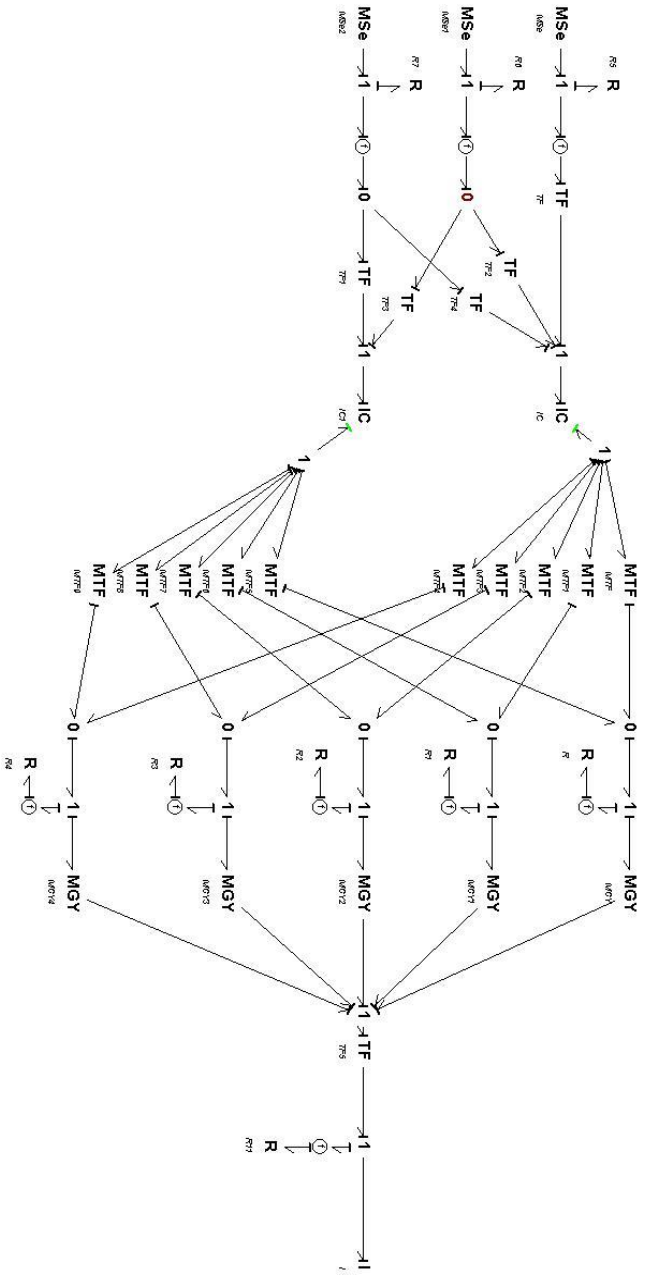


Fig. 31. BG Model of the Asynchronous Motor for the Diagnosis.

The stator voltages are given by the following equations:

$$\begin{bmatrix} V_{\alpha s} \\ V_{\beta s} \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} R_s + \frac{L_s d}{dt} & 0 & \frac{L_m d}{dt} & 0 \\ 0 & R_s + \frac{L_s d}{dt} & 0 & \frac{L_m d}{dt} \\ \frac{L_m d}{dt} & L_m \omega_r & R_r + \frac{L_r d}{dt} & L_r \omega_r \\ -L_m \omega_r & \frac{L_m d}{dt} & -L_r \omega_r & R_r + \frac{L_r d}{dt} \end{bmatrix} \begin{bmatrix} i_{\alpha s} \\ i_{\beta s} \\ i_{\alpha r} \\ i_{\beta r} \end{bmatrix} \quad (56)$$

The electromagnetic torque for an induction motor with pole P is given by.

$$T_e = \frac{P}{2}\left[i_{\alpha r}\left(L_m i_{\beta s} + L_r i_{\beta r} \right) - i_{\beta r}\left(L_m i_{\alpha s} + L_r i_{\alpha r} \right) \right] \quad (57)$$

The mechanical equation is:

$$T_e = J\frac{d\omega}{dx} + c\omega + T_L \quad (58)$$

Such as:

The moment of inertia is given by J = 0.4 kg m2 • c the friction of the shaft bearings is + = 0.15 N • s / m load torque TL. Vαs, Vβs are the stator voltages of the α and β axes in the Park coordinate system. iαs and iβs are the stator currents of the α and β axes in the Park coordinate system. iαr, iβr are the rotor currents of the α and β axes in the Park coordinate system. Rs is the stator resistance 0.0788Ω Rr1... Rr5 bars are the Rotor resistors 0.0408Ω Ls = stator inductance = 0.

The equation characterizing the IC element of Fig. 31 is given by:

$$\phi_{IC} = \begin{bmatrix} \lambda_{\alpha s} \\ \lambda_{\alpha r} \end{bmatrix} = \begin{bmatrix} L_s & L_m \\ L_m & L_r \end{bmatrix} \begin{bmatrix} i_{\alpha s} \\ i_{\alpha r} \end{bmatrix} \quad (59)$$

Expression of the currents in each rotor bar is as follows: [23]

$$i_{rk} = m\left[i_{\alpha r}\cos\left\{\theta + \frac{2(k-1)\pi}{n}\right\} + i_{\beta r}\sin\left\{\theta + \frac{2(k-1)\pi}{n}\right\}\right] \quad (60)$$

Such as:

$$m = \sqrt{\frac{2}{n}}$$

We ask:

$$mr_k = m * \cos\left\{\theta + \frac{2(k-1)\pi}{n}\right\}$$
$$k = 1, 2, \ldots, n \quad (61)$$

$$mr_{k+n} = m * \sin\left\{\theta + \frac{2(k-1)\pi}{n}\right\}$$
$$k = 1, 2, \ldots n$$
$$whith$$
$$n = 5 \quad (62)$$

The mr_k y represents the modulated Transformer Modules revealed in Fig. 31. By substituting the expression of the currents in the electromagnetic torque equation (57):

$$T_e = \sum_{k=1}^{5} T_k = \frac{P}{2}\sum_{k=1}^{5}\frac{\sqrt{2}}{\sqrt{5}}\left[\lambda_{\beta r}\cos\left(\theta + \frac{2(k-1)\pi}{n}\right) - \lambda_{ar}\sin\left(\theta + \frac{2(k-1)\pi}{n}\right)\right] i_{rk} \quad (63)$$

We ask:

$$r_k = \sqrt{\frac{2}{n}}\left[\lambda_{\beta r}\cos\left(\theta + \frac{2(k-1)\pi}{n}\right) - \lambda_{ar}\sin\left(\theta + \frac{2(k-1)\pi}{n}\right)\right] \quad (64)$$

r_k Represent the modules gyrators $MGY\ \ MGY \rightarrow 4$ in Fig. 31 the stator currents and the angular velocity are depicted in Fig. 32.

The rotor current of the induction motor healthy cage is shown in Fig. 33.

c) Asynchronous engine diagnostics: The application of the method presented in the previous section on the model shown in Fig. 31 results in the generation of the following analytical redundancy relations:

$$RAA_1 = V_a - \phi_{R_{sa}} - m_1 * \left(\phi_{I1} + \frac{1}{m_2}\left(V_b - \phi_{R_{sb}}\right) - \frac{1}{m_3}\left(V_c - \phi_{R_{sc}}\right)\right) = 0 \quad (65)$$

$$RAA_2 = \phi_{I2} + \phi_1 + \phi_2 + \phi_3 + \phi_4 + \phi_5 = 0 \quad (66)$$

With:

$$\phi_{IC} = \begin{bmatrix} \phi_{I1} \\ \phi_{I2} \end{bmatrix}$$

$$\phi_i = m_{ri}\left(\phi_{Rri} + \frac{r_i}{m_6}\omega\right)$$

Residues of an asynchronous motor without fault are shown in Fig. 34.

A bar breakage at the instant (t = 1.5s) on the rotor of the asynchronous squirrel-cage motor produces the following residues (Fig. 35).

The rotor currents are shown in Fig. 36.

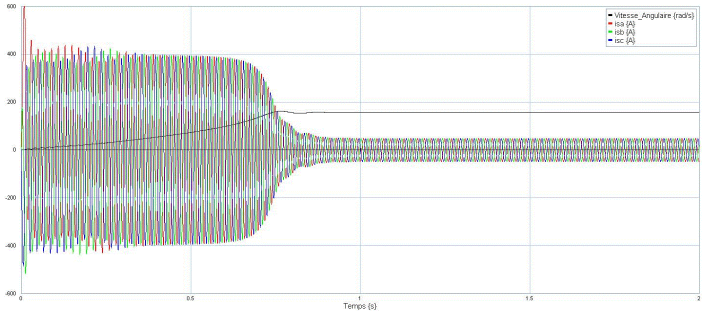


Fig. 32. Stator Currents and Speed of the Asynchronous Motor Healthy.

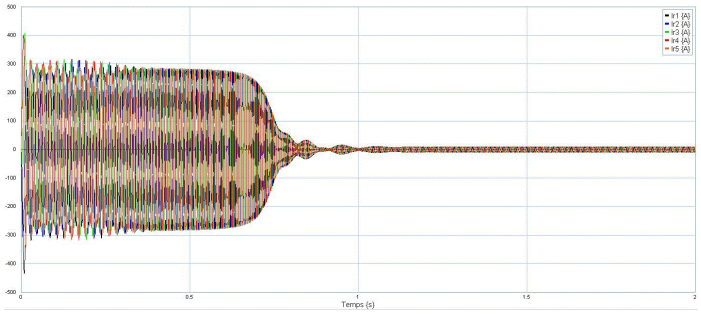


Fig. 33. Rotor Asynchronous Motor Currents of the Healthy.

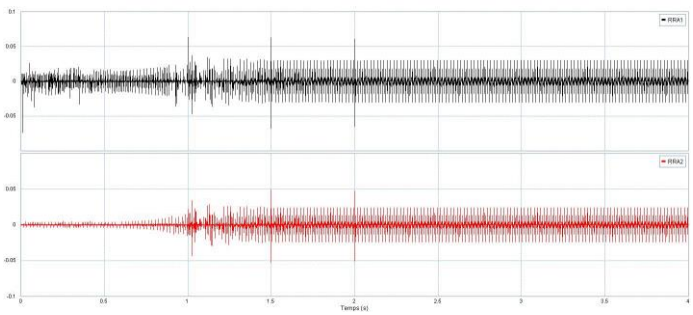


Fig. 34. Residues of a Healthy Asynchronous Motor.

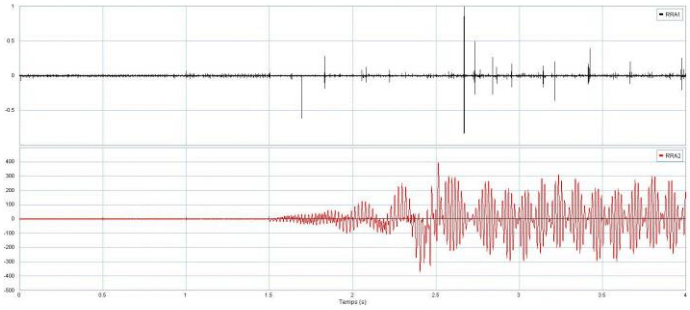


Fig. 35. Residues of an Asynchronous Motor with One Broken Bar.

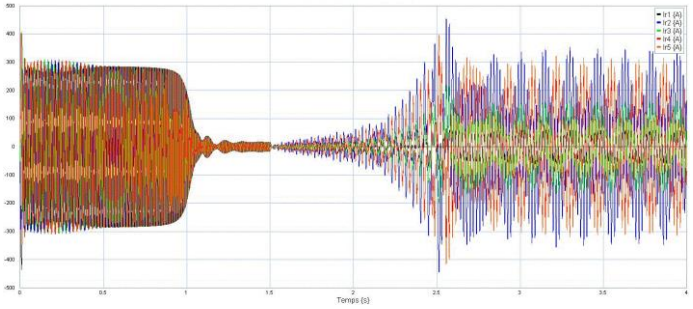


Fig. 36. The Rotor Currents of an Asynchronous Motor with One Broken Bar.

A short circuit turns to (t = 1.5s) of a stator coil produces the residues represented by Fig. 37.

An asynchronous motor fault is detected by passing the residues obtained from the RRAS to a non-zero value. The isolation is achieved by the sensitivity of each RRAS to a particular fault. A rotor failure (bar breakout) is isolated bypassing the residual 2 (RRA2) to a non-zero value (Fig. 35). A stator fault (short circuit) is isolated from the residue 1 (RRA1) at a value other than zero (Fig. 37).

d) Robust diagnostic asynchronous motor with cage: The uncertain Bond Graph model of an asynchronous motor with a cage is shown in Fig. 38.

A deviation in the value of the resistance of a stator coil causes a variation of the residue 2, the alarm is not triggered until there is no excess of the value of the adaptive thresholds (± a) (Fig. 39).

The detection of the index D allows us later to detect the defect. A short circuit in a stator coil is detected and isolated bypassing the detection index D to a positive value (Fig. 40).

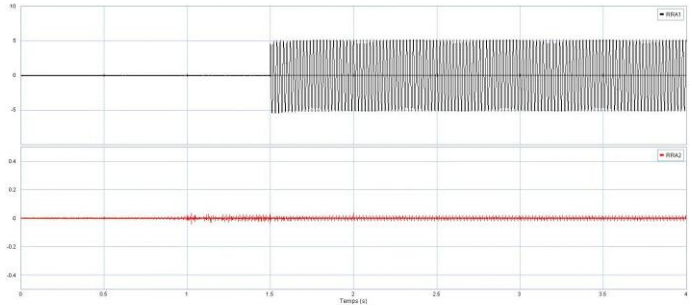


Fig. 37. Residues with Short Circuit the Turns of a Stator Winding.

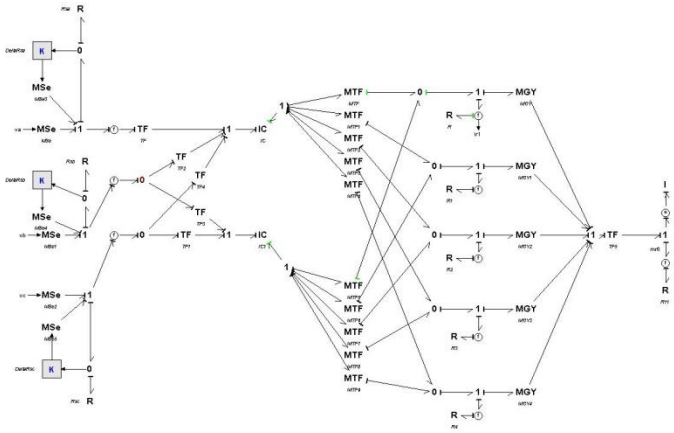


Fig. 38. BG-LFT Model of Asynchronous Motor with Cage.

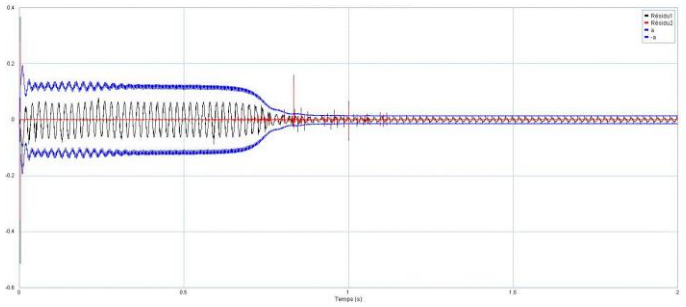


Fig. 39. Residues Robust to Parameter Variations.

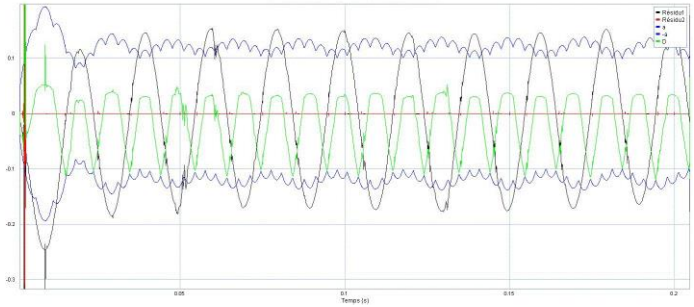


Fig. 40. Fault Detection in the Presence of Parametric Variations.

This section presents the BG LFT modeling and the reliable diagnosis of a cage asynchronous motor. The interaction of different phenomena is taken into account through the energetic properties of the link graph tool. The use of the LFT form to model the link graph elements is

generated, from the model, the residuals and the adaptive thresholds for normal operation. The detection index is used to detect the defects with the parametric variations of the support in the monitored system.

VI. Conclusion

In the current economic climate, business performance must be growing. For that, the pumping system must always be produced with good performance, with low cost, and inefficient severe security conditions. Also, the processes are increasingly complex and increasingly computerized. Thus, it is less obvious or intuitive to know if everything is going well in a process. For this purpose, monitoring methods that allow the detection and diagnosis of faults (errors) are presented. Over a fault is detected early and correctly diagnosed, the production process will comply with the requirements of the safety requirements. We presented a method that allows a robust diagnostic link graph to include it in a single tool: the modeling and the diagnostics.

There are many perspectives for this research work. Diagnosis wise, complex systems are usually no linear and no stationary, which makes developing diagnosis algorithms that are capable of covering most of the operation ranges very difficult.

Robust diagnosis of no stationary systems is a perspective theme that can be developed with multi-model approach. The difficulty in such approaches lies in the discontinued transition between models which can trigger false alarms.

References

[1] H.Belgacem. Simulation and Modeling of a Photovoltaic Pumping Installation by Bond Graph, indjst, Indian, 2018.

[2] B. Dubuisson. Diagnosis and Recognition Of Shapes. Hermes, Paris, 1990.

[3] S. Gentile. artificial intelligence for monitoring continuous processes. In Proceedings of Summer School On Auto Grenoble, Grenoble, France, 2-6 September 1996.

[4] R. Iserman. Process modeling is based on fault detection and estimation methods. A Survey Automatica, 20 (4): 387-404, 1984.

[5] Frank PM. Fault diagnosis in dynamic systems using analytical and knowledge-based redundancy - a survey and some new results. Automatica, 26 (3): 459-474, 1990.

[6] J. Ragot and D. Maquin. An algorithm for redundancy Obtaining equation of LTI systems. Automatica, 30 (3): 537-542, 1994.

[7] D. Maquin AND J. Ragot. Diagnosis Of Linear Systems. Hermes, Paris, France, Hermes edition 2000.

[8] R. and B. Iserman Freyermuth. Process Fault Diagnosis Based on Process Model Knowledge-Part I: Principle For Fault Diagnosis With Parameter Estimation. Transaction of the ASME, 113: 620-626, 1991.

[9] DG Luenberger, An Introduction to Observers. IEEE Transactions on Automatic Control. Flight AC-16, N6, pp 596-602, December 1971.

[10] AS Willsky. A Survey of Design Methods for Failure Detection in Dynamic Systems. Automatica, Vol 12, pp 601-611, 1976.

[11] RV Beard. Failure Accommodation in Linear Systems Through SelfReorganization. Ph.D. dissertation, MIT, Dep Aero Astro Cambridge, February 1971.

[12] PJ Feenstra, PJ Masterman G. Biswas, PC Breedveld, Bond graph modeling procedures for fault detection and isolation of complex flow processes, in Proc. ICBGM'01, Simulation Series, Vol. 33, no. 1, 2001, pp. 77-82, ISBN: 1-56555-103-6.

[13] T. Kohda H. Katsube H. Fujihara and K. Inoue. Identification of system failure causes using bond graph models. International Conference on Systems, Man and Cybernetics. Conference Proceedings, 5: 269-274, 1993.

[14] C. Ghiaus. Fault diagnosis of air conditioning systems is based qualitative bond graph. Energy and buildings, 30: 221-232, 1999.

[15] P. Haves, T. Salsbury and J. Wright. Condition monitoring in HVAC sub-systems using first-principles models. ASHRAE Transactions (Part 1), pages 519-527, 1996.

[16] W. Lee, C. and G. Kelly Park. Fault detection in an air-handling unit using residual and recursive parameter identification methods. ASHRAE Transactions (Part 1), pages 528-539, 1996.

[17] S. F. Lin et A. P. Wang. Design of Observers with unknown inputs using eigenstructure assignement. International Journal of Systems Science, 31(6): 705-711,2000.

[18] Mr. Blanke, Mr. Kinnaert, Lunze J., and M. Staroswiecki. Diagnosis and Fault Tolerant Control. Springer-Verlag, 2003.

[19] G. Dauphin-Tanguy, A. Rahmani, and C. Sueur. Bond graph aided the design of controlled systems. Simulation Practice and Theory, 7(5-6): 493-513, 1999.

[20] Mr. Basseville and IV Nikiforov. Detection of Abrupt Changes: Theory and Application. Prentice Hall, ISBN 0-13-126780-9, 1993.

[21] A. Oustaloup. (1994). Robustness. Hermes ISBN. 2-86601-442-1.

[22] A. Djeziri. Diagnosis of uncertain systems by the bond graph approach. Ph.D. thesis of the University of Science and Technology of Lille, December 17, 2007.

[23] J. Kim and Bryant. Bond graph model of a squirrel cage induction motor directly with a physical connection, ASME Journal of Dynamic Systems, Measurement, and Control, Vol. 122, pp. 461-469, September 2000.

[24] B. Umesh Rai L. Umanand. Bond graph model of doubly fed induction three-phase motor using the Axis Rotator element for frame processing. Simulation Modeling Practice and Theory Volume 16, Issue 10, November 2008, Pages 1704-1712.

[25] B. Umesh Rai L. Umanand. Generalized bond graph model of a rotating machine. International Journal of Power Electronics 2009 - Vol.1, No.4 pp. 397-413.

Speculating on Speculative Execution

Assessing the Risk of Simultaneous Hyperthreading

Jefferson Dinerman
Secondary School Student and Independent Researcher
Alexandria, VA | United States of America

***Abstract*—Threat actors continue to design exploits that specifically target physical weaknesses in processor hardware rather than more traditional software vulnerabilities. The now infamous attacks, Spector and Meltdown, ushered in a new era of hardware-based security vulnerabilities that have caused some experts to question whether the potential cybersecurity risks associated with simultaneous multithreading (SMT), also known as hyperthreading (HT), are potent enough to outweigh its computational advantages. A small pool of researchers now touts the need to disable SMT completely. However, this appears to be an extreme reaction; while a more security focused environment might be inclined to disable SMT, environments with a greater level of risk tolerance that may need the performance advantages offered by SMT to facilitate business operations, should not disable it by default and instead evaluate software application-based patch mitigations. This paper provides insights that can help make informed decisions when determining the suitability of SMT by exploring key processes related to multithreading, reviewing the most common exploits, and describing why Spectre and Meltdown do not necessarily warrant disabling HT.**

Keywords*—Speculative execution; hyperthreading; Spectre; meltdown; simultaneous multithreading

I. Introduction

Although the news fervor regarding hardware-based vulnerabilities has begun to subside, the potential risk to unprotected systems remains just as relevant. Threat actors continue to design exploits that specifically target physical weaknesses in processor's hardware. The now infamous attacks, Spector and Meltdown ushered a new era of hardware-based security exploits by attacking vulnerabilities in computer processor hardware instead of attacking software vulnerabilities. Immediately following their disclosure, Intel and AMD scrambled to quickly release firmware patches to their processors in order to mitigate the potential risk of exploitation.

However, not everyone felt that the mitigations were sufficient. Google later announced that it was disabling Hyper-threading on all Chromebooks running Chrome OS 74**.** Additionally, Theo de Raddit, founder and owner of OpenBSD, railed against Hyper-threading stating that, "SMT is fundamentally broken because it shares resources between the two CPU instances and those shared resources lack security differentiators." [1] He went on to explain that the risk of side-channel attacks like Spectre and Meltdown are dangerous enough to warrant disabling Hyper-threading on all computers running OpenBSD OS [2].

Despite the previously mentioned security concerns, system architects should not automatically follow Google and de Raddit's lead. Instead, architects ought to conduct a thorough analysis of their own environment to determine the risk level of leveraging multithreading. The following provides insights that can help architects make informed decisions when determining the suitability of SMT by exploring key processes related to SMT, reviewing prominent SMT exploits, and describing why Spectre and Meltdown does not necessarily warrant disabling SMT. Building this case, the remainder of the paper will first provide a high-level description of the key processes and components involved during speculative execution. Second, briefly describe the most renown Spectre and Meltdown variants. Third, leveraging the Common Vulnerability Scoring System, provide a methodology to characterize these exploits' severity.

II. Key Processes and Components

A. Simultaneous Multithreading

Processors were originally constructed from a single core with a single thread of execution. However advantages in a number of areas to include energy efficiency, true concurrency, performance, isolation, and reliability led to CPUs designs with multiple physical cores (each possessing their own ALU, registers, and other necessary components) on a single die [3]. The die is still commonly referred to as a single CPU despite it being composed of numerous individual cores. Fig. 1 below depicts how multiple cores can operate within a single die.

However, additional transitors packed onto a more compact form led to greater heat dispertion and power consumption - something that is not desirable in a processor. In order to combant this, SMT was created. SMT allowed a single core to to appear as two (or more) logical cores to an OS with each logical core running a single thread of execution. This meant that although a CPU may only have four physical cores (quad core), with SMT, the OS would percieve it as having eight logical cores. If a program required that the processor fetch a section of data from main memory, instead of the rest of the core sitting idly by waiting for the data transfer, the ALU or FPU could begin computation on another section of instructions.

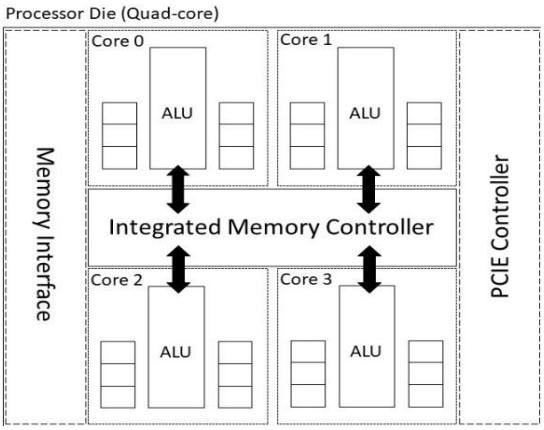


Fig. 1. Typical Architecture and Interactions for Multiple Cores on a Single Die.

B. Caching

Caching is a technique used by processors to compensate for the dichotomy between the processing speeds of the CPU and the slower speeds of main memory (RAM). Modern CPUs use a hierarchy of successively slower but larger caches built directly into the chip in order to decrease the latency between execution of instruction sets. The cache is divided into fixed-sized chunks of memory called lines. Each line is typically 64 or 128 bytes long, with larger cache sizes resulting in greater speed performance. Depicted in Fig. 2, when the processor attempts to fetch data from memory, it will first check the L1 cache at the top of the hierarchy for a copy of the data [4]. If the data is found, it is referred to as a cache hit, if not it is referred to as a cache miss. This process is then repeated moving down the chain from L1 to L2 to L3 cache until a hit is found. If all three caches result in a miss, then the processor will check system memory for the necessary data.

C. Speculative Execution

Speculative execution, also known as branch prediction, is the process by which a microprocessor closely tied into the fetch stage of the CPU instruction cycle makes a prediction as to what is most likely the next sequence of instructions in a program.

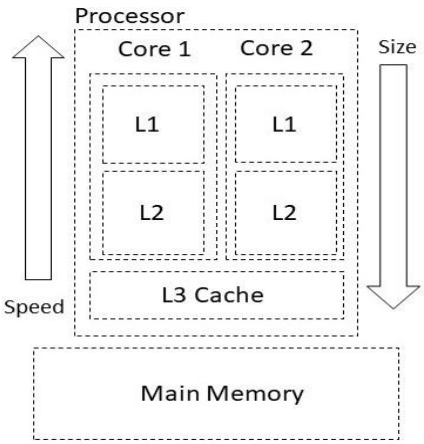


Fig. 2. Typical Cache Hierarchy.

Modern Intel processors have multiple forms of speculative execution for direct and indirect branches. Direct branch instructions relocate the stack pointer to a predefined memory address prior to the execution of the program [5]. In contrast, indirect branch instructions can jump to random memory addresses in the program computed at run time. In the Intel x86 architecture, this can be accomplished via the `jmp` instruction to jump to an address in a register, memory location, or on the stack. `jmp eax`, `jmp [eax]`, and `ret` respectively. Similar indirect and direct branch calls are also supported on ARM, MIPS, and RISK V architectures.

There are several functions that optimize indirect branches in order to compensate for the additional clock cycles necessary to process the instruction. The Branch Target Buffer (BTB) is a simple cache managed by the control unit that stores a mapping from addresses that recently executed branch instructions to destination addresses [6]. The BTB is leveraged by the processor to predict future code addresses before the decoding stage of a branch instruction. The Return Stack Buffer (RSB) stores a clone of the most recently processed section of the call stack [7]. Both BTB and RSB can greatly improve the speed of a running program by reducing the amount of computational work necessary for the processor.

D. Protected Memory

Protected memory is a method of controlling memory access rights on embedded systems. Its main purpose is to prevent apps from accessing regions of memory that they do not have proper security rights. For instance, one tab open in a browser should be restricted from accessing working memory from another tab. Without proper memory protection, data sections are vulnerable to memory related exploits or code injections [8]. This can be prevented by either software or hardware solutions. Software solutions assign a key value to a program during runtime that it must provide in order to gain access to the protected memory [9]. Hardware solutions work in a similar manner but separate threads of execution with logical barriers.

III. The Exploits

A. Spectre

Spectre is a general term used to describe a group of microarchitecture attacks that 'trick' the processor into speculatively executing malicious instruction sequences [10]. Because these instructions are eventually reverted by the CPU, they are referred to as transient instructions. By influencing which transient instructions are speculatively executed, information about memory addresses can be leaked from protected memory. Two prominent variants of the Spectre attacks exist - CVE-2017-5753 and CVE-2017-5715.

The first variant maliciously trains the branch prediction algorithm into erroneously executing a section of code that would not normally have been executed in the normal Von Neumann sequence. Listing 1 provides a short code example provided by the original Google Project Zero paper that better illustrates how this attack occurs [11].

In listing 1, the untrusted_offset_from_caller variable contains attack-controlled data. During the first phase of the

attack, the code is repeatedly invoked with a valid value (i.e. a value between 0 and arr1->length-1) for untrusted_offset_from_caller and thusly trains the branch predictor to predict the conditional on line 11 to evaluate as true. Next, during the second (or exploit) phase, the attacker invokes the same code but this time with the untrusted_offset_from_caller variable set to a value out of bounds for arr1. Because the first phase of the attack trained the branch predictor to expect the conditional to return true, if arr1->length is not cached, the processor will begin speculatively executing.

```
1.  struct array {
2.      unsigned long length;
3.      unsigned char data[];
4.  };
5.
6.  struct array *arr1 = ...; /* small array */
7.  struct array *arr2 = ...; /* array of size 0x400 */
8.  /* >0x400 (OUT OF BOUNDS!) */
9.
10. unsigned long untrusted_offset_from_caller = ...;
11. if (untrusted_offset_from_caller < arr1->length) {
12.     unsigned char value = arr1-
    >data[untrusted_offset_from_caller];
13.     unsigned long index2 =
    ((value&1)*0x100)+0x200;
14.     if (index2 < arr2->length) {
15.         unsigned char value2 = arr2->data[index2];
16.     }
17. }
```

Listing. 1. Spectre Exploit Pseudocode.

arr1->data[untrusted_offset_from_caller] even before the conditional has been fully evaluated.

Eventually the processor will finish evaluating the conditional and return to its normal non-speculative path. The out-of-bounds index call will be rolled back along with value2. However, the speculative execution will still temporarily store arr2->data[index2] in the L1 cache. By measuring the difference between the time to load arr2->data[0x200] and.

arr2->data[0x300], it can be determined whether value of index2 was 0x200 or 0x300; this determines if arr1->data[untrusted_offset_from_caller]&1 is 0 or 1. By selecting an appropriate value for untrusted_offset_from_caller, this process can leak address information stored in protected memory that usually would not be released but due to speculative evaluation is temporarily stored in the L1 cache [12].

The second variant of Spector relies on selecting a gadget in the victim's address space and influencing the target to speculatively execute that gadget. A gadget is a series of predefined machine instructions from the program being exploited. In order to execute the gadget, the attacker trains the BTB to erroneously predict an indirect branch to the address of the gadget. The training consists of the attacker repeatedly indirectly branching to the address of the gadget. After the BTB is trained to speculatively execute the address of the gadget, a similar approach as in variant one can be applied to leak protected memory.

B. Meltdown

Unlike Spector, Meltdown (CVE-2017-5754) does not rely on vulnerabilities in the victim's source code, but instead leverages out of order execution to run malicious code instructions in user-space. Note, an important part of OS memory management is how the OS links virtual memory to physical memory. When a process requests system memory, the OS will allocate a section of physical memory for use by the program. The OS then provides the running process with a virtual memory address that links to the actual physical memory address. A mapping between all virtual memory addresses and their physical counterparts is stored and referenced by the memory management unit (MMU).

To better illustrate how Meltdown leaks kernel physical memory addresses, consider the following short code section written in Listing 2 [13].

```
1.  ; rcx = kernel address, rbx = probe array
2.  xor rax, rax
3.  retry:
4.  mov al, byte [rcx]
5.  shl rax, 0xc
6.  jz retry
7.  mov rbx, qword [rbx + rax]
```

Listing. 2. Meltdown Exploit Pseudocode.

Three main steps are involved in the execution of the Meltdown vulnerability. Step one, an attacker selects the kernel restricted memory location they are attempting to gain access to and then loads that address into a specified register. This is accomplished in line 4 where the values of the kernel address (virtual memory) are stored in the least significant byte of the *RAX* register. When line 4 is executed, the *mov* instruction is fetched by the core before being decoded into microcode (µOps), allocated, and sent to the record buffer. By leveraging a process called out-of-order execution, the decoded and allocated µOps of lines 5-7 will be executed before line 4 is completed.

Step two consists of 'tricking' the processor into storing the restricted memory addresses in the L1 cache. Line 5 multiplies the secret value from Step 1 (the linked physical address to the virtual memory location) by the page size. This negates the ability for the hardware pre-fetcher to load adjacent memory locations into cache. In the example above, a single byte is read at a time resulting in the dimensions of the probe being 256 x 4096. Finally, Line 7 adds the multiplied secret to the base address of the probe array. Similar, to the Spectre attack, once the processor finishes the *mov* instruction it will throw an interrupt error and roll-back the following instructions, but the probe array will have already been stored in the L1 cache.

Step three, the exploit recovers the secret value from Step 1 via a microarchitecture side-channel attack on the L1 cache. When the transient instructions defined in step two are

executed, only one line of the probe array is cached. The position of that line in the array will depend on the value of the original secret. Therefore, by iterating over the full 256-page array and measuring the quickest load time, (*i.e. the cached one)* the original secret value can be determined. If this same process is repeated for each of the kernel restricted memory addresses, a complete memory dumb can be constructed of the kernel protect memory.

IV. Understanding the CVSS

An understanding of vulnerability severity is an important guidepost for architects deciding if they want to disable HT. CVSS scores are a useful tool to measure vulnerability severity. CVSS scores are developed by the multi-stakeholder organization Forum of Incident Response and Security Teams (FIRST) and serve as an important vulnerability severity assessment engine for many prominent organizations that include the National Institute of Standards and Technology (NIST) NVD database. CVSS assigns a vulnerability severity score that ranges from 0 – 10, with 10 being the most severe.

The heart of CVSS scoring is a combination of an exploitability assessment and a vulnerability impact assessment. Exploitability assessments characterize how easily a malicious actor may be able to exploit the vulnerability. Exploitability is comprised of possible attack vectors (AV), attack complexity (AC), the level of privilege (PR) required on a computer needed to execute an exploit, and whether the exploit can be executed without user interaction (UI). Impact assessments characterize the magnitude of the vulnerability in terms of confidentiality loss, integrity loss, and availability loss to the data on the computer.

Fig. 3-5 from the NIST National Vulnerability Database demonstrates that neither Spectre variants nor Meltdown exhibit an overall CVSS score above a 'MEDIUM'. (4.0 – 6.9 Overall Score).

For a more detailed explanation of CVSS scoring, refer to the CVSS user guide [14].

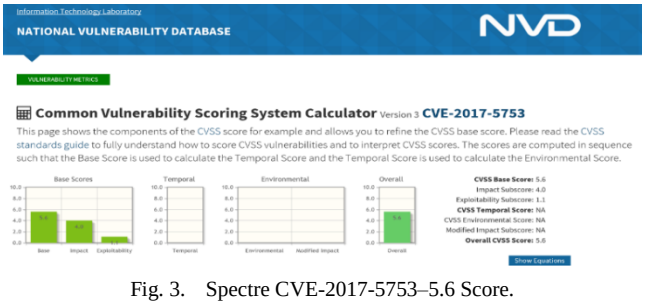


Fig. 3. Spectre CVE-2017-5753–5.6 Score.

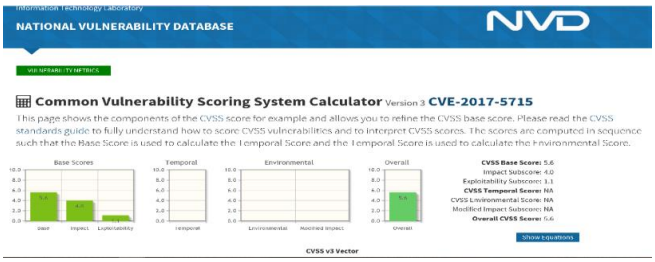


Fig. 4. Spectre CVE-2017-5715–5.6 Score.

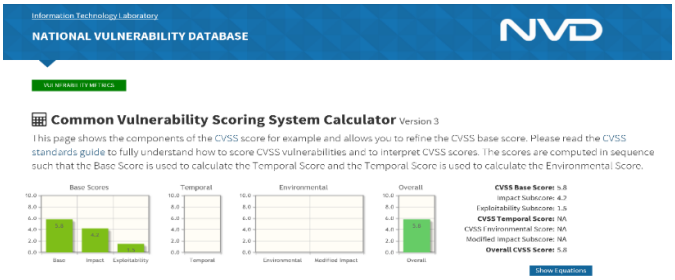


Fig. 5. Meltdown CVE-2017-5754–5.8 Score.

V. To Disable or Not to Disable SMT

Prominent subject matter experts such as Theo de Raddit argue that SMT's security vulnerabilities outweigh its performance advantages. However, this paper contends that while disabling hyperthreading may be appropriate in some environments, it should not be a defacto standard for enterprise architects. The CVSS assessment does not warrant such an action.

Although Spectre and Meltdown do present serious security concerns, their overall vulnerability severity remains a relatively unremarkable 'MEDIUM'. They both have a 'LOW' severity for exploitability due to the fact that neither attack can leverage a network connection for lateral movement. Additionally, these exploits are extremely difficult to operationalize and the ability for a malicious actor to successfully launch an attack is far from certain. Resultantly, both attacks have a higher attack complexity and a lower exploitability severity.

Spectre and Meltdown's impact severity do slightly elevate to the 'MEDIUM' range but remains well below the 'HIGH' severity threshold. Data confidentiality risks are more concerning because of memory dumping from kernel protected addresses, or information leaking from protected memory, but the risk to data availability or data integrity remains 'LOW'. Potential data leaks do not result in an alteration of stored data or the ability to access saved data.

VI. Conclusion

There is no 'one size fits all' approach to risk tolerance. Unique to each environment, is a careful balance between security and performance. Business and operational requirements should drive cybersecurity risk mitigation decisions. This balance aptly applies when determining whether to disable SMT. Even though both Spectre and Meltdown both rank 'Medium' in CVSS severity, a more security focused environment might be inclined to disable SMT and accept the performance loss. However, environments with a less cautious risk tolerance that needs the performance advantages from SMT to facilitate business operations should not disable SMT by default and instead evaluate software application-based patch mitigations.

References

[1] Theo Raditt, Disable SMT/Hyperthreading in all Intel BIOSes, e-mail message, OpenBSD Journal, August 24, 2018. https://undeadly.org /cgi?action=article;sid=20180824024934

[2] Ibid.

[3] Donald Firesmith, “Multicore Processing”, Carnegie Mellon Software Institute Blog, August 21, 2017, https://insights.sei.cmu.edu/sei_blog/multicore-processing-and-virtualization/ttps://insights.sei.cmu.edu/sei_blog/2017/08/multicore-processing.html

[4] Paul Kocher, Daniel Genkin, Daniel Gruss, Werner Haas, Mike Hamburg, Moritz Lipp, Stefan Mangard, Thomas Prescher, Michael Schwarz, and Yuval Yarom, “Spectre Attacks: Exploiting Speculative Execution”, ArXiv e-prints, January 2018, p 4 - 7.

[5] David Gregg, M. Ertl, (2003). "Optimizing indirect branch prediction accuracy in virtual machine interpreters", Sigplan Notices - SIGPLAN 38, 2003, p 278-288.

[6] Po-Yung Chang, Eric Hao, and Yale Patt, “Target Prediction for Indirect Jumps,” ACM SIGARCH Computer Architecture News, March 1998, pg 274 – 282.

[7] Giogo Maisuradze and Christian Rossow, “Speculative Execution Using Return Stack Buffers”, Proceedings of the 2018 ACM SIGSAC Conference on Computer and Communications Security, October 15 – 19, 2018, pg 2109 – 2111.

[8] Ibid, pg 2111 – 2114.

[9] Ibid, pg 2110.

[10] Paul Kocher, Daniel Genkin, Daniel Gruss, Werner Haas, Mike Hamburg, Moritz Lipp, Stefan Mangard, Thomas Prescher, Michael Schwarz, and Yuval Yarom, “Spectre Attacks: Exploiting Speculative Execution”, ArXiv e-prints, January 2018, pg 2.

[11] Jann Horn,“Reading Privileged Memory with a Side-Channel Attack”, Google Project Zero Blog, January 3, 2018. https://googleprojectzero.blogspot.com/2018/01/reading-privileged-memory-with-side.html

[12] John Criswell, Nicholas Geoffray, and Vikram Adve, “Memory Safety for Low-Level Software/Hardware Interactions”, USENIX Security Symposium, August 10 – 14, 2009, pg 10.

[13] Moritz Lipp et all. 2018, “Meltdown: Reading Kernel Memory from User Space”, USENIX Security Symposium, August 15 – 17, 2018, pg. 980.

[14] CVSS User Guide. 2019. FIRST.org. https://www.first.org/cvss/user-guide.

Performance Analysis of Acceleration Sensor for Movement Detection in Vehicle Security System

A.M. Kassim[1], A. K. R. A. Jaya[2], A. H. Azahar[3], H. I. Jaafar[4], S Sivarao[5], F. A. Jafar[6], M. S. M. Aras[7]
Centre of Excellence for Robotic, and Industrial Automation (CERIA)
Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya
Durian Tunggal, 76100 Melaka, MALAYSIA

***Abstract*—The vehicle security system is a critical part of an entire car system in order to prevent unauthorized access into the car. As the statistic has shown that the number of cases of the private car being stolen is increasing and the recovery rate is decreasing sharply, it shows that the car security system failed to perform to prevent unauthorized access. Most of the vehicle security system simply consists of a few door-open detection switches, siren, and remote control to protect the car, which appears to be weak against experienced car theft. Therefore, the project is carried out to develop a vehicle security system that can measure the dynamic acceleration inside the vehicle using the ADXL345 accelerometer and locate the coordinate of the vehicle by using U-Blox Neo-6M GPS receiver. In order to evaluate the performance of the proposed vehicle security system, the experiment to determine the most suitable position among the four places inside a car to place the device was conducted. Then, the performance analysis of the GPS receiver for accurate tracking also was done. The results showed that the most suitable position to place the device is inside the center of the car dashboard and the GPS receiver has a mean cold start-up time of 5 minutes 47 seconds and hot start-up time of 11.72 seconds, with a standard deviation of 0.000003706° in latitude and 0.000002762° in longitude for position tracking.**

Keywords*—Security system; acceleration sensor; movement detection; ADXL345

I. INTRODUCTION

The vehicle security system is a critical part of an entire car system in order to prevent unauthorized access into the car. Unfortunately, most of the car security system failed to prevent car theft. Starting from the first case of car theft in the year 1896, the number of cars being stolen has been raised rapidly. The statistic of the number of stolen private cars in Malaysia is increased drastically from 1980 to 2010 Although there is some decrease in the stolen cases for some years the number of cases is raised rapidly overall. The statistic shown that the number of cases of the private car being stolen is increasing year by year, it shows that the car security system failed to perform to prevent unauthorized access[1-2].

In addition, there are many methods used by car theft. The study conducted in 2009 in the United Kingdom, most cases happen when the car keys are being stolen in the burglary, which is 37% [2]. Followed by the cases where the owner left their car key inside the car (18%). 14% of the car stolen by forced ignition, where the theft hijacks the car wiring system to start the car and drive away. Hence, the conclusion that 72% of the cases are related to car keys (Other using keys 12%, Keys stolen in burglary 37%, Keys stolen in robbery 5%, Keys left in car 18%) which reflects that car keys failed to protect the car[3-5].

On the other hand, there is some lucky owner who could recover back their car after being stolen by car theft. The recovery rate for the year 2003-2004 (59.4% total) is higher than 2008-2009 which is only 10% of total cases. The recovery rate dropped sharply due to the rapid rise in the number of cases of a stolen vehicle in 2008-2009. With the low recovery rate, the performance and effectiveness of the vehicle security system should be taken into consideration seriously to prevent further increase in vehicle stolen cases [1]. Most of the cars today are equipped with a security system as a vehicle security system is becoming "must-have" equipment for the safety of every car. Different types of security systems are designed by a manufacturer or third party organization according to the car owner's need, some may include a vibration sensor or even a tilt sensor for additional protection.

Some researchers presented the vehicle security system, which consists of the remote keyless entry (RKE) and Immobilization with the use of the microcontroller unit (MCU). This system improves the safety of remote key control by introducing a unique authentication technique in which the remote unit generates different authentication codes to the MCU during each transmission which makes the decoding job difficult for car theft. This immobilizer system works by implementing an Integrated Circuit (IC) inside the car key remote control unit which communicates with the MCU by using a low frequency (LF) radio signal at 125 kHz with inductive coupling technique. After receiving the correct authentication code, the MCU will allow the engine to be started up by the user. This system has the advantages of secure communication which makes the radio intercept and replay technique failed to gain access to the vehicle[6-10].

In addition, there are some researchers also come out with a vehicle security system using radio-frequency identification (RFID). This system reduced the hacking probability to 10^{-14} by sending an 8-bit rolling unique authentication code each time the transmitter operates. Compared to passive RFID, active RFID has a longer range of up to 200 m for operation, which enables the owner to disable the stolen car in a safe distance. This system consists of three units which are transmitting unit, receiving unit and intelligent vehicle control unit that communicating with each other. In case a vehicle is in danger, the owner can simply press the disable button on the portable transmitting unit, which will then sends out the unique

authentication code to the receiving unit. After the receiving unit decoded the signal, the receiving unit communicates with the intelligent vehicle control unit to turn off the car engine. One of the advantages of this system is that the system includes an automatic gear shifter controller, which will shift the transmission to the neutral position in case the vehicle is at high speed and allows the vehicle to bring down the speed before the engine shuts down [11-14].

Iman M.Almomani, et al. and some researchers also designed a global positioning system (GPS) vehicle tracking and management system. This system combined both the global system for mobile communication (GSM), general packet radio service (GPRS) and GPS to achieve vehicle tracking. The GSM is used to send an alert message through short messaging service (SMS) which consists of four types of alert: over-speeding, enter/ exit a geofence area, car stops/ moves, and alarm status. GPRS is used to upload the tracking data onto GPRS Server in the user-defined interval which then allows online tracking via Web Server. Google Maps is used to display the vehicle position, which includes the geometrical information and graphical presentation, allows the user to recognize the vehicle's position easily. This system has the advantages of being user-friendly and easy management via the use of a computer or mobile phone. On the other hand, this system has disadvantages require internet connectivity to be functional [15-17].

Moreover, most of the vehicle security system simply consists of a few door-open detection switches, siren, and remote control to protect the car from unauthorized access, which appears to be weak against an experienced car thief. Besides, a remote control based vehicle security system only allows one way of communication, remote-to-car, this limitation causing the remote control based vehicle security system becoming passive as the owner only able to know the car is being intruded when he/she hears the siren. If the owner is inside a building, the system fails to inform the owner that his/her car is in danger. Besides, the conventional vehicle security system is not able to detect the location and movement of the vehicle, which fails to protect the car if it's pushed or towed away [18-20].

Hence, these issues lead to the development of a more advanced vehicle security system which is able to detect movement and/or vibration of the vehicle with location coordination reporting and two-way communication between the owner and the security system. The appropriate sensor will be selected to trigger the security system and immobilizer will be added to turn off the car engine after the movement has been detected.

II. Hardware Configuration

A. System Overview

The system overview is illustrated in Fig. 1 shows the relationship for each component to the microcontroller. The development of prototype consists of two parts where the first part is the hardware selection and construction. The hardware consists of a sensor, microcontroller, and actuator. The second part is about the development of software, the software is the coding programmed into the microcontroller for the control part. Microcontroller a device made up of processor, RAM, ROM, input and output (I/O) peripherals into an integrated circuit. Arduino microcontroller is preferred as it is open-source and it provides free content to be downloaded from the internet. Arduino Pro Mini 328 is chosen for this project as it has a small form factor of 18 mm x 33 mm, which is ideal for a vehicle security system where hidden installation can be made easily.

The Arduino microcontroller running at a clock speed of 16 MHz and provides 14 digital input/output (I/O) ports and eight analog input which is exactly the same as the famous Arduino Uno R3 microcontroller. Although it is small, it provides the serial peripheral interface (SPI) and I2C protocol for connecting sensors. In this project, Arduino Pro Mini 328 that is shown in Fig. 2 is used to process sensor reading from the ADXL345 accelerometer, U-Blox Neo-6M GPS receiver, RF remote module and GSM modem by C-language programming using Arduino Integrated Development Environment (IDE) software.

The ADXL345 accelerometer sensor comes with a small and thin integrated circuit and the module used in this project is made by the CJMCU Company. This module features dual voltage supply options of 5V and 3.3V for user convenient. ADXL345 accelerometer sensor is able to measure acceleration in X, Y and Z-axis with high resolution of 13-bits and user-configurable measurement range of ± 2g, ± 4g, ± 8g and ± 16g, which is more than enough for this project. Besides, the ADXL345 also features SPI (3 or 4 wire) and I2C digital interface for interfacing with microcontroller. The ADXL345 provides the measurement of tilt angle by measuring the static acceleration of gravity and dynamic acceleration in 3-axis, which is suitable for this project to detect any vehicle movement in all axis and transmit to the microcontroller. Fig. 3 shows the ADXL345 accelerometer used in this project.

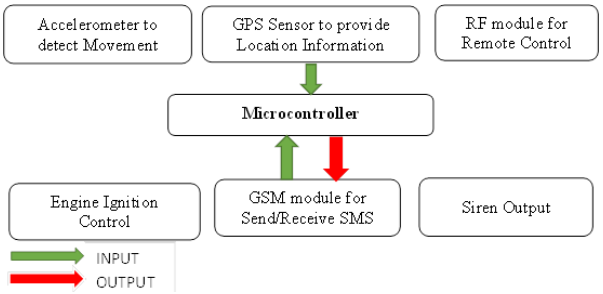


Fig. 1. System overview of Acceleration-based Movement Detection.

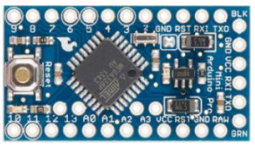


Fig. 2. Arduino Pro Mini 328.

Fig. 3. CJMCU_ADXL345 Accelerometer Sensor.

On the other hand, the global positioning system (GPS) receiver is a device which gathers satellite signal from the GPS satellite and calculates the position based on the received signal. The U-Blox Neo-6M GPS device, which is shown in Fig. 4, have featured high-performance tracking ability while maintaining cost-effective which makes it suitable for this project. This sensor can be connected by UART, USB, SPI and I2C protocol which makes it popular across many platforms. The cold start of the sensor takes 27 seconds for the first reliable reading at outdoor and a 1 second for hot-start ability. The U-Blox Neo 6M has a horizontal accuracy of 2.5 m which is enough for the tracking purpose. In addition, this sensor also provides velocity output at an accuracy of 0.1m/s and an altitude reading of a maximum of 50,000 m. In this project, the U-Blox Neo-6M GPS sensor will be connected to the Arduino Pro Mini microcontroller via UART protocol at 9600 baud rate and a reading update rate of 1Hz.

In addition, the GSM modem is a module that enables communication, SMS and internet connectivity over the cellular network. The Neoway M590E operates on the GSM network at 900 MHz and 1800 MHz which is supported in most countries and generally classified as 2G Network. A Sim card is needed for proper identification at Telecommunication Company. This module comes in the small form factor of 27.6 mm x 21.2 mm which enables a compact arrangement of this project. The Neoway M590E enables communication between the user and the Arduino Pro Mini by Send and Receive SMS. It connects with the microcontroller by using the UART protocol at 4800 baud rates. Fig. 5 shows the hardware overview of system configuration for each component used in this proposed system.

B. Acceleration Measurement Method

Fig. 6 shows the flowchart of the acceleration measurement part when the alarm is turned ON by the user, the sensor will be initialized with the first measurement reading as a reference point. After initializing, the sensor will measure the dynamic acceleration continuously to detect changes in acceleration in X, Y and Z-axis. If a measured acceleration value is higher than the threshold value, the siren alarm is triggered and followed by the activation of the engine ignition control relay, which will turn of the power of the ignition system. SMS will be sent to alert the user.

The output of the ADXL345 sensor through the I2C protocol needs to be filtered by taking average value to minimize the effect of noise. This is achieved by taking an average of five readings continuously and calculate the average value in 3-axis. The value is then converted to unit G based on the formula stated in ADXL345 datasheet as shown below. (±2g measurement range)

$$X_g = x\left(\frac{4}{1024}\right) \quad (1)$$

$$Y_g = y\left(\frac{4}{1024}\right) \quad (2)$$

$$Z_g = z\left(\frac{4}{1024}\right) \quad (3)$$

C. GPS Localization

Fig. 7 shows the flowchart of the GPS locating part of the project. From the datasheet, the U-Blox Neo-6M GPS Receiver will receive the GPS satellite signal and output national marine electronics association (NMEA) GPS data to the Arduino Pro Mini microcontroller. The microcontroller will decode the NMEA data by using the TinyGPS library [21] into GPS coordinate in Latitude and Longitude. These values will be stored in the microcontroller RAM as the Last Known Position. A link to Google Maps will be generated by using the Last Known Position and sent to the user when requested or intrusion detected. Formula (4) below shows the method of generating a Google Map Link. [22]

http://maps.google.com/?q=<lat>,<lng> (4)

where <lat> is the Latitude and <lng> is the Longitude.

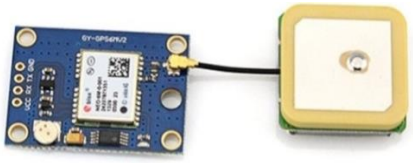


Fig. 4. U-Blox Neo-6M GPS Sensor.

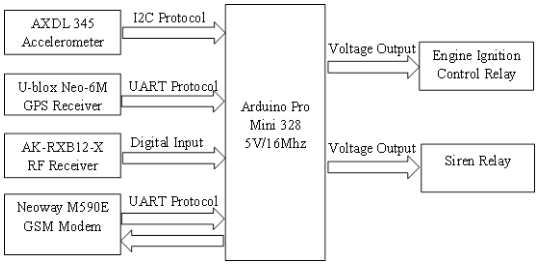


Fig. 5. Hardware Overview.

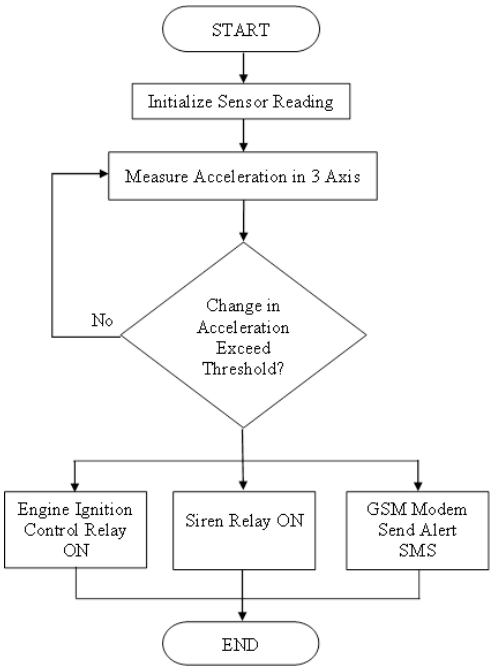


Fig. 6. Flowchart of the Acceleration Measurement.

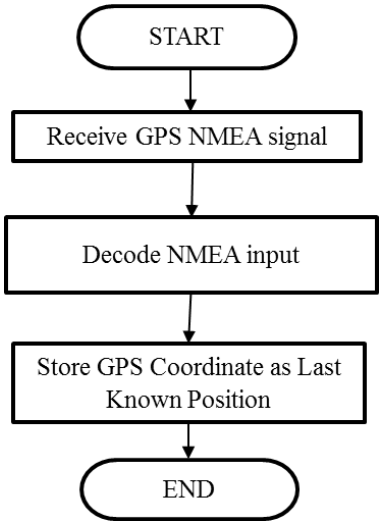


Fig. 7. Flowchart of the GPS Localization.

III. Experimental Setup

A. Experiment 1: Performance Analysis for Device Installation Place

In experiment 1, the objectives are to compare and find the best position of the accelerometer inside a car which gives a better reading when starting the engine. Measurement was made in four positions inside a car: 1) Center of the dashboard, 2) Storage compartment, 3) Under driver seat, and 4) Back bonnet. A prototype consists of accelerometer ADXL345, Arduino Pro Mini 328 and a Bluetooth module is developed to carry out this task. The Bluetooth adapter is used to transfer the measured acceleration data to the laptop wirelessly, which can reduce the error in measurement caused by the data cable. Fig. 8 shows the set-up of the prototype used in this experiment.

In order to maximize the validity of data measured from the experiment, three variable is identified before the experiment, which is an acceleration in X-Axis, Y-Axis, and Z-axis in-unit g (gravitational acceleration which is equal to 9.81 m/s). All the measurement is made in the same car, which is Proton Exora 1.6 CPS MT in this experiment, to increase the reliability of the measured data. The prototype is also secured to the surface using double-sided tape to ensure no sliding occurs. Besides, the orientation of the device is also fixed so that the three-axis did not interchange for better comparison.

B. Experiment 2: Performance Analysis for the GPS Receiver for Accurate Tracking

In experiment 2, the objective is to locate the coordinates of the device in a fixed position. The data from the U-Blox Neo-6M GPS Receiver will be collected and analyzed, which includes cold-start time (time from power on until first valid reading without satellite data in memory), hot-start time (Time from power on until valid reading with satellite data in memory), mean coordinate and standard deviation. By collecting this data, the performance of the device to locate the coordinate can be analyzed. Fig. 9 shows the working principle of the coordinate locating prototype.

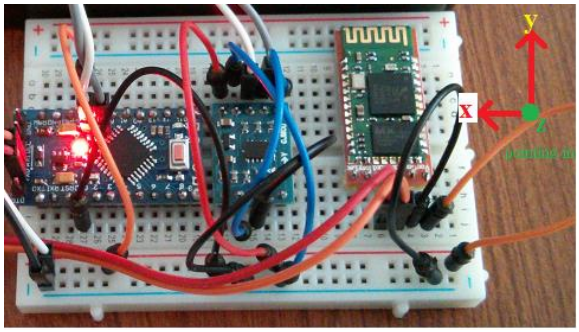


Fig. 8. The Orientation of the Acceleration Measurement Prototype Across all Measurement.

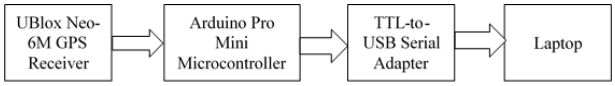


Fig. 9. Working Principle of the Coordinate Locating Prototype.

The cold-start time is measured by taking the time taken from power until the first valid reading shown in the serial monitor on the laptop. This process is repeated five times to get the mean cold-start time. The hot-start time is measured by taking the time taken from power loss of the device to resumed reading after power on in serial monitor on the laptop. This process also repeated five times to get a mean value. The mean coordinate and standard deviation is calculated from 20 times measurement at a fixed position.

IV. Experimental Results

A. Performance Analysis for Device Installation Place

Fig. 10 to 13 show the acceleration measured at a different position from experiment 1 such as at the center of the dashboard, storage compartment, under the driver seat, and back bonnet. The Z-axis experienced a steady 1g of acceleration from the gravity acting towards the ADXL345 sensor. It was found that the Y-axis shows a little bit of deviation from the 0 point, this may due to the calibration error inside the sensor. From all the figures, the Z-axis shows the most changes in acceleration across all positions compared to the X-axis and Y-axis, which is doesn't react much to the starting of the car engine.

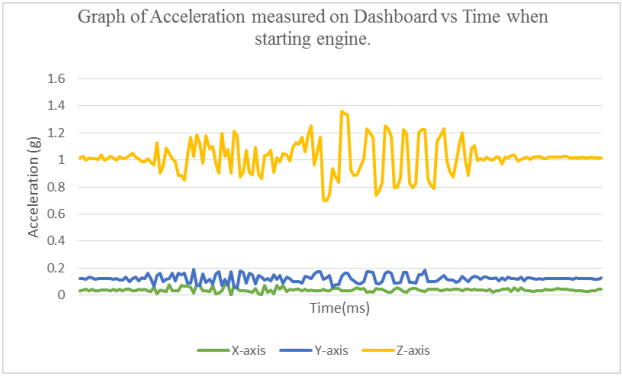


Fig. 10. Installation at the Center of Dashboard Result.

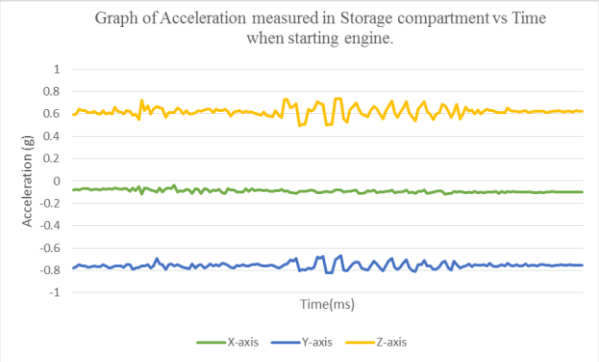


Fig. 11. Storage Compartment Result.

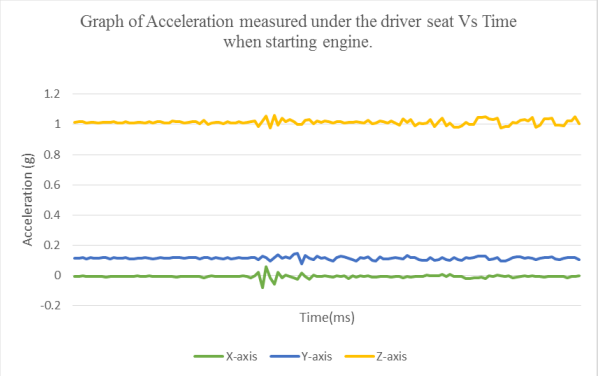


Fig. 12. Under Driver Seat Result.

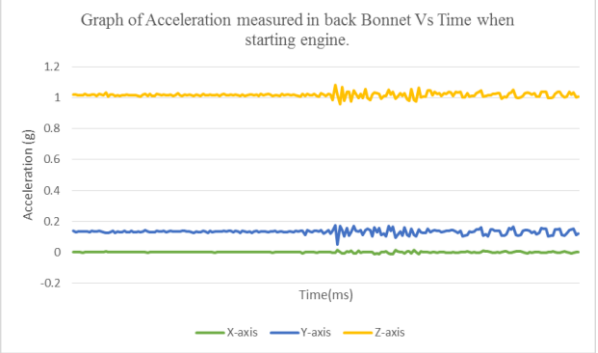


Fig. 13. Back Bonnet Result.

The vibration of the car engine causes this condition during starting, as the engine of the Proton CPS engine used in the testing car is an inline engine, the piston moves upward and downward for each burning cycle, which causes the vibration at the Z-axis. For the X-axis and Y-axis, they do not experience huge changes in acceleration value due to the car is stationary during testing. Fig. 14 shows the comparison of the Z-axis for the four positions together. From the graph, it was found that the Z-axis acceleration value has deviated from the rest, which is caused by the Storage compartment has an angled design at the bottom and this makes the prototype hard to achieve the standard measurement position.

The center of the dashboard position shows the highest change in acceleration at Z-axis among all the positions, which makes it the best position to install this project compared to the others. Under-seat and bonnet position shows the lowest change in acceleration compared to the others, which is not suitable for the installation of this project. This condition can be explained by the distance from the engine to the device. As the testing car has an FF (front-engine front-wheel-drive) configuration, the engine is located at the front of the car. This explains the large changes of acceleration detected on the dashboard and storage compartment due to the short distance to the car engine. On the other hand, the bonnet and under-seat position are far away from the car engine which results in lower amplitude readings. In order to improve the security of the device while maintaining high sensitivity, the device will be installed inside the dashboard which makes the car theft harder to access. The device is simply placed on top of the dashboard due to the difficulty to remove the dashboard on the testing car that is too high.

B. *Performance Analysis for of the GPS Receiver for Accurate Tracking*

Fig. 15 shows the time needed from the power-on of the GPS module until the first valid reading is getting from the GPS module (time-to-first fix). Cold-start of the GPS module is carried out when the GPS module is powered off without backup supply for more than 4 hours. The data collected in Fig. 15 shows that the U-Blox Neo-6M GPS module's cold-start time is between 291 seconds to 417 seconds with a mean of 347 seconds and a standard deviation of 48.929 seconds.

Fig. 16 shows the time taken for the hot-start action of the GPS module. The hot-start action of the GPS Module is carried out when the GPS module is powered on from the state of standby with all the previous satellite locating data inside the memory. The hot-start action can be carried out even the module is powered off when there is a backup power to support the memory chips on the module. From Fig. 16, the hot-start time varies from 9.90 seconds to 15.21 seconds with a mean of 11.72 seconds and a standard deviation of 2.162 seconds.

Fig. 17 and 18 show the 20 sets of GPS coordinate data collected from experiment 2 and converted into a graph for better analysis. From the graph, the GPS coordinates from the U-Blox Neo-6M GPS module can be said consistence, with a mean GPS coordinates of latitude 2.25102195° and longitude 102.2859226 ° . The standard deviation for latitude and longitude is 0.000003706° and 0.000002762°, respectively. This result shows that the GPS coordinates collected from the GPS module at a fixed position have a high precision which is suitable for tracking purposes for this project.

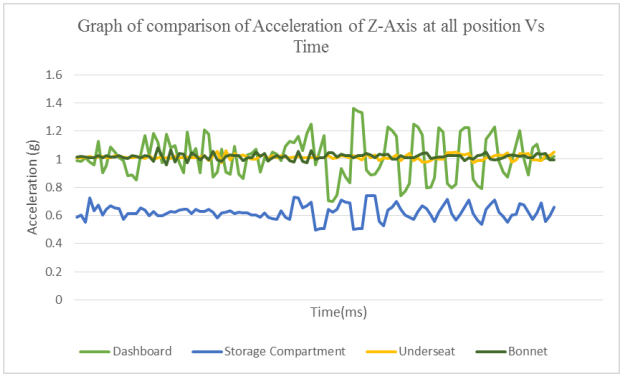


Fig. 14. Comparison of Z-Axis at all Position.

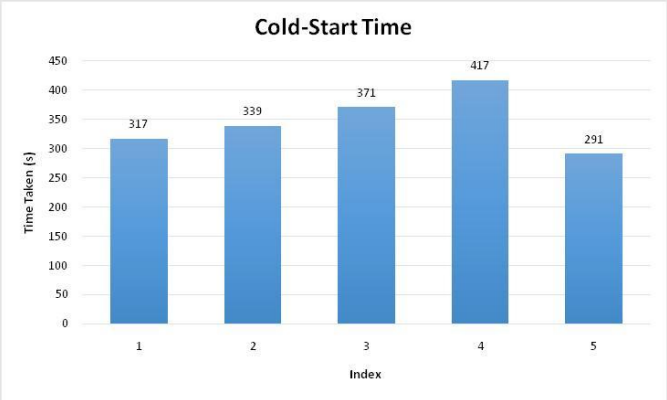


Fig. 15. Time is Taken for Cold Start-ups.

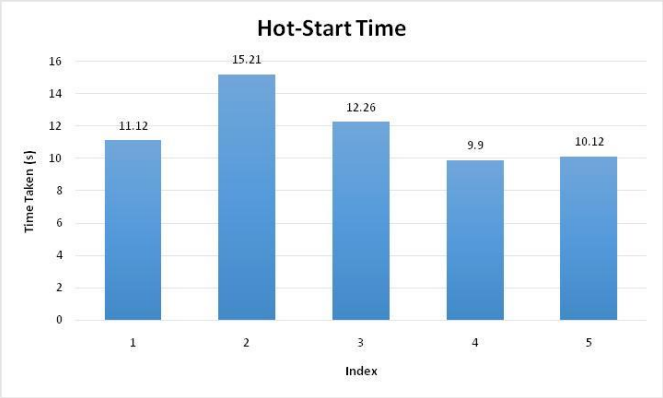


Fig. 16. The time is taken for a hot start-up

Based on these results, the accuracy of the GPS coordinates to be detected during the cold-start and hot-start time are evaluated. The cold-start time and hot-start time collected in experiment 2 are important in determining the performance of the GPS module. A shorter time to first valid fix is preferred so that the user able to locate the vehicle faster. Besides, the hot-start action is preferred over the long cold-start action, hence, the GPS module should be always powered on and going to standby mode if power saving is required.

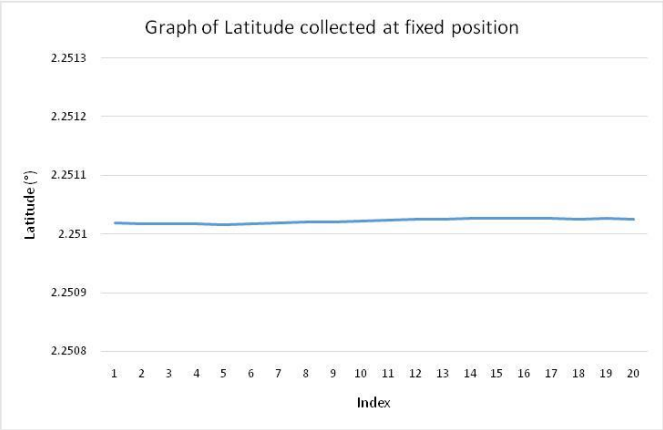


Fig. 17. The Graph of Latitude Collected from GPS at a Fixed Position.

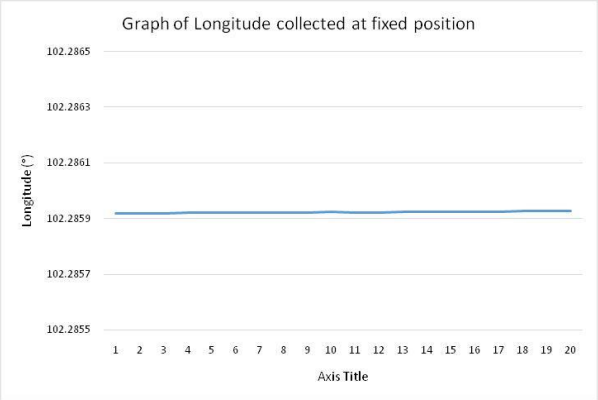


Fig. 18. The Graph of Longitude Collected from GPS at a Fixed Position.

V. Conclusions and Future Tasks

In conclusion, the first objective which is to measure dynamic acceleration with accelerometer ADXL345 in X-axis, Y-axis, and Z-axis for movement and vibration detection, based on installation location is achieved in the experiment 1. The analysis of the data taken from the experiment is useful in determining the installation position of the device and method of detecting the intrusion of car theft. The center of the dashboard is the best position to install the vehicle security system and the best detecting method by measuring the vibration of the car engine in the Z-axis. In experiment 2, the performance of the GPS module is evaluated for use in this project. The GPS coordinates collected from the GPS module at a fixed position has a high precision which is suitable for tracking purpose for this project.

For future development of the vehicle security system, door open detection switch can be included to further improve the ability to detect intrusion of car theft. The door open detection switch plus the acceleration detection can work together to detect intrusion at a different level of alert. Besides, the backup battery can be included in this project to provide an emergency power source in case the wiring system has been modified so that the user is still able to know the coordination of the vehicle by SMS.

References

[1] C.Teh, “Private car theft statistics in Malaysia: One Stolen every 24 minutes.” Available at: http://christopherteh.com/blog/2010/09/ private-car-theft-statistics-in-Malaysia-one-stolen-every-24-minutes/ (2019).

[2] Rosenfeld, R. “Crime and Inflation in Cross-National Perspective”. Crime and Justice, 43(1), 341-366, 2014.

[3] N. Morgan, O. Shaw, A. Feist, and C. Byron, “Reducing criminal opportunity: vehicle security and vehicle crime”, Research Report 87, January 2016.

[4] Kamkar, S. “Drive It Like You Hacked It: New Attacks and Tools to Wirelessly Steal Cars”. Presentation at DEFCON 23, August 2015.

[5] Brown, R., Explaining the property crime drop: The offender perspective. Trends & issues in crime and criminal justice”. No. 495. Australian Institute of Criminology, 2015.

[6] B. Davis, R. DeLong, “Combined Remote Key Control and Immobilization System for Vehicle Security”, Motorola Semiconductor Products Sector, Arizona, pp 125- 132, 1996.

[7] Van Ours, J. C. & Vollaard, B., “The Engine Immobiliser: A Non-Starter For Car Thieves”. The Economic Journal, 2014.

[8] Brown, R., “Reviewing the effectiveness of electronic vehicle immobilization: Evidence from four countries”. Security Journal, 2013.

[9] A.M Kassim, M.S Jamri, M.S.M Aras, M.Z.A Rashid, "Design and Development of Vibration Method for Vehicle Reverse System (VRS)," Procedia Engineering, Vol. 41 pp. 1114-1120, 2012.

[10] F. D. Garcia, D. Oswald, T. Kasper, P. Pavlidès, "Lock it and still lose it–on the (in) security of automotive remote keyless entry systems", Proc. 25th USENIX Security Symp. (USENIX Security), pp. 929-944, 2016.

[11] G. Jayendra, S. Kumarawadu, L. Meegahapola, “RFID-Based Anti-theft Auto Security System with an Immobilizer”, University of Moratuwa, Sri Lanka, pp 441-446, 2007.

[12] Kasper, T., Oswald, D., and Paar, C. “Wireless security threats: Eavesdropping and detecting of active RFIDs and remote controls in the wild”. In 19th International Conference on Software, Telecommunications and Computer Networks – SoftCOM’11 pp. 1–6, 2011.

[13] A. Kassim, H. Jaafar, M. Azam, N. Abas, and T. Yasuno, “Design and development of navigation system by using RFID technology,” in Proc. IEEE 3rd Int. Conf. Syst. Eng. Technol. (ICSET), pp. 258–262, Aug. 2013.

[14] Tseloni, A., Thompson, R., Grove, L., Tilley, N. & Farrell, G, “The effectiveness of burglary security devices. Security Journal”. Available at: http://www.palgrave-journals.com/sj/journal/vaop/ncurrent/pdf/sj201430a.pdf, 2014.

[15] A. M. Kassim, T. Yasuno, H. Suzuki, H. I. Jaafar, M. S. M. Aras, "Indoor navigation system based on passive RFID transponder with digital compass for visually impaired people", Int. J. Adv. Comput. Sci. Appl., vol. 7, no. 2, 2016.

[16] K. T. Cho, K. G. Shin, "Fingerprinting electronic control units for vehicle intrusion detection", Proc. 25th USENIX Security Symp., pp. 911-927, 2016.

[17] I. M. Almomani, N. Y. Alkhalil, E. M. Ahmad and R. M. Jode, “Ubiquitous GPS Vehicle Tracking and Management System”, University of Jordan, Jordan, 2011.

[18] Choudhuri, S. B., Kumar, J. S. J., Venkatesh, B. & Pandey, R. K., “Vehicle Anti-Theft and Passenger Safety System”. Global Journal of Research and Engineering-GJRE-B, 14(1), 2014.

[19] M. Z. M. Rashid, H. N, M Shah, M. S. M Aras, M. Kamaruddin, A. M. Kassim, H. I. Jaafar, "Metal Line Detection: A New Sensory System For Line Following Mobile Robot", Journal of Theoretical and Applied Information Technology, vol. 64, no. 3, pp. 756-764, June 2014.

[20] A.M. Kassim, H. I Jaafar, M.A. Azam, N. Abas, T.Yasuno, “ Performances study of distance measurement sensor with different object materials and properties” 3rd IEEE International Conference on System Engineering and Technology (ICSET), pp. 281–284, 2013.

[21] M. Hart, “TinyGPS Library”. Available at: http://arduiniana.org/libraries/tinygps/ (2019).

[22] R. Rodger, “Beginning Mobile Application Development in the Cloud”, Crosspoint Boulevard, Indianapolis, 2012.

A Framework for Hoax News Detection and Analyzer used Rule-based Methods

SY. Yuliani[1]
Information Security and Networking Research Group(InFORSNET), Faculty of Information Communication Technology, Universiti Teknikal Malaysia Melaka, Melaka, Malaysia, Widyatma University

Mohd Faizal Bin Abdollah[2]
Information Security and Networking Research Faculty of Information Communication Technology Universiti Teknikal Malaysia Melaka Melaka, Malaysia

Shahrin Sahib[3]
Information Security and Networking Research Group(InFORSNET), Faculty of Information Communication Technology, Universiti Teknikal Malaysia Melaka, Melaka, Malaysia

Yunus Supriadi Wijaya[4]
Informatics Department
Telkom University
Bandung, Indonesia

Abstract*—Currently, the era where social media can present various facilities can answer the needs of the community for information and utilization for socio-economic interests. But the other impact of the presence of social media opens an ample space for the existence of information or hoax news about an event that is troubling the public. The hoax also provides cynical provocation, which is inciting hatred, anger, incitement to many people, directly influencing behavior so that it responds as desired by the hoax makers. Fake news is playing an increasingly dominant role in spreading Misinformation by influencing people's Perceptions or knowledge to distort their awareness and decision-making. A framework is develope dataset collection of hoax gathered using web crawlers from several websites, using classification techniques. This hoax news will be categorized into several detection parameters including, page URL, title hoax news, publish date, author, and content. Matching each word hoax using the similarity algorithm to produce the accuracy of the hoax news uses the rule-based detection method. Experiments were carried out on eleven thousand-hoax news used as training datasets and testing data sets; this data set for validation using similarity algorithms, to produce the highest accuracy of hoax text similarity. In this study, each hoax news will label into four categories, namely, Fact, Hoax, Information, Unknown. Contributions propose Automatic detection of hoax news, Automatic Multilanguage Detection, and a collection of datasets that we gather ourselves and validation that results in four categories of hoax news that have measured in terms of text similarity using similarity techniques. Further research can be continued by adding objects hate speech, black campaign, blockchain technique to ward off hoaxes, or can produce algorithms that produce better text accuracy.

Keywords*—Component; hoax; news; framework; web crawling; detection; multilanguage; unsupervised algorithm; similarity algorithm

I. Introduction

Social media are very supportive and act as an interface to spread information, facilitate communication as well as news. News defined as new information or information about something that is happening, presented in print, broadcast, internet, or word of mouth to third people or many people. News must account for its truth, actual, and informative; news must be current and interesting [1], which can significantly affect many people [2][3]. Some news, especially on social media, uses false news as a political weapon [4],[5]. Social media for news consumption is a double-edged sword. On the, there is no need to pay a lot of money to get information, because access to information is easily available for now, and very quickly with seconds information can be disseminated, this makes people search for and consume news from social media. Even though fake news and real news are straightforward to distinguish [6], Hoaxes are impossible to predict, and when they distributed, it's hard to stop. Headlines from hoax news often use fewer words and nouns. A hoax is a news article that is intentional and untrue and can mislead readers. The public still cannot distinguish between true and false news, this happens as a result of low public literacy of messages on social media, [5] Hoax is defined as a series of information that is intentionally misled, but sold as truth. Other words closely related to Hoax are Fake News, Allcott [6] “Hoax News Defined as a deliberate and verifiable news article that can mislead readers”, and other definitions from some of the latest research. [7],[8],[9],[10],[11], there are many more studies related to hoax news detection.

In general, hoaxes, identification can be identified with four criteria. First, hoax information usually has the characteristics of chain letters by including sentences like "Spread this to everyone you know; otherwise, something unpleasant will happen." Second, hoax information usually does not include the date of the event or does not have a real-time or can be verified, for example, "yesterday" or "issued by..." statements that do not show clarity. Thirdly, hoax information usually does not have an expiry date on the information alert, even though the actual presence of that date will also prove nothing, but can have a prolonged disquieting effect. Fourth, no identifiable organization is cited as a source of information or includes the organization but is usually not linked to data.

One of the characteristics of hoax news consists of disinformation and Misinformation; these two words are different but interrelated, According to Bernd [12], Misinformation and disinformation are strictly related to information, Misinformation is inaccurate information and disinformation is false information that spreads on social media networks [13]. Data from Kemominfo there are around 800,000 sites in Indonesia that have indicated as hoax news spreaders, social media has been by individuals for personal and group benefits by spreading harmful content that causes unrest and mutual suspicion in the community [14]. With the difference between the number of facts and hoaxes, "many current news verification mechanisms already exist, and a large volume of information, then a new automatic hoax news detection approach is needed" [15].

The last stage is validation testing the detection results by matching the similarity of hoax news text, title, or content hoax news. An explanation of the related hoax detection framework will explain in the next section.

II. Related Work

The concept of news hoax is often associated with, fake news, lies, disinformation, misinformation, deception, misleading, rumors, fraud, some related work can be found at, for disinformation [16][17], for misinformation [12], for fake news [18][19],for deception[20] ,for lies [5], for rumors [21], for fraud [22][23], for misleading [24], etc. Problems related to this topic have been seen concerning classification, detection, filtering. Likewise, most published works have hoax news detection as hoax classification problems or not hoaxes. The following is some research work related to news hoaxes.

Arjun [25] proposes an automatic hoax framework technique that classifies hoax news into several classes, true, mostly true, half true, almost untrue, false, and shorts with models based on Convolutional Neural Networks (CNN) and Bi-directional Long Short Term Memory (Bi-LSTM). Representations obtained from these two models included in the Multi-layer Perceptron Model (MLP) the final classification.

Ishak et al. [26] proposed a framework of a text-based deception detection system using the Levenshtein Distance algorithm. Then identifying the potential deception of the email content by comparing it with a database of deception, the required component consists of three main components: preprocessing of text, detection of deception, and detection of a new deception. For the Pre-processing text stage, collect emails that will test for validity as genuine or fraudulent emails.

Shu et al. [9] propose the Tri-Relationship hoax detection framework, called TriFN, with data objects taken from social media. This technique explores the correlation of publisher bias, news establishments, and relevant user involvement simultaneously, and proposes Tri-Relationship. Shu et al. provide two comprehensive real-world fake news datasets to facilitate hoax news research.

Tacchini et al.[27], have an automated online As a contribution that is by showing that Facebook posts can be classified with high accuracy as a hoax or not a trick based on users who "like" them. System presents two classification techniques, one based on logistic regression, the other based on new adaptations crowdsourcing Boolean algorithm. The dataset consists of 15,500. Facebook posts and 909,236 users, the research results obtained classification accuracy exceeding 99% even when the training set contained less than 1% of the job. Shows the power of the technique for which they purposed the system worked even to users who like hoaxes and Fact posts these results indicate that the diffusion pattern mapping information can be a useful component for automatic hoax detection system.

Veronica et al. [28] make a framework for the automatic identification of fake content in online news. And has two contributions. The First contribution introduces two new data sets for the detection of hoax news, covering seven different news centers. It further explains the collection, announcement, and validation processes in detail and presents some exploratory analysis about identifying linguistic differences in fake and legitimate news content. Another controversy, conducting a series of learning experiments to build an accurate phony news detector provides a comparative analysis of automatic and manual identification of fake news. Support Vector Machine (SVM) classifier and five-fold cross-validation, with accuracy, precision, recall, and measures averaged over the five iterations, using classification techniques for hoax news detection.

Orissa Rasywir [29] make a framework for the conduct hoax news classification in Indonesian using a statistical approach based on machine language, with application based on text categorization, where the proposed system consists of preprocessing, feature extraction, feature selection and execution of classification models. The machine learning algorithm technique chosen in the hoax news classification system is Naïve Bayes (NV), Support Vector Machine (SVM). The results of the conclusions Research results in The best experimental results achieved with naïve bays algorithms with unigram features where feature selection uses union operations between information gain and mutual information.

Sethi [30] proposes a prototype framework or social argumentation to verify the validity of alternative facts intended to help curb the spread of false news, a prototype system used social argumentation to verify the validity of proposed alternative facts and help with detection of hoax news, uses the principles of fundamental argumentation in a graph-theoretic framework which also combines the semantic and web.

III. Methodology

A. Hoax News Methodology

Hoax detection methodology used in this study into three stages: stage one is PreProcessing, stage two is a process, and phase three is The Post Process. Fig. 1 below is a chart of the hoax news detection methodology research stages.

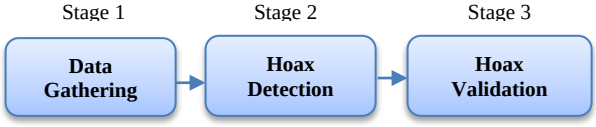


Fig. 1. Hoax News Methodology

Hoax news detection methodology consists of three stages, one stage named Pre-Processing, the preprocess stage, namely the stage of data gathering, by crawling from the web, and then a web register containing hoax news data, after the data is collected, by crawling than the data will then be stored in a database, and will classify as data hoaxes and not hoaxes.

The methodology here is the Process stage at this stage will be the second stage known as hoax news detection, hoax news detection is done by taking extracted data and searching data by extracting features to determine many words, and similarity in words, which will then proceed to the next method, feature selection, and labeling the data, which is divided into four news categories, Hoax, Fact, Information, Unknown.

The third phase is the Post Process phase; this phase validation the similarity of text extraction from the detection of hoax text data security using the similarity algorithm and produces the results of the validation done in the form of a percentage.

B. Hoax News Dataset Collection Method

The Hoax News Dataset collection is done in several stages, namely, Registering website & Social Media, Automatic Parse, Web Crawlers, Pre-processing, Labeling Categorizing Classification, Validity. For phase one, which collects data, data collection done by asking for the URL address, next is the Automatic Parse process, and finally crawling the deceptive data, which will then move into the dataset. Fig. 2 is for Stage one:

1) Registering website: The initial stages of collecting hoax data are by taking hoax data from several websites that contain hoax news that has gone through the analysis stage of checking hoax news facts that have verified the web used is taken from the web for English-language hoaxes including: www.hoaxslayer.net, www.sophos.com, www.truthorfiction. com, www.symantec.com, and for Indonesian-language hoaxes produced from several government websites and online media websites that have been trusted including stophoax.id, turnbackhoax.id, indeks.kompas.com, and cekfakta.com.

2) Automatic parse: Automatic parsing is a way to break up a series of hoax words that will produce a description tree that will be used in the next compilation stage, namely, syntactic analysis [31],[32] related research about parse[33]. Automatic Parse consists of three stages and below is the Fig. 3 of the automatic parsing stage.

a) Planning and Defining Object: Planning and Defining Object is achieved by writing code cleaner for the web crawlers through scrapping and storing various data from various news article websites or blog posts from multiple sites, each with a different template and layout. Contains the title of the article, another contains the website's title, and the title of the article in , then collects a number of "types" of data, news reviews, news articles, author from various website, and which stores this data type as an object that can be read and written to a database.

SELECT WEBSITE

(insert into table)

DEFINE OBJECTS

1) Title
2) Text
3) Category
4) Author
5) Date Published
6) Analysis

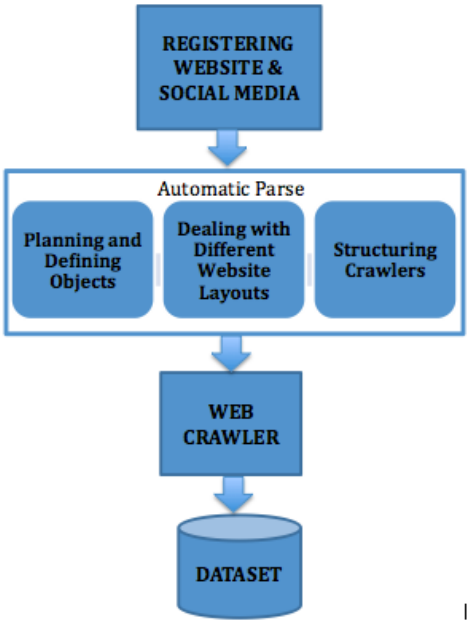


Fig. 2. Hoax News Dataset Collection Method.

Fig. 3. Hoax News Automatic Parsing Method.

b) Dealing with Different Website Layout: Dealing with Different Website Layouts is extracting relevant and useful data from various websites, without having upfront knowledge about the structure of the site itself. Identify the title and main content of a page and retrieve the URL, string, or object. Website classes store h1 string tags that indicate where titles can found. Necessary template extensions can handle missing fields, collect various types of data, crawl only through certain parts of the website, and store more complicated information about the page.

https://www.hoax-slayer.net/hiv-food-and-drink-contamination-hoaxes-continue/

Inspect Html Element

Defining HTML Title position

<h1 class="post-title single-post-title">

HOAX -'Breast Larvae Infestation From Undergarments'

</h1>

c) Structuring Crawlers: Structuring Crawlers is to create a type of website layout that is flexible and can be modified, incorporating this method into a well-structured and expandable website crawler that can collect links and find data automatically.

Get Html Page Source

file_get_contents (php function)

Get Title Html Positions

@$first_title = explode('<h1 class="post-title single-post-title">', $response);

@$second_title = explode(' </h1>', $first_title[1]);

@$title = $second_title[0];

7) Web crawlers: Web Crawler is a program that parses the hypertext structure of the web [34], starting with an initial address called a seed and secretly visiting the web address on a web page [35]. Related research about crawler [36],[37],[38], Hoax data collected from several websites that contain hoaxes, following the stages in collecting hoax data using crawler techniques:

- Stage one makes a website name or URL that contains hoax news that will be crawled. Starting with the copy of the start page URL, and the total page to the last page, then suffix or case and system status finish or begin.
- Stage two is to check the language to use, Indonesian or English.
- Stage three does Description; the Description contains a summary of the web.
- Stage four, namely the Page URL is a series of characters according to a specific standard format, for example, characters / or =
- Step five stemming is the process of changing the affected words into essential words, and this is needed if the hoax news is in Indonesian, we give a sign then we give the indication "YES" if the news hoax is in English then no stemming is needed "NO."
- Stage Six Header Page: Header Page explains about pages to help search engines find content.
- Element HTML Tag: Category, Title, Author, Date Publisher, Text, Web Text, Analysis, Rating

C. Pre-processing

The second stage is the Pre-processing Stage. In-Text mining applications, textual data representation dramatically influences the accuracy of the results [39]. The preprocessing phase consists of the process of data cleaning and feature selection. In this study, preprocessing was carried out in the following Fig. 4.

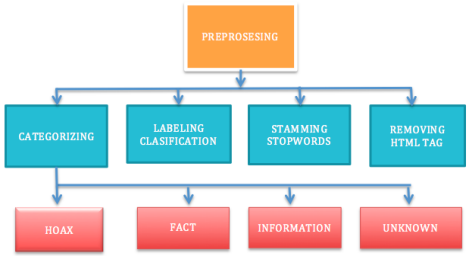


Fig. 4. Preprocessing Phase.

1) Removing html tag: Removing HTML Tags is designed to strip HTML tags from the text. It will also strip embedded JavaScript code, style information (style sheets), as well as a system inside PHP tags (<php > <php > < >), one time the command, will replace the sequence of new (multiple) lines and the next will be a list of allowed tags.

2) Case folding: Case Folding is the stage of changing all character letters to lowercase. Next, do the character removal by removing all the characters that considered not needed, namely all aspects other than letters (a-z).

3) Tokenizing: Tokenizing is the process of getting words from documents, which are the embryo of attributes. The next process. Synonym Normalization is a stage of normalizing words that have the same meaning to reduce the dimensions of the data and get quality attributes. Hardalov defines stop words as the most common and functional words in a language [40].

4) Stop words: Stopword Removal removes words that do not affect class classifications, such as conjunctions, clothing words, pronouns, etc. The process by filtering each word with the database that has provided. [github.com/masdevid/ID-Stopwords]

5) Stemming: Stemming is a process that finds the essential word of a word. By eliminating all affixes (affixes) useful consisting of prefixes, insertions (infixes), suffixes (suffixes), and confides (the combination of prefix and suffix) in words derivative. Stemming is used to replace the form of a

word that becomes the basic word of the word that fits the structure of good Indonesian morphology right.

D. Labeling Categorizing Classification

Data labeling is one of the processes for labeling hoax data categories, some related research [41], [42]. Hoax news labeling is a stage by labeling hoax news data, labeling is done, on datasets that have not to be labeled, or unknown data. An anonymous data process will carry out several stages, including labeling news information, then determine features selection and selected features using unsupervised algorithms, and produce news classification in the form of labels into categories, namely, Fact, Hoax, Information. The following Fig. 5 shows the process of data labeling stages.

E. Multilanguage Detection

Multilanguage identification: Language identification is the task of automatically detecting the language in hoax news data — some of the same research for multilanguage detection [43]. Vu, uses multilanguage by introducing statistical rule-based methods to create rules for detecting in various languages [44]. Bouarara [45], uses multilanguage to detect email with learning-based methods automatically and ranks the steps to generate spam emails [47]. Contributing to our research by using the technique of collecting hoax news from the web in several different countries or languages, and produce site data effects are news hoax news from several languages including, Indonesian, English and Malaysian. The following steps are carried out for automatic language detection, randomly select documents for each List.

F. Validity

Validation is to detect hoax news using a similar method. Most existing approaches consider the hoax news problem as a classification problem that predicts whether a news article is a hoax or not. [9]. Problems encountered in text mining are large amounts of data, high dimensions, data and structures, constantly changing data, and data noise [46]. Overcoming unstructured data, we need to evaluate the accuracy of words. A similarity algorithm is used in this evaluation to detect hoax news [47]. The similarity algorithm calculates the similarity between two strings; the complexity of this algorithm is O, where N is the length of the longest string. The parameter used is. The first string. The second string. The third is to calculate the similarity in percent's. The similar text will calculate the similarity in percent, by dividing the results of similar text by the average length of the given string times 100. Finding the longest general substring first, and then doing this for the prefix and suffix, recursively calculate the number of matching characters. The length of all common substrings found is added. Example:

Example #1 similar_text() argument swapping example

```
<?php

$sim = similar_text('bafoobar', 'barfoo', $perc);

echo "similarity: $sim ($perc %)\n";

$sim = similar_text('barfoo', 'bafoobar', $perc);

echo "similarity: $sim ($perc %)\n";
```

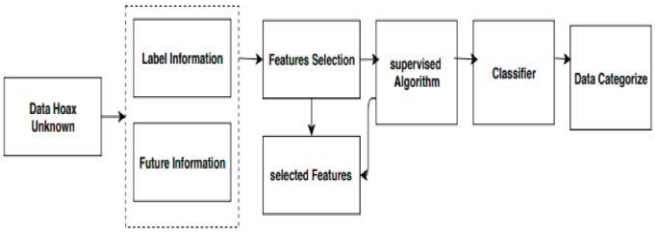


Fig. 5. Hoax News Labeling Categorizing.

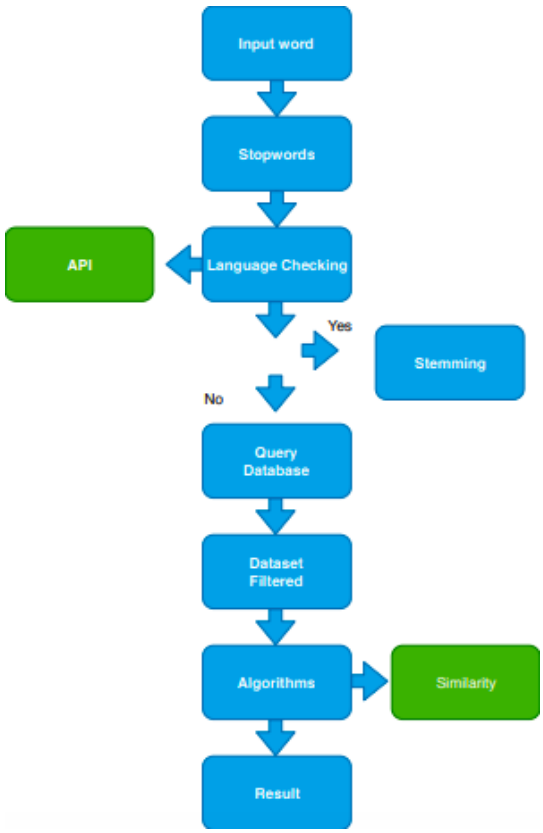


Fig. 6. Hoax New Validity Method.

This example shows that swapping the first and second argument may yield different results as shown in Fig. 6.

Stages of Validation of hoax news similarity detection:

- Word Input: Input by comparing some of the words contained in the hoax news dataset provided in the hoax detection engine. Document reading: reading text documents
- Stop word: Optimization by removing all words that classified as stop words. Stop words are common words that usually appear in large numbers and are considered to have no meaning. Stop words are generally used in information retrieval, stop words for English include, among others, the, while for Indonesian, among others are, at, too.
- Language checking: Check the language using Multilanguage using an application that is already available in the API.

- Stemming: return various kinds of word formations to the representation of essential words, stemming method requires input in the form of words contained in a document, by producing output in the form of crucial words. Basic word search for words that influence Indonesian.
- Database Query: Search for words contained in the hoax news database.
- Algorithm: The selection is carried out one by one testing of four algorithms namely similarity algorithm, Levenshtein algorithm, Smith-Waterman algorithm, Damerau Levenshtein algorithm.
- Result: Shown Results of the similarity of words in percent and the amount of time needed to process in seconds.

G. Hoax News Detection and Analyzer Framework

Generally, the hoax news detection framework represented as follows in Fig. 7:

Detection Hoax framework has three stages where the first stage is called the stage Preprocess, and this preprocess stage we named the stage of gathering hoax news from several web sites, the scene consists of a web Registering by entering a web URL. The Automatic Parse step is taking the clean text from unnecessary HTML marks. There are three stages for automatic parsing i.e., Planning and defining objects, then dealing with different website layouts and structure crawling. And the third stage in gathering data is web crawlers.

The second stage is "Process"; at this stage, the process is called the Process Data Hoax Detection Generator. This process has three stages, namely Preprocessing, Labeling, and Categorization; the Pre-processing stage consists of Removing HTML Tags, then stemming, then stop word stages. The output of this process will produce four categories of hoax news, namely Hoax, Fact, Information, and Unknown.

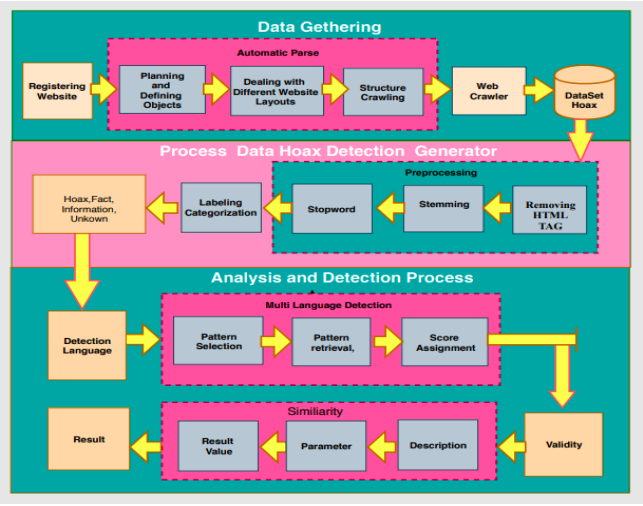


Fig. 7. Hoax News Detection Framework.

The third stage is the Post-processing process; this stage is named the Analysis and Detection Process. This stage produces two methods, namely Multi Detection Language and Validity and Result. The Multilanguage detection process consists of three processes, namely pattern selection, pattern retrieval, and score assignment. The Validation process is the Similarity text technique, which has three methods, namely Description, finding Parameters, and producing Result Value similarity of data hoax words in percent.

IV. Result

Result of research of the hoax news detection: The contribution of the hoax news detection framework. Stage of gathering the hoax news dataset. Collecting data is carried out by the crawling method, which results in twelve contributions thousand hoax or corpus data sets. The second contribution is hoax news detection through the preprocessing stage. Analysis Using the text of news headlines or news content. Producing a 12000 accurate and reliable dataset can set more versions of several different parts of the world can then strength by multilingualism. Detection of results in terms of accuracy and processing time will be well validated. Additional research can be done. Hoax data labeling with classification techniques using unsupervised algorithms results in the participation of four categories of hoax news, namely, hoax, fact, information, and unknown.

The third contribution is multilanguage detection; at this stage, the API; this is a language detection web service. It accepts the text and returns the results with the detected language code and score. Validation detection of hoax, this validation produces hoax news accuracy using the similarity text algorithm method, and results in a percentage of the accuracy of text similarity, and calculates the length of time it takes to detect hoax news in seconds. The strengths of developing a proposed hoax news detection framework are hoax datasets, hoax data labels, multilanguage, and validation of detection results.

V. Conclusion

Social media is one of the media that makes it very easy for us to get information, find references in the scientific field; it is also straightforward for us to do business and get news. Still, of the many good things produced by social media, there are also things bad stuff, i.e., the amount of false or fake news information known as a hoax. Conclusions of the research on creating a text-based hoax detection framework. This framework is needed to reduce the dissemination of hoax news in the community. This study's findings may well detect hoax news. The analysis is done using the news title text or news content. Producing a 12000 accurate and reliable dataset can set more versions of several different parts of the world can then strengthened by multilingualism. Detection of results in terms of accuracy and processing time will be well validated. Additional research can be done

ACKNOWLEDGEMENTS

This work been supported under Universiti Teknikal Malaysia Melaka research grant Gluar/CSM/2016/FTMK-CACT/100013. The Author would like to thanks University Teknikal Malaysia Melaka, CyberSecurity Malaysia and all member of INFORSNET research group for their incredible support in this project.

REFERENCES

[1] J. Fiske, Understanding Popular Culture. Paperback, 1989.

[2] Fang, "Writing Style Differences in Newspaper , Radio , and Television News Writing Style Differences in Newspaper , Radio , and Television News Irving Fang," no. 2, 1991.

[3] S. Y. Yuliani, S. Sahib, M. F. Abdollah, M. N. Al-mhiqani, and A. R. Atmadja, "Review Study of Hoax Email Characteristic," vol. 7, pp. 778–782, 2018.

[4] M. N. Al-Mhiqani, R. Ahmad, W. Yassin, A. Hassan, Z. Z. Abidin, N. S. Ali, and K. H. Abdulkareem, "Cyber-Security Incidents: A Review Cases in Cyber-Physical Systems," Int. J. Adv. Comput. Sci. Appl., vol. 9, no. 1, pp. 499–508, 2018.

[5] H. Berghel, "Lies, Damn lies, and fake news," Computer (Long. Beach. Calif)., vol. 50, no. 2, pp. 80–85, 2017.

[6] H. Allcott and M. Gentzkow, "Social Media and Fake News in the 2016 Election," J. Econ. Perspect., vol. 31, no. 2, pp. 211–236, 2017.

[7] E. Mustafaraj, "The Fake News Spreading Plague : Was it Preventable ? The Fake News Spreading Plague : Was it Preventable ?," 2017.

[8] N. J. Conroy, V. L. Rubin, and Y. Chen, "Automatic Deception Detection: Methods for Finding Fake News."

[9] K. Shu, A. Sliva, S. Wang, J. Tang, and H. Liu, "Fake News Detection on Social Media : A Data Mining Perspective," no. i, 2016.

[10] M. Potthast, "A Stylometric Inquiry into Hyperpartisan and Fake News," pp. 231–240, 2018.

[11] V. L. Rubin, N. J. Conroy, Y. Chen, and S. Cornwell, "Fake News or Truth ? Using Satirical Cues to Detect Potentially Misleading News." pp. 7–17, 2016.

[12] B. C. Stahl, "On the Difference or Equality of Information ,Misinformation , and Disinformation : A Critical Research Perspective," vol. 9, 2006.

[13] K. Shu, A. Sliva, S. Wang, J. Tang, and H. Liu, "Fake News Detection on Social Media : A Data Mining Perspective," vol. 19, no. 1, pp. 22–36, 2016.

[14] B. Fitnah, J. Ajak, K. Milenial, B. Hoax, M. Pembangunan, H. Bentuk, L. Teror, P. Masyarakat, T. B. Informasi, J. M. Terprovokasi, K. Hitam, P. B. Politik, M. C. Menjadi, and A. M. Hoax, "Heboh HOAX Nasional."

[15] Y. Chen and V. L. Rubin, "Towards News Verification : Deception Detection Methods for News Discourse Towards News Verification : Deception Detection Methods for News Discourse," vol. 2015, 2015.

[16] S. Kumar, R. West, and J. Leskovec, "Disinformation on the Web: Impact, Characteristics, and Detection of Wikipedia Hoaxes," Www, pp. 591–602, 2016.

[17] N. A. Karlova and K. E. Fisher, "' Plz RT ' : A Social Diffusion Model of Misinformation and Disinformation for Understanding Human Information Behaviour," vol. 2012, pp. 1–17.

[18] Ö. Özgöbek and J. A. Gulla, "Towards an Understanding of Fake News," 2017.

[19] J. Thorne, M. Chen, G. Myrianthous, J. Pu, X. Wang, and A. Vlachos, "Fake News Detection using Stacked Ensemble of Classifiers," pp. 80–83, 2017.

[20] V. L. Rubin, Y. Chen, and N. J. Conroy, "Deception Detection for News: Three Types of Fake News," Proc. Assoc. Inf. Sci. Technol., vol. 52, no. 1, pp. 1–4, 2015.

[21] S. Zannettou, M. Sirivianos, J. Blackburn, and N. Kourtellis, "The Web of False Information : Rumors , Fake News , Hoaxes , Clickbait , and Various Other Shenanigans," pp. 1–26.

[22] S. Vidros, C. Kolias, G. Kambourakis, and L. Akoglu, "Automatic detection of online recruitment frauds: Characteristics, methods, and a public datase," Futur. Internet, vol. 9, no. 1, pp. 1–19, 2017.

[23] L. Akoglu and C. Faloutsos, "Opinion Fraud Detection in Online Reviews by Network Effects," pp. 2–11, 2012.

[24] Y. Chen, N. J. Conroy, and V. L. Rubin, "Misleading Online Content : Recognizing Clickbait as ' False News ,'" pp. 15–19, 2014.

[25] A. Roy, K. Basak, A. Ekbal, and P. Bhattacharyya, "A Deep Ensemble Framework for Fake News Detection and Classification," 2017.

[26] A. Ishak, Y. Y. Chen, and S. Yong, "Distance-based Hoax Detection System," pp. 215–220, 2012.

[27] E. Tacchini, G. Ballarin, M. L. Della Vedova, S. Moret, and L. de Alfaro, "Some Like it Hoax: Automated Fake News Detection in Social Networks," 2017.

[28] B. Kleinberg, A. Lefevre, and R. Mihalcea, "Automatic Detection of Fake News," no. August, 2017.

[29] E. Rasywir, A. Purwarianti, and K. Kunci, "Eksperimen pada Sistem Klasifikasi Berita Hoax Berbahasa Indonesia Berbasis Pembelajaran Mesin," J. Cybermatika, vol. 3, no. 2, 2015.

[30] R. J. Sethi, "Spotting Fake News : A Social Argumentation Framework for Scrutinizing Alternative Facts."

[31] I. Retrieval, Introduction to Information Retrieval. 2008.

[32] D. O. One and P. Description, "Web Crawling Models."

[33] J. Nilsson and J. Hall, "Parsing Formal Languages using Natural Language Parsing Techniques," no. October, pp. 49–60, 2009.

[34] C. Castillo and M. Marin, "Effective Web Crawling," no. November 2004.

[35] B. J. Holmes, Crawling the Web with Java 6. 2005.

[36] A. Heydon and M. Najork, "Mercator : A scalable , extensible Web crawler," vol. 2, pp. 219–229, 1999.

[37] B. Pinkerton, "WebCrawler : Finding What People Want," 2000.

[38] C. Olston, "Web Crawling."

[39] F. A. Ozbay and B. Alatas, "A Novel Approach for Detection of Fake News on Social Media Using Metaheuristic Optimization Algorithms," pp. 62–67, 2019.

[40] M. Hardalov, I. Koychev, and P. Nakov, "In Search of Credible News," no. November 2017, 2016.

[41] "Ranking, Labeling, and Summarizing Short Text in Social Media," no. May, 2013.

[42] A. Mukherjee, B. Liu, and N. Glance, "Spotting fake reviewer groups in consumer reviews," Proc. 21st Int. Conf. World Wide Web - WWW '12, p. 191, 2012.

[43] M. Lui, J. H. Lau, and T. Baldwin, "Automatic Detection and Language Identification of Multilingual Documents," vol. 2, pp. 27–40, 2014.

[44] M. T. Vu, Q. A. Tran, F. Jiang, and V. Q. Tran, "Multilingual Rules for Spam Detection," vol. 1, no. July 2009, pp. 107–122, 2014.

[45] H. A. Bouarara, T. Moulay, R. M. Hamou, A. Amine, and T. Moulay, "A Novel Bio-Inspired Approach for Multilingual Spam Filtering," vol. 11, no. September, 2015.

[46] A. Huang, "Similarity Measures for Text Document Clustering," no. April, 2008.

[47] M. Vuković, K. Pripužić, and H. Belani, "An intelligent automatic hoax detection system," Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics), vol. 5711 LNAI, no. PART 1, pp. 318–325, 2009.

Classification of Arabic Writing Styles in Ancient Arabic Manuscripts

Mohamed Ezz[1]
Computer and Information Sciences
Jouf University, Saudi Arabia
Systems and Computers Eng. Dept.
Al-Azhar University, Caio, Egypt

Mohamed A. Sharaf[2], Al-Amira A. Hassan[3]
Systems and Computers Eng. Dept.
Al-Azhar University
Caio, Egypt

***Abstract*—This paper proposes a novel and an effective approach to classify ancient Arabic manuscripts in "Naskh" and "Reqaa" styles. This work applies SIFT and SURF algorithms to extract the features and then uses several machine learning algorithms: Gaussian Naïve Bayes (GNB), Decision Tree (DT), Random Forest (RF) and K-Nearest Neighbor (KNN) classifiers. The contribution of this work is the introduction of synthetic features that enhance the classification performance. The training phase encompasses four training models for each style. For testing purposes, two famous books from the Islamic literature are used: 1) Al-kouakeb Al-dorya fi Sharh Saheeh Al-Bokhary; and 2) Alfaiet Ebn Malek: Mosl Al-tolab Le Quaed Al-earab. The experimental results show that the proposed algorithm yields a higher accuracy with SIFT than with SURF which could be attributed to the nature of the dataset.**

***Keywords*—Arabic manuscripts; classification; feature extraction; machine learning; GNB; DT; RF; K-NN classifiers; SURF; SIFT**

I. Introduction

Ancient manuscripts (AMs) are considered references for several centuries in history and witness on human literature and development. AMs are held in high esteem by national archives (NAs), museums and libraries all over the world. Nevertheless, NAs – in many countries – still go with traditional procedures when dealing with manuscripts. Yet, they count on experts' talents to manually process and handle manuscripts. This is considered a big concern when we deal with a heritage of thousands of years of human literature. Furthermore, to keep a manuscript in sound condition, restoration and preservation processes are applied on degraded manuscripts before pursuing any document learning procedures. For example, National Archives of Egypt (N.A.E.) has several digitization projects that work on manuscripts to achieve better results. The aim behind this work is to recognize the style of AMs. Hence, we build a model that is trained on a labeled dataset. Then we use the model to recognize a test set that has never been exposed to the model to evaluate the performance of the model before deploying it. Since Arabic manuscripts have several styles of writing which differ according to area, country, occasion and materials. They also have some characteristics as writing tools for handwritten scripts, i.e., calligraphy pens, writing direction and orientation (right to left style). In our study, we take into consideration the horizontal projection profiles of Arabic texts that have a single peak around the middle of the text-line and the alphabet letters whose shapes differ according to the location of a letter – beginning, middle or at the end of the word. Another level of difficulty is that Arabic manuscripts vary over the ages, from writer to another and this introduces variability (in the learnt features). Several books explain each style in the two modes: whole words, and separate letters. For examples, Mosoet Al Khat Al Araby comes in two volumes: (Vol. I) for Naskh [1] and (Vol. II) for Reqaa [2]. The two volumes handle each letter in the cases, i.e., words and isolated letters.

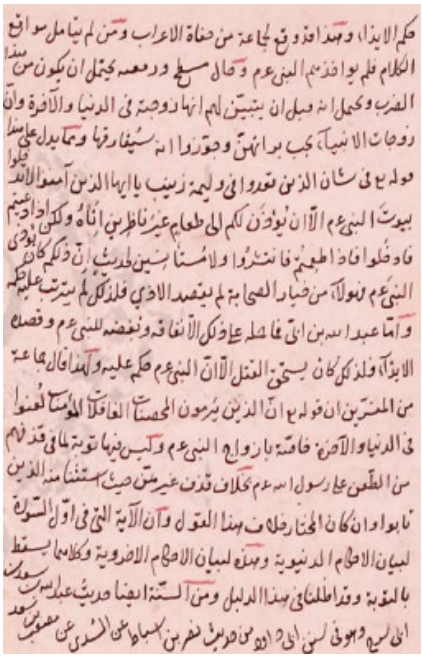
Naskh style has been derived from the "Thuluth" style and has evolved to its own form during the 10^{th} century. In addition, Naskh style is a simple and more legible style, especially in small font sizes. Also, its lines are thin and naturally round. Moreover, Naskh has become the most popular style in Arabic book publishing in general and the holy Quran in particular [3]. However, Reqaa is the simplest style for everyday non-official handwriting. It has a round fluid style [4] and was introduced in the 9^{th} century. Due its simplicity, Reqaa has become the favorite style in the eastern Arab world for everyday writing. Its words are of dense ligature structure, thick baseline and short horizontal strokes [5]. However, the scope of this work is limited to two styles: Naskh and Reqaa.

In addition, the importance of this research stems from the fact that Arabic script is the third most commonly used writing system in the world by the number of users after Latin and Chinese scripts and the second by the number of countries [6]. Also, recognizing the style of handwriting in Arabic manuscripts helps in identifying the origin and date of ancient documents and adds a step toward a large-scale digitization process. While text analysis forms the basis of object recognition and classification in several domains, our work can help in building a database for all Arabic fonts. Fig. 1 shows samples of both styles, Naskh and Reqaa.

II. Related Work

A great body of research has discussed the recognition and classification of handwriting styles in ancient manuscripts. The work of Adam, Al-Maadeed and Bouridan [7] has focused on letters that have been segmented manually from manuscripts. Then they apply Gabor Filter (GF) to extract features. The classification is accomplished by support vector machines (SVM) and yields a recognition rate close to 82% that increased to 86.84% when local binary pattern feature vector was added to GF vector. The work of Yosef et al. [8] uses

(a) Naskh style.



(b) Reqaa style.

Fig. 1. Font styles.

topological feature of letter Aleph to classify documents and the case study was the ancient Hebrew documents. Amin and Mari [9] propose a system for segmentation and recognition of characters and words that uses horizontal and vertical projections and shape-based primitives. Gillies et al. [10] split words into overlapping vertical segments. Then the location of each segment is compared against the resultant locations from the hidden Markov model (HMM). Siddiqi and Vincent [11] have applied a similar idea to solve the problem of writers identification. The method is based on the presence of the following features in a handwriting manuscript: certain patterns, orientation and curvature. For evaluation purposes, several languages are tested. However, the reported accuracy for Arabic handwritten texts was up to 92% for 100 writers. A hybrid convolutional neural network (CNN) and SVM model [12] for handwritten digit recognition is designed to automatically extract features from the raw images and yield predictions. It used non-saturating neurons and a very efficient GPU implementation of the convolution operation to reduce over fitting in the fully-connected layers. Both artificial neural network (ANN) and SVM were used in [13] to recognize Arabic numbers that have been written in different styles. A multi-agent approach to segment Arabic handwriting words [14] relies on recognition to verify the validity of the candidate segmentation points. The proposed approach uses seven agents to figure out regions where segmentation is not allowed. Tensmeyer et al. [15] present a simple CNN-based framework for classifying page images or text lines into font classes. They achieve 98.8% text line accuracy on the King Fahd University Arabic font database. Echi et al. [16] propose a set of features that have been employed successfully for the discrimination between handwritten and machine-printed Arabic and Latin scripts.

III. Proposed Model

Our training data are collected from historical books in Arabic calligraphy. Arabic by nature is a cursive language. This inspires us to introduce a novel training model that is depicted in Fig. 2. The model focuses on letters and studies all possible relative locations of a letter in inscriptions. Then we divide the combinations into four groups and build a model for each. Therefore, the final models after training: Letter at Start of inscription (LST) model which contains all characters once at the beginning of inscription, Letter at Mid of inscription (LMT) model which contains all characters once at the middle of a word, Letter at End of Work (LET) model which contains all characters once at the end of a word and Composite Training Model (CTM). CTM is the focal point of our attention because it encompasses all previous models. Hence, CTM is a model that contains every letter in the alphabet joined cursively with the set of letters in alphabet. Table I gives examples of how to construct the four models, LST, LMT, LET, and CTM.

As stated earlier, we limit our case studies to "Naskh" and "Reqaa" styles. In training stage, we study each letter with all other letters by applying the following procedure. Let i be a letter, s.t., $\forall i \in Alphabet$ do:

Build four models for letter i as follows:

1) Build a model in which each letter i pairs cursively with all letters $\in Alphabet$, i.e., CTM model,
2) Build a model in which each letter i is drawn as it comes in the beginning of a word, i.e., LST model,
3) Build a model in which each letter i is drawn as it comes in the middle, i.e., LMT model, and
4) Build a model in which each letter i is drawn as it comes at the end of a word, i.e., LET model.

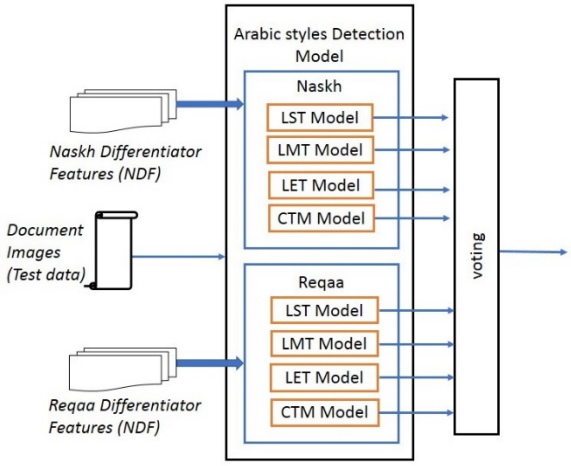


Fig. 2. Proposed classification model.

A. Training Dataset

Training dataset has been divided into eight partitions in Naskh and Reqaa styles every one represents a model. Each one of the first six models contains 24 images of 200×200 pixels, the last two contains 30 images.

B. Testing Dataset

Test dataset has two partitions in Naskh and Reqaa styles which were collected from ancient Arabic documents, historical books and Arabic calligraphy resources. The total number of images equal 200 images and are divided as follows: 1) Naskh contains 100 images of ancient documents from different ages in various fields and samples of images. 2) Reqaa contains 100 images of ancient documents, a copy of holy Quran that is written in Reqaa style and samples of images of old books that were written in Reqaa style like "Alfaiet Ebn Malek" and "Mosl Al-tolab Le Quaed Al-earb". All images in training dataset are digitized at 200×200 dpi. Then the resized images are preprocessed/filtered for noise removal. Noise in our dataset appears usually on form of isolated dots that are due to tiny drops of ink that have fallen from calligraphers' pens during the handwriting process. Several filters have been applied like mean filter, Laplacian of Gaussian filter and median filter. Empirical results show that median filter (3×3 window) yields the best results because it is highly effective in removing salt-and-pepper noise [18]. Median filter computes the median value of all the pixels under the kernel window and assign this value to the central pixel. Image set are separated into two sets: Naskh and Reqaa.

To extract the features and build our proposed approach, we need two datasets per model (LST, LMT, LE, and CTM). This mandates the construction of eight sets, four sets per style (Naskh and Reqaa). Generally, the image size is kept to 200×200 pixels.

In training phase, we kept the testing datasets (our proposed model has never trained on them) in two separate sets: First set is Naskh which contains eighty images of ancient documents from different ages in various fields and samples of images of old books were written in Naskh style like, "Al-kouakeb Al-dorya fi Sharh Saheeh Al-Bokhary". Second set is Reqaa which contains eighty images of ancient documents, a copy of the holy Quran in Reqaa style and samples of images from "classical" books in Reqaa style like, "Alfaiet Ebn Malek" and "Mosl Al-tolab Le Quaed Al-earab".

C. Feature Extraction

Khorsheed [17] proposes an approach to filter out all attributes and preserve the properties that make one character or word different from another. Features of Arabic text could be represented statistically and spatially. The statistical features analyze the spatial distribution of pixels while the structural features, the most commonly used, are based on geometrical and topological characteristic of a character, see [17] for details. Applying scale-invariant feature transform (SIFT) which uses the Difference-of-Gaussian (DOG) operator to detect distinct features in images. Lowe [18] explains that the main task of SIFT is to detect local features and describe them. While the main capacity of SIFT is preserving salient features, the big computational cost and high dimensionality of features are issues of concern. Sample runs of SURF and SIFT on the synthetic labeled dataset (CTM models for Naskh and Reqaa) are shown in Fig. 3.

Algorithm 1 learns from the labeled dataset and extracts the features. As a result, the training phase concludes with distinct features for each given class (style) of the labeled data. Therefore, the output of the training phase is either Naskh features (FN) or Reqaa features (FR).

Algorithm 1: Training Algorithm

Input: {images, labels} where labels $\in$ {'Naskh', 'Reqaa'};
Output: Features of Naskh and Reqaa styles, i.e., FN and FR;
/* $\forall$ image $i \in$ training set */
for $i = 1$ *to* n **do**
  Resize i;
  Binarize i;
  Apply SIFT/SURF algorithm;
  if $i \in$ *Naskhstyle* **then**
    Save features as FN;
  else
    Save features as FR;
  end
end

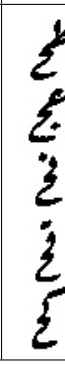
D. Image Classification

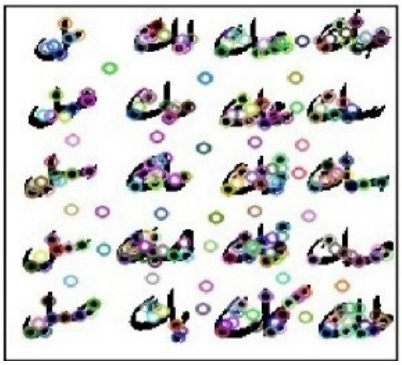
After features extraction phase, classification is conducted using the four different classifiers for performance evaluation. Algorithm 2 entails the steps that each image undergoes till a classification decision is reached. Algorithm 2 takes an image instance as an input and classify it as either Naskh or Reqaa.

IV. Experimental Results

Table II shows the results of using SIFT to learn from the four models (LST, LMT, LET and CTM) and the corresponding accuracy with the four classifiers. For the CTM

TABLE I. LST, LMT, LET, AND CTM MODELS FOR ARABIC ALPHABET

	Font Styles	
	Naskh	*Reqaa*
LST		
LMT		
LET		
CTM		



(a) Using SURF.

(b) Using SIFT.

Fig. 3. Features extraction.

Algorithm 2: Testing Algorithm

```
/* ∀ image i ∈ testing set                    */
```
Input: {image};
Output: The class to which an image belongs, i.e., $Reqaa$ or $Naskh$;
```
/* Preprocessing Stage:                       */
```
Resize image;
Binarize image;
Apply noise removal filter;
Apply SIFT / SURF algorithm and save features of image as FT;
```
/* Classification Stage:                      */
```
Apply GNB / KNN / DT / RF classifiers;
Save each classifier result;
Apply voting;
Return voting result;

TABLE II. SIFT RESULTS WITH THE FOUR CLASSIFIERS

Classifier	Style	LST	LMT	LET	CTM	Voting	Mean
GNB	NASKH	90%	91%	93%	96%	92.5%	92%
	REQAA	92%	88%	93%	95%	92%	
DT	NASKH	86%	88%	89%	89%	88%	89%
	REQAA	90%	85%	91%	94%	90%	
RF	NASKH	86%	89%	86%	93%	88.5%	88%
	REQAA	89%	86%	84%	93%	88%	
KNN	NASKH	91%	88%	90%	95%	91%	91%
	REQAA	90%	90%	91%	94%	91.3%	

model, DT classifier yields at least 89%. While RF classifier yields accuracy that is exactly 93% in both styles. In addition, KNN classifier yields accuracy that is greater than 94% in both styles. However, the best performance is achieved by GNB classifier which yields accuracy that is greater than 95%. It is apparent that the CTM model outperforms the remaining models as it is more inclusive and representative when it comes to the learnt extracted features

Similarly, the empirical performance results of GNB, DT, RF and KNN classifiers on the two case studies: Naskh and Reqaa using SURF is shown in Table III. For the CTM model, DT classifier yields accuracy that is between 87% and 89%. While RF classifier yields accuracy that is at least 90% in both styles. In addition, KNN classifier yields accuracy that is between 90% and 93%. However, the best performance is achieved by GNB classifier which yields accuracy that is greater than 91%.

Table IV shows the confusion matrices for the four training models resulting from applying GNB classifier on features extracted by using SIFT algorithm.

By analogy, Table V shows the confusion matrices attained by feeding features that are extracted by SURF algorithm and employing GNB as a classifier.

In our study, SIFT local descriptor outperforms SURF; see Fig. 3 which shows how SISFT gives higher performance than SURF.

A. Voting Procedure

Our proposed CTM contains the most distinct features of handwritten text, therefore it gives the most appealing results. As a rule of thumb in the voting process, we give CTM higher weight than the three other models. The resulting output prediction is the one that receives more than half of the votes. Table VI shows the voting process where number 1 represent class of Naskh and number 0 refers to Reqaa.

B. Performance Comparison

Finally, we conduct a performance comparison between our proposed model and two models as shown in Table VII. To have an objective comparison, a fixed setting with the literature is adopted by using the same dataset as in [15] and [19], a printed Arabic text extracted from King Fahd University Arabic Font Database (KAFD). Tensmeyer, Saunders and Martinez [15] have adopted convolutional neural network(CNN) to perform text classification. They use two sets for training: one with base-line in the manuscript and the other without a base-line. Nevertheless, their model is suffering a performance degradation when a part of the writing is cropped. While our proposed model is immune to this problem because of the plethora of features that have been introduced by the four-letter model (LST, LMT, LET, CTM). Hence, we assert that if the proposed model surpasses the existing approaches given a common dataset then we can fairly attribute this to the novel training approaches that we propose in our model.

TABLE III. SURF RESULTS WITH THE FOUR CLASSIFIERS

Classifier	Style	LST	LMT	LET	CTM	Voting	Mean
GNB	NASKH	88%	82%	81%	94%	86.3%	87%
	REQAA	89%	86%	82%	91%	87%	
DT	NASKH	84%	86%	80%	87%	84.3%	86%
	REQAA	88%	88%	85%	89%	87.5%	
RF	NASKH	85%	96%	92%	91%	91%	89%
	REQAA	86%	89%	81%	90%	86.5%	
KNN	NASKH	89%	90%	88%	90%	89.3%	90%
	REQAA	94%	91%	88%	93%	91.5%	

V. CONCLUSION AND FUTURE WORK

In this work, we propose a model for classifying Arabic writing styles in ancient Arabic manuscripts using novel models for training. To these models, we attribute the superior performance. First, the features have been extracted by using SIFT and SURF algorithms. Second, the classification stage has employed four classifiers for evaluation purposes. Then, we present the empirical performance results of GNB, DT, RF and KNN classifiers on the two case studies: Naskh and Reqaa to give results up to 92% in case of GNB classifier where KNN gives results reach to 91%. Empirically, KNN classifier gives good performance with SURF results 90%. However, the best performance in case of SIFT is achieved by GNB classifier and KNN classifier in case of SURF. Obviously, GNB and KNN classifiers have shown superior performance in Arabic manuscripts written in Naskh and Reqaa styles. Hence, the experimental results show that the learnt features from the synthetic dataset are extremely powerful in discriminating between the two styles that are considered for this study. Future work could entail conducting a comparative study of the proposed approach on other cursive languages. Also, we can introduce a meaningful weighting scheme for the voting system that guarantees an output that is at least equals to that of the CTM model.

REFERENCES

[1] K. AlGabory, *Encyclopedia of Arabic fonts, Vol.I*. Dar Alhilal, 1999.

[2] K. AlGabory, *Encyclopedia of Arabic fonts, Vol.II*. Dar Alhilal, 1999.

[3] M. Ja'Far and V. Porter, *Arabic Calligraphy : Naskh Script for Beginners*. British Museum Pubns Ltd, 2001.

[4] E. Smitshuijzen, *Arabic Font Specimen Book*. De Buitenkant, 2008.

[5] J. Janbi, "Classifying Arabic Fonts Based on Design Characteristics: PANOSE-Ao," Ph.D. dissertation, Concordia University Montreal, Quebec, Canada, 2016.

[6] N. Ghali, *Write It in Arabic: A Workbook and Step-by-Step Guide to Writing the Arabic Alphabet*, 2nd ed. Fun With Arabic, 2009.

[7] K. Adam, S. Al-Maadeed, and A. Bouridane, "Letter-based classification of Arabic scripts style in ancient Arabic manuscripts: Preliminary results," *2017 1st International Workshop on Arabic Script Analysis and Recognition (ASAR)*, pp. 95–98, 2017.

[8] I. B. Yosef, K. Kedem, I. Dinstein, M. Belt-Arie, and E. Engel, "Classification of Hebrew Calligraphic Handwriting Styles: Preliminary Results," *Proceedings - First International Workshop on Document Image Analysis for Libraries - DIAL 2004*, no. ii, pp. 299–305, 2004.

[9] A. Amin and J. F. Mari, "Machine recognition and correction of printed Arabic text," *IEEE Transactions on Systems, Man, and Cybernetics*, vol. 19, no. 5, pp. 1300–1306, 1989.

[10] A. Gillies, E. Erl, J. Trenkle, and S. Schlosser, "Arabic Text Recognition System," *Proceedings of the Symposium on Document Image Understanding Technology*, vol. 11, no. 3, pp. 127–141, 1999. [Online]. Available: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.21.947

[11] I. Siddiqi and N. Vincent, "Text independent writer recognition using redundant writing patterns with contour-based orientation and curvature features," *Pattern Recognition*, vol. 43, no. 11, pp. 3853–3865, 2010. [Online]. Available: http://dx.doi.org/10.1016/j.patcog.2010.05.019

[12] X. X. Niu and C. Y. Suen, "A novel hybrid CNN-SVM classifier for recognizing handwritten digits," *Pattern Recognition*, vol. 45, no. 4, pp. 1318–1325, 2012. [Online]. Available: http://dx.doi.org/10.1016/j.patcog.2011.09.021

[13] L. Yang, C. Y. Suen, T. D. Bui, and P. Zhang, "Discrimination of similar handwritten numerals based on invariant curvature features," *Pattern Recognition*, vol. 38, no. 7, pp. 947–963, 2005.

[14] A. Elnagar and R. Bentrcia, "A Multi-Agent Approach to Arabic Handwritten Text Segmentation," *Journal of Intelligent Learning Systems and Applications*, vol. 04, no. 03, pp. 207–215, 2012.

TABLE IV. CONFUSION MATRICES (FOUR MODELS) FOR GNB CLASSIFIER AND SIFT

	LST		**LMT**		**LET**		**CTM**	
	Pred. Naskh	Pred. Reqaa	Pred. Naskh	Pred. Reqaa	Pred. Naskh	Pred. Reqaa	Pred. Naskh	Pred. Reqaa
Naskh	90	10	91	9	93	7	96	4
Reqaa	8	92	12	88	7	93	5	95

TABLE V. CONFUSION MATRICES (FOUR MODELS) FOR GNB CLASSIFIER AND SURF

	LST		**LMT**		**LET**		**CTM**	
	Pred. Naskh	Pred. Reqaa	Pred. Naskh	Pred. Reqaa	Pred. Naskh	Pred. Reqaa	Pred. Naskh	Pred. Reqaa
Naskh	88	12	82	18	81	19	94	6
Reqaa	11	89	14	86	18	82	9	91

TABLE VI. VOTING SCHEME

Image	LST	LMT	LET	CTM	Voting
image#1	1	0	1	1×1.5	1
image#2	0	0	1	0×1.5	0
image#3	1	1	0	0×1.5	1
...	...	...	...	...	...
image#200	0	1	0	1×1.5	1

TABLE VII. PERFORMANCE COMPARISON

Model	**Accuracy**
CNN Font Classification by Tensmeyer et al. [15]	95.05%
KAFD Arabic font database by Luqman et al. [19]	96.1%
Our Proposed Model	96.83%

[15] C. Tensmeyer, D. Saunders, and T. Martinez, "Convolutional Neural Networks for Font Classification," *Proceedings of the International Conference on Document Analysis and Recognition, ICDAR*, vol. 1, pp. 985–990, 2018.

[16] A. K. Echi, A. Saïdani, and A. Belaïd, "How to separate between machine-printed/handwritten and arabic/latin words?" *Electronic Letters on Computer Vision and Image Analysis*, vol. 13, no. 1, pp. 1–16, 2014.

[17] M. Khorsheed, "Off-Line Arabic Character Recognition – A Review," *Pattern Recognition*, vol. 31, no. 5, pp. 517–530, 1998. [Online]. Available: http://linkinghub.elsevier.com/retrieve/pii/S0031320397000848

[18] D. G. Lowe, "Distinctive image features from scale-invariant keypoints," *International Journal of Computer Vision*, vol. 60, no. 2, pp. 91–110, 2004.

[19] H. Luqman, S. A. Mahmoud, and S. Awaida, "KAFD Arabic font database," *Pattern Recognition*, vol. 47, no. 6, pp. 2231–2240, 2014. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0031320313005463

A Method for Segmentation of Vietnamese Identification Card Text Fields

Tan Nguyen Thi Thanh[1]
Faculty of Information and Technology
Electric Power University
Hanoi, Vietnam

Khanh Nguyen Trong[2]
Faculty of Information and Technology
Posts and Telecommunications
Institute of Technology
Hanoi, Vietnam
Sorbonne University, IRD, UMMISCO,
JEAI WARM, F-93143, Bondy, France

***Abstract*—The development of deep learning in computer vision has motivated researches in related fields, including Optical Character Recognition (OCR). Many proposed models and pre-trained models in the literature demonstrate their efficient in optical text recognition. In this context, image processing techniques has an essential role in improving the accuracy of recognition task. Because, depending on the practical application, image text often suffering several degradation from blur, uneven illumination, complex background, perspective distortion and so on. In this paper, we propose a method for pre-processing, text area extraction and segmentation of Vietnamese Identification Card, in order to improve the accuracy of Region of Interest detection. The proposed method was evaluated with a large data set with different practical qualities. Experiment results demonstrate the efficiency of our method.**

***Keywords*—Optical Character Recognition (OCR); text identification; identification card detection and recognition**

I. Introduction

Identification (ID) Card is a personal card, providing basic information of citizen such as full name, date of birth, place of origin, place of permanent residence, nationality, religion, date and place of issue. In almost daily business, those information are required and usually extracted manually. It is not efficient process because we need a lot of time to input data one by one. Therefore, we need a method that processes automatically which is know as Optical Character Recognition (OCR).

Typically, a method for recognition of optical characters contain three main phrases: pre-processing, layout analysis and recognition [1], [2]. The pre-processing usually relates to improving the input image to reduce the noise, and to enhance the processing speed in the next phrases. Different basic image processing can be applied at this step such as: automatic contrast adjustment, noise reduction and so on.

The output of pre-processing phrase is passed to the next one where page layout analysis is essentially performed for detection of Region Of Interest (ROI), such as text, image region [1]. At the final phrase, where the main principle of what usually called Optical Character Recognition happens, the potential text areas are recognized by different methods/models.

Therefore, the optical character recognition task is in fact performed at the last step, after a series of image processing techniques. With the development of deep learning in computer vision recently, many efficient models/methods has been proposed which allow us to recognize optical character with high accuracy, for example Tesseract OCR [3], CHAR model [4], CTPN [5] and so on. In this context, with a same method or model, the key factor to improve the accuracy depend now on the way that data input is processed and also on the accuracy of ROI (the text fields) detection. Because, depending on the practical application, image text, especially ID Card images, often suffering several degradation from blur, uneven illumination, complex background, perspective distortion and so on.

A Vietnamese ID card usually contains text fields with different font styles and size. In many cases, the characters and also the other parts like rows, the seal, the signature was not well printed which cause the inaccurate information, like the overlap of characters, of rows. In addition, by the time, the card is normally faded and blurred.

In the literature, there are already existing works to improve the accuracy of ID card reading by different techniques before the recognition of optical characters [1], [2], [6], [7], [8], [9], [10], [11]. But for the Vietnamese ID Card, especially with the old form, it still lacks an efficient method to improve the quality of input data, reduce noise or time for the recognition task.

In this paper, we proposes a method to detect and separate text fields in a Vietnamese ID Card by analyzing image structure and basic pre-processing image technique like tilt adjusting, noise filtering, background removing, color channel analysing, connected component analysing, mask line creating, table structure analysing and binary image.

The paper is organized as follows: Section 2 presents the work that relates to our problem; Section 3 proposed our method for detection and separation of ROI; Section 4 provides the experimental evaluation; Section 5 is our conclusion and further work.

II. Related Work

Regarding to the process of text identification from a text image, it composes of six steps as shown in Fig. 1, in which page layout analysis and text zone recognition are two important ones. These two steps determine success or failure of an identification system.

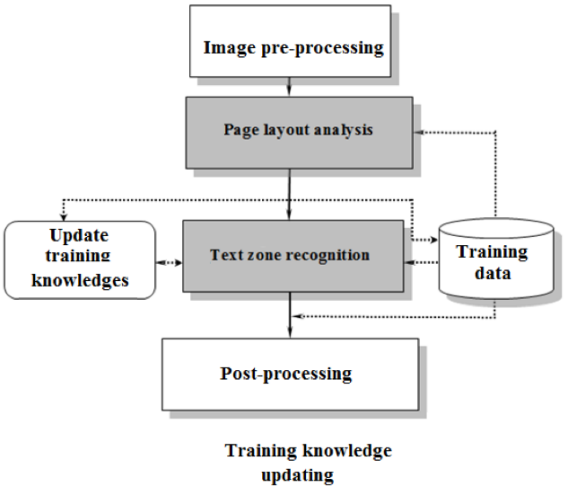


Fig. 1. Text identification process

Page layout analysis is to analyze and determine locations, structures of different information areas on the input image such as text, image, table an so on. At this step, after being defined (detected) text zone will be removed/separated from the background and sent to next step.

In the literature, many methodologies for page layout analysis are proposed [11], [12], [13], [14], [15], [16] [17]. Basically, there are three main approaches including top-down approaches, bottom-up approaches and hybrid approaches.

For the Top-down approaches, starting from the input image page, a loop is performed where the image is divided into smaller ones until it satisfies given conditions or the gained areas are unified. The execution speed is main advantage of this approach. But it requires the knowledge about structure of the page layout. Typical top-down algorithms include algorithm that use the projection [14], X-Y cut algorithm, white stream algorithm [13], analytical algorithms based on region-specific transformations [15].

With respect to the Bottom-up ones, starting from pixels of the input page, the approaches pair them into bigger homogeneous regions (connected components, characters, row, text block . . .). Advantages of those approaches are flexibility and ability to bear tilt of the page (even much tilted). However, it is slower than top-down approaches. In the literature, there are several works based on this approaches, for example Docstrum [18], algorithms basing on Voronoi diagram, run-length smearing [19], segmentation algorithm based on the development of regions [11], differential algorithm using morphological operators [20].

Regarding to the Hybrid approaches, the advantage of the above approaches are combined to analyze the page layout. Many works related to this approaches can be found in the literature, like spit-and-merge [21], bottom-up analysis method combined with tab-stop detection technique (tab-stops) [12], method combining of bottom-up analysis and machine learning techniques [14].

With respect to Vietnamese ID card image, the traditional text structure analysis faces following difficulties in detection and separation of text field:

- Background of the ID card contains complicated patterns and not unified; text and background colors are sometimes similar and it is difficult to separate them.
- Personal information fields may be deviated from the standard lines or overprinted in the preprinted section.
- Uneven text among ID cards, even in a same ID, there are words which are too dark or too light (translucent).
- ID cards can be stained, moldy, creased, and in some cases the text is more blurred than the background pattern.
- Quality of the image is unstable, which depends a lot on the light source at the time of image acquisition.
- For the back side of the ID card, it is very common that stamp or signature overlaps with information such as date of issue, place of issue.

Due to this complexity of structure and quality, for detection and separation of the information fields in a Vietnamese ID Card, we can not simply use only one algorithm. For each concrete information field, it needs a suitable method to deal with its specific situation. In the next section, we will present four main steps supporting in analyzing a Vietnamese ID Card.

III. Detection and Separation of Information Fields in ID Cards

The Vietnamese ID Card is in rectangular form, sized 85.6 mm in length and 53.98 mm in width; its two sides are flower-patterned in light white blue. The front side contains two main parts: (i) to the left from top to bottom is the national emblem of the Socialist Republic of Vietnam, sized 1.9 cm in diameter; the 3 x 4 cm photo of the identity card holder; its valid time-limit; (ii) To the right, from top to bottom: the first rows is *"Cong Hoa Xa Hoi Chu Nghia Viet Nam"* (The Socialist Republic of Vietnam), and the second one is *"Doc Lap - Tu Do - Hanh Phu"* (Independence - Freedom - Happiness); words "*Chung minh nhan dan*" (People's identity card) (in red); the number, birth name and family name; sex; commonly used name; birth date; birth place; residence place.

Similarly, the back side also composes of two parts: (i) to the left: there are 2 blocks, the upper block for the left forefinger print, the lower block for the right forefinger print; and (ii) to the right, from top to bottom: identification particulars; day, month, year of issuing the identity card; the title of the issuer, his/her signature and seal. The detail information are described in Table I.

Due to this variety, the analysis of the front side and the back side should be done separately. Even for each part in a same side, for the front side, the ID card Number has a different style comparing with the other fields, so that it will be processed differently. Regarding to the back side, it contains a table that requires a specific structure analysis while detecting and separating information fields.

Therefore, we propose an adaptive method, as illustrated in Fig. 2, for detection and separation of the Vietnamese ID

TABLE I. FRONT PAGE OF THE ID CARD

Information	Feature	Location
Nam National Emblem of Viet Nam	Printed in yellow and red color	Upper left corner
Image of ID card holder	Card format with blue background	Lower left corner
Heading: - "Socialist..." - "Independence..." - "ID card..."	The 2 above lines are black. The 2 below lines are red	On the right side of the National Emblem
ID card No.	Red, printed on the wavy line of the same color	Printed under heading, on the right side of the National Emblem
Full name	Black, including 2 lines	Printed under ID card No.
Date of birth	Black, including 1 line	Printed under full name
Place of origin	Black, including 2 lines	Printed under date of birth
Place of permanent residence	Black, including 2 lines	Printed under place of origin

card. The method will process the two sides separately, but it has a same procedure:

- Step 1: Image processing
- Step 2: ID card Number detection for the front side, and Table structure analysis for the other side
- Step 3: Text fields analysis and detection
- Step 4: Estimate the accuracy

The details of each step are presented in the next section.

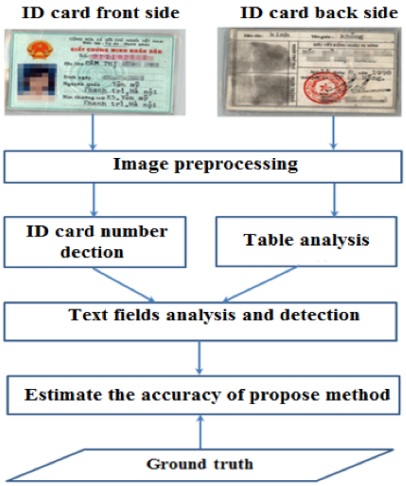


Fig. 2. Procedure for detection and separation of information fields

1) Image pre-proceeding, enhancing the quality of input data: As mentioned above, ID cards can be stained, moldy, crumpled and worn out over time. Therefore, improving and enhancing the quality of input image is necessary and important.

Pre-processing was done in both front and back side of the card. It includes basic steps: Convert the color image to the gray-scale one; align tilt, smooth and create the binary image.

2) Detecting and separating the ID card number: For the front side, the important information we need is the ID card Number, so that with this side we firstly detect and separate the ID Card Number field.

However, due to the same color among the ID card Number, wavy lines, the national emblem and sometimes clothes of ID card holder; therefore, firstly we highlight the ID card Number by the color channel analysis technique.

Then, based on the location and structure combining with vertical and horizontal projections we can detect the number. The algorithm is described as follows:

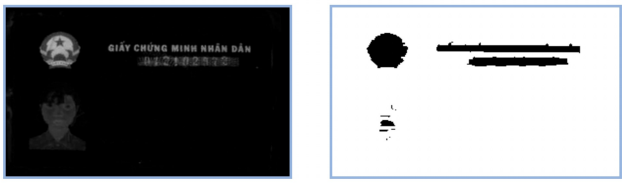
Algorithm 1: Detecting and separating ID card No.

Input: Front side of the ID card: $I_{Color} = U(I_{Red}, I_{Green}, I_{Blue})$
Output: Area containing ID card No.: I_{Number}
1: Convert image to grayscale image: $I_{Gray} = Max(I_{Red}–I_{Green}, 0)$
2: Apply operator *Closing 31x7*
3: Make binary image by Otsu method
4: Reverse grayscale
5: Separate connected components: L; $L = b_i, whereb_i = (xb_i, yb_i, wb_i, hb_i)$
6: Search for "ID card": $b_{Title} \leftarrow \{b_i | i = xb_i \rightarrow max\}$
7: $b_{Number} \leftarrow IDcardNo.field$
8: **if** $(hb_{Title} > hbMax_{Title})$ **then**
9: separate b_{Number} from b_{Title}
10: **else**
11: look for b_{Number} in L (which is under b_{Title})
12: **end if**
13: Remove ID card No. field: $I_{Number} \leftarrow Clip(I_{Color}, b_{Number})$

The first step is to convert the input image to the gray-scale. Then the closing morphology is applied to "connect" adjacent characters (components) into rows (blocks). After that, Otsu's method [22] is used to separate pixels into two classes, foreground and background. Then, we reverse gray-scale to convert gray-scale image to binary image and separate connected components. Connected components collected from this step can include heading "ID card", ID card No., one part of national emblem or portrait, as shown in Fig. 3.

Finally, based on characteristics of their location, size, horizontal and vertical projects, we eliminate connected components in image areas and the heading. The obtained result is a image area containing ID card No that is separated from the others.

3) Analysis of table structure: For the back side, the ROI is a table that contains different information. The table is formed



a) Separate the red channel *b) Connected components*

Fig. 3. Detecting for ID card No. field

by horizontal and vertical lines but those lines is usually blurred or dashed.

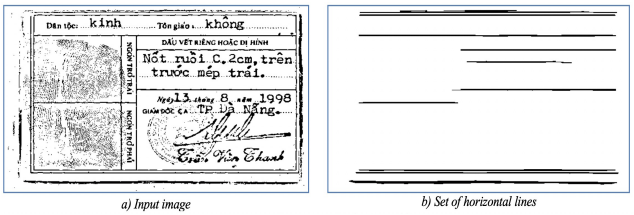
Moreover, while stamping/printing and finger-print, the characters or the fingerprints may overlap with lines which makes it difficult to detect the table structure.

Therefore, to determine table structure, the horizontal and vertical lines should be clearly defined. Since they have a same characteristic, we apply also a same algorithm to define these lines. The algorithm is describe as follows, in Algorithm 2.

Algorithm 2: Determining horizontal lines in the table

Input: Binary image: I_{Bin}
Output: List of horizontal lines in the image: H_{Lines}
1: Apply morphological transformations to I_{Bin}:
2: *erosion 15x1*: Erode vertical line and stroke of characters
3: *dilation 1x3*: Thicken the horizontal line
4: *closing 51x1*: Close the broken horizontal line
5: Analyse connected components: $CC_Analysis(I_{Bin})$
6: Determines the horizontal lines in the image

The morphological changes is applied for the first step to highlight the horizontal lines. Then connected components is analysed (function $CC\_Analysis(I_{Bin})$ to define and separate interconnected components. From this, we can define a set of horizontal lines in the image. This set may contain the actual horizontal lines of the table or the horizontal lines made by adjacent dots of the baseline or underline of signature, as shown in Fig. 4.



a) Input image *b) Set of horizontal lines*

Fig. 4. Define horizontal lines

In the next step, based on the characteristic of distance, relative location and length, we eliminate horizontal lines which is not in the table. In addition, the missing parts is added; and the rows of the table is also adjusted and smooth.

The algorithm to define the vertical lines is the same with the horizontal ones. After defining the horizontal and vertical lines, the areas with information fields for verification from the table would be separated.

4) Detecting text rows: The detection of text rows is applied on the binary image block after separating national emblem, portrait, headings and ID card Number in the front side, or the text image defined from the table in the back side.

Traditionally, in order to identify the text in a paragraph, the histogram can be used horizontally in the text block, as shown in Fig. 5. However, as analysed above, the information rows may be tilted/deviated from the standard row or overlap on header or the other information rows, so that the traditional approach is sometimes not effective.

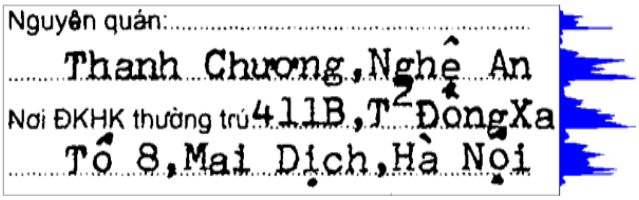


Fig. 5. Histogram of a information block in ID card

To resolve this issue, we apply the bottom-up algorithm to define text row, as presented in Algorithm 3.

Algorithm 3: Defining text rows

Input: Binary block image: $Text\_Block\_Image$
Output: List of information rows to define: Row_List
1: Analyze and define connected components: $CC\_List \leftarrow CC_Analysis(Text\_Block\_Image)$
2: Filter temporarily noises in row:
- $Noise\_List \leftarrow \{cc\_noise | cc\_noise \in CC\_List \ AND \ size\_of(cc\_noise) \leq noise\_size\}$
- $Small\_List \leftarrow \{cc\_small | cc\_small \in CC\_List \ AND \ size\_of(cc\_small) \in (noise\_size, small\_size\}$
- $CC\_List \leftarrow \{CC\_List \setminus Noise\_List\} \cap \{CC\_List \setminus small\_List\}$

3: Arrange CC_List according to x abscissa
4: Create format of first row from the arranged CC_List
5: Edit the baseline of the newly created lines
6: Calculate overall deviation of the text block
7: Temporarily filtered items to their respective lines

Firstly, a list of connected component (CC-Connected Component) is defined as a sequence of pixels (black dots) consecutively. This list contains characters, circumflex/tones (or interference) where the first ones relate to the typically components of the row while the second one is untypical. In the next step, we temporarily remove untypical ones in order to format and adjust the row precisely.

At Step 3, we arrange the typical components by the abscissa operation. It is not only a process which support to format the row, but also enable the algorithm to detect tilt of the row.

In order to format the row, for each connected component in the set of the CC_List, we check if there is row that intersect the component, if yes, adding the component to the row and reformat the row; if not creating a new row. In the

case there are many such rows, the most intersected one is selected.

In the next steps, we add the baseline for the new created rows and put the untypical components (temporarily filtered) in the corresponding row. It allow us to avoid the omission and lost of information during the character segmentation at identification step.

IV. Experiments

A. Experiment Configuration

The experiments is carried out using 1856 ID Card images, in which there are 928 front-side-images and 928 back-side-images of ID cards. ID cards were collected from many provinces, in various qualities, font sizes, printing style and scanned at resolutions of 200dpi, 300dpi and 400dpi. For actual assessment, each ID card was given ground-truth data, which contains information about the information areas to be detected in the image such as total number of areas, coordinates of areas. The experiments is performed HP computer, with speed 2.4GHz, 6.0 GB RAM, on Window 10.

In order to evaluation of the result, we based on Precision, Recall and F-measure [23], which are calculated as following:

- **Precision**: Precision = (Number of correct detected area)/[Number of correct detected area + Number of incorrect detected area] [23]
- **Recall**: Recall = (Number of correct detected area)/[Number of correct detected area +Number of undetectable areas] [23]
- **F-measure** = = (2*Precision*Recall)/ (Precision+Recall) [23]

Let V be the area to be detected (defined in ground-truth file) and V' be the detected area (by the program), we call *undetected area* are the area that can not be detected if its ordinate exists in ground-truth file but the program can not detect, which mean $V' = \phi$. The correct detected area is considered as corrected detected if square of the intersection of V' with area to be detected Vt meet the following requirements:

$$req_1 = \begin{cases} V' \neq \phi \\ S(V \cap V') \geq C_1 \times S(V) \\ S(V \cap V') \geq C_2 \times S(V') \end{cases}$$

In which: $S(.)$ is square; C_1, C_2 are optional constants $(C_1 = C_2 = 1/3)$; $(V \cap V')$ is intersection between V and V'.

An area is considered as *incorrect detection area* if it is not included in two cases mentioned above. It will satisfy the following requirements:

$$req_2 = \begin{cases} V' \neq \phi \\ S(V \cap V') < C_1 \times S(V) \\ S(V \cap V') < C_2 \times S(V') \end{cases}$$

B. Results Analysis

Let N_T be the correct detected area, N_M be the undetectable area, N_F be the incorrect detected area, the result is shown in Table II.

The experiment results show that the detection measure based on the separation of color channel support a high precision with ID card No. field (100%). Because the area is clearly contrasted with neighboring areas, as shown in Fig. 6.

Fig. 6. The ID number (the red number) is well separated from others

In total of 925 ID Card Numbers, there was only 3 undetected cases. It happened to ID card images which was too old and unclear, as illustrated in Fig. 7. Therefore, these fields could not be detected.

Fig. 7. An unclear ID card

For remaining information fields, the omission or wrong detection was often caused by the fact that the lines of information was oblique, or overlapping, as presented in Fig. 8 and 9.

By observing Table II, we can see that the performance is reduced from the top information fields to the bottom ones. It is explained by the increase of number of information of these fields. As illustrated in Fig. 6 where the ID card Number (the red number in the fourth line) has only 11 characters, while the place of origin and residence (the last two fields) has more than that; or as presented in Fig. 10 where the date and place of issues have the most information (the last fields with the red stamp), while the ethnic group and region (the first line) has only a few character.

In general, the detection and segmentation of front side perform better that the back one. F-Measure of the first one perform 1.64% higher (98.98% vs. 97.34%). Because, the

TABLE II. EXPERIMENT RESULT

Information field	N_T	N_M	N_F	Precision (%)	Recall (%)	F-Measure(%)
ID card No.	925	3	0	100	99.68	99.84
Full name	923	5	11	98.82	99.46	99.14
Date of birth	921	7	15	98.40	99.25	98.82
Place of origin	917	11	16	98.29	98.81	98.55
Place of residence	915	13	14	98.49	98.60	98.55
Front side	**4601**	**39**	**56**	**98.80**	**99.16**	**98.98**
Ethnic group	911	17	21	97.75	98.17	97.96
Religion	912	16	19	97.96	98.28	98.18
Date of issue	889	39	21	97.69	95.80	96.74
Place of issue	886	42	23	97.47	95.47	96.46
Back side	**3598**	**114**	**84**	**97.72**	**96.93**	**97.34**

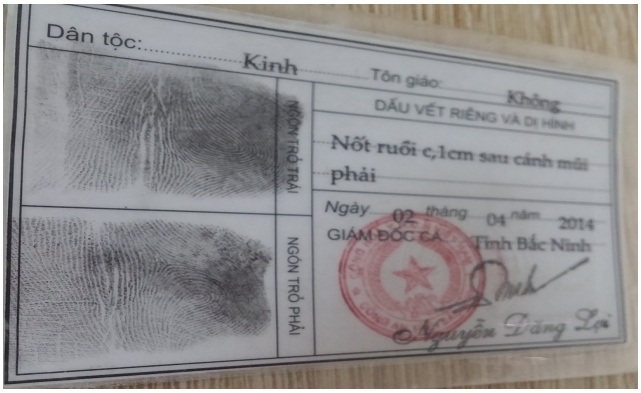


Fig. 8. Oblique baseline and overlap between baselines and other fields

Fig. 10. Back side with the overlap among date, place of issue, stamp and signature

Fig. 9. Full-name value is not in the same line with the Full-name filed

field of the front side are well separated than the back side. Moreover, the back side fields are usually overlap with each others. Especially the date and place of issue which are overlap by the stamp and signature (as shown in Fig. 10), that why the F-Measure of these fields is the lowest.

V. CONCLUSION

The article propose a solution for detection and segmentation information fields, which is suitable for identification (automatic data input) of personal information on Vietnamese ID card. Based on its specific feature, the detection and segmentation are divided into two separated step for the back side and the front side. After a series of basic image processing,for the front side, we detect the ID Card Number, and the other fields in the front side, while for the back side, we analysis the table structure.

We performed an experiment with 928 Vietnamese ID Card. Experimental results show the effectiveness of the proposed method which obtain more than 97% of accuracy, more than 95% of recall and measure effectively more than 96% of all information fields.

Future developments regard the extension of the proposed method in whole process of the recognition of Vietnamese ID card. Moreover, we need collect more ID model in order to test and improve the accuracy of the method.

REFERENCES

[1] M. Ryan and N. Hanafiah, "An Examination of Character Recognition on ID card using Template Matching Approach," *Procedia Computer Science*, vol. 59, no. Iccsci, pp. 520–529, 2015.

[2] R. Valiente, M. T. Sadaike, J. C. Gutiérrez, D. F. Soriano, and G. Bressan, "A process for text recognition of generic identification documents over cloud computing," *IPCV'1International Conference on Image Processing, Computer Vision, and Pattern Recognition*, no. April 2017, p. 4, 2016.

[3] R. Smith, "An overview of the tesseract ocr engine," vol. 2, no. 1, pp. 629–633, Sep. 2007.

[4] M. Jaderberg, K. Simonyan, A. Vedaldi, and A. Zisserman, "Synthetic data and artificial neural networks for natural scene text recognition," 2014.

[5] Z. Tian, W. Huang, T. He, P. He, and Y. Qiao, "Detecting text in natural image with connectionist text proposal network," 2016.

[6] S. Shabbir and I. Siddiqi, "Optical character recognition system for urdu words in nastaliq font," *International Journal of Advanced Computer Science and Applications*, vol. 7, no. 5, 2016.

[7] S. Lu, Y. Qu, Y. Cheng, and Y. Xie, "Id numbers recognition by local similarity voting," *International Journal of Advanced Computer Science and Applications(IJACSA), Special Issue on Image Processing and Analysis*, vol. 1, no. 1, 2011.

[8] R. Arief, A. B. Mutiara, T. M. Kusuma, and Hustinawaty, "Automated extraction of large scale scanned document images using google vision ocr in apache hadoop environment," *International Journal of Advanced Computer Science and Applications*, vol. 9, no. 11, 2018.

[9] W. Satyawan, M. Octaviano Pratama, R. Jannati, G. Muhammad, B. Fajar, H. Hamzah, R. Fikri, and K. Kristian, "Citizen Id Card Detection using Image Processing and Optical Character Recognition," *Journal of Physics: Conference Series*, vol. 1235, p. 012049, 2019.

[10] P. D. Hung and D. Q. Linh, "Implementing an android application for automatic vietnamese business card recognition," *Pattern Recognition and Image Analysis*, vol. 29, no. 1, pp. 156–166, Jan 2019.

[11] F. Shafait and T. M. Breuel, "The effect of border noise on the performance of projection-based page segmentation methods," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 33, no. 4, pp. 846–851, April 2011.

[12] R. W. Smith, "Hybrid page layout analysis via tab-stop detection," pp. 241–245, July 2009.

[13] F. Shafait and T. M. Breuel, "The effect of border noise on the performance of projection-based page segmentation methods," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 33, no. 4, pp. 846–851, April 2011.

[14] S. M. Hanif and L. Prevost, "Text detection and localization in complex scene images using constrained adaboost algorithm," pp. 1–5, July 2009.

[15] W. Huang, Z. Lin, J. Yang, and J. Wang, "Text localization in natural images using stroke feature transform and text covariance descriptors," pp. 1241–1248, Dec 2013.

[16] S. Puri and S. P. Singh, "A technical study and analysis of text classification techniques in n - lingual documents," pp. 1–6, Jan 2016.

[17] L. Quirós, "Multi-task handwritten document layout analysis," 2018.

[18] F. Shafait, A. ul Hasan, daniel. keysers, and T. M. Breuel, "Layout analysis of urdu document images," *2006 IEEE International Multitopic Conference*, pp. 293–298, 2006.

[19] P. P. Rege and C. Chandrakar, "Text-Image Separation in Document Images Using Boundary/Perimeter Detection," *International Journal on Signal and Image Processing*, vol. 03, no. 01, pp. 10–14, 2012.

[20] S. S. Bukhari, F. Shafait, and T. M. Breuel, "High performance layout analysis of arabic and urdu document images," pp. 1275–1279, Sep. 2011.

[21] A. M. Namboodiri and A. K. Jain, "Document Structure and Layout Analysis," pp. 29–48, 2007.

[22] N. Otsu, "A threshold selection method from gray-level histograms," *IEEE Transactions on Systems, Man, and Cybernetics*, vol. 9, no. 1, pp. 62–66, Jan 1979.

[23] D. M. W. Powers, "Evaluation: from precision, recall and f-measure to roc, informedness, markedness and correlation," 2011.

Static Analysis on Floating-Point Programs Dealing with Division Operations

MG Thushara[1]
Department of Computer Science and Applications
Amrita School of Engineering, Amritapuri
Amrita Vishwa Vidyapeetham, India

K. Somasundaram[2]
Department of Mathematics
Amrita School of Engineering-Coimbatore
Amrita Vishwa Vidyapeetham, India

***Abstract*—Numerical accuracy is a critical point in safe computations when it comes to floating-point programs. Given a certain accuracy for the inputs of a program, the static analysis computes a safe approximation of the accuracy on the outputs. This accuracy depends on the propagation of the errors on the data and on the round-off errors on the arithmetic operations performed during the execution. Floating point values disposes a large dynamic range. But the main pitfall is the inaccuracies that occur with floating point computations. Based on the theory of abstract interpretation, in the paper an upper bound to the precision of the results of these computations in program have been demonstrated.**

***Keywords*—Abstract interpretation; static analysis; forward analysis; abstract domain**

I. Introduction

The optimization of floating point computations in high performance computing is a critical problem. Most of the programming language is restricted in the ability to optimize the computations. The error propagation factor in the computations are considered to the minimal. Here, the paper introduces manual static analysis for floating point computation that deals with division operations in programs. The semantics of floating-point numbers are complicated and range of values comes in accordance with the precision.

There are different sources of inaccuracies in floating-point numbers like limited precision arithmetic, error accumulation as a result of floating-point computations, the result of a floating point computation when it becomes an input to some other function or process.

In programs with floating-point computations, it is demanding to have numerical accuracy in the results. Our approach is to combine a forward and a backward static analysis, done by abstract interpretation. The forward analysis is a classical approach where the errors on the inputs and on the results of the intermediary operations are safely propagated to determine the accuracy of the results. Based on the results of the forward analysis and on assertions indicating the accuracy required by the user for the outputs at the end of the execution, the backward analysis will be carried out. Backward analysis computes the minimal accuracy needed for the inputs and intermediary results of the program in order to satisfy the assertions made. In order to refine the results until a fixed-point is reached, the forward analyses and backward analyses can be applied repeatedly.

Static analysis are useful in several safety critical contexts. For instance, the explosion of the rocket-Ariane 5 [1], owing to a software error in the inertial reference system. Specifically, a 64-bit floating-point number was converted to a 16 bit signed integer which was larger than 32,767, the largest integer in a 16 bit signed integer, and that lead to the failure. Another instance was Patriot Missile [2] failed in detecting and intercepting an incoming Iraqi Scud missile and killing 18 American army men during the Gulf war. The cause of the incident was an inaccurate calculation of the time due to computer arithmetic errors.

Technically,abstract values are used in the form $[a, b]_p$ where a and b are floating-point numbers defining an interval and p is an integer giving the accuracy. Intuitively, $[a, b]_p$ is the set of numbers between a and b which have at least p correct digits.

Using the principles of abstract interpretation, an abstract domain is defined for floating point numbers using intervals. By static analysis with forward and backward analysis the input and results of the computations are optimized using the division operations.

II. Background Study

A. Abstract Interpretation

Static analysis involves defining a abstract domain [3] and computing automatically the program text with the abstract semantics according to predefined abstractions. Abstract interpretation uses theory of sound approximation of computer program semantics. Using the control-flow or data-flow, without doing all computations, information can be obtained about semantics of the program. In formal static analysis, these information can be used to analyze the behaviour of the possible executions of computer programs. The concept of Abstract interpretation was coined by the computer scientist working couple Patrick Cousot and Radhia Cousot in 1970s.

Real numbers are approximated by floating-point arithmetic [4], so error may propagate due to rounding during computations. Even though this seems to be accurate, losing precisions in safety critical applications will make the results useless. For dealing with this issue the authors in [4], came up with a tool using static analysis which allows to find the possible programming errors.

B. IEEE 754 Floating-Point Arithmetic

The programs containing floating-point computations [5] is critical when it comes to verification. This is mainly due to rounding errors, infinities, non-numeric objects (NaNs), signed zeroes, denormal numbers, different rounding modes, etc. Here, the authors has define and proved the correctness of algorithms which are using the values bound with variables x, y or z. This filtering algorithms are defined and formally proved for their correctness.

David Goldberg in his paper [6] discusses most of the aspects related to floating-point arithmetic. A look through on the implications of rounding for operations like addition, subtraction, multiplication and division. Also, explains the IEEE floating-point standard and also discusses different aspects of computer systems include design of instruction set, compiler optimization and exception handling.

In [7], a classification of floating point formats, including IEEE Standard 754 is presented by the author.

In [8], the author discusses about Interval mathematics that guarantees result but the arithmetic on existing processors makes these methods very slow. The paper looks into the efficiency of interval arithmetic on computers. Interval arithmetic can be considered as an extension of floating-point arithmetic. This controls the precision of a computation as well as the accuracy of the computed result.

C. Literature Reviews

FLUCTUAT [9] is a static analyzer for analysing the errors generated from approximations of floating-point arithmetic operations on real numbers. It mainly focuses on error computation using relational methods.

Round-off error in floating-point is formally verified using the tool FPTaylor in [10]. The approach used in the paper is Symbolic Taylor Expansions and the implementation of the tool called FPTaylor which is built on this approach.

The tool -VCFloat [11] automatically deals with rounding errors in real-number expressions of C floating-point computations and does the correctness proof using Coq.

In [12], a static analysis computing round-off error bounds on floating-point computation is introduced. The paper uses denotational semantics for the estimation of round-off errors.Authors have developed a prototype - PRECiSA (Program Round-off Error Certifier via Static Analysis) for verification in NASA for floating-point computations.

III. Methodology

In Fig. 1, a sample code that can lead to inaccuracies is depicted an the expected and actual result is shown in Fig. 2. An error of 0.00000000000000011102 is found in the result.

In this paper, static analysis for numerical accuracy is introduced. The information gained by this analysis will be used for the optimizing the floating-point representation. In order to show the correctness, experimental results will be presented in the coming sessions. Concrete semantics of a program is the set of all possible executions in all possible

```
double x=0.1; int i=1;
while (i <= 10)
{
  x = x + 0.1;
  printf("x=%0.20f", x);
  i++;
}
```

Fig. 1. Error Propagating code.

```
Expected output: At 10th iteration x = 1.0

Actual output:
(1) x=0.10000000000000000555
(2) x=0.20000000000000001110
(3) x=0.30000000000000004441
(4) x=0.40000000000000002220
(5) x=0.50000000000000000000
(6) x=0.59999999999999997780
(7) x=0.69999999999999995559
(8) x=0.79999999999999993339
(9) x=0.89999999999999991118
(10)x=0.99999999999999988898
```

Fig. 2. A simple Code snippet.

environment. Whereas Abstract semantics is a super set of the concrete semantics. In general, Abstract Interpretation [3] is a theory of semantics-based program analysis.

An abstract domain α is chosen replacing the objects of concrete domain S as $\alpha(S)$. For every program there is a corresponding computation tree or control flow graph.

```
(0) a = 1; b = 0;
(1) while (a < 10)
    {
      (2)  b = b + 1;
      (3)  a = a + 1;
    }
(4) Print b
(5) End
```

Fig. 3. A simple Code snippet.

Consider the code in Fig. 3, the corresponding control flow graph is shown in Fig. 4. The rules that allows us to compute the precision of the noes in a control flow graph is known as transfer functions. Two classes of transfer functions are used-the one that computes the past behaviour for each control point is transfer functions for forward analysis and the one that computes information about the future behaviour for each program point is transfer functions for backward analysis.

Here, floating point numbers are represented as intervals in the abstract domain. The transfer functions for division operation is then formulated. Using the principle of interval arithmetic the computations are further proceeded.

In this paper the approach is by defining the abstract domain whose elements are floating-point intervals with an associate precision. Then the transfer function for the division

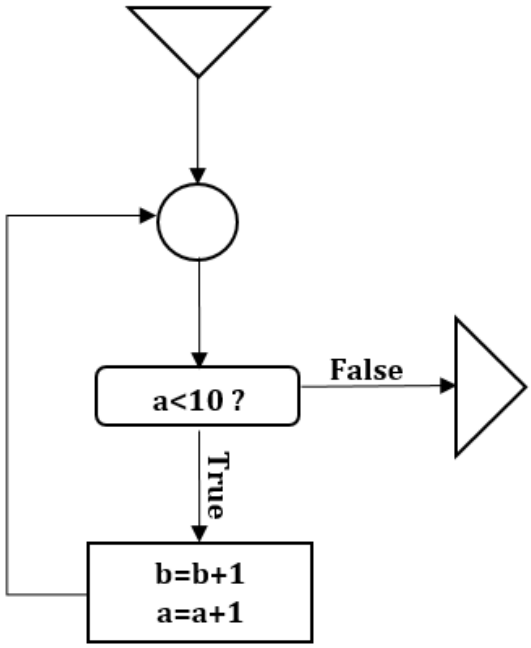


Fig. 4. A sample control flow graph

operator is formulated. Here the abstract domain is defined as $[a, b]_p$ where a and b are interval bounds and p is the precision. The IEEE754 standard Fig. 5 defines four different precisions: single, double, single-extended, and double-extended. In IEEE 754, single and double precision correspond roughly to what most foating-point hardware provides.

Parameter	Format			
	Single	Single-Extended	Double	Double-Extended
p	24	≥ 32	53	≥ 64
e_{max}	+127	≥ 1023	+1023	> 16383
e_{min}	-126	≤ -1022	-1022	≤ -16382
Exponent width in bits	8	≤ 11	11	≥ 15
Format width in bits	32	≥ 43	64	≥ 79

Fig. 5. IEEE standard

IV. Abstract Domain and Running Example

Let I_p be the set of all floating-point intervals with a precision p. An element $i \in I_p$ is denoted as $i = [a, b]_p$ where a and b are two floating-point numbers and p is the precision (length of the mantissa). Consider β_p as the set of all binary representations with p as the mantissa length.

Then,

$$I_p = [a, b]_p = \{c \in \beta_p : a \leq c \leq b\}$$

and

$$I = \bigcup_{p \in \mathbb{N}} I_p.$$

The abstract domain is defined as $\langle I, \sqsubseteq, \sqcup, \sqcap, \bot_I, \top_I \rangle$. The elements are ordered by

$$[a, b]_p \sqsubseteq [c, d]_q \iff [a, b] \subseteq [c, d] \text{ and } q \leq p.$$

a) Transfer Functions: The computations in a program can be represented using computation tree which demonstrates the control-flow of the program. For this, transfer functions are used which analyses the value at each computation node using the information from the past behaviour of the node.

To define Control Flow Graph(CFG) semantics, an operational semantics can be defined which is like an interpreter where the entry node is the input and is the initial state which is the mapping from variables to values and the final state is the output of the program. These semantics are defined in terms of transfer functions. The transfer function holds the execution semantics of that node and specifies the next node to be executed. If an abstract interpretation is done and then formulate a transfer function, the result is exactly the same as that of the results of doing operational semantics to actual value and then do abstraction. Consider the division of two intervals $x = [a, b]_{p1}$ and $y = [c, d]_{p2}$ with $a = s_1 \cdot m_1 \cdot 2^{e_1}$, $b = s'_1 \cdot m'_1 \cdot 2^{e'_1}$, $c = s_2 \cdot m_2 \cdot 2^{e_2}$ and $d = s'_2 \cdot m'_2 \cdot 2^{e'_2}$.

In the forward analysis, in order to estimate the precision for z different cases are taken. Let $d = e_2 - e_1$.

$$p = \begin{cases} max(p_1, p_2), \text{if } e_1 = e_2, \\ min(p_1 - 1, p_2) + d, \text{if } e_1 > e_2, \\ min(p_1, p_2 - 1) + d, \text{if } e_1 < e_2. \end{cases}$$

Rounding error [6] is part of floating-point computations. If z is the floating-point number represented by $d.d..dx\beta^e$, then the error can be represented as $d.d..d - (z/\beta^e)|\beta^{p-1}$.

In this section, the numerical analysis is demonstrated using a sample code snippet given in Fig. 6. Each value is represented as a floating point interval in the form $[a, b]_p$ where a and b are the interval range and p is the precision of the float value. All the variable values are represented in the form of interval of float value in their abstract form. Each time an operation is performed, the precision is affected and in the paper optimization of the precision is tried by applying forward analysis.

```
(1) float b=102.0 , a=2.0_15;
(2) while(b>1.0)
    {
(3)         b=b/a;
(4)         printf("%f",b);
    }
```

Fig. 6. An example Code snippet.

In Fig. 6, two variables a and b are used and they are initialized as 102.0 and 2.0_{15}. Which is internally mapped to abstract domain in the form $[102.0, 102.0]_{32}$ and $[2.0, 2.0]_{15}$. Here, the while loop is used to reduce the value of b by dividing b by a. Static forward analysis is applied on the given code snippet which is demonstrated in Fig. 7.

The predefined abstractions are used to compute the abstract semantics automatically from the program text which is then optimized automatically or manually by the user. At control point (3), b' is calculated by interval division of b and a. The new value is obtained as $[51.0, 51.0]_{32}$ by using transfer function for division. At beginning of each iteration a join operation is performed on the values of b. After control point (3), a join ($\cup$) operation based on previous value of b from control point (1) and current value of b from (3) is performed.

To over approximate the value of b a widening operation is performed after control point (3)". It is observed that the value of b becomes unchanged after every iteration. Then the loop is stopped and determines the forward analysis result of b. This is shown in Fig. 7.

```
(1) float b=[102.0,102.0]32,
    a=[2.0,2.0]15;

(3)     b'= [102.0,102.0]32/ [2.0,2.0]15
        =[51.0,51.0]32

    b=b ∪ b'
    =[102.0,102.0}32 ∪ [51.0,51.0]32
    =[51.0,102.0]32

(3)' b''=[51.0,102.0}32/ [2.0,2.0]15
        =[25.5,51.0]15

    b=b' ∪ b''
    =[51.0,102.0}32 ∪ [25.5,51.0]15
    =[25.5,51.0]32

(3)'' b'''=[25.5,51.0]32/ [2.0,2.0]15
        =[12.75,25.5.0]15

    b=b'' ▽ b'''
    =[25.5,51.0]32 ▽ [12.75,25.5]15
    =[12.0,26.0]32

(3)''' b''''=[12.0,26.0]32/ [2.0,2.0]15
        =[6.0,13.0]15

    b=b''' ∪ b''''
    =[12.0,26.0]32 ∪ [6.0,13.0]15
    =[12.0,26.0]32
```

Fig. 7. An example Code snippet.

V. Conclusion

In this paper, A static numerical analysis is demonstrated on floating-point computation with the help of a code snippet. The abstract domain of the form $[a, b]_p$ is used where a and b are the range of float values and p is the precision. Here, forward analysis is applied to show the float-interval division operation. The aim of the paper is to prove that a minimal accuracy is achieved on the result of the floating-point computations where mostly due to rounding errors and error propagation, the results get affected. With the help of transfer function, the analysis result is demonstrated in Fig. 7. Transfer functions are used to show the numerical analysis applied on the floating-point computations.

References

[1] European Space Agency. European Space Agency, Ariane 501 Inquiry Board Report. Technical report, , 1996.

[2] Information Management and D.C. Technology Division, Washington. Patriot missile defense: Software problems led to system failure at Dhahran, Saudi Arabia. Technical report, Information Management and Technology Division, US General Accounting Office, 1992.

[3] Patrick Cousot and Radhia Cousot. Abstract interpretation: A unified lattice model for static analysis of programs by construction or approximation of fixpoints. In *Proceedings of the 4th ACM SIGACT-SIGPLAN Symposium on Principles of Programming Languages*, POPL '77, pages 238–252, New York, NY, USA, 1977. ACM.

[4] Eric Goubault, Matthieu Martel, and Sylvie Putot. Asserting the precision of floating-point computations: A simple abstract interpreter. In Daniel Le Métayer, editor, *Programming Languages and Systems*, pages 209–212, Berlin, Heidelberg, 2002. Springer Berlin Heidelberg.

[5] Roberto Bagnara, Abramo Bagnara, Fabio Biselli, Michele Chiari, and Roberta Gori. Correct approximation of ieee 754 floating-point arithmetic for program verification, 2019.

[6] David Goldberg. What every computer scientist should know about floating-point arithmetic. *ACM Comput. Surv.*, 23(1):5–48, March 1991.

[7] David M. Russinoff. *Floating-Point Formats*, pages 63–75. Springer International Publishing, Cham, 2019.

[8] Ulrich Kulisch. Mathematics and speed for interval arithmetic: A complement to ieee 1788. *ACM Trans. Math. Softw.*, 45(1):5:1–5:22, March 2019.

[9] Eric Goubault and Sylvie Putot. Static analysis of numerical algorithms. In Kwangkeun Yi, editor, *Static Analysis*, pages 18–34, Berlin, Heidelberg, 2006. Springer Berlin Heidelberg.

[10] Alexey Solovyev, Charles Jacobsen, Zvonimir Rakamarić, and Ganesh Gopalakrishnan. Rigorous estimation of floating-point round-off errors with symbolic taylor expansions. In Nikolaj Bjørner and Frank de Boer, editors, *FM 2015: Formal Methods*, pages 532–550, Cham, 2015. Springer International Publishing.

[11] Tahina Ramananandro, Paul Mountcastle, Benoît Meister, and Richard Lethin. A unified coq framework for verifying c programs with floating-point computations. In *Proceedings of the 5th ACM SIGPLAN Conference on Certified Programs and Proofs*, CPP 2016, pages 15–26, New York, NY, USA, 2016. ACM.

[12] Mariano Moscato, Laura Titolo, Aaron Dutle, and César A. Muñoz. Automatic estimation of verified floating-point round-off errors via static analysis. In Stefano Tonetta, Erwin Schoitsch, and Friedemann Bitsch, editors, *Computer Safety, Reliability, and Security*, pages 213–229, Cham, 2017. Springer International Publishing.

Using Project-based Learning in a Hybrid e-Learning System Model

Luis Alfaro[1], Claudia Rivera[2], Jorge Luna-Urquizo[3]
Universidad Nacional de San Agustín de Arequipa
Arequipa - Perú

***Abstract*—After conducting the historical review and establishing the state of the art, the authors of this paper focus on the incorporation of Project Based Learning (PBL), in an adaptive e-Learning environment, a novel and emerging perspective, which allows the application of what today constitutes one of the most effective strategies for the process of teaching learning. In PBL, each project is defined as a complex task or problem of reality, for which resolution, the student must develop research activities, planning, design, development, validation, testing, etc. For the proposal of the Hybrid Architecture of the e-Learning system model, the authors use artificial intelligence techniques, which make it possible to identify the Learning Styles (LS), with the purpose of automatically assigning the projects, according to the characteristics, interests, expectations and demands of the student, who will interact with an e-Learning environment, with a high capacity of adaptation to each individual. Finally, the conclusions and recommendations of the research work are established.**

Keywords*—Adaptative e-Learning; Project Based Learning (PBL); intelligent agents; back propagation neural networks; fuzzy logic; case base reasoning

I. Introduction

Over the last few years, important research has been carried out concerning teaching-learning environments, with the support of Information and Communication Technologies, such as: intelligent tutor systems, Pedagogical Agents, Trainer Tutors and, mainly, environments with multiple functionalities and, in some cases, oriented to operate using the emerging resources of the Internet, such as e-Learning, m-Learning and u-Learning systems, among others, and more recently the Massive Open Online Courses (MOOC) that are gaining popularity very quickly, attracting a large number of users and expanding the market for this type of technological solutions. Special attention is given to adaptive e-learning systems for this research.

The development of these environments was based on the use of Artificial Intelligence techniques, such as: Intelligent Agents, Back Propagation Neural Networks, Fuzzy Logic and Case Base Reasoning (CBR); ability to handle large amounts of data (Big Data); as well as diverse techniques and teaching-learning approaches, such as Project Based Learning (PBL), which focuses on the realization of a project that seeks to integrate theory, practice and cooperative work; developing critical and creative thinking, and promoting active learning; being the approach considered by the authors. According to [1], the PBL approach: "is opposed to the behaviorist pedagogy which is based on a unilateral and passive transmission of the knowledge from the teacher to the student".

However, the most commercially used Learning Management Systems (LMS) do not natively support the PBL approach or content presonalization based on Learning Styles (LS), and even fewer developments have addressed the combination of both approaches, as proposed in this paper. For the development of this proposal, several Artificial Intelligence techniques were incorporated, which have made it possible to propose an original and singular Multi-Agent Architecture, as well as a Neural Network for the online identification of LS, through the analysis of user's interactions with the system, and a CBR module for the assignment of course projects to be developed by the students.

The rest of the paper is organized as follows. Section II presents a literature review of the state of the art and related works; Section III, describes the model system development, including the architecture proposal and a brief description of the main components, a module for automatic online recognition of LS, and a module for course project selection and assignment; Section IV, shows the results obtained in the tests carried out and the analysis of these; and finally, Section V presents the conclusions and future recommendations established in the work.

II. Literature Review

In this section, the authors conduct a historical review, identifying the state of the art and exploring the theoretical foundation of the research project.

A. Project Based Collaborative Learning

According to [2], PBL is a collaborative learning methodology for stimulates critical thinking, autonomy and creativity on students. One of the main advantages of this method is that it "produces the skills and strengthens the cognitive attributes that are necessary for one to succeed in the twenty-first century" [3], and it's considered as one of the most effective methods for developing employability skills [4], students' attitudes toward sustainability, such as severity, susceptibility, self-efficacy, response-efficacy [5], and others complex sustainability issues [6].

This approach has been adopted by many U.S. organizations as part of a government campaign to increase the rigor and relevance of STEM education [7], which was declared as a national priority for maintaining economic stability and innovation capacity. According to [7], PBL is engaging, rigorous, teacher-facilitated, student-centered, standards-based, and relevant. In [8], 46 comparisons were analyzed, based on 30 eligible journal articles published from 1998 to 2017, which

together represents 12,585 students from 189 schools in 9 countries, and the results obtained showed that the overall mean weighted effect size (d+) was 0.71, indicating that project-based learning has a medium to large positive effect on students' academic achievement in relation to the traditional instruction.

In [9], the concept of Learning Progressions is related to the PBL approach, as a way of measuring and analyze the effectiveness of this approach, by defining nodes of learning, giving rise to the concept of PBL Learning Progressing, and concluding that "there are numerous teaching and learning benefits from both learning progressions and project-based learning" and that the evidence found in the study suggests that "learning progressions occur through project-based learning paradigms".

According to [10], collaborative learning approaches, such as PBL, transfers the responsibility for learning to the student, who becomes a researcher, encourages active and responsible participation, and can generate many positive impacts in the process [11]; however, for [10] the achievement of the objectives also requires strategies designed according to the LS of the students, and should be both group goals and individual goals for ensure that each group member has learnt something new.

While collaborative learning can be of great value to the student, the implementation of technological environments that support such a paradigm can be a great challenge, where recent studies suggest that wikis and forums are the most promising tools in this area [12]. In [13], a comparison between the use of wikis and forums is shown, revealing that these activities involve different processes: "processes such as inferencing, evaluating, organizing and supporting characterized forum discussions while wikis induced mainly processes of producing and developing", so the use of the tools should be oriented towards the purpose to be achieved.

The collaborative learning approach can be used with various technologies, such as: virtual worlds and blended reality environments [14], augmented-reality learning environments [15], [16], mobile devices and interactive digital media [17][18], collaborative and competitive game-based learning [19], social networks and networks analitycs [20], cloud-based technologies, big data and massive open online courses, among others.

B. Learning Styles

According to [21], the implementation of any Learning Management System (LMS) presents two major challenges, one of which is the identification of each student's preferred learning style (LS), and the personalization of contents and learning materials based on those preferences. For [21], the LS are directly related to online participation, academic achievement and course satisfaction.

Recent studies on the importance and effectiveness of LS show that "adaptive e-learning environments based on specific LSs are not only more productive, but also create higher student satisfaction levels, decrease learning times, and increase students' academic achievement" [22][23], while on the other hand: "students with a strong preference for a specific LS have difficulty learning when it is not supported by the teaching environment"[22].

According to [24], there is a relationship between the use of some collaborative tools and LS, so it is possible to say that considering LS could not only improve the personalization of content, but also could improve the design of collaborative learning strategies [11]. The LS also have some relation with the personality of the students [23], this being another aspect to consider for the design of the architecture.

The identification of learning styles has been approached in different ways, among which the following stand out: using behavioral features and twin support vector machine [25], social learning analitycs [26], SVM and PCA based learning feature classification [27], dynamic modeling of student profiles, learning patterns and feature extraction [22], fuzzy C means [28], machine learning approaches and learning analitycs [29], among others.

The main application of the LS can be summarized in the personalization and adaptation of learning contents, resulting in the adaptive LMS approach used in various work [30], [31], [32]. For example, [30] presents a cloud oriented LMS model, with autonomous task grading and task assignment, based on intelligent context-aware implemented with fuzzy logic techniques, using the concept of TMA (Tutor Marked Assignments), with the aim of achieving a high degree of personalization of content, in an environment centered on the user experience, focused from the pedagogical experience of the tutors.

C. Intelligent Agents

The use of intelligent agents is closely related to the implementation of adaptive systems and virtual assistants, for example, [33] implemented an Adaptive Intelligent Tutoring System, which includes three main models: the domain model, the student model and the pedagogical model, considering the concept of LS as part of the student model, as well as an interface model, responsible for customizing and adapting content, based on the information provided by the other models. This technology has also been widely used in recommendation systems, either based on concepts such as LS [34], [35] or in combination with other techniques.

Multi-agent systems have also been applied to other more complex tasks, such as the analysis of emotions during the learning process [36], where three emotional measurement methods (automatic facial expression recognition, self-report, electrodermal activity) and their agreement regarding learners' emotions are used; or an approach to the never-ending learning paradigm within the machine learning field [37], which is based on the premise that humans are better learners because they "learn many different types of knowledge from diverse experiences over many years, and become better learners over time", and uses intelligent agents to try to replicate that human behavior.

Intelligent agents have also been used for the identification of learning styles, through Conversational Intelligent Tutoring Systems, in combination with fuzzy decision trees [38]; the construction of fuzzy predictive models that use behavioral variables obtained from expressions in natural language, or

in combination with ontologies [39], to realize adaptive personalization according to the learner's changing behavior and validate its integration with the semantic web environment; and even as a tool to analyse the relationship between personality and emotions within learning contexts [40], through interactions with pedagogical agents (agent-directed emotions), to predict the emotions that could generate certain contents and adapt them for each user, making the learning experience more agreeable and pleasant.

D. Back Propagation Neural Network

According to [41], neural networks are the most widely used data mining tool for classification and clustering tasks, whose main objective is to build machines that can mimic brain processes and the ability to learn, and within this approach the Back Propagation algorithm is one of the most popular, due to its simplicity and generalization ability. Author in [42] reviews some recent theories on how neural circuits in the brain might approximate the back propagation algorithm used by artificial neural networks, including experimental evidence on neural connectivity, responses, and plasticity.

The power of Back Propagation neural networks has made them be used in several fields, such as prediction of time series [43], prediction of the concentration and behavior of Air pollutants considering the meteorological conditions [44], information security through anomaly network intrusion detection [45], Molecular Classification of Breast and Prostate Cancers [46], among others.

E. Case Based Reasoning (CBR) and Recommendation Systems (RS)

For [47], CBR is a process in which specific experiences are retrieved, reused, revised, and retained for use in problem solving and/or interpreting the state of the world. CBR has been described, alternately, as a cognitive theory of human problem solving, a paradigm for conducting AI research, and as a knowledge engineering methodology for deploying practical systems. One of the highest impacts of CBR applications areas is recommender systems. In addition to their practical challenges, according to [48] they provide a rich vein of research challenges, especially related to determining product similarity.

The selection and assignment of projects can be seen, in a general way, as the application of the systems recommendation approach, which has been applied in various areas of real-world knowledge and applications. In the state of the art, this approach has been approached mainly through two techniques of Artificial Intelligence: Expert Systems and CBR, the latter being the technique that will be used in this work. For example, in [49], CBR is used for the selection and recommendation of pedagogical strategies, from an initial set of strategies stored in the student's model, considering the particular characteristics of each individual, such as personality profiles, multiple emotions and intelligences, and cognitive processes of the students, within virtual learning systems [49]; while in [50], the assumption is considered that "learners struggle to identify and retrieve the optimal case to solve a new problem", and proposes a CBR-based recommendation system to "support the decision-making process about which case is most relevant to solve new problems".

The potential of RBC means that it can be applied to large-scale systems, such as [51], where it is used in the implementation of Massive Open Online Courses (MOOCs) platforms, with the aim of finding the best online learning resources, from different providers, filtering requests based on user profiles, using Crawler's specialised in information retrieval, based on Levenshtein's distance, in combination with RBC, where case adaptation uses operations such as: transformational adaptation (including substitutional and structural adaptation), and generative adaptation; and [52], where it is applied to the implementation of an intelligent tutorial system with Big Data and Internet of Things (IoT) management, with the ability to customize the contents and select the most appropriate learning resources for each student, according to their user profile, in real time.

RBC has also been applied in content personalization by [53], where the tool is capable of automatically producing and generating a model curriculum based on e-Learning standards, in a large number of real scenarios, naming this approach as Case-Based Planning adaptation process, which "reduces the differences between the original and the new route, thus enhancing the learning process" [53]; the same approach has been used by [52], where learning materials are also classified from the most recommendable to the least suitable for each specific user, according to their preferences, allowing to present different alternatives or learning routes, which allow to improve the efficiency and effectiveness of the teaching/learning process.

Other applications of interest of the RBC are: Ontology-Based Learner Categorization through Case Based Reasoning and Fuzzy Logic, which: "exploits the machine learning based techniques for learner categorization taking into account the cognitive and inclinatory attributes of learners at finer level of granularity" [54]; A novel method of case representation and retrieval in CBR for e-learning, where Artificial Neural Networks (ANN) is combined with Data mining (DM) and CBR, to adapt the contents of the course and the levels of difficulty to the specific characteristics of each student [27]; an artificial intelligence case based approach to motivational students assessment in e-learning environments, where RBC is combined with Knowledge Representation techniques, to evaluate "the different dimensions on student's motivational assessment in e-learning environments" [55], integrating knowledge-based reasoning and collaborative filtering into e-learning material recommendation system [56], etc.

However, according to [56], recommendation-based approaches also present some problems such as data preprocess, feature extraction, and clustering, proposing the combination of knowledge-based reasoning and collaborative filtering algorithms, to obtain a complex hybrid recommendation system, capable of offering better predictions and more precise recommendations of learning materials, comparing it with techniques such as rule-based reasoning (RBR), CBR and Matrix Factorization (MF).

This work proposes a project assignment module, which based on the results of the identification of learning styles, carried out by the Fuzzy Neuro subsystem detailed in [57], assigns projects in a personalized way, considering the learning objects that best contribute to the objectives proposed within the framework of the Adaptive e-Learning system strategies.

F. Fuzzy Logic

Fuzzy logic can be seen as a "formalization mode of imprecise reasoning that represents certain human capacities to make approximate inferences and judgements within conditions of uncertainty" [58]. According to [59], determining the learning style most adequate to the individual capacities of the student is very important for quick, easy, and effective learning. However, the quantification of said capacities and the rules to follow in order to determine the most convenient learning style are of an imprecise nature, for which any approach one wishes to follow should incorporate fuzzy-logic techniques.

In [60], the study part from the premise from which it is possible to define much more practical mechanisms adjusted to the real educative action for the detection of learning styles, utilizing techniques associated with fuzzy logic. The proposed approach is based on the concept of learning pathways to establish the type of preference that the learners possess with respect to how they perceive and process information [60], where the inputs are defined by fuzzy combinations.

III. Model System Development

Next, we will describe the different elements that were developed, as well as the procedural steps that were followed in order to build the adaptative e-learning-model system.

A. Multiagent System Model Architecture Proposal

Technology of Intelligent Agents Systems was used as the basis for the implementation of the virtual learning platform, and the main advantages are:

- They allow to model an individual profile of each student, facilitating tasks like the search of information and contents.
- They facilitate the incorporation of a model of knowledge representation, and can facilitate the tasks of adaptation and customization of content in the proposed platform.
- They allow the incorporation of machine learning characteristics, together with other Artificial Intelligence approaches and techniques.
- They can be endowed with characteristics such as autonomy, initiative, mobility (even between different platforms), adaptability, among others.

The general architecture of the multi-agent model proposed in this paper is shown in Fig. 1.

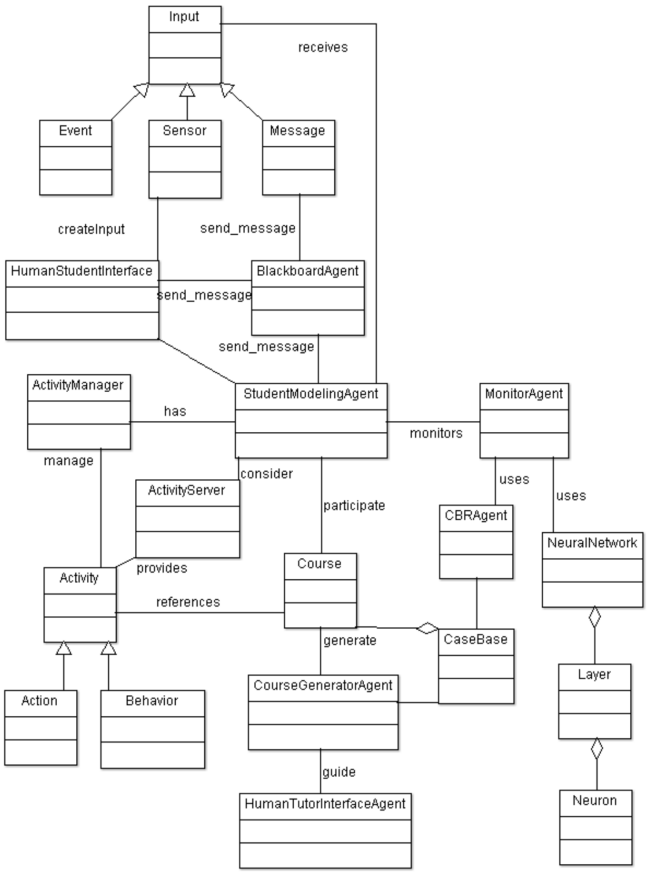


Fig. 1. Multi-agent system architecture

The implementation of the proposed intelligent agents was carried out using the JADE platform, which provides a container for each host in which the agents are executed, has support for various languages and ontologies, and complies with the FIPA (Foundation for Intelligent Physical Agents) specifications, so it can be easily integrated with agents developed in other languages and platforms, including proprietary ones. Six classes of Intelligent Agents have been implemented, defined as follows:

- Student Modelling Agent: represents the student and is in charge of building and maintaining the student's profile, including his or her achievements, needs and learning objectives. The software agent is associated with an interface that allows direct interaction with the student.
- Centralizing communications agent (BlackboardAgent): centralizes communications within the proposed model through a shared data structure, which allows the storage of any message or information that may be useful for a user or group of users, associated with keywords, message source, among others.
- Monitoring Agent: monitors student activities, to determine possible profile changes that require updating the learning style or content types within the platform, and notifies the teacher or other platform components of detected inconsistencies or problems in order to take appropriate action.
- Course/Project Generator Agent: responsible for the consolidation of the teacher's requirements and specifications, and for generating the structure and contents of the course, through interaction with the CBR mechanism, represented by the CBRAgent. To execute this task, the agent consults the activities and resources available for the course, stored in the Activity Server, in order to select the most appropriate and relevant.
- Activity Manager: is a reactive agent whose purpose is to manage the flow of activities or resources required

within a course for a particular user, according to their characteristics or user profile, and to the requirements established by the tutor, with the objective of achieving the proposed learning objectives. This agent manages a highly specialized repository of content, learning resources, activities, links to external resources, etc., designed or compiled by various specialists (tutors) over time, and designed to be highly interactive. This component favors the reuse and availability of content, optimizes the use of resources, and facilitates the maintenance tasks of the platform.

- CBR Agent: represents and interacts with the CBR module, implemented in the Back-end of the platform, which will be described in more detail in Section III-C. This agent is oriented to two specific tasks: (i) to provide the Course Generator Agent with a selection of contents and a course structure that responds to the student's background and profile; and (ii) to collaborate with the Activity Manager in the selection of the most appropriate learning activities and/or resources for each student throughout the course.

B. Module for Automatic Recognition of Learning Styles based on Neural Networks and Fuzzy Logic

The online learning styles identification module, developed as part of this work, considered as a reference the learning styles model proposed by [61], where four learning styles are defined: active, reflective, theoretical and pragmatic, because this model focuses on how information is perceived and processed by the user, a particularly relevant aspect in the development of e-Learning platforms.

For the development and implementation of this module, four stages were followed, which will be explained in detail in the following sections. These are:

1) Experimental data collection: The experimental data were obtained by applying the questionnaire proposed in [61], which consists of 80 questions of type Yes/No, to a group of 34 undergraduate students of the Professional School of Marketing of the National University of San Agustín de Arequipa - Perú. It is worth mentioning that the selected group was the only group enrolled in said course of the virtual platform during the indicated semester, representing the entire universe for that course.

The distribution of the preferences of the group of students, according to the different LS, is shown in Fig. 2, in which it can be seen that there is a significant number of cases where it is not possible to determine a predominant learning style, an interesting fact from the point of view of the use of educational technologies, since it allows inferring that at present students adapt better to different types of learning materials and contents.

The data obtained through the traditional method (questionnaires) was also used for the validation of the results obtained from the backpropagation neural network, for which the data were divided into two sets of equal cardinality, which were used as a training set and test set in the implementation of the Neural Network.

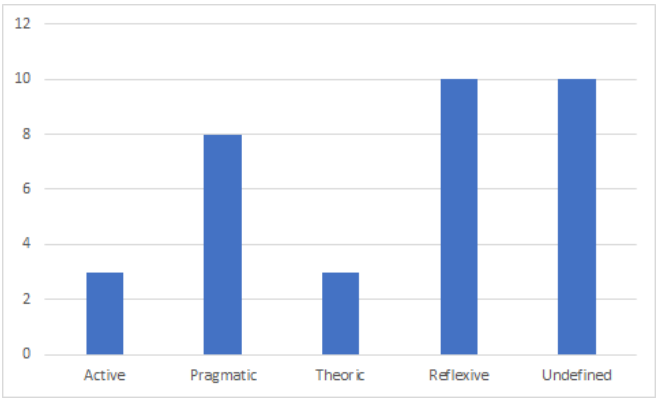


Fig. 2. Results of questionnaire

2) Input pre-processing: During the initial tests of the proposed model some disadvantages were found in the performance and results of the implemented neural network, which, according to the analysis carried out, will correspond to two facts:

- The level of "noise" present in the input data set of the Neural Network: for example, for the case of the user whose answers are reflected in Table I, where according to the proposed method the "pragmatic" style would correspond to him; however, the values of the four categories are very close to each other, to the point that a single answer could change the identification made, as shown in Table II, which makes it difficult to establish a clear differentiation between their preferences.

TABLE I. EFFECT OF NOISE ON INPUT DATA - CASE I

Active	Reflexive	Theoric	Pragmatic
14	16	15	17

TABLE II. EFFECT OF NOISE ON INPUT DATA - CASE II

Active	Reflexive	Theoric	Pragmatic
14	16	16	16

- Input sets, for which it is impossible to define a single output; for example, the user whose answers are shown in Table III, where it can be seen that, according to the proposed model, it would not be possible to identify a predominant learning style.

TABLE III. DATA SETS WITH UNDEFINED OUTPUT

Active	Reflexive	Theoric	Pragmatic
15	15	13	15

In order to reduce the impact of the inconveniences mentioned above on the model's performance, it was decided to include a pre-processing stage for the input data of the

neural network, using a fuzzy set that represents a better categorization of users' preferences for a certain type of resources (Fig. 3), considering the percentage and relevance of user interactions in each resource category. For the definition of the fuzzy set, the trapezoidal function was used, since it is the one that best adapts to the nature of the problem.

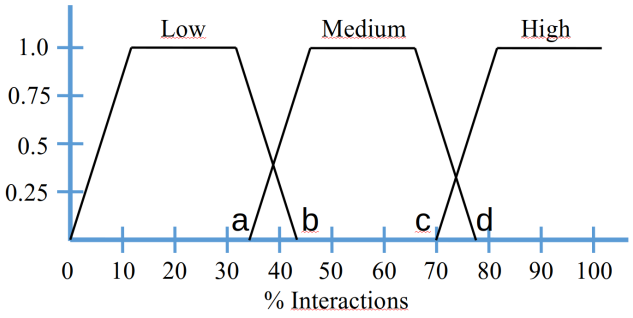


Fig. 3. Fuzzy sets

This decision was based on the premise proposed by [60], who points out that determining the specific learning style of a student may become a problem of a fuzzy nature, since situations and evaluative characteristics must be considered with a certain level of imprecision, characteristic of human nature, that require a treatment according to the nature of the problem, as in this case.

On the other hand, for the analysis and classification of user interactions, 20 resource categories were defined, considering all types of resources available on the Moodle platform, so that each and every one of the selections (click's) made by the user can be considered, and a log of their interactions can be stored on the platform, and therefore a record of their preferences. Each of these categories was related to the four learning styles defined in the Honey model, through the application of fuzzy logic concepts in relation to the theoretical and behavioral characteristics associated with each learning style, as shown in Table IV.

A Backpropagation Neural Network (BPNN) was used for the identification of the LS of each student, consisting of an input layer, a hidden layer and an output layer, as shown in Fig. 4. Among the reasons for using this model we have to: (i) allow to train the weights of a neural network with an indeterminate number of layers, an important characteristic given the starting point of the problem; (ii) allow to use differentiable transfer functions to execute approximation, association and classification functions according to the objective; (iii) the versatility of this approach.

The input neurons represent each of the previously defined resource categories (Table IV), so 20 input neurons have been defined, which take as input value the percentage of interactions in that category, as a value between 0 and 1, calculated from the user's activity log on the platform, where 0 indicates that the user did not choose any type of resource in that category, and 1 indicates that the user only uses resources in that category.

Sigmodidal function was used for the activation of neurons, due to the fact that it permits the modeling of temporal progressions, which go from beginning levels, in which the contents

TABLE IV. RESOURCE CATEGORIES AND THEIR RELATION TO LEARNING STYLES

	Resource Type	Activist	Reflector	Theorist	Pragmatist
1	Content (Textual)	Low	High	High	Medium
2	Content (Mixed)	Medium	High	High	High
3	Content (Multimedia)	High	Medium	Medium	High
4	Content (Simulation)	High	High	Medium	High
5	Content (Url's)	Low	High	High	Low
6	Case Study (Textual)	Medium	High	High	Medium
7	Case Study (Multimedia)	High	Medium	Medium	High
8	Examples (Textual)	Medium	High	High	High
9	Examples (Multimedia)	High	High	Medium	High
10	Examples (Url's)	Medium	High	High	Low
11	Glossary (Reading)	Low	High	High	Medium
12	Glossary (Writing)	Null	High	High	Low
13	Wiki (Reading)	Medium	High	Medium	Medium
14	Wiki (Writing)	Medium	Medium	Low	Low
15	Forum (Reading)	Medium	Medium	Medium	Medium
16	Forum (Writing)	Medium	Low	Medium	Medium
17	Chat (Reading)	High	Low	Medium	Medium
18	Chat (Writing)	High	Low	Low	Medium
19	Self-assessments	Medium	High	High	Low
20	Conceptual maps	Nulo	High	High	Medium

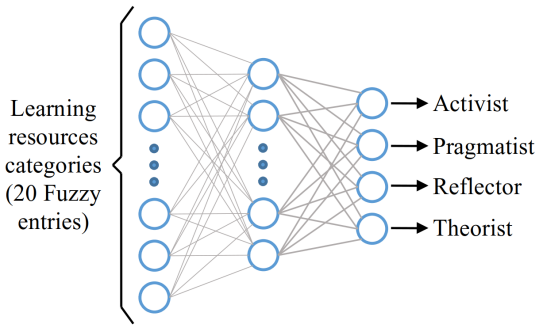


Fig. 4. Neural Network architecture. Source: [57]

are generic and do not require sophisticated knowledge of the users preferences, to advanced levels, which with the passage of time, as content personalization is refined, permit the attainment of the required knowledge for a more precise identification of LS.

As mentioned in [57]: "In the neural network, the hidden layer increases the processing capacity, and the number of neurons in the hidden layer directly affects the capacity of the 'neural network' for learning". In the proposed case, during the initial experimentation phase, before pre-processing the inputs, tests were conducted with distinct numbers of neurons in the hidden layer. After experimentation with different network

designs and number of hidden layers, the best balance between results obtained and execution time was obtained by placing in a single hidden layer the same number of neurons as in the input layer.

For the testing of this model, user interactions obtained through the activity logs of the online platform, and test data, obtained through the traditional method (questionnaire), were used, which were divided into two sets of data: the training set and the test set.

C. CBR-based Project Selection and Assignment

The model is based on the application of CBR techniques, according to the architecture shown in Fig. 5, where cases are associated with course projects (PBCL approach), so that the problem to be solved can be defined as:

"Given a learning objective and a student or group of students with certain learning styles: What will be the most appropriate project for the achievement of the proposed objectives?"

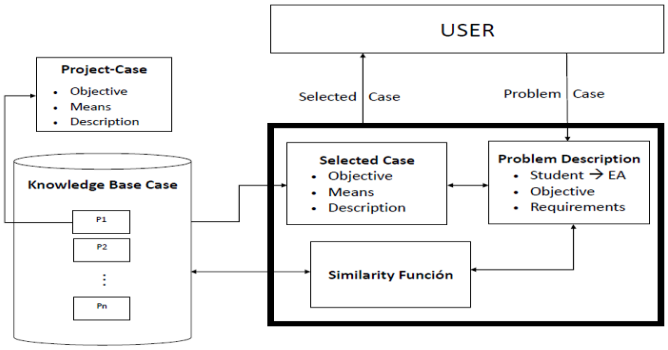


Fig. 5. Architecture of the RBC model.

For the implementation of the techniques, the starting point was the JColibri tool, which features a layered architecture, and the Colibri Studio environment. The methodology used to solve the problem consists of five steps or tasks:

1) Case representation: A case represents a previous experience, which is to say projects utilized in previous years or similar courses. What is more, they must store the knowledge necessary for the functioning of the reasoning model. The available, previous case set can be labeled 'case base'. Therefore, in a case or project (Fig. 6), as a minimum the following attributes can be understood: (i) the problem: description of the topic or necessity according to which the project will be laid out and which must also be associated with a learning objective; (ii) the solution: the description of the project laid out in order to satisfy the problem or necessity; (iii) the available resources for the execution of the project, defined as learning objects (LO); (iv) the characteristics recommended for the team members, which can include recommended LS; (v) the restrictions or limitations established.
2) Case retrieval: This consists of cross-referencing or comparing the current problem with the problems

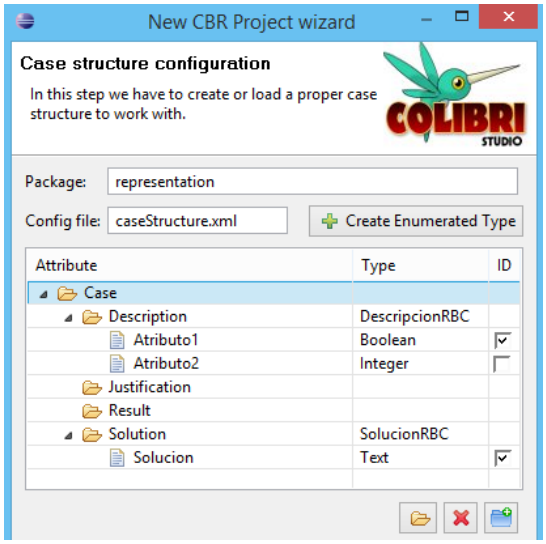


Fig. 6. Definition of Case structure

stored in the case base, utilizing some measurement of similarity, with the objective of determining the degree of similitude and pertinence, in order to retrieve the project most similar to the proposed problem. The quality of the results obtained will depend on the measurements of similitude utilized, for which a relative weight is established for each one of the attributes according to its importance (Fig. 7).

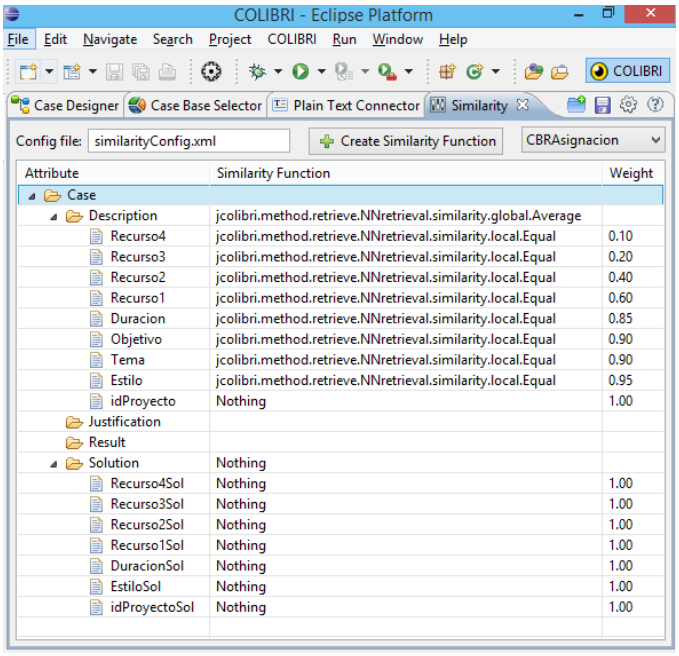


Fig. 7. Definition of case attributes, similarity functions and weights in Colibri Studio.

3) Case reutilization: This consists of copying or integrating the retrieved cases' in order to solve the current problem, formulating a new project according to the objectives and requirements laid out, for which this phase is also known as 'case adaptation'. There

are three principle ways of reutilization: substitution, transformation, and generative adaptation.

4) Case revision: This consists of evaluating the solution that originated in the reutilization or adaptation phases in the resolution of the new case. This task is conducted by field experts, and in the case that the solution requires some adjustment or improvement, solution repairing is carried out iteratively until it can be validated.
5) Case retention: Once the new solution is validated, the new case is stored in the case base for future use under criteria previously defined, hence increasing the case base. It should be highlighted that while a greater number of cases is kept stored, new solutions will also become more and more complete and precise.

In the context of the proposed platform, a Learning Object is defined as digital material which can be taken advantage of for educative purposes, starting from an explicitly or implicitly defined intentionality for educative objectives, and which contain metadata that allow for their description and retrieval, among those which can be utilized: subject, pedagogic style, format, difficulty level, or age range, and these can include keywords and descriptors. This facilitates their reutilization and adaptation to different environments.

In this way a typical question (Fig. 8), is based on the student's learning style, taking as an input datum the output of the automatic-identification-of-learning-style module, the topic to solve, the learning objective, the duration of the project, and available resources or OAs to which one has access in the online repository, among other attributes.

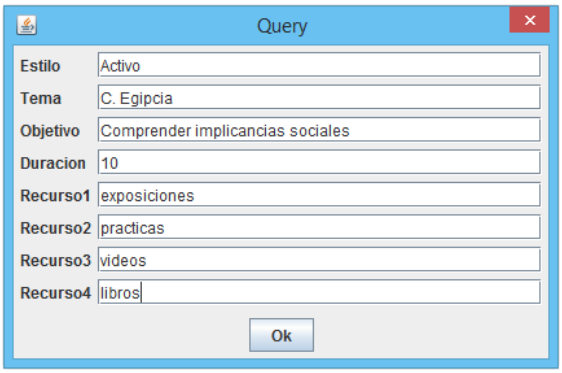


Fig. 8. Example of RBC query.

The linear comparison for each of the attributes is utilized as a similitude function in the following way:

- If a search characteristics is equal to a stored characteristic, the linear score of the case is increased by the weight of the similarity (match weight), previously defined for that attribute.
- If a search characteristic is partially similar (like the textual responses), the linear score of the case will be increased by a fraction of the weight of the similarity, depending on the quality of the similarity.
- A mismatch weight is defined, in which case a distinct response with respect to the search case results in a decrease in the linear score of the case.
- An absence penalty is also defined, applied to the linear score of each stored case, which consists of a small decrease applied to each search-case characteristic that is not shared by the stored case.
- Finally, the linear score is tallied for each case and normalized within each assigned range, which restricts the final value to the range [-100,100], where a normalized value of 100 indicates a perfect similarity, and in which case the project selection will be automatic.

IV. Results

This section will first detail the results obtained from the Automatic Identification of Learning Styles module, which serves as the input for the Project Selection and Assignment module, the results of which will be detailed in the last part of this section.

A. Learning Style Identification Module Results

For the experimentation, the students were asked to perform some activities as part of a university course throughout the semester. It is important to note that the identification must be made throughout a period of platform-utilization time, given that the data analyzed in just one session might be seen as influenced by the time available for the identification of the style, the emotional state of that particular moment, problems in the environment, etc. making it possible for errors in the perception, analysis and identification of the learning style to arise.

For example, Fig. 9, shows the identification of the LS of four students throughout each week of the 20-week duration of the semester, where it can be appreciated that, for example, for the 'case-1' student, the identification realized in weeks 3 and 20 might indicate that the student fits into second category. However, when the general panorama is observed, it is clear that instead, this student fits into the first category.

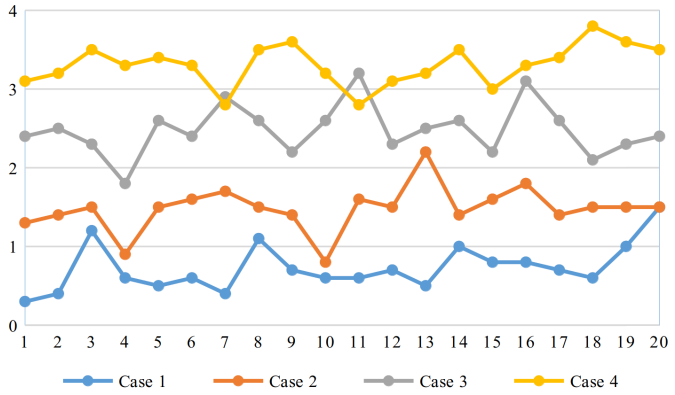


Fig. 9. Identification of LS of four students throughout time. Source: [57]

This phenomenon is relatively normal, given the proximity among some LS and the mixed preferences of some students. In this sense, the most feasible option would be to identify the LS during some introductory course or previous activities, before starting with the tasks of adapting and personalising the contents of the e-Learning platform, and then validating

and iteratively refining the identification carried out in the following activities or courses.

Finally, the results obtained by the neural network demonstrated a 77.1% coincidence with those obtained through the traditional method, which is to say that the learning styles of 26 of the 34 students were obtained correctly with respect to the manual method proposed by Honey. It is worth mentioning that the results obtained with other techniques are in the range between 66% and 79.6% efficiency [62][63], [64], [65], [66], so it is considered an acceptable result within the methods foun in the literature review.

B. Project Selection and Assignment Module Test Results

For the tests of this module, 50 case recovery consultations were carried out, following the procedure shown in Fig. 8, which translates into selection and assignment tests of projects, taking as main search criteria the learning objective, the problem to be solved, the duration of the project, and the learning style previously identified.

These consultations were carried out using a library of cases generally defined by specialists in LS and LO, obtaining that for 90% of the consultations, the module could find at least 3 similar cases, and at least one of them with a measure of similarity greater than 90%, as shown in Fig. 10, where it can be appreciated that the alternatives are ordered from greater to lesser according to the degree of similarity, and the first alternative has a similarity of 1.0, i.e. 100%.

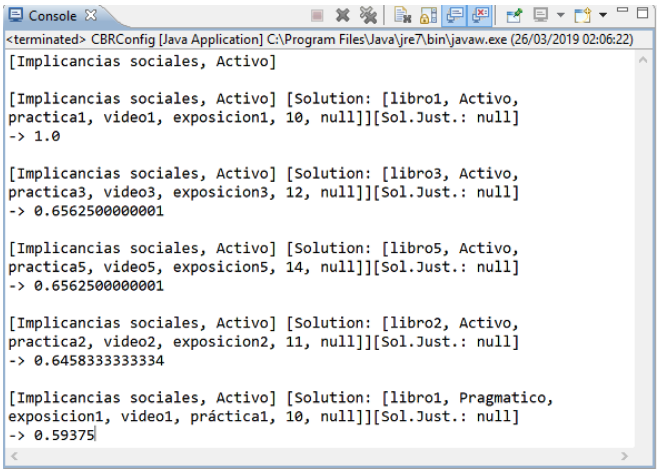


Fig. 10. Results of example query for project assignment. Source: [57]

Table V shows the summary of the tests conducted and the best similitude value obtained for each one of them, utilizing the comparison by linear similitude, in which it can be appreciated that the results are highly acceptable.

The main objective of the work was to identify the LS, so that according to the student's profile, the projects are assigned with the learning objects that best contribute to the users' interaction with the system. It would be convenient to subsequently add data from several semesters to make more tests and analyze the real impact of the proposal on student learning.

TABLE V. RESULTS OF RBC TEST QUERIES (% SIMILARITY)

Test	Result	Test	Result	Test	Result
1	85	18	84	35	93
2	81	19	74	36	81
3	100	20	88	37	61
4	82	21	94	38	88
5	91	22	78	39	84
6	69	23	81	40	100
7	100	24	80	41	80
8	80	25	68	42	95
9	87	26	100	43	85
10	92	27	83	44	77
11	84	28	90	45	82
12	72	29	86	46	83
13	82	30	80	47	91
14	86	31	57	48	87
15	91	32	87	49	80
16	100	33	100	50	66
17	66	34	95		

V. CONCLUSION

- An adaptive e-Learning system model based on Intelligent Agents was proposed and developed incrementally, using the Project Based Learning approach, and with a high degree of personalization, for the assignment of projects and learning objects whose tests and results obtained were satisfactory in relation to other works that use diverse approximations.
- A neurodiffuse subsystem was proposed and developed for the automatic on-line identification of learning styles, based on the analysis of the user's interaction with the system.
- It was proposed and developed, a subsystem based on CBR, using the J-Colibri Software, which allowed a project assignment, with quite high percentages of relevance to the learning styles and student profiles.
- The use of a neurofuzzy neural network and the CBR, allowed a novel approach and approach to the treatment of this complex problem, with satisfactory results.

Finally, the author's recommends as future work, explore the possibilities of incorporating students thinking styles into the model, and Immersive Virtual Reality and Augmented Reality resources into the adaptive e-learning model, so that interaction with students problems and learning objects are based on direct experiences.

ACKNOWLEDGMENT

The authors would like to thank Universidad Nacional de San Agustín (UNSA) for supporting this research.

REFERENCES

[1] F. Abdallah, C. Toffolon, and B. Warin, "Models transformation to implement a project-based collaborative learning (PBCL) scenario:

Moodle case study," in *2008 Eighth IEEE International Conference on Advanced Learning Technologies*, IEEE, 2008.

[2] M. Esteves, R. Matias, E. Bernardino, V. Távora, and A. Pereira, "Project based learning a new approach in higher education: A case study," in *The Challenges of the Digital Transformation in Education*, pp. 525–535, Springer International Publishing, 2019.

[3] J. Ravitz, "Project based learning as a catalyst in reforming high schools," *Buck Institute for Education*, 2008.

[4] J. L. Hart, "Interdisciplinary project-based learning as a means of developing employability skills in undergraduate science degree programs," *Journal of Teaching and Learning for Graduate Employability*, vol. 10, p. 50, may 2019.

[5] E. K. Perrault and C. A. Albert, "Utilizing project-based learning to increase sustainability attitudes among students," *Applied Environmental Education & Communication*, vol. 17, pp. 96–105, oct 2017.

[6] A. Stokes and N. Harmer, "The value of 'having a go': Trialing a project-based learning activity to inform curriculum design," *Journal of Geoscience Education*, vol. 66, pp. 278–292, oct 2018.

[7] A. Sahin, "The role of interdisciplinary project-based learning in integrated STEM education," in *STEM Education 2.0*, Brill | Sense, aug 2019.

[8] C.-H. Chen and Y.-C. Yang, "Revisiting the effects of project-based learning on students' academic achievement: A meta-analysis investigating moderators," *Educational Research Review*, vol. 26, pp. 71–81, feb 2019.

[9] L. A. Annetta, R. Lamb, D. Vallett, and M. Shapiro, "Project-based learning progressions: Identifying the nodes of learning in a project-based environment," in *Contemporary Technologies in Education*, pp. 163–181, Springer International Publishing, nov 2018.

[10] G. Babu, P. Suresh, and K. Pariventhan, "Enhancement of learning through collaborative learning techniques," *New Man Journal of Multidisciplinary Studies*, vol. 4, no. 1, pp. 29–38, 2017.

[11] S. Y. Chen and L.-P. Chang, "The influences of cognitive styles on individual learning and collaborative learning," *Innovations in Education and Teaching International*, vol. 53, pp. 458–471, jun 2014.

[12] B. Zheng, M. Niiya, and M. Warschauer, "Wikis and collaborative learning in higher education," *Technology, Pedagogy and Education*, vol. 24, pp. 357–374, jan 2015.

[13] M. Biasutti, "A comparative analysis of forums and wikis as tools for online collaborative learning," *Computers & Education*, vol. 111, pp. 158–171, aug 2017.

[14] M. Bower, M. J. W. Lee, and B. Dalgarno, "Collaborative learning across physical and virtual worlds: Factors supporting and constraining learners in a blended reality environment," *British Journal of Educational Technology*, vol. 48, pp. 407–430, mar 2016.

[15] J. Martín-Gutiérrez, P. Fabiani, W. Benesova, M. D. Meneses, and C. E. Mora, "Augmented reality to promote collaborative and autonomous learning in higher education," *Computers in Human Behavior*, vol. 51, pp. 752–761, oct 2015.

[16] N. Enyedy, J. A. Danish, and D. DeLiema, "Constructing liminal blends in a collaborative augmented-reality learning environment," *International Journal of Computer-Supported Collaborative Learning*, vol. 10, pp. 7–34, feb 2015.

[17] B. Gan, T. Menkhoff, and R. Smith, "Enhancing students' learning process through interactive digital media: New opportunities for collaborative learning," *Computers in Human Behavior*, vol. 51, pp. 652–663, oct 2015.

[18] Y.-T. Sung, J.-M. Yang, and H.-Y. Lee, "The effects of mobile-computer-supported collaborative learning: Meta-analysis and critical synthesis," *Review of Educational Research*, vol. 87, pp. 768–805, apr 2017.

[19] C.-H. Chen and V. Law, "Scaffolding individual and collaborative game-based learning in learning performance and intrinsic motivation," *Computers in Human Behavior*, vol. 55, pp. 1201–1212, 2016.

[20] S. Zhang, Q. Liu, W. Chen, Q. Wang, and Z. Huang, "Interactive networks and social knowledge construction behavioral patterns in primary school teachers online collaborative learning activities," *Computers & Education*, vol. 104, pp. 1–17, jan 2017.

[21] G. Cheng and J. Chau, "Exploring the relationships between learning styles, online participation, learning achievement and course satisfaction: An empirical study of a blended learning course," *British Journal of Educational Technology*, vol. 47, pp. 257–278, dec 2014.

[22] S. M. Nafea, F. Siewe, and Y. He, "A novel algorithm for dynamic student profile adaptation based on learning styles," in *Advances in Intelligent Systems and Computing*, pp. 29–51, Springer International Publishing, aug 2019.

[23] A. Seyal, N. Z. Siau, and W. S. H. Suhali, "Evaluating students' personality and learning styles in higher education: Pedagogical considerations," *International Journal of Learning, Teaching and Educational Research*, vol. 18, pp. 145–164, jun 2019.

[24] S. M. Rutherford, G. Limorenko, and A. M. Shore, "Correlations between deep, surface or strategic learning styles and perceptions of collaborative learning in higher education," in *Ireland International Conference on Education (IICE-2016)*, Oct. 2016.

[25] N. Jalaledin, M. A. MAHMOOD, and F. Somayeh, "Classification of learning styles using behavioral features and twin support vector machine," *JOURNAL OF TECHNOLOGY OF EDUCATION*, vol. 13, no. 3, pp. 459–469, 2019.

[26] J. Aguilar, O. Buendia, A. Pinto, and J. Gutiérrez, "Social learning analytics for determining learning styles in a smart classroom," *Interactive Learning Environments*, pp. 1–17, aug 2019.

[27] A. Khamparia and B. Pandey, "SVM and PCA based learning feature classification approaches for e-learning system," *International Journal of Web-Based Learning and Teaching Technologies*, vol. 13, pp. 32–45, apr 2018.

[28] I. Azzi, A. Jeghal, A. Radouane, A. Yahyaouy, and H. Tairi, "A robust classification to predict learning styles in adaptive e-learning systems," *Education and Information Technologies*, aug 2019.

[29] E. Kurilovas, "Advanced machine learning approaches to personalise learning: learning analytics and decision making," *Behaviour & Information Technology*, vol. 38, pp. 410–421, nov 2018.

[30] P. Moore, Z. Zhao, and H. V. Pham, "Towards cloud-based personalised student-centric context-aware e-learning pedagogic systems," in *Advances in Intelligent Systems and Computing*, pp. 331–342, Springer International Publishing, jun 2019.

[31] N. A. Ali, F. Eassa, and E. Hamed, "Adaptive e-learning system based on personalized learning style," *Journal of Fundamental and Applied Sciences*, vol. 10, no. 4, pp. 246–251, 2018.

[32] Özcan Özyurt and H. Özyurt, "Learning style based individualized adaptive e-learning environments: Content analysis of the articles published from 2005 to 2014," *Computers in Human Behavior*, vol. 52, pp. 349–358, nov 2015.

[33] M. A. Al-Nakhal and S. S. A. Naser, "Adaptive intelligent tutoring system for learning computer theory," *EUROPEAN ACADEMIC RESEARCH*, vol. 4, pp. 8770–8782, Jan. 2017.

[34] M.-I. Dascalu, C.-N. Bodea, A. Moldoveanu, A. Mohora, M. Lytras, and P. O. de Pablos, "A recommender agent based on learning styles for better virtual collaborative learning experiences," *Computers in Human Behavior*, vol. 45, pp. 243–253, apr 2015.

[35] H. M. Truong, "Integrating learning styles and adaptive e-learning system: Current developments, problems and opportunities," *Computers in Human Behavior*, vol. 55, pp. 1185–1193, feb 2016.

[36] J. M. Harley, F. Bouchet, M. S. Hussain, R. Azevedo, and R. Calvo, "A multi-componential analysis of emotions during complex learning with an intelligent multi-agent system," *Computers in Human Behavior*, vol. 48, pp. 615–625, jul 2015.

[37] T. Mitchell, B. Kisiel, J. Krishnamurthy, N. Lao, K. Mazaitis, T. Mohamed, N. Nakashole, E. Platanios, A. Ritter, M. Samadi, B. Settles, W. Cohen, R. Wang, D. Wijaya, A. Gupta, X. Chen, A. Saparov, M. Greaves, J. Welling, E. Hruschka, P. Talukdar, B. Yang, J. Betteridge, A. Carlson, B. Dalvi, and M. Gardner, "Never-ending learning," *Communications of the ACM*, vol. 61, pp. 103–115, apr 2018.

[38] K. Crockett, A. Latham, and N. Whitton, "On predicting learning styles in conversational intelligent tutoring systems using fuzzy decision trees," *International Journal of Human-Computer Studies*, vol. 97, pp. 98–115, jan 2017.

[39] M. Rani, R. Nayak, and O. Vyas, "An ontology-based adaptive personalized e-learning system, assisted by software agents on cloud storage," *Knowledge-Based Systems*, vol. 90, pp. 33–48, dec 2015.

[40] J. M. Harley, C. K. Carter, N. Papaionnou, F. Bouchet, R. S. Landis, R. Azevedo, and L. Karabachian, "Examining the predictive relationship between personality and emotion traits and students' agent-directed emotions: towards emotionally-adaptive agent-based learning environments," *User Modeling and User-Adapted Interaction*, vol. 26, pp. 177–219, feb 2016.

[41] M. Cilimkovic, "Neural networks and back propagation algorithm," tech. rep., Institute of Technology Blanchardstown, Road North Dublin, 15 - Ireland, 2015.

[42] J. C. Whittington and R. Bogacz, "Theories of error back-propagation in the brain," *Trends in Cognitive Sciences*, vol. 23, pp. 235–250, mar 2019.

[43] L. Wang, Y. Zeng, and T. Chen, "Back propagation neural network with adaptive differential evolution algorithm for time series forecasting," *Expert Systems with Applications*, vol. 42, pp. 855–863, feb 2015.

[44] Y. Bai, Y. Li, X. Wang, J. Xie, and C. Li, "Air pollutants concentrations forecasting using back propagation neural network based on wavelet decomposition with meteorological conditions," *Atmospheric Pollution Research*, vol. 7, pp. 557–566, may 2016.

[45] Z. Chiba, N. Abghour, K. Moussaid, A. E. Omri, and M. Rida, "A novel architecture combined with optimal parameters for back propagation neural networks applied to anomaly network intrusion detection," *Computers & Security*, vol. 75, pp. 36–58, jun 2018.

[46] Z. Shahweli and B. Dhannoon, "Neural network with new relief feature selection for predicting breast cancer based on tp53 mutation," *International Research Journal of Computer*, vol. 4, no. 12, 2017.

[47] D. W. Aha, C. Marling, and I. Watson, "Case-based reasoning commentaries: introduction," *The Knowledge Engineering Review*, vol. 20, no. 3, pp. 201–202, 2005.

[48] D. B. Leake, B. Smyth, and R. Weber, "Guest editors' introduction: special issue on case-based reasoning," *Journal of Intelligent Information Systems*, vol. 46, no. 2, pp. 235–236, 2016.

[49] A. C. Dantas, S. de Melo, M. Fernandes, L. Lima, and M. Z. do Nascimento, "Recomendação de estratégias pedagógicas através de emoções, perfis de personalidade e inteligências múltiplas utilizando raciocínio baseado em casos," in *Brazilian Symposium on Computers in Education (Simpósio Brasileiro de Informática na Educação-SBIE)*, vol. 29, p. 1213, 2018.

[50] A. A. Tawfik, H. Alhoori, C. W. Keene, C. Bailey, and M. Hogan, "Using a recommendation system to support problem solving and case-based reasoning retrieval," *Technology, Knowledge and Learning*, vol. 23, no. 1, pp. 177–187, 2018.

[51] F. Bousbahi and H. Chorfi, "Mooc-rec: a case based recommender system for moocs," *Procedia-Social and Behavioral Sciences*, vol. 195, pp. 1813–1822, 2015.

[52] M. Masood and N. A. M. Mokmin, "Case-based reasoning intelligent tutoring system: An application of big data and iot," in *Proceedings of the 2017 International Conference on Big Data Research*, pp. 28–32, ACM, 2017.

[53] A. Garrido, L. Morales, and I. Serina, "On the use of case-based planning for e-learning personalization," *Expert Systems with Applications*, vol. 60, pp. 1–15, 2016.

[54] S. Sarwar, R. García-Castro, Z. U. Qayyum, M. Safyan, and R. F. Munir, "Ontology-based learner categorization through case based reasoning and fuzzy logic.," *International Association for Development of the Information Society*, 2017.

[55] J. Ribeiro, A. Dias, J. Marques, L. Ávidos, I. Araújo, N. Araújo, and M. Figueiredo, "An artificial intelligence case based approach to motivational students assessment in (e)-learning environments," in *Proceedings of the 10th International Conference on E-Education, E-Business, E-Management and E-Learning*, pp. 1–6, ACM, 2019.

[56] P. Do, K. Nguyen, T. N. Vu, T. N. Dung, and T. D. Le, "Integrating knowledge-based reasoning algorithms and collaborative filtering into e-learning material recommendation system," in *International Conference on Future Data and Security Engineering*, pp. 419–432, Springer, 2017.

[57] L. Alfaro, C. Rivera, J. Luna-Urquizo, E. Castaneda, and F. Fialho, "Utilization of a neuro fuzzy model for the online detection of learning styles in adaptive e-learning systems," *International Journal of Advanced Computer Science and Applications*, vol. 9, no. 12, 2018.

[58] R. Timothy, *Fuzzy Logic With Engineering Aplications*. Wesley, 2010.

[59] A. Ozdemir, A. Alaybeyoglu, N. Mulayim, and K. F. Balbal, "Performance evaluation of learning styles based on fuzzy logic inference system," *Computer Applications in Engineering Education*, vol. 24, pp. 853–865, jul 2016.

[60] M. Ángel Palomino, M. Strefezza, and L. Contreras, "Sistema difuso para la detección automática de estilos de aprendizaje en ambientes de formación web," *Ciencia, Docencia y Tecnología*, vol. 27, pp. 269–294, May 2016.

[61] C. Alonso, D. Gallego, and P. Honey, *Los estilos de aprendizaje. Procedimientos de diagnóstico y mejora*. Bilbao: Mensajero, 1994.

[62] P. Garcia, A. Amandi, S. Schiaffino, and M. Campo, "Evaluating bayesian networks' precision for detecting students' learning styles," *Computers & Education*, vol. 49, pp. 794–808, nov 2007.

[63] E. Özpolat and G. B. Akar, "Automatic detection of learning styles for an e-learning system," *Computers & Education*, vol. 53, pp. 355–367, sep 2009.

[64] Ömer Şimşek, N. Atman, M. M. İnceoğlu, and Y. D. Arikan, "Diagnosis of learning styles based on active/reflective dimension of felder and silverman's learning style model in a learning management system," in *Computational Science and Its Applications – ICCSA 2010*, pp. 544–555, Springer Berlin Heidelberg, 2010.

[65] Q. D. Pham and A. M. Florea, "A method for detection of learning styles in learning management systems," *UPB Scientific Bulletin, Series C.*, vol. 75, no. 4, pp. 3–12, 2013.

[66] F. A. Dorca, L. V. Lima, M. A. Fernandes, and C. R. Lopes, "A stochastic approach for automatic and dynamic modeling of students' learning styles in adaptive educational systems," *Informatics in Education*, vol. 11, no. 2, pp. 191–212, 2012.

Towards a Prototype of a Low-Priced Domestic Incubator with Telemetry System for Premature Babies in Lima, Peru

Jason Chicoma-Moreno
Facultad de Ciencias e Ingeniería
Universidad de Ciencias y Humanidades
Lima, Peru

***Abstract*—Complications due to preterm birth are the main factors of death in the group of children with five years of age or less. Hence, a thorough care for these babies is needed especially during the first weeks or months after birth. Because in Peru not too many families can afford to rent or buy a incubator, this work puts forward the design and construction of a low-priced domestic incubator with telemetry system. The most important parameters to monitor are considered to be: the temperature and the humidity inside of the incubator and the heart pulse of the baby. To maintain the levels of temperature and humidity according to medical standards, a software was developed in an Arduino Uno. In order that the parents monitor the aforementioned parameters not necessarily being in the same room where the incubator is, a bluetooth module was used with the Arduino Uno to transmit the data to an app installed in a mobile phone. The first tests have shown that the humidity and temperature levels within the incubator are maintained as desired, also the the heart pulse is the expected one. However, there is still some work to do in regard to the upper limits of the humidity and temperature levels, which will be implemented as the next step of the project. It is expected that this incubator will serve Peruvian families, specially those living at the edge of poverty, who do not have the possibility of affording an expensive incubator at home or paying for these services at hospitals, for their premature babies.**

***Keywords*—Preterm babies; incubator; Arduino; telemetry**

I. Introduction

A baby born before 37 weeks of gestation is considered premature. According to the World Health Organization [1], 15 million babies are born preterm each year. Difficulties arising from preterm birth are the number one causes of death among children aged 5 years or less. Preterm birth is divided in three subcategories according to gestational age [1]:

- Extreme preterm (less than 28 weeks)
- Very preterm (28 to 32 weeks)
- Moderate to late preterm (32 to 37 weeks).

As of 2014, a study [2] estimated that out of 14.8 million preterm births worldwide, 12 million of these happened in Asia and sub-Sharan Africa; nearly 81.1%. The preterm birth rate in Europe, on the other hand, was estimated to be quite low; around 8.7%. Among the countries that belong to the Caribbean and Latin America region, Peru was ranked in the year 2010 in the position fifteen with a preterm birth rate of 7.3 % [3].

Because the organ systems of preterm babies are not well developed, special care is needed and also permanent monitoring [4]. For instance, preterm infants are affected by heat and fluid loss. Hence, in order to maintain their body temperatures within an adequate range they need to be placed in special controlled environments. Closed incubators are perfect for this task because by adjusting ambient humidity, heat and fluid evaporation can be reduced.

In Peru, many people who have premature babies do not have the enough acquisition power to buy or rent incubators, which are mostly expensive. Thus, they are only able to afford low-priced ones, but many times these are difficult to find or are not available in the market. As a consequence premature babies are likely to develop some complications which can lead to their deaths. The present work, therefore, seeks to reduce the mortality rate of premature babies in Peru. To achieve this goal, the design and construction of a low-cost domestic incubator with telemetry system for premature babies is presented. In Section II, the methodology will show both, the electronic and mechanical, parts and the developed software in charge of controlling the incubator. Section III presents the mechanical and electronic design, medical functions and results generated by the prototype of the incubator. Finally, Section IV indicates the conclusions.

II. Methodology

A. Electronic Parts

Because a low-priced domestic incubator is desired, the following electronic components were selected for its design and implementation:

- Arduino Uno
- Sensor DHT11
- Sen-11574
- Bluetooth module
- Ultrasonic humidifier
- Heating resitor
- Fans and exhaust fan
- LED indicators
- LCD screen

- I2C converter
- Relay module

The Arduino Uno microcontroller board will control the reading of sensors and actuators that will be used. This will be also used for wireless communication with, for example, mobile phones and will also manage of the entire domestic incubator. DHT11 is the temperature and humidity sensor that will be used to take the measurements from the controlled environment of the incubator. Sen-11574 is the heart rate sensor; its function as implied will be to measure the heart rate of the premature baby so that it can give an early warning of any cardiac anomaly. The ultrasonic humidifier is an actuator that will serve to create the precise humidity needed inside the incubator for the premature baby. The bluetooth module will make possible the wireless communication of the microcontroller with, for example, mobile phones.

B. Mechanical Materials

Some of the most important mechanical materials that were used to build the prototype of the incubator are listed:

- Wood
- Plastic film
- Screws
- Wood sealing machine

By choosing wood and plastic film, the prototype of the baby incubator is easily portable and also quite cheap. The incubator is divided in two main areas. The area where the baby will be placed is located in the upper part of the incubator and the other one (in the lower part) is for the electronics that will be in charge of providing the right conditions for the area of the premature baby.

Algorithm 1 Temperature and humidity control pseudocode

```
if temperature ≤ 36.5° then
    Fan heating = ON
    Heating resistor = ON
    LED indicator = ON
else
    Fan heating = OFF
    Heating resistor = OFF
    LED indicator = OFF
end if
if humidity ≤ 70% then
    Fan humidifier = ON
    Humidifier = ON
    LED indicator = ON
else
    Fan humidifier = OFF
    Humidifier = OFF
    LED indicator = OFF
end if
```

C. Software

The program developed in the Arduino Uno is in charge of keeping the temperature and humidity inside the incubator according to the needs of the premature baby. The pseudocode shown in the Algorithm 1 and loaded into the Arduino demonstrates how the temperature and humidity levels are kept inside the incubator.

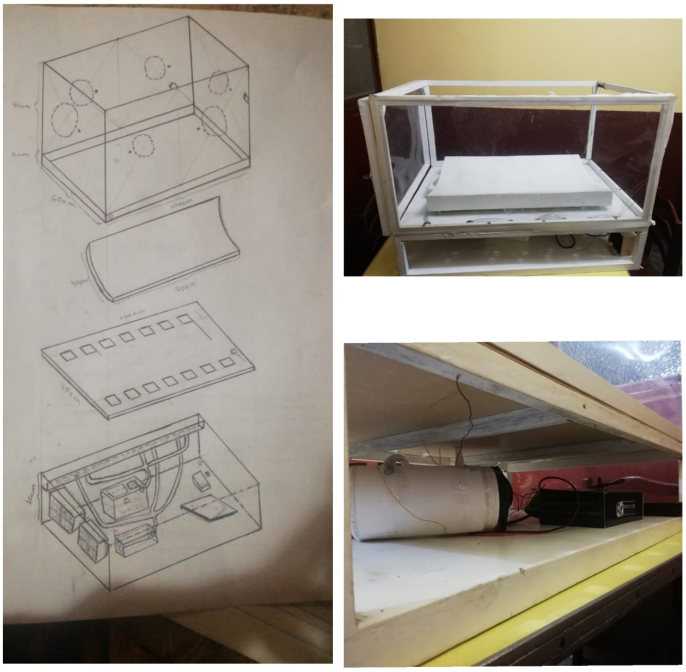


Fig. 1. Left: Schematic of thel incubator. Top Right: The incubator prototype showing the area where the premature baby lays (top) and the area of the electronics (bottom). Bottom Right: Area where the electronics are located.

It is well know [5], [6], [7] that newborn temperature levels have to be kept within the range of 36.5 and 37.5°C. Thus, the algorithm developed has to consider this upper and lower temperature limits. As shown in the Algorithm 1, the Arduino uno will turn on the heating resistor and also the fan of the heating in order to elevate the temperature of the incubator's baby area if this falls below 36.5°C (which is detected by the DHT11 sensor). Once this lower limit is passed, the heating resistor and its fan will turn off. The relative humidity of the area where a premature baby is located has to be maintained within the 70–75% range [8]. It can also be seen that the code developed (Algorithm 1) will turn on the ultrasonic humidifier and its respective fan once the humidity drops below 70%. The fan of the humidifier will cause the water vapor to flow towards the area where the baby is located. The variation of the humidity is also detected by the DHT11 sensor. Once the humidity returns to a level above 70%, the ultrasonic humidifier and its fan will turn off.

The heart rate sensor (Sen-11574) to measure the pulse is a plug-and-play one to use with the Arduino Uno. A holder was adapted for this sensor inside the incubator to use when desired. This sensor start taking measurements when it is attached to the baby's finger. The expected measured pulse has to be between 120 and 160 beats per minute (bpm) [9].

The three parameters, temperature, humidity and beats per minute, can be visualized in the LCD screen attached to one side of the incubator. The aforementioned is directly connected

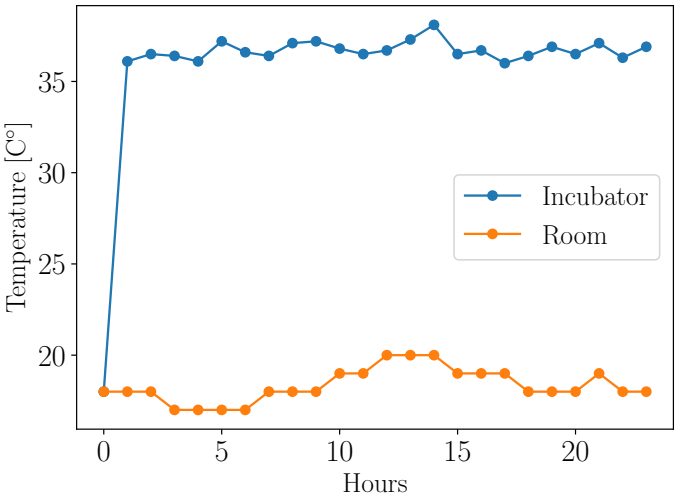


Fig. 2. Temperature monitoring over a whole day inside and outside the incubator.

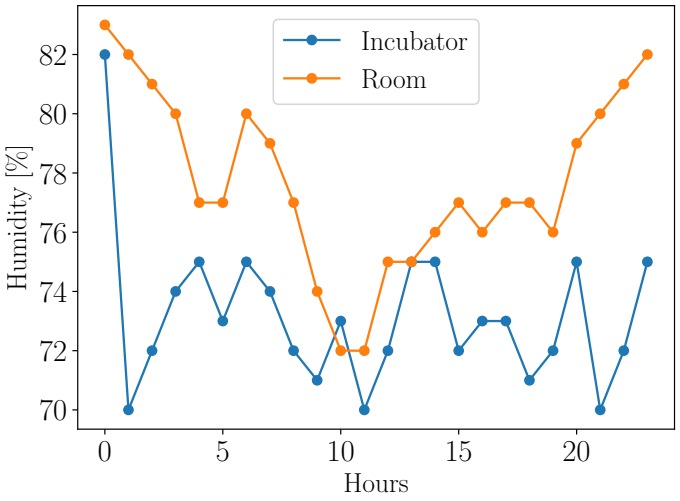


Fig. 3. Humidity monitoring over a whole day inside and outside the incubator.

to the Arduino Uno and receives and displays the data in real time.

III. Results and Discussion

The first prototype of the mechanical part of the incubator can be seen in Fig. 1; the right upper panel . The left panel of Fig. 1 shows the schematic of the incubator. The main box at the top is where the baby be will placed. The curved plate will serve as support for the mattress where the baby will be laid. The plate with seven squared holes to the sides will serve as support and also as ventilation. The box at the bottom is where the electronics are located. Two external fans, one normal and the other an exhaust one, are in charge of keeping ventilated the electronics. The right lower panel of Fig. 1 shows a partial view of the area of the electronics.

In order to verify that the temperature system was correctly implemented, we added a new sensor DHT11 outside of the incubator and connected it to the Arduino Uno. Hence, measurements were taken over a whole day. In Fig. 2 it can be observed the measurements of both sensors, inside and outside the incubator. When the measurements initiated both temperatures were the same, that is to say at room temperature. However, once the incubator was closed, the temperature inside the incubator, in the area of the premature baby, was stabilized to the 36.5–37.5°C range. These tests were done during the month of April 2019, when in the capital city of Peru, Lima, usually it is autumn time, which means that it does not get really hot, more than 38°C for instance. If the test would have been during summer time, when in some days the temperature can be more than 38°C, it would mean that also the temperature inside the incubator would be more that the upper accepted limit (37.5°C) for the premature baby. A solution to this is the next step in the implementation of the prototype. This steps consists in adding a cooling unit. For this purpose, the use a Peltier module with its respective fan is planned. This is in order that when it gets higher than 37.5°C in the area of the baby the Peltier module along with is fan will turn on in order to blow cool air into the aforementioned area. If the temperature falls below this level the Peltier module and its fan are expected to turn off.

To measure the humidity as mentioned above, it is also done with the sensor DHT11. To compare again the adequate operation of this sensor along with our software, we placed a second one outside the incubator (which is the same one that measured the room temperature). In Fig. 3 the measurements of humidity levels inside and outside the incubator can be seen during a whole day. At the beginning of the measurements, the humidity levels were very similar; however, once the incubator was closed it can be seen that these stabilized within the accepted range of 70–75%. Even though the exhaust fan in the area of the electronics and also also the time of the year during which the test were done has helped to reach the adequate humidity levels, this could not have been possible during summer time, where the exhaust fan alone located in the electronics area could not have done the task or reducing really high humidity levels. Therefore, as also a next step to finishing our prototype is to place an exhaust fan to remove the moisture from the area of the baby so it can reach humidity levels less than 75%. As observed in Fig. 3, the humidity levels above 75% are well controlled by the ultrasonic humidifier and its respective fan.

The sensor Sen-11574 was attached to a adult male (20 yrs. old) in order to take his heart rate pulse. In Fig. 4, a sample of these measurements is observed and it is quite clear that the waveform of the pulse along with the periodicity are the expected ones.

The telemetry system is implemented via the bluetooth module hc-06 that is directly connected to the Arduino Uno. The data regarding the temperature and humidity levels and the heart rate pulse are transmitted via bluetooth from the Arduino Uno to an app installed in the mobile phone of the parents, so that they do not need to be necessarily in the same room of the incubator to monitor these parameters.

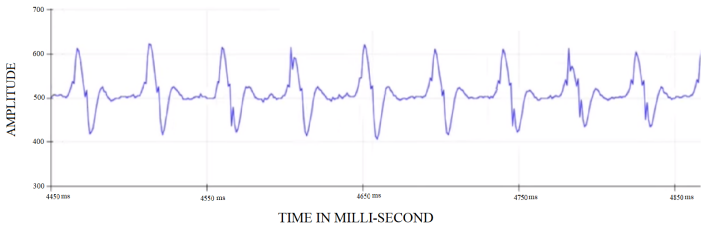


Fig. 4. Heart Rate Sample.

IV. Conclusions and Future Work

The first results of the prototype of the implemented incubator for preterm babies have shown to be very encouraging. The temperature and humidity levels inside the incubators were kept between 36.5–37.5°C and 70–75%, respectively, which are the expected ones according to medical standards. The heart pulse sensor has show to be working properly as well. Additionally, wireless communication via bluetooth was possible by using the module hc-06 and an app installed in a mobile phone.

As a future work, the incubator also has to consider what happens when the temperature inside de incubator goes beyond 37.5°C. For this, a cooling unit based on a Peltier module is put forward. On the other hand, when the humidity level reaches 75% or more an exhaust fan in the area of the baby within the incubator is also proposed. This work is expected to serve Peruvian families, especially the ones who can not afford to rent or buy an expensive incubator at home or pay for this type of services at hospitals, with the care of their premature babies.

Acknowledgments

The author is very thankful to Dr. Carlos Sotomayor Beltran for his insightful comments and helpful suggestions.

References

[1] World Health Organization (WHO). (2018) Premature births. [Online]. Available: https://www.who.int/es/news-room/fact-sheets/detail/preterm-birth

[2] S. Chawanpaiboon, J. Vogel, A. Moller, P. Lumbiganon, M. Petzold, D. Hogan, S. Landoulsi, N. Jampathong, K. Kongwattanakul, M. Laopaiboon, C. Lewis, S. Rattanakanokchai, D. Teng, J. Thinkhamrop, K. Watananirun, J. Zhang, W. Zhou, and A. Gülmezoglu, "Global, regional, and national estimates of levels of preterm birth in 2014: a systematic review and modelling analysis," *The Lancet. Global Health*, vol. 7, pp. e37–e46, 2019.

[3] L. A. Mendoza Tascón, D. I. Claros Benítez, L. I. Mendoza Tascón, M. D. Arias Guatibonza, and C. B. Peñaranda Ospina, "Epidemiología de la prematuridad, sus determinantes y prevenciíon del parto prematuro," *Revista chilena de obstetricia y ginecología*, vol. 81, pp. 330 – 342, 2016.

[4] W. McGuire, P. McEwan, and P. Fowlie, "Care in the early newborn period," *BMJ*, vol. 329, pp. 1087–1089, 2004.

[5] C. A. V. D. Bosch and C. H. W. Bullough, "Effect of early suckling on term neonates' core body temperature," *Annals of Tropical Paediatrics*, vol. 10, no. 4, pp. 347–353, 1990.

[6] A. Singh, T. Newton, and M. Watkinson, "Improving neonatal unit admission temperatures in present babies: exothermic mattresses, polythene bags or a traditional approach?" *Journal of Perinatology*, vol. 30, pp. 45–49, 2010.

[7] T. Tisa, Z. Nisha, and M. Kiber, "Design of an enhanced temperature control system for neonatal incubator," *Bangladesh Journal of Medical Physics*, vol. 5, pp. 53–61, 2013.

[8] F. Elahi and Z. A. Nisha, "Low cost neonatal incubator with smart control system," in *8th International Conference on Software, Knowledge, Information Management & Applications (SKIMA)*, 12 2014.

[9] Stanford Children's Health. (2019) Assessments for newborn babies. [Online]. Available: https://www.stanfordchildrens.org/en/topic/default?id=assessments-for-newborn-babies-90-P02336

Sentiment Analysis and Classification of Photos for 2-Generation Conversation in China

Zhou Xiaochun[1], Choi Dong-Eun[2], Panote Siriaraya[3], Noriaki Kuwahara[4]
Graduate School of Engineering and Science
Kyoto Institute of Technology
Kyoto, Japan

***Abstract*—Appropriate photos can help the Chinese empty-nest elderly and young volunteers find common topics to promote communication. However, there are little researches on such photo in China. This paper used 40 online photos with 160 sessions for the conversation experiment for the Chinese elderly and young people to analyze these photos and classify them. Sentiment analysis of Chinese conversational texts was used to estimate the speaker's attitude towards these photos. We collected the data set from the average value of sentiment analysis, the number of words uttered by the speakers, the pulse of the elderly, and the stress level of the youth for each photo. Principal Component Analysis (PCA) was carried out as a data preprocessing step to improve classification accuracies, and we selected four Principal Components (PCs) that account for 85.20% of total variance in the data. Next, we normalized these four PCs scores for Hierarchical Clustering Analysis (HCA) of the photos, and we got four clusters with different features. The results showed that photos in cluster2 were only optimal for the youth; cluster3 only made the elderly participants speak more; cluster1 and cluster4 was not suitable for the elders and the young people. This paper firstly classified the photos for 2-generation conversation and describing their features in China. Although, we did not find any photos suitable for both the elderly and the youth, this empirical study took a step forward in the investigation of photos for 2-generation conversation in China.**

***Keywords*—Photo; 2-generation conversation; sentiment analysis; Principal Component Analysis (PCA); Hierarchical Clustering Analysis (HCA); China**

I. Introduction

A. Cognitive Impairment in the Empty-Nest Elderly in China

As most of the first generation of only-child in China has entered the age of marriage and childbearing, the pattern of "421" families (four grandparents, two parents, and one child) began to show a mainstream tendency [1]. It has led to an increase in empty-nesters who do not live with their married children. They live with their spouses (empty-nest-couple) or alone (empty-nest -single). The empty-nesters accounted for 47.53% of the Chinese elderly in 2016, 60% of them have mental problems [2]. Recent research has shown that empty-nest-related psychological distress is associated with cognitive impairment in the elderly. Ensuring good social ties and minimizing psychological distress may help delay or prevent the progression of cognitive impairment in the empty-nest elderly [3].

B. Related Works

A large number of works have shown that daily conversations with the elderly can promote their social communication and maintain their cognitive function. Although it is difficult, using photos as topics can be a "switch" to activate the conversation [4]. Now in China, the study the voice interaction with companion robots aims to improve the cognitive level of the elderly [5].

However, most of the elderly in China have poor mandarin, and their intention is too colloquial. This first put a great test on the technology of speech recognition. Besides, the language itself has the characteristics of ambiguity and diversity, and there is great uncertainty in man-machine dialogue [6]. Moreover, elderly care requires emotional devotion, which is irreplaceable for the robot. Relevant government should take adequate measures to actively respond, such as vigorously improving community home care services, and organizing and promoting volunteer service activities to help the elderly from physical and psychological aspects.

In summary, the photo is currently the most effective media to help the elderly and young volunteers communicate, but there are little researches on the photos for 2-generations conversation in China.

C. Research Objectives

The goal of this research is to create a "2-generation conversation support system" in China. It can help the elders and the young volunteers quickly and effectively find and switch the photo they like to talk about on the web. However, few studies in China revealed the features of appropriate photos for the 2-generation conversation. The purpose here is to investigate the effects of the photos on the 2-generation conversation in China and classify them.

D. Materials and Methods

We set up 160 sessions with 2 participants for 40 photos for the experiment.

1) Sentiment Analysis: There are many methods to investigate the effects of photos on the conversation, such as the questionnaire survey, physiological monitoring, and emotion recognition method. Sentiment analysis as an emotion recognition method is designed to automatically discriminate textual data such as comments, opinions, opinions published by users with emotions, and calculate the emotional intensity of each text data to observe the user's emotions. The Chinese dictionary-based sentiment analysis is to mark the emotional polarity and intensity of these topic words by extracting the domain keywords in the corpus text to be analyzed [7]. At present, the development of the Chinese general sentiment dictionary

has been relatively complete, such as the Chinese artificial intelligence open platform of Baidu, Inc (https://ai.baidu.com). We used "Baidu AI" to carry out the sentiment analysis.

2) Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA): This study collected data set from the average value of sentiment analysis, the number of words uttered by the speakers, the pulse of the elderly, and the stress level of the youth for each photo. To explore similarities and hidden patterns among samples where relationship on data and grouping are until unclear, principal component analysis (PCA) and hierarchical cluster analysis (HCA) are the most widely used tools. Moreover, an objective multivariate statistical methodology (PCA and HCA) incorporating can effectively do the data pre-preprocessing [8]. Principal component analysis (PCA) is a method used to perform dimensionality reduction [9]. We applied PCA to the data set and obtained six principal components (PCs). We selected four PCs that explain 85.2% variance in data for hierarchical clustering analysis (HCA) of the photos. Ward's method is the only agglomerative clustering method based on a classical sum-of-squares criterion. It can produce groups that minimize within-group dispersion at each binary fusion, look for clusters in multivariate Euclidean space [10]. By this method, we obtained four photo clusters.

E. Results and Conclusion

For the first time, this paper classified photos for 2-generations conversation in China and obtains four clusters with different features. Because there are not many experimental photos and the types of participants are incomplete, it is not appropriate to organize the clusters into a complete classification system. Nevertheless, from the above analysis, it is feasible to combine the PCA method with HCA for photo classification, and it can receive good results, enabling researchers to quickly find the difference between photos, thus improving the classification quality. With the deepening of the work, it is expected that a classification system for photos can be formed based on the method of this paper.

II. Experiment

A. Participants

The participants were four elderly Nanjing citizens over 65 years without dementia (two males, two female) and four female students from Nanjing Medical University. They did not know each other before the experiment.

In Table I, we present the participants and the conversation sessions number. We set up 160 sessions with 2 participants and 1 photo each, which ensured that each elderly participant had the opportunity to talk to each young participant about each photo.

B. Photos and Apparatus

40 photos searched from Baidu (http://image.baidu.com) were used for the 2-generation conversation. Referring to the related work in Japan, these photos are about things around that people are familiar with, such as the photo7 of "lotus" showed in Fig. 1.

We used A MacBook Air and a projector for displaying photos, and an iPad mini4 for video recording. Experiment processes were recorded to convert the conversation to text (Fig. 2).

TABLE I. Participants and Sessions for Each Photo

Photo No.	Elders No.	Youth No.	Session No.	Session Duration
1~10	1	1	1~10	1 minute X 10
1~10	4	2	11~20	1 minute X 10
1~10	3	3	21~30	1 minute X 10
1~10	2	4	31~40	1 minute X 10
11~20	2	2	41~50	1 minute X 10
11~20	4	1	51~60	1 minute X 10
11~20	1	3	61~70	1 minute X 10
11~20	3	4	71~80	1 minute X 10
21~30	3	1	81~90	1 minute X 10
21~30	1	2	91~100	1 minute X 10
21~30	4	4	101~110	1 minute X 10
21~30	2	3	111~120	1 minute X 10
31~40	2	1	121~130	1 minute X 10
31~40	3	2	131~140	1 minute X 10
31~40	1	4	141~150	1 minute X 10
31~40	4	3	151~160	1 minute X 10

Fig. 1. Photo7 for experiment (source: http://image.baidu.com). It is known to all Chinese as the lotus flower.

A fingertip oximeter (Guangdong medical device registration number: 20152210273) was used for measuring the pulse of the elderly participants (Fig. 3), which was friendly to the elderly users.

We used the Stress-Check-Sheet for subjective stress survey for the young participants. It was a 7-level rating from 1 to 7, 1 is the lowest, and 7 is the highest stress level (Fig. 4).

C. Design

A research design aims to investigate the effects of the photos on the 2-generation conversation. Thus, we set this experiment to the form of 2-person conversation by watching the photo. In Table II, we present six evaluation factors for each photo. They are positive probability, number of words, pulse, and stress of the participants.

We collected the data set from the average value of these factors. PCA was carried out as a data preprocessing step before HCA to improve classification accuracies of the photos.

Fig. 2. State of experiment. A pair of participants are in the first row, who are talking about the projected photo.

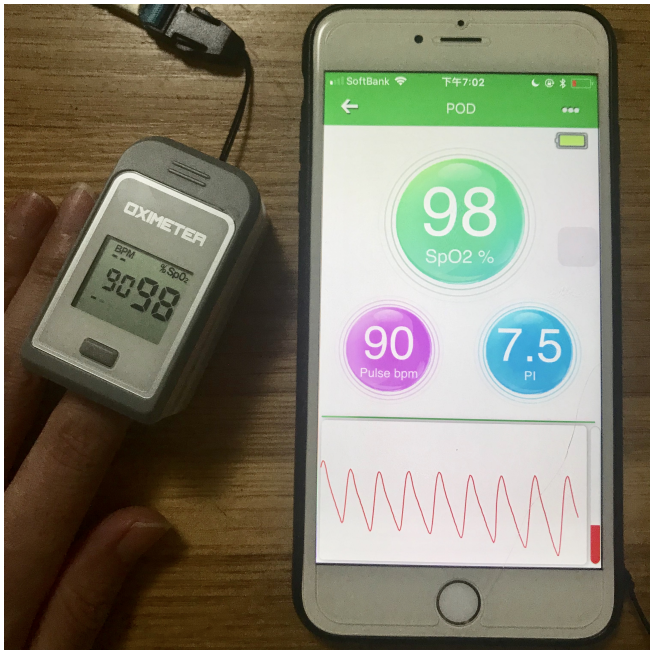


Fig. 3. Fingertip Oximeter was used to record the pulse of the elderly participants.

D. Procedure

The following was the experimental procedure:

- Participants were instructed to watch the photo and talk freely about it with their partners.
- Each photo was automatically played for 1 minute.
- During the conversation, the pulse of the elderly was recorded with a fingertip oximeter.
- At the end of each session, the young participant evaluated their stress level with the Stress-Check-Sheet (Fig. 4).

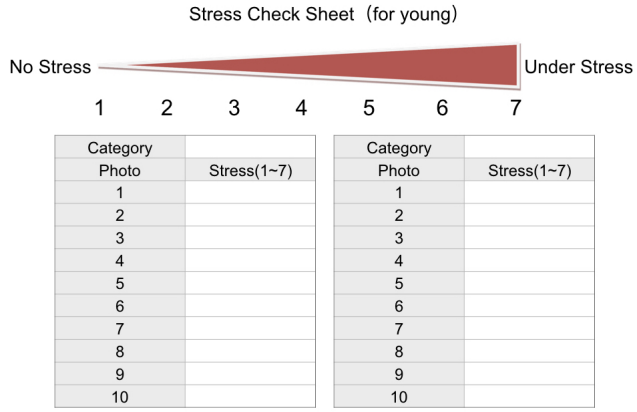


Fig. 4. Stress Check Sheet for the young participants. 1 is the lowest, and 7 is the highest stress level.

TABLE II. EVALUATION FACTORS FOR PHOTOS

Factor	Elderly	Youth
Positive probability (%)	Yes	Yes
The number of words	Yes	Yes
Pulse	Yes	No
Stress level	No	Yes

- After the experiment, conversation video recording was exported for textualization, sentiment analysis, and word counts.
- PCA was applied to the data set.
- HCA was applied to the normalized principal component scores by ward method.

E. Analysis

1) Sentiment Analysis: Sentiment Analysis of Chinese text can use Baidu AI Open Platform to automatically classify the opinioned text into sentiment polarity: positive, negative, and neutral.

We analyzed the sessions sentence by sentence by code written in Python 2.7.10. For example, the sentence of "This is a panda, a rare animal." is more positive, because its sentiment polarity is 2 (positive) and the positive probability is 0.607345 more than the negative probability of 0.392655. There are only three classes of sentiment polarity, and the negative probability is equal to 100% minus the positive probability. In order to compare the differences between the photos accurately, we only report the average of positive probability for each photo.

2) Principal Component Analysis (PCA): The following was the results of PCA of the data set shown in Table III:

- Standard Deviation: This is simply the eigenvalues in our case since the data has been normalized. The average of all eigenvalues is 0.965, which is exceeded up to PC4. Since an eigenvalue <1 would mean that the component explains less than a single explanatory variable we would like to discard PC5-PC6.
- Proportion of Variance: This is the number of variances the component accounts for in the data. PC1

accounts for 28.07% of the total variance in the data, PC2 accounts for 20.78% of the total variance, and PC3 accounts for 19.36% of the total variance. These three PCs are essential.

- Cumulative Proportion: This is simply the accumulated number of explained variance, i.e., if we used PC1-PC4, we would be able to account for 85.20% of total variance in the data.

TABLE III. THE VALUES OF PC1-PC6

Principal Component	Standard Deviation (Eigenvalues)	Proportion of Variance (%)	Cumulative Proportion (%)
PC1	1.298	28.07	28.07
PC2	1.117	20.78	48.85
PC3	1.078	19.36	68.21
PC4	1.010	16.99	85.20
PC5	0.816	11.09	96.29
PC6	0.472	3.71	100.00

The factor loading is shown in Fig. 5:

- PC1 has a strong correlation with the number of words uttered by the elders and the youth. The less the elders speak, the more the youth speak.
- PC2 has a strong correlation with positive probability of the elderly and the number of words uttered by the youth. We found that the more positive the elders become, the less the youth speak.
- PC3 has a strong correlation with the stress level of the youth and the pulse of the elders. The lower the stress of the youth is, the lower the pulse of the elders is.
- PC4 has a strong correlation with the positive probability of the youth and the pulse of the elders. The less the positive probability of the youth is, the lower the pulse of the elders is.

In summary, we summarize the followings:

- PC1 is "number of words uttered by participants".
- PC2 is "positivity of elders" for "number of words uttered by youth".
- PC3 is "stress of youth" for "pulse of elders".
- PC4 is "positivity of youth" for "pulse of elders".

F. Photo Clustering

PCA was carried out as a data preprocessing step to improve classification accuracies. For four PCs selected from the results of PCA, their scores were normalized to an average value of 0 and variance 1. In all cases, the ward method was used, which is a method that treats each principal component equally, emphasizes factors with a small contribution rate.

Then HCA was performed by RStudio3.3.3. A dendrogram of 40 photos as a result of HCA is shown in Fig. 6: the vertical line indicates the cluster of connections, and the length of the horizontal line indicates the distance between the two types of connections.

As we can see from Fig. 6, the distance between photo2 and photo14 is the closest (<1), so photo2 and photo14 are combined into one cluster (photo2, photo14), so nodes photo2 and photo14 are first connected in the dendrogram to make it become a child node of a new node (photo2, photo14) and set the height of this new node; then select the nearest distance among the remaining clusters, and the distance between (photo2, photo14) and photo5 is the closest (1), so (photo2, photo14) and photo5 are combined into one cluster ((photo2,photo14), photo5), which is reflected in the dendrogram, connecting nodes (photo2, photo14) and photo5 to make it a child node of a new node ((photo2,photo14), photo5), and set the height of this new node to 1;.... Generate a dendrogram in this mode until there is only one cluster left.

It can be intuitively seen that if we want to get a clustering result, we just cut a vertical line on the dendrogram. For example, this dendrogram can be cut to 4 clusters with the red borderline.

HCA is an unsupervised learning, a classification model in the absence of labels. The primary assumption is that there is a similarity between the data, and the similarity is valuable, so it can be used to explore the features in the data to generate value. In China, due to the lack of research on photos for the 2-generation conversation, we used HCA to group photos into four different clusters, each of which should have its unique properties. Next, we will conduct an in-depth analysis of each cluster separately to get more detailed results.

III. RESULTS

The PCs scores of each photo in each cluster are represented on the principal component space for compare. Fig. 7 shows the location classes in 4th-dimensional principal component space with the confidence interval around a linear regression line. The features of photos for each cluster can be interpreted as follows:

1) Cluster1: Photos in cluster 1 focus on the positive correlation area of PC1 and negative correlation area of PC3. It has a strong correlation with "number of words uttered by participants" and "stress of youth".

2) Cluster2: Photos in cluster 2 focus on the positive correlation area of PC1 and negative correlation area of PC4. It has a strong correlation with "number of words uttered by participants" and "positivity of youth".

3) Cluster3: Photos in cluster 3 focus on the negative correlation area of PC1. It has a strong correlation with "number of words uttered by participants".

4) Cluster4: Photos in cluster 4 focus on the positive correlation area of PC4. It has a strong correlation with "positivity of youth" for "pulse of elders".

5) Photo38 in Cluster2 (Fig. 8): It has the highest PC1 score in all photos, which has the strongest correlation with the "number of words uttered by participants".

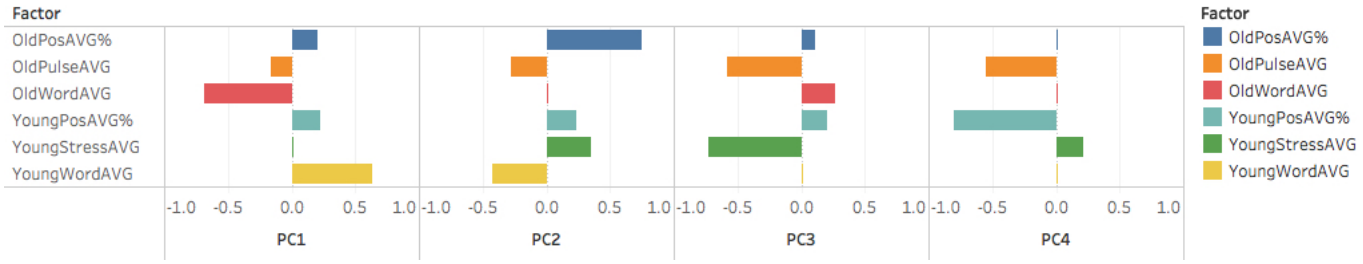


Fig. 5. Factor loading plot for PC1-PC4.

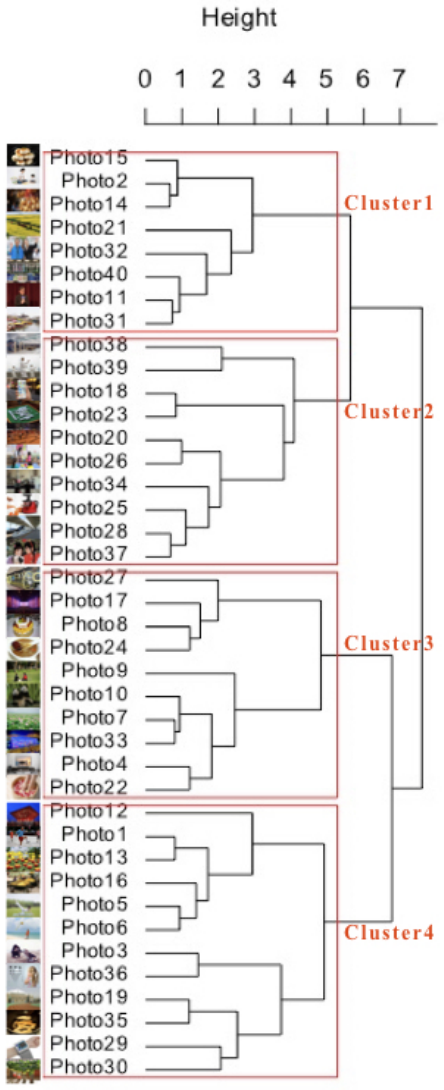


Fig. 6. Cluster Dendrogram: clustering of normalized principal component scores by ward method. It is set to 4 clusters with red borderline.

IV. Discussion

We have shown that PCA is very useful in reducing the dimension of data. We selected four PCs that explain 85.2% variance in data. HCA was used to group these normalized PCs scores in four clusters. Fig. 9 restored the factors data for each cluster and photo, which can explain each photo cluster in more detail in Table IV:

TABLE IV. Features of Each Photo Cluster

Cluster	Elderly	Youth
Cluster1	Less utterance	High stress
Cluster2	Least utterance for photo38	More utterance / More positivity
Cluster3	More utterance	Less utterance
Cluster4	Slow pulse	Less positivity

1) Cluster1: It has a strong correlation with "number of words uttered by participants" and "stress of youth". In cluster1, all "number of words uttered by the elderly" below average, and all "stress of youth" above average.

2) Cluster2: It has a strong correlation with "number of words uttered by participants" and "positivity of youth" for "pulse of elderly". In cluster2, almost all "number of words uttered by youth" above average, and almost all "positivity of youth" above average.

3) Cluster3: It has a strong correlation with "number of words uttered by participants". In cluster3, almost all "number of words uttered elders" above average, oppositely all "number of words uttered by youth" below average.

4) Cluster4: It has a strong correlation with "positivity of youth" for "pulse of elders". In cluster4, almost all "positivity of youth" below average, and almost all "pulse of elderly" below average.

V. Conclusion

In this study, we described an emotion recognition method of sentiment analysis of Chinese conversation texts, which can obtain the positive probability of speakers for the photos during the conversation. The data set from the average value of sentiment analysis, the number of words, pulse, stress was used for PCA to obtain four PCs. As a result of HCA of normalized these PCs scores, we got four photo clusters with different features, from which we generalized the following conclusions:

- Photos in cluster2 are optimal only for the youth, which make the youth speak more and feel positive, and the photo38 make the youth speak the most, oppositely the elders speak the least in all photos.
- Photos in cluster3 make the elders speak more, oppositely make the youth speak little.

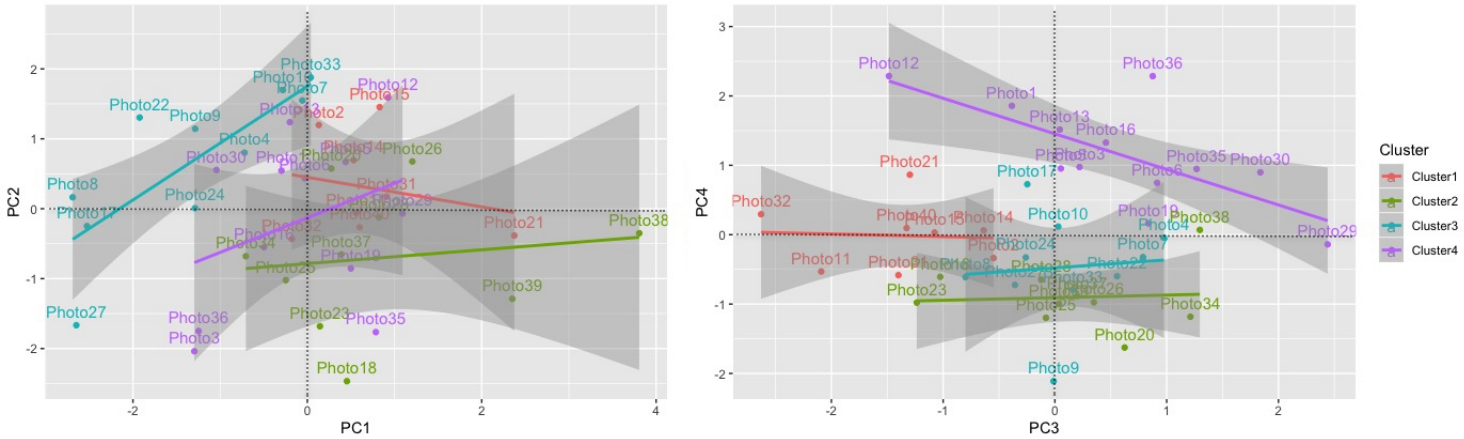


Fig. 7. Location classes in 4th dimensional principal component space with confidence interval around a linear regression line.

Fig. 8. Photo38 in cluster2 with the highest PC1 score (source: http://image.baidu.com). It makes the youth utter the most, and the elders utter the least.

- Photos in cluster1 make the elders speak little and the youth under stress.
- Photos in cluster4 make the youth do not feel positive and have no appeal to the elders.

From the above analysis, it is feasible to combine the PCA method with HCA for photo classification, and it can receive good results, enabling researchers to quickly find the difference between the influence factors between photos, thus improving the classification quality.

This paper firstly analyzed and classified the photos for 2-generation conversation and describing their features in China. However, we did not find the photo cluster optimal for both the Chinese elderly and young people in this study. Even so, we believe that our empirical study is one step forward to investigate the effectiveness of photos for 2-generation conversation, which can help the Chinese elderly promote their social communication and maintain their cognitive function. With the deepening of the work and the increase in the number of photo samples, it is expected that a classification system for photos can be formed based on the method of this paper.

VI. Future Works

We should continue our experiments with more photos to find photos optimal for both the Chinese elderly and young people.

Sentiment analysis only considers conversation text and ignores the speaker's information. That is very useful for classifying photos, mainly in the speaker's different preferences for the same photos. For example, for the photo5 with "Yuga" (Fig. 10), the elderly women were concerned about "it is difficult for the elderly", while the elderly men were concerned about "advantages of exercise". This study only divided the participants into the elders and youth, whose information can be expanded, such as gender, education level, and birthplace. Next, we will consider how to introduce such information into our study to better improve the classification accuracies of the photos.

Acknowledgment

This work was supported by a grant from JSPS KAKENHI Grant Number 19H04154.

References

[1] X. Zheng, *Research on 421 Household Smart Home Products in Jiangsu and Analysis of Consumer Evaluation Factors*. Design, 2019.

[2] Q. Wang, *Nursing Service System and Countermeasures for the Elderly Living Alone and Empty-Nesters*. China Economic Times, vol.12851, April 2019.

[3] D. Duan et al., *Empty-Nest-Related Psychological Distress is Associated with Progression of Brain White Matter Lesions and Cognitive Impairment in the Elderly*. Scientific Reports, 7:43816, March 2017.

[4] M. Iwamoto, N. Kuwahara, *Investigation of Quantification of Suitable Photo for Conversation Support with Elderly People by Emotion of Youth*. Lecture Notes in Computer Science, vol.10897, June 2018.

[5] C. Wang, *Study of Voice Interaction Based on Elderly Companion Robot*. Beijing: School of Digital Media & Design Arts of Beijing University of Posts and Telecommunications, 2019.

[6] Y. Ni, *Analysis on Speech Interaction Design for Elderly Cognition*. Industrial Design, pp.37-38, 2019.

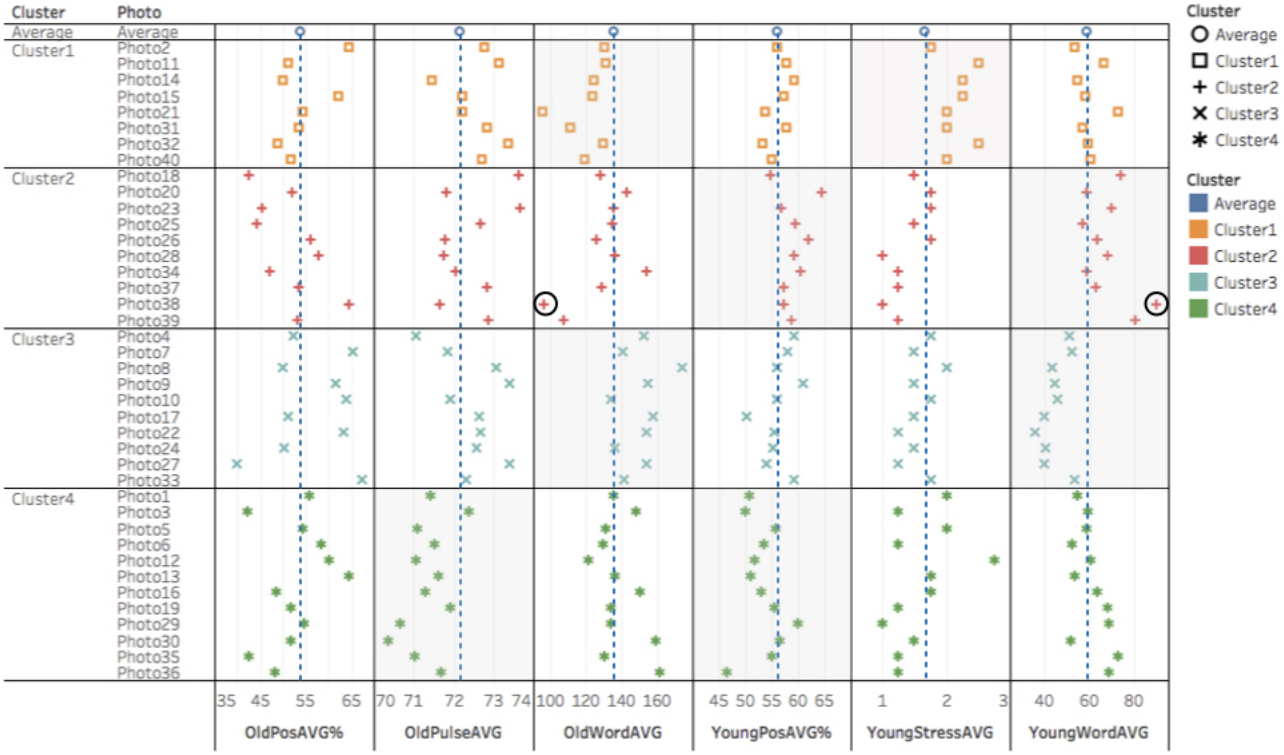


Fig. 9. Factors data for each cluster and photo.

Fig. 10. Photo5 in cluster 4 (source: http://image.baidu.com).

[7] Y. Li et al., *The Evolution Characteristics of Tourism Opinion Crisis based on Emotion Mining and Topic Analysis: A Case Study of the Incident of "Female Tourist Attacked in Lijiang"*. Tourism Tribune, vol.34 No.9, 2019.

[8] D. Granato et al., *Use of Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA) for Multivariate Association between Bioactive Compounds and Functional Properties in Foods: A Critical Perspective*. Trends in Food Science & Technology, vol.72, pp.83-90, February 2018.

[9] I.T. Jolliffe, *Principal Component Analysis*. Series: Springer Series in Statistics, 2nd ed., Springer, NY, 1999.

[10] F. Murtagh, P. Legendre, *Ward's Hierarchical Agglomerative Clustering Method: Which Algorithms Implement Ward's Criterion?*. Journal of Classification, vol.31, Issue 3, pp. 274–295, October 2014.

LSSCW: A Lightweight Security Scheme for Cluster based Wireless Sensor Network

Ganesh R. Pathak[1]
1. PhD Scholar,
Department of Computer Science and Engineering,
Satyabhama Institute of Science and Technology
(Deemed to be University),
Jeppiaar Nagar, Rajiv Gandhi Road,
Chennai, Tamilnadu, India 600119
2. Sinhgad College of Engineering,
Vadgaon (Bk), Pune 411041

M.S.Godwin Premi[2]
School of Electrical and Electronics Engineering,
Satyabhama Institute of Science and Technology
(Deemed to be University),
Jeppiaar Nagar, Rajiv Gandhi Road,
Chennai, Tamilnadu, India 600119

Suhas H. Patil[3]
Department of Computer Engineering,
Bharati Vidyapeeth (Deemed to be University),
Pune-Satara Road, Katraj,
Pune, Maharashtra, India 411043

***Abstract*—In last two decades, Wireless Sensor Network (WSN) is used for large number of Internet of Things (IoT) applications, such as military surveillance, forest fire detection, healthcare, precision agriculture and smart homes. Because of the wireless nature of communication, Wireless Sensor Network suffers from various attacks such as Denial of Service (DoS) attack and replay attack. Dealing with scalability and security issues is the challenging task in WSN. In this paper, we have presented a Lightweight Security Scheme for Cluster based Wireless Sensor Network (LSSCW). LSSCW has two phases: Initialization phase and data transfer phase. The work focuses on secured data aggregation in wireless sensor network with the help of symmetric and session key generation technique. Data from sensor nodes are securely transferred to base station. LSSCW is lightweight and satisfies security requirements including authenticity, confidentiality and integrity. The performance of LSSCW is verified using Automated Validation of Internet Security Protocols and Applications (AVISPA) tool. Results shows that LSSCW is secured and is efficient in terms of computation and communication overhead.**

Keywords*—Authentication; Automated Validation of Internet Security Protocols and Applications tool; Internet of Things (IoT); key management; security; Wireless Sensor Network (WSN)

I. Introduction

Wireless Sensor Network (WSN) is a collection of large number of sensor devices which cooperatively work with each other for monitoring the environmental conditions [1], [2]. Limited energy and limited computational capability of Sensor Nodes (SN) make the WSN critical compared to traditional networks.

Covering large geographical area needs numerous sensor nodes which introduces the scalability issue while developing the routing solutions for WSN [3].

The cluster based architecture [4], as shown in Fig. 1, able to handle the scalability issue due to distributed control of the sensor nodes in the network. Each cluster is controlled by a special node having more computational capability and energy compared to sensor nodes; referred as Cluster Head (CH). CH collects the information from the sensor nodes under its cluster, if required, aggregates the data and sends the aggregated data to the Base Station (BS). BS is the final destination node where all the sensor nodes' data is collected and used for further analytic. Large number of applications are developed based on the WSN which ranges from applications such as military/battlefield surveillance, forest fire detection, health care, precision agriculture, smart homes and smart grid [5] [6].

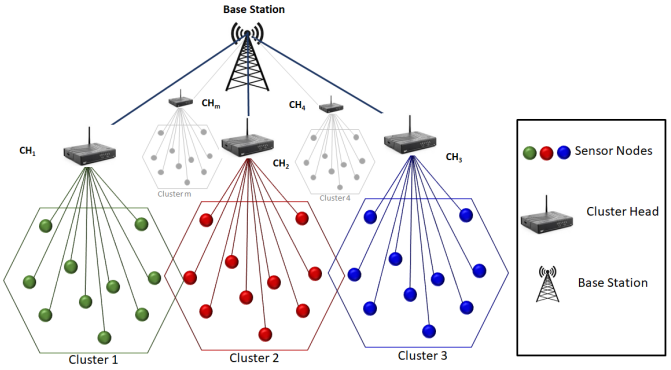


Fig. 1. Cluster based Wireless Sensor Network

Similar to computer networks, WSN faces the security concerns [7] challenging integrity, confidentiality and authenticity of nodes and data. Data stored at legitimate nodes and the data communicated over the wireless channel must be protected from the attacker. The passive attack by the attacker breaks the confidentiality of the communicating parties and the data whereas the active attack by the attacker raises the

question regarding integrity and authenticity of the messages. The intensity of these attacks varies based on the applications where the WSN is used. Thus, the security becomes critical requirement in WSN.

In this paper, we presented the security solution for cluster based WSN which satisfies security requirements including authentication of communicating parties, confidentiality and integrity of data. The network model consists of track and sector architecture [8] [9] to introduce various clusters in the network and each cluster covers number of sensor nodes. To control the sensor nodes, each cluster has two special nodes namely; Data Cluster Head (DCH) and Routing Cluster Head (RCH). DCH is responsible for collecting data from all sensor nodes under respective cluster, aggregating the data and sending the aggregated data to RCH. RCH is responsible for routing the data received from DCH to BS. Thus, the data by all sensor nodes is collected at BS. During the communication, data is securely communicated to other party using our proposed scheme. Our major contributions are as follows:

1) Communicating parties are mutually authenticated and the lightweight solution is provided for key generation between communicating parties.
2) Lightweight security scheme is proposed which provides end-to-end security and satisfies security requirements including authenticity, confidentiality and integrity.
3) The proposed scheme is simulated using Automated Validation of Internet Security Protocols and Applications(AVISPA) tool and the results show that the scheme is secured.

The paper is organized as follows. Section II presents related work. Section III presents the system model for the proposed work which covers network model, adversary model and security requirements and security goals. Section IV gives details of the proposed Lightweight Security Scheme for Cluster based Wireless Sensor Network (LSSCW). Security analysis is discussed in Section V. Security verification using AVISPA is presented in Section VI. Performance evaluation is done Section VIIfollowed by the conclusion in Section VIII.

II. Related Work

Key generation and distribution plays an important role in secured data transfer in WSN. Initially, the methods are developed for secure data transfer between communicating parties in WSN. In recent years, WSN is used for Internet of Things (IoT) applications which has introduced new methods for key generation concentrating on specific applications.

Saraswathi et al. [10] presented the multi-stage key management scheme for cluster based WSN. It has three stages including pre-deployment of required parameters, key generation and key authentication and verification. After cluster formation, each node is loaded with the predefined network key. In the key generation stage, keys are generated for sensor nodes, CH and BS using GM Encryption scheme [11]. The third stage consists of key authentication and verification between sender and receiver before sending every data message. This work has major two limitations. As all nodes are preloaded with the same network key, it becomes harmful if an attacker recognizes this key from a single node. The second limitation is communication overhead incurred for authentication of sender and receiver in the third stage. Jiang et al. [12] proposed the Rabin cryptosystem based authentication and key agreement protocol. Even though it has advantage from security perspective, it needs more computation overhead at gateway node compared to Das's protocol and Amin et al.'s protocol. Athmani et al. [13] solved the key distribution problem but not secured against replay attack and insider attack. Turkanovic et al. [14] invented the authentication scheme which is lightweight in terms of computation overhead but faces security weaknesses as per [15]–[17].

Key management in dynamic environment was also the focus of number of researchers. Vaneeta and Kumar [18] presented a key generation scheme for dynamic network of WSN. The work presents multiple layers of security using lightweight cryptography to secure the system against key-based attacks. Various key pre-distribution schemes are presented in [19]–[22]. Hu and Gharavi [19] used merkle tree for multi way handshaking during dynamic key distribution process. Choi et al. [20] used eighenvectors for securing the WSN from malicious tampering of the secret keys. Bag and Roy [21] presented the key pre-distribution scheme for general and grid-group deployment in WSN whereas Bechkit et al. [22]proposed the key distribution scheme for scalable WSN. In 2016, Pathak and Patil [23], we have presented the key distribution protocol for mobile WSN. The protocol was based on one-way hash function and exclusive-or operation.

Elliptic Curve Cryptography (ECC) was the choice of many researchers to develop the mutual authentication and key establishment protocol [15], [24]–[27]). As the ECC provides same level of security compared to traditional techniques such as RSA with reduced key size and simple computations, these protocols show better performance in terms of computation overhead. Khan et al. [28] presented ECC based mutual authentication and key establishment protocol where different classes of nodes can authenticate each other and establish the secure communication. Qin et al. [29] presented the key management scheme for scalable network where Elliptic Curve Paillier encryption [30] is used for communication and AVL tree is used to store the neighbors' ID and public key which reduces the search time. Node addition and deletion in the network was supported by the scheme. Nadir et al. [31] used ECC for generation of pairwise symmetric keys. Recently, Agarkar and Agrawal [32] presented the Password Authenticated Key Exchange by Juggling (J-PAKE) and ECC based authentication protocol for smart grid which is designed for mutual authentication and key generation between communicating parties in smart grid. Lattice cryptography based security and privacy preservation schemes are developed for smart grid network which includes key generation and secured data transfer for smart grid [33], [34]. Shen et al. [35] has introduced key generation and authentication protocol for wireless body area networks (WBANs). The protocol was developed based on ECC and message authentication code (MAC). The limitation the work is the protocol was vulnerable to replay and impersonation attack.

Wireless sensor network is used in Internet of Things applications. El-hajj et al. [36] has presented the review on various authentication schemes which are developed for IoT

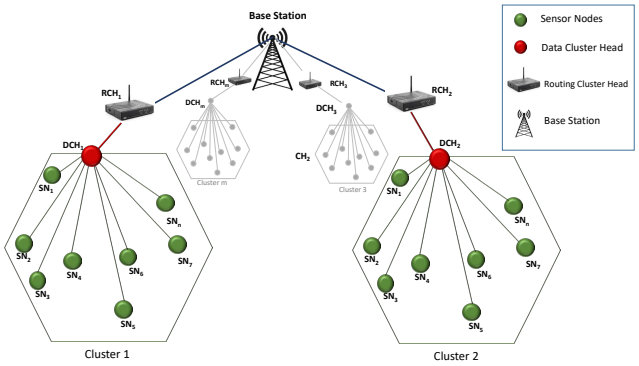


Fig. 2. Proposed Cluster based Wireless Sensor Network

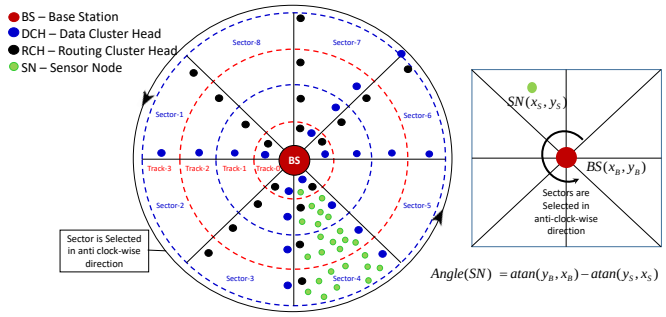


Fig. 3. Logical Track and Sector Mechanism for Cluster Formation

applications using WSN. Recently, Al-Zubaidie et al. [37] presented the user authentication scheme for health care application to protect patient's data from internal and external attackers. It uses Elliptic Curve Integrated Encryption Scheme (ECIES) and PHOTON for protecting data against malicious users. Performance of the proposed work was checked on AVISPA tool.

The above literature review indicates that the security mechanism increases both, the communication and computation overhead. The schemes which provides high security are heavy in terms of computation overheads. On the other hand, other schemes are lightweight but weak in terms of security concern and suffers from various attacks. Therefore, a lightweight solution minimizing theses overheads is an open research problem.

In this paper, we have presented the scheme consisting of key generation and secured data transfer mechanism which is lightweight in terms of computation and communication overhead.

III. System Model

System model describes about the network model, adversary model and security requirements. Finally, it lists the security goals of the proposed scheme.

A. Network Model

The network consists of large number of sensor devices arranged in a cluster based topology as shown in Fig. 2. A track and sector based mechanism ([8] [9]) is used to define clusters in the network. Fig. 3 shows an example of arrangement of sensor nodes in the clusters. Dotted circles are tracks and each track is divided into 8 sectors with each sector originating at base station. A cluster is a part of the track bounded by a sector. As the objective of the work is to develop secured data aggregation, it is assumed that the node deployment strategy shall ensure that there are at least three nodes in a cluster to facilitate sensing within the cluster, single hop/multi-hop communication between the cluster heads and base station. Each cluster has sensor nodes to sense the environmental conditions, a Data Cluster Head for data aggregation and a Routing Cluster Head to perform routing decisions.All sensor nodes are informed about DCH and RCH of their respective clusters. DCH collects the sensor data from all sensors from respective cluster and aggregates the data. The aggregated data is sent to RCH which is responsible to send the data to BS. We have divided the task of aggregation and routing to balance the energy consumption for these two nodes. Our network consists of one BS, m DCHs namely, $\{DCH_1, DCH_2, ..., DCH_m\}$, m RCHs namely, $\{RCH_1, RCH_2, ..., RCH_m\}$ and n sensor nodes under each cluster. Communication between all parties is through wireless channel. It is assumed that each sensor has its unique ID and stored in secured way.

B. Adversary Model and Security Requirements

Because of the wireless nature of communication, WSN has risks from various attacks from adversary. The probable attacks in WSN are passive and active attacks. As the part of passive attack, adversary is interested to sense the data sent on the communication network whereas in the active attack, an adversary may tamper the data and the false data is sent to the receiver. The example attacks in WSN are node compromise attack, Denial of service (DoS) attack, black hole attack, sinkhole attack, selective message forwarding attack, Man-in-the-middle (MITM) attack and replay attack. To protect the WSN from these attacks, the system model must satisfy security requirements such as confidentiality, message integrity, authenticity and availability.

C. Security Goals

Our proposed scheme achieves two major goals:

- LSSCW guarantees security of all parties during the communication. Sensors' data is securely communicated till BS and achieves integrity and confidentiality of data. The scheme also takes care about the availability of communicating parties during communication.
- LSSCW is efficient in terms of computation and communication overhead.

IV. A Lightweight Security Scheme for Cluster based Wireless Sensor Network (LSSCW)

The proposed LSSCW scheme consists of two phases: Initialization phase and data transfer phase. As the part of initialization phase, symmetric and session keys are generated between communicating parties. Once the keys are generated, the data is transferred from sensor node to base station as the part of data transfer phase. The shared symmetric keys are also

TABLE I. LIST OF SYMBOLS

Symbol	Description
BS	Base station
C_{DCH}	Cipher text computed by DCH
C_{RCH}	Cipher text computed by RCH
C_S	Cipher text computed by sensor node
DCH	Data cluster head
$h(.)$	Hash function
$\oplus$	Exclusive OR operation
$\|\|$	Concatenation operation
ID_S, ID_D, ID_R, ID_B	Identity of sensor node, DCH, RCH and BS respectively
k_{DR}	Shared key between DCH and RCH
k_{RB}	Shared key between RCH and BS
k_{SD}	Shared key between sensor node and DCH
M	Data generated at sensor node
n_B	Nonce generated by BS
n_D	Nonce generated by DCH
n_R	Nonce generated by RCH
PSW_d	Shared password between DCH nd RCH
PSW_r	Shared password between BS and RCH
PSW_s	Shared password between Sensor node and DCH
RCH	Routing cluster head
S	Sensor node
SK	Session key between DCH and BS
T_1 to T_x	Time stamp
TS_{dr}	Transaction sequence number between DCH and RCH
TS_{rb}	Transaction sequence number between RCH and BS
TS_{sd}	Transaction sequence number between sensor node and DCH
V_1 to V_4	Verification values

refreshed in this phase. Table I shows the list of symbols used in this scheme.

1) *Phase I: Initialization Phase:* Initialization phase is initiated by BS. After defining the clusters and respective DCH and RCH for each cluster, BS initiates the process of shared secret key generation. Fig. 4 shows the symmetric key generation process whereas Fig. 5 shows the session key generation process. During communication, BT_1, BT_2 are the temporary values computed by BS, RT_1, RT_2 are the temporary values computed by RCH and DT_1, DT_2, AID_D are the temporary values computed DCH.
   a) Shared symmetric key generation:
      - *Message 1(BS $\rightarrow$ RCH):* BS has the shared password with RCH which is PSW_r. BS generates the nonce n_B and computes $BT_1 = h(ID_R||PSW_r||ID_B) \oplus n_B$. BS also maintains the transaction sequence number for RCH. Consider TS_{rb} is the current transaction sequence number. Using this TS_{rb}, BS computes, $BT_2 = h(ID_R||n_B) \oplus TS_{rb}$. BS sends the message containing (BT_1, BT_2) to RCH. After receiving the message, RCH tries to find the values of the nonce generated by BS and the transaction sequence number. RCH computes $n_B = h(ID_R||PSW_r||ID_B) \oplus BT_1$ and $TS_{rb} = h(ID_R||n_B) \oplus BT_2$. Now RCH and BS computes the shared key $k_{RB} = h(BT_1||n_B||TS_{rb})$.
      - *Message 2(RCH $\rightarrow$ DCH):* RCH generates PSW_d and computes $PSW_d^* = h(ID_D||ID_R) \oplus PSW_d$. RCH maintains the record of transaction sequence number TS_{dr} for communication with DCH. RCH generates the nonce n_R and computes $RT_1 = h(ID_D||PSW_d||ID_R) \oplus n_R$ and $RT_2 = h(ID_D||n_R) \oplus TS_{dr}$. RCH sends (PSW_d^*, RT_1, RT_2) to DCH. DCH finds password as, $PSW_d = h(ID_D||ID_R) \oplus PSW_d^*$, the nonce n_R as $n_R = h(ID_D||PSW_d||ID_R) \oplus RT_1$ and transaction sequence number TS_{dr} as $TS_{dr} = h(ID_D||n_R) \oplus RT_2$. RCH and DCH computes the shared key as, $k_{DR} = h(RT_1||n_R||TS_{dr})$.
      - *Message 3 (DCH $\rightarrow$ sensor node):* DCH starts the process of key generation with sensor node. DCH generates a password PSW_s and computes, $PSW_s^* = h(ID_S||ID_D) \oplus PSW_s$. DCH generates nonce n_D and computes $DT_1 = h(ID_S||PSW_s||ID_D) \oplus n_D$. DCH maintains the sequence num-

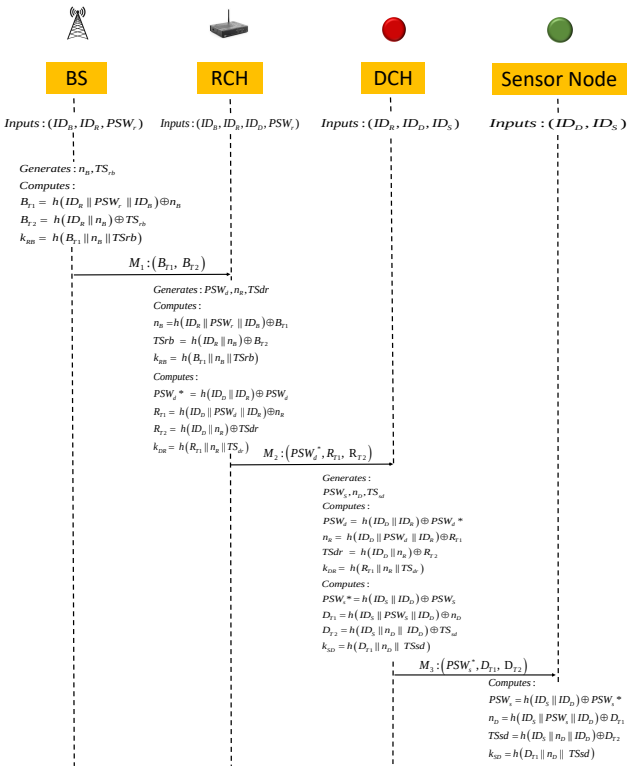


Fig. 4. Phase I: Symmetric Key Generation

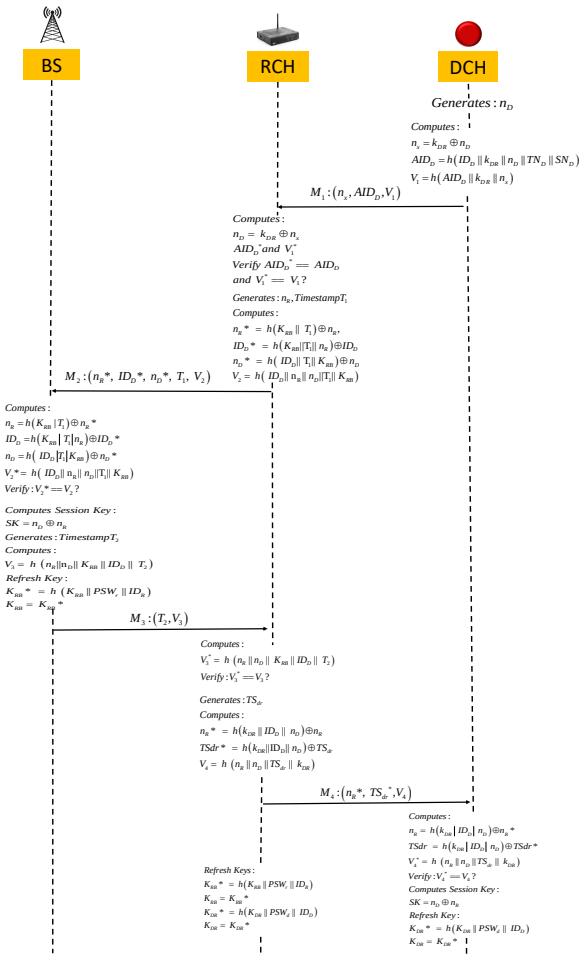


Fig. 5. Phase I: Session Key Generation

ber for each sensor node. TS_{sd} is the recent transaction sequence number for specific sensor node. DCH computes $DT_2 = h(ID_S||n_D||ID_D) \oplus TS_{sd}$. DCH sends the message containing (PSW_s^*, DT_1, DT_2) to sensor node. DCH maintains the record of shared password, nonce and transaction sequence number for each sensor node in its database.

After receiving the message, sensor node computes, $PSW_s = h(ID_S||ID_D) \oplus PSW_s^*, n_D = h(ID_S||PSW_s||ID_D) \oplus DT_1$ and $TS_{sd} = h(ID_S||n_D||ID_D) \oplus DT_2$. Now both parties computes the shared secret key as $k_{SD} = h(DT_1||n_D||TS_{sd})$. Sensor node uses k_{SD} for securely sending data to DCH during data transfer phase.

b) *Shared session key generation:* Once the pairwise keys are generated, DCH starts the process of session key generation between DCH and BS. This key helps in reducing the computation overhead during data transfer phase. The session key is generated with the help of nonce generated at DCH and RCH. Following is the process for generating the key.

- *Message 1 (DCH $\rightarrow$ RCH):* DCH generates a nonce n_D. This nonce need to be send to BS with the help of RCH in secured way. Hence, DCH computes $n_x = k_{DR} \oplus n_D$. DCH also generates the one time alias identity as $AID_D = h(ID_D||k_{DR}||n_D||TN_D||SN_D)$ and verification value $V_1 = h(AID_D||k_{DR}||n_x)$. DCH sends (AID_D, n_x, V_1) to RCH. After receiving the message, RCH finds the value of nonce as $n_D = k_{DR} \oplus n_x$. RCH computes AID_D and V_1 value at its end and compares with the received entries. If verification holds, RCH considers the n_D as the valid value.
- *Message 2 (RCH $\rightarrow$ BS):* RCH generates a nonce n_R and sends n_D and n_R values to BS in secured way. RCH computes

$$n_R^* = h(k_{RB}||T_1) \oplus n_R \quad (1)$$
$$ID_D^* = h(k_{RB}||T_1||n_R) \oplus ID_D \quad (2)$$
$$n_D^* = h(ID_D||T_1||k_{RB}) \oplus n_D \quad (3)$$
$$V_2 = h(ID_D||n_R||n_D||T_1||k_{RB}) \quad (4)$$

Where T_1 is time stamp and V_2 is the verification value which will be used at BS. RCH sends $(n_R^*, ID_D^*, n_D^*, T_1, V_2)$ to BS.

BS receives the message from RCH and finds the nonce values generated by DCH and RCH. The BS computes,

$$n_R = h(k_{RB}||T_1) \oplus n_R^* \quad (5)$$
$$ID_D = h(k_{RB}||T_1||n_R) \oplus ID_D^* \quad (6)$$
$$n_D = h(ID_D||T_1||k_{RB}) \oplus n_D^* \quad (7)$$

and verify the computed value by calculating $V_2^* = h(ID_D||n_R||n_D||T_1||k_{RB})$. If V_2^* and V_2 are same, BS considers the computed values as valid and computes the session key with DCH as,
$SK = n_D \oplus n_R$

- BS should acknowledge RCH that it has received the correct values of n_D and n_R. BS computes the verification value $V_3 = h(n_R||n_D|k_{RB}||ID_D||T_2)$ where T_2 is the time stamp and it sends (V_3, T_2) to RCH.

BS also refresh the shared key with RCH as, $k_{RB}^* = h(k_{RB}||PSW_r||ID_R)$
$k_{RB} = k_{RB}^*$

RCH receives the message from BS, computes V_3 and confirms that BS has correctly received nonce values.

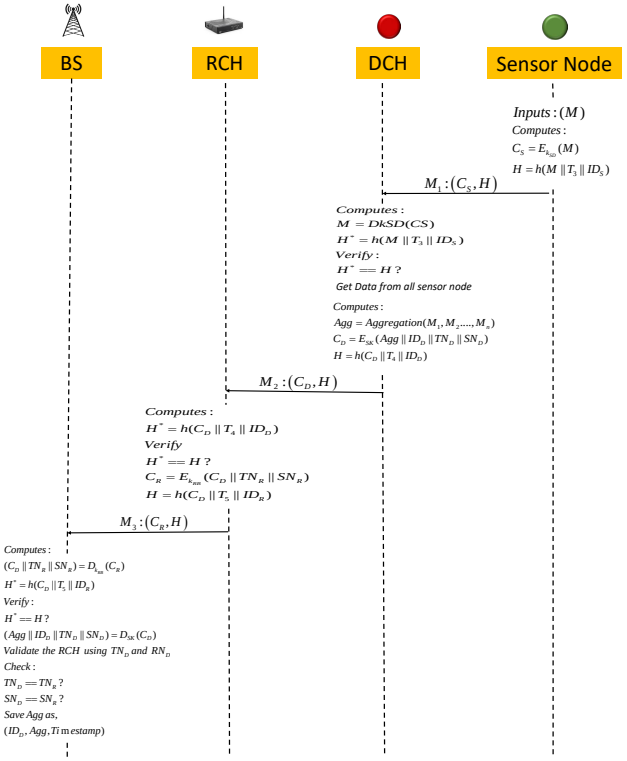


Fig. 6. Phase II: Data transfer phase

- Finally, RCH sends nonce n_R to DCH. RCH computes $n_R^* = h(k_{DR}||ID_D||n_D) \oplus n_R, TS_{dr}^* = h(k_{DR}||ID_D||n_D) \oplus TS_{dr}$ and $V_4 = h(n_R||n_D||TS_{dr}||k_{DR})$ where TS_{dr} is the current transaction sequence number. RCH sends (n_R^*, V_4, TS_{dr}^*) to DCH.
  RCH also refresh the shared keys with BS and DCH. RCH computes,
  $k_{RB}^* = h(k_{RB}||PSW_r||ID_R)$
  $k_{RB} = k_{RB}^*$
  $k_{DR}^* = h(k_{DR}||PSW_d||ID_D)$
  $k_{DR} = k_{DR}^*$
  After receiving the message, DCH computes $n_R = h(k_{DR}||ID_D||n_D) \oplus n_R^*$ and finds the new transaction sequence number as $TS_{dr} = h(k_{DR}||ID_D||n_D) \oplus TS_{dr}^*$. DCH verify these values using V_4. DCH computes the session key for communication with BS as $SK = n_D \oplus n_R$. DCH also refreshes the shared key k_{DR} with DCH as,
  $k_{DR}^* = h(k_{DR}||PSW_d||ID_D)$
  $k_{DR} = k_{DR}^*$

2) *Phase II: Data transfer phase:* Fig. 6 shows the messaging in data transfer phase. In data transfer phase sensor node senses the information and send the generated data in encrypted form to DCH. DCH decrypts the data with the shared symmetric key with respective sensor nodes, aggregates the data of all sensor nodes under its cluster. The aggregated data is encrypted using the session key between DCH and BS and forwarded to RCH. RCH again encrypts the information using its shared key with BS and finally data reaches to BS. BS performs decryption operations and recognizes the aggregated data sent by DCH. Following are the steps while sending the messages from sensor node till BS.

- *Message 1 (Sensor node $\rightarrow$ DCH):* Sensor node generates the data M. Sensor node encrypts the data using symmetric key of DCH as $C_S = E_{k_{SD}}(M)$. It also computes the hash over the data M, node's ID ID_s and time stamp T_3 as $H = h(M||T_3||ID_s)$. The encrypted data along with the hash value (C_S, H) is sent to the DCH.
  After receiving the message from sensor node, DCH decrypts the message as $M = D_{k_{SD}}(C_S)$ and check the validity using hash value H. DCH computes the hash value over the data M, node's ID ID_s and time stamp T_3. If the computed hash value and received hash value from sensor node matches, DCH saves the data M in its database.
- *Message 2 (DCH $\rightarrow$ RCH):* After collecting and decrypting data of all sensor nodes, DCH performs the aggregation operation over the received data. The aggregation function can be summation, average, finding maximum or minimum value. Choosing the aggregation function depends on the application in which the WSN is used. Consider Aggregation is the Aggregation function. DCH computes,

$$Agg = Aggregation(M_1, M_2, ..., M_n) \tag{8}$$

  Where,
  Agg is the aggregated value
  $M_1, M_2, ..., M_n$ are the data values received from sensor nodes

  The aggregated value is encrypted using the shared session key of DCH with BS. DCH performs $C_D = E_{SK}(Agg||ID_D||TN_D||SN_D)$. It also computes hash value $H = h(C_D||T_4||ID_D)$ where T_4 is the time stamp. DCH sends (C_D, H) to RCH.
- *Message 3 (RCH $\rightarrow$ BS):* RCH receives (C_D, H). RCH verifies the value of C_D by computing hash as $H^* = h(C_D||T_4||ID_D)$. If H^* and received H values matches, then RCH considers C_D as the valid value. RCH further encrypts the cipher text, C_D , using shared key between RCH and BS and finds its cipher text, $C_R = E_{k_{RB}}(C_D||TN_R||SN_R)$ and finds the hash $H = h(C_D||T_5||ID_R)$. The computed values (C_R, H) are sent to BS.
  BS receives the message and decrypts it by k_{RB} as, $(C_D, TN_R, SN_R) = D_{k_{RB}}(C_R)$.

It verifies the value of CD using received hash value. BS further decrypts C_D using session key between DCH and BS as $(Agg||ID_D||TN_D||SN_D) = E_{SK}(C_D)$. BS checks the ID of DCH from its database and confirms that the particular DCH is related to track number TN_D and SN_D. BS also checks the received track number and sector number of DCH and RCH are same. If track number of DCH, TN_D, is same as track number of RCH, TN_R, and the sector number of DCH, SN_D, is same as the sector number of RCH, SN_R then BS confirms that it has received valid aggregated value from legitimate DCH with ID_D. BS saves Agg value received from DCH in its database as $(ID_D, Agg, Timestamp)$ and can further use it for analytic purpose.

V. Security Analysis

Security analysis demonstrates that the proposed scheme preserves the privacy to individual sensor data and holds security properties which are necessary during the communication in WSN.

1) *Privacy Preservation:* In the proposed scheme, individual sensor's data is sent only to the respective DCH. DCH aggregates data from all sensor nodes and then send the aggregated data towards BS. Thus individual sensor's data is not available to RCH and BS. It helps in preserving the privacy of the sensor's data and reduces the possibility of hacking individual sensor's record.
2) *Confidentiality:* In data transfer phase, all the messages are encrypted using respective keys. Sensor node encrypts the data using shared key with DCH, k_{SD}. DCH uses the session key, SK, for encrypting the data whereas RCH uses the shared secret key between RCH and BS. Thus all messages are securely communicated to receiver nodes.
3) *Mutual Authentication:* In the proposed scheme, no third party is involved during key generation process. All the keys are generated mutually within the communicating parties. During pairwise key generation process, verification of the message is done using the hash values based on ID, password and Transaction sequence number. As the part of session key generation between DCH and BS, the one-time identity value, AID_D and the verification values V_1 to V_4 helps in verification of the messages at receiver end. During data transfer phase, the data is encrypted using respective keys and receiver authenticates the received data based on the shared key, ID and time stamp.
4) *Fair Key Agreement:* In fair key agreement scheme, each participant contribute to generate the session key. It ensures that not an individual party has unfair advantage to control the session key. In the proposed scheme, the session key between DCH and BS is generated with the help of nonce generated by DCH and RCH. DCH generates the nonce nD and RCH generates the nonce n_R. The session key is computed by DCH and BS as $SK = n_D \oplus n_R$. Thus DCH and RCH has fair involvement in the process of session key generation.
5) *Data Integrity:* In the key generation process, the nonce and transaction sequence numbers are sent to the receiver node. Integrity of the received nonce and transaction sequence numbers are verified based on ID and passwords between sender and receiver node. As the part of data transfer phase, DCH computes the cipher text CD by encrypting the sensed data M using session key between DCH and BS. It also computes hash over the cipher text CD, Time stamp and ID of DCH. RCH use this hash value to check the integrity of the C_D at its end. When RCH forwards the C_D to BS, the verification of the message is done based on hash over ID of RCH and Time stamp.
6) *Data Freshness:* Data freshness ensures that the data received by the receiver is the fresh and not the old one. It helps in resisting the replay attack. As the part of replay attack the attacker can resend the messages number of times. The proposed scheme takes care about verification of the data freshness using transaction sequence number and time stamp during message transfers. As the part of key generation phase, the transaction sequence number helps in ensuring the data freshness. During data transfer phase, the time stamp is involved in message transfer which helps in checking the freshness of data.

VI. Security Verification using AVISPA

The proposed scheme contains initialization phase and data transfer phase. Initialization phase consists of messages which are required for generation of symmetric keys between different parties and session key is also generated generated between DCH and RCH. Data transfer phase is designed for sending actual data from sensor node till base station in secured way. We have simulated the initialization phase using Automated Validation of Internet Security Protocols and Applications (AVISPA) tool. AVISPA is designed for simulation of authentication protocols and is the standard tool referred by number of researchers. It gives the information regarding whether the designed protocol is safe and gives the time requirement for execution of the protocol. AVISPA has back end analyzers for verification of the protocol. We have verified the security of our proposed scheme using On-the-fly Model-Checker (OFMC) and Constraint-Logic-based Attack Searcher (CL-AtSe) analysers under AVISPA. OFMC employs several symbolic techniques to explore the state space in a demand-driven way where as CL-AtSe applies constraint solving with simplification heuristics and redundancy elimination techniques. AVISPA provides High Level Protocol Specification Language (HLPSL) for designing the code. We have developed the code for symmetric key generation and session key generation processes of the initialization phase.

A. Symmetric Key Generation using AVISPA

Base station, RCH, DCH and sensor node are involved in generation of symmetric keys. Pairwise keys are generated between consecutive parties. Fig. 7, Fig. 8, Fig. 9 and Fig. 10

```
%Symmetric Key geneartion: Role of Base Station (BS)
role basestation(R,B            :agent,
          PSWr                  :text,
          Hsh                   :hash_func,
   Snd,Rcv                      :channel(dy))
played_by B
def=
local State                     :nat,
TSrb,NB,BT1,BT2                 :text,
KRB                             :symmetric_key
%constants
const sec_K_RB                  :protocol_id
init State :=0
transition
1. State=0          /\ Rcv(start)  =|>
  State' :=1        /\ NB' := new()
                    /\ BT1' := xor(Hsh(R.PSWr.B),NB')
                    /\ BT2' := xor(Hsh(R.NB'),TSrb)
                    /\ KRB' := Hsh(BT1'.NB'.TSrb)
                    /\ Snd(B.BT1'.BT2'.R)
                    /\ witness(B,R,k_br, KRB')
                    /\ secret(KRB', sec_K_RB,{B,R})
end role
```

Fig. 7. Symmetric key generation: Role specification of Base Station in HLPSL

```
%Symmetric Key generation: Role of Routing Cluster Head (RCH)
role rch(  D,R,B                :agent,
           PSWr                 :text,
           Hsh                  : hash_func,
           Snd,Rcv              :channel(dy))
played_by R
def=
local State                     :nat,
PSWd,TSdr,NR                    :text,
NB,TSrb,RT1,RT2,BT1,BT2         :text,
PSWdT                           : text,
KRB, KDR                        :symmetric_key
const sec_K_DR                  :protocol_id
init State :=0
transition
1. State=0          /\ Rcv(B.BT1'.BT2'.R)=|>
  State':=1         /\ NB':= xor(Hsh(R.PSWr.B),BT1') /\ TSrb' := xor(Hsh(R.NB'),BT2')
                    /\ KRB' := Hsh(BT1.NB'.TSrb')  /\ PSWd' := new()
                    /\ PSWdT' := xor(Hsh(D.R),PSWd) /\ NR' := new()
                    /\ RT1' := xor(Hsh(D.PSWd.R),NR')  /\ TSdr' := new()
                    /\ RT2' := xor(Hsh(D.NR'), TSdr') /\ KDR' := Hsh(RT1'.NR'.TSdr')
                    /\ Snd(R.PSWdT'.RT1'.RT2'.D) /\ witness(R,D,k_rd, KDR')
                    /\ secret(KDR', sec_K_DR,{R,D})
end role
```

Fig. 8. Symmetric key generation: Role specification of Routing Cluster Head in HLPSL

```
%Symmetric Key generation: Role of Data Cluster Head (DCH)

role dch(  S,D,R                :agent,
           Hsh                  : hash_func,
           Snd,Rcv  :channel(dy))
played_by D
def=
local State                     :nat,
PSWs,ND,TSsd                    :text,
PSWd,PSWdT,NR,TSdr              :text,
PSWsT, DT1, DT2, RT1, RT2       :text,
KDR, KSD:symmetric_key
const sec_K_SD                  :protocol_id
init State :=0
transition
1. State=0          /\ Rcv(R.PSWdT'.RT1'.RT2'.D) =|>
  State':=1         /\ PSWd' := xor(Hsh(D.R),PSWdT') /\ NR' := xor(Hsh(D.PSWd'.R),RT1')
                    /\ TSdr' := xor(Hsh(D.NR'), RT2') /\ KDR' := Hsh(RT1'.NR'.TSdr')
                    /\PSWs' := new()    /\ PSWsT' := xor(Hsh(S.D),PSWs')
                    /\ ND' := new()     /\ DT1' := xor(Hsh(S.PSWs.D),ND')
                    /\ TSsd' := new()   /\ DT2' := xor(Hsh(S.ND'.D),TSsd')
                    /\ KSD' := Hsh(DT1'.ND'.TSsd') /\ Snd(D.PSWsT'.DT1'.DT2'.S)
                    /\ witness(D,S, k_ds, KSD')    /\ secret(KSD', sec_K_SD,{D,S})
end role
```

Fig. 9. Symmetric key generation: Role specification of Data Cluster Head in HLPSL

```
%Symmetric Key geneartion: Role of Sensor node
role sensornode(S,D  :agent,
          Hsh        : hash_func,
          Snd,Rcv    :channel(dy))
played_by S
def=
local State             :nat,
PSWsT, PSWs, ND, TSsd, DT1, DT2:text,
KSD                     :symmetric_key
const sec_K_DS  :protocol_id
init State :=0
transition
1. State=0          /\ Rcv(D.PSWsT'.DT1'.DT2'.S)=|>
 State':=1          /\ PSWs' := xor(Hsh(S.D),PSWsT')
                    /\ ND' := xor(Hsh(S.PSWs'.D),DT1')
                    /\ TSsd' := xor(Hsh(S.ND'.D),DT2')
                    /\ KSD' := Hsh(DT1'.ND'.TSsd')
end role
```

Fig. 10. Symmetric key generation: Role specification of Sensor Node in HLPSL

```
role session(S,D,R,B            :agent,
             PSWr               :text,
             Hsh                : hash_func)
def=
%send, receive channels for all parties
local SB,RB, SR,RR,SD,RD,SS,RS: channel(dy)
composition
basestation(R,B, PSWr,Hsh,SB,RB) /\
rch(D,R,B,PSWr, Hsh, SR, RR) /\
dch(S,D,R,Hsh, SD, RD) /\
sensornode(S,D,Hsh, SS, RS)
end role
%-------------------------------------------------------
role environment() def=
          const k_br,k_rb, k_rd, k_dr,k_ds, k_sd :
protocol_id,
          s,d,r,b               :agent,
          krb,kdr,ksd           :symmetric_key,
          pswr                  :text,
          hsh                   :hash_func
intruder_knowledge = {s,d,r,b}
composition
session(s,d,r,b,pswr,hsh)
end role
```

```
goal
secrecy_of sec_K_RB,sec_K_DR, sec_K_SD
%secrecy_of KRB, KDR, KSD
%authentication
authentication_on k_rb
authentication_on k_dr
authentication_on k_sd
authentication_on k_br
authentication_on k_rd
authentication_on k_ds
end goal
%-------------------------------------------------------
environment()
```

Fig. 11. Symmetric key generation: Specification of session, environment and goal in HLPSL

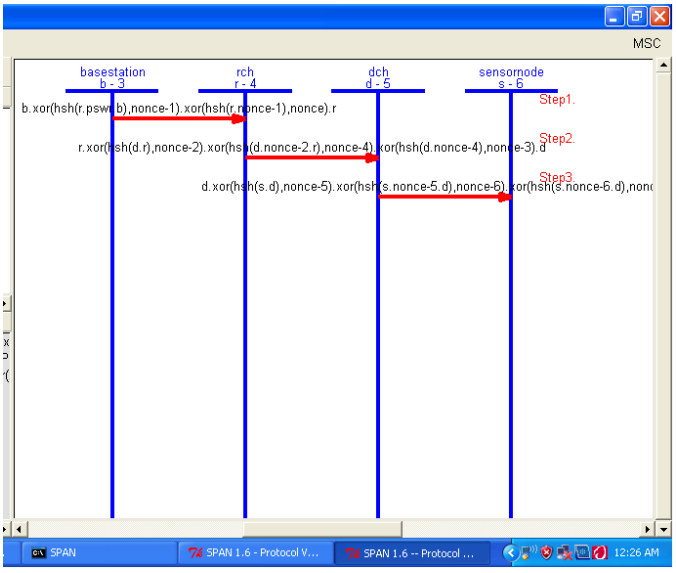


Fig. 12. Symmetric key generation: Simulation

shows the roles specified by BS, RCH, DCH and sensor node,

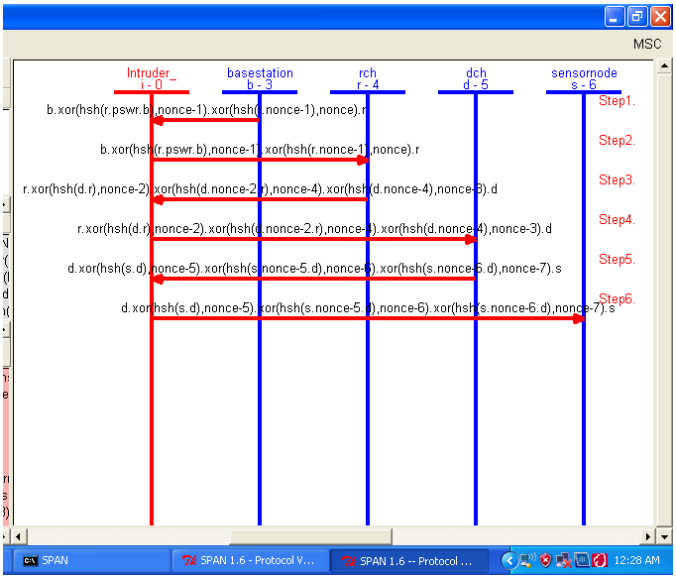


Fig. 13. Symmetric key generation: Intruder simulation

```
% OFMC
% Version of 2006/02/13
SUMMARY
  SAFE
DETAILS
  BOUNDED_NUMBER_OF_SESSIONS
PROTOCOL
  C:\progra~1\SPAN\testsuite\results\Symmetric.if
GOAL
  as_specified
BACKEND
  OFMC
COMMENTS
STATISTICS
  parseTime: 0.00s
  searchTime: 0.14s
  visitedNodes: 5 nodes
  depth: 4 plies
```

(a)

```
SUMMARY
  SAFE

DETAILS
  BOUNDED_NUMBER_OF_SESSIONS
  TYPED_MODEL

PROTOCOL
  C:\progra~1\SPAN\testsuite\results\Symmetric.if

GOAL
  As Specified

BACKEND
  CL-AtSe

STATISTICS

  Analysed   : 6 states
  Reachable  : 3 states
  Translation: 0.03 seconds
  Computation: 0.01 seconds
```

(b)

Fig. 14. Simulation results of Symmetric key generation: (a) OFMC model, (b) CL-AtSe model

respectively. Each node works in state cycle and when an event occurs, the specified action is done by respective party. Fig. 11 defines the specification of session, environment and goal in HLPSL code.

The symmetric key generation process is simulated using AVISPA. Fig. 12 shows the simulation of the messages sent between the communicating parties. Fig. 13 shows the intruder simulation. Fig. 14 shows the output of OFMC and CL-AtSe model which gives the result as the designed work is secured.

B. Session Key Generation using AVISPA

Session key is generated between DCH and BS with the help of RCH. The session key is generated using the random numbers generated by DCH and RCH. During communication, BS checks the authenticity of DCH using track and secor numbers of DCH and RCH. Fig. 15 shows the roles specified by DCH and RCH. Fig. 16 shows the role of BS and session, environment and goal sections of HLPSL code. Fig. 17 shows the simulation results of Session key generation by OFMC model and CL-AtSe model.

```
% Session Key Generation: Role of Data Cluster Head (DCH)
role dch(D,R:agent,
         Hsh : hash_func,
         KDR,KSD:symmetric_key,
         TND,SND,PSWd  :text,
       Snd,Rcv  :channel(dy))
played_by D
def=
local State                :nat,
ND,NX,AIDD,V1,V4T                  :text,
NRT,V4,TSDRT,NR,TSDR,VRT,KDRT :text,
SK : symmetric_key
const sec_K_DR             :protocol_id
init State :=0
transition
1. State=0          /\ Rcv(start) =|>
  State':=1         /\ ND' := new() /\ NX' := xor(KDR,ND')
                    /\ AIDD' := Hsh(D.KDR.ND'.TND.SND)
                    /\ V1' := Hsh(AIDD'.KDR.NX')
                    /\ Snd(D.NX'.AIDD'.V1'.R)
1. State=1          /\ Rcv(R.NRT'.TSDRT'.V4'.D)  =|>
  State':=2         /\ NR' := xor(Hsh(KDR.D.ND),NRT')
                    /\ TSDR' := xor(Hsh(KDR.D.ND),TSDRT')
                    /\ V4T' := Hsh(NR'.ND.TSDR'.KDR) %
verify
                    /\ SK' := xor(ND.NR')
                    /\ KDR' := Hsh(KDR.PSWd.D)

end role
```

(a)

```
% Session Key Generation: Role of Routing Cluster Head (RCH)

role rch(D,R,B  :agent,
 TND,SND,TNR,SNR,PSWr,PSWd:text,
       Hsh  : hash_func, KRB,KDR:symmetric_key,
   Snd,Rcv              :channel(dy))
played_by R
def=
local State             :nat,
ND,AIDD,V1,NR
          :text,
NX,AIDDT,V1T,T1,NRT,IDDT,V2                  :text,
V3,V3T,T2,KRBT,TSDRT,TSDR,V4,NDT,KDRT        :text
const sec_K_RB,sec_K_RD  :protocol_id
init State :=0
transition
1. State=0  /\  Rcv(D.NX'.AIDD'.V1'.R) =|>
  State':=1 /\ ND' := xor(KDR,NX') /\ AIDDT' := Hsh(D.KDR.ND'.TND.SND)
            /\ V1T' := Hsh(AIDD'.KDR.NX')  /\ NR' := new()
            /\ T1' := new()          /\ NRT' := xor(Hsh(KRB.T1'),NR')
            /\ IDDT' := xor(Hsh(KRB.T1'.NR'),D)
            /\ NDT' := xor(Hsh(D.T1'.KRB),ND')
            /\ V2' := Hsh(D.NR'.ND'.T1'.KRB)
            /\ Snd(R.NRT'.IDDT'.NDT'.T1'.V2'.B)
1. State=1 /\ Rcv(B.T2'.V3'.R) =|>
  State':=2/\ V3T' := Hsh(NR.ND.KRB.D.T2') /\ KRB' := Hsh(KRB.PSWr.R)
            /\ NRT':= xor(Hsh(KDR.D.ND),NR)/\ TSDR' := new()
            /\ TSDRT' := xor(Hsh(KDR.D.ND),TSDR')
            /\ V4' := Hsh(NR.ND.TSDR'.KDR)
            /\ KDR' := Hsh(KDR.PSWd.D)   /\ Snd(R.NRT'.TSDRT'.V4'.D)
end role
```

(b)

Fig. 15. Session key generation: Role specification of in HLPSL (a)Data Cluster Head (b)Routing Cluster Head

```
%Session Key Genearation: Role of Base Station
role basestation(R,B  :agent,
                 PSWr      :text,
                 Hsh       : hash_func,
                 KRB       :symmetric_key,
                 Snd,Rcv              :channel(dy))
played_by B
def=
local State:nat,
NR,NRT,IDDT,NDT,V2                   :text,
T1,IDD,ND,V2T,T2,V3,KRBT      :text,
SK:symmetric_key
const sec_K_BR                       :protocol_id
init State :=0
transition
1. State=0          /\ Rcv(R.NRT'.IDDT'.NDT'.T1'.V2'.B)  =|>
  State' :=1        /\ NR' := xor(Hsh(KRB.T1'),NRT')
                    /\ IDD' := xor(Hsh(KRB.T1'.NR'),IDDT')
                    /\ ND' := xor(Hsh(IDD'.T1'.KRB),NDT')
                    /\ V2T' := Hsh(IDD'.NR'.ND'.T1'.KRB)
                    /\ SK' := xor(ND',NR') /\ T2' := new()
                    /\ V3' := Hsh(NR'.ND'.KRB.IDD'.T2')
                    /\ KRB' := Hsh(KRB.PSWr.R)
                    /\ Snd(B.T2'.V3'.R)
end role
```

(a)

```
role session(D,R,B:agent
   TND,SND,TNR,SNR,PSWd,PSWr  :text,
    KDR,KSD,KRB: symmetric_key,
    Hsh       : hash_func)
def=
local SB,RB,SR,RR,SD,RD          : channel(dy)
composition
dch(D,R,Hsh,KDR,KSD,TND,SND,PSWd,SD,RD) /\
rch(D,R,B,TND,SND,TNR,SNR,PSWr,PSWd,Hsh,KRB,KDR,SR,RR) /\
basestation(R,B, PSWr,Hsh,KRB, SB,RB)
end role
%-----------------------------------------------------------------
role environment() def=
        const k_br,k_dr, k_rb, k_rd      :protocol_id,
        d,r,b:agent,
        kdr,ksd,krb :symmetric_key,
        tnd,snd,tnr,snr,pswd,pswr:text,
        hsh  :hash_func
intruder_knowledge = {d,r,b}
composition
session(d,r,b,tnd,snd,tnr,snr,pswd,pswr,kdr,ksd,krb,hsh)
end role
%-----------------------------------------------------------------
goal
secrecy_of sec_K_BR,sec_K_DR,sec_K_RB,sec_K_RD
authentication_on k_br
authentication_on k_rb
authentication_on k_dr
authentication_on k_rd
end goal
%-----------------------------------------------------------------
environment()
```

(b)

Fig. 16. Session key generation: Role specification of in HLPSL (a)Base Station (b)Session, Goal and Environment

```
% OFMC
% Version of 2006/02/13
SUMMARY
  SAFE
DETAILS
  BOUNDED_NUMBER_OF_SESSIONS
PROTOCOL

C:\progra~1\SPAN\testsuite\results\Session.if
GOAL
  as_specified
BACKEND
  OFMC
COMMENTS
STATISTICS
  parseTime: 0.00s
  searchTime: 0.10s
  visitedNodes: 10 nodes
  depth: 3 plies
```

(a)

```
SUMMARY
  SAFE

DETAILS
  BOUNDED_NUMBER_OF_SESSIONS
  TYPED_MODEL

PROTOCOL
  C:\progra~1\SPAN\testsuite\results\Session.if

GOAL
  As Specified

BACKEND
  CL-AtSe

STATISTICS

  Analysed   : 1 states
  Reachable  : 1 states
  Translation: 0.03 seconds
  Computation: 0.00 seconds
```

(b)

Fig. 17. Simulation results of Session key generation: (a) OFMC model, (b) CL-AtSe model

TABLE II. SYMMETRIC KEY GENERATION: COMPUTATION OVERHEAD AT BS, RCH, DCH AND SENSOR NODE

Message	BS	RCH	DCH	Sensor Node
Message 1	$3T_H + 2T_X$	$3T_H + 2T_X$		
Message 2		$4T_H + 3T_X$	$4T_H + 3T_X$	
Message 3			$4T_H + 3T_X$	$4T_H + 3T_X$
Total	$3T_H + 2T_X$	$7T_H + 5T_X$	$8T_H + 6T_X$	$4T_H + 3T_X$

TABLE III. SESSION KEY GENERATION: COMPUTATION OVERHEAD AT BS, RCH AND DCH

Message	BS	RCH	DCH
Message 1		$2T_H + T_X$	$2T_H + T_X$
Message 2	$4T_H + 3T_X$	$4T_H + 3T_X$	
Message 3	T_H	T_H	
Message 4		$3T_H + 2T_X$	$3T_H + 2T_X$
Session key computation	T_X	T_X	
Key freshness	T_H	$2T_H$	T_H
Total	$6T_H + 4T_X$	$12T_H + 7T_X$	$6T_H + 3T_X$

TABLE IV. DATA TRANSFER PHASE: COMPUTATION OVERHEAD AT BS, RCH, DCH AND SENSOR NODE

Message	BS	RCH	DCH	Sensor Node
Message 1			$T_D + T_H$	$T_E + T_H$
Message 2		T_H	$T_{Agg} + T_E + T_H$	
Message 3	$2T_D + T_H$	$T_E + T_H$		
Total	$2T_D + T_H$	$T_E + 2T_H$	$T_{Agg} + T_E + T_D + 2T_H$	$T_E + T_H$

TABLE V. MAKA: COMPUTATION OVERHEAD

Phase	BS	CH	CM
Initialization	$1T_{SM}$		
Key generation		$1T_{HG} + 1T_{SM}$	$1T_{HG} + 1T_{SM}$
Node Registration	$mT_{AD} + mT_{SM} + n\,(1T_{SM})$	$1T_{AE}$	-
Authentication		$3T_{SM} + 1T_{AE} + 1T_{AD}$	$3T_{SM} + 1T_{AE} + 1T_{AD}$
CM $\leftrightarrow$ CH			
Authentication	$1T_{AD} + 1T_{SM}$		
CH $\leftrightarrow$ BS			
Session key agreement	$1T_P$	-	$1T_P$

VII. PERFORMANCE EVALUATION

The aim of the proposed LSSCW scheme is to provide the security for data transfer in the cluster based WSN and at the same time the scheme should be lightweight in terms of communication and computation overhead. Communication overhead is related to the number of message transfers in the network whereas computation overhead deals with the time required for execution of the scheme.

1) Communication Overhead: In LSSCW, number of message transfers takes place during shared symmetric key generation phase, session key generation phase and data transfer phase. The network contains n sensor nodes, m DCH and m RCH nodes. Symmetric key generation process requires $2m + n$ message transfers and session key generation needs $4m$ messages to generate session keys for each DCH. During data transfer phase, each sensor node periodically send the data to DCH. After aggregation process at DCH, only 2 messages per DCH are required to send the data till BS.
2) Computation Overhead: LSSCW uses hash and exclusive OR operations for symmetric key and session key generation. During the data transfer, the data is encrypted using shared symmetric and session keys. Consider the time required for hash function is T_H, time required for Exclusive OR operation is T_X, Time required for encryption is T_E and time required for decryption is T_D. Time required by DCH for aggregation operation is T_{Agg}. Table II shows the number of operations required at each node during symmetric key generation. Table III shows number of operations required for session key generation. Data transfer phase requirement is defined in Table IV. To define the total computation cost, we neglect Exclusive OR operation as the time requirement for Exclusive OR operation is very very small. Considering the network contains one BS, m RCH, m DCH and n sensor nodes, Computation cost for symmetric key generation phase is $(14m + 8n)T_H$ and session key generation phase is $(20m)T_H$.

A. Comparative Analysis

In this section we presented the comparative analysis of the proposed work with Mutual Authentication and Key Agreement (MAKA) scheme presented by Harbi et al. [38] in the year 2019 and few other authentication and key agreement schemes. For comparison, we have considered the operations related to key generation process of LSSCW. MAKA defines the cluster based network model consisting of BS, CH and Cluster Members (CMs) which are sensor nodes. MAKA has five phases: initialization, key generation, node registration, node authentication, and session key agreement. Following are the notations used for basic operations performed in MAKA.

- T_{HG}: Time for hash function on G
- T_{SM}: Time for ECC scalar multiplication
- T_{PA} : Time for ECC point addition
- T_{AE}: Time for asymmetric encryption
- T_{AD}: Time for asymmetric decryption
- T_P: Time for pairing on G
- m: Number of cluster heads in the network
- n: Number of cluster members in the network

TABLE VI. COMPARISON OF MAKA AND LSSCW

Scenario 1			Scenario 2		
Sensor nodes	MAKA	LSSCW	CH	MAKA	LSSCW
10	473.735	0.2622	1	473.735	0.2622
20	902.445	0.4462	2	947.47	0.5244
30	1331.155	0.6302	3	1421.205	0.7866
40	1759.865	0.8142	4	1894.94	1.0488
50	2188.575	0.9982	5	2368.675	1.311
60	2617.285	1.1822	6	2842.41	1.5732
70	3045.995	1.3662	7	3316.145	1.8354
80	3474.705	1.5502	8	3789.88	2.0976
90	3903.415	1.7342	9	4263.615	2.3598
100	4332.125	1.9182	10	4737.35	2.622

We have computed the number of operations performed in each phase. Table V shows the number of operations performed for MAKA scheme. During initialization phase BS generates the public key and sends to all other nodes. As the part of key generation phase, (public key, private key) pairs are generated for each CMs. Node registration phase is responsible for registering CHs and CMs at BS end. In the table, we have defined total cost for node registration considering m CHs and n CMs. Authentication phase is designed for mutual authentication between CM and CH, CH and BS. Finally, session key is generated at BS and CM end.

Considering the network contains one BS, m CHs and n CMs, the computation cost related to BS is $2m\,(T_{AD} + T_{SM}) + n\,(T_{SM} + T_P)$, total computation cost related to m CHs is $m\,(T_{HG} + 4T_{SM} + 2T_{AE} + T_{AD})$ and the cost related to sensor n nodes is $n\,(T_{HG} + 4T_{SM} + T_{AE} + T_{AD} + T_P)$. Thus the total cost for the MAKA scheme is $(m+n)T_{HG} + (6m+5n)T_{SM} + (2m+n)T_{AE} + (3m+n)T_{AD} + 2nT_P$.

To compare the computation time between MAKA and LSSCW, we exploited the time requirement for each basic operation presented in Kilinc and Yanik [39]. Thus, time required for one-way hash function T_H = 0.0023 ms, symmetric key encryption / decryption = T_E = T_D = 0.0046 ms, hash function on group G T_{HG} = 12.419 ms, ECC scalar multiplication T_{SM} = 2.226 ms, ECC point addition T_{PA} = 0.0288 ms, asymmetric encryption/decryption T_{AE} = T_{AD} = 3.85 ms, pairing on G T_P = 5.811 ms and MAC T_{MAC} = 0.0046 ms.

Two scenarios are considered for comparison between MAKA and LSSCW. In the first scenario, the network contains one BS, one cluster and number of sensor nodes varies from 10 to 100. In the second scenario, the network contains one BS, number of clusters vary from 1 to 10 where each cluster contains 10 sensor nodes each. Table VI shows the computation time of Scenario 1 and Scenario 2 for LSSCW and MAKA. The results in the Table VI indicates that LSSCW is very lightweight compared to MAKA as the average computation overhead is lesser by approximately 30%.

Fig. 18 shows the logarithmic graph of comparative computation cost of LSSCW and other authentication and key agreement schemes. Table VII summarises the computation costs

TABLE VII. COMPUTATION COST COMPARISON

Sr. No.	Scheme	Computation cost	Time (in ms)
1	LSSCW	$22T_H + 24T_H$	0.1058
2	[38]	$6T_{SM} + 5T_{AE/AD} + 3T_P$	50.039
3	[40]	$3T_{HG} + 7T_{SM} + 2T_{PA} + 2T_P$	64.5186
4	[41]	$10T_H$	0.023
5	[42]	$18T_H$	0.0414
6	[16]	$22T_H$	0.0506
7	[17]	$26T_H$	0.0598
8	[43]	$19T_H + 2T_{SM}$	4.4957
9	[44]	$10T_H + 2T_{SM}$	4.475
10	[45]	$17T_H + 2T_{SM}$	4.4911
11	[35]	$2T_{HG} + 21T_{SM} + 11T_{PA}$ $+2T_E + 4T_H + 6T_{MAC}$	71.9468

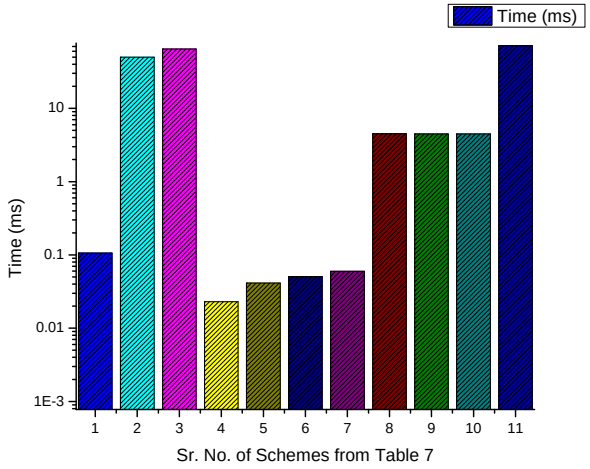


Fig. 18. Computation cost comparison

related to the LSSCW scheme and other schemes presented in [16], [17], [35], [38], [40]–[45]. LSSCW is more efficient than [35], [38], [40], [43]–[45] in terms of time requirement. The LSSCW performance is 0.1058 ms which is far better than the performance of [44] which is 4.475 ms.

Compared to [16], [17], [41], [42], LSSCW requires few additional hash operations for session key generation process. The session key is used in the data transfer phase for secure transfer and verification of data between DCH and BS. Hence, even though LSSCW requires few additional hash operations, it provides end-to-end security to the transferred data. LSSCW session key helps in sender authentication and protection against Man-in-the-middle attack. The schemes presented in [16], [17], [41], [42] do not use session key thereby providing a less secure environment compared to LSSCW for data communication in WSN.

VIII. CONCLUSION

Wireless sensor network needs solutions for securing data during communication while handling large number of sensor

nodes. In this paper, we have proposed a security framework which covers details of cluster management, key generation and secured data transfer. The lightweight solution for security based on hash and exor makes the proposed work suitable for WSN. Security analysis is done using AVISPA tool which proves that the proposed work is secured and is efficient in terms of time requirement.

The analysis shows that LSSCW is approximately 30% better computation time requirement compared to MAKA. Though the computation time for LSSCW is greater than few protocols in the literature, its session key mechanism provides security against MITM attack. For the session key based protocols in the literature, it is observed that the LSSCW scheme offers a better performance in terms of computation cost.

As the part of future work, we expect to evaluate the performance of the proposed scheme on actual hardware devices. Based on the experimentation, we will examine the effectiveness of the scheme for various applications.

REFERENCES

[1] K. Sohraby, D. Minoli, and T. Znati, "Wireless sensor networks: technology, protocols, and applications," *John Wiley & Sons*, pp. 203–209. ISBN 978-0-471-74300-2.

[2] W. Dargie, and C. Poellabauer, "Fundamentals of wireless sensor networks: theory and practice," *John Wiley & Sons*, pp. 168–183, 191–192, 2010, ISBN 978-0-470-99765-9.

[3] M. S. Karyakarte, A. S. Tavildar, and R. Khanna, "Dynamic node deployment and cross layer opportunistic robust routing for PoI coverage using WSNs," *Wireless Personal Communications*, Vol. 96, No. 2, 2741-2759,2017.

[4] C. Wei, J. Yang, Y. Gao, and Z. Zhang, "Cluster-based routing protocols in wireless sensor networks: A survey," *In Proceedings of 2011 International Conference on Computer Science and Network Technology*, Vol. 3, pp. 1659–1663, December 2011, IEEE.

[5] C. F. García-Hernández, P. H. Ibarguengoytia-Gonzalez, J. García-Hernández, and J. A. Pérez-Díaz, "Wireless sensor networks and applications: a survey," *IJCSNS International Journal of Computer Science and Network Security*, Vol. 7, No. 3, pp. 264-273, 2007.

[6] L. Atzori, A. Iera, and G. Morabito, "The internet of things: A survey," *Computer networks*, Vol. 54, No. 15, pp. 2787–2805, 2010

[7] A. S. K. Pathan, H. W. Lee, and C. S. Hong,"Security in wireless sensor networks: issues and challenges," *In 2006 8th International Conference Advanced Communication Technology*, Vol. 2, pp. 6-pp, IEEE, 2006

[8] N. Gautam, W. I. Lee, and J. Y. Pyun, "Track-sector clustering for energy efficient routing in wireless sensor networks," *In 2009 Ninth IEEE international conference on computer and information technology*, Vol. 2, pp. 116–121, IEEE, October 2009.

[9] S. M. Jung, Y. J. Han, and T. M. Chung, "The concentric clustering scheme for efficient energy consumption in the PEGASIS," *In The 9th international conference on advanced communication technology*, Vol. 1, pp. 260–265, IEEE, February 2007.

[10] R.V.Saraswathi, L. P. Sree, and K. Anuradha, "Multi-stage Key Management Scheme for Cluster based WSN,", *International Journal of Communication Networks and Information Security*, Vol. 10, No. 3, pp. 552, 2018.

[11] X. Yi, R. Paulet, and E. Bertino, "Homomorphic encryption and applications," *Springer Briefs in Computer Science*, Vol. 3, Cham: Springer, 2014.

[12] Q. Jiang, S. Zeadally, J. Ma, and D. He, "Lightweight three-factor authentication and key agreement protocol for internet-integrated wireless sensor networks," *IEEE Access*, Vol. 5, pp.3376–3392, 2017.

[13] S. Athmani,A. Bilami, and D. E. Boubiche,"EDAK: An efficient dynamic authentication and key management mechanism for heterogeneous WSNs," *Future Generation Computer Systems*, Vol. 92, pp.789–799, 2019.

[14] M. Turkanovic, B. Brumen, and M. Hölbl, "A novel user authentication and key agreement scheme for heterogeneous ad hoc wireless sensor networks based on the Internet of Things notion," *Ad Hoc Networks*, Vol. 20, pp. 96–112, 2014.

[15] Q. Chang, Y. P. Zhang, and L. L. Qin, "A node authentication protocol based on ECC in WSN," *In 2010 International Conference On Computer Design and Applications*, Vol. 2, pp. V2-606, IEEE, 2010.

[16] M. S. Farash, M. Turkanović, S. Kumari,and M. Hölbl, "An efficient user authentication and key agreement scheme for heterogeneous wireless sensor network tailored for the Internet of Things environment," *Ad Hoc Networks*, 36 (2016), pp. 152–176, 2016.

[17] R. Amin, S. H. Islam, G. P. Biswas, and M. S. Obaidat,"A robust mutual authentication protocol for WSN with multiple base-stations," *Ad Hoc Networks*, Vol. 75, pp. 1–18, 2018.

[18] M. Vaneeta,and S. S. Kumar,"NPKG: Novel Pairwise Key Generation for Resisting Key-based Threats in Wireless Sensor Network," *IJ Network Security*, Vol. 21, No. 1, pp.122–129, 2019.

[19] B. Hu,and H. Gharavi, "Smart grid mesh network security using dynamic key distribution with merkle tree 4-way handshaking," *IEEE Transactions on Smart Grid*, Vol. 5, No. 2, pp.550–558,2013.

[20] S. J. Choi, K. T. Kim, and H. Y. Youn,"An energy-efficient key predistribution scheme for secure wireless sensor networks using eigenvector," *International Journal of Distributed Sensor Networks*, Vol. 9, No. 6, pp.216754, 2013.

[21] S. Bag,and B. Roy,"A new key predistribution scheme for general and grid-group deployment of wireless sensor networks," *EURASIP Journal on Wireless Communications and Networking*, Vol. 2013, No.1, pp. 145, 2013.

[22] W. Bechkit, Y. Challal, A. Bouabdallah, and V. Tarokh, "A highly scalable key pre-distribution scheme for wireless sensor networks," *IEEE Transactions on Wireless Communications*, Vol. 12, No.2, pp. 948–959, 2013.

[23] G. R. Pathak, and S. H. Patil,"Mathematical Model of Security Framework for Routing Layer Protocol in Wireless Sensor Networks," *Procedia Computer Science*, Vol. 78, pp. 579–586, 2016.

[24] H. L. Yeh, T. H. Chen, P.C. Liu, T. H. Kim, and H. W. Wei,"A secured authentication protocol for wireless sensor networks using elliptic curves cryptography," *Sensors*, Vol. 11, No.5, pp. 4767–4779, 2011.

[25] X. Huang, P. Shah, and D. Sharma,"Fast algorithm in ECC for wireless sensor network," *In Proceedings of the International MultiConference of Engineers and Computer Scientists*, Vol. 2, pp. 17–19, 2010.

[26] O. Arazi, and H. Qi, "Self-certified group key generation for ad hoc clusters in wireless sensor networks," *In Proceedings. 14th International Conference on Computer Communications and Networks, 2005. ICCCN 2005*, pp. 359-364, IEEE, October 2005.

[27] O. Arazi, I. Elhanany, D. Rose,H. Qi, and B. Arazi,"Self-certified public key generation on the intel mote 2 sensor network platform," *In 2006 2nd IEEE Workshop on Wireless Mesh Networks*, pp. 118–120. IEEE, September, 2006.

[28] S. U. Khan, C. Pastrone,L. Lavagno, and M. A. Spirito,"An authentication and key establishment scheme for the IP-based wireless sensor networks," *Procedia Computer Science*, Vol. 10, pp. 1039–1045, 2012.

[29] Z. Qin, X. Zhang, K. Feng, Q. Zhang,and J. Huang, "An efficient key management scheme based on ECC and AVL tree for large scale wireless sensor networks," *International Journal of Distributed Sensor Networks*, Vol. 11, No. 9, pp. 691498, 2015.

[30] P. Paillier, "Public-key cryptosystems based on composite degree residuosity classes," *International Conference on the Theory and Applications of Cryptographic Techniques*, Berlin, Heidelberg, pp.223–238, 1999.

[31] I. Nadir, W. K. Zegeye, F. Moazzami, and Y. Astatke, "An efficient key management scheme based on ECC and AVL tree for large scale wireless sensor networks," emphInternational Journal of Distributed Sensor Networks, Vol. 11, No. 9, pp. 691498, October 2016.

[32] A. A. Agarkar, and H. Agrawal, "J-PAKE and ECC Based Authentication Protocol for Smart Grid Network", *In International Conference on Advances in Computing and Data Sciences*, pp. 507–522. Springer, Singapore, April 2018.

[33] A. A. Agarkar, and H. Agrawal,"Lightweight R-LWE-based privacy preservation scheme for smart grid network," *International Journal of Information and Computer Security*, Vol. 11, No. 3, pp. 233–254, 2019.

[34] A. A. Agarkar, and H. Agrawal, "LRSPPP: lightweight R-LWE-based secure and privacy-preserving scheme for prosumer side network in smart grid," *Heliyon*, Vol. 5, No. 3, e01321, 2019.

[35] J. Shen, S. Chang, J. Shen, Q. Liu, and X. Sun, "A lightweight multi-layer authentication protocol for wireless body area networks," *Future generation computer systems*, Vol. 78, pp. 956–963, 2018.

[36] El-hajj, M., Fadlallah, A., Chamoun, M., and Serhrouchni, A., "A survey of internet of things (IoT) Authentication schemes," *Sensors*, Vol. 19, No. 5, 1141, 2019.

[37] Al-Zubaidie, M., Zhang, Z., and Zhang, J., "Ramhu: A new robust lightweight scheme for mutual users authentication in healthcare applications," *Security and Communication Networks*, 2019.

[38] Y. Harbi, Z. Aliouat, A. Refoufi, S. Harous, and A. Bentaleb, "Enhanced Authentication and Key Management Scheme for Securing Data Transmission in the Internet of Things,", *Ad Hoc Networks*, pp. 101948, 2019.

[39] H.H. Kilinc, and T. Yanik, "A survey of SIP authentication and key agreement schemes," *IEEE Communications Surveys & Tutorials*, Vol. 16, No. 2, pp. 1005–1023, 2013.

[40] A. Mehmood, M. M. Umar, and H. Song, "ICMDS: Secure inter-cluster multiple-key distribution scheme for wireless sensor networks," *Ad Hoc Networks*, Vol. 55, pp. 97–106, 2017.

[41] A. Gupta, M. Tripathi, T. J. Shaikh, and A. Sharma, "A lightweight anonymous user authentication and key establishment scheme for wearable devices," *Computer Networks*, Vol. 149, pp. 29–42, 2019.

[42] D. Mishra, P. Vijayakumar, V. Sureshkumar, R. Amin, S. H. Islam, and P. Gope, "Efficient authentication protocol for secure multimedia communications in IoT-enabled wireless sensor networks," *Multimedia Tools and Applications*, Vol. 77, No. 14, pp. 18295–18325, 2018.

[43] C. Wang, G. Xu, and J. Sun, "An enhanced three-factor user authentication scheme using elliptic curve cryptosystem for wireless sensor networks," *Sensors*, Vol. 17, No. 12, pp. 2946, 2017.

[44] X. Li, J. Niu, M. Z. A. Bhuiyan, F. Wu, M. Karuppiah,and S. Kumari, "A robust ECC-based provable secure authentication protocol with privacy preserving for industrial Internet of Things," *IEEE Transactions on Industrial Informatics*, Vol. 14, No. 8, pp. 3599–3609, 2017.

[45] F. Wu, L. Xu, S. Kumari, and X. Li, "A privacy-preserving and provable user authentication scheme for wireless sensor networks based on internet of things security," *Journal of Ambient Intelligence and Humanized Computing*, Vol. 8, No. 1, pp. 101–116, 2017.

A Method for Designing Domain-Specific Document Retrieval Systems using Semantic Indexing

ThanhThuong T. Huynh[1]
University of Information Technology
VietNam National University HCMC
Ho Chi Minh city, Viet Nam

TruongAn PhamNguyen[2]
University of Information Technology
VietNam National University HCMC
Ho Chi Minh city, Viet Nam

Nhon V. Do[3]
Ho Chi Minh City Open University
Ho Chi Minh city, Viet Nam

***Abstract*—Using domain knowledge and semantics to conduct effective document retrieval has attracted great attention from researchers in many different communities. Ultilizing that approach, we presents the method for designing domain-specific document retrieval systems, which manages semantic information related to document content and supports semantic processing in search. The proposed method integrates components such as an ontology describing domain knowledge, a database of document repository, semantic representations for documents; and advanced search techniques based on measuring semantic similarity. In this article, a model of domain knowledge for various information retrieval tasks, called The Classed Keyphrase based Ontology (CK-ONTO), will be presented in details. We also present graph-based models for representing documents together measures for evaluating the semantic relevance for usage in searching. The above methodology has been used in designing many real-world applications such as the Job-posting retrieval system. Evaluation with real-world inspired dataset, our methods showed noticeable improvements over traditional retrieval solutions.**

***Keywords*—Document representation; document retrieval system; graph matching; semantic indexing; semantic search; domain ontology**

I. Introduction

A. Indispensible Need for Semantic Document Retrieval System

In this Information Age, the need for better management of digitalized documents in various aspects of daily life is ever more pressing. In education for example, searching for documents in your particular area of interest is an indispensible need of learners. That raises the problem of building a system to manage digitalized document in the domain of interest and support searching based on document content or knowledge. In media and publication, the vast amount of online news published everyday are making it more and more difficult for any entity in charge of managing and dissecting all those news article in their particular domain. Even the internal clerical and administrative work flow of a single organization can produce large amount documents that are in need of better content-based book keeping.

Another challenging document retrieval task can be found in job-posting management. The special nature of job-postings, which are often quite short but packed to the rim with keywords in the domain make the content of those documents very difficult to search.

To provide for those needs, we propose a model to build a class of document retrieval systems that optimize to manage a collection of documents in the same domain. The key challenging for those systems is a high precision semantic based search engine, which would be the focal point of the work discussed in this article. We follow the recent trend of ontology based semantic search as well as graph based document representation, combined in a coherent system.

B. Ontology-based Document Retrieval

Nowadays, many researches attempt to implement some degree of syntactic and semantic analysis to improve the document retrieval performance. In contrast to keyword based systems, the result of semantic document retrieval is a list of documents which may not contain words of the original query but have similar meaning to the query. Therefore, the objects of searching are concepts instead of keywords and the search is based on space of concepts and semantic relationships between them. To analyze the content of queries and documents, one has to consider extracting basic units of information from documents, queries and interpreting them. The main idea behind semantic search solutions is using semantic resources of knowledge to resolve words / phrases ambiguities, thus facilitate the understanding of query and document.

Knowledge representation models as well as knowledge resources play an increasingly importance role in enhancing the intelligence of document retrieval systems, in supporting a variety of semantic applications. Semantic resources include taxonomies, thesauri, and formal ontologies, among which ontologies are getting the most attention. Ontologies have proved to be powerful solutions to represent knowledge, integrate data from different sources, and support information extraction. One of the more common goals in developing ontologies is to share common understanding of the structure of information among people and/or systems. That goal leads to the development of gigantic general knowledge resources like DBPedia [1] or Yago, etc. However, even with the help of those generic knowledge bases, it remains extremely challenging to build a semantic search system that can cope with real world adhoc query. The current trend in Document Retrieval researchs is to focus on retrieval tasks in a very specific domains. The focus allows knowledge bases to be more carefully prepared, and thus both the query and the document can be better interpreted.

Many domains now have standardized ontologies developed for them by communities of domain experts and researchers. Those ontologies are often publicly shared and can

be used in a variety of tasks, some well-known large-scale and up-to-date ontologies are: The MeSH and SNOMED in Medicine, PhySH in Physics, JEL in Economics , AGROVOC and AgriOnt [2] in Agriculture, CSO [3] in Computer Science, MSC in Mathematics, etc. However, often an ontology of the domain is not a goal in itself. Developing an ontology is akin to defining a set of data and their structure for other programs to use. Problem-solving methods, domain-independent applications use ontologies and knowledge bases as data. Sadly, few of those wonderful ontologies were built with the document retrieval task in mind.

The CK-ONTO [4] is an ontology model developed first and foremost for the task of document retrieval in a specific domain. We tried to built a model powerful enough to support various information retrieval tasks, yet lean and efficient enough so that a CK-ONTO knowledge base can be quickly constructed in a new domain. The next section in this article describes the architecture of CK-ONTO in detail and then discusses a sample knowledge base built on the CK-ONTO model.

C. Document Representation

Document representation (DR) plays an important role in many textual applications such as document retrieval, document clustering, document classification, document similarity evaluation, document summarization, that is documents are transformed in form of readable and understandable way by both human and computer. The challenging task is to find the appropriate representation of document as so to be capable of expressing the semantic information of the text.

In statistical approaches, documents are described as pairs (feature, weight). Such models are based on the assumption that documents and user queries can be represented by the set of their features as terms (a simple word or phrase). Additionally, weights or probabilities are assigned to such terms to produce a list of answers ranked according to their relevance to the user query.

Among the first, widespread representations are the Bag Of Words (BoW)and the Vector Space Model (VSM). The document retrieval approaches using these representations primarily based on the exact match of terms in the query and those in the documents, they do not address multiple meanings of same word and synonymy of words [5].

In order to address polysemy, synonymy and dimensionality reduction, researchers have proposed several methods such as Latent Semantic Analysis (also called Latent Semantic Indexing), Probabilistic Topic Models or Latent Topic Models. In topic models, e.g. Probabilistic Latent Semantic Indexing [6], Latent Dirichlet Allocation [7], Word2Vec [8], documents are represented as vectors of latent topics. A latent topic is a probability distribution over terms or a cluster of weighted terms. The length of topic vectors is much smaller than the vectors of traditional models. Such models assume that words which are close in meaning tend to occur in similar pieces of text (contexts). These approaches are also widely used because of their simplicity and usefulness for describing document features, however, some of their drawbacks include: Most of such techniques are largely based on the term frequency information, but lack the reflection of semantics of text, e.g. ignore the connections among terms, structural and semantic (or conceptual) information is not considered; The topic models do not consider the structure of topics and relationships among them and have limitations when representing complex topics; Besides, the representations might be difficult to interpret. The results which can be justified on the mathematical level, but have no interpretable meaning in natural language. The good formalisms should make them easy to understand their meaning and the results given by the system, and also how the system computed the results.

Semantic or conceptual approaches attempt to implement some degree of syntactic and semantic analysis; in other words, they try to reproduce to some degree of understanding of the natural language text. Such researches indicate that semantic information and knowledge-rich approaches can be used effectively for high-end IR and NLP tasks.

Given such problem, many studies have been directed to the designing of more complex and effective features which aim to achieve a representation based on more conceptual features than on words. The multi-word terms or sometimes called phrases can be used as features in document vectors/bags. Some of complex feature models are: Lemmas, N-grams, Nouns Phrases, (head, modifier, ... modifier) tuples which are complex phrases with syntactic relations like subject-verb-object or contain non adjacent words. Such features can be detected via pure statistical models. Unfortunately, such representations are derived automatically, thus the (few) errors in the retrieval process compensate in accuracy provided by the richer feature space.

The rapid growth of information extraction techniquies and popularity of large scale general knowledge bases, thesauri as well as formal domain ontologies brought some new forms of representing vectors. The i-th component of vector is the weight reflecting the relevance of the i-th concept (or entity) of the knowledge resource in the represented document. For instance, Explicit Semantic Analysis (ESA) [9] uses Wikipedia articles, categories, and relations between articles to capture semantics in terms of concepts. ESA expresses the meaning of text as a vector of Wikipedia concepts. Each Wikipedia concept corresponds to an article whose title is concept name. The length of vector is the number of concepts defined in Wikipedia (a few millions). Semantic relatedness of documents is measured by cosin of the angle between their vectors. Document representation can be enriched by adding the annotated entities in to the vector space model [10], [11]. In [12], a document is modeled as bag of concepts provided by entity linking systems, in which concepts correspond to entities in the DBpedia knowledge base or related Wikipedia articles. Instead of centering around concepts or entities and using an additional resource, the work in [13] treats entities equally with words. Both word based and entity based representations are used in ad-hoc document retrieval. Word based representations of query and document are standard bags of words. Entity based representations of query and document are bags of entities constructed from entity annotations. An entity linking system finds the entity mentions in a text and links each mention to a corresponding entity in the knowledge base.

The meaning of a document as expressed through knowledge base concepts (or entities) is easier for human interpre-

tation as opposed to topics of latent topic models. However, the length of vectors equals the number of concepts in the knowledge base, which could be very large. Most of these approaches relies on "flat" meaning representations like vector space models, more sophisticate but still do not exploit the relational knowledge and network structure encoded within wide-coverage knowledge bases.

In recent years, modeling text as graphs are also gathering attraction in many fields such as document retrieval, document similarity, text classification, test clustering, text summarization, etc. Graph based approach for information retrieval has been widely studied and applied to different tasks due to its clearly-defined theory foundations and good empirical performance.

Because this topic is studied by different communities from different viewpoints and for usage in different applications, a wide range of graph models have been proposed. They greatly vary in the types of vertices, types of edge relations, the external semantic resources, the methods to produce structured representations of texts, weighting schemes, as well as the many subproblems focused on, from the selection feature as vertex and detection relationships between features, to matching graphs and up to ranking results. The rich choices of available information and techniques raise a challenge of how to use all of them together and fully explore the potential of graphs in text - centric tasks.

In [17], the text is represented as a graph by viewing the selected terms from the text as nodes and the co-occurrence relationships of terms as edges. Edges direction are defined based on the position of terms that occur together in the same unit . The weight is assigned to each edge so that the strength of relationship between two terms can be measured. Such graph model have the capability of retaining more structural information in texts than the numerical vector, but they do not take into account the meanings of terms and semantic relations between them.

Many richer document representation schemes proposed in [14]–[16], in which semantic relationship between words is considered to construct graphs. Vertex denotes terms mapped to concepts and edge denotes semantic relations specified in a controlled vocabulary or thesaurus, like synonymy or anotomy.

The method in [18], [19] took advantage of the DBpedia knowledge base for fine-grained information about entities and their semantic relations, thus resulting in a knowledge-rich document models. In these models, nodes are the concepts extracted from the document through references to entities in DBpedia using existing tools such as SpotLight or TagME. Those nodes are then connected by semantic relations found in DBpedia. The edges are weighted so as to capture the degree of relevance between concepts within an ontology. The different between these two works is that [18] also applied their model in the 'entity ranking' task in addition to the shared 'document semantic similarity evaluation' task. Moreover, not only [19] weighted edges like [18], they also weights concepts using closeness centrality measure which reflects their relevance to the aspects of the document. Another note is that these works disregarded structural information of the text, the relationships between nodes are independent of the given text.

The major difficulties in modeling document content with graphs are the development of an automated system to extract graph representation of text and the computation time limitation (time complexity). Besides, there may be difficulties in finding maximum common subgraph (subgraph isomorphism) between two document graphs, that are able to catch the semantic similarity between documents. Graph matching can be also accomplished in polynomial time making it impractical for large data sets.

In yet another attempt at those difficulties, we employ the graph based approach for representing and retrieving document in a very specific domain, where a fine grain ontological knowledge base can help noticeably improve retrieval performance. Our approach would be evaluate extrinsicly, which means only the final performance of the system will be considered, the quality of every internal processes are not yet attested. Our contributions are thus listed as follows:

- We propose a framework for building a semantic document retrieval system in a specific domain. Our framework aims to provide a systemmatic approach to better rank documents against a user query, with the help of a semantic resource.
- We also propose an Ontology model for domain knowledge to support various information retrieval tasks
- Graph-based document models along with a method to produce structured representations of texts are presented
- A graph matching algorithm to evaluate the semantic relevance for usage in searching would be introduced
- Finally, we evaluate search performance with the dataset of Information Technology Job Posting in Viet Nam

The remaining sessions of this paper are organized as follows: Section 2 is about a kind of document retrieval systems, called Semantic Document Base System, system architecture and design process; Sections 3 and 4 introduce an ontology model describing knowledge about a particular domain, a graph-based semantic model for representating document content; Section 5 presents techniques in semantic search; Section 6 introduces experiment, applications and finally a conclusion ends the paper.

II. Semantic Document Base System

A Semantic Document Base system (SDBS) is a computerized system focus on using artificial intelligence techniques to organize a text document repository on computer in an efficient way that supports semantic searching on the repository based on domain knowledge. It incorporates a repository (database) of documents in a specific domain, where content (semantics) based indexing is required, along with utilities designed to facilitate the document retrieval in response to queries. A SDBS considered here must have a suitable knowledge base used by a semantic index and search engine to obtain a better understanding and interpreting of documents and query as well as to improve search performance.

A semantic document base system has two main tasks:

- Offering multiple methods to retrieve documents from its database, especially the capability of semantic search for unstructured texts (i.e. the ability to exploit semantic connections between queries and documents, evaluate the matching results and rank them according to relevance).
- Storing and managing text documents and metadata, content based indexing to facilitate semantic search as well as managing the knowledge of a special domain for which the systems are developed.

Some other characteristics of a semantic document base system among the various kinds of document retrieval systems are as follows:

- A SDBS focuses on dealing with documents that belong to one particular domain, whereas existing knowledge resources in that domain can be exploited to improve system performance.
- A knowledge-rich document representation formalism as well as a framework for generating the structured representation of document content are introduced.
- A certain measure of semantic similarity between a query and a document is introduced.
- A proper consideration is imposed on the exploration of domain knowledge, the structural information and semantic information of texts, in particular, the occurrence of concepts and the relations existing between concepts.
- Offers a vast amount of knowledge in a specific area and assists in the management of knowledge stored in the knowledge base.

An overview of the system architecture is presented in Fig. 1. The structure of a SDB system considered here consists of some main components such as:

Semantic Document Base (SDB): This is a model for organizing and managing document repository on computer that supports tasks such as accessing, processing and searching based on document content and meaning. This model integrates components such as: (1) a collection of documents, each document has a file in the storage system, (2) a file storage system with the rules on naming directories, organizing the directory hierarchy and classifying documents into directories, (3) a database of collected documents based on the relational database model and Dublin Core standard (besides the common Dublin Core elements, each document may include some special attributes and semantic features related to its content), (4) an ontology partially describes the relevant domain knowledge and finally (5) a set of relations between these components.

Semantic Search engine: The system uses a special matching algorithm to compare the representations of the query and document then return a list of documents ranked by their relevance. Through the user interface, the search engine can interact with user in order to further refine the search result.

User Interface: Provide a means for interaction between user and the whole system. Users input their requirement for information in form of a sequence of keywords. It then displays search result along with some search suggestions for potential alternations of the query string.

Query Analyzer: Analyze the query then represent it as a "semantic" graph. The output of query analyzing process then be fed into search engine.

Semantic Collector and Indexing: Perform one crucial task in supporting semantic search, that is to obtain a richer understanding and representation of the document repository. The problems tackled in this module include keyphrase extraction and labeling, relation extraction and document modeling. This work presents a weighted graph based text representation model that can incorporate semantic information among keyphrases and structural information of the text effectively.

Semantic Doc Base Manager (including Ontology Manager): Perform fundamental storing and organizing task in the system.

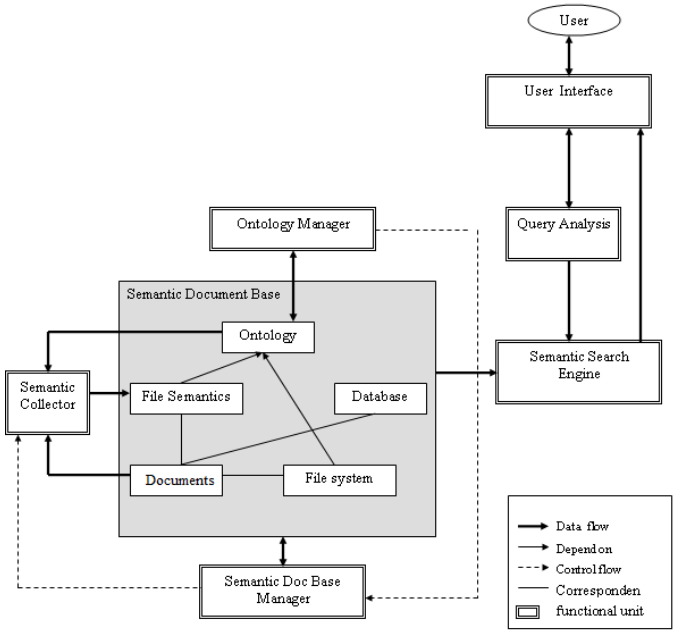


Fig. 1. Architecture of the SDB system

This paper describes the theoretical model of a semantic document base system by giving formal definitions to the "document representation" and the "similarity", with the occurrences of keyphrases, concepts and the semantic relations among them taken into consideration. Furthermore, there are some other important problems in a SDBS implementation point of view. The procedures as well as various kinds of data formats are described in order to implement the above model as a computerized system. The main models for representation of semantic information related to document's content will be presented in the next section.

III. The Classed Keyphrase based Ontology

Ontologies give us a modern approach for designing knowledge components of Semantic Information Retrieval Systems. Practical applications expect an ontology consisting of knowledge components: concepts, relations, and rules that support

symbolic computation and reasoning. In this article, we present an ontology model called Classed Keyphrase based Ontology (CK-ONTO). The CK-ONTO was made to capture domain knowledge and semantics that can be used to understand queries and documents, and to evaluate semantic similarity, first introduced in [20] and had some improvements in [4]. This ontology model was used to produce some practical applications in Information Retrieval. It can also be used to represent the total knowledge and to design the knowledge bases of some expert systems.

The preliminary CK-ONTO, however, was more of a lexical model than a fully structured Ontology. The central points in previous versions of CK-ONTO were the vocabulary of keyphrases (terms), as well as the internal relations between those keyphrases. Concepts and their structure received little attention.

In contrary, Gruber defined an ontology as an 'explicit specification of a conceptualization', which essentially means 'An ontology defines (specifies) the concepts, relationships, and other distinctions that are relevant for modeling a domain. The specification takes the form of the definitions of representational vocabulary (classes, relations, and so forth), which provide meanings for the vocabulary and formal constraints on its coherent use' [21].

Another definition of ontology was also given in [22]:

'An ontology may take a variety of forms, but necessarily it will include a vocabulary of terms, and some specification of their meaning. This includes definitions and an indication of how concepts are inter-related which collectively impose a structure on the domain and constrain the possible interpretations of terms.'

This paper presents a revised CK-ONTO model that is more on the line with contemporary ontology definitions. We still employ a vocabulary of keyphrases as the building block of our model but focus our efforts on structuralized concepts and their inter-relations. Ontologies must be both human-readable and machine-processable. Also, because they represent conceptual structures, they must be built with a certain composition.

Definition 1. *The Classed Keyphrase based Ontology (CK-ONTO), a computer interpretable model of domain knowledge for various information retrieval tasks, consists of four components:*

(K, C, R, Rules), where

- K is a set of keyphrases in a certain knowledge domain.
- C is a set of concepts in the domain.
- R is a set of relations that represent association between keyphrases in K or concepts in C.
- Rules is a set of deductive rules.

The structure of these components is presented in detail below, using the *Computer Science* domain as example:

A. A set of keyphrases: K

A keyphrase is an unequivocal phrase of relative importance in the domain. It can be a term that signifies a specific concept, an attribute of a concept or a unique entity in the domain.

Keyphrase is a linguistic unit structured as a word or a phrase. The syntactical classification of keyphrases yields three kinds: single keyphrase, compound keyphrase and modified keyphrase. A single keyphrase is either a single word or fixed phrase. For example, *computer, network, database, data structure, operating system, algorithm analysis and design, Arithmetic and logic unit, data mining* . A fixed phrase functions as a word, either with unique reference or as an idiom, is common in technical usage. The dividing line between a widely used ordinary phrase and a fixed phrase is not easy to determine. The degree of fixedness depends on frequency of occurrence and people's perception of the usage.

Compound keyphrases, on the other hand, are formed by two other keyphrases, or more. Based on the semantic of the relationship between constituents, compound keyphrases can be further classified as follows:

- Endocentric compound: one keyphrase is the 'head' and the others function as its modifiers, attributing a property to the head. For example: *database programming, network programming, document retrieval, wireless communication*.
- Dvanda compound: takes the form of multiple keyphrases concatenated together by using conjunctions, prepositions. For example, *data structures and algorithm, computer graphic and image processing*.

It is important to note that a single kephrase could be a complex combination of multiple words. But this 'combined word' contains only one keyphrase and thus can not be split into multiple keyphrases like a compound keyphrase.

A modified keyphrase, often consists of an adjective and a keyphrase, serves the same function as keyphrase. The adjective provides detail about, or modifies the original keyphrase. For example, *Low complexity, High complexity, classic Web content, rich multi-domain knowledge base*. There are numerous combinations created from this method, because there is no high stability so it may not have been collected in language dictionaries.

So, syntatically, we can consider the set of keyphrase K as $K = \{k|k \text{ is a keyphrase of knowledge domain}\}, K = K1 \cup K2 \cup K3$, in which, K1, K2, K3 are three sets of elements called single keyphrases, compound keyphrases and modified keyphrases, respectively.

On the semantic side, the set of keyphrases K can be partitioned into four subsets $K = K_A \cup K_E \cup K_C \cup K_N$ in which:

K_A, K_E, K_C are three subsets of keyphrases that imply attributes of some concepts, named entities (real-world objects such as persons, locations, organizations, products, etc.) or concepts respectively. And K_N is a set of keyphrases that have not been classifed. This semantic partition would prepare such set of keyphrases as the building block for other components of CK-ONTO discussed below. The partition is constructed by first identifying the relevant objects of the application domain, together with their relevant features.

B. A Set of Concepts: C

The main components of an ontology are concepts, relations, instances. A concept represents a set or class of entities (or objects, instances) or 'things' within a domain.

Concepts are basic cognitive units, each associated with a name and a formal definition providing an unambiguous meaning of the concept in the domain.A preferred label (name) is used for human readable purposes and in user interfaces. The matching and alignment of things is done on the basis of concepts (not simply labels) which means each concept must be defined. Concept can be defined by its intension and extensions. An extensional definition of a concept specifies a set of particular objects (also called instances) that the concept stands for. An intensional definition of a concept specifies its internal structure (attributes or slots) in either formal or informal way.

The definitional structure of each concept $c \in C$ can be modeled by *(cnames, Statement, Kbs, Attrs, Insts)*.

- $\emptyset \neq cnames \subseteq K_C$ is a set of keyphrases that can be used to name this concept. A $cnames$ is also called a synset which means a series of alternate labels to describe the concept. These alternatives include synonyms, acronyms that refer to the same concept.
- *Statement* is an informal (natural language) definition of this concept. For example, the *statement* of concept *PROGRAMING LANGUAGE* is *'A programming language is an artificial language designed to communicate instructions to a machine, particularly a computer. Programming languages can be used to create programs that control the behavior of a machine and/or to express algorithms'*. The statement is a non-nullable human-readable string and does not need to be interpretable by computer.
- $Kbs \subseteq K$ is a set of "base" keyphrases where each keyphrase can be a descriptive feature of the concept. For example, concept *PROGRAMING LANGUAGE* can be described by the following base keyphrases: *artificial language, instructions, computer, program, algorithm*. The first place to look for base keyphrases could be the *Statement* of that concept.
- *Attrs* is either an empty set or a set of attributes of the class, describes its interior structure.
- Finally, *Insts* is an empty set or a set of instances. If *Attrs* is not empty, then each instance is a copy of the abstract concept with actual values for attributes. In case *Attrs* is an empty set, *Insts* would be a set of instance names which are keyphrases related to each other in certain semantics sense.

There are two most notable kinds of concepts. The first kind often refers to an area of interest in the domain, it is very difficult to define the exact attributes and instances of these concepts. Therefore, contents of these concepts would be described in our ontology through their base keyphrases and their relations to other concepts. Their attributes and instances would remain empty.

The second kind often refers to well-structured concepts, which means we can specify both their attributes and instances.

TABLE I. THE ATTRIBUTES OF CONCEPT *ALGORITHM*

Attribute name	type	range	sample value
isHeuristic	Boolean		true, false
isRecursive	Boolean		true, false
useDataStructure	Instance	{ARRAY, LIST, GRAPH, TREE}	liked list, stack, balanced tree, hash table, etc.
hasComplexity	Instance	{COMPLEXITY}	linear complexity, logarit complexity, exponential complexity, factorial complexity, etc.

The structure of an attribute and instance for these concepts is discussed below:

1) Attributes of a concept: Attributes (called properties or slots) are definitional constituents of concepts. Each instance of a concept will have the same set of attributes but with different values.

Each attribute $a \in Attrs$ is a triple $(attname, type, range)$, where $attname \in K_A$ is the naming keyphrase of the attribute. The $type$ of an attribute can be primitive data type in computer like string, integer, float, boolean, etc. For some attributes, the value could be an instance of another concept. In such case the *range* of such attribute would be a set of concepts from which instances can come. For example, some attributes of concept *ALGORITHM* are given in Table I.

2) Instances of a concept: Insts is the set of instances belonging to the concept, represents extensional components of the concept. All instances share the same structure as defined by the concept and thus can be model as a tuple $(instname, values)$ where $instname \in K \backslash K_A$ is the naming keyphrase of that instance and $values$ is the tuple of attribute values. In general, the sets of instances and attributes are expected to be disjoint. In case the concept has empty *Attrs* but non-empty *Insts*, each instance in *Insts* would consist of a name and an empty value set.

Some sample instances of concept *ALGORITHM* is given in Table II. Also, another example, the concept *PROGRAMMING* is described by Fig. 2.

TABLE II. SAMPLE INSTANCES OF CONCEPT *ALGORITHM*

instname	attribute	value
binary search	hasComplexity	logarithm
	useDataStructure	sorted array
	isHeuristic	false
	isRecursive	true
heap sort	hasComplexity	linearithmic
	useDataStructure	array
	isHeuristic	false
	isRecursive	false

C. A Set of Binary Relations on C - R_{CC}

The set of binary relations R is a tuple of two set $R = (R_{KK}, R_{CC})$.

A binary relation **r** on C is a subset of $C \times C$, i.e. a set of ordered pairs of concepts in C. It encodes the information of

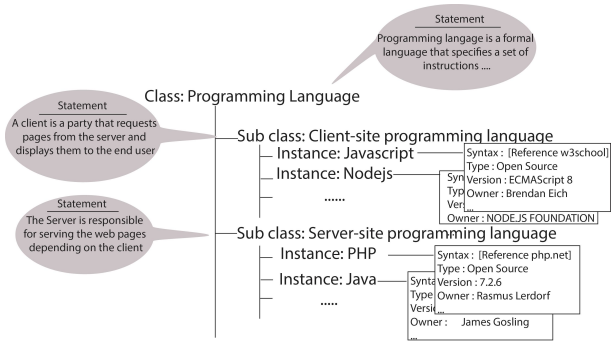


Fig. 2. An example of class *Programming language* in IT domain

relation: a concept c_1 is related to a concept c_2 if and only if the pair (c_1, c_2) belongs to the set. The statement $(c_1, c_2) \in r$ is read "concept c_1 is r-related to concept c_2", and is denoted by $c_1 r c_2$.

Each relation r will have an inverse denoted by r^{-1}, which is a relation with the order of two concepts reversed. In other words $\forall c_1, c_2 \in C, c_1 r c_2 \iff c_1 r^{-1} c_2$.

There are several kinds of semantic relations between concepts. The amount of relations may vary depending on the knowledge domain. These relations can be divided into two groups: hierarchical relations, non-hierarchical relations. So, relations also fall into two broad kinds:

1) Hierarchical relations among concepts: The most common forms of these are:

Hyponymy relation, also called 'is a' or 'kind of' relation links specific concepts with more general meaning ones, like *SORTING ALGORITHMS* is a more specific case of concept *ALGORITHMS*. We denote this relation as $r_{HYP} \in R_{CC}$. An interesting fact about this relation is that it can give us insights into the instances and attributes of concepts. Given two concepts $c_1, c_2 \in C$, it is possible to establish $c_1 r_{HYP} c_2$ if and only if the following conditions hold:

- Every instance of c_1 is also an instance of c_2

- Every attribute of c_2 is also an attribute of c_1

A class can include multiple sub classes or be included in other classes. A subclass is a class that inherits some properties from its superclass. The inheritance relationships of classes give rise to a hierarchical structure among classes.

Meronymy relation (r_{PART}), also known as 'a part of' or 'part-whole' or 'has a' relation, is another important hierarchical relation between concepts. For example, *CPU* is a part of *COMPUTER*.

Sub-topic relation (r_{SUB}) indicates that a concept is a sub area of another one like *ARTIFICIAL INTELLIGENCE* and *COMPUTER SCIENCE*, or, *LINKED DATA* and *SEMANTIC WEB*. While these so-called 'topical' concepts are hard to describe structurally, the capture of their hierachical relation play a vital role in many retrieval tasks.

2) Non-hierarchical relations : The three aforementioned hierarchical relations will incur three **'sibling' relations** denote as $r_{HYPSIB}, R_{PARTSIB}$ and r_{SUBSIB} respectively. Two concepts are sibling if they share a direct common parent in their hierarchy.

Domain-range relation, r_{RANGE}, links a concept to another concept in the *range* of its attributes. Given $c_1, c_2 \in C$, if there exists an attribute a of c_1 whose *type* is 'instance' and $c_2 \in range$ of a, we can say that $c_2 r_{RANGE} c_1$. For example, *COMPLEXITY* is in the range of attribute has Complexity of *ALGORITHM* , thus $(COMPLEXITY, ALGORITHM) \in r_{RANGE}$.

Depending on the domain knowledge, there exists many other types of non-hierarchical relationships that link concepts which are semantically related to each other without forming a hierarchy and no clear structural definition, such as Expansion, Cause, Influence, Instrument, Make, Possession, Source, Aim, Location, Temporal, Manner, Support, Beneficiary, Property, Agent, Circumstance, Related, etc.

Like binary relations general, our relations between concepts may have some properties like symmetric, transitive or reflexive, etc. A non-exhausted list of properties of relations in R_{CC} is given in Table III

TABLE III. PROPERTIES OF RELATIONS IN R_{CC}

relation	properties
Hierachical relations	transitive, reflexive, antisymetric
Domain-range relation	antisymetric
Sibling relations	transitive, reflexive, symetric

D. A Set of Binary Relations on K: R_{KK}

In addition to being a knowledge model of concepts and their relations, CK-ONTO also resembles a lexical model, in that it groups keyphrases together based on their meaning similarity and labels the semantic relations among keyphrases. This information is vital in many semantic retrieval tasks.

A binary relation **r** on K is a subset of $K \times K$. The statement $(x, y) \in r$ is read"keyphrase x is r-related to keyphrase y", and is denoted by xry. Keyphrases are interlinked by means of conceptual-semantic and lexical relations. There are three kinds of relations among keyphrases:

1) Equivalence relations: link keyphrases that have the same or similar meaning and can be used as alternatives for each other. There are two types of equivalence relations. The first one is 'abbreviation' relation, which links a short form or acronym keyphrase to its full form like *AI* and *Artificial Intelligence* or *Twittworking* and *Twitter networking*. This relation, denoted as r_{abbr}, is neither symmetric or transitive since two completely different keyphrases can share the same abbreviation, like *Best First Search* and *Breadth First Search* can both be abbreviated as *BFS*.

The other type of equivalence is synonymy relation, denoted as r_{syn},links keyphrases that can be used interchangably, like *Ontology Matching* and *Ontology Mapping*. This relation is fully symmetric and transitive, thus can be used to group keyphrases that share the same semantic meaning. The distinction between these two relations, therefore, should come from their semantical effects. If a short form keyphrase can

replace its full form ubiquitously with no additional disambiguation needed, that should be considered synonym rather than abbreviation.

When creating a synonymous groups of keyphrase, one should consider the spoke-and-hub model with one keyphrase serves as the centroid (hub) for the group and links to its synonymous keyphrase. The choice of hub keyphrase may not be trivial but the most popular keyphrase in the domain literature should be chosen in most cases.

2) Syntactical relations: that link compound keyphrase with its components. For dvanda compound, we have a simple 'formed by' relation (r_{formby}) from the compound keyphrase to each of its components. For endocentric compound, however, we have the 'head component' keyphrase and the 'modifier component' keyphrase, hence, there are 'headed by' relation (r_{headby}) and 'modified by' relation (r_{modby}) from an endocentric compound to its components respectively.

3) Semantic relations derived from concept relations: In information retrieval, there are many tasks that can be facilitated by the processing of terms and their relations, without any need for uncovering the structure of concepts. To better prepared our model for such tasks, we enrich R_{KK} with derived version of relations from R_{CC} including r_{hyp}, r_{part} and r_{sub} as hierarchical relations; $r_{hypsib}, r_{partsib}, r_{subsib}, r_{range}$ and $r_{related}$ as non-heirachical relations.

The exact keyphrase-keyphrase pair for each of these relations can be specified explicitly in addition to derivation from each element of R_{CC}. Since a keyphrase can express either a concept, an attribute or an instance, we would need some rules to deduce relations between keyphrases from relations between concepts. These rules will be discussed in the next section.

E. The Set of Rules

Rules is a set of deductive rules on facts related to keyphrases and concepts. A rule can be described as follows: $rule : \{f_1, f_2, ..., f_n\} \Rightarrow \{g_1, g_2, ..., g_m\}$ with $\{f_1, f_2, ..., f_n\}$ are hypothesis facts and $\{g_1, g_2, ..., g_m\}$ are goal facts of the rule.

Facts are concrete statements about 'properties of relations', 'relations between keyphrases' or 'relations between concepts'. The notations for each kind of facts are listed below:

Facts about properties of relations are written as $[< relation\ symbol > is < property >]$. For example, [r_{syn} is symmetric] means that the synonym relations between keyphrases is symmetric.

Facts about relations between keyphrases are written as $[< first\ keyphrase >< relation\ symbol >< second\ keyphrase >]$. For example, ['quick sort' r_{hyp} 'sorting algorithm'] means that keyphrase *quick sort* has hyponymy relation with keyphrase *sorting algorithm*.

Facts about relations between concepts are written as $[< first\ concept >< relation\ symbol >< second\ concept >]$. For example, ['EXPERT SYSTEMS' r_{SUB} 'ARTIFICIAL INTELLIGENCE'] means concept *EXPERT SYSTEMS* is a sub-topic of concept *ARTIFICIAL INTELLIGENCE*.

Some examples of rule include:

$\forall k_1, k_2, k_3 \in K, \forall r \in S_{R_{KK}}$ where $S_{R_{KK}}$ is aa set of symbols (or names) of the relations in R_{KK}

rule 1: if [r is symmetric] and $[k_1 r k_2]$ then $[k_2 r k_1]$

rule 2: if [r is transitive] and $[k_1 r k_2]$ and $[k_2 r k_3]$ then $[k_1 r k_3]$

rule 3: if $[k_1 r_{syn} k_2]$ and $[k_2 r k_3]$ then $[k_1 r k_3]$

Once keyphrases, classes and relations had been defined, rules should be described for constraint checking and inferring relation between two kephrases, between a keyphrase and a class, and between two classes. Moreover, rules also help (1) saving storage cost now that we don't have to manually store every single relationship, (2) enforce constraint and help reduce workload of a knowledge engineer when building ontology data, (3) the set of rules is an essential tool to deduce the direct or indirect relationships between keyphrases or concepts, the key step in evaluating the semantic similarity among keyphrases and concepts.

The Roles of CK-ONTO in Document Retrieval Systems

There are many ways to utilized CK-ONTO in different components of a document retrieval system.

- Document representation can be enriched.
  CK-ONTO can be viewed as a specific knowledge resource which be effective for language understanding tasks, i.e. can be used to understand and interpret queries and documents. In lexical models like WordNet, concepts correspond to senses of words. A concept in WordNet is represented as a synonym set and each synset is provided a textual definition, examples of its usage. Typical semantic relations between synsets include is-a relation, instance-of relation, part-of relation. In contrast, our CK-ONTO contains many different lexical and semantic relations between concepts or keyphrases. Keyphrases can refer well-structuralized concepts or specific entities.
  On the other hand, there are several existing general ontologies that can provide internal structural information about concepts or entities. However, they are massive in size, require additional disambiguation processing. Whereas CK-ONTO can facilitate quick, painless keyphrase extraction and graph-based document representation as pointed out in our previous iteration [4].
- Relevance evaluation between concepts or keyphrases is arguably the most common utilization of knowledge resources in retrieval systems. The semantic relevance between two concepts or keyphrases can be measured through their relations to other concepts. This measurement can then be used to expand query, ranking entities, representing document, semantic matching and so on. A good relevance evaluation strategy, tend to be specifically tuned to maximize the utilization of information provided in a specific resource. Therefore, we will propose a semantic relevance evaluation strategy based on CK-ONTO in the next section.

- The use of the ontology can also be useful for query expansion by means of introducing related keyphrases (or entities, concepts) and their content to expand the query. A 'heavy' domain ontology is preferred for fine-grain and precise expansion. However, we are yet to conduct formal experiment to substantiate the usefuleness of CK-ONTO in supporting query expansion tasks. Only system-wide experiment results are discussed in this article.
- Ranking model can exploit the ontology for matching the representations of texts. This is among the last steps in a retrieval systems, to determine the order of search results. A ranking scheme relied on earlier versions of CK-ONTO can be found in [4].

To build a knowledge base in CK-ONTO model is a task best supervised by well-trained domain experts. The process often involves these following steps:

- Collect a set of keyphrases in the domain from existing resources like dicitonaries, thesauri, Wikipedia, etc.
- Scan the document repository for any keyphrases that could have been missed in the previous step.
- Identify concepts and define their structures in CK-ONTO model.
- Determine the possible relations among concepts and employ inference engine based on the set of rules to deduce any additional relations among concepts and keyphrases.

Since the performance of various retrieval tasks heavily relied on ontology quality, it's ineluctable to have manual tuning from a team of experts in the domain. We built a web-based CK-ONTO management tool to help co-ordinate the efforts among teams of users. A screenshot of that tool is given in Fig. 3.

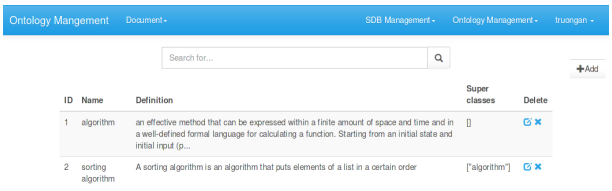


Fig. 3. A screenshot of CK-ONTO management tool

IV. Keyphrase Graphs for Document Representation

The work will focus on studying the method of text document representation, with the aim of converting documents into a structured form suitable for computer programs while still being able to describe core content of that text. We first briefly outline document representation formalism properties that we consider to be essential.

A. Requirements for a Document Representation Formalism

The content of document can be understood and interpreted in various ways. We are interested in document formalisms that comply, or aim at complying, with the following requirements:

- To allow for a structured representation of document content.
- To have a solid mathematically foundation.
- To allow users to have a maximal understanding and control over each step of the building process and use.

Document representation formalisms can be compared according to different criterias, such as expressiveness, formality, computational efficiency, ease of use, etc. A model is considered good if the following criterias are met:

1) Expressiveness: One of the fundamental challenges of text representation is the ability to represent information in text. The *Expresiveness* measures how "well" a representation can reflect the content of a document, i.e, what concepts and/or entities are mentioned in the document and what information can be inferred about them. A good representation has to capture both important structural information and semantic information, whereas structural information comprising of:

- The set of selected representative terms from text: A term is a simple word or phrase which helps to describe the content of document, and which may indeed occur in the document, once or several times (also called keywords, or keyphrases). Besides, "representative terms" can be more complex features like *n-grams*, *nouns phrases*, etc. extracted using various linguistic processing techniques
- Frequency of terms: the number of occurrences of terms in a document or in a collection of documents reflects their importance and specificity in the texts.
- The ordering information among terms.
- The co-occurrence of terms in different window sizes, i.e. terms can occurrence together in a sentence, a paragraph, or in a fixed window of n words and the evaluation for the strength of this relation. There is an assumption that if terms appear together in the units (as a sentence, different parts of a sentence) with a higher frequency, it means there is a close relationship between them, so thus the corresponding link should be weighted stronger.
- Location of terms in text: position information of terms at any content item (title, abstract, subtitle, content, etc.), at the beginning, middle or end of the text.

We define three levels of effectiveness in capturing structural information, described in Table IV.

Richer document representation schemes can be obtained by considering not only words or phrases but also semantic relations between them. The meaning of a document is the result of an interpretation done by a reader. This interpretation task needs much more information than the data contained in the document itself. The understanding the content of a document involves not only the determination of the main concepts mentioned in the document but also the determination of semantic relations between these concepts. Besides, the importance of representative concepts, how strongly they relate to each other should also be considered. The semantic information discussed in this paper is the meaning of a text derived

TABLE IV. LEVEL OF STRUCTURAL INFORMATION EXPRESSIVENESS

Criteria	Level 1	Level 2	Level 3
Model can capture structural information	Record the set of words appear in the document, with or without weighting parameter to indicate the importance of those words in the document.	Record set of phrases or features in the document along with their weights, location information	In addition to level 2, also record the co-occurence relation among features.
Example model	Bag of Words, Vector Space Models, etc.	Bag of complex features such as n-grams, Nouns phrases, (head, modifier, ..., modifier) tuples, etc.	Co-occurrence Graph based on the co-occurrence of feature terms in the document.

TABLE V. LEVEL OF SEMANTIC INFORMATION EXPRESSIVENESS

Criteria	Level 1	Level 2	Level 3
Model can capture semantic information	Represent document as a bag or vector of concepts (or entities) mentioned in the document with or without frequency weighting. Concepts are linked to an external semantic resource	Represent document as a bag or vector of concepts where relations between such concepts in the semantic resource are exploited in the weighting process.	Represent document as a graph of concepts with vertex weights reflecting the importance of concepts in document and edge weights representing the strength of relationship between two corresponding concepts. Difference kinds of relationships are recorded

from lexical semantics which are the underlying meanings of terms in the document and term relations or conceptual semantics which capture the cognitive structure of meaning. There are two main approaches to extracting semantic information. The first one employs Natural Language Processing techniques to parse the grammatical structure of the document into computer friendly representation. In this article, however, we will focus on the second approach, that is employing an external knowledge source to infer the meaning of document. The semantic information unearth using this approach may consist of:

- List of concepts or entities discussed in the document. Depending on the type of semantic resource being used, the structure of concepts may vary. In lexical models, concepts correspond to senses of words whereas concepts in knowledge models (abstract models of knowledge) stand for classes of real-world entities. Lexical concepts may refer to entities, classes, relations, attributes, or other senses of words and can be organized along lexical relationships in a lexical model. Knowledge models basically represent classes, attributes associated with these classes, and relations between classes.
- Relationships between concepts or entities reflected in the document. There are various kinds of association between concepts that raises a challenge of how to explore fully the potential of them and how to use some or all of them together.
- Weights associated with concepts (or entities) which reflect their relevance to the aspects or topics of the document.
- Weights associated with relationships between concepts which capture the strength of those relationships, i.e. the degree of associativity between concepts, how strongly related the two corresponding concepts are.

Levels of effectiveness in capturing semantic information may be considered as in Table V.

2) Formality: Components in a representation model have to be defined on a strong foundation with logically and mathematically sound notations. Further operations facilitated by the model also have to be well stated in the same notations so that they can be proved and implemented.

The formality is vital since it helps with the disambiguation and thus reduces error rate when using the model on real life data.

3) Computational efficiency: The specification language of the model has a simple structure but can represent knowledge domain and content of documents adequately. Users can employ it to represent, update, search, store easily as well as control over each step of the building process. Moreover, technical difficulty and utilization available tools or technologization should be considered. We are interested in representation formalisms that can be used for building systems able to solve real, complex problems. It is thus essential to anchor these formalisms in a computational domain having a rich set of efficient algorithms so that usable systems can be built. Due to the importance of natural language, a document representation formalism should allow the user to easily understand the results given by the system. The ability for describing the natural semantics is a good empirical criteria for delimiting the usability of the formalism.

Motivated by the previous work, this paper deals with the problem of document representation, provides a more expressive way to represent the texts for multiple tasks such as document retrieval, document similarity evaluation, etc. We propose graph based semantic models for representing document content which consider the incorporation of structural (syntactic) information and semantic information in texts to improve performance. Exploiting domain specific or general knowledge have been studied for acquiring fine - grained information about concepts and their semantic relations, thus resulting in knowledge-rich document models.

B. Modeling Document as Graph over Domain Knowledge

This subsection is devoted to an intuitive introduction of Keyphrase Graphs. The graph-based document representation formalism is introduced in detail. This formalism is based on a graph theoretical vision and complies with the main principles delineated in the previous subsection. Document Representation has long been recognized as a central issue in Document Retrieval. Very generally speaking, the problem

is to symbolically encode text document in natural language in such a way that this encoded document can be processed by a computer to obtain intelligent understanding.

We use the term "keyphrase graphs" (KGs in short) to denote the family of formalisms and use specific terms, e.g. simple keyphrase graph, weighted keyphrase graph, full weighted keyphrase graph —for notions which are mathematically defined in this paper.

A simple keyphrase graph is a finite, directed, muligraph. "Multigraph" means that a pair of nodes may be linked by several edges. Each node is a keyphrase that occurs and of relative importance in the domain. Edges express relationships that hold between these keyphrases. Each edge has a label. An edge is labeled by a relation name. A simple keyphrase graph is built relative to an ontology called CK-ONTO and it has to satisfy the constraints enforced by that ontology.

Definition 2. *Let $O = (K, R_{KK})$ be a sub-model derived from a domain ontology in the CK-ONTO formalism. A simple keyphrase graph (KG) defined over O, is a tuple (V, E, ϕ, l_E) where:*

- $V \subset K$ is the non-empty, finite set of keyphrases, called set of vertices or nodes of the graph.
- E is a set of directed edges.
- $\phi : E \to \{(x, y)|(x, y) \in V^2, x \neq y\}$ an incidence function mapping every edge to an ordered pair of distinct vertices. The edge represents a semantic (conceptual) relationship between its two adjacent vertices. The two vertices $k1, k2 \in V$ are connected if there exits a relation $r \in R_{KK}$ such that $(k1, k2) \in r$.
- $l_E : E \to T_R$ is a labeling function for edges. Every edge $e \in E$ is labeled with a relation name $l_E(e) \in T_R$. T_R is a set of names of binary relations found in R_{KK}.

O is composed of two sets: a set of keyphrases and a set of binary relations between keyphrases and can be considered as a rudimentary ontology. In contrast to lexical resourses like WordNet, our ontology contains many different, well-controlled semantic relations. In some works, it is assumed that O has a specific structure, such as a graph, thus a simple keyphrase graph can be viewed as a subgraph of O. A KG has nodes representing defined keyphrases in the domain ontology and edges representing semantic relationships found in the ontology between these keyphrases. Keyphrase nodes can refer to concepts or specific entities of domain knowledge. Important differences between the keyphrase graph model and other semantic networks are to be pointed out:

Compared to Conceptual Graph (CG), the structure of Keyphrase Graph is leaner. CGs are buit on a vocabulary of three pairwise disjoint sets: the ordered set of concept types, the set of relation symbols, and the set of typed individual markers. A concept type can be considered as a class name of all the entities having this type. In KG definition, on the contrary, the vocabulary K is a mixture of concepts' names (the counterpart of concept types), entities' names (the equivalence of individual markers) and many other things. A concept node in CG refers to either a specific entity, labeled by a pair (type, marker), or an unspecified entity with just the 'type' label. On the other hand, the nodes in KG are labeled with only the keyphrase. This is possible because the majority of information about each keyphrase can be inferred from CK-ONTO, we can get by with fewer annotations on keyphrase graph nodes.

Since the definition of CGs does not specified any relationship among concepts beyond simple a-kind-of relations. The determination of possible semantic relationships between concept types in CGs must use some complex natural language processing techniques and external resources. Whereas for keyphrase graphs, relationships can be quickly found by exploiting information about relations within the ontology or deducing from them.

Recently, various graph models use general kwowledge bases (e.g. DBpedia, Freebase) as the backend ontologies. Such knowledge bases contain knowledge about concepts or real-world entities such as descriptions, attributes, types, and relationships, usually in form of knowledge graphs. They share the same spirit with controlled vocabulary but are created by community efforts or information extraction systems, thus have a large scale, wide-coverage [23].

Due to such wide-coverage, when comparing to a domain specific ontology like CK-ONTO, those general knowledge bases often have a higher degree of conceptual overlapping and ambiguity. Thus various disambiguation techniques are required when using those knowledge bases, an unnecessary burden for retrieval tasks in a specific domain.

Definition 3. *Let $O = (K, R_{KK})$ be a sub-model derived from CK-ONTO. A weighted keyphrase graph (wKG) defined over O, is a tuple $(V, E, \phi, l_E, w_V, w_E)$ where:*

- (V, E, ϕ, l_E) is the simple keyphrase graph.
- $w_V : V \to \mathbb{R}^+$ and $w_E : E \to \mathbb{R}^+$ are two mappings describing the weighting of the vertices and edges.

In some works, not all keyphrases or all relations are equally informative, so numerical weights associated with them are necessary. Such weight might represent for example cost, length, capacity, descriptive importance or degree of associativity, depending on the problem at hand.

Graphs are commonly used to encode structural information in many fields, and graph matching is an important problem in these fields. The matching of a graph to a part of another graph is called subgraph matching problem or subgraph isomorphism problem. So, we are interested here in subgraphs of a KG that are themselves KGs.

Definition 4. *Let $G = (V, E, \phi, l_E)$ be a simple keyphrase graph. A sub keyphrase graph (subKG) of G is a simple keyphrase graph $G' = (V', E', \phi', l'_E)$ (denoted as $G' \leq G$) such that: $V' \subseteq V$, $E' \subseteq E$, ϕ', l'_E are the restrictions of ϕ, l_E to E' respectively, and $\phi'(E') \subseteq V' \times V'$. Conversely, the graph G is called a super keyphrase graph of G'.*

Definition 5. *Let $G = (V, E, \phi, l_E, w_V, w_E)$ be a weighted keyphrase graph. A sub weighted keyphrase graph (sub-wKG) of G is a weighted keyphrase graph $G' = (V', E', \phi', l'_E, w'_V, w'_E)$ (also denoted as $G' \leq G$) such that: $(V', E', \phi', l'_E) \leq (V, E, \phi, l_E)$ and the weights of every vertices and edges of G' are equal to their counterparts in the super keyphrase graph G.*

A subKG of G can be obtained from G only by repeatedly deleting an edge or an isolated vertex.

Keyphrase graphs are building blocks for representing different kinds of texts, e.q. used for the semantic representation of documents and queries. Keyphrases are the most relevant phrases that best characterize the content of a document. Keyphrases provide a brief summary of the content, and thus be used to index the document and as features in further search processing. Furthermore, understanding the document content involves not only the determination of the main keyphrases occur in that document but also the determination of semantic relationships between these keyphrases. Therefore, each document can be represented by a compact graph of keyphrases in which keyphrases are connected to each other by semantic relationships. Nodes represent keyphrases extracted from the document through references to explicit keyphrases in a domain ontology. We can assign a weight to each keyphrase in the given document, representing an estimate of its usefulness as a descriptor of the document. Similarly, each relation edge in the document graph also allocated a weight (usually but not necessarily statistical) which reflects the membership degree between two direct keyphrases. This is a distinctive feature of weighted keyphrase graphs: they allow to represent semantic and structural links between keyphrases and measure the importance of keyphrases along with the strength of relationships whereas poor representation models cannot.

Definition 6. *Let $O = (K, R_{KK})$ be a sub-model derived from CK-ONTO. Given a document d which belongs to a collection D of documents in a specific knowledge domain. A weighted keyphrase graph, which represents the document d (denoted as $docKG(d)$), defined over O, is a tuple $(V, E, \phi, l_E, w_V, w_E)$ where:*

- $(V, E, \phi, l_E, w_V, w_E)$ is a weighted keyphrase graph whose vertices and edges can be weighted with some statistical or linguistic criterion.
- (l_E, w_E) are two labeling functions for edges of the graph. Every edge $e \in E$ is labeled by a pair $(l_E(e), w_E(e))$ where $l_E(e)$ is a name of semantic relation in R_{KK} , $w_E(e)$ is the weight assigned to the current edge . This weight is a measure of semantic similarity between two keyphrases.
- w_V is a labeling function for vertices of the graph Each keyphrase vertex $k \in V$ is assigned a weight $w(k, d)$, which is a measure of how effective the keyphrase k is in distinguishing the document d from others document in the collection

The most expressive keyphrase graph is called full weighted keyphrase graph. The basic idea of the extension from weighted keyphrase graph to full weighted keyphrase graph is that there are various kinds of association between keyphrase vertices considered. We consider different types of relationships among keyphrases and their environment in the domain ontology as well as in the documents.

Definition 7. *Let $O = (K, R_{KK})$ be a sub-model derived from CK-ONTO. Given a document d which belongs to a collection D of documents in a specific knowledge domain. A full weighted keyphrase graph, which represents the document d (denoted as $fulldocKG(d)$), defined over O, is a tuple $(V, E_1, E_2, \phi_1, \phi_2, l_{E_1}, l_{E_2}, w_V, w_E)$ satisfying the following conditions:*

- $(V, E_1, \phi_1, l_{E_1}, w_V, w_E)$ is a weighted keyphrase graph representing d .
- E_2 is a set of directed edges representing syntactic relationships between keyphrase vertices (the edge set of graph is $E = E_1 \cup E_2$) and $\phi_2 : E_2 \rightarrow \{(x, y) | (x, y) \in V^2, x \neq y\}$ maps every edge to an ordered pair of distinct vertices. In addiction to semantic relationships, the two keyphrase vertices $k1, k2 \in V$ can also be connected if there exits some forms of syntactic relationship between them such as co-occurrence or grammatical relationships.
- $l_{E_2} : E_2 \rightarrow T_S$ is a labeling function for edges in E_2. T_S is a set of names of binary syntactic relations used for labeling such edges.
- $w_E : E \rightarrow \mathbb{R}^+$ is used for weighting edges. Such weights capture the degree of relevance between keyphrases in the graph.
- Two keyphrases are connected by co-occurence relationship if they appear in the same sentence. The edge connecting them is labeled "co-occurrence", its direction is based on the order in which those two keyphrases appear. The weight of such edge reflects how strongly the two keyphrase related and could be measured by the frequency they appear together.
- The syntactic relationship is a special kind of co-occurence relationship, when grammatical roles of the two keyphrase can be inferred. The label, direction and weight of edge in case may vary depending on the domain knowledge and the parsing technique.

C. Weighted Keyphrase Graph Construction

1) A general framework for document graph generation: We present a method to generate the structured representation of textual content using CK-ONTO as the backend ontology. The key idea of document representation by a keyphrase graph is to link the keyphrases in the document text to concepts/entities of a domain ontology in the CK-ONTO formalism, and to explore the semantic and structural information among them in the ontology as well as in the text body.

Given an input text document d, the process of generating a full weighted keyphrase graph *fulldocKG(d)* representing d consists of the following stages:

- Step 1: Extract keyphrases in the text d, that correspond to defined keyphrases in the knowledge base CK-ONTO. This step is in iteself an active research problem, resulting in a variety of existing tools. However, in some specific domains, human intervention is still unavoidable to form a concise list of vertices of the graph. Then weights will be assigned to each vertex and some popular weights like tf, idf¸, ect. are good starting point.
- Step 2: Connect the extracted keyphrase vertices using their semantic and/or structural relationships. Each

pair of keyphrases k_i and k_j are connected by an edge in two cases: 1) If they are directly linked by a relation defined on CK-ONTO, that relation name is also used to label the edge. 2) If they occur together in a sentence, syntactic parsing techniques are employed to determine the syntactical relation between them, otherwise they only have simple "co-occurrence" relation.
Based on the observation that the core aspects of a document should be a set of closely related keyphrases, the strength of associations among keyphrases are used for the representation to better reflect the semantics of the text. The weight on the directed edge r connecting k_i and k_j reflects the strength of relationship between two keyphrases, based on their features and relationships in the domain ontology. Moreover, keyphrases that frequently appear together in a document or in many documents of the collection tend to have stronger links between them. This kind of association reflects how often two keyphrases share contexts. However, the exact formula for edge's weight may vary depending on the type of the document.

- Step 3: If a group of synonym keyphrases are extracted, remove all but the one with highest weight and update the weight of this keyphrase.
- Step 4: Compute the weight for each edge to evaluate the strength of the corresponding relation.

A query may be specified by the user as a set of keyphrases or in natural language. In the latter case, the query can be processed exactly like a miniature document in similar manner. A natural language query can receive the usual processing, i.e., keyphrase extraction, relationship identification, etc. transforming it into a graph of keyphrases.

2) Assigning weights to keyphrase vertices and relation edges: Each keyphrase vertex k of the keyphrase graph representing the document d is assigned a weight w(k, d), which is a measure of how effective the keyphrase k is in distinguishing the given document d from other documents in the same collection. There are many strategies to weight keyphrase nodes and a variety of weighting schemes have been used. The exact scheme for automatic generation of weights may vary depending on the characteristics of the document repository. The formulas below were used in some of our applications and are listed here for examplary purpose.

The weight associate with the keyphrase node k of the keyphrase graph docKG(d), representing an estimate of the usefulness of the given keyphrase as a descriptor of the document d, is computed by:

$$w(k,d) = tf(k,d) \times idf(k,D) \times ip(k,d) \tag{1}$$

The "term frequency" tf(k,d) is the frequency of occurrence of the keyphrase k within the given document d, that reflects the importance of the keyphrase within a given document according to the number of times it appears in the document, is computed by:

$$tf(k,d) = c + (1-c)\frac{n(k,d)}{max(\{n(k',d)|k' \in d\})} \tag{2}$$

where $n(k,d)$ is the number of occurrences of the keyphrase k in the document d. Parameter $c \in [0,1]$ is the predefined minimum tf value for every keyphrase. This parameter reflects one's confident in the keyphrase extraction process, that means any keyphrase extracted must have a certain value of importance as a descriptor of the document and in the worst case it should have a tf of at least c.

In large (long) documents like books and thesis, some 'popular' keyphrases can appear a thousand fold more times than a more specific keyphrase, leading to a very low frequency for this specific keyphrase. This parameter also help prevent keyphrases from being overshadowed in large documents. The value of c is chosen through experimenting and can be fine-tuned to suit different specific applications.

The "Inverse document frequency" idf(k, D) is a measure of how widely the keyphrase k is distributed over the given collection of documents D and computed by:

$$idf(k,D) = log\left(\frac{|D|}{1+|\{d \in D, k \in d\}|}\right) \tag{3}$$

where $|D|$ is the total number of documents in the collection and $|\{d \in D, k \in d\}|$ is the number of documents where the keyphrase k appears.

The "Importance of Position" ip(k,d) represents an estimate of the importance of keyphrase k in document d based on the location of occurrence of k in the document, is defined as:

$$ip(k,d) = a + (1-a)\frac{\sum_{i \in A} w_i}{\sum_i w_i} \tag{4}$$

in which, w_i is the weight assigned for the ith component of document d , representing the importance of ith component of document structure. The set of the index of all components in which k appear defined as $A = \{x|n_x(k,d) > 0\}$, on top of that we can defined Parameter $a = max(w_i|i \in A)$ as the weight of the most important component where k appears, also serves as the predefined minimum value for $ip(k,d)$. The number of a document's component and the weight for each component is different for each type of document. In a paper, for example, the title and abstract are much more important in helping readers quickly grasp the general meaning of the text, so the keyphrases appear in these components are always considered to be more significant and should have the largest weight.

By adopting $tf \times idf \times ip$ weighting scheme, such weighting scheme assumes that the best descriptors of a given document will be the keyphrases that occur often in the document and very rarely in other documents and they are likely to occur in important content items of the document (such as title, subtitle, abstract, etc.).

Similarly, weights are also assigned to relation edges in the graph. The weight on the directed edge r connecting k_i and k_j reflects the strength of the relationship between pair

of keyphrases. Commonly, if keyphrases appear together in a sentence with a higher frequency (within given document), it means there is a stronger link between them. However, in some types of documents, the number of times that keyphrases occur in the texts could be low, so k_i and k_j rarely co-occur more than once. Therefore, the weight assigned to an edge can be considered by the relative frequency of co-occurrence of its both adjacent keyphrase vertices (in a sentence) over the given collection. Thus, the formula for edge's weight may vary depending on the type of the document. An example forumla will be given in Section **??**.

We demonstrate the benefits of these semantic representations in the following search task:

V. Graph based Document Retrieval

This paper deals with the problem of document representation for the task of ad-hoc document retrieval. The main task is to retrieve a ranked list of (text) documents from a fixed corpus in response to free-form keyword queries. In this work, the query and documents are modeled by enhanced graph-based representations. We define several semantic similarity measures which consider both semantic and statistical information in documents to improve search performance.

A. Semantic Relevance Evaluation

Relevance evaluation between the target query and documents is done by calculating the semantic similarity between two keyphrase graphs that represent them. A keyphrase graph is constituted by keyphrase nodes and relation edges, so the similarity between two keyphrase graphs is calculated by means of their pairwise similarity.

1) Semantic similarity between two keyphrases: This subsection will discuss a method to estimate the similarity between two keyphrases, the most basic components in CK-ONTO, from which other similarity metric can be built upon.

Let $\alpha : K \times K \rightarrow [0, 1]$ be the mapping to measure semantic similarity between two keyphrases. Value 1 represents the equivalence between two keyphrases and value 0 corresponds to the lack of any semantic link between them. To calculate the value of α we first have to present some preliminary definitions:

Definition 8. *Given a knowledge domain modeled by CK-ONTO O = (K, C, R, Rules) and two keyphrases $k, k' \in K$, the keyphrase k' is called **directly reachable** from the keyphrase k if there exists a relation $r \in R_{KK}$ such that $(k, k') \in r$ (or written as k r k'). We can also said that k' is directly reachable from k by r.*

*When k' is directly reachable from k by relation $r \in R_{KK}$, the triplet (k, r, k') could be assigned a decimal number in the interval (0.0 ... 1.0], denoted as $val(k, r, k')$. This number stands for the **axiomatic similarity degree** of k and k' according to r.*

The similarity degree of two keyphrases linked by a relation depends mostly on that relation. For example, two keyphrase linked by $synonym$ relation must have much larger similarity degree than two keyphrases linked by $hyponym$ relation. On the other hand, two pairs of keyphrases linked by the same relation may have slightly different semantic similarity. This value should be established by a panel of experts in the given domain adhering to some constraints, for example:

- $\forall k_1, k_2, k_3, k_4, k_5, k_6 \in K$, if $k_1 r_i k_2, k_3 r_j k_4, k_5 r_t k_6$, where r_i is a equivalence relation, r_j is a hierarchical relation and r_t is a non-hierarchical relation then $val(k_1, r_i, k_2) > val(k_3, r_j, k_4) > val(k_5, r_t, k_6)$
- $\forall k, k' \in K$ if $k r_i k'$ where $r_i \in \{r_{syn}, r_{abbr}\}$ then $val(k, r_i, k') \approx 1$

Definition 9. *Given a knowledge domain modeled by CK-ONTO O = (K, C, R, Rules) and two keyphrases $k, k' \in K$, the keyphrase k' is **reachable** from the keyphrase k if there is a chain of keyphrases $k_1, k_2, ..., k_n$ with $k_1 = k$ and $k_n = k'$ such that k_{i+1} is directly reachable from k_i, for i = 1,..., n-1.*

Let $R_{KK} = \{r_1, r_2, ..., r_m\}$ be a set of binary relations on K, sequence of integers $S = (s_1, s_2, ..., s_{n-1}), s_i \in [1, m], r_{s_i} \in R_{KK}$, the notation $(k_1 r_{s_1} k_2, k_2 r_{s_2} k_3, ...k_{n-1} r_{s_{n-1}} k_n)$, called a **path** of length n-1 from k to k' in CK-ONTO, denotes a finite sequence of relations which joins a sequence of distinct keyphrases and obtained from the reachable relation between k and k'. $(r_{s_1}, r_{s_2}, ..., r_{s_{n-1}})$ is the relation sequence of the path and $(k_1, k_2, ..., k_n)$ is the keyphrase sequence of the path.

Definition 10. *Given a path $(k_1 r_{s_1} k_2, k_2 r_{s_2} k_3, ...k_{n-1} r_{s_{n-1}} k_n)$ from k_1 to k_n in CK-ONTO, the **weight** of such path is defined by the formula*

$$V(k_1 r_{s_1} k_2, k_2 r_{s_2} k_3, ...k_{n-1} r_{s_{n-1}} k_n) = \prod_{1}^{n-1} val(k_i, r_{s_i}, k_{i+1})$$

Definition 11. *For all $k, k' \in K$, the mapping α measuring semantic similarity between k and k' would be defined as follows:*

- $\alpha(k, k') = 1$ if $k = k'$
- $\alpha(k, k') = 0$ if k' is not reachable from k
- $\alpha(k, k') = Max(\{V(P) \mid P \text{ is a path from k to k'}\})$ otherwise

There may exist many paths from k to k' and the value of $\alpha(k, k')$ would be the maximum weight of those paths. So to calculate $\alpha(k, k')$ we have to solve the **maximum weight path problem**, which is to find the path of maximum weight from keyphrase k to k'.

However, one may note that if we extend an existing path by adding one more relation and keyphrase to it, its weight will be multiplied by a number between 0 and 1, thus will likely to decrease. Therefore, our maximum weight path problem is indeed a special case of shortest path problem which can be solved quite easily.

The algorithm 1 is a modified version of the classic Dijkstra algorithm that can calculate $alpha$ between two keyphrase. The typical complexity of Djkstra algorithm implement using binary heap is $O((|E| + |V|) * log|V|)$ whereas in our case, $|E| = \sum_{r \in R_{KK}} |r|$ and $|V| = |R_{KK}| * |K|$

Algorithm 1 Calculate semantic similarity between two keyphrase k_1 and k_2

Data: $O = (K, C, R, Rules)$ - the knowledge domain modeled by CK-ONTO, where $R = (R_{KK}, R_{CC})$
Input : Two keyphrases $k_1, k_2 \in K$
Output: The semantic similarity $\alpha(k_1, k_2)$

```
Q ← Empty Priority Queue /* Each item in Q is a {keyphrase, value} pair and item with maximum value is at the front of the queue */
visited ← Empty hash table /* Used to keep track of visited keyphrase */
Q.enQueue({k1, 1})
while Q is not empty do
    {k, value} ← Q.DeQueue()
    visited.insert(k)
    if k = k2 then
        return value
    else
        foreach relation r in R_KK do
            foreach keyphrase k' in K where k r k' do
                /* We consider every keyphrase k' with whom k have relationship r */
                nextValue ← value × val(k, r, k')
                if visited.Contain(k') = false then
                    Q.enQueue({k', nextValue})
                end
            end
        end
    end
end
return 0 /* There is no more keyphrase to visit */
```

2) Semantic similarity between two relations: When dealing with the determination of possible relationships between keyphrases, one may notice that there could be more than one way to making sense of the relation between a pair of keyphrases. For example, when two keyphrases that occur in the same sentence, one can try to deduce their relation in terms of grammatical role in the sentence or just simply leave them as having 'co-occurence' relation, whatever suits the application at hand. Another example is the 'kind-of' relation and 'subtopic' relation. They are sometimes interchangeable (depend on how one categorizes the set of keyphrase). This notion of interchangeability between relations gives rise to the demand for semantic similarity evaluation between two relations:

Let $\beta : T_R \cup T_S \times T_R \cup T_S \rightarrow [0, 1]$ be a mapping which allows to value the semantic similarity between two relations. T_R is a set of relation names found in R_{KK} and T_S is a set of names of syntactic relations between keyphrases. Because the number of relations is small, we can determine the values of β through an arbitrary pre-defined lookup table. Although the expression of this function can be determined arbitrarily (even the values of β can manually been chosen), some constraints should be considered, for example:

- $\forall r \in T_R \cup T_S, \beta(r, r) = 1$.
- $\beta(synonymy, abbreviation) = 1$.
- Relations that are in the same group (such as Hierarchical relations) should have more semantically likeness than relations in different groups.

3) Semantic similarity between two keyphrase graphs: The fundamental notion for studying and using KG is homomorphism, also called a projection. A KG projection is a mapping between two KGs that preserves the KG structure and provides means to evaluate the relevance between two KGs. More concretely, a projection from a KG H to a KG G is a function from the nodes of H to the nodes of G, which respects their structure, i.e. it maps adjacent vertices to adjacent vertices.

Definition 12. *Let $H = (V_H, E_H, \phi_H, l_{E_H})$ and $G = (V_G, E_G, \phi_G, l_{E_G})$ be two simple keyphrase graphs defined over the same $O = (K, R_{KK})$ of CK-ONTO. A KG projection from H to G is an ordered pair $\Pi = (f, g)$ of two mappings $f : E_H \rightarrow E_G$, $g : V_H \rightarrow V_G$ satisfying the following conditions:*

- f and g are injective functions.
- The projection preserves the relationships between vertices of H, i.e. for all $e \in E_H, g(adj_i(e)) = adj_i(f(e))$, $adj_i(e)$ denotes the ith vertex adjacent to edge e.
- $\forall e \in E_H, \beta(l_{E_H}(e), l_{E_G}(f(e))) \neq 0$.
- $\forall k \in V_H, \alpha(k, g(k)) \neq 0$.

The following condition can be set if desired: $\forall r, r' \in T_R \cup T_S$ where $r \neq r', \beta(r, r) \neq 0$. This condition allows that there exists a projection from any relation edge to any other one.

The definition of KG projection provides the vessel through which we can evaluate the relevance between two piece of texts represented by keyphrase graphs. However, some texts can be considered as related to each other even if only a portion of them are similar. Therefore, it could be more feasible to find a projection from only a portion of keyphrase graph to another keyphrase graph. We call this a partial projection:

Definition 13. *There is a partial projection from a keyphrase graph H to a keyphrase graph G if there exists a projection from H', a sub keyphrase graph (subKG) of H (H' $\leq$ H), to G.*

Below described formula allows valuation of one projection. In valuation formula of the projection from H to G, H is a query graph and G is a document graph.

Definition 14. *Let H is a keyphrase graph of the query q and G is a keyphrase graph of the document d and H' $\leq$ H. A valuation of a partial projection* Π *from H' to G is defined in formula (5):*

$$v(\Pi) = \frac{|V_{H'}|/|V_H| \sum_{k \in V_{H'}} w(g(k), d) \cdot \alpha(k, g(k)) + \sum_{e \in E_{H'}} \beta(e, f(e)) \cdot w(e)}{|V_{H'}| + |E_{H'}|} \quad (5)$$

The main idea of a searching method is the semantic relevance calculation between a query and a document. Therefore, it is necessary to evaluate the similarity between two keyphrase graphs that represent them. There can be a (total) KG projection from the query graph to document graph even if the document does not perfectly fit the query. The valuation of this projection will not be maximum. However, there may not be any total projection between the two graphs even though they may be related, and then partial projections between them are necessary. The result of relevance evaluation would be the maximum value of those partial projections.

Definition 15. *Let H is a keyphrase graph of the query q and G is a keyphrase graph of the document d. Semantic similarity between two keyphrase graphs H and G is defined as:* $Rel(H,G) = Max(\{v(\Pi)|\Pi$ *is a partial projection from H' to G,* $H' \leq H)\}$

The problem of finding a partial projection between two keyphrase graphs such that the value of projection is maximized is posed. The process for finding the maximum partial projection between two keyphrase graphs is very complicated. The general way to calculate Rel(H,G) is to start with finding all sub keyphrase graphs of H and then for each sub keyphrase graph H' of H to find every projections from H' to G and return the maximum evaluation value of all projections. Unfortunately, the computation involved in this way may be a NP-complete problem. In this paper, we do not follow the definition of maximum partial projection in a mathematical way as well as find the optimal solution.

Fig. 4 and 5 shows a document graph and the best projection from a query with the relevance ratio of 53.7%.

TITLE: **Frontend Engineer - Core**
- 5+ years experience building highly-scalable interactive web applications (e-commerce preferred)
- Expert knowledge of JavaScript
- Strong knowledge of HTML5 & CSS3.
- Knowledge of Angular & Reat are definitely a plus
- Strong familiarity of server-side web technologies such as Nodejs, Python, Ruby, JSP, etc.
- Experience writing object-oriented code, especially in Javascript
- Experience working with database technologies
- Experience working in a test-driven development
- Familiar with Agile methodologies
- Experience working with open source technologies is required and contribution to open source systems is a plus

Fig. 4. An excerpt from a job posting (document)

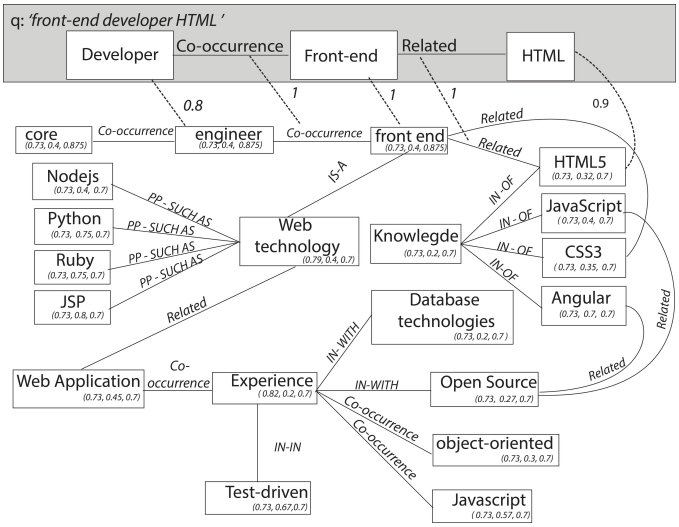


Fig. 5. An excerpt of keyphrase graph corresponding to above document and an example of keyphrase graph matching

Algorithm 2 Find every sub keyphrase graph of KG

Function `findAllSubKG(`*subkg, kg, minSize*`)`
- **input :** $subkg$ the collection of all sub keyphrase graph - passed by reference
- **input :** kg the orginal keyphrase graph - passed by value
- **input :** $minSize$ the minimum number of keyphrase in a sub keyphrase grap - default to 1
- **Result:** All keyphrase graph of kg will be stored in $subkg$

if `Count( Vertices(`kg`)) >` $minSize$ **then**
- **foreach** *keyphrase* k *in* `Vertices(`kg`)` **where** k *has no relation* **do**
  - $tmp \leftarrow kg$
  - tmp`.RemoveKeyphrase(`k`)`
  - $subkg \leftarrow subkg \cap \{tmp\}$
  - `findAllSubKG(`*subkg, tmp, minSize*`)`
- **end**
- **foreach** *relation* r *in* `Relations(`kg`)` **do**
  - $tmp \leftarrow kg$
  - tmp`.RemoveKeyphrase(`k`)`
  - $subkg \leftarrow subkg \cap \{tmp\}$
  - `findAllSubKG(`*subkg, tmp, minSize*`)`
- **end**

end

B. Semantic Search Algorithm

With all the similarity measurement defined, the next ingredient for the semantic search system would be the algorithms to effectively calculate all those measurement. First we have to find all sub kepyrase graph of the query keyphrase graph. Since query keyphrase graphs are usually small, about 6 vertices or less, we can exhaustively search for all sub KG using algorithm 2

Exhaustively search for all projections between two keyphrase graph however is not a trivial task, so we opted for a heuristic approach as presented in algorithm 5.

VI. Application and Experiment

This section discuss the hand-on experience in building a semantic document retrieval system with SDB framework. We present a few most notable experiment systems we have built, especially the newest - it job posting retrieval system and how we evaluate its retrieval performance.

The section also discuss the experiment and evaluation setup for our SDB framework. The contemporary trend is evaluating each key tasks in the systems using standardized dataset. This line of evaluation would allow for easier comparison between approaches as well as help pointing weakpoints for future refinements. However, this paper want to strive for

Algorithm 3 Evaluate all projections from keyphrase graph h to larger keyphrase graph g

input : keyphrase graph h
input : a smaller keyphrase graph g
output: The maximum relevance value of all projection from g to a subKG of h

```
isolateProjection ← Maximum weight matching from all isolated keyphrase in g to isolated keyphrase in h
result ← 0
matchComplete ← TRUE
foreach relation rh in h do
    foreach relation rg in g where β(rh, rg) > 0 do
        /* We consider every keyphrase k'
           with whom k have relationship r */
        if α(rh.sourcce, rg.source) = 0 or
         α(rh.destination, rg.destination) = 0 then
            continue /* source and destination
               keyphrase of rh and rg have no
               relevance */
        end
        projection ← Empty matching
        projection (rh) ← rg
        projection (rh.source) ← rg.source
        projection (rh.destination) ← rg.destination
        Q ← Empty Queue
        Q.enQueue(rg.source)
        Q.enQueue(rg.destination)
        while Q is not Empty do
            kg ← Q.deQueue()
            kh ← projection (kh)
            hNeighbors ← { adjacent keyphrase vertices i
             from kh in h where projection (i) is null }
            gNeighbors ← { adjacent keyphrase vertices i
             from kg in g where projection (i) is null }
            if gNeighbors not = ∅ then
                matched ← the maximum weight matching
                 from gNeighbors to hNeighbors
                if matchednot = null then
                    projection ← matched ∪ projection
                    Q.enQueue (gNeighbors)
                end
                else
                    matchComplete ← FALSE
                    break
                end
            end
        end
        if matchComplete not =FALSE then
            projection ← matched ∪ isolateProjection
            result = max (result, evaluate (projection))
        end
    end
end
return result
```

real-world applications with extrinsicly evaluating. Therefore an application-specific dataset that can simulate real-world documents and queries may be a better setup.

A. Meet ITJPRS: An IT Job Posting Retrieval System

The prime motivation for this system is to help job-seekers, people who are interested in another career opportunity, in searching for the most relevant job description on various job posting websites.

We target the Information Technology job posting domain for this systems due to the sheer amount of job postings available online, as well as a large number of potential users. Especially in Viet Nam, where the Tech Industry is fast growing and oversee a high job switching rate.

The special nature of job postings also provides interesting challenges for retrieval systems. Most job postings are very brief but contain a lot of keywords and catchphrases. They also do not conform to formal grammar and as our experiment will later show, traditional text retrieval systems have a lot of struggle with them.

While building the system as well as the experiment settings, we focus solely on the job's description. Special information about employment conditions, like salary, benefits, work hours, etc., if ever mentioned in the job posting, are not given any special consideration.

Our userbase demographic survey reveals three groups of job-seekers. The first group includes people interested in information technology domain but haven't completed or even received any training. They are not really looking for new position, and only want to take a peek and the available opportunities in this field and thus they do not have any particular information need and tend to throw trending keywords at the retrieval system. While our system may serve this group of users, we do not really focus efforts on their usecase.

The second group of users are people looking for their first job in the field. This group have a rough sketch of their information need but struggle to find the best keywords to describe it. While we provided some filters and suggestions to help them narrow down the retrieved results. We don't evaluate the retrieval performance in their usecase.

Our focal group of users are experienced job-seekers who have worked for at least a year or more than one jobs in Information Technology industry. This group can describe their information need effectively both in natural language as well as through selected keywords. They are the dominant demographic group in our assessors forces, helped us forming the experiment scenario and evaluated our system performance.

B. Design SDB for ITJPRS

The IT Job-posting retrieval system are built using SDB framework, the blue print design for this system can found in Fig. 6. Some important steps are discussed in detail below:

1) Building IT Jobs knowledge base: The first step in building a knowledge base in CK-ONTO formalism is to collect the set of keyphrases in the domain. Our starting point would be other reputable open-access resources. Many lexical

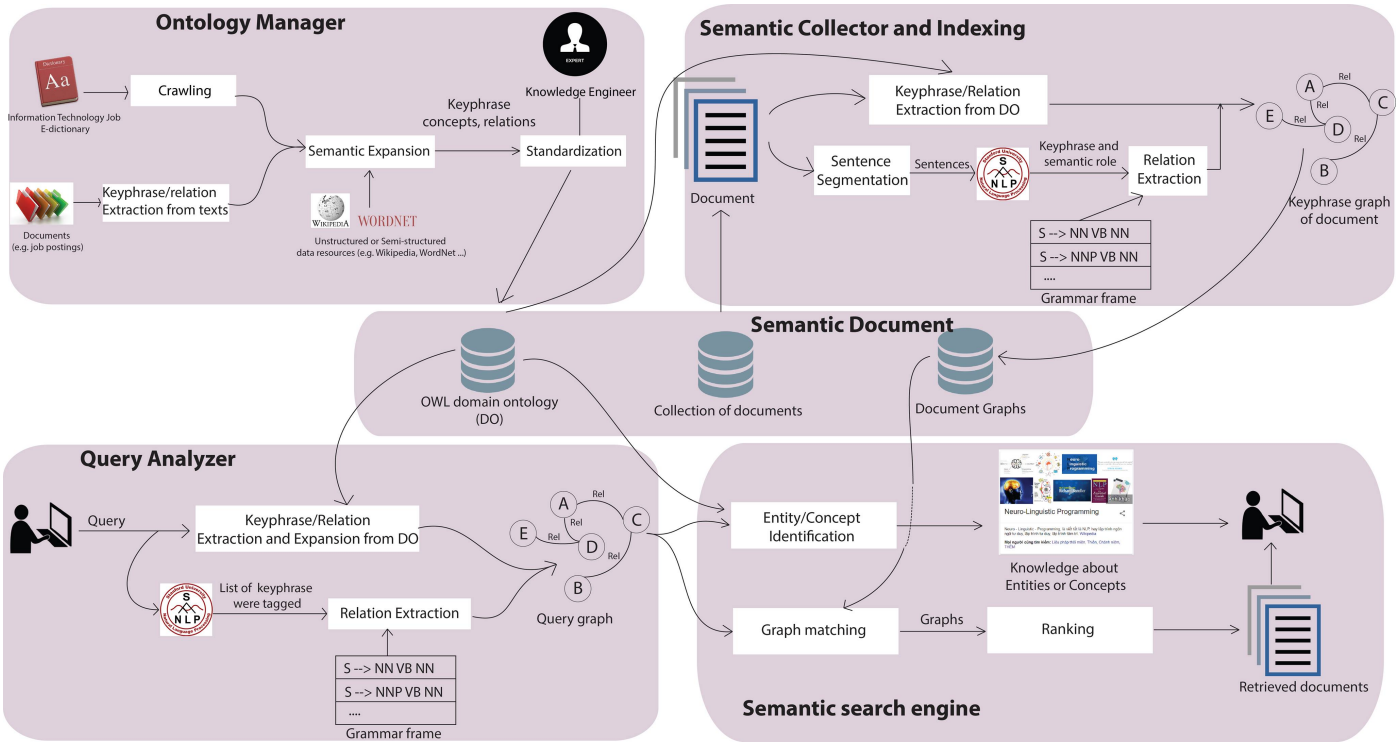


Fig. 6. Architecture of the IT Job posting retrieval system

resources provide a list of keyphrase in a domain along with some manner or categorization for those keyphrase.

Another source we used was the website whatis.techtarget.com, which provides an extensive and up-to-date list of 'terms' in information technology domain, organized in a hierarchy of 'topics'.

Another source of keyphrases is the name of softwares and other Information Technology toolkits deployed in enterprise environment. We notice that a considerable amount of job postings often require hands-on experience with a foray of tools and softwares, many of which are yet to be registered as a term in other lexical resources. Therefore, we also included the list of softwares we found on trustradius.com, a review aggregate service with a hefty list of softwares organized into many categories.

We then cross-referenced with Wikipedia to acquire the definitions of terms as well as the relations among terms. All the data from those sources was indispensible to our knowledge engineers when building the knowledge base.

2) Building weighted keyphrase graphs to represent job posting: Building a keyphrase graph to represent a job posting follows the general framework described in Section IV-C1. However, the challenging characteristics of job postings would dictate some special attention when connecting keyphase vertices in the graph and assigning weighs for those edges.

To determine syntactical relationships among keyphrases that appear in the same sentence, we perform POS tagging using the Stanford Parser on that sentence with special care to make sure the Pos-Tagger won't break keyphrases down into multiple normal words. Then we devise a list of syntactical rules to determine the relationships between tagged keyphrases. The nodes and edges will be assigned weights using the same formulas presented in Section IV-C1 with the parameter c in 'term frequency' formula set to 1.

We allocated each edge of the graph a weight coming from its frequency information in the whole document repository. It is assumed that if two keyphrase vertices connected by the same relationship occur in a lot of document graphs then we can safely say that this relationship between them should be strong and a large weight should be assigned to the corresponding edge. Given an edge e in the document graph $docKG(d)$ connects two keyphrases k_1, k_2, e is labeled with a relation symbol r, and thus can denoted as $e = (k_1, r, k_2)$. The example formula for calculating the weight of e is given below:

$$w(e) = \frac{tf(e, D)}{Max(\{tf(e', D)|e' \in KG(D)\})} \quad (6)$$

in which, $tf(e, D)$ is the number of documents in D where its keyphrase graph contains e (thus it is a "global" statistic) and $KG(D)$ is the set of keyphrase graphs that each represents a document in D.

C. Evaluating Job Posting Retrieval Performance

1) Experiment setup: We evaluate our system performance in ad hoc search, the most standard retrieval task, in which a system aims to collect a list of job-postings that are relevant to an arbitrary user's information need. Our model users are experienced job-seekers in Information Technology domain, who frequently look for and read job-postings, and thus are quite familiar with keyphrases in the domain.

A typical test collection for text retrieval system consists of 3 parts: (1) a collection of documents, (2) a set of sample queries and (3) the golden standard relevance assessment that states which document is relevant to which query by a group of human accessory experienced in the domain.

2) Documents: For our document collection, we collected job postings on the website stackoverflow.com[1] during three months of summer, 2018. To assert the high quality of collected documents, we only download job-postings that filled in all following fields: title, job overview, company's name, expected salary, technology, job descriptions, benefit and company overview. A total of 2500 job postings was downloaded in HTML format, we then parsed them into plain texts for the retrieval system to process.

3) Topics: We format our sample queries in a similar fashion to TREC "topics". Each topic represents an information need from users and contains a title field and a narrative field. The title contains between one to five keyphrases that best describe the information need. This is the data that was given to the system as a search query. The narrative field is a natural language statement that gives a concise description of the information need and potential relevant job-postings. This field is used to co-ordinate our assessors, making sure all assessors have the same understanding of each topic to judge its relevance to documents.

To make sure the information need in our experiment reflect real world situations, half of our topics was inspired by suggestions from popular search engines. Our assessors would input one keyphrase into the search engine then scan the suggestions for valid job-seeker's need and build a topic around them. Since most search engines will suggest queries as you type based on previous search request history they received, those suggestions give an insight to real queries submitted by a broad user-base. Around 50 topics were built in this way. Another 50 topics were synthesized by our accessors, based on their own experience in job seeking as well as in coporate recruiting process.

4) Relevance assessing: The relevance assessments are the combining factor that turn documents and topics into a test collection. We told our assessors to assume that they have the information need described in the topic and they are 'between jobs'. If there is a reasonable chance they would apply for the opening described in the job posting, that job posting is to be marked as 'relevant', otherwise, that posting is to be marked as 'irrelevant'. Assessors are also told to look at job title, overview and description only, information like company's name, benefits and working conditions are hidden from assessors.

It is a well known fact that the relevance is highly subjective, the assessments may vary not only across assessors but also vary for the same assessor across different times. To circumvent this, we schedule our assessors to work only on a subset of topics that he/she feels most comfortable with. We make sure those subsets overlap so that each topic-document pair is assessed by at least five assessors. To avoid assessing fatigue and to ensure that documents are assessed independently from each others, assessors are told to work on a batch of 500 documents at a time. They would assess one topic across 500 documents, then go on to the next topic. Only when they complete their set of topics that they comeback to judge the first topic across another 500 documents.

Working in this manner, it took our assessors about six months to complete their work. We then combine assessors' opinion in a majoritarianism manner. A document is relevant to a query only if more than half the number of assessors agree it is relevant.

5) Evaluation results and discussion: The classic recall and precision index are used to evaluate the effectiveness of the our document retrieval system. We compared our system against Lucene, a traditional search engine that has been long established as the baseline for information retrieval. The verbatim installation of Lucene however, got abysmal performance with only single digit precision overall as seen in Table VI. This is owing the characteristics of job postings we mentioned before. While some jobs may have vastly different job descriptions. In Lucene's eye, a good response for the query 'front-end web developer' could be job-postings for 'junior mobile developer' or 'senior game developer' or anything contain the term 'develope'.

To dewindle this challenge, we also run Lucene with our customized tokenizer to make sure that Lucene can recognize keyphrases in the domain. This 'Lucene + CK-tokenizer' method achieved a drastical improvement in precision while maintained a decent recall rate and would serve as the new baseline for our comparisions.

Another improvement that can be done on behalf of Lucene is to perform query expansion using our knowledge base before passing the keyphrase sets to Lucene. We experimented to find out the best limit for the expansion, starting off with keyphrases that have 'equivalence' relationships with the original query, then keep adding keyphrases while watching the performance record. It is observed that F1-score would peak out with the inclusion of both 'equivalence' keyphrases and 'hyponymy' keyphrases, including evermore keyphrases would just diminish the precision. This 'Lucence + CKQe' experiment helps evaluating the potent of our CK-ONTO model in boosting the performance of traditional simple baseline retrieval method.

For our method, we performed one extra experiment besides the final method presented in this article. We created an SDB system that represents job-postings using the form of keyphrase graph with only semantic relation edges. That means even if two keyphrases appear in the same sentence in the document, they will not be linked by an edge if their relationships cannot be found in the knowledge base. This 'SDB+docKG' experiment helps attesting the potential of combining semantic relationships and syntatical relationships.

TABLE VI. PERFORMANCE OF JOB SEEKING SYSTEM (IN PERCENTAGE)

Model	Precision	Recall	F-score
SDB + fulldocKG	77.1	77.8	77.4
SDB + docKG	70.3	71.9	71.1
Lucene	8.7	98.5	16.0
Lucene + CKTokenizer	43.7	58.5	50.0
Lucene+ CKQe	45.1	70.3	54.9

[1] stackoverflow.com/jobs

TABLE VII. PROTOTYPE KNOWLEDGE BASE METRICS

statistic	Computer Science KB	IT-Jobs KB	Labor & Employment KB
keyphrases	15968	6755	2764
concepts	10946	4356	1523
keyphrase relationships	192089	40757	20347

One can observe that our models can maintain better performance compare to two other models. While the Lucence combine with query expansion model can provide quite high recall, it still falls short in precision and F measurements.

D. Others Applications Facilitated by SDB Framework

Throughout the development of SDB, we have implemented and tested it in three document retrieval systems:

- *The learning resource repository management system* [20] (educational assistance program) in the University of Information Technology HCM City, Vietnam. This system employs our first version of CK-ONTO to provide semantic search on a repository of English documents (mostly textbooks) in Computer Science domain.
- *The Vietnamese online news aggregating system* [24] in Labor and Employment domain alongside Public Investment and Foreign Investment domain. This system periodically aggregates news articles and provides semantic search capability. It was used Binh Duong Department of Information and Communications, Viet Nam.

Corresponding to those two systems, we built two prototype knowledge bases in CK-ONTO model: Computer Science KB, and Labor & Employment KB. The size of those knowledge bases are described in Table VII.

The prebuilt knowledge bases was used when extracting keyphrases from documents in order to help with the disambiguation of terms. After that, they also helped with determining the relations between keyphrases and forming a graph based representation of documents, which will be used in various retrieval tasks later on. Also, knowledge bases was used when processing queries that users put into the systems. They enable query expansion to include more relevance keyphrases into the search, and support interactive search by suggesting user with potential keyphrases. And finally, the most important use of knowledge base in document retrieval would be to estimate semantic similarity between keyphrases and between concepts. These semantic similarity metrics would be the basis for determining the relevance between document and query or between documents, which is the essence of semantic search.

VII. CONCLUSIONS

In this paper, we proposed a method for designing a kind of document retrieval systems, called Semantic Document Base Systems (SDBS). A semantic document base system is distinguished from a traditional document retrieval system by its capability of semantic search on a content-based indexed document repository in a specific domain.

The Classed Keyphrase based Ontology (CK-ONTO in short) was made to capture domain knowledge and semantics that can be used to understand queries and documents, and to evaluate semantic similarity. CK-ONTO contains keyphrases of relative importance in the domain, which is the building block for other components. Another main component is a set of concepts with definitional structures to provide an unambiguous meaning of the concept in the domain. In addition to being a knowledge model of concepts and their relations, CK-ONTO also resembles a lexical model, in that it groups keyphrases together based on their meaning similarity and labels the semantic relations among keyphrases. Finally, there is a set of rules for constraint checking and inferring relation between two kephrases, between a keyphrase and a class, and between two classes. The structure of CK-ONTO is general and can be easily extended to fit different knowledge domains as well as different kind of applications.

To model document content and to design measures along with algorithms for evaluating the semantic relevance between a query and documents, keyphrase graph - based models and weighting schemes were proposed. Each document can be represented by a compact graph of keyphrases in which keyphrases are connected to each other by semantic relationships. A distinctive feature of weighted keyphrase graphs: they allow to represent semantic and structural links between keyphrases and measure the importance of keyphrases along with the strength of relationships whereas poor representation models cannot. Relevance evaluation between the target query and documents is done by calculating the semantic similarity between two keyphrase graphs that represent them. We defined a KG-projection between two KGs along with necessary formulas and algorithms to evaluate the similarity between them.

The proposed design method has been applied in a foray of applications, the latest of which is IT Job-posting retrieval system. The designing process of that system was presented in depth along side with experimental setup and dataset preparing and evaluating process.

As future work, we are planning on building a public gateway to provide access to our aforementioned knowledge bases. Moreover, we are revising said knowledge bases as to enable linking data between our knowledge bases and others knowledge sources on Semantic Web. Finally, we are resolved to incrementally update the CK-ONTO model and periodically release new versions. A few elements of CK- ONTO that still in need of additional work are the inferring rule and a formal reasoning engine to go along with it. Besides tools to help knowledge engineer through automation of some tasks are in dire need. Moreover, the rich choices of available weighting schemes and techniques also raise a challenge of how to incorporate them together and fully explore the potential of keyphrase graphs for better retrieval performance. And finally, the algorithms to calculate similarity between keyphrase graphs can also use some improvements.

ACKNOWLEDGMENTS

This research is funded by Vietnam National University HoChiMinh City (VNU-HCM) under grant number C2018-26-08

REFERENCES

[1] Bizer, Christian, Jens Lehmann, Georgi Kobilarov, Sören Auer, Christian Becker, Richard Cyganiak, and Sebastian Hellmann. "DBpedia-A crystallization point for the Web of Data." Web Semantics: science, services and agents on the world wide web 7, no. 3 (2009): 154-165.

[2] Ngo, Quoc Hung, Nhien-An Le-Khac, and Tahar Kechadi. "Ontology Based Approach for Precision Agriculture." In International Conference on Multi-disciplinary Trends in Artificial Intelligence, pp. 175-186. Springer, Cham, 2018.

[3] Salatino, Angelo A., Thiviyan Thanapalasingam, Andrea Mannocci, Francesco Osborne, and Enrico Motta. "The computer science ontology: a large-scale taxonomy of research areas." In International Semantic Web Conference, pp. 187-205. Springer, Cham, 2018.

[4] ThanhThuong T. Huynh, Nhon V. Do, TruongAn PhamNguyen, and NgocHan T. Tran. "A Semantic Document Retrieval System with Semantic Search Technique Based on Knowledge Base and Graph Representation." In SoMeT, pp. 870-882. 2018.

[5] Yuan Ni, Qiong Kai, Xu Feng Cao. "Semantic Documents Relatedness using Concept Graph Representation", WSDM '16 Proceedings of the Ninth ACM International Conference on Web Search and Data Mining, Pages 635-644, ACM, 2016.

[6] Thomas Hofmann, "Probabilistic Latent Semantic Indexing", Proceedings of the Twenty-Second Annual International SIGIR Conference on Research and Development in Information Retrieval (SIGIR-99), 1999.

[7] Blei, David M.; Ng, Andrew Y.; Jordan, Michael I. Lafferty, John. "Latent Dirichlet Allocation". Journal of Machine Learning Research. 3 (4–5): pp. 993–1022. doi:10.1162/jmlr.2003.3.4-5.993.

[8] Mikolov, Tomas; et al. "Efficient Estimation of Word Representations in Vector Space", 2013. arXiv:1301.3781

[9] Gabrilovich, Evgeniy, Markovitch, Shaul, *Computing Semantic Relatedness using Wikipedia-based Explicit Semantic Analysis*, IJCAI International Joint Conference on Artificial Intelligence. Vol. 6, 2007.

[10] Chenyan Xiong , Jamie Callan , Tie-Yan Liu, Bag-of-Entities Representation for Ranking, Proceedings of the 2016 ACM International Conference on the Theory of Information Retrieval, September 12-16, 2016, Newark, Delaware, USA.

[11] Hadas Raviv, Oren Kurland, and David Carmel. 2016. Document retrieval using entity-based language models Proceedings of the 39th International ACM SIGIR Conference on Research and Development in Information Retrieval (SIGIR 2016). ACM, 65–74.

[12] Faezeh Ennsan, Ebrahim Bagheri, *Document Retrieval Model Through Semantic Linking*, ACM, WSDM, 2017.

[13] Chenyan Xiong , Jamie Callan , Tie-Yan Liu, Word-Entity Duet Representations for Document Ranking, Proceedings of the 40th International ACM SIGIR Conference on Research and Development in Information Retrieval, August 07-11, 2017, Shinjuku, Tokyo, Japan [doi¿10.1145/3077136.3080768]

[14] S S Sonawane, P A Kulkarni, *Graph based Representation and Analysis of Text Document: A Survey of Techniques*, International Journal of Computer Applications 96(19):1-8, 2014.

[15] Faguo Zhou, Fan Zhang and Bingru Yang, *Graph-based text representation model and its realization*, In Natural Language Proceeding and knowledge Engineering (NLP-KE), 2010, pp 1-8.

[16] Francois Rousseau, Michalis Vazigiannis, *Graph-of-word and TW-IDF: New Approach to Ad Hoc IR*, Proceedings of the 22nd ACM international conference on Conference on information and knowledge management 2013, pp. 59-68.

[17] Jianging Wu, Zhaoguo Xuan and Donghua Pan, *Enhancing text representation for classification tasks with semantic graph structures*, International Journal of Innovative Computing, Information and Control Volume 7, Number 5(B), 2011.

[18] Michael Schuhmacher, Simone Paolo Ponzetto, *Knowledge-based graph document modeling*, WSDM '14 Proceedings of the 7th ACM international conference on Web search and data mining, Pages 543-552, 2014.

[19] Yuan Ni, Qiong Kai Xu, Feng Cao, *Semantic Documents Relatedness using Concept graph representation*, ACM, WSDM, 2016.

[20] Nhon V. Do, ThanhThuong T. Huynh, and TruongAn PhamNguyen. "Semantic representation and search techniques for document retrieval systems." In Asian Conference on Intelligent Information and Database Systems, pp. 476-486. Springer, Berlin, Heidelberg, 2013.

[21] Gruber, Tom. Ontology. springer US, 2009.

[22] M. Uschold, M. King, S. Moralee, and Y. Zorgios, The Enterprise Ontology, The Knowledge Engineering Review, 13(1):31-89, 1998.

[23] Chenyan Xiong, Jamie Callan, Tie-Yan Liu, *Word-Entity Duet Representations for Document Ranking*, SIGIR'17, August 7-11, 2017, Shinjuku, Tokyo, Japan, ACM 2017.

[24] Nhon V. Do, Vu Lam Han, and Trung Le Bao. "News Aggregating System Supporting Semantic Processing Based on Ontology." In Knowledge and Systems Engineering, pp. 285-297. Springer, Cham, 2014.

Immersive Technologies in Marketing: State of the Art and a Software Architecture Proposal

Luis Alfaro[1]
and Claudia Rivera[2]
and Jorge Luna-Urquizo[3]
Universidad Nacional de San Agustín
Arequipa - Perú

Juan Carlos Zuńiga[4]
and Alonso Portocarrero[5]
Universidad Tecnológica del Perú
Arequipa - Perú

Alberto Barbosa Raposo[6]
Pontifícia Universidade Católica do Río do Janeiro
Río do Janeiro - Brazil

***Abstract*—After conducting the historical review of marketing and especially experiential marketing, which considers various types of experiences such as sensations, feelings, thoughts, actions and relationships, seeking in the consumer greater satisfaction and therefore greater effectiveness in the action of marketing, as well as establishing the state of the art of immersive technologies and their applications in marketing, the authors propose a software architecture model for hotel services, which includes the description of hardware and software elements for development and implementation. The model would make it possible to bring customers closer to experiences that are very close to reality, based on their profiles and characteristics, previously treated by a recommendation module included in the proposal, a fact that supports the decision of purchase, with a high degree of adaptation to their needs and requirements. The proposal and development of the model with attributes of originality, aims to contribute to the development and technological innovation of marketing in the hotel industry. Finally, conclusions and recommendations for future work are established.**

***Keywords*—Marketing; experiential marketing; immersive technologies; immersive technologies in marketing**

I. Introduction

In recent years, the hotel industry has presented a significant growth of investments, not only in physical infrastructure, but also in the provision of services, having focused on updates and innovations concerning the technologies used, such as information systems for carrying out operations and business processes and later with the revolution of the Internet and Web portals, and also for offering and advertising hotel services, which allow the realization of reservations and payment of services, as well as the execution of various business transactions. The development of technological concepts such as Internet of Things (IoT), Virtual Reality and Immersion, have led some companies in the tourism sector and the hotel industry to focus on the intensive use of these technologies to explore innovations in marketing and advertising actions, infrastructure and services offered.

Marketing and specifically experiential marketing, which includes the five types of customer experience such as sensations, feelings, thoughts, actions and relationships, according to Schmitt's proposal [1], seeks consumer experiences, greater satisfaction and therefore greater effectiveness in marketing action, which focuses on enriching experiences based on direct communication of marketing actions towards the senses of the consumer so as to influence on their decision and relationship with a product, service or brand.

These marketing approaches, added to the technological resources mentioned, as well as the possibilities of their implementation at a low cost, allow the conception and design of applications that, for example, could show landscapes and diverse hotel services among others, using metaphors through simulation, interaction and rectification, making images and other sensory stimuli connected to sensors and actuators seek the approximation to experiences that are only possible to be lived in the real world, enriching the sensory experiences notably in this way.

These concepts and technologies are considered for the formulation of the proposed model of software architecture of the authors of this work, which includes the descriptions of the hardware and software elements required for its implementation, as well as a recommendation system, which can constitute a trend in the technological development and marketing of the hotel industry, with possibilities of a direct impact on the results of business operations in the tourism sector.

The rest of this paper is organized as follows: Section II describes the fundamentals of Marketing and Experiential Marketing; Section III deals with and explores immersive technologies; Section IV explores immersive technologies applied for marketing and tourism; Section V presents the related works to the topic under study that were developed using immersive technologies; Section VI presents the proposal of software architecture for marketing systems based on immersive technologies for the tourism and hotel industry, and finally, the conclusions and future recommendations for this work are established in Section VII.

II. Marketing and the Experiences

Marketing has been in force since the 1960's and lays its foundations in the consumer's perception of the product or service they consume. For [2], this perception passes through stages on the product or service knowledge, its acceptance or usefulness, to finally decide the purchase of the goods.

For this reason the current paradigm of marketing is to bring the consumer closer to experiences, rather than presenting the attributes of a product or service. According to [3], the lived experience also generates an increase of personal valuations on the good and with it, increase the mouth-to-mouth marketing.

In that sense, several highly successful companies, of Online or Internet nature, are implementing omnicanal strategies and entering the off-line channel, in inverse form to the regular process in the evolution of digital channels. For [4], this is because they seek to generate experiences with their clients through sensory stimulation in physical spaces and digital media.

That is why some authors [3], [5], [6] maintain that products should be offered in the market as experiences; in other words, the conditions should be created so that the use or consumption of the product is more valued than the attributes of the product itself. This implies a greater elaboration in the design of marketing strategies for the promotion and sale of these goods. From the perspective of experience, intangible products also known as services, may be easier to promote and sell, since the customer may be more sensitive to the impact they could have. The intangibility of services, or of places, as well as of the so-called experiences themselves, can allow for greater sensory stimulation, for example, through virtual reality (VR) technologies used in immersive marketing [7].

In this sense, sensory stimulation seeks to ensure that the attributes and properties of products can be perceived through human senses. According to [8], it has been possible to identify that the sense of sight influences persuasion at the moment of deciding; smell at the level of remembrance, by evoking a certain circumstance or moment; touch as a decision maker of acquisition and of greater relationship; hearing as a conditioner of experience; and taste as a complement to experience through the other senses.

Although the ideal case would be that the consumer be exposed to an experience through all senses, in practical terms it is not feasible because of the circumstances in which the product or service is offered to the consumer, the cost incurred and the technology related to the nature of the product or service offered. Whether for intangible products or services, there are several marketing management models that can be considered. However, one particular model allows to establish the characteristics of experiential marketing: the service gap model. This model proposed by Parasuraman, Valarie, Zeithalm and Berry [9], establishes the gap that exists in the perception of the consumer, when comparing the expectation versus the experience itself. This perception impacts the consumer in such a way that it influences their purchase decision and loyalty. In this model, the expectation has a prevailing role since it is the element of comparison, with which the real experience of the consumer establishes a differential that impacts on his memory and sensations. According to [9], expectation is formed from previous experience with the service, explicit and implicit communication, and word-of-mouth comments . Therefore, for [5] experiential marketing must induce customer satisfaction through proportionate emotional and functional values.

Therefore, companies should consider that the consumer today no longer chooses a product or service solely for cost-benefit, but should also include other factors such as emotions, sensations and experiences, which are experienced in the purchase of a product or consumption of a service [10]. Various companies have already begun to implement marketing strategies that provide their consumers with unique and memorable shopping experiences; according to [6], it's in this context that sensory perception plays an important role within experiential marketing.

In seeking to generate a shopping experience in the consumer, sensory marketing aims to generate memories through sensory experiences via sight, hearing, touch, taste and smell. The studies carried out by Mancillan [11], have shown that sensory impacts provoke memories linked to emotions, which make them more enduring in memory.

The role that the mind unconsciously acquires in decision making is increasingly considered relevant, making it clear that purchasing decisions have an emotional component. On the other hand, in recent years, many studies have been published on sensations, consumer behavior focused on sight, taste, touch, smell and hearing, and clearly sensory perception and sensory marketing constitute an emerging area of research [12]. As to the marketing experiences, we already have the first references with Gilmore and Pine [13] in 2002, as a result of specialization from what Hui and Bateson [14], mentioned as service experience in 1991; and Holbrook and Hirschman [15], as experience consumption.

The review of literature allows us to establish that in various investigations, the sensory experience, produced by a marketing action, begins to be related to the immersion experience, using the different senses of the consumer. The first studies found in this area were developed in 2006 [16] and 2008 [17]. In the first case, the article refers to advertising immersion based on video information, exploring mainly the visual aspect in television advertising campaigns [16]. Already in [17], a solution based on the consumer orientation of a bookstore is presented, without describing in greater detail the technologies used to make this visualization of information immersive.

Likewise, in the platform, the research carried out in [7], [18], deals with the concept of immersive marketing with the implementation of various technologies such as NFC, RFID and other types of screens, mainly to induce consumer behavior.

III. Immersive Technologies

A. Virtual Reality (RV)

For [19], RV is defined as: "A computer-synthesized three-dimensional environment in which the plurality of human participants, with appropriate interfaces, can make contact or interact with representations of other humans from the past, present, fiction, and/or invented creatures". For Yoh [20], VR is a technology that simulates reality through software, recreating the effect, essence and sensations of a given situation that does not materialize in real events. It is currently applied in the world of entertainment, education [21], advertising, marketing, Knowledge Management, etc.

According to Psotka [22], in VR there are two types of applications, the "Immersive", where the user is inside the simulation and the "Non-immersive", where the user is outside of the simulation. Another important feature of immersive VR is "Stereoscopy", which allows users to distinguish the depth of the objects they observe, adapting to our natural way of seeing the world around us, which, according to [23] is generated by a binocular vision, creating the illusion of perceiving objects in

three dimensions from two images that are taken from different positions, recreating human three-dimensional vision inside the simulation.

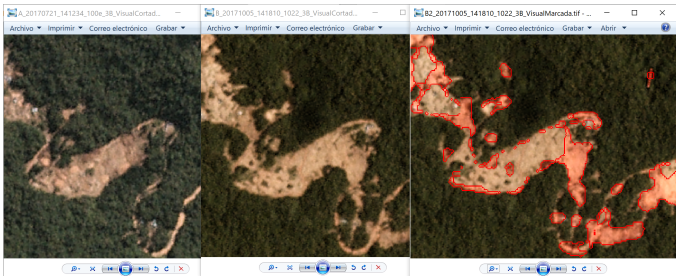
A very important element of VR is depth, which gives us an idea of the position of the objects shown, for which we use various configurations of lights, shadows, colors, slides, including even shapes [24]. For this reason Stereoscopy is a valuable alternative that improves depth perception [23]. Virtual Reality has evolved rapidly in recent decades; in its beginnings VR could only be used by scientific-military laboratories at an excessive cost of implementation. Today, due to technological progress, virtual reality equipment can be available at an affordable cost. It is precisely the unique and special features of these two devices, which are the key components considered for the design of the proposed architecture located in a virtual environment corresponding to this research.

B. 2D, 3D and RV Visualization Modes

There are different approaches to the use of 2D, 3D and RV representations in relation to the Visualization of Information [25], with the following brief description of each of them:

- 2D is the mode of representation that uses only two dimensions, the images are flat, it stands out for its simplicity, clarity and precision when displaying information. At present, a large part of the interfaces are designed for this type of representations. These environments stand out for their precision and clarity in interpreting information. In most of them the interaction is very traditional, using the most common interaction techniques such as: Select and Zoom, Zoom.
- 3D is the mode in which an object is represented in a three-dimensional space, showing its width, length and height, which are mapped in a two-dimensional superficial, as is a monitor. The visual perception of three dimensions is achieved through the use of deep visual elements such as lights, shadows and perspectives, but the final appreciation is flat. These environments facilitate navigation, however, they result only from an extension of the techniques of interaction in two-dimensional environments, which resort to visual effects of lights and shadows to generate the illusion of volume, but the final representation continues to be two-dimensional.
- RV is a technique that enables immersion in a multimodal viewing environment, which also uses stereoscopic images to improve depth perception. In this mode, the three dimensions are perceived as in the real world. Visualization environments based on virtual reality allow the immersion of the user, causing the interaction to be different. Unlike visualization techniques in 2D and 3D environments, VR techniques have not been studied in depth or standardized. An example of VR interaction techniques are: Direct manipulation, in which a virtual hand is available to interact directly with the visualization, and the metaphor of the laser beam, in which a virtual laser pointer is available, with which we can select and manipulate objects and elements.

Generally between 60 and 80 percent of the study objects to be visualized are three dimensional, but most of the visual representations implemented are in 2D, followed by those made in 3D, and as far as those conceived in VR, these are currently very scarce [24]. The debate regarding the quality between 2D and 3D visualizations is still very extensive, but many authors agree that 2D representations are the most appropriate for precision and better interpretation, while 3D representations are useful for better navigation and relative positioning [26]. Fig. 1 shows an example of the three types of environments described above.



(a) Image in 2D. Source: [27]

(b) Image in 3D captured by Scanner. Source: [19]

(c) Composition of Immersive Virtual Reality images. Source: [19]

Fig. 1. Modes of 2D (a), 3D (b), and RV (c) visualization

C. Immersion

For [22], it is a feature of Virtual Reality in which users are within the simulation. Psotka [22], maniests that the fact

that a user is within a simulated virtual environment, has an enormous emotional factor that facilitates cognition and improves information retention, because the user feels that they are part of the software.

In addition, immersion widens the user's range of vision, even allowing displacement (which has been very useful in virtual tours) and collaboration (used for manufacturing applications) [28], [29]. For this purpose, immersion has been achieved through different configurations, for example, it could be that a single giant screen is used as well as anaglyph lenses; another configuration is a CAVE environment consisting of a room with four walls and a projector for each and another is using a headset or glasses that inside have small LCD screens, on which images are projected to the user.

In this research, use will be made of immersion based on a Virtual Reality headset, which is one of the most comfortable to use because of the tiny space taken up, in comparison with others and above all because it provides a greater sense of presence that helps memory and other cognitive processes [30]. However, one of the main drawbacks of this configuration is that it can cause dizziness in certain users.

D. Immersive VR Devices

Over the years different Virtual Reality devices have emerged, most of them manufactured for a specific purpose and not for common use. In this research, in relation to the proposed system architecture, the hardware configuration would be composed of the following devices: 'Oculus Rift', 'Leap Motion' and 'Oculus Go'. Fig. 2 shows the main virtual reality viewers on the market so far. Oculus Rift (Fig. 2a) is the first to include a series of improvements such as stereoscopy and a low latency in the refresh rate . Hololens (Fig. 2b) experiments with how to mix virtual reality and augmented reality, in addition to creating the first holographic processor. PlayStation VR (Fig. 2c) is created for entertainment purposes and stands out for its sophisticated design. HTC Vive (Fig. 2d) on the other hand, stands out for its good features and development platform. Gear VR (Fig. 2e) uses virtual reality with a wireless approach for which it requires a smart phone. Oculus Go (Fig. 2f) is a similar alternative to the previous one with the difference that its cost is much lower. In Table I, these visors are compared considering the main technical characteristics such as: screen resolution, refresh rate, viewing angle and price.

TABLE I. COMPARISON OF VIEWERS CONSIDERING TECHNICAL ATTRIBUTES AND COSTS. SOURCE: ADAPTED FROM [24]

Visor	Resolution	Refresh rate	Vision angle	Price $
Oculus Rift	2160x1200	90 Hz.	110°	700.00
Hololens	1920x1080	120 Hz.	110°	3,000.00
PlayStation VR	1920x1080	120 Hz.	100°	400.00
HTC Vive	2160x1200	90 Hz.	110°	900.00
Gear VR	2560x1440	60 Hz.	96°	100.00
Oculus GO	2560x1440	72-60 Hz.	110°	169.00

E. Natural User Interfaces

Natural User Interfaces (NUI) are those interfaces in which the user's interaction is natural, common and familiar to him [32]. That is why their design implies the use of new devices that allow this interaction, which goes beyond the use of the keyboard and mouse. These new generations of devices allow the use of software by gestures, tactile contact, corporal movement, voice communication, etc. Examples of NUI devices are the Kinect [33], [34], a device that is capable of copying the movements of the body and passing them to a virtual avatar; this device allows the user to control the application, without requiring another peripheral for the use of software, because it also allows voice recognition for the interpretation of commands.

Fig. 2. Prototypes of interaction devices. Source: [31]

The great advantage of using Natural Interfaces is that they are intuitive and easy to use, unlike traditional ones. For example, for non-native digital users learning to use the mouse is quite complicated, but using Kinect is relatively easy for any user. It is this ease of use that is desired in any user interface, but the NUI should not be applied to any application; for example, it would be very difficult to use a Kinect to operate a word processor.

The recent development of input peripherals and other devices is changing the way of interaction with digital screens; the mouse and keyboard, are being replaced by tactile interfaces and based on body movement [35]. These new ways of interacting are part of the evolution of interfaces, which throughout the history of computing have been evolving, changing and diversifying.

The term Natural User Interfaces - NUI, was coined by Mann [36], who explores new forms of human-computer interaction, prompting a variety of research that focuses on new fields of application. Natural User Interfaces and Virtual Reality are closely related, since the user, being part of the simulation, expects to act as if they were in the real world,

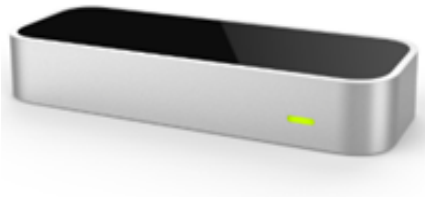
therefore the best option to interact with the software is to use natural user interfaces.

Finally, the NUI are a revolution in the world of computing, not because they will replace the traditional interfaces already existing and which are widely used, but because they make the creation of new types of applications possible,as well as new forms of original and novel interactions that can be applied in Production Engineering, Administration, Marketing, etc.

F. Natural Devices Interaction

Fig. 3 shows the main devices needed to create natural interfaces. Microsoft Kinect 2.0 (Fig. 3a), is the first to appear for the consumer market, created for entertainment purposes for games controlled through transduction, but it was then used for more advanced applications. Nimble VR (Fig. 3b), focuses only on hand recognition.Manus VR (Fig. 3c) unlike the others , uses motion sensors built into gloves.

(a)



(b)

(c)

Fig. 3. Natural Devices Interaction

The historical review and the establishment of the state of the art, allow to glimpse the enormous potential of the resources and elements of immersive technologies, whose use in the marketing strategies, will allow innovative and original approaches.

IV. Applied Technologies for Immersive Marketing

As a marketing and sales strategy, Multichannel is relevant for access to customer segments that otherwise could not be reached. The delimitation of financial and non-financial factors and the criteria for evaluating the development of hotel marketing in the tourism sector is oriented towards the design of the multichannel marketing mix [37]. This multichannel marketing is based increasingly on the use of different devices and technological solutions such as social networks, which according to [38], today are a means of selling and positioning in what is called social media, a means that the tourism sector and especially the hotel sector is using.

Social media plays an important role as it allows the company to communicate and interact with its customers [39]. Techniques such as text-mining are being used, among others, for the analysis of customer opinions in the competitive hotel industry [39]. Techniques that use technical attributes of online text review and that seek to predict the level of consumer satisfaction [40], is another of the current lines of development. However, the so-called “immersive” technologies are the most promising to carry out the effective implementation of the concepts of experiential and sensory marketing.

Research in immersive technology is applied to diverse environments, including education, marketing, business, and medical care [41], y and is implemented through technologies called Virtual Reality (VR) and Augmented Reality (AR), which have greater utility and depth over immersion.

In [42], researched the effect of recent Virtual Reality technologies on consumer behavior and established guidelines for designing an environment capable of delivering a memorable, high-impact experience and attracting potential audiences and consumers, anytime, anywhere. These authors propose a VR environment design with technological characteristics of interactivity, hypertextuality, virtuality (presence of virtual elements), modality, location specificity, mobility and connectivity. The environment considers the technological characteristics of virtual reality, in terms of the capacity of virtual reality devices, which can have an effect on cognition, affectivity and behavioral manifestations.

It is in this context is that the Immersive Virtual Reality offers unique experiences in which the client or user lives an immersion that allows the perception of a reality through the different senses and, as Winn [43] maintains, there would be possibilities to expand these experiences through transduction, an experience in which the traditional interfaces between the user and the computer are changed and the user literally “dresses the computer” which makes it possible for one to live experiences, using the bodily movements that interact with the system. It is also possible to transform reality through reification, allowing beaches, oceans, swimming pools, hotel facilities, etc. to be seen from various angles and even magnified.

V. Related Works about Immersive Marketing Systems for the Tourism Industry

In [44] a study of the state of the art on the application of Virtual Reality technologies in the tourism sector is carried out, where the concepts of immversive marketing begin to be explored. Among the main contributions of this research we can indicate:

- The immersion of Virtual Reality in the tourism sector determines the type of technological solution applied,

which can be non-immersive, semi-immersive and totally immersive. The more immersive the solution, the more complex and complicated will the technological devices and the virtual content be.

- The technological devices, which for cost-benefit and immersion capacity, are mostly used in VR solutions in tourism are the HMDs - Head Mounted Displays or also called lenses or virtual reality headsets. There are high immersion HMDs that communicate with cable or wireless computer systems. There are also low cost and low immersion HMDs based on smartphones and cardboard parts.

Already in [45] the concept of "Customer Journey" is developed which illustrates all stages of a tourist's travel experience as a circular sequence. These stages consider that travelers use technology to: planning, booking, preparing, travel, arrive at the destination, and finally enjoy the destination. Considering these stages and the technologies that can be applied in each of them to explore experiential sensory marketing, this proposal seeks to apply in a first moment the development of technological solutions for the stages of planning, booking, arrival at the hotel, and enjoyment of hotel services [45].

Considering the "planning" stage, the digital technologies with which the traveler initially interacts are the Web sites and/or Web portals that offer tourist and hotel services [46]. Other factors to consider in "planning" are cultural characteristics, age ranges, and social conditions of travelers [47], in order to adequately outline the services to be offered, as mentioned by [48]. Therefore, our present proposal will consider all these factors to have a first contact with the traveler with immersive technologies appropriate not only from the technological point of view but also cultural context, which will allow us to develop concepts and solutions of profiling and recommendation.

The "arrival at destination" stage refers to the different services, products, events and other situations that may be in the context of the tourist and hotel service [44]. In this sense, immersive technology seeks to expand and improve the experience with these services, products and events, adding more information and allowing travelers to have a sensory experience. For [49], this requires not only immersive technology but also other hardware technologies that allow this information to be provided considering the context and location of services, products and events.

The review made it possible to establish that there are many research works that dealt with marketing actions, based on immersive technologies. However, in the opinion of the authors, it is important that in the specific case of experiential marketing, which considers five types of consumer experiences, the focus must be on aspects related to:

- Sensations, which appeal to the senses with the aim of creating sensory experiences, through sight, hearing, touch, taste and smell [1], which can be generated with display devices and natural NUI user interfaces, allowing to create experiences through different senses.
- Feelings, which appeal to the innermost feelings and emotions of consumers, with the aim of creating affective experiences, ranging from slightly positive moods linked to a brand to strong emotions of joy and pride, which can be experienced through the use of metaphors that awaken feelings and emotions based on visual devices and NUI.
- Thoughts, which appeal to the intellect in order to create cognitive experiences, that solve problems and attract consumers creatively; which can be implemented using metaphors and even avatars [50], defined as digital objects, which can represent people, animals or any object that represents information corresponding to the need and preferences of the consumer.
- Actions [10], which focus on creating customer experiences, related to physical aspects, behavioral patterns and lifestyles, as well as experiences that arise from the result of interacting with other people and scenarios, which in this case may be real, virtual world or even avatars.
- Relationships, which aim to offer the customer deep experiences in the social and cultural context, reflected in a brand, which goes beyond the feelings, sensations and actions of the customer as it can create connections between consumers and other users of the brand, which can be emulated, using simulation, transduction, navigation, among other resources of immersive technologies, to generate social relationships with real or simulated characters in virtual worlds.

Although all these types of experiential marketing have their own structure and principles, these are connected and interrelated with each other, the experiential marketing strategy being the incorporation of these 5, for the creation of a holistic experience, which simultaneously integrates each of these five types of experiential marketing elements proposed by Schmitt [1], whose feasibility of realization is possible, using the hardware and software resources of the Emerging Immersive Technologies.

Finally, the personalization of experiences, based on information on user preferences and profiles would be possible through the classification and recommendation module proposed in the model, presented in Section VI.

VI. Software Architecture Proposal

The tourism sector is key to the social and economic development of diverse communities and the fight against poverty. Traditionally, the development of the tourist sector has been directly related to the tourist infrastructure and to the products or tourist routes. Tourism infrastructure requires investments from governments for means of transportation and access, such as airports and highways. Private investments focus mainly on the hotel industry and means of final transportation to the tourist resource.

Currently, the hotel industry not only serves as operational support for the tourism sector, but is increasingly taken as a deciding factor for the realization of events and conventions of great magnitude for sporting, scientific, business and even governmental activities. In this sense, the hotel industry has

become more sophisticated not only in its physical infrastructure, but also in the various services offered and the technology used in all its business processes and activities.

The technological evolution of the tourism and hotel sector began with information systems to improve business processes. Then the Internet revolution, the Web portals to show the hotel services, allowing the reservation and payment of such services. Already the development of technological concepts such as the Internet of Things (IoT), Virtual Reality and Immersion, has made the tourism sector and the hotel industry begin to take advantage of these technologies to better explore the marketing and advertising actions of the infrastructure and services they offer.

The combination of the concepts of experiential marketing and sensory marketing seeks to enrich the experience based on the direct communication of the marketing action to the senses of the consumer, to influence their decision and relationship with a product, service or brand. These marketing concepts, added to the immersive devices and technologies already described, allow the development of actions that generate added value and competitive advantage. In other words, the use of virtual reality lenses to show a hotel landscape or service, whose image is connected to sensors and actuators to enrich the sensory experience, which also considers information on consumer preferences and interests is a sum of concepts and technologies that are trends in technological development and marketing of the hotel industry with direct impact on the tourism sector.

Based on the above, a general and scalable software architecture is proposed that allows the development of VR systems for the scenarios of the tourism and hotel industry. In Fig. 4, the architecture organized in four related modules is presented. The first module at the top is called "Immersive Marketing Strategy", where the marketing strategy to be implemented is defined. This includes formally defining deadlines, content types and metrics to evaluate the expected results. The strategy leads to the virtual content generation module to determine what types of objects and virtual content should be created. For example, if the strategy seeks to promote a particular museum, this strategy defines what virtual objects should be created and what interactions are expected to be used.

The "virtual content generation" module provides the structure and links the tools that allow the generation of virtual objects. This includes the generation of 360 degree videos and simulations, which can be complemented with virtual objects that extend the information and interaction that is desired to be represented in the marketing strategy. This module is also responsible for the storage, simulation and testing of virtual content. The evaluation refers to the fact of verifying compliance with the strategy. The simulation already corresponds to the behavior of the solution with respect to different user profiles.

The "Virtual Content Recomendation" module represents the business logic and intelligence that effectively executes the established marketing strategy, since this module is responsible for building user or traveler profiles, considering parameters such as age, gender, country of origin, cultural or religious considerations, etc. In the same way, the recommendation algorithms determine according to the profile and the available immersion device which virtual objects and which interaction dynamics are presented to the consumer.

Finally, the "End User" module refers to the devices available to represent the marketing strategy. These devices and their characteristics determine the degree of immersion that can be achieved. For example, devices such as HMDs, Wired HMDs (Oculus Rift or HTC Vive) or Wireless HMDs (Samsung Gear VR) can allow a high degree of immersion. Already devices such as Google Cardboard represent Low-immersion HMDs, which may allow less interaction, however, from a cost point of view, you may have a greater presence of these devices in the market. In addition, if there is no immersion device itself, the concepts of 360 Video / Web Browser AR / VR can be explored to interact with consumers. It is also important to note that the record of information regarding the interaction and immersion are recorded and used according to the evaluation metrics of the marketing strategy, to determine the effectiveness of it and rethink new actions to follow.

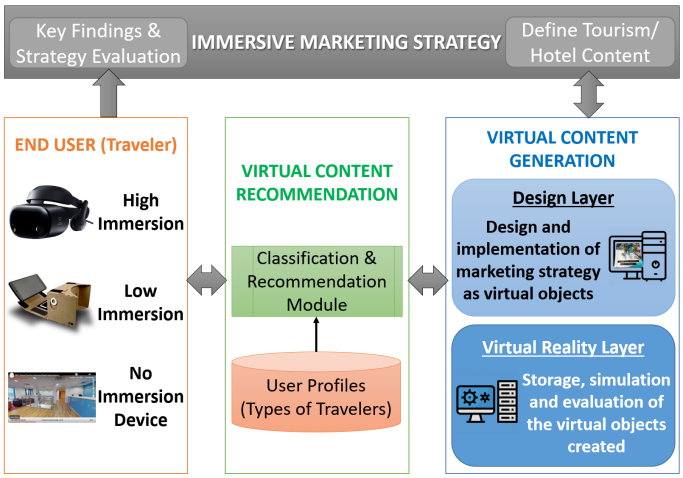


Fig. 4. System model for marketing, using immersive technologies

One of the most important contributions of this proposal is to incorporate a module of business logic and intelligence, whose responsibility is to execute the established marketing strategy, for which it builds profiles of the user or traveler, taking into consideration some specific parameters such as age group, gender, languages, country of origin, cultural and / or religious considerations, and so on. Using recommendation algorithms for this which will allow to determine according to the profile and the available immersion device, which virtual objects and which interaction dynamics will be presented to the user-consumer, and which will make possible the modeling of an immersive Marketing system with important attributes of adaptation to the user-consumer profile, a fact that will allow experiences with a high degree of customization. Likewise, it is also intended to contribute to the technological development and marketing of the hotel industry because technological innovation can have a significant impact on the results of business operations and specifically the tourism sector.

VII. Conclusion

- The state of the art of immersive Virtual Reality and its applications in the marketing of hotel services has been established, allowing us to know the enormous potential of this emerging technology which would make it possible to innovate the forms and methodologies for innovative marketing practices, since experiences close to reality can be considered, using metaphors that include multi-sensorial perceptions that arouse emotions and sensations in the client.
- A software architecture has been proposed oriented to the marketing of hotel services, based on immersive technologies incorporating recommendation algorithms, whose attributes of originality and innovation are unique.
- It is recommended that, in the development of the model proposal, the concepts of experiential and sensory marketing, as well as the immersive technology devices described, should come together. The use of Artificial Intelligence approaches will provide the model with some adaptive features, derived from user profiles, as well as the different environments that may have significance, using recommendation algorithms for this purpose
- It is recommended that the metaphors to be developed for the implementation of the proposed model should be carefully elaborated from the experiences of specialists in hotel and service marketing and Computer Science.
- It is recommended that, for the development of the proposed architecture, the conformation of a multidisciplinary work team should be contemplated, with diverse sources of experience, given the complexity of the investigation to be developed.
- It is important to use Artificial Intelligence approaches in order to provide the model with some adaptive characteristics, derived from the profiles of the users, as well as from the different environments that may have significance for it.

Acknowledgment

The authors would like to thank National University of San Agustín (UNSA), Technological University of Peru (UTP) and Pontifícia Universidade Católica (PUC-Rio- Brazil) for supporting this research.

References

[1] B. Schmitt, "Experiential marketing," *Journal of Marketing Management*, vol. 15, no. 1-3, pp. 53–67, 1999.

[2] C. Grönroos, *Service management and marketing: Managing the moments of truth in service competition*. Jossey-Bass, 1990.

[3] I. Gallo, C. Townsend, and I. Alegre, "Experiential product framing and its influence on the creation of consumer reviews," *Journal of Business Research*, vol. 98, pp. 177–190, 2019.

[4] A. Simone and E. Sabbadin, "The new paradigm of the omnichannel retailing: Key drivers, new challenges and potential outcomes resulting from the adoption of an omnichannel aproach," *International Journal of Business and Management*, vol. 13, no. 1, 2018.

[5] E. Y. Yi-Hua and K. W. Chihkang, "Relationships among experiential marketing, experiential value, and customer satisfaction," *Journal of Hospitality & Tourism Research*, vol. 32, no. 3, pp. 387–410, 2008.

[6] T. H. Pham and Y.-Y. Huang, "The impact of experiential marketing on customer's experiential value and satisfaction: An empirical study in vietnam hotel sector," *Journal of Business Management & Social Sciences Research (JBM&SSR)*, vol. 4, no. 1, 2015.

[7] H. Hyunwoo, S. K. Yang, and J. C. Kyung, "Use of the smart store for persuasive marketing and immersive customer experiences: A case study of korean apparel enterprise," *Mobile Information Systems*, vol. 2017, 2017.

[8] L. Ortegón-Cortázar and A. G. Rodríguez, "Management of sensory marketing on the consumer's experiencer," *Revista de Ciencias Sociales (Ve)*, vol. 12, no. 3, pp. 67–83, 2016.

[9] A. Parasuraman, V. A. Zeithaml, and L. L. Berry, "A conceptual model of service quality and its implications for future research," *Journal of marketing*, vol. 49, no. 4, pp. 41–50, 1985.

[10] F. Balan, "Marketing experiencial," 2015.

[11] M. López-Rúa, "Persuasión a través del marketing sensorial y experiencial," *Opción*, vol. 31, no. 2, pp. 463–478, 2015.

[12] A. Krishna, "An integrative review of sensory marketing: Engaging the senses to affect perception, judgment and behavior," *Journal of consumer psychology*, vol. 22, no. 3, pp. 332–351, 2012.

[13] J. H. Gilmore and B. J. Pine, "Differentiating hospitality operations via experiences: Why selling services is not enough," *Cornell Hotel and Restaurant Administration Quarterly*, vol. 43, no. 3, pp. 87–96, 2002.

[14] M. K. Hui and J. E. Bateson, "Perceived control and the effects of crowding and consumer choice on the service experience," *Journal of consumer research*, vol. 18, no. 2, pp. 174–184, 1991.

[15] M. B. Holbrook and E. C. Hirschman, "The experiential aspects of consumption: Consumer fantasies, feelings, and fun," *Journal of consumer research*, vol. 9, no. 2, pp. 132–140, 1982.

[16] E. P. Goodman, "Stealth marketing and editorial integrity," *TEX. l. rEV.*, vol. 85, p. 83, 2006.

[17] J. W. Donald, "The blood on the stacks arg: Immersive marketing meets library new student orientation," 2008.

[18] H. Skouteris, S. Edwards, H. Morris, R. Cox, L. Baur, L. Wolfenden, and T. T. Huang, "Early childhood education and health working in partnership: the critical role early childhood educators can play in childhood obesity prevention," *Early Child Development and Care*, vol. 187, no. 8, pp. 1239–1243, 2017.

[19] L. A. Alfaro, "Contribuições para a modelagem de um ambiente inteligente de educação baseado em realidade virtual," 1999.

[20] M.-S. Yoh, "The reality of virtual reality," in *Proceedings Seventh International Conference on Virtual Systems and Multimedia*, pp. 666–674, IEEE, 2001.

[21] J. Psotka, "Immersive training systems: Virtual reality and education and training," *Instructional science*, vol. 23, no. 5-6, pp. 405–431, 1995.

[22] J. Psotka, "Educational games and virtual reality as disruptive technologies," 2013.

[23] J. R. Juang, W.-H. Hung, and S. C. Kang, "Simcrane 3d+: A crane simulator with kinesthetic and stereoscopic vision," *Advanced Engineering Informatics*, vol. 27, no. 4, pp. 506–518, 2013.

[24] R. Linares, "Exploration of scientific articles with virtual reality and natural language processing," 2017.

[25] B. S. Zohra, G. Fabrice, R. Paul, B. Julien, and P. Fabien, "An overview of interaction techniques and 3d representations for data mining," *Applications of Virtual Reality*, p. 185, 2012.

[26] S. Dübel, M. Röhlig, H. Schumann, and M. Trapp, "2d and 3d presentation of spatial data: A systematic review," in *2014 IEEE VIS International Workshop on 3DVis (3DVis)*, pp. 11–18, IEEE, 2014.

[27] L. Alfaro, C. Portugal, J. Luna-Urquizo, and J. S. na, "Technical report: Development of image processing algorithms oriented to the recognition and analysis of forestation," tech. rep., Universidad Nacional de San Agustín, Arequipa - Perú, 2019.

[28] K. Wanarat and T. Nuanwan, "Using 3d visualisation to improve public participation in sustainable planning process: Experiences through the creation of koh mudsum plan, thailand," *Procedia-Social and Behavioral Sciences*, vol. 91, pp. 679–690, 2013.

[29] N. Menck, X. Yang, C. Weidig, P. Winkes, C. Lauer, H. Hagen, B. Hamann, and J. Aurich, "Collaborative factory planning in virtual reality," *Procedia CIRP*, vol. 3, pp. 317–322, 2012.

[30] E. Lombardo, S. Agostinelli, and M. Metge, "Could an interactive and total immersive device with hmd improve memory and give the presence sensation?," 2013.

[31] L. Alfaro, R. Linares, and J. Herrera, "Scientific articles exploration system model based in immersive virtual reality and natural language processing techniques," *INTERNATIONAL JOURNAL OF ADVANCED COMPUTER SCIENCE AND APPLICATIONS*, vol. 9, no. 7, pp. 254–263, 2018.

[32] D. Wigdor and D. Wixon, *Brave NUI world: designing natural user interfaces for touch and gesture*. Elsevier, 2011.

[33] N. Villaroman, D. Rowe, and B. Swan, "Teaching natural user interaction using openni and the microsoft kinect sensor," in *Proceedings of the 2011 conference on Information technology education*, pp. 227–232, ACM, 2011.

[34] G. Calle Condori, E. Castro-Gutierrez, and L. Alfaro Casas, "Virtual rehabilitation using sequential learning algorithms," *INTERNATIONAL JOURNAL OF ADVANCED COMPUTER SCIENCE AND APPLICATIONS*, vol. 9, no. 11, pp. 639–645, 2018.

[35] A. Câmara, "Natural user interfaces," in *IFIP Conference on Human-Computer Interaction*, pp. 1–1, Springer, 2011.

[36] S. Mann, *Humanistic Intelligence as a Basis for Intelligent Image Processing*. Wiley-IEEE Press, 2002.

[37] A.-P. Kontis and D. Lagos, "Factor framework for the evaluation of multichannel marketing mixes in 5* city hotels," *Procedia-Social and Behavioral Sciences*, vol. 175, pp. 408–414, 2015.

[38] P. Phillips, S. Barnes, K. Zigan, and R. Schegg, "Understanding the impact of online reviews on hotel performance: an empirical analysis," *Journal of Travel Research*, vol. 56, no. 2, pp. 235–249, 2017.

[39] X. Tian, W. He, R. Tao, and V. Akula, "Mining online hotel reviews: a case study from hotels in china," 2016.

[40] Y. Zhao, X. Xu, and M. Wang, "Predicting overall customer satisfaction: Big data evidence from hotel online textual reviews," *International Journal of Hospitality Management*, vol. 76 Part A, pp. 111–121, January 2019.

[41] A. Suh and J. Prophet, "The state of immersive technology research: A literature analysis," *Computers in Human Behavior*, vol. 86, pp. 77–90, 2018.

[42] M. G. Violante, E. Vezzetti, and P. Piazzolla, "How to design a virtual reality experience that impacts the consumer engagement: the case of the virtual supermarket," *International Journal on Interactive Design and Manufacturing (IJIDeM)*, vol. 13 no. 1, pp. 243–262, September 2019.

[43] W. Winn, "A conceptual basis for educational applications of virtual reality," *Technical Publication R-93-9, Human Interface Technology Laboratory of the Washington Technology Center, Seattle: University of Washington*, 1993.

[44] J. Beck, M. Rainoldi, and R. Egger, "Virtual reality in tourism: a state-of-the-art review," *Tourism Review*, 2019.

[45] L. Neuburger, J. Beck, and R. Egger, "the "phygital" tourist experience: the use of augmented and virtual reality in destination marketing," in *Tourism Planning and Destination Marketing*, pp. 183–202, Emerald Publishing Limited, 2018.

[46] S. Moro, P. Rita, and C. Oliveira, "Factors influencing hotels' online prices," *Journal of Hospitality Marketing & Management*, vol. 27, no. 4, pp. 443–464, 2018.

[47] T. H. Jung, H. Lee, N. Chung, and M. C. tom Dieck, "Cross-cultural differences in adopting mobile augmented reality at cultural heritage tourism sites," *International Journal of Contemporary Hospitality Management*, vol. 30, no. 3, pp. 1621–1645, 2018.

[48] V. Komianos, E. Kavvadia, and K. Oikonomou, "Cultural heritage recommendations and user navigation in large scale virtual environments.," *IJCIStudies*, vol. 4, no. 2, pp. 151–172, 2015.

[49] J. Scholz and A. N. Smith, "Augmented reality: Designing immersive experiences that maximize consumer engagement," *Business Horizons*, vol. 59, no. 2, pp. 149–161, 2016.

[50] R. Linares, J. Herrera, and L. Alfaro, "Aliciavr: Exploration of scientific articles in an immersive virtual environment with natural user interfaces," in *2016 IEEE Ecuador Technical Chapters Meeting (ETCM)*, pp. 1–6, IEEE, 2016.

A Review of Blockchain based Educational Projects

Bushra Hameed[1], Muhammad Murad Khan*[2], Abdul Noman[3], M. Javed Ahmad[4],
Prof. Dr. M. Ramzan Talib[5], Faiza Ashfaq[6], Hafiz Usman[7], M. Yousaf[8]
Department of Computer Science, Govt College University Faisalabad, Faisalabad, Pakistan

***Abstract*—Blockchain is a decentralized and shared distributed ledger that records the transaction history done by totally different nodes within the whole network. The technology is practically used in the field of education for record-keeping, digital certification, etc. There have already been several papers published on this, but no one can't find a single paper covering the blockchain-based educational projects. So, There is a gap of latest trends to education. Blockchain-based educational projects resolve the issues of today's educators. On that basis, we conclude that there is a need for conducting a systematic literature review. This study, therefore, reviews the artistic gap between these two based on educational projects. For this purpose, the paper focuses on exploring some block-chain based projects and protocols that are used in these projects. It also analyses the block-chain features that are being used and the services are offered by the existing educational projects using block-chain features to improve the execution of this technology in education.**

***Keywords*—Blockchain; educational-project; education; digital-certification; record-keeping**

I. Introduction

Block-chain technology was developed first for Bitcoin crypto-currency. The attraction in block-chain has been catching the attention since the idea was coined in 2008 [1], [2]. It is a decentralized and self-regulating technology [3], keeps an open record of all transactions or computerized events that have been executed and shared among partaking parties [4]. Every transaction on a block-chain is verified with digital signatures that demonstrate its originality. Since the use of encryption and digital signatures, the information stored on the block-chain is sealed and can not be changed [5], [6]. Through this, data can be handled and sorted out in another manner: open-source, verified, and shared without the need for a central charge [7].

Because of its unchanging nature, transparency, and security of all transactions implemented in a block-chain, this innovative technology is used in many applications such as health care, education, governance and the business industry [8], [9], [10], [11].

In today's era, block-chain highlights the major and burning issues regarding education and provides suitable solutions for them. The certificate is considered to be depicting the pictorial images of the ability of a person, which was a conventional method of displaying grades on paper. Now, this technology has provided a new trend of imprinting the digital certificate [12]. Unlikely paper certificates, the digital certificates has simplified the process of management [13], [14], [15], [16], [17], [18]. Block-chain technology also causes to reducing degree fraud and improve the system for calculating scholarships for students,evaluation system and salaries for teachers and will provide a fair mechanism with complete transparency for funding projects of education and its grants [15], [19].

For the conversion of today's education system, different educational projects introduced for the user's benefits, but we have to see that these educational projects are not discussed majorly in the single study. There is a gap for describing the latest educational trends.This study views the gap between block-chain in education to the latest educational trends as well as their implementations(applications). To fill this gap, this paper describes some vital blockchain-based educational projects and protocols.

It also analyses the blockchain features that are being used and the services are offered by the existing educational projects using blockchain features to enhance the implementation of block-chain technology in education. This review paper includes some important block-chain educational models from 2013 to 2018. These are Edgecoin, Sucesslife, TeachMePlease, SonyGlobalEducation project, Blockcert, Gradbase, Origin Stamp, Echolink and Tutellus. But there are still some problems, like, scalability issues [20], [21], [11], [3], [9]. Scalability is defined as: "The times is taken to place a transaction within the block,The time is taken to reach a consensus,The time taken to put a transaction in the block".

The paper is divided into 5 sections. Section 2 is concerned with the literature review and describes the features of block-chain. Section 3 explores the Research methodology, Research questions and Search strategy is mentioned. Section 4 covers the results of the research question and the last section concludes the restriction of our review.

II. Review of Literature

This segment of this paper describes a few ideas and theories related to existing studies in the field of block-chain based educational projects and highlights some primary features of block-chain. It also constructs a correlation between the existing secondary studies

A. Blockchain

A blockchain in the simplest term is an immutable record of data that cannot be changed once it becomes part of a blockchain hosted on a decentralized network [11], [22]. Since all record is handled by a group of nodes not owned by a single entity, it is nearly impossible to tamper and update the record on all objects of the network. Every one of these Blocks is bound to use cryptographic proof for signing and verifying the transactions. Nodes start the procedure by making the blocks. Block is hash-checked by each node on the network for verification. The verified block is added to the chain which is archived by the whole system, making not just a tamper-proof record but rather a particular record with a unique history [4], [23], [24], [25].

B. Types of Blockchain

The basic types of blockchain are as follows:

Permissioned Blockchain: Permissioned blockchains act as closed ecosystems, where users are not freely capable of joining the community, see the records, or issue transactions of their own. Permissioned blockchains are favored by using centralized organizations, which leverage the strength of the network for his or her own, inner business operations. Employer consortiums also are likely to hire personal blockchains to file transactions securely, and exchange facts among one another.

Permissionless Blockchain: A permissionless blockchain is open to everyone. It allows every user to create a non-public deal with and start interacting with the network, by way of submitting transactions, and subsequently adding entries to the ledger.

Hybrid Blockchain: The blockchain that utilizes the combination of both private and public blockchain. The hybrid network means permissionless blockchain is used where a permissioned blockchain is hosted. This blockchain is not open to everyone but quietly provides basic features like integrity, security, and traceability.

C. Blockchain Features

The Basic features of blockchain are as follows:

Decentralized: Blockchain is a common open record wherein all nodes are associated with one another in a network [9], [10], [26], [27], [1]. Decentralization refers to the procedure of data confirmation, storages, preservation and transmission on the blockchain which depend on distributed framework structure [28], [30].

Traceability: All transactions on the blockchain are indexed in sequential order, and a block is associated with two adjoining blocks by a cryptographic hash. A total chain of a block is kept up by mining pools, which gives cloud-based sites to investigating the block [9], [28], [30].

Consensus mechanism: A fault tolerant mechanism is a consensus mechanism that is used in PC and blockchain frameworks to accomplish the agreement on a single data of network state among distributed processes or multi-agent frameworks. It is helpful in record keeping. POW, POS, and DPOS are the few procedures of consensus mechanism [9], [32].

Currency: In this revolutionary era, bitcoin was the first digital currency of all cryptocurrencies that have been proposed. Cryptocurrency whose property is blockchain technology which is a digital or virtual currency that ensures end-to-end transactions making it protected and trustworthy. Different mining algorithms are used for the formation of these currencies. Thus, the combined product of blockchain and cryptocurrency can be used in several aspects such as Accounting and Finance [33], [9], [28].

Smart contract: A smart contract is a necessary blockchain protocol that allows developers to code the financial agreement on the blockchain, which is activated by the involved parties [30], [9], [34], [28], [35]. It did not just decrease outsider cost" in conventional transactions yet also significantly ensures the transaction security and quality.

Immutability: When data is entered, it can't be changed [36]. Successful tampering (make unauthorized alterations) would need to change more than 51 per cent of the records put away in the system [9], [28], [29].

Fig. 1 represents the name of basic features of blockchain.

Fig. 1. Basic Features of Blockchain

D. Blockchain Application in Education

Blockchain is a technology that has applications within the world of learning at the individual, institutional, group, national, and international levels. It is applicable in all kinds of frame of reference: Schools, colleges, universities, cooperates, studentship and knowledge bases, instead of old hierarchical structures, the technology becomes the main target, with trust migrating towards the technology, not the institutions. It extremely is decentralized technology (Donald Clark). Some of the Blockchain-based educational projects used across the world are as follows:

Edgecoin: Edgecoin is inside the strategy to structure a Dapp stage for cost bringing down, efficient and Fraud protected ensured great arrangements. It stores academic documents like degrees and accelerated the tip of the paper-based system. This cut expenses for students since they don't need to pay for a legal official. Edgecoin, the innovative reforms the education trade totally, conveyance interruption of the fouled and non-current education, its certifications and validated the procedure. So they're defensive against Fraud, damages, and losses of any kind [36].

Sony Global Education (SGE): Sony Global Education is a new educational platform that came into existence by the partnership of IBM in which we secure and share the record of a student by using blockchain. On 10th August 2017, Sony Corporation and Sony global education announced that we would form such a system on which blockchain technology

will be applied specifically in the Education system. In 2018, Sony will start to establish its service offerings that will start with the global math challenge whose purpose will be to bring 150000 participants from all over the world cooperatively [28], [16], [17], [37], [38].

Tutellus: Tutellus is a new blockchain platform that is expecting to solve the current educational costs for college-level students and in fact paying students for learning. In 2016, online education was having a specified value of USD 165 billion. It is insufficient to complete the need for education in the whole world. Whether the number of graduates who remain unemployed is over 300 million, there is an increasing number of educated people in the market and opposition to the fact, the number of vacancies or posts is gradually decreasing to a great extent. In Europe, 80 percent imbalance between job supply and demand is expected, specifically affecting the technology sector. Resultantly, there is increasing awareness that educational institutions are lacking up to date knowledge according to the employer's needs [**?**]. On the other side, developing countries have millions of unemployed people who are getting access to the Internet with the help of their mobile phones. They can join this platform because, for the poorest, it's rarely affordable. A new method also required to tackle the key problems that market faces that current educational institution has tried to resolve [39], [40], [41].

TeachMePlease (TMP): Teachmeplease (TMP) provides a database of learning institutions for both online and offline schools, as well as different educational programs, from group learning classes for kids to individual sessions with the personal instructor. It needs to work on the delicate data, for example, courses, assignments, solutions, and grades. TMP used permission less blockchain, as Ethereum or EOS, would require revealing this data to the general public, though the agreeable ones, like Hyperledger, need open unquestionable status. TMP promises "a quality platform that provides easy to use service for each of our clients" [42], [9].

SuccessLife: From success resources, Successlife is that the original front runner product, the world-leading seminar and workshop organizer. To make personal and professional development available to as many people as possible. Success Resources founded the blockchain company SuccessLife. Around 543000 new businesses begin every month, of which the SuccessLife primary target. More than 50 percent of the working population work in a private venture small business. Fifty-two percent of all small businesses are home-based.

Blockcerts: Blockcerts is an open-source blockchain platform that was developed for the educational record by MIT Lab with the collaboration of the learning machine. The wallet app is used to encrypt the student information. The main purpose is to produce secure, validate and issue e-certificate by using bitcoin blockchain technology [43], [14].

GradBase: Gradbase is an educational record verification system based upon the bitcoin blockchain technology. It provides an online profile system simply and inexpensively. This system provides a QR code to be included in student CVs. For the enhancement of the user experience, it provides a web browser extension with LinkedIn support. Universes can easily log in the web app for the updation, cancellation the qualifications in the appropriate procedure.

Echolink: Echolink is the abbreviation of "Education Carrier Skills Human Capital Opportunity Link". Echolink is a blockchain-based system that organizes a relationship between educational entities, i.e., Students, teachers, and other organizations. It stores the verified data of individual related to the professional career in the hashed and unalterable format on the permission-less blockchain. All the information are provided by trusted sources.The identified projects are further compared, and related synthesis is presented in the following sections [43], [44].

Origin-Stamp: Origin-Stamp is secure time-Stamping for ensuring the security of digital data. It determines the eccentric fingerprints of the client data and keeps the fingerprints permanently in the Bitcoin blockchain technology [38].

The identified projects are further compared, and related synthesis is presented in the following sections:

E. Compared Secondary Studies

Blockchain technology is, no doubt has got a tremendous appreciation all over the world by its magic and rapid progress. However, while searching for secondary studies, we found just a couple that talks about the latest educational projects. Firstly, a report that was published by the European Commission was found, and we have recognized that in this study there is only a few latest project described in short length, rest latest are not described and even not touched. Second, a systematic literature review that was published in Springer, which discussed the application of blockchain in education, Table I enlists secondary studies concerning the educational project.

TABLE I. COMPARED SECONDARY STUDIES

No	*Blockchain Features*	*BC Based Educational Projects*	*Projects Services*
Grech [8]	3	4	Gap
Yumna [43]	6	3	Gap
This Study	6+3	10	Discussed

III. RESEARCH METHODOLOGY

A Systematic Literature Review is defined as "A method of gathering, identifying and interpreting all available research in order to answer a specific research question" [46], [9]. In this study, we follow the guidelines provided by "Barbara Kitchenham" [45]. The results of this examination help us to distinguish research area related to Blockchain technology and conceivable research gaps. According to Kitchenham, SLR comprises on three main stages as given below:

- Planing the review.
- Conducting the review.
- Reporting the review.

In this research, we follow above these steps for completing research; Fig. 2 shows the steps that are further divided into more stages.

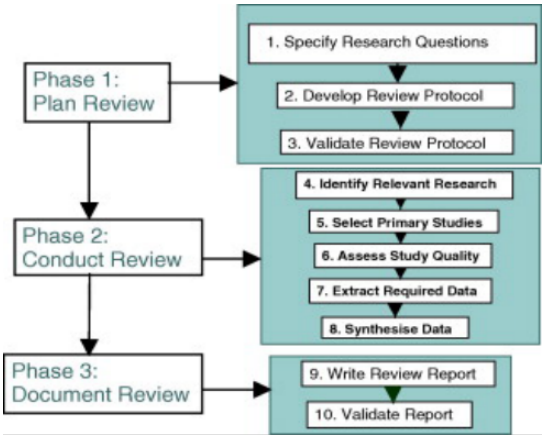


Fig. 2. SLR Methodology

A. Need of Conducting SLR

The properties of secondary studies as per the classification of these studies are illustrated in Table I. After analyzing the current studies, it is recognized that few holes have not been talked about yet and should to be filled for further suggestions. During the process of conducting this study, there are only a few studies discovered that have addressed the blockchain-based educational projects. But it was not done unanimously in single time paper. Henceforth, this led us to conduct this study to precisely accomplish our goals, and the quantitative research approach are used.

B. Research Question

The first part of this systematic literature review is to state the research questions. However, the following section is concentrated on the research questions:

RQ1: What are some of the blockchain projects related to education? (**Aim**: To illustrate some blockchain project that was developed for educational Motive)

RQ2: Which Protocols are used by these projects? (**Aim**:To)

RQ3: Which blockchain features are used by these projects? (**Aim**: To extend the blockchain features which are not discussed in existing studies & elaborate on the implementation of blockchain features used in existing projects)

RQ4: What services are being offered by the existing educational projects using Blockchain features? (**Aim**: To highlight the similar and dissimilar services to enhance the implementation of blockchain technology in education.)

C. Search Strategy

Blockchain plays an essential role in the field of education. We studied different analysis papers from Google scholar. On Google Scholar, we tend to search the keywords like 'Blockchain', 'education' and 'review'. As a result, 200 papers were found on those subjects. After studying, we chose those papers which were related to our keywords. We inspected various research papers, reports an article published in different journals and conferences.

D. Inclusion and Exclusion Criteria

For inclusion, 35 papers were collected that were related to the keyword and Research question. After reading the abstract and conclusion, we selected 11 primary studies for data extraction, which were about Blockchain based educational projects as per the need of the latest educational trends. Other papers were eliminated because of the content of those papers about the "Blockchain in education" whereas they were not related to the topic "Blockchain-based educational project". Table II presents the papers which were selected.

TABLE II. PAPER WITH REFERENCE ID

ID	*Publish year*	*Paper name*
[14]	2018	Ethereum Use Cases
[55]	2018	Blockchain Based Professional Networking and Recruiting Platform
[17]	2018	CredenceLedger: A Permissioned blockchain for Verifiable Academic Credentials
[54]	2017	Stampery Blockchain Timestamping Architecture (BTA)-Version 6
[51]	2018	OriginStamp: A blockchain-backed system for decentralized trusted timestamping
[18]	2018	Disciplina: block-chain for Education
[30]	2016	Participation and sharing economy: The Spanish case of compartirmola
[52]	2018	The Changing Tide of Corporate Social Responsibility
[9]	2018	Exploring block-chain technology and its potential applications for education
[10]	2018	Blockchain for education: lifelong learning passport
[49]	2018	Historico-Sociological Analysis of the Sharing Economy from its Early Digital Foundations to the Present

E. Data Extraction

After being shortlisted, data extracting process was applied on studies. In this stage, the appropriate data was selected from the shortlisted primary studies concentrating on blockchain based educational projects and basic features followed by identified projects. The extracted data was then used for analysis purpose. 12 primary studies covered the educational projects [36], [44], [43], [55], [38], [42], [41], [39], [28], [14], [40], [17].

F. Publication Trend

Since the research on Blockchain was started in 2008, From that time, the adoption and advancement of this technology increased at a greater rate. However, the very first paper that was discussed in the Blockchain-based educational project was found to be published in 2017. But no paper was found explicitly focusing on the identified educational projects.

IV. RESULTS

The result section is divided into three parts. The first part classifies some of the blockchain projects related to education. The second part describes the features of Blockchain that are used by these projects. The third subsection highlights the common and uncommon services of identified educational projects, and the fourth section describes the future direction.

A. RQ1: What are Some of the Blockchain Projects related to Education?

Blockchain technology has brought a revolution in education. Our first research question is related to projects that are selected by studying different review papers. This review includes some important educational projects from 2017 to 2018, as shown in Fig. 3. These are Edge-coin, success life, Teach Me Please, Sorry Global Education Project, Echolink, Gradbase, OriginStamp, and Tutellus. With the general introduction, it appeals to find out the reason behind this evolution. Our contributions consist of:

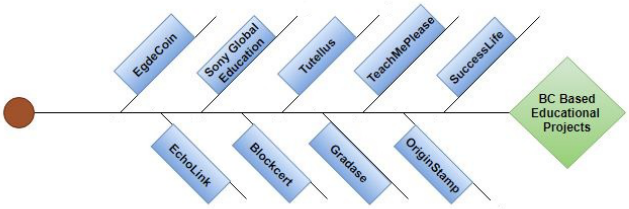


Fig. 3. BC Based Educational Projects

- Why we need blockchain-based educational projects?

Needs of blockchain-based educational projects: Today universities, individuals and employers face multiple challenges that include degree fraud, education verification, and problem translating and comparing the same degrees across different learning institutions [47]. Additionally, printing, authenticating, and storing degree and certification are the high costs for universities and schools in many parts of the world. While e-learning becomes the more and more popular, popular, verification of certification and validation of skills remains as there is no standard guideline that is accepted by all companies, countries, and institutions. The inability to validate skills continues to contribute to the large gap in the workforce. The multi-billion-dollar education industry needs solutions that make it easier to validate, verify, aggregate an individual's "learning record", making it easier to apply for the job and hire a qualified candidate.

We need a solution to all the challenges. So, blockchain-based educational projects resolved all the issues because blockchain is a safe, fast, the cost-efficient way to structure the records and data such as colleges degree, e-learning certificate, and much more. Blockchain enables products and services will disrupt the education system.

B. RQ2:Which Protocols are being used by these Projects?

All the educational projects have been built by following the blockchain technology whose main aim is to promote the real sense of education and check out all the hurdles and issues which comes in its way as threads; It provides a rational way out and solutions for all these issues. The major problems which emerge in the way of education are these: Lack of educational data protection/security, too much traditional paperwork the long and inefficient certification process, insufficient ways of storing data, unsecured and non-immutable record keeping, etc. [27]. In the third world countries, the most common and root cause of illiteracy is poverty. The most significant achievement of the models, they not only provide the skills to the learners and also gives them a chance to improve their economical positions [22]. Table III represents the educational projects and technologies that are used by these projects.

TABLE III. DIFFERENT EDUCATIOAL PROJECTS AND USED TECHNOLOGY

S:NO.	*Models*	*Technology*
1	Edge-Coin	Proof of Scale (POS)
2	TeachMePlease	DPoS
3	SuccessLife	BOLT
4	SonyGlobalEducation	HyperLedger Fabric
5	Tutellus	Sharding
6	Echolink	PoS
7	OriginStamp	POW
8	Gradbase	POW
9	Blockcerts	POW

Edge-Coin stores educational documents like degrees and course certificates on its block for third parties to directly confirm their validity. This cut costs for students since they don't have to pay for a notary. It also reduces costs for institutions as it eliminates bureaucracy and paperwork discuss in Section II.

POS: Edge-Coin and EchoLink have used a proof of stake (PoS) as opposed to the standard Proof of Work (PoW). PoS is just a select few nodes, for the most part yet not chosen by the network on the quantity and age of their stack. By choosing a select few individuals to oversee the site, the transmission of smart contracts goes faster, Edge-Coin & EchoLink can deal with its platform all the more speedily [48], [52], [49], [51].

POW: Blockcerts, Gradbase, OriginStamp, and Stempery have used a Proof of Work (POW). This Protocol used to validate the transactions. Through this Protocol, miners compete against each other to complete the transaction and get rewarded after solving cryptographic puzzles that have required more processing power.

DPoS: TeachMePlease used a DPoS Technology. Delegated Proof of Stake (DPoS) is a consensus mechanism algorithm maintaining undeniable agreement on reality across the network, authorizing transactions and providing a digitally democratic platform. Lisk has chosen it as its Protocol of choice due to its marvelous reputation and performance. Delegated ProofProof of stake uses voting in real-time combined with a scheme of name to achieve consensus. It is seen to be the smallest amount of centralized consensus protocol compared to all because it is most comprehensive of all. Each token holder will exercise a degree of influence regarding what happens on the network.

The TMP blockchain architecture divides itself into two layers: private and public. *Private layer:* This layer is used to store private and personal user data as well as those materials that are protected by copyright [42]. *Public layer:* This layer is used to provide access to the data that verifies the integrity of

TABLE IV. FEATURES ARE USED BY THESE PROJECTS

Feature / Projects	*Edgecoin*	*Tutellus*	*SGE*	*TMP*	*SuccessLife*	*EchoLink*	*Blockcert*	*Gradbase*	*OriginStamp*
Decentralize	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Immutability	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes
Traceability	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Currency	Yes	Yes			Yes				
Open Source	Yes	Yes	Yes		Yes		Yes		
Anonymity			Yes						
Consorship Resistant	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes
Transaction Rate	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

private data and the reliability of the data store by the network [42].

BOLT: To make professional and personal development available to as many people as possible, success Resources founded the blockchain company SuccessLife. SuccessLife used a BOLT Technology. The BOLT technology creates an entry in the Blockchain and enables Provenance.

- The interest in level, as well as search history of the user, has been captured in the level blockchain. This process will give better know-how and understanding of student's interests.
- The viewing of a demo step will create an entry in the blockchain lesson level that would certainly help the trainer identifying how many times his lessons were requested for a demo.

Hyperledger: The Sony Global Helpledger is a general-purpose business platform that Supports various educational institutions for educational record storage and digital certificates. The solutions give an Application Programming Interface (API) to customize the attributes of data collections of student's records and control use rights for educational institutions [50], [35], [10], [53], [37].

Sony hyperledger solves the scalability problem by separating the standard PoW transaction processing that is performed at one go into three phases: building the blocks, ordering the blocks, and validating each of these blocks.

Sharding: Sharding is a type of database partitioning that separates more massive databases into smaller, faster, more easily managed parts called data shards [30]. Often, it can be relatively easy to shard data. This way, a lot of transactions will get validated at the same time on the Ethereum network. In connection to Tutellus, this sharding allows the company to delegate its different tasks so that it maximizes its capacities for its educational functions[54], [31]

Tutellus has become extremely popular in the Spanish-speaking world over 1,000,000 users total. They also provide over 150 education video courses. With many students taking on loans that can range from 20,000-60,000 dollars, there is undoubtedly a marketplace for an application that can reduce those costs.

C. RQ3: Which Blockchain Features are used by these projects?

The Goal of this research question is to describe the blockchain features which are used by these projects. The common blockchain features which are used in these projects are listed in Table IV:

- Blockchain-based educational projects are entirely decentralized, rather than the store on a central authority. Educational projects data store in the decentralized blockchain network that will provide transparency and independence in the system. As a blockchain is an open-source of information, it is very important that the collection is being stored in honest and accurate. Projects decentralized management system would additionally facilitate institutions or employers validate quality with merely one click, instead of going through the time consuming and technical method of validating every certification individually.
- Blockchain technology uses the consensus mechanism to validate the new block in a distributed ledger. The recognized projects used a consensus mechanism like POS, DPOS, POW. Hence, this feature of blockchain is also the path of these projects.
- The educational projects focus on the immutable record. Once information is stored in the network, it cannot be changed until the 51 percent of the total node agreed to change.
- Blockchain-based educational projects are open source. The projects are a supportive environment, always open to everyone, and ensure complete transparency.
- Only SGE provides anonymous data. This feature inverse the traceability, Users can store personal data without using any encryption method
- Censorship Resistant means no alteration of data, no rewrite. But everyone can see every transaction. But SGE can censor the transaction due to its anonymity features.

D. RQ4: What Services are being Offered by the Existing Educational Projects using Blockchain Features?

The basic purpose of this research question is to identify the services which are being offered by Educational projects using blockchain features. First of all, we thoroughly studied the given research projects. After being analyzed deeply, we figure out the result which is given below in Fig. 3.
Table V presents a comparison between blockchain-based educational projects. There many advantages of all the technologies, which can be combined, and get an improved outcome.

TABLE V. SERVICES PROVIDED BY THE PROJECTS

Projects / Services	*Edge-Coin*	*SGE*	*TMP*	*SuccessLife*	*Tutellus*	*Blockerts*	*Grad base*	*EchoLink*	*OriginStamp*
Content Library	Yes	Yes	Yes	Yes	Yes				
Store personal data	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
E-Certficate	Yes	Yes	Yes	Yes		Yes	Yes		
Scoring system		Yes	Yes						
B2B apporach	Yes	Yes		Yes	Yes			Yes	
Token system	Yes			Yes	Yes	Yes	Yes		
Coooperative learning	Yes				Yes				
Job opportunites		Yes			Yes		Yes		
Providing Feedback services					Yes				

The educational projects have a lot of benefits; especially the decentralized approach solves a lot of problems regarding security, paperwork reductions, and job issues. Adopting a standardized blockchain to process several billions of transactions between devices will fundamentally reduce the expenses related to maintaining large centralized data centers and will appropriate calculation and capacity needs over the billions of devices. This will prevent avoid in any single node in the network from conveying the whole system to an ending collapse. These projects are used to connect a wide range of students and teachers for the last few years and will keep on supporting small scale IoT systems. In any case, it won't be capable of providing the needs to broaden the blockchain system in education in the future.

TABLE VI. SERVICES OFFERED BY BLOCK-CHAIN FEATURES

Services offered by Projects	*BC Features*
Content Library	Transactiuon Rate , Decentralized
Store personal data	Anomity
E-Certficate	Transaction Rate
Scoring system	Smart Contract
B2B apporach	Smart Contract
Token system	Smart Contract , Currency, Consensus Mechnism
Coooperative learning	Decentralized , Smart Contract
Job opportunites	Smart Contract
Providing Feedback services	Traceability

Table VI shows the services that are being offered using blockchain features.

Content Libary: Massive records offered the blockchain-based educational projects by using the blockchain Features transaction rate and decentralization. This service is a platform-independent, which means that if a customer leaves content at one point in one device, he/she continue studying the material at another device.

Store Personal data: Customer can store the personal data into two ways, Encryption method, The transaction that is stored on the network show everyone but in encryption form. Data is encryption by using different codes, and all the projects provide this kind of data security. Second is the anonymous method this technique is utilized only sony global education, unknown transaction store secretly nobody saw the transaction the single customer can see this.

E-Certificate: Existing blockchain provides us with a facility of e certificates by using blockchain features transaction rate. E-certificate is a digital certificate that adopts a digital signature; the client can accomplish it by utilizing the public and private key.

Scoring System: Grades are provided according to the performance of students by using blockchain feature smart contract. Just sony global, and TeachMePlease gives a service of the scoring system. On the off chance that the understudy's performance is adequate, at that point, the evaluation is superb generally ordinary.

B2B approach: It is direct contact starting with one business then onto the next, blockchain helps this System as a result of its decentralized nature. Two business is connected with each other; This service is offered by utilizing the blockchain feature smart contract.

Token System: The token framework could be utilized with the end goal of the transaction and for a reward. Various methods and components are utilized for this, and this service is being offered by feature, currency smart contract and consensus mechanism feature.

Cooperative learning: People learn together in the same place. They talk about the things and create the new thoughts block-chain-based educational projects gave that sort of condition by using blockchain features decentralized and smart contract.

Job opportunities: Block-chain-based educational projects give occupations to individuals. They provide them with the opportunities of work to the certified and skilled person, So, the blockchain reduces the unemployment by using smart contract.

Providing Feedback services: Tutellus Block-chain based educational project provide the facility to the people to give their feedback for that purpose traceability feature is used.

V. CONCLUSION

In this study, we have a trend to map out by using a systematic literature approach that can be useful in this regard. We have perceived suitable blockchain-based educational projects and also presented a comparison between the features of these projects. The implementation of the projects in the field of education has resolved the common issues of the educators. Since this technology is on its initial experimental stages and needs to go through evaluation processes. This technology can bring much more innovation in the future.

REFERENCES

[1] Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system.

[2] Pilkington, M. (2016). 11 Blockchain technology: principles and applications. Research handbook on digital transformations, 225. *

[3] Conoscenti, M., Vetro, A., & De Martin, J. C. (2016, November). Blockchain for the Internet of Things: A systematic literature review. In 2016 IEEE/ACS 13th International Conference of Computer Systems and Applications (AICCSA) (pp. 1-6). IEEE.

[4] Crosby, M., Pattanayak, P., Verma, S., & Kalyanaraman, V. (2016). Blockchain technology: Beyond bitcoin. Applied Innovation, 2(6-10), 71.

[5] Samaniego, M., & Deters, R. (2016, December). Blockchain as a Service for IoT. In 2016 IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData) (pp. 433-436). IEEE

[6] Bhowmik, D., & Feng, T. (2017, August). The multimedia blockchain: A distributed and tamper-proof media transaction framework. In 2017 22nd International Conference on Digital Signal Processing (DSP) (pp. 1-5). IEEE.

[7] Lemieux, V. L. (2016). Trusting records: is Blockchain technology the answer?. Records Management Journal, 26(2), 110-139

[8] Iansiti, M., & Lakhani, K. R. (2017). The truth about blockchain. Harvard Business Review, 95(1), 118-127 *

[9] Yumna, H., Khan, M. M., Ikram, M., & Ilyas, S. (2019, April). Use of Blockchain in Education: A Systematic Literature Review. In Asian Conference on Intelligent Information and Database Systems (pp. 191-202). Springer, Cham.

[10] M.B. Hoy, "An Introduction to the block-chain and Its Implications for Libraries and Medicine," Med. Ref. Serv. Q., vol. 36, no. 3, pp. 273–279, 2017. *

[11] Yli-Huumo, J., Ko, D., Choi, S., Park, S., & Smolander, K. (2016). Where is current research on blockchain technology? a systematic review. PloS one, 11(10), e0163477

[12] Makridakis, S., Polemitis, A., Giaglis, G., & Louca, S. (2018). Blockchain: The Next Breakthrough in the Rapid Progress of AI. In Artificial Intelligence-Emerging Trends and Applications. IntechOpen.

[13] Yang, X., Li, X., Wu, H., & Zhao, K. (2017). The application model and challenges of blockchain technology in education. Modern distance education research, (2), 34-45

[14] Grather, W., Kolvenbach, S., Ruland, R., Schütte, J., Torres, C., Wendland, F. (2018). Blockchain for education: lifelong learning passport. In Proceedings of 1st ERCIM Blockchain Workshop 2018. European Society for Socially Embedded Technologies (EUSSET) *

[15] Cheng, J. C., Lee, N. Y., Chi, C., & Chen, Y. H. (2018, April). Blockchain and smart contract for digital certificate. In 2018 IEEE international conference on applied system invention (ICASI) (pp. 1046-1051). IEEE.

[16] Turkanovic, M., Holbl, M., Kosic, K., Hericko, M., & Kamisalic, A. (2018). EduCTX: A blockchain-based higher education credit platform. IEEE Access, 6, 5112-5127

[17] Sharples, M., & Domingue, J. (2016, September). The blockchain and kudos: A distributed system for educational record, reputation and reward. In European Conference on Technology Enhanced Learning (pp. 490-496). Springer, Cham.

[18] Albeanu, G. (2017). Blockchain technology and education. On Virtual Learning, 271.

[19] Rooksby, J., & Dimitrov, K. (2017). Trustless education? A blockchain system for university grades. In New Value Transactions: Understanding and Designing for Distributed Autonomous Organisations, Workshop at DIS

[20] Vukolic, M. (2015, October). The quest for scalable blockchain fabric: Proof-of-work vs. BFT replication. In International workshop on open problems in network security (pp. 112-125). Springer, Cham.

[21] McConaghy, T., Marques, R., Muller, A., De Jonghe, D., McConaghy, T., McMullen, G., ... & Granzotto, A. (2016). BigchainDB: a scalable blockchain database. white paper, BigChainDB.

[22] Zheng, Z., Xie, S., Dai, H., Chen, X., & Wang, H. (2017, June). An overview of blockchain technology: Architecture, consensus, and future trends. In 2017 IEEE International Congress on Big Data (BigData Congress) (pp. 557-564). IEEE.

[23] Biswas, K., & Muthukkumarasamy, V. (2016, December). Securing smart cities using blockchain technology. In 2016 IEEE 18th international conference on high performance computing and communications; IEEE 14th international conference on smart city; IEEE 2nd international conference on data science and systems (HPCC/SmartCity/DSS) (pp. 1392-1393). IEEE

[24] Alharby, M., & van Moorsel, A. (2019). BlockSim: A Simulation Framework for Blockchain Systems. ACM SIGMETRICS Performance Evaluation Review, 46(3), 135-138.

[25] Twesige, R. L. (2015). A simple explanation of Bitcoin and Blockchain technology.

[26] X. Liang, S. Shetty, D. Tosh, C. Kamhoua, K. Kwiat, and L. Njilla, "ProvChain: A Blockchain-Based Data Provenance Architecture in Cloud Environment with Enhanced Privacy and Availability," Proc. 2017 17th IEEE/ACM Int. Symp. Clust. Cloud Grid Comput. CCGRID 2017, pp. 468–477, 2017.

[27] D.J. Skiba, "The Potential of Blockchain in Education and Health Care," Nurs. Educ. Perspect., vol. 38, no. 4, pp. 220 221, 2017.

[28] Chen, G., Xu, B., Lu, M., Chen, N. S. (2018). Exploring block-chain technology and its potential applications for education. Smart Learning Environments, 5(1), 1.

[29] Aste, T., Tasca, P., & Di Matteo, T. (2017). Blockchain technologies: The foreseeable impact on society and industry. Computer, 50(9), 18-28.

[30] Lin, I. C., & Liao, T. C. (2017). A Survey of Blockchain Security Issues and Challenges. IJ Network Security, 19(5), 653-659.

[31] Team, H. Technical Whitepaper.

[32] A. Grech and A. F. Camilleri, Blockchain in Education. 2017.

[33] Nofer, M., Gomber, P., Hinz, O., & Schiereck, D. (2017). Blockchain. Business & Information Systems Engineering, 59(3), 183-187.

[34] E.Buterin, "A next-generation smart contract and decentralized application platform," Etherum, no. January, pp. 1 36, 2014.

[35] Swan, M. (2015). block-chain: Blueprint for a new economy. " O'Reilly Media, Inc

[36] Mohanty, D. (2018). Ethereum Use Cases. In Ethereum for Architects and Developers (pp. 203-243). Apress, Berkeley, CA.

[37] Ocheja, P., Flanagan, B., & Ogata, H. (2018, March). Connecting decentralized learning records: a blockchain based learning analytics platform. In Proceedings of the 8th international conference on learning analytics and knowledge(pp. 265-269). ACM

[38] Hepp, T., Schoenhals, A., Gondek, C., & Gipp, B. (2018). OriginStamp: A blockchain-backed system for decentralized trusted timestamping. it-Information Technology, 60(5-6), 273-281.

[39] Soucy, C. (2018). The Changing Tide of Corporate Social Responsibility.

[40] Martos Carrion, E. (2018). Historico-Sociological Analysis of the Sharing Economy from its Early Digital Foundations to the Present.

[41] Martinez-Polo, J., Martinez-Sanchez, J. T., & Vivo, J. M. N. (2016). Participation and sharing economy: The spanish case of# compartirmola. In Entrepreneurship, Business and Economics-Vol. 1 (pp. 15-22). Springer, Cham

[42] Kuvshinov, K., Nikiforov, I., Mostovoy, J., Mukhutdinov, D., Andreev, K., & Podtelkin, V. (2018). Disciplina: Blockchain for Education.

[43] Arenas, R., & Fernandez, P. (2018, June). CredenceLedger: A Permissioned Blockchain for Verifiable Academic Credentials. In 2018 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC) (pp. 1-6). IEEE..

[44] Chan, S. Blockchain Based Professional Networking and Recruiting Platform.

[45] Kitchenham, B., & Charters, S. (2007). Guidelines for performing systematic literature reviews in software engineering.

[46] S.E. Group, "Guidelines for performing Systematic Literature Reviews in Software Engineering," 2007.

[47] Elendner, H., Trimborn, S., Ong, B., & Lee, T. M. (2016). The cross-section of crypto-currencies as financial assets: An overview (No. 2016-038). SFB 649 Discussion paper.

[48] Kiayias, A., Russell, A., David, B., & Oliynykov, R. (2017, August). Ouroboros: A provably secure proof-of-stake blockchain protocol. In Annual International Cryptology Conference (pp. 357-388). Springer, Cham.

[49] King, S., & Nadal, S. (2012). Ppcoin: Peer-to-peer crypto-currency with proof-of-stake. self-published paper, August, 19. Evaloation process

[50] Gromovs, G., & Lammi, K. (2017). Blockchain and internet of things require innovative approach to logistics education. Transport Problems, 12.

[51] Vasin, P. (2014). Blackcoin's proof-of-stake protocol v2. URL: https://blackcoin. co/blackcoin-pos-protocol-v2-whitepaper. pdf, 71.

[52] S. King and S. Nadal, "Ppcoin: Peer-to-peer crypto-currency with proof-of-stake," Self-Published Paper, August, vol. 19, 2012.

[53] Reyna, A., Martín, C., Chen, J., Soler, E., & Díaz, M. (2018). On blockchain and its integration with IoT. Challenges and opportunities. Future Generation Computer Systems, 88, 173-190.

[54] Luu, L., Narayanan, V., Zheng, C., Baweja, K., Gilbert, S., & Saxena, P. (2016, October). A secure sharding protocol for open blockchains. In Proceedings of the 2016 ACM SIGSAC Conference on Computer and Communications Security (pp. 17-30). ACM.

[55] Crespo, A. S. D. P., & García, L. I. C. (2017). Stampery Blockchain Timestamping Architecture (BTA)-Version 6. arXiv preprint arXiv:1711.04709.

Virtual Reality Full Immersion Techniques for Enhancing Workers Performance, 20 years Later: A Review and a Reformulation

Luis Alfaro[1], Claudia Rivera[2], Jorge Luna-Urquizo[3], Sofía Alfaro[4], Francisco Fialho[5]
Universidad Nacional de San Agustín de Arequipa[1,2,3,4]
Federal University of Santa Catarina-Florianópolis-SC[5],
Brazil

***Abstract*—The principal aim of this article is to review and reformulate the work published by Alfaro-Casas, Bridi and Fialho [1], in 1997, about the use of virtual reality immersion techniques for enhancing workers performance'. The challenge to be solved is related to the discussion about eventual advances occurring since the publication of the original work published. The strength of the achievements relies on the open dialogue established with different human cognition theories. We consider not only Humberto Maturana and Francisco Varela autopoiesis (human biological foundations theories) but also some other approaches derived from Education Sciences and Knowledge Management. The focus is on Artificial Intelligence and the use of Immersive technologies. The state of the art is established and its contributions towards the construction of knowledge are investigated, as a means for the development of formation and capacitation activities of the workforce. The methodology used is the bibliographical revision on several databases and the search of theses in the main universities. The greatest weakness of the research relies on the fact that we limited the search to documents using the English, Spanish, or Portuguese language. Some of the open immersion problems of virtual immersion are also treated.**

Keywords*—Autopoiesis; knowledge construction; knowledge management; knowledge construction by full immersion in virtual reality environments

I. Introduction

The emergence of new technologies, the differences in countries' economic and legal environments due to the process of integrating into the global economic community together with changes in the social mentality of today, make the education received obsolete from primary school all the way to university. As time goes by, today's education turns to be insufficient to face the new situations that arise at the workplace and in everyday life. The obsolescence and the natural forgetfulness of the acquired knowledge provoke a reduction in the effectiveness of the company's work force. Physical and virtual environments present a challenge to the way we prepare this work force.

The education system, responsible for the integral formation of the individual, is not prepared to move forward adapting to technological innovations changes, and demands of the production and service processes and of the organizations themselves. The highest demands are within the industry and services, which face the question of how to make the workforce be formed and updated at the same rate.

The introduction of new technologies and innovations in the production process are altering not only the way of performing tasks in the company, but also the way of understanding and organizing the work, for whose development types of tacit and explicit knowledge are required [2]. The instruction or training in the traditional canons carried out within mass production systems is no longer sufficient and does not capture contemporary company staff formation needs such as: knowledge creation, knowledge management, services management, production, extraction, etc. At the same time, the highly rotating nature and the growing diversity of the workforce require new formation and training approaches where the new paradigm is learning while working.

Learning in organizations aims to improve the performance of the workforce, which is reflected in value: better products and services, low costs, a more competitive market position, greater innovation, improved productivity, increase when market sharing, etc. In the context of business, learning is the process through which workers acquire new knowledge or skills with the purpose of improving their performance.

This challenge can be covered in part by the formation and capacitation technologies associated with the Internet, such as the systems of : E-Learning, Adaptive E-Learning, M-Learning, U-Learning and especially systems based on Immersive and Augmented Reality Technologies.

The original work was published more than 20 years ago by Alfaro-Casas, Bridi and Fialho [1], considering mainly the biological bases of human cognition (autopoiesis theory), and the most important approaches on Education Sciences. We now also discuss concepts derived from Knowledge Management and Intellectual Capital ideas, whose emergence and maturity period have transformed the forms of organization management. Information and Communication technologies are elements that allow organizations to acquire competitive advantage. Likewise, it was necessary to establish the state of the art of immersive technologies, and analyze and reformulate their possibilities of application in workforce formation, capacitation and learning environments.

In this paper, Section II explores human cognition; Section III explores immersive technologies; Section IV explores and analyzes the potential of immersive technologies in the construction of knowledge; Section V discusses some virtual immersion open problems. Finally, future conclusions and recommendations for this work are established in Section VI.

II. Human Cognition

In this part of the work, organization of living beings' concepts, and the concepts of plasticity, cognition, learning, and language are reviewed according to the proposal of Maturana and Varela [3], considering the reformulations proposed by subsequent authors [4], as well as other approaches derived from Education Sciences Knowledge Construction and neurosciences as well as other approaches from the organization theories tradition, such as knowledge management and intellectual capital as well as marketing, considering the points of view and requirements of these areas, whose action impacts organizations and their systems of human talent capacitation.

A. Biological Bases of Human Cognition

The concept of Autopoiesis proposed by Maturana and Varela [3], and summarized by Razzeto-Barry [4], as "An autopoietic system is a network of processes which produces all the components whose internal production is necessary to maintain the network operating as a unit", that is; It is the ability of living beings to self-produce themselves. In accordance with Dittus and Vasquez [5], "You have the idea that the nervous system is an instrument that obtains information from the environment, which is then used by living beings to build their world."

Each autopoietic unit is unique, since it is characterized by phylogenetic inheritance or Phylogeny (history of the species) defined as, the succession of organic forms that are related due to a sequence of reproductive relationships; and by the history of individual adaptations or ontogeny [6]. Ontogeny is defined as "the history of the structural change of a unit without losing its organization". At the level of a living being's organization, all organic operation is knowledge, as the aphorism says: "all doing is knowing and all-knowing is doing".

Social systems are systems of coordination of actions in language, that is, a conversation network that Maturana [7] defines as: "Flow of coordination of actions and emotions, which we, observers, distinguish as occurring between human beings who interact recurrently in language". The author also argues that "We live in communities that exist as networks of conversations, intercrossed, not intersected, of different types, that match each other in their flow through the intersection in our corporality". The author mentions the following types of conversations:

- Coordination of present and future actions.
- Complaints and apologies for agreements not taken.
- Of wishes and expectations.
- Command and obedience.
- Characterizations, attributions and evaluations.
- Complaints about unfulfilled expectations.

Consequently, different human autopoietic systems generate their own networks of conversations, which even affect their bodies. As a result, they move through these networks on a daily basis, regardless of their conscience, in domestic, educational, political, social, religious, etc. spaces, acting in tune with the actions related to these conversation systems they motivate to be and do. For Maturana [7], human relations that are not based on the acceptance of the other as "A legitimate other in coexistence" are not social relations, the author affirming that labor relations, "are not social because they are founded on the commitment to fulfill a task, and in them the fulfillment of the task is the only thing that matters".

In Flores and Terry [8], the role of the background and interpretation is highlighted while retaining the focus centered on the commitment engendered by the acts of language. These concepts are of paramount importance in the design of contemporary computer systems for the support of educational activities, which at present have involved the conception of systems that consider the Ontological level, as well as predictive and highly adaptive functions to the characteristics and profiles of the apprentices, and the same ones that have the support of the techniques and methodologies and techniques of Artificial Intelligence. A cognitive system is "a system whose organization defines a domain of interactions where it can act with relevance to the maintenance of itself, the process of cognition being the actual performance or behavior in this domain" [7]. On the other hand, for Austin [9], speech acts consist of three elementary levels:

- Locutive act: it is the idea or concept of the phrase, that is, what is said.
- Illocutive act: it is the specific intention of speech acts.
- Perlocutive act: it is the effect(s) that the statement produces in the receiver in a given circumstance.

Speech acts can be classified according to their intention or purpose to which they refer, as follows:

- Assertive or expository acts: the speaker denies, asserts or corrects something, with a different level of certainty.
- Management acts: the speaker tries to force the listener to execute an action.
- Commitment acts: the speaker assumes a commitment, an obligation or a purpose.
- Declarative acts: the speaker intends to change the state in which something is found.
- Expressive acts: the speaker expresses their mood.

Communication mediated by speech acts enables communication in relation to the so-called explicit knowledge, which becomes the tradition of knowledge management [10], establishing the difficulty to establish communication in relation to tacit knowledge [11]. With regard to the use of knowledge for the understanding of language, the processes involved in the acts of speech, listening and reading, have similarities; even having some different attributes. In reading, each word can be seen as a whole; however, a spoken word spreads in the environment. The word provides a more ambiguous and confusing signal than a printed text [12].

Most theories about text comprehension are also relevant for speech comprehension, as there is a lot of evidence that indicates that there is a close relationship between these two processes. It is important to establish an understanding of the mind and its realizations in the perception, learning,

thinking and using language, considering the processes in which individuals deal with stimuli, how they organize data, how they solve problems and use verbal symbols [12].

Understanding a situation requires that the cognitive subject have a model of that situation. However, at a certain moment a model may be insufficient for the construction of certain concepts, arising from the need to resort to another model, which raises the need to propose systems that have a high degree of adaptation to the requirements of the cognitive subject, which has different learning and thinking styles, and therefore the diversity of demands for processes and resources must be recognized. Consequently, individual learning models evolve towards models with a higher level of organization and converge in the actions of business organizations in the direction of team learning.

In contemporary organizations, there are profound changes due to the increasingly growing demands, in relation to quality, productivity, innovative capacity among others, for the production of goods and the provision of services that make organizations focus on obtaining competitive advantage and generally favoring teamwork over the individual, which brings with it the requirement of establishing new ways of organizing tasks, new instruments for controlling results and new ways of successfully evaluating the management of operation processes , changes that have an impact on the training of the workforce, which presents demands for skills to acquire, often for the treatment of complex issues in short periods of time. Team learning, defined by Senge [13], as the process of alignment and capacity development, is today privileged by organizations over personal and / or individual learning systems.

Likewise, for Maturana [7], "Education is constituted in the process in which the child or the adult lives with another and when living with the other, transforms spontaneously, so that their way of living, is progressively done more congruent with another, in the living space". Education occurs, therefore, all the time, in a reciprocal way, as a contingent structural transformation to a history in living together in which it turns out that people learn to live together in a way that is configured, according to the living of the community where they live. Education as an "educational system," shapes a world, and students confirm in their living the world they lived by being educated in education.

The perspective of teaching in the biology of love [14], considers that many of the different forms of bodily dynamics, which emerged with the evolutionary history that gave rise to humanity, reappear in the ontogeny of the child's physical and mental development. Children's free play, when emerging without the influence of adults, is organized spontaneously based on innate forms of actions, movements and perceptions, which come from human evolutionary history or phylogeny. Thus, the forms of children's free play are not arbitrary; they are forms of body dynamics that are linked to ancestral behavioral territories, to expressions and connections between the living being and its environment, and whose current forms are just transformations of archaic forms.

These concepts have given rise to what is now known as the Biology of knowledge, an approach in which, as human beings are like other living beings, operationally closed and engaging with others through linguistic mediation, -that is, they live in language- they learn, relate, coordinate with others and live experiences in the emotional world in which they are immersed. Finally, in relation to training in the context of knowledge biology, these ideas point to the use of the new technologies such as ICTs, VR, Augmented Reality and Social networks, that meet the demands of education and training of organizations and the workforce.

B. Approaches from the Perspective of Education Sciences

Regarding the explanation of the development of human autopoietic units, it can be said that various approaches try to explain this, and some theorists propose educational philosophies or currents, which are briefly explained as follows:

1) Constructivist Perspective: The works of Gestalt psychologists, Piaget [15], Vygotsky [16], Bruner Bartlett [17] and Dewey [18], emphasize the active construction of meaning by the individual. This approach, instead of postulating the memorization of information, postulates the creation of meaning and construction of knowledge.

A constructivist point of view makes us recognize the potential of an 'invented reality', strongly influenced by the individual's capacity for perception and action [19]. The epistemological point of view identifies the nature of knowledge as caused primarily by a process of construction and interpretation that is based on personal experiences, mental structures and perceptual mechanisms, which are deeply rooted in the individual's corporeity and in real or simulated contexts.

Many constructivist perspectives consider the social context as one of the fundamental factors of knowledge that people acquire regarding themselves and the world. Various theories that also try to explain the information processing carried out by the human autopoietic unit, the representation of knowledge in memory, and the individual differences between students.

2) Constructionism is one of the contemporary dogmas in education theory: According to this approach, learners assimilate knowledge through constructive tasks. The goal of the approach is to foster creativity and motivate learning through activities. Learning is most effective when placed in an activity, passively received [20]. For Bruckman [21], the term "constructionism", involves two types of construction:

- Learning is an active process, in which people actively build their knowledge and experiences in the world (idea based on the theories of J. Piaget).
- The idea that people build new knowledge when they are involved in the construction of products of personal significance. What is important is that they are actively involved in the creation of something that is meaningful to themselves and others in their environment.

Finally, Winn [22] points out that Immersion in a virtual world allows us to construct knowledge from direct experience, not from descriptions of experience. Any learning that is mediated by a symbol system, whether text, spoken language, or computer, is inevitably a reflection of someone else's experience not our own.

In Maturana [23], it is suggested that intelligence or "plasticity", comes from the greater or lesser capacity of organisms

to adapt to their environment. Immersive VR can be one of the emerging technologies, which allow to recreate real or virtual environments, with the advantage of being able to abstract and synthesize some variables, such as time, and space among others, that will allow unique and original experiences in First person, that is to say without symbolic mediation and therefore reflection, enabling formation and learning that involve tacit and explicit knowledge, in a direct, original, unique and unforgettable way. Next, immersive technologies and their application possibilities will be explored, for the construction of first-person learning environments that generate rich and lasting personalized experiences.

C. The Perspective of Knowledge Management and Intellectual Capital

Knowledge is interpreted as the fact of knowing, mastering certain activity, situation, task, etc., based on the information, experience, and beliefs that the individual possesses, within a given environment [10]. Many authors claim that the only source of competitive advantage is knowledge, and knowledge is the only significant resource, being more than a simple resource in the equation of the factors of production, land, labor and capital [24]. The industries that have managed to grow in the last 40 years have grown because they were structured around knowledge and information. In this scenario, the center of gravity in employment is rapidly moving from manual and administrative work to the knowledgeable employee [25]. There is another way of understanding knowledge, associated with the ability to respond quickly to customers, create new markets, develop new products and master new technologies [26]. The company that creates knowledge as a place where "inventing new knowledge is not a specialized activity (...) but a way of acting; a way of being where everyone can be considered as a knowledge worker. There is a relationship between organizational learning and continuous improvement.

On the other hand, tacit knowledge is knowledge hidden from the consciousness of the knower. Tacit knowledge resides in the human brain and cannot be easily captured or codified [27]. All our knowledge rests in a tacit dimension. Tacit knowledge expresses itself in human actions in form of evaluations, attitudes, points of view, competences, experiences and skills stored so deep in the worldview of an individual that it is often taken for granted [11]. It can be observed through action.

On the other side, the Explicit Knowledge can be articulated in formal language and transmitted amongst individuals. Explicit Knowledge implies factual statements about such matters as material properties, technical information and tool characteristics [28]. Thus, explicit knowledge can be compressed into a few summary symbols that can be encoded by language in written words and / or machine. By its very nature, explicit knowledge is capable of being captured and widely distributed throughout the organization. In the organizational field, the following types of learning are established [12]:

- Individual learning can be understood as a cycle in which people assimilate new data, information, reflect with past experiences, reach a conclusion or a conception of new knowledge which is used to achieve a new objective. Thus, learning is based on research and problem solving. The processes in which learning happens have a predominant role, so the central point of teaching consists of process and not learning products.
- Team learning [29], is defined as the process of alignment and development of a team's ability to create the results that its members really want through the development of coordinated actions, establishing the open flow of knowledge, conversations and active participation in the elaboration of the logic to be followed, where teams are the largest unit of learning. The skills developed by a group can establish a pattern for organizational learning, so they have three critical dimensions [12].
    1) Teams need to learn to use the potential of many minds, in order to have greater intelligence than a single mind.
    2) Each team member acts in a way that complements the actions of the others.
    3) A team that learns, stimulates other teams through the dissemination of team learning practices and skills more widely.

In this case, the introduction of immersive technologies allow incorporating apprentices and team members, whether human or virtual, who are able to use avatars that assume the role of apprentices, masters, team members, or even specialists who have a broad repertoire of explicit and tacit knowledge. The existence of the relationship between Organizational Knowledge Management and the competitive advantage goes through various aspects, but mainly through people and their knowledge. Other aspects are: Knowledge Engineering, and the technology integration between knowledge management and the organizational learning process areas. Each of these three dimensions can be worked on, from the perspective of the generation, preservation and dissemination of knowledge, in order to create a competitive advantage for the company.

III. Immersive Technologies

A. Virtual Reality (VR)

VR is defined as [30]: "A three-dimensional environment synthesized by computer, in which the plurality of human participants, with appropriate interfaces, can establish contact or interact with representations of other humans from the past, present, and fictional and / or invented creatures". For Yoh [31], VR is a technology that simulates reality through software, recreating the effect, essence and sensations of a given situation that does not materialize in real events.

According to Gonzales and Lanier [32], VR refers to completely artificial environment generated by computer, in which the user experiences an immersive and interactive feeling without having any eye contact with their real environment. This virtual world can be the result of a process of digital creation, being able to place the user in a totally fictional world in which the physical and perceptual laws differ completely from their real world. In addition, in the latest systems it is possible to make certain displacements within this virtual world, beyond simple head movements. It is also possible to move the user to a point in real-time, but different from that of the user, previously registered in a 360° recording, so that it can be reproduced as a virtual deferred experience.

As a variant, is the real-time broadcast or streaming of a recording made anywhere in the world, so that a user can view it as a virtual world elsewhere, and interact with the source through a digital audio connection over the Internet. All these variants allow the user to live a truly immersive experience in a real or fictional world; however, the fact of not being able to observe one's own anatomy within the virtual world subtracts the system from some realism, limiting perception regarding the surrounding reality. Similarly, VR systems excessively evade the user from their immediate environment, producing a certain feeling of dizziness after a prolonged period of use. It is currently applied in entertainment, education [33], advertising, marketing, Knowledge Management, etc.

In VR there are two types of applications: the "Immersive", where the user is within the simulation, and the "Non-Immersive", in which the user is outside [34]. An important feature of immersive VR is 'Stereoscopy', which allows users to distinguish the depth of the objects they observe, adapting to their natural way of seeing the surrounding environment . This is generated by a binocular vision, creating the illusion of perceiving objects in 3D from two images that are taken from different positions, recreating the human 3D vision [35].

VR has evolved rapidly. At the beginning it could only be used by scientific-military laboratories at an excessive cost, but it is now possible to have VR equipment at an affordable cost. It is precisely the special characteristics of these devices which are the key components for the design of the proposed architecture located in a virtual environment.

B. 2D, 3D and RV Viewing Modes

For Zohra [36], there are different approaches to the use of 2D, 3D and RV representations in relation to the Visualization of Information, presenting a brief description of each:

- 2D uses only two dimensions; the graphics are flat, it stands out for its simplicity, clarity and precision when displaying information. A large part of the actual interfaces are designed for this type of representation. In most, the interaction is traditional, using the most common interaction techniques such as: Select and Zoom.
- 3D, is the way in which an object is represented in a three-dimensional space, mapped on a two-dimensional surface. The visual perception of 3D it is achieved through the use of visual elements of depth such as lights, shadows and perspectives, but the final appreciation is flat. These environments facilitate navigation, however, they result only from an extension of the interaction techniques in 2D environments, which use visual effects to generate the illusion of volume.
- VR is a technique that enables immersion in a multimodal viewing environment, which also uses stereoscopic images to improve depth perception, making possible to perceive 3D as in the real world. VR environments allow the user to be immersed, causing the interaction to be different. Unlike the visualization techniques in 2D and 3D, VR techniques have not been thoroughly studied or standardized. An example of VR interaction techniques is: Direct manipulation, in which a virtual hand is available to interact directly with the visualization.

Between 60% and 80% of the objects of study to be viewed are of 3D, but most of the visual representations implemented are in 2D, followed by those made in 3D, because those conceived in VR are currently very scarce [37]. The debate regarding the quality between 2D and 3D is still extensive, but many authors reach the consensus that 2D are the most appropriate if accuracy and better interpretation are desired; instead, 3D are useful if better navigation and relative positioning are preferred [38]. Fig. 1 shows an example of the three types of environments.

(a) 2D Image

(b) Scanner captures 3D image

(c) Immersive VR Image Composition

Fig. 1. Interaction device prototypes. Source: [30]

C. Immersion

This is a feature of VR in which users are in a simulated environment. An immersive VR system seeks the user to lose contact with reality by exclusively perceiving the stimuli of the virtual world. However, the immersion achieved so far in VR systems is restricted only to spatial immersion; that is, the perception of being physically present in a virtual world [39]. Psotka [33], states that the fact that a user is in a simulated virtual environment has a huge emotional factor that facilitates cognition and improves information retention, because the user feels that they are part of software. In addition, immersion broadens the user's range of vision, including their displace-

ment (very useful in virtual tours) and collaboration (used for manufacturing applications) [40] [41].

Slater [42] distinguishes two ways of experiencing immersive VR: an HMD VR helmet (acronym for head-mounted display) and a three-dimensional cave-like environment . For this purpose, immersion has been achieved through different configurations, for example, a single giant screen may be used as well as anaglyph lenses. Another configuration is that of a CAVE environment, which consists of four or 6 walls of almost 3m3, which function as stereo projection screens. The images are determined as a head tracking function so that, at least with respect to the visual system, participants can physically move through a limited space and orient their head arbitrarily to be able to perceive. Usually, the audio is delivered by a set of speakers in discrete positions around the CAVE [43].

In this investigation, the immersion will be used based on a VR helmet, which is one of the most comfortable compared to the others and because it gives a greater sense of presence that helps memory and other cognitive processes [44]. But one of the main drawbacks of this configuration is that it can cause dizziness in certain users.

D. Immersive RV Devices

Over the years, different VR devices have emerged, most of them manufactured for a specific purpose. In this investigation, in relation to the proposed system architecture, the hardware configuration would consist of the following devices: 'Oculus Rift', 'Leap Motion', and 'Oculus Go'. Fig. 2 shows the main VR viewers in the market. Oculus Rift (Fig. 2(a)) is the first to include a series of improvements such as stereoscopy and low latency in the refresh rate. HoloLens (Fig. 2(b)) experiences how to mix VR and augmented reality, in addition to creating the first holographic processor. PlayStation VR (Fig. 2(c)) is created for entertainment purposes and noted for its sophisticated design. HTC Vive (Fig. 2(d)) on the contrary, stands out for its good performance and development platform. Gear VR (Fig. 2(e)) uses VR with a wireless approach for which it requires a smartphone. Oculus Go (Fig. 2(f)) is an alternative similar to the previous one, with the difference that its cost is much lower.

In Table I, these viewers are compared considering the main technical characteristics such as: Screen resolution, refresh rate, viewing angle and price.

TABLE I. COMPARISON OF VIEWERS CONSIDERING TECHNICAL ATTRIBUTES AND COSTS. SOURCE: ADAPTED FROM [37]

Visor	Resolution	Refresh rate	Vision angle	Price $
Oculus Rift	2160x1200	90 Hz.	110°	700.00
Hololens	1920x1080	120 Hz.	110°	3,000.00
PlayStation VR	1920x1080	120 Hz.	100°	400.00
HTC Vive	2160x1200	90 Hz.	110°	900.00
Gear VR	2560x1440	60 Hz.	96°	100.00
CardBoard	Variable	Var	90°	5.00
Oculus GO	2560x1440	72-60 Hz.	110°	169.00

E. Natural User Interfaces (NUI)

NUI are those interfaces in which user interaction is natural, common and familiar [45]. That is why its design

Fig. 2. Interaction device prototypes. Source: [37]

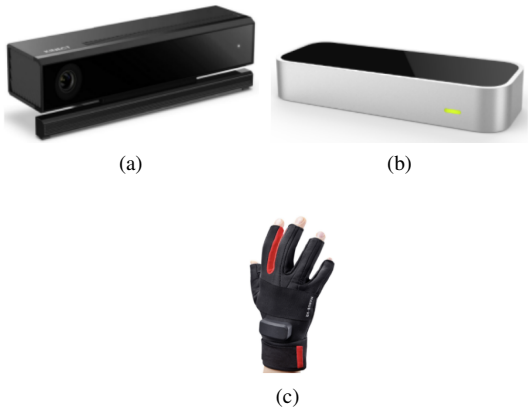
implies the use of new devices that allow this interaction, which goes beyond the use of the keyboard and mouse. These new generations of devices allow the use of the software by gestures, touch, body movement, voice, etc. Examples of NUI devices are Kinect [46], [47], that copy the movements of the body and send them to a virtual avatar. This device allows the user to control the application without requiring another peripheral, because it also allows voice recognition for command interpretation. The great utility of using NUI is that they are intuitive and easy to handle. For example, for non-native digital people, learning how to use the mouse is quite complicated, but using Kinect is relatively easy for any user. It is this ease of use which is desired in any user interface, but NUI should not be applied to any application; for example, it would be difficult to use Kinect to operate a word processor.

The recent development of input peripherals is changing the way of interaction with digital screens, the mouse and keyboard, and these are being replaced by tactile interfaces based on body movement [48]. These new ways of interacting are part of the evolution of the interfaces, which throughout the history of computing have evolved, changed and diversified. The term NUI was coined by Mann [49], who explores new forms of computer human interaction, emerging a variety of investigations that focus on new fields of application.

Finally, the NUI, constitute a revolution in the world of computing, not because they will replace the existing and widely used traditional interfaces, but because they enable the creation of new types of applications and new forms of original and novel interactions liable to be applied in Production, Administration, Marketing, etc.

F. Natural Devices Interaction

Fig. 3 show the main devices necessary for the creation of NUI. Kinect (Fig. 3(a)), is the first to appear in the market, created for entertainment purposes for games controlled through transduction, but then used for more advanced applications. Nimble (Fig. 3(b)), focuses only on hand recognition. Manus (Fig. 3(c)), unlike the others, uses motion sensors built into gloves.



(a) (b)

(c)

Fig. 3. Natural Devices Interaction. Source: [37]

The historical review and the establishment of the state of the art allow us to glimpse the enormous potential of the resources and elements of immersive technologies, whose use in marketing strategies will allow innovative approaches.

IV. Knowledge Construction by Immersion in Immersive Technologies

Constructivist learning supported by technology, focuses on how representations and applications can mediate interactions between learners and natural and social phenomena. The key to VR compatibility with constructivism relies on the notion of immersion. First-person experiences consider the treatment of activities in the world and in learning about this. First-person experiences occur when interaction with the world does not involve reflection of consciousness or use of symbols. According to the constructivist theory and with the perspectives of the Biology of Knowledge, the construction of knowledge arises from first-person experiences, which can never be entirely shared. Immersive VR allows first-person experiences through the elimination of interfaces that act in the user-computer interaction [50]. In this, the contribution of the VR is unique, since it allows a synthetic experience to capture the essence of what it really is. The meaning for the person approaching in order to know the world.

Immersion in a virtual world allows to build knowledge from a direct experience, not from a description of the experience. Any learning that is mediated by a system of symbols, whether textual, spoken language or by a computer, is inevitably a reflection of the experience of the other. Any communication in which we use a symbolic system to communicate to another person, can never allow that person to know that world as we know it. The Constructivist theory describes how first-person worlds become internalized and argues that any imposition of symbolic representations motivated by communication requires negotiation in relation to the dominant meaning for commitment [51]. However, in the multi-participant VR, in which a group of participants is immersed in the same world at the same time, it will allow the negotiation of meaning to be established, and communication between participants may be required.

Immersion in VR environments, allows a type of interaction with the objects with which participants interact, similar to the interaction that takes place in the real world. Biology of Knowledge, Constructivism and the so-called "Tacit Knowledge" concept (derived from Knowledge Management Theory), sustain that cognition is non-symbolic and learning is "linked" stated by Maturana [52], "learning occurs when behavior of an organism varies during its ontogeny, in a manner consistent with the variations of the environment, which it does following a contingent course in its interactions with it". Likewise, the organism does not construct a representation of the environment, nor does it find a proper behavior for it. For it to operate, there is no medium, there are no things to be remembered or memory, only a structural dance in the present, which follows a course consistent with the structural dance of the medium. Otherwise the organism disintegrates. Likewise, learning is action-oriented through interaction with the virtual world, being in that moment that knowledge is built. Papert [20], [21] uses the word "constructionism" to describe the construction of knowledge that arises from physical interaction with objects in the world. Immersive VR allows physical and perceptual interactions to occur in that synthesized world.

VR extension can simulate the real world. This allows workforce formation and capacitation inside the context they are supposed to apply the acquired knowledge. In order to do this, environments must be proposed and designed following Anchored Instruction [53] perspective, which enable experiences with better results than that obtained when learning out of context. Learning scenarios in factories, respecting logistics and supply operations, simulating experiential marketing actions, supporting Tacit and Explicit Knowledge management, among others, will enable the tuning of learning activities, for example, within the framework of Project Based Learning (PBL) [54], allowing immersions in simulated synthetic environments, to consider aspects of reality or fiction, by modifying some variables such as time, dimensions, costs, Etc. Due to the fact that the virtual environment is computed from data, this allows the participant three kinds of knowledge building experiences that are not available in the real world; however, it can have enormous potential in workforce formation and capacitation: These concepts are called "Dimension", "Transduction" and "Reification" [50].

The immersion in RV, allows radical changes in the dimensions in relation to the participant and the virtual objects. In the real world, when approaching an object, it appears larger and as it moves away, it decreases in size, there are limits to both ends. There is a point at which there can be no closer approximation to the physical object and this point marks the maximum apparent dimension of an object. In the same way, there is a point at which the object disappears when distance is taken from it. In a virtual world, otherwise, one can infinitely approach or move away from objects, allowing large changes in dimension. For example, before hitting the virtual wall, the subject could obtain approximations, so that

smaller and smaller details of the material from which it is constituted, the cellular structures of a wooden panel can be shown and visualized, even the molecules and atoms of which it is basically composed. From another perspective, you can expand the vision of a wall, the exterior of a house, a country or even the planet or the galaxy, all this without violating any of the four conditions for immersion. The advantages of such changes in the dimension for education are significant. Finally, it is possible for the cognitive subject to have a notion of the relative dimensions and distances between the planets of the solar system through flights from one to another. These experiences will depend largely on the metaphors proposed by the designers of these environments.

Likewise, the immersion and interaction technology used in 3D VR systems allows us to overcome didactic obstacles present in topics that contain, due to their nature, situations of danger or potential risk for students [55]; for example, places of difficult access or that are dangerous can be known easily and safely without the need to physically move to them, solving some problems such as: security issues, industry confidentiality restrictions, long distance trips from work or education centers, which cause transfer costs.

VR, in general, is widely used in the fields of education and formation due to its potentials in stimulating interactivity [56] and motivation [57][58]. Furthermore, it offers an ideal manner to approach, study and remember new knowledge for all those who prefer this learning style [59].

On the other hand, the primary motor cortex is the main source of neural signals that control movement, whereas the premotor cortex and supplementary motor appear to be involved in the preparation and planning of movement. Many more parts are involved in motion and communicate through neural signals. The most interesting part is the cerebellum, meaning "small brain", which it seems to be a special processing unit that is mostly devoted to motion, but is also involved in functions such as attention and language. Damage to the cerebellum has been widely seen to affect motor control and learning of new motor programs. One of the most relevant uses of the cerebellum for VR [60], is in learning sensorimotor relationships, which become encoded into a motor program. All body motions involve some kind of sensory feedback. The most common example is hand-eye coordination; however, even if you move your arms with your eyes closed, proprioception provides information in the form of reference copies of the motor signals. Developing a tight connection between motor control signals and sensory and perceptual signals is crucial to many tasks.

The transducers, similar to eyephones and earphones are used in VR hardware to present information to participants, and to convert participants behavior into software interpretation commands. Transducers are devices that convert information not available to our senses in other ways that are. Changes in size and transduction for access to cognitive subjects to first-person experiences could not be made otherwise. Some of these experiences arise from simulations in relation to some aspects of objects and or events. Others arise from representations through the transduction of objects and events that do not have a physical form, making them perceptible to experiences or the senses, in cases such as algebraical equations, and dynamic populations among others.

"Reification" is the process of creating these perceptible forms. Reification is placed as opposed to simulation. In the simulation, the virtual world contains representations of real objects and their behaviors. Its advantage is that students can interact with them and generally, RV is a more economical alternative for building physical simulators. However, it should be noted that the power of VR can be underutilized, when used for simulation. VR is not used efficiently when it is used to create simulations that can be performed through traditional simulators.

V. Some Open Problems in VR Immersion

Immersion characteristics were analyzed by Postka [61], through questionnaires designed to access individual susceptibilities for immersion and how deep this experience was to the participants. In the research reported, the questions were carefully built to cover the cognitive factors mentioned in the literature as meaningful for VR environments. A five-point scale of categorical answers was used. Two psychological factors considered as dominants for predicting immersion deepth were: the imagination needed for accepting another reality (a living imaginary turns the participation integral and satisfactory) and the concentration, attention, and self-control needed to exclude real world effects of distraction. The extension of the visual field in an HMO, the precision of the egocentric localization, audio precise information (synchronized with visual changes like rotations, head movements of affirmation, or accelerations), are determinant factors of an in depth immersion. A "cognitive tracking" paradigm was used to get visual-vestibular interactions. The precise synchronization of the spatial head movements and the changes in visual perspective result in a deeper immersion, even with an imprecise coupling between head movement and changes in the visual presentation [61]. Cognitive factors were grouped in two categories, immersion susceptibility and quality:

- Susceptibility depends on imagination (dreams, a gift for replacing old beliefs), a living imaginary (dreaming, previous expectations about VR environments), concentration and attention (attention filtering, cognitive conflict by two recursive immersions, spatial navigation), and self-control (active participation and catharsis).
- Quality depends on the environmental resources provided by the VR immersion (object persistence, sensorial perfection, interactivity, environment realism, delays, visual field, localization of the ego center or corporal image, pleasure and satisfaction with the new experience), distractions due to the real environment (noise, tactile presence, tiredness, irritation with the equipment, similarity between real and virtual world), psychological effects (simulator disturbances, disorientation after immersion), and other effects (preference for a lonely immersion, surprise when the HMD is removed). Movements in the virtual environment, at the present stage of technology can originate several errors (an extremely slow answer, failures). The main causes of movement errors are: imprecise scenery for the inter ocular distance, absence of convergence and accommodation signals, lack of good texture gradients for depth and improperly designed models. They are

easily perceived and remain a disturbance factor in several VR applications.

Psotka [24] reports that with an exhibition vision greater than 60° (field of view, FOV), several individuals relate some level of discomfort although not mentioning nausea, (fields of vision less than 60° FOV, produce a poor sense of immersion. Nowadays a FOV 210° horizontal and 130° vertical is reached). The relationship between behavior and the study about self-oriented emotions are strongly dependent on FOV. The most influent requirement for immersion is a solid coupling between head movement and visual exhibition. Data input delays in visual exhibition using HMD immersion results in a brisk interruption of spatial orientation and a poor immersion experience [24].

Immersion can be understood as a dual phenomenon; from one side it depends on subconscious skills and, from the other side it depends on our voluntary attention abilities that depend on self-control, self-consciousness, will, expectations, etc. Those two factors (implicit versus conscious immersion control) are captured by the found correlation that immersion is more complete in someone that is able to have dreams in colours [24]. How those two components interact is a mystery. The implicit and conscious components seem to perform different things without affecting one another directly. These factors appear so briskly that they make themselves visible in all three sets of correlation: in the susceptibility factors, in the immersion factors, and in their inter correlations. Implicit factors present a kind of dominance. If the delay between the iteraction and the visual feedback of a movement perceived by a hand in VR is too big, there is no image filtering technique sufficient to reduce this delay, disturbance occurs. When the visual system indicates that the egocentric or corporal image is in a certain location but the kinesthetic centers are in some near place, there is no way to integrate these two positions. A long time may be necessary for the learning and adaptation processes to change the cognitive machinery [61].

Despite the important advances, the treatment of the cognitive and perceptual components of immersion is a longterm challenge, which is required for capacitation and formation, and for educational proposals, because it is known that many of the cognitive representations are in the form of mental models for the understanding of complex systems. Research in VR should be focused on transforming knowledge into experience and turning education, formation and capacitation into more direct and effective action [10]. Instead of supplying access to a greater cyberspace, the equipment used nowadays is still causing sensations like claustrophobia, nausea and confusion after the experiment [10].

For La Valle [60], signals from multiple senses and proprioception are being processed and combined with our experiences by our neural structures throughout our lives. In ordinary life, without VR or drugs, our brains interpret these combinations of inputs in coherent, consistent, and familiar ways. Any attempt to interfere with these operations is likely to cause a mismatch among the data from our senses. The brain may react in a variety of ways. It could be the case that we are not consciously aware of the conflict, but we may become fatigued or develop a headache. Even worse, we could develop symptoms of dizziness or nausea. In other cases, the brain might react by making us so consciously aware of the conflict that we immediately understand that the experience is artificial. This would correspond to a case in which the VR fails to convince people that they are present in a virtual world.

While it is true that since the publication of the original article to the present, many of these problems have been overcome or their effects have been reduced, mainly due to innovative approaches and contemporary technological resources applied in the design and development of different elements of hardware and software of immersive technologies, it is seen that efforts and constant research in the area, must achieve improvements and optimizations that are increasingly important, envisioning the improvement of quality, usability and ergonomic attributes of different devices in human-machine interaction. However, some of these problems must be considered in the analysis and development of systems for education, training and human talent, since the characteristics and particularities of different work environments, the diversity of learning styles and thinking of apprentices, as well as the different educational approaches and conceptions of resources, generate demands for systems and learning objects, with a high degree of adaptability to individual profiles, interests and characteristics of cognitive subjects. The holistic incorporation of some characteristics of the different approaches reviewed, such as the Biology of Cognition, Educational Sciences and especially of Knowledge Management, would make possible the construction of useful environments for a diversity of scenarios and cognoscent subjects.

VI. Conclusion and Recommendations

- The biology of Cognition that establishes the biological basis of Human Cognition, as well as approaches from the educational and Knowledge Management perspective, suggest that intelligence or “plasticity”, come from the greater or lesser capacity of organisms to adapt to their environment. Immersive VR can be one of the technologies that allow recreating synthesized real or virtual environments to achieve first-person experiences; that is, without symbolic mediation and therefore reflection, with a high degree of adaptation to profiles and particularities of the cognitive subject, enabling formation and capacitation that involve tacit and explicit knowledge in a direct, original, personalized, unique and unforgettable way.
- The materialization of the perceptual and cognitive components of immersion seems to be a long and arduous task but, the results will compensate all the effort. It is particu1arly satisfactory for formation and educational proposals because we already know that most of the cognitive representations assume the form of mental models that are used for understanding complex systems. VR promises to turn education and formation in tools that will be much more direct and effective than nowadays.
- The state of the art of the biological foundations of cognition, of the different approaches to education and of the immersive VR have been established, allowing to know the enormous potential of this emerging technology, which would make it possible to innovate

the forms and methodologies for Innovative formation and capacitation practices, since experiences close to reality can be considered, when using metaphors that include multisensory perceptions, for first-person learning experiences.

- The creation of intelligent formation and capacitation systems is a complex issue that demands the participation of various sources of experience. That is why, for the development of this kind of systems, it is required to employ the method of work in multidisciplinary teams, which include specialists in the fields of pedagogy, psychology, neurosciences, specialists in the domain of knowledge that It aims to teach, technicians in graphic, artistic, computer, multimedia, VR and project management.
- It is essential to insist on a continuous, open and personalized education that allows the individual to update and adapt knowledge throughout their professional life.
- It is important to employ AI approaches, in order to provide formation and capacitation with some adaptive characteristics, derived from user profiles.

ACKNOWLEDGMENT

The authors would like to thanks to Saint Augustin National University (UNSA) – Arequipa - Perú and the Federal University of Santa Catarina – Florianópolis - Brazil

REFERENCES

[1] L. Alfaro-Casas. L. Bridi. F. Fialho. *Virtual reality full immersion techniques for enhancing workers performance.* L. M. Camarinha-Matos (ed.), Re-engineering for Sustainable Industrial Production © Springer Science+Business Media Dordrecht 1997

[2] A. Uriarte. *"Introduction to Knowledge Management Copyright*. ASEAN Foundation 2008. ISBN No. 978 - 979 - 19684 - 0 - 9

[3] H. Maturana; F. Varela. *De máquinas y seres vivos - una teoría sobre la organización biológica.* Chile. Editorial Universitaria S.A. 1972. 121 p.

[4] P. Razeto-Barry. *Autopoiesis 40 years Later.* A Review and a Reformulation. In Origins of Life 42(6), 2012. DOI: 10.1007/s11084-012-9297

[5] Dittus, R. y Vásquez, C. 2016. *Abriendo la autopoiesis: implicancias para el estudio de la comunicación organizacional.* OPENING AUTOPOIESIS: IMPLICATIONS FOR THE STUDY OF ORGANIZATIONAL COMMUNICATION Cinta moebio 56: 136-146 doi: 10.4067/S0717-554X2016000200002

[6] H. Maturana; F. Varela. *El árbol del conocimiento. Octava Edición.* Santiago de Chile. Editorial Universitaria. 1992. 172 p.

[7] H. Maturana, H. *Emociones y lenguaje en educación y política. Sexta edición Editorial universitarias.* 1992. ISBN: 956-201-087-1

[8] F. Flores. W. Terry. *Hacia la comprensión de la informática y la cognición.* Ordenadores y conocimiento para el diseño del siglo XXI. Barcelona. Editorial Hispano Europea. S.A. 1989. 266 p.

[9] Xin, Yin. *as teorías de los actos de habla.* Una sinopsis. Centro internacional de pos grado. Universidad de Oviedo. Maestría. 2015.

[10] J. Psotka. *Immersive tutoring system: virtual reality and education and formatiom.* 1995. 31 Jan. http://205.130.63/its.html.

[11] T. Koulopoulos. C. Frappaolo, C. *Smart things to know about knowledge management.* Oxford: Capstone Publishing. 1999.

[12] Fialho, F,. Et. Al. (2007). *Emprendedorismo na era do conhecimento.* 2da . Impresión. Florianópolis – SC . Visual Books Ltda. 188 p. ISBN: 85-7502-180-X

[13] P. Scnge, Peter.*La quinta disciplina : El arte y la práctica de la organización abierta al aprendizaje* . – 2 ed. 10 Reimp. - Buenos Aires : Granica, 2010. ISBN 978-950-64 M306

[14] Verden-Zöller, Gerda. *El juego en la relación materno infantíl: Fundamento biológico de la conciencia de si mismo y de la conciencia social.* In: Amor y Juego. Fundamentos olvidados de lo humano. Maturana, Humberto R. e Verden-Zöller, Gerda. Santiago de Chile: Editorial Instituto de Terapia Cognitiva, 1994. p. 71-136. ISBN: 956-7344-01-9.

[15] Piaget, Jean. Gréco, Pierre. *Aprendizagem e Conhecimento.* Rio de Janeiro, Freitas Bastos, 1974.

[16] Vygotsky, Lev Semenovictch. *A Formação Social da Mente: o desenvolvimento dos processos psicológicos superiores.* 2a ed. São Paulo. Martins Fontes. 1994.

[17] A. Woolfolk E. *Psicologia educativa.* Sexta edición. Mexico: Prentice Hall Hispanoamericana S.A., 1996. 642 p. ISBN: 968-880-689-7

[18] I. Shor. *Educations is politics.* Paulo Freire's critical pedagogy. New York. Edited by Peter McLaren and Peter Leonard. 1993. p. 25-35.

[19] Watzlawick, P. (Ed.) (1981) Die Erfundene Wirklichkeit. Munich: Piper

[20] Roussos, M. Johnson, A. Leigh, J. Vasilakis, C. Constructing *collaborative histories within virtual learning landscapes.* 1996. Http://www.Ice.eecs.uic.edu/NICE/PAPERS/EUROAIED/HTML/aied.html

[21] Bruckman, Amy. Resnick, Michel. *The Media MOO project: constructionism and professional community.* 1995. Http://asb.www.media.mit.edu/peple/asb/convergence.html

[22] W. Winn. *A conceptual basis for educational aplications of virtual reality.* 1993. http://www.hitl.washington.edu/projects/education/winn/winn-R-93-9.txt

[23] H. Maturana. *Biology of cognition.* Biological Computer Laboratory Research Report BCL 9.0. Urbana IL: University of Illinois, 1970. http://www.enolagaia.com/M70-80BoC.html

[24] J. Psotka. *Immersive formatiom systems: immesion in virtual reality and formatiom.* 1996 - 31 Jan: http://205.130.63.7/vrFormatiom.html

[25] P. Drucker. *Llega una nueva organización a la empresa. Harvard Business Review.* Gestión del Conocimiento. Ediciones Deusto: Bilbao. 2003 P.1-22.. ISBN: 84-234-2023-2003

[26] I. Nonaka. *La empresa creadora del conocimiento.* Harvard Business Review. Gestión del Conocimiento. Ediciones Deusto: Bilbao. 2003. P. 23-50. ISBN: 84-234-2023-2003

[27] Nonaka, I. and Takeuchi, H. *The knowledge creating company: How Japanese companies create the dynamics of innovation.* Oxford: Oxford University Press. 1995.

[28] K. Koskinen. P. Pihlanto, H. Vanharanta.*Tacit knowledge acquisition and sharing in a project work context.* International journal of project management. Vol. 21, pp. 281-290. 2003

[29] P. Senge. *A Quinta disciplina: arte , teoria y pratica da organização da aprendizagen.* São Paulo. Ed. Best Seller, 1990.

[30] L. Alfaro, *"Contribuições para a modelagem de um ambiente inteligente de educação baseado em realidade virtual,"* Doutorado. Programa de Pós-Graduação em Engenharia de Produção. Universidade Federal de Santa Catarina, Brasil, 1999.

[31] M.-S. Yoh, *"The reality of virtual reality,"* in In Proceedings Seventh International Conference on Virtual Systems and Multimedia, IEEE, 2001.

[32] M. Gonzales- Franco. J. Lanier. *Model of Illusions and Virtual Reality.* Review Article. Front. Psychol., 30 June 2017. https://doi.org/10.3389/fpsyg.2017.01125

[33] J. Psotka, *"Immersive formatiom systems: Virtual reality and education and formatiom,"* Instructional science, vol. 23, no. 5, p. 405–431, 1995.

[34] J. Psotka, *"Educational games and virtual reality as disruptive technologies,"* Journal of Educational Technology & Society, vol. 16, no. 2, p. 69–80, 2013.

[35] J. Juang, W. Hung and S. Kang, *"Simcrane 3d+: A crane simulator with kinesthetic and stereoscopic vision,"* Advanced Engineering Informatics, vol. 27, no. 4, p. 506–518, 2013.

[36] B. Zohra, G. Fabrice, R. Paul, B. Julien and P. Fabien, *"An Overview of Interaction Techniques and 3D Representations for Data Mining,"* Applications of Virtual Reality, p. 185, 2012.

[37] R. Linares, *"Exploración de artículos científicos con realidad virtual y procesamiento del lenguaje natural,"* Maestría en Ing. Informática. Escuela de Posgrado. Universidad Nacional de San Agustín de Arequipa., 2017.

[38] S. Dübel, M. Röhlig, H. Schumann and M. Trapp, *"2d and 3d presentation of spatial data: A systematic review,"* in In 2014 IEEE VIS International Workshop on 3DVis (3DVis), 2014.

[39] L. Freina. M. Ott. *A literature review on immersive virtual reality in education: State of the art and perspectives.* Conference: eLearning and Software for Education (eLSE), At Bucharest (Romania), 2015.

[40] K. Wanarat and T. Nuanwan, *"Using 3d visualisation to improve public participation in sustainable planning process: Experiences through the creation of koh mudsum plan, thailand,"* Procedia-Social and Behavioral Sciences, vol. 91, p. 679–690, 2013.

[41] N. Menck, X. Yang, C. Weidig, C. Winkes, C. Lauer, H. Hagen, B. Hamann and J. Aurich,*"Collaborative factory planning in virtual reality,"* Procedia CIRP, vol. 3, p. 317–322, 2012.

[42] Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. The Royal Society, pp. 3549-3557. 2009. https://doi.org/10.1098/rstb.2009.0138

[43] Olguín Carbajal, Mauricio; Rivera Zarate, Israel; Pozas Quiteria, Oliver. *Desarrollo de un sistema inmersivo de realidad virtual basado en cabina multipersonal y camino sin fin.* Polibits, núm. 37, pp. 79-82. 2008. Recuperado de http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1870-90442008000100011

[44] E. Lombardo, S. Agostinelli and M. Metge, *"Could an interactive and total immersive device with hmd improve memory and give the presence sensation?,"* Issues in Information Systems, vol. 14, p. 315–321, 2013.

[45] D. Wigdor and D. Wixon, *" Brave NUI world: designing natural user interfaces for touch and gesture",* Elsevier, 2011.

[46] N. Villaroman, D. Rowe and B. Swan, *"Teaching natural user interaction using openni and the microsoft kinect sensor,"* in In Proceedings of the 2011 conference on Information technology education, 2011.

[47] G. Calle, E. Castro-Gutierrez and L. Alfaro, *"Virtual Rehabilitation Using Sequential Learning Algorithms,"* International Journal of Advanced Computer Science and Applications (IJACSA), vol. 9, no. 11, 2018.

[48] A. Cámara, *"Natural user interfaces,"* in In IFIP Conference on HumanComputer Interact, 2011.

[49] S. Mann,*" Intelligent image processing",* John Wiley & Sons, 2001.

[50] W. Winn. *A conceptual basis for educational aplications of virtual reality.*1993. http://www.hitl.washington.edu/projects/education/winn/winn-R-93-9.txt

[51] P. Thi Hoa and H. Ying-Yuh, *"The Impact Of Experiential Marketing On Customer's Experiential Value And Satisfaction: An Empirical Study In Vietnam Hotel Sector,"* Journal of Business Management & Social Sciences Research, vol. 4, no. 1, 2015.

[52] H. Maturana. Refexiones: *Aprendizaje o deriva ontogénica.* In: Desde la biología a psicologia. Santiago de Chile: Editorial Mitech Ltda. Ediciones Synthesis, 1993. p. 82-102. ISBN: 956-7335-01-X

[53] B. Bottge, Et al. *Impact of Enhanced Anchored Instruction in Inclusive Math Classrooms.* Exceptional Children. 2015, Vol. 81(2) 158–175 © 2014 The Author(s) DOI: 10.1177/0014402914551742 ec.sagepub.com

[54] PROJECT-BASED LEARNING HANDBOOK *Educating the Millennial Learner".* FIRST EDITION: SEPTEMBER 2006 Copyright © 2006 Educational Technology Division, Ministry of Education. Kuala Lumpur: Malaysia. ISBN: 983-3244-31-9

[55] J. Flores. P. Camarena Gallardo, E. ávalos .*La realidad virtual, una tecnología innovadora aplicable al proceso de enseñanza de los estudiantes de ingeniería.* Revista Apertura, vol. 6, núm. 2. 2014. Recuperado de http://www.udgvirtual.udg.mx/apertura/index.php/apertura/article/view/547/369

[56] M. Roussou.*Learning by doing and learning through play: an exploration of interactivity in virtual environments for children.* Computers in Entertainment (CIE), 2(1), 10-10. (2004)

[57] Garris, R., Ahlers, R., & Driskell, J. E. (2002). *Games, motivation, and learning: A research and practice model.* Simulation & gaming, 33(4), 441-467.

[58] Ott, M., & Tavella, M. (2009). *A contribution to the understanding of what makes young students genuinely engaged in computer-based learning tasks.* Procedia-Social and Behavioral Sciences, 1(1), 184-188.

[59] C. Carol. *Learning styles in Higher Education. A case study in History formatiom The 6th International Conference Edu World 2014 "Education Facing Contemporary World Issues",* 7th - 9th November. Procedia - Social and Behavioral Sciences 180 (2015) 256 – 261

[60] S. La Valle. *Virtual Reality.* University of Oulu. Cambritch University Press. 2019. Availablefordownloadingathttp://vr.cs.uiuc.edu/

[61] J. Psotka. Davison, *Sharon Cognitive factors associated with immersion in virtual environments.* 1996a- 29 Abril. http://205.130.63.7/vrfopub.htm

Classification of People who Suffer Schizophrenia and Healthy People by EEG Signals using Deep Learning

Carlos Alberto Torres Naira[1]
Escuela Profesional de, Ingeniería de Sistemas
Universidad Nacional de, San Agustín de Arequipa
Arequipa, Perú

Cristian José López Del Alamo[2]
Escuela Profesional de, Ciencia de la Computación
Universidad Nacional de, San Agustín de Arequipa
Arequipa, Perú

***Abstract*—More than 21 million people worldwide suffer from schizophrenia. This serious mental disorder exposes people to stigmatization, discrimination, and violation of their human rights. Different works on classification and diagnosis of mental illnesses use electroencephalogram signals (EEG) because it reflects brain functioning, and how these diseases affect it. Due to the information provided by the EEG signals and the performance demonstrated by Deep Learning algorithms, the present work proposes a model for the classification of schizophrenic and healthy people through EEG signals using Deep Learning methods. Considering the properties of an EEG, high-dimensional and multichannel, we applied the Pearson Correlation Coefficient (PCC) to represent the relations between the channels, this way instead of using the large amount of data that an EEG provides, we used a shorter matrix as an input of a Convolutional Neural Network (CNN). Finally, results demonstrated that the proposed EEG-based classification model achieved Accuracy, Specificity, and Sensitivity of 90%, 90%, and 90%, respectively.**

***Keywords*—Convolutional Neural Network (CNN); electroencephalography; Electroencephalogram Signals (EEG); deep learning; schizophrenia; classification; Pearson Correlation Coefficient (PCC); Universidad Nacional de San Agustín (UNSA)**

I. Introduction

Schizophrenia is a serious mental disorder that is characterized by alterations in thinking, often including psychological experiences such as hearing things or delusions. More than 21 million people worldwide suffer from schizophrenia, of which more than 50% do not have adequate medical attention [1], being men the ones that suffer it more frequently than women [2].

According to [3], this severe mental disorder can present these symptoms: delusions, hallucinations, disorganized discourse (for example, disaggregation or frequent incoherence), very disorganized or catatonic behavior and negative symptoms (i. e. diminished emotional expression).

The schizophrenics who do not have the proper treatment are more prone to suffer stigmatization, discrimination, and violation of their human rights [1], the life expectancy of people in these patients according to [2], [4] is between 10 to 15 years and their risk of suicide is 10% .

The World Health Organization (WHO) [1] has several programs for the correct treatment of this disorder, which includes pharmacotherapy and psychosocial support, since schizophrenia generally begins in late adolescence or early adulthood [2], the earlier diagnosis is important.

For a schizophrenic to receive adequate treatment, diagnosis is necessary. Due to EEG has unique characteristics, high dimensionality, and variability [5], there are diverse approaches for the diagnosis and treatment of different mental disorders, which work on the data presented by an EEG.

An EEG provides information about the electrical activity of the brain [6], [7], with this information is possible to identify emotions [8], [9], [10], [11], whether a person is healthy or suffer some neurological disease [12], [13], [14], [15], [16], [17].

In different researches, Deep Learning algorithms are used for classification and extraction of characteristics of an EEG, among the most seen are The work of Acharya et al. [6], where the authors used a CNN with 13 layers to detect normal, practical, and seizure classes. In [18] the authors used a CNN with Random Forest and a voting layer to classify high-risk individuals, clinically stable first-episode patients with schizophrenia and healthy controls.

On the other hand, en [19], the authors used CNN to detect and classify segments of EEG which display abnormal brain activity. In [20] was used CNN to classify people who listened and imagined music and compare strategies for learning features. Author in [21] used graph signal representation of an EEG in a CNN, [22] used a CNN to decode and visualize features of an EEG and [23] used CNN to classify between listen to music, reading, and watching augmented reality application, Convolutional Deep Belief Networks [5], Deep Recurrent-Convolutional Neural Networks [24], Deep Neural Networks [9], [15], Restricted Boltzmann Machines [8], Non-Ruinous Autocoder Stacked [25], Deep Belief Network [26].

Observing the performance shown by the Deep Learning algorithms working on EEG signals and the features extracted from them, we propose a method to classify schizophrenic and healthy people. For the other hand, we use PCC to reduce the high-dimensionality and variability presented by each channel of an EGG into a single matrix. This way, the correlation matrix is presented as an input of a CNN for the classification.

In [11] PCC is used to represent the correlation between the 32 channels of an EEG as a matrix, then the correlation matrix

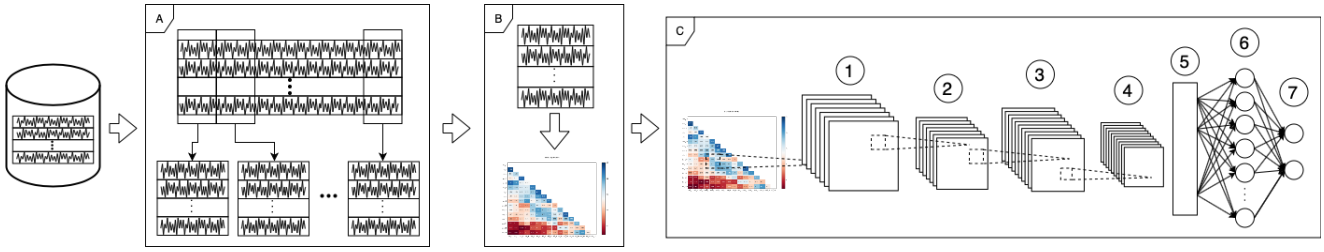


Fig. 1. Methodology proposed (A) Data Segmentation, (B) Pearson Correlation Coefficient and (C) Convolutional Neural Network

is presented as an input for CNNs, obtaining an accuracy of 94.44% for a CNN with five convolutional layers.

The rest of the paper is organized as follows. In Section II, we give a description of PCC and CNN. In Section III, we describe the data used, the classification procedure and the results obtained. In Section IV, we discuss the results and future work. Finally, in Section V we provide conclusions.

II. Methodology

The methodology proposed is shown in Fig. 1 consists of four parts. The first one is how the dataset is composed, which consists of 122880 records per subject (16 channels, and 7680 records per channel). The second part (Section A of Fig. 1) is the Data Segmentation, detailed in subsection II-A, which consists of how the data per subject is segmented and ordered to get a (channels $*$ records) matrix.

The third part (Section B of Fig. 1) is the Pearson Correlation Coefficient, detailed in subsection II-B, is to obtain a matrix that represents the correlation between the channels per subject applying PCC on each (16 channels $*$ 7680 records) matrix, the finale matrix is $16 * 16$ dimensions.

The fourth part (Section C of Fig. 1) is the classification with Convolutional Neural Network, detailed in subsection II-C, which consists of using the correlation matrix as an input to a CNN, this way the performance of the CNN improves performance due to the values of the correlation matrix are between -1 and 1, instead of the variable values raw EEG signal presents. The CNN consists of two convolutional layers, two max-pooling layers, one fully connected layer, and softmax.

A. Data Segmentation

Each file that corresponds to a subject contains the 122880 EEG recordings in a column, those 122880 EEG recordings turned as a $16 * 7680$ matrix. 7680 recordings per each channel, taking the first 7680 recordings for the first channel, the second 7680 recordings for the second channel and so on.

Since the length of each channel is too long, we partitioned each EEG recordings matrix per subject into six parts, each one of those partitioned matrices represents ten seconds of each EEG recordings. It means that each $16 * 7680$ matrix turned into six $16 * 1280$ matrices.

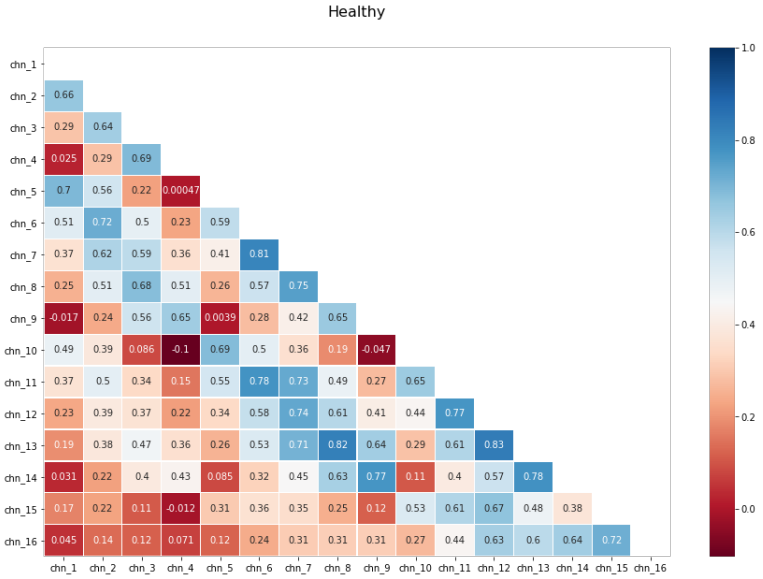


Fig. 2. Heat map of the correlation matrix for a healthy person.

B. Pearson Correlation Coefficient

The Pearson Correlation Coefficient represents how two variables are related, and in this work, these variables are the signals captured for the electrodes, generating one channel by each of them.

PCC was used to represent how a channel is related to the other ones, this way we turned each sample ($16 * 1280$ matrix) as a square matrix, which is suitable to be used as an image on a CNN, the Fig. 2 and the Fig. 3 show the correlation matrices of a healthy and schizophrenic person, respectively.

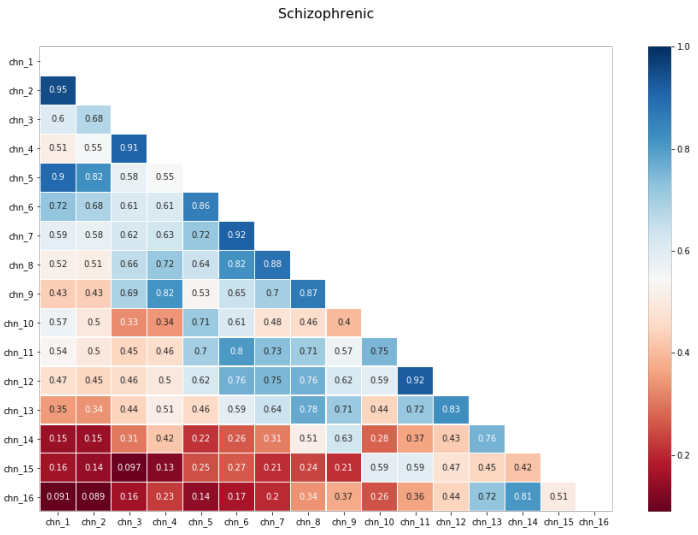


Fig. 3. Heat map of the correlation matrix for a schizophrenic person.

If the two signals are x and y, PCC is calculated as:

$$PCC = \frac{cov(x, y)}{\sigma_x \sigma_y} \tag{1}$$

Where $cov(.)$ is the covariance, σ_x and σ_y the standard deviations of the signals. The value PCC ranges between -1 and 1, which indicates a perfect negative and perfect positive linear relationship, respectively. So, if PCC is 0, it means that there is no linear relationship between the two signals.

C. Convolutional Neural Network

Once we obtained the correlation matrix per subject, we treated each one as an image for the input of the CNN.

In Table I, we detailed the CNN structure used for this work.

A Stochastic Gradient Descent (SGD) optimizer was used, with a learning rate value of 3, decay learning value of 0.5, and momentum of 0.1. And as loss function, Mean Squared Error.

For a better understanding, we define a CNN and its parts below.

CNN is a subset of deep learning [6]. His name comes from the use of convolution filters for complex operations [14], and according to [27], it was inspired biologically by the visual cortex and design at the beginning for image processing.

A typical configuration of a CNN consists of a sequence of convolution and sub-sampled layers. After the last subsampling layer usually follows a series of fully connected layers, this way the 2-D map of characteristics turns into a 1-D vector, and then the classification as traditional Neural Networks (NN) is performed [14].

To avoid overfitting, regularization methods, as dropout, are usually used during training.

CNN comprises three types of layers:

1) **Convolutional Layer** A set of filters that slide through the input. A Filter is a matrix that convolves the input data and strides control how much the Filter convolves through the length of the input data. The output of the convolution is known as a feature map [6].
2) **Pooling Layer** Also known as down-sampling layer. Reduce the previous layer neurons output dimension, to relieve the computational intensity and prevent overfitting [6].
   Max pooling partitions the input data into rectangles and takes the maximum value from each partition, reducing the output dimension [23].
3) **Fully Connected Layer** In this layer, all the neurons have a connection with each one of the previous layer neurons, like a hidden layer of a Multilayer Perceptron (MLP).

TABLE I. CNN STRUCTURE

LAYER	DESCRIPTION
(C.1) CONVOLUTIONAL LAYER	Layer that uses $3 * 3$ filters that strides $1 * 1$ through the input data.
(C.2) MAXPOOLING LAYER	Layer that partitions the output data from the previous layer in $2*2$ matrices and reduces them taking the max value of each partition. The partitions stride is $2 * 2$.
(C.3) CONVOLUTIONAL LAYER	Layer that uses $3 * 3$ filters that strides $1 * 1$ through the input data.
(C.4) MAXPOOLING LAYER	Layer that partitions the output data from the previous layer in $2*2$ matrices and reduces them taking the max value of each partition. The partitions stride is $2*2$. Also, we applied a dropout of 0.25 to the output data of this layer.
(C.5) FLATTEN	Turn the output data from the previous layer in a 1-D vector.
(C.6) FULLY CONNECTED LAYER	Layer with 256 neurons.
(C.7) SOFTMAX	Output layer with softmax activation to the classification.

It is common to use activation functions after each convolutional layer. An activation function is an operation that maps an output for a group of input.

In this work an activation function is used:

1) **Softmax** This function computes the probability distribution of the k output classes. The last layer applies this function to predict, which class the input belongs. The output values are between 0 and 1, and the sum is 1.

III. Experiments and Results

A. Data Description

EEG recordings data used for this work, also analyzed in [12], is available at http://brain.bio.msu.ru/eeg_schizophrenia.htm. The recordings belong to two groups. The first one consists of 39 healthy boys (11-13 years old). The second consists of 45 boys (10-14 years old) diagnosed with schizophrenia using clinical interviews at the Research Center for Psychological Disorders of the Russian Academy of Medical Sciences [12]. For all subjects, from 16 channels (electrode positions) the EEG signals were registered, those channels are F7, F3, F4, F8, T3, C3, Cz, C4, T4, T5, P3, Pz, P4, T6, O1, O2.

During the recordings, the patients were in a rest state with eyes closed. The signal was recorded for 1 minute at a frequency of 128 Hz, obtaining 7680 records per each channel of a subject.

B. Results

All this work was developed, executed, and tested using the Google environment Colaboratory, and for the CNN, Keras python library. The EEG signals used in this work come from 45 subjects who suffer schizophrenia and from 39 healthy subjects.

Since the total length of the EEG signals per subject is 60 seconds, we divided those signals into six same length parts. Therefore there will be 270 samples of subjects who suffer schizophrenia, and 234 samples of healthy subjects, each sample with 10 seconds length.

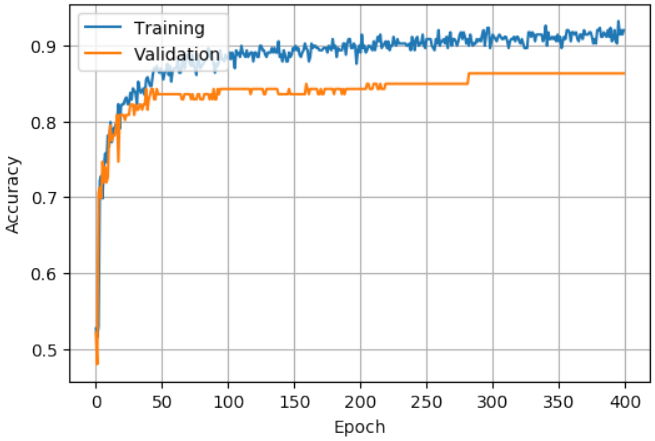


Fig. 4. Accuracy evolution in the training stage.

From all the 504 samples of EEG signals, 484 samples were the training data, and the rest 20 samples the test data.

In the training stage, the number of epochs was set up in 400, and the validation was set up in 30% for the training data input. Fig. 4 and Fig. 5 show the results in the training stage. For training, the accuracy, and loss values are 92.01%, and 0.076 respectively and for validation, the accuracy and loss values are 86.3% and 0.094, respectively.

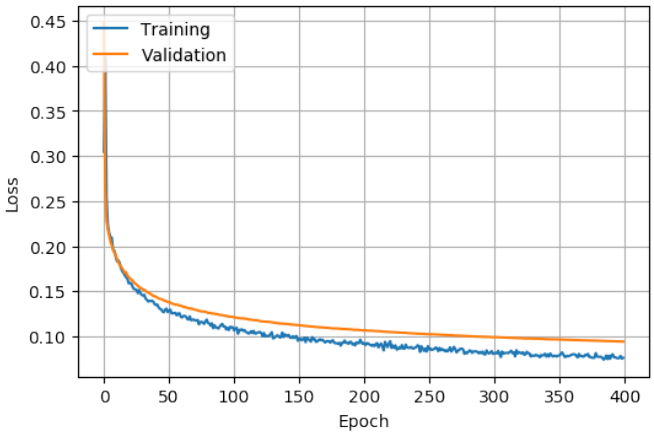


Fig. 5. Loss evolution in the training stage.

The model's performance was calculated in terms of Sensitivity or True Positive Rate (TPR)(2), Specificity or True Negative Rate (TNR)(3) and Accuracy (4) defined as below:

$$Sensitivity = \frac{TP}{TP + FN} \tag{2}$$

$$Specificity = \frac{TN}{TN + FP} \tag{3}$$

$$Accuracy = \frac{TP + TN}{TP + FP + FN + TN} \tag{4}$$

Where TP denotes True Positive (number of Schizophrenia correctly classified as Schizophrenia), FN denotes False Negative (number of Schizophrenia wrongly classified as Healthy), TN denotes True Negative (number of Healthy correctly classified as Healthy), and FP denotes False Positive (number of Healthy wrongly classified Schizophrenia).

The confusion matrix is presented in Table II. It shows that 0.9 of the schizophrenia EEG signals were correctly classified (TPR), and the normal EEG signals reached 0.9 of correct classification (TNR) and accuracy of 0.9.

TABLE II. Confusion Matrix

		PREDICTED	
		Schizophrenia	Normal
ORIGINAL	Schizophrenia	0.9	0.1
	Normal	0.1	0.9

IV. Discussion

The problem of the classification of EEG signals to aid the diagnosis of mental diseases is still open nowadays [12]. Because of this, new researches are developed, trying to

improve the performance of the previous works.

In this work, a model to classify people who suffer schizophrenia and healthy people by EEG signals using deep learning has demonstrated performance with an accuracy of 0.9.

Piryatinska et al. [12] presented a model that calculates ϵ-complexity coefficients of the original signal. Then they classified these coefficients with Random Forest (RF) and support vector machine (SVM). Table III shows a comparison between the accuracy reached by [12] and the proposed method, Piryatinska et al. [12] reached an accuracy of 84.5% applying RF on ϵ-complexity coefficients, and 81.07% utilizing SVM on ϵ-complexity coefficients, lower than the accuracy of 90% obtained by our method applying CNN on the channels correlation matrix obtained from raw EEG signals.

TABLE III. COMPARISON OF RESULTS FOUND IN [12] WITH THE RESULT OF OUR METHOD

	Accuracy
ϵ-complexity coefficients with RF	84.5%
ϵ-complexity coefficients with SVM	81.07%
Our method	90%

V. CONCLUSION

In conclusion, we proposed a model that uses PCC to obtain the correlation matrix of the EEG signal and present it to a CCN architecture, to classify people who suffer schizophrenia and healthy people from publicly available data. The proposed methodology obtained an accuracy of 90%, with a specificity of 90% and a sensitivity of 90%. The performance of the proposed method is better than the existing work that used the same data.
Increasing the amount of data, the performance of the proposed method can be better.

ACKNOWLEDGMENT

The authors would like to thank the support and subvention of the UNIVERSIDAD NACIONAL DE SAN AGUSTÍN DE AREQUIPA with contract N° TP-5-2018-UNSA.

REFERENCES

[1] W. H. Organization, "Schizophrenia," https://www.who.int/en/news-room/fact-sheets/detail/schizophrenia, 2018.

[2] J. M. Lyness, "Psychiatric Disorders in Medical Practice," *Goldman's Cecil Medicine: Twenty Fourth Edition*, vol. 2, pp. 2236–2245, 2011. [Online]. Available: http://dx.doi.org/10.1016/B978-1-4377-1604-7.00404-8

[3] Asociación Americana de Psiquiatría, "Guia De Consulta De Los Criterios Diagnóticos Del Dsm-5," pp. 107–110, 2014. [Online]. Available: www.psych.org

[4] M. A. Nihart, "The neurobiology of schizophrenia," *Journal of the American Psychiatric Nurses Association*, vol. 2, no. 5, pp. 61–82, 2016.

[5] Y. Ren and Y. Wu, "Convolutional deep belief networks for feature extraction of EEG signal," *2014 International Joint Conference on Neural Networks (IJCNN)*, pp. 2850–2853, 2014. [Online]. Available: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=6889383

[6] U. R. Acharya, S. L. Oh, Y. Hagiwara, J. H. Tan, and H. Adeli, "Deep convolutional neural network for the automated detection and diagnosis of seizure using eeg signals," *Computers in biology and medicine*, vol. 100, pp. 270–278, 2018.

[7] F. Lotte, L. Bougrain, A. Cichocki, M. Clerc, M. Congedo, A. Rakotomamonjy, and F. Yger, "A review of classification algorithms for eeg-based brain–computer interfaces: a 10 year update," *Journal of neural engineering*, vol. 15, no. 3, p. 031005, 2018.

[8] Y. Gao, H. J. Lee, and R. M. Mehmood, "Deep learninig of eeg signals for emotion recognition," in *Multimedia & Expo Workshops (ICMEW), 2015 IEEE International Conference on*. IEEE, 2015, pp. 1–5.

[9] A. Frydenlund and F. Rudzicz, "Emotional affect estimation using video and eeg data in deep neural networks," in *Canadian Conference on Artificial Intelligence*. Springer, 2015, pp. 273–280.

[10] S. Jirayucharoensak, S. Pan-Ngum, and P. Israsena, "Eeg-based emotion recognition using deep learning network with principal component based covariate shift adaptation," *The Scientific World Journal*, vol. 2014, 2014.

[11] S.-E. Moon, S. Jang, and J.-S. Lee, "Convolutional neural network approach for eeg-based emotion recognition using brain connectivity and its spatial information," in *2018 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*. IEEE, 2018, pp. 2556–2560.

[12] A. Piryatinska, B. Darkhovsky, and A. Kaplan, "Binary classification of multichannel-eeg records based on the ϵ-complexity of continuous vector functions," *Computer methods and programs in biomedicine*, vol. 152, pp. 131–139, 2017.

[13] B. Pandey and D. Kundra, "Diagnosis of eeg-based diseases using data mining and case-based reasoning," *International Journal of Intelligent Systems Design and Computing*, vol. 1, no. 1-2, pp. 43–55, 2017.

[14] D. Ravì, C. Wong, F. Deligianni, M. Berthelot, J. Andreu-Perez, B. Lo, and G.-Z. Yang, "Deep learning for health informatics," *IEEE journal of biomedical and health informatics*, vol. 21, no. 1, pp. 4–21, 2016.

[15] A. S. Heinsfeld, A. R. Franco, R. C. Craddock, A. Buchweitz, and F. Meneguzzi, "Identification of autism spectrum disorder using deep learning and the abide dataset," *NeuroImage: Clinical*, vol. 17, pp. 16–23, 2018.

[16] H. Liu, T. Zhang, Y. Ye, C. Pan, G. Yang, J. Wang, and R. C. Qiu, "A data driven approach for resting-state eeg signal classification of schizophrenia with control participants using random matrix theory," *arXiv preprint arXiv:1712.05289*, 2017.

[17] M. Shim, H.-J. Hwang, D.-W. Kim, S.-H. Lee, and C.-H. Im, "Machine-learning-based diagnosis of schizophrenia using combined sensor-level and source-level eeg features," *Schizophrenia research*, vol. 176, no. 2-3, pp. 314–319, 2016.

[18] L. Chu, R. Qiu, H. Liu, Z. Ling, and X. Shi, "Individual Recognition in Schizophrenia using Deep Learning Methods with Random Forest and Voting Classifiers: Insights from Resting State EEG Streams," *arXiv preprint arXiv:1707.03467*, pp. 1–7, 2017.

[19] A. Ganta, "Detection and Classification of Epileptiform Transients in EEG Signals Using Convolution Neural Network," 2017.

[20] S. Stober, A. Sternin, A. M. Owen, and J. A. Grahn, "Deep feature learning for eeg recordings," *arXiv preprint arXiv:1511.04306*, 2015.

[21] S. Jang, S.-E. Moon, and J.-S. Lee, "Graph signal representation of eeg for graph convolutional neural network," 2018.

[22] R. T. Schirrmeister, J. T. Springenberg, L. D. J. Fiederer, M. Glasstetter, K. Eggensperger, M. Tangermann, F. Hutter, W. Burgard, and T. Ball, "Deep learning with convolutional neural networks for eeg decoding and visualization," *Human brain mapping*, vol. 38, no. 11, pp. 5391–5420, 2017.

[23] S. Sarkar, K. Reddy, A. Dorgan, C. Fidopiastis, and M. Giering, "Wearable eeg-based activity recognition in phm-related service environment via deep learning," *Int. J. Progn. Health Manag*, vol. 7, pp. 1–10, 2016.

[24] P. Bashivan, I. Rish, M. Yeasin, and N. Codella, "Learning Representations from EEG with Deep Recurrent-Convolutional Neural Networks," *arXiv preprint arXiv:1511.06448*, pp. 1–15, 2015. [Online]. Available: http://arxiv.org/abs/1511.06448

[25] Z. Yin and J. Zhang, "Cross-session classification of mental workload levels using eeg and an adaptive deep learning model," *Biomedical Signal Processing and Control*, vol. 33, pp. 30–47, 2017.

[26] F. Movahedi, J. L. Coyle, and E. Sejdić, "Deep belief networks for electroencephalography: A review of recent contributions and future outlooks," *IEEE journal of biomedical and health informatics*, vol. 22, no. 3, pp. 642–652, 2017.

[27] S. Vieira, W. H. Pinaya, and A. Mechelli, "Using deep learning to investigate the neuroimaging correlates of psychiatric and neurological disorders: Methods and applications," *Neuroscience & Biobehavioral Reviews*, vol. 74, pp. 58–75, 2017.

Securing Informative Fuzzy Association Rules using Bayesian Network

Muhammad Fahad[1], Khalid Iqbal[2], Somaiya Khatoon[3], Khalid Mahmood Awan[4]
Department Computer Science
COMSATS University Islamabad,
Attock Campus

***Abstract*—In business association rules being considered as important assets, play a vital role in its productivity and growth. Different business partnership share association rules in order to explore the capabilities to make effective decision for enhancement of business and core capabilities. The fuzzy association rule mining approach emerged out of the necessity to mine quantitative data regularly present in database. An association rule is sensitive when it violates few rules and regulation for sharing particular nature of information to third world. Like classical association rules, there is a need for some privacy measures to be taken for retaining the standards and importance of fuzzy association rules. Privacy preservation is used for valuable information extraction and minimizing the risk of sensitive information disclosure. Our proposed model mainly focuses to secure the sensitive information revealing association rules. In our model, sensitive fuzzy association rules are secured by identifying sensitive fuzzy item to perturb fuzzified dataset. The resulting transformed FARs are analyzed to conclude/calculate the accuracy level of our model in context of newly generated fuzzy association rules, hidden rules and lost rules. Extensive experiments are carried out in order to demonstrate the results of our proposed model. Privacy preservation of maximum number of sensitive FARs by keeping minimum perturbation highlights the significance of our model.**

***Keywords*—Fuzzy association rules; privacy preservation; fuzzification; sensitive rules; Bayesian network; perturbation**

I. Introduction

Data mining is a systematic way for extracting useful information from large repositories of data using many effective tools and techniques [1]. Association rule mining being one of most effective techniques of data mining is used for extraction of interesting association rules from large databases [2]. Association Rule Mining (ARM) is focused on extraction of recurrent item sets from crisp data but association rule mining usually looks for attribute that are categorical by nature. Real life data is combination of both categorical and numerical data and it does not focus on either categorical or numerical only. The general scheme used is to transform numerical data into categorical attributes using different ranges of data but this conversion leads to more uncertainty and multiple sharp boundary problems. To cope with this problem, fuzzy methods are taken into account which helps in transformation of numerical data into fuzzy categorical data [3], [4]. This method gives surety for zero or negligible loss of information regardless of considering particular value of numerical attributes. Consequently, the inherent uncertainty that exists in numerical database is also appropriately taken care off. Fuzzy logic [5] is an efficient technique that has been used in many fields for dealing with uncertainty that lies in every type of data. Data is uncertain by nature when it is related to humans. Therefore, there must have a suitable and useful approach to build for handling uncertainty in combination of fuzzy logic to protect privacy of association rules. Fuzzy set theory concept and association rule mining integration results in formation of fuzzy association rules which covers the drawback and sharp boundary problems of classical association rules. Apart from extraction of information or knowledge from database, few techniques are required for safeguard of information or extracted patterns. Basically, knowledge sharing will possibly involve intimidations and threats that privacy or sensitive information (in any form) could be unintentionally revealed. That is, as knowledge sharing increases it become more important for people to keep information more secure and safe regardless of the fact for what purpose and in which form it is being shared. To reduce the information disclosure risk, sensitive information from shared database should be kept out of sight. Therefore, PPDM techniques are widely used in knowledge discovery. The main goal of PPDM is to lessen the risk of ill use of data while keeping quality of data mining practices. Privacy preserving data mining was first familiarized by Agrawal [2]. Basically, there are two problems being address in PPDM [6]; First is privacy of data and second is privacy of sensitive rules (knowledge) extracted from the data. The latter problem which is called Knowledge Hiding in Database (KHD), tells how to conceal sensitive rules keeping the extraction of non-sensitive rules normal in record. This (Association rule hiding) problem is most substantial and hotspot in research field now a days. In [7], [8], [9], a detailed view of privacy preservation of data mining techniques for lessening the disclosure of sensitive information is presented. Support and confidence are two significant measures for discovery of item sets for association rules. Association rules which satisfy the required support confidence threshold, such rules are considered as interesting rules. These measures have been focused by researchers to improve privacy of association rules by manipulating support, confidence such as process of increasing support of antecedent of rules (ISL) and decrease in support of consequent of rule (DSR) [10], Decrease of Support Rule (DSR) and manipulation with support of LHS and RHS of rule [11], Decrease Support Confidence (DSC) algorithm introducing Pi-tree in [12], algorithm dealing with support and confidence framework naming Decrease Support of Sensitive Items (DSSI) [13] for improving issues of [12], [10]. Advanced Decrease Support of Sensitive Item ADSSI algorithm introduced for tackling security problem in effective way [14]. In 1965, Zadeh first introduced fuzzy set theory. This

theory is under focus of many researches of data mining to find interesting fuzzy association rules or sequential patterns in transaction data with quantitative values [15], [16], [17], extraction of fuzzy rules between key phrases in documents using Extractor Package [18] and defining significance factor and certainty factor in item sets and association rules [19]. Limitations in the support and confidence-based methodologies gave researchers the path to work on perturbation and other different approaches [8], [23] for minimizing the limitation of aforementioned framework-based techniques and enhancing the work. Firstly, these various techniques result into some flaws and limitation of generating lost and ghost rules, multiple database scans, incomplete transformation of database and side effects of adding noise in original database. Secondly, all such techniques tend to hide sensitive rules on assumption bases instead of proper certainty of particular node. ARs are considered as sensitive if they disclose valuable and critical information to third party. Thus, data mining techniques must hide such sensitive rules with proper strategy and selection with proper formulation rather than assumption. All aforementioned techniques became unable to give a solid picture for sensitive item identification for perturbation. On contrary, our proposed methodology not only identifies sensitive items accurately, but also recommends particular transactions for modification. To report this challenging problem, our work proposes a PPDM model for securing fuzzy association rules that are sensitive. Proposed agenda comprise of few steps; using fuzzy logic and membership function for preprocessing of original data set and converting it into fuzzy dataset, preparing input for K2 algorithm and apriori algorithm, determining the sensitive node/item using Bayesian network developed by K2 algorithm, hiding the considered sensitive rules, performing minimum perturbation for max. degree transaction in database using sensitive item/node. Bayesian network has been widely used in fields [19], [20]. Bayesian networks basically helps in discovering information about uncertainty of particular domain by building a probabilistic graphical structure. This particular graphical model contains vertices (V) representing items and edges (E) representing the dependencies of variables probabilistically on parallel items. Items and nodes are variables/attributes of proposed work. Bayesian networks can be developed using K2 algorithm [19]. K2 algorithm discovers relationship among items/nodes in an increasing order.

Remaining part of paper is organized as follows: Section II contains related work done by previous researchers, in Section III we proposed our methodology, Section IV is with experimental section and Section V presents conclusion.

II. Related Works

Different techniques have been used by researcher for privacy preservation of association rules and fuzzy association rules. Most of algorithms in privacy preservation mostly rely on support and confidence manipulation of rules and transformation in databases. Two algorithm increasing support of L.H.S (ISL) and Decreasing support of R.H.S (DSR) proposed by Wang et al. [10] ISL increase the support of antecedent of rule below minimum threshold while DSR with no hiding failure, lowers the support and confidence of rule for hiding the sensitive rules. Wang et al. [10], proposed two hiding algorithms ISL (Increase Support of LHS) and DSR (Decrease Support of RHS) algorithm. ISL through rising support of rules' LHS confidence will be reduced under the threshold; as a result, the sensitive association rules will be unseen. DSR decreases the whole rule's support and confidence below the threshold to hide sensitive association rules. DSR has no hiding failure; notwithstanding, whereas ISL will fail if there is no suitable transaction to add. Two more algorithm introduced by Wang et al. [21] naming Decrement in Confidence by Decrease support (DCDS) and decrement in confidence by increase support (DCIS). This algorithm puts combined recommendation association rules under curtain. Rule hiding is done by decreasing support of suggested item keeping others items support constant and increment in support of non-suggested items while keeping support of suggested items constant in (DCDS) and (DCIS) algorithms respectively. Wang et al. [12] presented another support confidence-based approach (DSC) Decrease support and confidence with multiple scan of database in Pi-tree structure. In [14], Chang and Chen proposed an improved version of [12] for securing complex rules sets naming DSSI (Decrease support of sensitive item set) [13] and also covering its limitation. DSSI is more effectual as compared to another algorithm as it requires only one scan of database and left no rule unhidden. However, it results in removal of some non-sensitive rules which minimizes the impact of its benefit over other algorithm. Another support confidence-based approach ADSSRC Advance Decrease Support of Right-Hand Side item of Rule Cluster) is proposed by Modi et al. [22] which start hiding process after makes cluster of assumed sensitive items picked from RHS hence reducing the number of alterations in original database. A Bayesian network-based model has been used as well in privacy preservation [23]. In [11], different fuzzy based mapping approaches are analyzed in context of privacy preservation aspect and abilities to maintain relationship with other fields. In [24], a technique in privacy preserving manner is proposed to find out comprehensive fuzzy rules with the similar traits from share data. In [29], a fuzzy c-regression method is used to produce artificial data generation process which helps third parties to statistical calculation with a narrow disclosure risk. Hong et al. [26], proposed an algorithm that extracts exciting fuzzy association rules from given transaction set by incorporating concepts of apriori algorithm and fuzzy set idea. This algorithm focused only the particular fuzzy region having more support than minimum support used to frame the rules. this algorithm claims better time complexity. Berberoglu [28], proposed a unique scheme to hide sensitive fuzzy association rules. This process is done by increment in support threshold of antecedent part of rule which later, results in lowering confidence of particular rule. Manoj Gupta et al. [30], proposed quantitative rules hiding by lowering the support after performing fuzzification with random membership function. This method needs predefined membership function for fuzzification and are typically constructed by human experts. Hameed et al. [16] proposed a framework for privacy preservation of fuzzy association rules. This framework (PPFAR) is based on fuzzy correlation study. Interesting association rules are highlighted and considered as sensitive by fuzzy set integration with aprioiri and fuzzy correlation study. Experimental results demonstrate that PPFAR approach tends to hide informative rules with minor level alterations and sustains quality of the modified dataset. Another technique for hiding sensitive FAR is introduced in [21] which extract fuzzified data with help of modified aprioiri algorithm. DSR (Decrease support of Right-hand side of rule) approach is used for hiding sensitive

rules. Chan and Au introduced an algorithm F-APACS in [27] for extraction of fuzzy association rule. Transformation from quantitative to linguistic data is performed in this algorithm. Furthermore, process of accustomed difference analysis is used. It helped in finding out the most interesting associations among variables. In [34] a secure framework for privacy preserving fuzzy co-clustering is proposed for handling both vertically and horizontally distributed co-occurrence matrices. A method to hide fuzzy association rule is proposed in [31] using modified apriori algorithm in order to identify sensitive rules to be hidden. A perturbation approach, algorithm Fast hiding sensitive association rules (FHSAR) proposed by Weng et al. [25]. This algorithm minimizes the execution time for hiding sensitive rules by taking single scan of database. All transactions are assessed one by one to capably select items for modification purpose. In addition to hide sensitive rules, Index table-based transformation of frequent item set is used by framework proposed by Wu et al. [32]. It is done for retrieving rules rapidly. In technique [20] process of binning and field rotation are used for securing sensitive information after perturbation in database. This methodology sustained the novelty of data even after recognition of items required for perturbation. In [33], [34], multiple rules hiding technique is proposed that requires two scans of database irrespective of sensitive items. Index table files are generated for speed up of locating sensitive transaction in firs scan whereas hiding algorithm is applied in dataset in second scan. A border-based approach is introduced by X. Sun [35] which is used to efficiently evaluate influence of any manipulation or alteration to the original database throughout hiding procedure. Alteration is performed with minimum side effects keeping the quality of database constant. Later on Sun [35] introduced enhanced usefulness of the work presented in [36]. Hybrid approaches like [37], EMO algorithm is also used for overcoming the failure of previous techniques-based algorithms by combining hybrid technique (e.g. distortion and genetic algorithm). Despite of this, optimal solution is NP-hard problem but there is always focus on optimal solution or methods for the discussed problem.

III. Proposed Methodology

Our proposed framework presented in Fig. 1 contains quantitative dataset. Initially original dataset is converted into fuzzified data using membership function $MF(i) : D(i) \rightarrow [0, 1]$. This transformation is resulted after fuzzy set intervals of every attribute of original dataset $D_{(org)}$. The resulting data is again processed into binary data $D_{(bin)}$ and transactional dataset $D_{(T)}$. Binary table represents presence and absence of item using binary digit 0 and 1. Transactional data is used as input for apriori algorithm to generate efficient fuzzy association rules FARS. Binary table D(bin) is prepared as input for K2 algorithm. K2 algorithm is used to get the corresponding node in order of the occurrence of items. Conditional Probability scores are generated using random orders of variables of binary table. Those scores help in measuring items dependency column by column on each other. Thus, this table is recorded during the execution of K2 algorithm. Probabilistic dependency and highest computation of particular item throughout this Bayesian network structure is fundamentally used to locate the sensitive item (I_S) and transform the transactional bi-vector dataset after minimum perturbation. The released or reformed dataset (D_R) is used as input again to apriori algorithm keeping the support and confidence constant to extract modified and non-sensitive rules (R_{NS}).

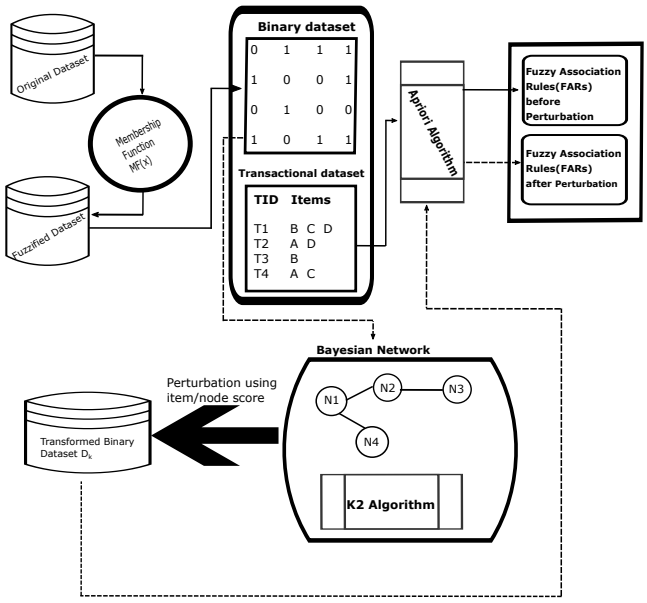


Fig. 1. Bayesian network-based Privacy preservation of sensitive fuzzy association rules

A. Important Components of the Proposed Model

After brief discussion of proposed model, few important components of this model are discussed below:

1) Apriori algorithm: Apriori algorithm, first introduced by agarwal [2] is extensively used and was one of the first attempt for extracting association rules from large datasets. This algorithm is count sub class of DFS algorithm. Though generating interesting association rules, this algorithm is unable to protect disclosure of sensitive rules.

2) Membership function MF(x): Membership function introduced by Lofti A. Zadeh, is a curve that determines how ever input value is mapped to degree of membership from 0 to 1. Gaussian membership function is effective function for achieving the smoothness in curve and removing uncertainty in data series. Gaussian membership function is computed in eq. (1):

$$gmf(x) = e^{-0.5(y)^2}; y = 8[\frac{X - X_{min}}{X_{max} - X_{min}}]4, x > 0 \quad (1)$$

Where X_{min} = Minimum value in given data series; X_{max} = Largest value in given data series; X= current value that is in queue to be fuzzified.

3) Fuzzy table: Fuzzy table is collection of record which is fuzzy in nature and is calculated after applying membership function using multiple intervals (expert domain based) as shown in Table I.

TABLE I. FUZZIFIED DATA EXAMPLE

TID	Age			Income		
	Low	Young	Old	Low	Average	High
T1	0.3	0	0	0.7	0	0
T2	0.122	0.55	0	0.8	0.1	0.002
T3	0	0.7	0.12	0	0.45	0.34
T4	0	0	0.67	0	0	0.9
T5	0	0.78	1	0.1	0.2	0

4) Fuzzy association rule (FARs): Fuzzy association rule mining is used for extracting association rules with fuzzy set concept such that the quantitative values can be controlled. Fuzzy association rules use fuzzy logic to convert the numerical, quantitative and crisp values into linguistic terms. They basically split information into multiple domains and represent it into more descriptive form.
$Customer_{age=young,marital\_status=widow} \rightarrow Loan_{Balance=low}$

5) Binary table of transactions: Table II represents particular item's presence and absence in form of 0s and 1s in every transaction.

TABLE II. BINARY TABLE

TID	A			B		
	A,1	A,2	A,3	B,1	B,2	B,3
T1	1	0	0	1	0	0
T2	1	1	0	1	1	0
T3	0	1	1	0	1	1
T4	0	0	1	0	0	1
T5	0	1	1	0	1	0

6) K2 Algorithm with Bayesian network: K2 algorithm [19] can be used to establish Bayesian network structure in increasing order. Bayesian networks are denoted in a (DAG) Directed Acyclic Graph according to given eq. (2)

$$f(i,\pi_i)=\prod_{i=1}^{n}\prod_{j=1}^{q_i}\frac{(r_i-1)!}{(N_{ij}+r_i-1)!}\prod_{k=1}^{r_i}\alpha_{ijk}! \qquad (2)$$

π_i: Parents of xi(node) $q_i = |\varphi_i|$ φ_i : List of all possible representation of the parents of x_i in Database. i.e, if $p_1, ..., p_s$ are the parents of x_i then φ_i is the Cartesian product $\{v_1^{p_1}, ..., v_r^{p_i}\}...\{v_1^{p_1}, ..., v_r^{p_s}\}$ of all possible values of attribute p_1 through p_s. $r_i = |v_i|$ v_i: All possible values of the attribute x_i α_{ijk}: Number of items in D in which the trait x_i is represented with its k^{th} value, and the parents of x_i in π_i are instantiated with the j^th instantiation in φ_i. $f(i,\pi_i)$; Database D probability that parents of attribute x_i are π_i.

7) Maximum degree transaction (Tmax): It is a transaction in data set which contains highest numbers of item in it. Maximum degree transaction is utilized for perturbation process.

8) Sensitive rule (RS)/ item(IS): A rule is sensitive (RS) when it discloses any private information. A sensitive rule (RS) is determined by scores obtained after k2. In this model, a sensitive node is identified through K2 algorithm on basis of Bayesian Network. A node is recognized as sensitive by taking its frequent occurrence or maximum likelihood calculation into account throughout this network structure. So the item having maximum column by column dependency after generating number of scores from their random orders, is used to perturb the transactional dataset.

9) Algorithm working and implementation: Before explanation of proposed model here some main steps of models are described that are to be followed:

STEP-1: Initially, text file contain quantitative data is read.
STEP-2: This quantitative data is then converted into fuzzified form by applying Gaussian membership function (gmf(x)).
STEP 3: Binary data is obtained from fuzzified data generated in STEP-2.
STEP-4: Transactional data (after manipulation of binary data with symbolic representation)is used as input to Apriori algorithm for generating fuzzy association rules.
STEP-5: Binary table from STEP 3 is given as input to K2 algorithm [34] for generating Bayesian Network of different random orders.
STEP-6: After K2 algorithm, scores on basis of conditional probability of items on each other is calculated and store in table from STEP-5.
STEP-7: An item with its symbol in transactional table having maximum score after different order based probability and dependency is identified.
STEP-8: Perturb the transactional table using STEP-7.
STEP-9: Transactional data altered in STEP-8 is used by Apriori algorithm.
STEP-10: Generate output of result based on STEP-9 (Hidden Informative FAR).

Proposed algorithm with each step is shown in Fig. 2. This algorithm initially takes original data as input for fuzzification process/Gaussian membership function being most productive in this domain. Gmf(x) is used to convert original data D into fuzzy data using various fuzzy sets. A membership function converts the crisp data into fuzzified form thus eliminating the factor of uncertainty and sharp boundary problem in quantitative or binary data. Furthermore fuzzified data is converted into binary table after applying filtration process of threshold of 0.1% to all fuzzy values and as this threshold is enough to prune negligible fuzzy values. This binary table is given as input to K2 algorithm for making Bayesian network and finding out probability computation of every variable. On the basis of this computation a node is identified as sensitive node. A node is a basically attribute/variable of binary table. A symbolized transactional data, created from binary table, is given input to apriori algorithm to produce efficient fuzzy association rules. Minimum perturbation is performed using maximum degree transaction in transactional table to remove sensitive item and pass the modified data set to generate non sensitive association rules.

Major factor of our proposed algorithm is firstly, highlighting the privacy in fuzzy association rule mining unlike previous researches and secondly, restriction in change of either support confidence threshold. Different dataset samples from literatures are used to test effectiveness and accuracy of our technique.

```
1. Input: Data.txt file, Support Threshold.
2. Output: Non sensitive Fuzzy Association Rules
3. Data < ---- readtxt(Orig_Data.txt)
4. while(sizeof_Trans>=j)
5. i=1;
6. while( sizeOf Fuzz_Col>=i)
7. while(Data_matrixSize(1)>=itrOfData)
8. Fuzz_data <----- Guass MF( 0;1)
9. Fuzz_data = Current_value
10. end
11. Bin_Data[j,i]
    ←(Fuzz_data[Bin_Data(j,i)>0.001]
12. Tran_Doc.txt←Bin_Dta[row, col]
13. Trans_Data←readdata(Tran_Doc.txt)
14. Num_of_Trans← length (Trans_Doc.tra)
15. for k = 1 to num_of_Trans
16. All nodes← [all Nodes,Trans_Data.tra,Node]
17. end
18. All_Nodes=unique(all_Nodes)
19. Node_Symbols←char(64+(1:length(all_Nodes)
20. for k =1 to length(all_Nodes)
21. nodeLookUpTable{k,1}←all_Nodes{k}
22. nodeLookUpTable{k,1}← node_Symbols(k)
23. end
24. BinaryTable←zeros(num_of_Trans.length(all_
    nodes)
25. List_Of_Trans←cell(num_of_Trans,1)
26. for k =1to num_of_Trans
27. Cur_Trans_Nodes←Trans_Data.tra(k).Node
28. for m=1 to length(all_Nodes)
29. nodeIndex←strmatch(all_Nodes{m}.cur_Tra_
    Nodes)
30. if~(isempty)(nodeindex))
31. List_Of_Trans{k}←[List_Of_Trans{k},nodeLo
    okUpTable{m,2}]
32. BinaryTable{k,m}←1
33. end
34. end
35. end
36. Bay_Network_Nodes<call K2{Bin_Data}
37. BayesScore←[K2Score,Order']
38. maxScore← max(abs(BayesScore(:,1)))
39. id# ←find(abs(BayesScore(:,1))>=maxScore)
40. Score_Item_No←BayesScore(id,2)
41. Score_Item_Symbol←
    itemLookUpTable{Score_Item_No,2}
42. Sensitive_Node←Score_Item_Symbol
43. Tran_And_Len←[];trans_Counter←0
44. for k = 1 to length (List_Of_Trans)
45. if
    any(List_Of_Trans{k}←Score_Item_Symbol)
46. Trans_Counter←trans_Counter+1
47. Tran_And_Len(trans_Counter,1)←k
48. Tra_And_Len(trans-
    Counter,2)←length(List_Of_Trans){k})
49. end
50. end
51. Max_length← max(tran_And_Len(:,2))
52. Tran_Delete←tran_And_Len(find(tran_And_L
    en(:,2)=Max_length),1)
53. for m = 1 to length(Tran_Delete)
54. Trans←List_Of_Trans){Tran_Delete(m)}
55. Trans(trans=Symbol_Item_Symbol)←[]
56. List_Of_Trans{Tran_Delete(m)}←Trans
57. end
58. call Apriori(List_Of_Trans) //use apriori
    algorithm to hide Sensitive FAR on transformed
    List_Of_Trans.
```

Fig. 2. Proposed algorithm with detailed steps.

IV. Experimental Result

To assess the working of proposed model is tested on different sample data sets based on other literatures to hide sensitive fuzzy association rules with backing of K2 and apriori algorithms. Our proposed methodology, initially reads a sample dataset containing five attributes of quantitative data in .txt format to apply fuzzification process. Resulting fuzzified data (example in Table I) is converted into binary table representing the presence or absence of particular item. Table II is showing (generic example of) binary data obtained from fuzzified data. Transactional items set Fuzzy association rules are produced from apriori algorithm. A sensitive node (i.e. "B", 2nd node) is identified using scores of different orders obtained from K2 algorithm. Thus FARs containing item "B" are considered as sensitive item and are presented in Table III. Minimum perturbation, based on sensitive item "B" is applied on maximum degree transaction i.e. 3rd row of transactional item set. Fig. 3 and Fig. 4 show the item dependency graph on each other for given sample dataset. Keeping the support constant (i.e. min_support is 20%) Apriori algorithm is again applied on perturbed transactional data to generate non sensitive association rules. As a result, 6 out of 7 rules from sensitive fuzzy association rules based on identified sensitive item, are hidden that are mentioned in Table IV.

In our proposed model, sensitive fuzzy association rules (FARs) are considered according to the identified sensitive item (Is), so these rules are not required to be shared in combined platform of business or publicly. Such rules need to be hidden which is successfully done by our proposed methodology. In Table V, summary of our proposed model on sample data set D is presented. We used HEART data set from UCI repository to evaluate our proposed methodology. This data set contains seven attributes out of which four attributes naming, "Age", "Cholesterol Level", "Blood pressure" and "Maximum

TABLE III. Sensitive Fuzzy Association Rules (FARs) using Sensitive Item

Rule No.	Fuzzy Association Rules	Support%	Confidence%	Lift Ratio%
1	B → D	25	66.6	16
2	B → H	25	66.6	13
3	B → I	25	66.66	22.5
4	B, D → H	25	100	20
5	B, D → O	25	100	33.3
6	B, H → O	25	100	33.33
7	B, D, H → O	25	100	33.33

TABLE IV. Hidden Sensitive Fuzzy Association Rules (FARs) using sensitive item

Rule No.	Fuzzy Association Rules	Support%	Confidence%	Lift Ratio%
1	B → D	25	66.6	16
2	B → H	25	66.6	13
3	B → I	25	66.66	22.5
4	B, D → H	25	100	20
5	B, H → O	25	100	33.33
6	B, D, H → O	25	100	33.33

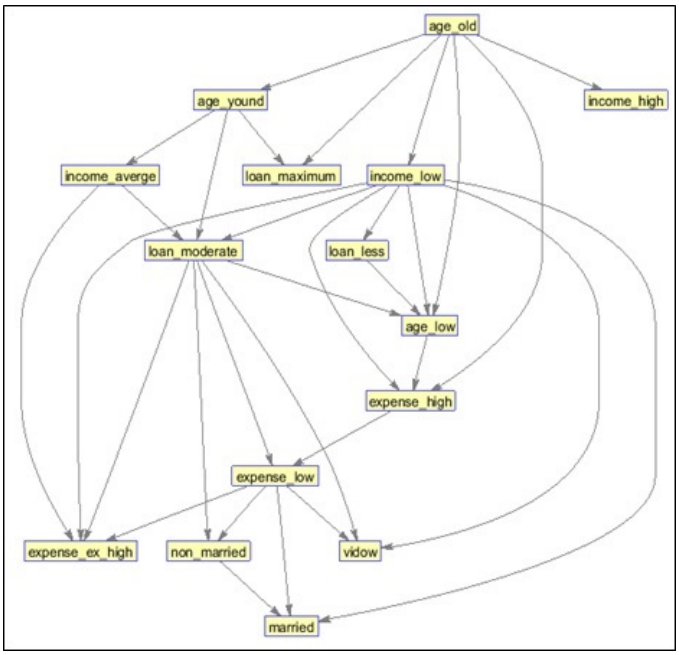


Fig. 3. Bayesian Network on given dataset (D)

Heart Rate" are taken into consideration for testing purpose. Our methodology performed the fuzzification operation to convert those attributes into fuzzified values. Binary table is generated to locate the item's presence and absence in particular tuple. Binary table of heart data set is presented in Table VI. This resulting data is passed to K2 algorithm to generate Bayesian network and computing the dependency scores of each fuzzified attribute (as shown in Fig. 5). This score is calculated using multiple order approach of nodes to find out constant maximum score of particular item and hence considered as sensitive node. A sample of identified sensitive item based FARs are shown in Table VII. Apriori algorithm is used on transactional item sets generated from binary table, to create non redundant fuzzified association rules. Minimum

TABLE V. SUMMARY OF PROPOSED MODEL ON SAMPLE DATASET

Total FARs	Sensitive FARs	Hidden FARS	Lost FARs	Ghost FARs	Modified Transactions	Total Trans-actions
86	07	06	00	00	01	07

perturbation is performed on maximum degree transaction in transactional table and in this case two transactions are perturbed as they both contains maximum number of items in it. Modified table is thus passed to Apriori algorithm to generate non sensitive Fuzzy association rules.

TABLE VI. A SAMPLE OF BINARY TABLE ON HEART DATA SET

ID#	A	B	C	D	E	F	G	H	I	J	K	L
1	0	0	1	1	1	0	0	1	0	1	0	0
2	0	0	1	1	0	0	0	0	1	0	1	1
3	0	1	1	1	1	0	0	1	0	1	1	0
4	0	1	1	0	1	0	1	1	0	0	0	0

TABLE VII. SENSITIVE FUZZY ARS USING SENSITIVE ITEM

Rule No.	Fuzzy Association Rules	Support%	Confidence%	Lift Ratio%
29	E→J	20	34.5	1.56
59	B,E→G	24.48	57.14	1.78
61	B,E→L	20.40	47.61	2.26
73	C,E→K	22.44	78.57	2.70
79	D,E→G	20.40	55.55	1.73
80	D,E→H	26.73	100	2.32
87	E,G→H	36.73	100	2.32
88	E,G→K	20.40	55.55	1,91
89	E,G→L	22.44	61.11	2.91
90	E,H→J	20.40	35.71	1.62
91	E,H→K	32.65	57.1	1.97
101	B,C,E→H	24.48	92.3	3.18
102	B,C,E→K	22.44	84.6	2.91
108	B,D,E→K	22.44	78.56	2.70
119	D,E,G→H	20.40	100	2.32
122	E,G,H→K	20.40	55.55	1.91

Pursuing our assessment on different UCI repository data sets proved effectiveness of our proposed methodology and it showed that our model was successful in hiding sensitive rules. Major factor of our model is restriction of ghost rules and lost rules unlike other algorithms like ISR, DSR and ADSSI. No. of lost rules are not found in our technique. In Fig. 5, a comparison analysis of our proposed methodology with different approaches is shown on hiding failure, number of ghost rules, lost rules. Our technique showed tremendous growth with zero hiding failure and ghost rules and minimizing the number of lost rules using least transformation in database unlike other compared approaches.

V. DISCUSSION

Privacy-Preserving Data Mining (PPDM) techniques are one step ahead in extraction of knowledge from large commercial and public data repositories while preventing the disclosure of sensitive information in form of association rules. In this work, we presented a Bayesian network based PPDM strategy for securing the critical fuzzy association rules. We not only summarized the previously researched work of hiding

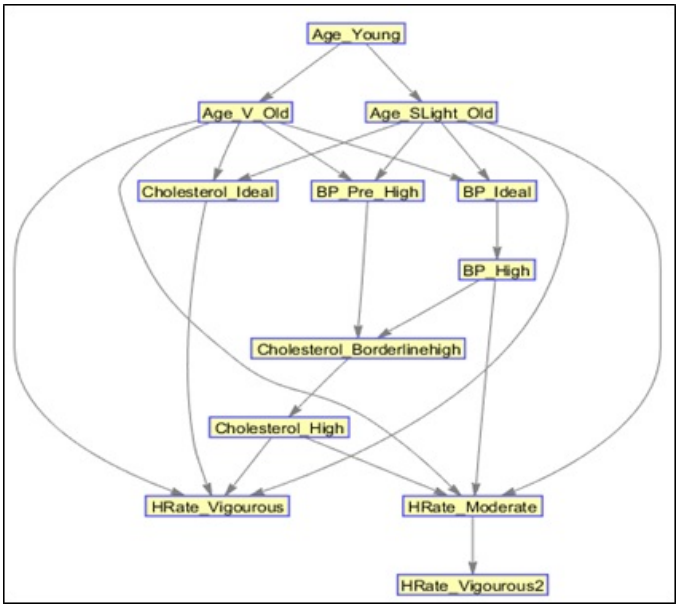


Fig. 4. Bayesian Network by K2 algorithm on HEART Dataset

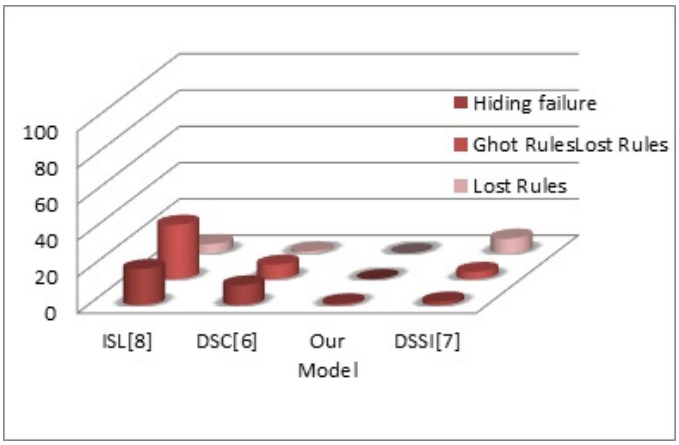


Fig. 5. Comparison of proposed model with few previous approaches

and securing sensitive information procedures like Support confidence, Perturbation techniques but also highlighted the lacking in their findings in context of information securing. After thorough study we came across main factors of previous work; i) Stress on extraction and securing of information from only classical association rule domain; ii) Assumption of sensitive information or target required to be concealed rather than proper formulation. We progressed with prior knowledge of aforementioned techniques to enhance the PPDM securing strategy in fuzzy domain. We mainly addressed privacy preservation of FARs which was not significantly taken into consideration in early contributions. We went through different highly significant phases in our work that includes fuzzification techniques for uncertain data, applying association rule mining technique for items relationships and their correlated behavior. Furthermore, Bayesian network incorporation into decision making procedure for sensitive items identification which later on, lead to creation of non-sensitive association rules after perturbation. The advantage of perturbing in this way, is

to keep the smallest influence to original database with the maximum subsidy with no side effects. Sensitivity analysis is a vital issue in different business and non-business organizations that progress collectively to achieve a given target. This model is proved to be very effective and beneficial in certain research areas which exploit fuzzy association rules like biomedical fields, criminal pattern discovery and financial transactions like supermarket data. When a biologist decides to conceal some sensitive pattern of health samples (may be tissue, patient or tumor), BN based approach can be incorporated to improves the security. In addition, State law enforcement are enduring to call upon data mining techniques to enhance crime analytics and well defend their communities and properties. Real-time solutions can save significant resources and push the capability of law enforcement closer to the pulse of criminal activity. In crime pattern discovery, extracted FARs are more accurate and interesting, and presented and discussed at national level, thus presented model can prove to be effective in dealing security of such high-level sensitive information. Association rules mined from a supermarket database using data mining methods can reveal sensitive information to business contestants. To confine sensitive information, supermarket database should be perturbed for this Bayesian Network-based identified sensitive attributes in a uppermost degree transaction. It is significant to put stress on fuzzy domain considering two facts; firstly, fuzzy logic adaptation to address uncertainty and impreciseness in real-world applications (mentioned above) requiring privacy safeguards and secondly is absence of privacy preservation in the domains. The results of our hiding strategy are quite impressing without any shortcomings and can have valuable research endeavor for future works.

VI. Conclusion

Privacy preservation turns out to be an important aspect in data mining to restrict the disclosure of sensitive information after mining process. In our proposed method, we tend to hide the sensitive fuzzy association rules with minimum or no side effects. Main goal is to uncover those sensitive items which participate in exposing secrets of healthy business to its business contestants during fuzzy association rule generation process. Privacy preservation of maximum number of sensitive FARs by keeping minimum perturbation highlights the significance of our model. Different pervasive tests over case studies and datasets will be held to validate the effectiveness and accuracy of proposed work and hiding sensitive association rules after comparison with current techniques. Support and confidence are extensively taken into account for privacy preservation by many researchers. Our model prospered in performing privacy preservation of association rules without alteration of these measures. The ability to produce the intended results of proposed model are demonstrated in the form of minimizing sensitive fuzzy association rules over different datasets with minimum perturbation to original dataset. In future, probability based multiple sensitive items can be identified to hide sensitive FARs with an aim to keep the minimum perturbation to original data and maximum hidden rules. In addition, machine learning algorithms can be used to discover the relevant and interesting candidate items to increase the effect of securing sensitive FARs.

References

[1] C. Clifton and D. Marks, *Security and Privacy Implications of Data Mining* In ACM SIGMOD Workshop on Research Issues in Data Mining and Knowledge Discovery, 1996, pp. 15–19.

[2] R. Agrawal, T. Imielinski and A. N. Swami, *Mining association rules between sets of items in large databases*, In Proceedings of the 1993 ACM SIGMOD International Conference on Management of Data, P. Buneman and S. Jajodia, Eds. Washington, D.C., 207-216.

[3] J. Han, J. Pei and Y. Yin, *Mining frequent patterns without candidate generation*, ACM SIGMOD International Conference on Management of Data, 29(2),pp. 1–12, 2000.

[4] T.-P. Hong, C.W. Lin,C.C. Chang and S.-L. Wang, *Hiding Sensitive Itemsets by Inserting Dummy Transactions*, In 2011 IEEE International Conference on Granular Computing, pp. 246-249. IEEE, 2011.

[5] Zadeh L, *Fuzzy sets*, Inf. Control. Vol.8, PP, 338 – 353.

[6] K. Pathak, N. S. Chaudhari and A. Tiwari, *Privacy-Preserving Data Sharing Using Data Reconstruction Based Approach*, SI:International Journal of Computer Applications (0975 – 8887) on Communication Security, No.13, 2012.

[7] C. C. Agarwal and S. Y. Philip, *Privacy Preserving Data Mining: Models and Algorithms*, Springer Science & Business Media., 2008.

[8] W. Xiaodan, C. Chao-Hsien, W. Yunfeng, L. Fengli and Y. Dianmin, *Privacy Preserving Data Mining Research: Current Status and Key Issues*,International Conference on Computational Science,Springer, Berlin, pp. 762-772, 2007.

[9] S. Samet and A. Miri, *Privacy-Preserving Bayesian Network for Horizontally Partitioned Data*, In International Conference on Computational Science and Engineering, Vol. 3, pp. 9–16, 2003.

[10] S.-L. Wang, B. Parikh and A. Jafari, *Hiding informative association rule sets*, In Expert Systemswith Applications 33(2), pp. 316–323, 2007.

[11] P. Kongchai, N. Kerdprasop and K. Kerdprasop, *The Fuzzy Search for Association Rules with Interestingness Measure*, International Journal of Computer Theory and Engineering, Vol.6,No.6,2014.

[12] S. L. Wang, R. Maskey, A. Jafari, and T.P. Hong, *Efficient Sanitization of Informative Association Rules*, Expert Systems with Applications, vol. 37, 2007.

[13] Y. C. Chang and S.T. Chen, *Fast Algorithm for Completely Hiding Sensitive Association Rule Sets*, Proceedings of the Cryptology and Information Security Conference, pp. 547-560, 2008.

[14] S. T. Chen, S.M. Lin, C.Y. Tang, and G.Y. Lin, *An Improved Algorithm for Completely Hiding Sensitive Association Rule Sets*, IEEE 2nd International Conference on Computer Science and its Applications, pp.1-6, 2009.

[15] K. Sathiyapriya, G. Sudhasadasivam and N. Celin, *A New Method for preserving privacy in Quantitative Association Rules Using DSR Approach With Automated Generation of Membership Function*, In the Proceedings of World Congress on Information and Communication Technologies, pp.148-153, 2011.

[16] S. Hameed, F. Shahzad and S. Asghar, *A Fuzzy Correlation Scheme For Privacy Preservation In Knowledge Based Systems*, Australian Journal of Basic and Applied Sciences,6,no.9, pp.562-571, 2012.

[17] T.P. Hong, M.J.Chiang and S.L. Wang, *Mining from quantitative data with linguistic minimum supports and confidences*, Proceedings of the 8th IEEE International Conference on Fuzzy Systems,vol.1, pp. 494-499,IEEE,2002.

[18] T.P. Hong, K.Y. Lin and B.C. Chien, *Mining fuzzy multiple-level association rules from quantitative data*, Applied Intelligence, 18(1), pp. 79–90, 2003.

[19] G.-F. Cooper and E. Herskovits,*A Bayesian method for the induction of probabilistic networks from data Machine Learning*, 9(4), pp. 309–347, 1992.

[20] M.-A. Kadampur and D.-V.-L.-N. Somayajulu, *A Data Perturbation Method by Field Rotation and Binning by Averages Strategy for Privacy Preservation*, In Intelligent Data Engineering and Automated Learning–IDEAL, Springer-Ver lag, pp. 250–257, 2008.

[21] S.-L. Wang, D. Patel and A. Jafari, *Hiding collaborative recommendation association rules*, Applied Intelligence, Vol.27, No.1,pp.67-77, 2007.

[22] K. Shah, A. Thakkar and A. Ganatra, *Association Rule Hiding by Heuristic Approach to Reduce Side Effects & Hide Multiple RHS Items*, International Journal of Computer Applications (0975 – 8887), 2012.

[23] K. Iqbal, X.-C. Yin, H.-W. Hao, Q. M. Ilyas and X. Yin, *A central tendency-based privacy preserving model for sensitive XML association rules using Bayesian networks*, Intelligent Data Analysis 18, no. 2, 281-303, 2014.

[24] G. Chen, P. Yan and E.E. Kerre, *Computationally Efficient Mining for Fuzzy Implication Based Association Rules in Quantitative Databases*, International Journal of General Systems,33, pp.163-182 2004.

[25] C.-C. Weng, N.D.U. Taoyuan, S.-T.Chen, H.-C. Lo, *A Novel Algorithm for Completely Hiding Sensitive Association Rules*, In Eight Intenrnational Conference on Intelligent Systems Design and Applications,pp. 202-208, 2008.

[26] T. P. Hong, C. S. Kuo and S. C. Chi, *Mining association rules from quantitative data*, Intelligent Data Analysis,3(5),pp.363–376, 1999.

[27] S.N. Mandal,J.P.CHoudhury and S.R.B. Chaudhuri *In Search of Suitable Fuzzy Membership Function in Prediction of Time Series Data*, International Journal of Computer Science Issues, Vol.9,Issue 3,pp. 293-302, 2012.

[28] T. Berberoglu and M. Kaya, *Hiding Fuzzy Association Rules in Quantitative Data*, In 3rd International Conference on Grid and Pervasive Computing-Workshops, pp. 387-392,IEEE, 2008.

[29] E. Hüllermeier, *Fuzzy methods in machine learning and data mining: Status and prospects*, Fuzzy Sets and Systems, 156, pp. 387-406, 2005.

[30] M. Gupta and R.C.Joshi, *Privacy Preserving Fuzzy Association Rules Hiding in Quantitative Data*, International Journal of Computer Theory and Engineering, Vol.1,No.4,pp.382-388,2009.

[31] J. Han, J. Pei and Y. Yin, *Mining frequent patterns without candidate generation*, ACM sigmod record, Vol.29, No.2, ACM, 2000.

[32] C.-M. Wu, Y.-F. Huang and J.-Y. Chen, *Privacy Preserving Association Rules by Using Greedy Approach*, WRI World Congress on Computer Science and Information Engineering, 4, pp.61–65,2009.

[33] S. R. M. Oliveira and O. R. Zaïane, *Privacy preserving frequent itemset mining*, In Proceedings of the 2002 IEEE International Conference on Privacy, Security and Data Mining (CRPITS), pp. 43–54, 2002.

[34] S.-R.-M. Oliveira and R.-Z. Osmar, *A Unified Framework for Protecting Sensitive Association Rules in Business Collaboration*, Inderscience Publishers 1(3),247–287, 2006.

[35] X. Sun and P.S. Yu, *Hiding sensitive frequent itemsets by a border-based approach*, Journal of Computing Science and Engineering, Vol.1, No.1, pp. 74-94, 2007.

[36] X. Sun, P.S. Yu, *A border-based approach for hiding sensitive frequent itemsets*, Fifth IEEE International Conference in Data mining, p. 1550-4786, 2005.

[37] P. Cheng, J.-S.Pan, C.-W.L. Harbin, *Use EMO to Protect Sensitive Knowledge in Association Rule Mining by Removing Items*, In IEEE Congress on Evolutionary Computation (CEC),2014.

Evaluating a Cloud Service using Scheduling Security Model (SSM)

Abdullah Sheikh[1], Malcolm Munro[2], David Budgen[3]
Department of Computer Science
Durham University
Durham, United Kingdom

***Abstract*—The development in technology makes cloud computing widely used in different sectors such as academic and business or for a private purposes. Also, it can provide a convenient services via the Internet allowing stakeholders get all the benefits that the cloud can facilitate. With all the benefits of cloud computing still there are some risks such as security. This brings into consideration the need to improve the Quality of Service (QoS). A Scheduling Security Model (SSM) for Cloud Computing has been developed to address these issues. This paper will discuss the evaluation of the SSM model on some examples with different scenarios to investigate the cost and the effect on the service requested by customers.**

***Keywords*—Cloud computing; security; scheduling; evaluating; cloud models**

I. Introduction

Cloud computing is significantly used by educational and business sectors and for personal use for various purposes. Due to the rapid growth and the development in technology and facilities that cloud services can provide it has added a fascinating transformation to the Information Technology (IT) industry. Also, cloud computing provides convenient services enabling access to different computing resources such as networks, storage, and applications.

Cloud computing includes services such as data services, storage services, scheduling services, accessing to applications via the Internet, on demand self-service, and service management. Data service is about all database services, processing, and data store. While storage services include using a cloud storage system to manage saving data remotely in different storage location. The scheduling services include allowing customers to execute tasks over virtual resources and trying to allocate these tasks to these resources efficiently.

All these services can be provided upon customer request without or with less service provider interaction. For example, a customer can request storage space by submitting the request to a provider website. Then the customer can get the service by finalising service payment without any interaction from the service provider.

Cloud services bring various benefits to stakeholders (providers and customers). These benefits include wide access to software and applications over the Internet without any need to install any software to the customer terminal device. Moreover, using cloud service can be cost effective and as the cloud computing environment depends on reducing infrastructure cost. Also, it comes with different kind of risks such as security risks and financial risks.

There are many kind of risks that are related to the use of cloud computing. Risks such as Security and Privacy are big concerns to all parties in a cloud environment as the cloud services must be trusted and secured. So, any breach or failure in security will cause loss of customers and the business. Another risks that makes customer aware of getting a service is that they will be locked into one provider until their service is finished. This makes the service provider more concern to provide a trusted service.

These considerations include the need of improving the Quality of Services (QoS) provided. QoS includes different aspects such as time, service performance, reducing cost, and some non-functional requirements like reliability and recovery [1]. The success of applying these QoS aspects will improve the cloud services to meet customer expectations.

With all the benefits of the cloud, security is still one of the main concerns that affect the use of the cloud service. Cloud providers will be subject to many threats at different level of the cloud. Similarly, customers have concern about security and they share some responsibility with the cloud providers to keep the service security at a high level.

For example, if a customer requests a cloud service with a set of tasks with different security levels, it is required to have a technique that can handle this request. This technique should be able to execute the tasks submitted in the right order combined with security and QoS aspects.

Executing tasks requires using a scheduling process that has security as the main category, then uses priority to put tasks in right order. Security as a feature will be applied to all parts of the service, and the QoS will be applied to make the service more reliable and more efficient while the service is running. This complex request should be cost effective because the customer needs a cloud service that is secure, reliable, and with a very competitive cost compared to other service provider.

A recent review [2] has investigated and described the current situation of the cloud models. It then discusses the requirement of having a cloud security model based on cost that can manage requests focusing on security as a main feature associated with QoS aspects to meet the customer requirements. Then to execute scheduled tasks over allocated resources.

Moreover, Sheikh et al. [3] define a Scheduling Security Model (SSM) for a Cloud Environment. The SSM considers Security, Quality of Service (QoS), and Scheduling to allocate

Resources for predefined tasks based on security as a key element for a cloud service request. The security aspect affects task scheduling process, service cost, and service time. QoS levels will be considered as a feature included for the service cost. The Scheduling process will be focused on serving Tasks with higher security and using Task Importance to ordering them depending on Tasks priority. Fig. 1 shows the position of the SSM combining these features for a cloud service.

This paper focuses on evaluating the SSM model on some examples with different scenarios to investigate the cost and the effect on the service requested by customers.

This paper is organised as follows. Section II gives an over view of the features that involved for developing the Scheduling Security Model (SSM) which are Scheduling, QoS, and Security.

Section III discusses the results of the examples from the SSM, then Section IV discusses the evaluation of the SSM answering the questions that helped to develop the model. Section V concludes explaining aspects that important to be addressed by the service.

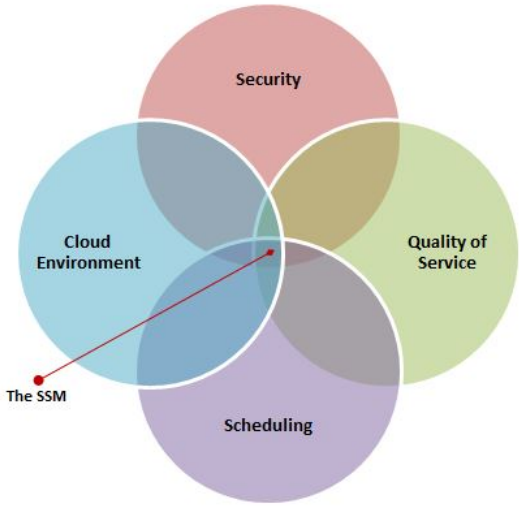


Fig. 1. SSM combined Features

II. Background

This section serves as a background and a general view of the features that involved to develop the Scheduling Security Model (SSM) for a cloud environment which are Scheduling, QoS, and Security.

A. Scheduling

Scheduling is a process of decision making to deal with allocating resources to tasks within a certain amount of time [4]. There are many type of resources and it can be a machine in a workshop, resource in computing environment [5]. A scheduler is classified as follows [4]:

- Batch Scheduling: used to avoid any handling during the running time [34]. There are two types of batch scheduling, serial and parallel batching. In serial batching tasks with same setting can be executed one by one on a machine. In parallel batching a set of tasks can be grouped and executed at same time.
- Interactive: to allow decision making at running time take an immediate response.
- Real Time: the ability to schedule tasks with specific time requirements.
- Parallel: tasks or group of tasks executed at the same time in one VM or more [4].

There are three level of scheduling decisions:

1) Long Term: to control and decide what task execute first and to be supported once at anytime.
2) Medium Term: to control switching tasks for different criteria such as non active, fault, and low priority.
3) Short Term: to allow frequent interactive to take decisions in short time slot.

The main scheduling goals are:

1) Performance:
   The scheduling algorithms should be able to consider the following measures in order to get good performance behaviour:
   a) Maximise CPU Utilisation: to control the number of tasks that can be processed.
   b) Maximise Throughput: to execute as many tasks as possible in a certain amount of time.
   c) Maximise Scheduling Efficiency: to execute all tasks without interrupting.
   d) Minimise Waiting Time: to reduce the amount of time that needed for executing tasks for users.
   e) Minimise Energy: to control and reduce the power consumption of resources.
2) Fairness:
   One of the important goals of scheduling is to treat all tasks to run in a reasonable time.
   a) Equal CPU consumption: to allocate tasks the same processing time in the CPU.
   b) Fair per(user, process, thread): giving all same characteristics for execution.
   c) CPU bound, I/O bound: to allow direct priority to task from a user.
3) Unfair:
   Sometimes the scheduling process tends to be unfair by giving advantage to one task over another for a specific aim.
   a) Priority System: to run task with higher priority to run first then the less priority one.
   b) Avoid starvation: to prevent that any task stays with no processing.

According to Yadav and Upadhayay [6], there are a number of existing scheduling algorithms as follows:

1) First-Come First-Served/ First-In First-Out (FCFS/FIFO):
Small tasks can be delayed behind large sized tasks.
2) Shortest Processing Time First/Shortest Job First (SPT/SJF):
The system just keep executing small tasks over large tasks.
3) Round Robin Scheduling (RR):
The scheduler allocates a fixed time to each task then executes tasks in a cycle way without any priorities.
4) Scheduling Priority (Priority):
Assigning priority to tasks will affect fairness of the system over other tasks. Also, tasks with less priority will never be executed and if so it will be delayed.
5) Multilevel Queue (MLQ) and Multi-level Feedback Queues (MLFQ):
Tasks queues can be divided into different categories where each class has its own scheduling requirements [6]. The difference is that the Multi-level Feedback Queues (MLFQ) can analyse the behaviour time of execution of the processing and according to changes on its priority.

B. Quality of Service (QoS)

Quality of Service (QoS) is one of the important factor that can help to improve any services, software, and applications [1]. So, the QoS means that the essential services features should meet all customer requirements.

According to Ramadan et al. [1], to have a good QoS there are some factors that need to be considered which affect the overall service as follows:

- Flexibility: It is all about managing any changes at the running time without any harms to the system.
- Maintainability and Readability: Similar to the flexibility but it is more focused on error correction and making any modification needed.
- Performance and Efficiency: It is all about the response time and making sure there is no delay or unexpected waiting time.
- Scalability: It is about responding to customers' activities in reasonable amount of time.
- Availability and Robustness: It is all about the availability all the time even if a failure has occurred.
- Usability and Accessibility: It is all about making the user interface the most visible side by making it very comfortable for the customer and easy to use.
- Platform Compatibility: For better quality the service should be running on as many different platforms as it can, with different system environments such as operating systems, and internet browsers.
- Security: It is the most important factor that needs to be considered in any service, and for QoS there is a need to apply security policies to make sure there are no security breaches at any level.

C. Security

Security is a concept that the process protect from physical or digital unauthorised use of any asset [7]. Also, security is a critical feature for any Service. The service must be secure and trusted for both customer and provider as they have both agreed in the Service Level Agreement (SLA) [8]. Security issues can affect Data, Networks, Communications, Privacy, unauthorised access and most things connected via the internet.

All of these aspects need to be protected, and each one requires a different way of security. So, these aspects can be classified into different security levels from high to low. This classification depends how valuable information is included in each asset. For example, storing very important government data requires a very high security level. This security level includes physical security measures and secure network connection and secure encrypted data storage. Also, it may require a limited access control to manage the process of retrieving and storing this data.

Security is also a very critical point that needs to be aware of all kind of information for all levels such as individuals, academic, business, and government even if it is digital or non digital materials.

Cloud computing as defined by the National Institute of Standard and Technology (NIST) [9] as "a model for enabling convenient, on-demand network access to a shared pool configurable computing resources (e.g. networks, servers, storage, application, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction". Customers need to communicate with a service provider to request a cloud service. This communication process makes the customer and the provider reach an agreement of the level of the service. This agreement referred to Service Level Agreement (SLA) [10]. This SLA is the basis for the expected level of the service between the customer and the provider. The provider of a cloud architecture can offer various services to a customer. Quality of Service (QoS) refers to cloud stakeholders expectation of obtaining a desirable service meeting requirements such as timeliness, scalability, high availability, trust and security specified in the Service Level of Agreement SLA [11]. These services can vary both in terms of functionality (such as storage capacity or processor count) or in terms of the Quality of Service (QoS) provided [12]. In terms of the QoS a provider will offer a defined SLA which the customer can use when determining the 'best' provider for their needs.

As a result of this review, the proposed model by Sheikh et al. [3] has considered the overall security discussed by Watson [13] to develop Scheduling Security Model (SSM) to address the issues found in other approaches such as security and cost. The SSM use a following equation to calculate the cost [3]:

$$AC = \sum_{i=1}^{N} (RC_i * RT_i(1 + q + Rw_i)) \quad (1)$$

Where

- RC_i is the cost per hour of Resource $_i$.
- RT_i is the time used on Resource $_i$.
- RC_i is the Quality of Service.

- Rw_i is the security weight of Resource $_i$.
- N is the number of Resources.

III. Examples and Scenarios

This section will discuss examples from Sheikh et al. [14]. The examples and scenarios will discuss aspects that are important to be addressed by the service which are Security, Time, and Cost.

In all examples and scenarios Tasks Security is identified by the customer and the value that added to the service request is to know all service requirements. Which is better than just requesting a service in a certain level of security with Resources then requesting a different Resource with different security level.

One of the main important issues for any cloud services is to be in a convenience time for any customer requests. Also, the service provider should manage to finish the cloud service on requested time or less.

It is very important that the customer identified all service requirements for any service request, because it would help the service provider to analyse the requirements and establish the service without any issues or asking the customer for more details.

A. Example: 1

A customer submits a service request with the details showing in Table I.

TABLE I. SSM Customer Requirement for Example 1

Security Level(Weight)/Importance	1	2	3	Resource	RC_i
1 (0.00)					
2 (0.25)			t_1	R_1	20
3 (0.50)		t_2		R_2	20
4 (0.75)					
5 (1.00)					

For this example the customer entered the Quality of Service q = 0.0

Tasks submitted as follows:

- Task t_1: p_1= 3, hw_1= 0.25
- Task t_2: p_2= 2, hw_2= 0.50

After analysing the customer inputs, the SSM created a Resource for each Task as follows:

- R_1 for t_1
- R_2 for t_2

1) Scenario: 1.1: The calculated AC will be as follows:
From equation 1

$$AC = ((20*1) * (1+0+0.25)) + ((20*1) * (1+0+0.50))$$

$$AC = 25 + 30 = £55$$

For Example 1, Table I: the actual running time each Resource is as follows:

- $R_1 : t_1$ and tm_1 = 18 minutes
- $R_2 : t_2$ and tm_2 = 13 minutes

Tasks time line for Scenario 1.1 is shown in Fig. 2. Here both actual time and the elapsed time will be equal because there are no dependencies between the tasks. As a result the AC will be the cost of actual running time for each resource. The actual running time for each Resource:

- tm_1 = 18, RT_1: Time for R_1 = 18 minutes
- tm_2 = 13, RT_2: Time for R_2 = 13 minutes

So, the SSM will use the actual running time for all Resources to Re-Calculating the Actual Cost.
Re−Calculating:
From equation 1

$$AC=((20*18/60)*(1+0+0.25))+((20*13/60)*(1+0+0.50))$$

$$AC=7.5 + 6.5$$

$$AC= £14$$

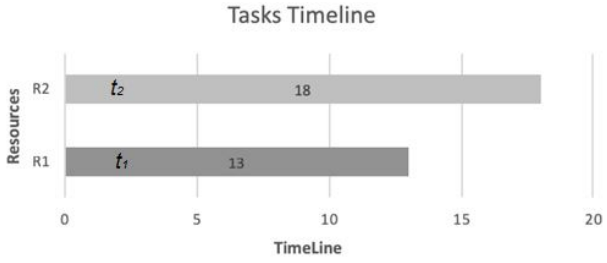


Fig. 2. Tasks Time Line for Scenario 1.1

B. Example: 2

A customer submitted a service request with the details shown in Table II.

TABLE II. SSM Customer Requirement for Example 2

Security Level(Weight)/ Importance	1	2	3	Resource	RC_i
1 (0.00)					
2 (0.25)	t_1	t_2		R_1	20
3 (0.50)					
4 (0.75)	t_3	t_4		R_2	20
5 (1.00)	t_5	t_6		R_3	20

For this example the customer entered the Quality of Service q = 0.0

1) Scenario: 2.1: For Example 2, Table II: Scenario: 2.1, the running time for each Resource, and the Tasks with ^{FT} indicates that is has been Fast Tracked as follows:

- $R_1 : t_1^{FT}$ and tm_1 = 18, t_2 and tm_2 = 15
- $R_2 : t_3^{FT}$ and tm_3 = 13 , t_4 and tm_4 = 10

- R_3 : t_6 and tm_6 = 10, t_5 and tm_5 = 5

The dependencies are: t_5 depends on t_1 and t_6 depends on t_3. If the SSM considers the running time for each Task, there will be a delay in executing Tasks t_6 and t_5 because of the dependencies. In this case, the calculated running time for each Resource will be as follows:

- tm_1 = 18, tm_2 = 15, RT_1 Time for R_1 = 18+15 = 33 minutes
- tm_3 = 13, tm_4 = 10, RT_2: Time for R_2 = 13+10 = 23 minutes
- tm_6 = 10, tm_5 = 5, RT_3: Time for R_3 = 10+5 = 15 minutes

Here there will be waiting time, so it will be added to RT_3: Time for R_3 = 13 + 10 + 5 = 28 minutes. The reason for adding tm_3 not tm_1 is that tm_3 is less than tm_1 which can let the related Task t_6 start just after it finishes.
Re−Calculating: From equation 1

$$AC = 13.75 + 13.42 + 18.67$$

$$AC = £45.84$$

This is illustrated in Tasks time line in Fig. 3. If, the SSM does not consider the waiting time and just calculates the elapsed time as follows:

- tm_1 = 18, tm_2 = 15, RT_1 Time for R_1 = 18 + 15 = 33 minutes
- tm_3 = 13, tm_4 = 10, RT_2: Time for R_2 = 13 + 10 = 23 minutes
- tm_6 = 10, tm_5 = 5, RT_3 Time for R_3 = 10 + 5 = 15 minutes

Re−Calculating: From equation 1

$$AC = 13.75 + 13.42 + 10.00$$

$$AC = £37.17$$

As a result of calculating the elapsed time the AC is less than calculating the AC with the running time.

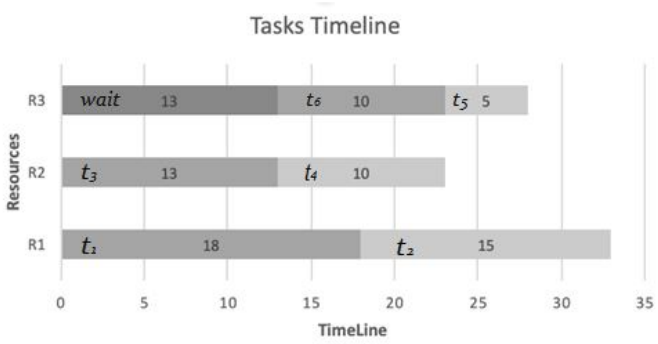


Fig. 3. Tasks Time Line for Scenario 2.1

IV. Evaluation Discussion

A. Evaluation Questions

The following questions are the evaluation questions that will be used to see how this research achieved its aims:

1) How does the SSM improve the security aspects of the cloud service?
The SSM applying security to the Tasks Level to make the customer to be more specific on the service requirement. After that the SSM applies to the Resource level to help running the cloud service at a trusted level.
2) How does the SSM impact Resource scheduling and performance and security?
Performance is a big issue, and currently the SSM is allowing for each Resource to run a single Tasks or a set of Tasks but there is a need to investigate how it impact the service from the performance prospective.
3) How well does the SSM help to achieve QoS?
The SSM applies different levels of QoS but it still need to clarify and inspect these QoS levels and how QoS affecting factors considered in these levels.

Fig. 4 shows the SSM features that are considered for a cloud service request. These features are Security, Priority, QoS, Time, and Cost per Resource. QoS contributes to the overall service cost and any change in QoS levels will affect the service cost. Security applied to the service cost as well and used in the scheduling process by Categorising the Tasks by the Task Security Level. Priority will be used in the scheduling process to put the Tasks in the right order for each Resource. Time will be calculated initially before establishing the service and after to show the different between the elapsed time and the actual running time. Resource Cost will be calculated before establishing the service and after receiving customer confirmation it will be Re-Calculating to have the Actual Cost.

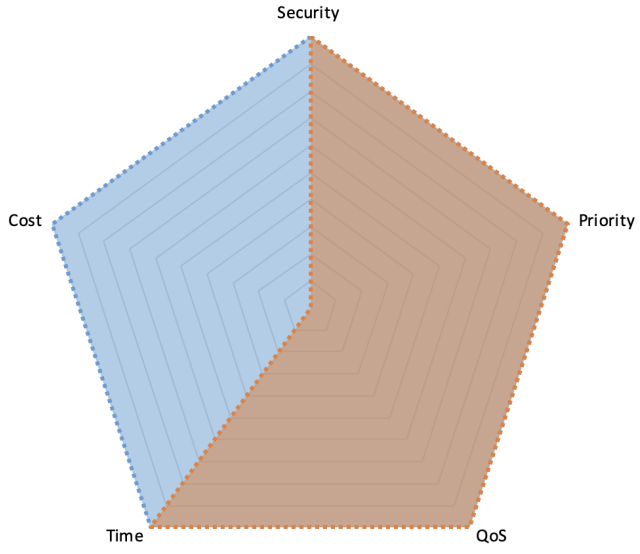


Fig. 4. Service Features of Applying the SSM

Table III shows the changes to the service requested on the SSM features in Example 1. The Features are Security, QoS, Priority, Time, and Cost. In this example, there are no change in the Security, Priority, and QoS. The change means there are no values reduced or increased that could cause any effects to the service. Also, the reason the starting points for all of this three features is in the centre of Fig. 4.

TABLE III. EXAMPLE 1.1

SSM Features	Example 1	
	Before	After
Security	Applied to Categorise Tasks	√
QoS	Customer Input	–
Priority	Applied to Order Tasks	√
Time	Initial Time Calculated for 1 hour or 60 minutes	18 minutes
Cost	Initial Cost Calculated £55	£14

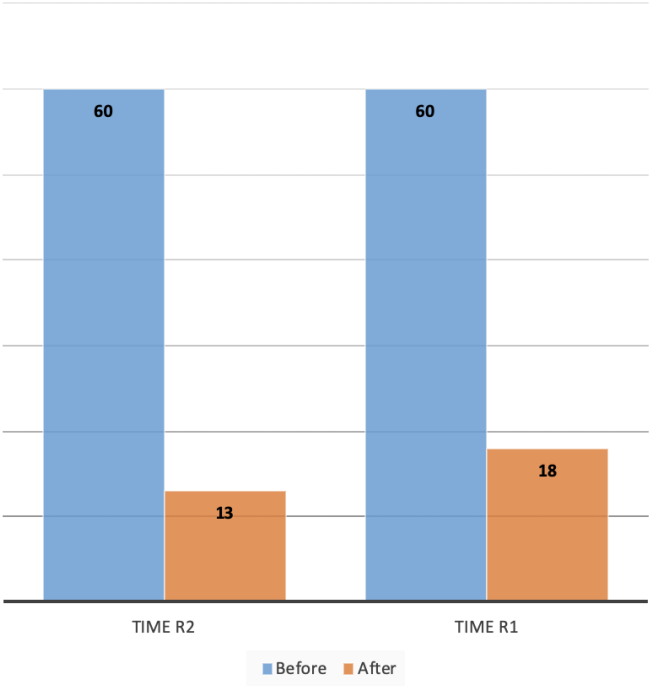


Fig. 5. Example 1 Scenario 1: Changes in Service Time Before and After SSM Applied

As shown in Fig. 5, the calculated time is less than the initial time after establishing the service. The Cost calculated in Pounds (£) as a cost unit for this example. As seen in Fig. 6, the initial cost before establishing the service is £55. Then it reduces after running the service to £14. Service time is calculated initially for 1 hour or 60 minutes, but the SSM will Re-calculating the service time after getting the Customer Confirmation to establish the service.

So, in Example 1 the service time calculated for each Resource and for the first Resource the time is 13 minutes and for the second Resource is 18 minutes. As a result, both Resources did not take more than the higher Time which is the time for the second Resource, and it reflected on the total or the Actual Cost (AC).

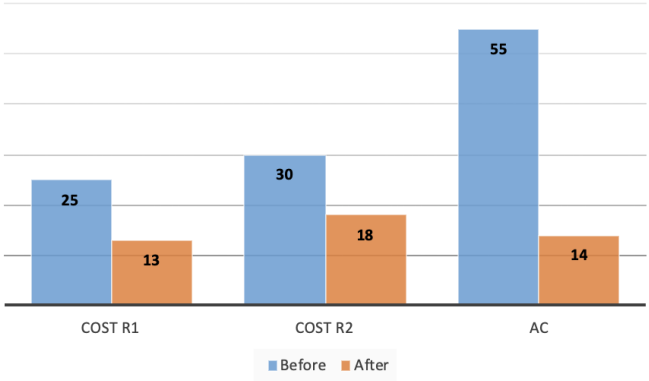


Fig. 6. Example 1 Scenario 1: Change in Service Cost Before and After SSM Applied

Table IV. Example 2 shows that in the Re-Calculating step the cost using either the elapsed time or the actual running time are less than the initial cost. Fig. 8 shows the change in service time for each Resource before and after applying the SSM. As a result, the AC of the elapsed time is less than the AC of the running time.

TABLE IV. EXAMPLE 2

SSM Features	Example 1	
	Before	After
Security	Applied to Categorise Tasks	√
QoS	Customer Input	–
Priority	Applied to Order Tasks	√
Time	Initial Time Calculated	√
Cost	Initial Calculated	√

The change in cost for each Resource and then the different between the initial cost and AC shown in Fig. 7. Also, this example has shown how the SSM works with the Tasks dependencies by using the Fast-Track technique with its benefits for scheduling the dependent Tasks with high Security Level.

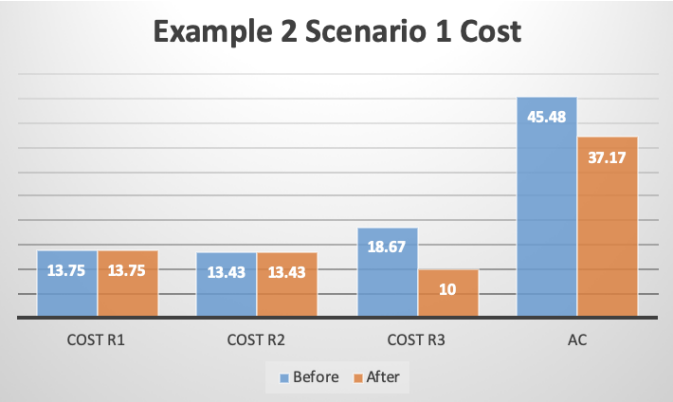


Fig. 7. Example 2 Scenario 1: Change in Service Cost Before and After SSM Applied

B. Compare with Other Approaches

In order to identify more implications and to clarify issues in the SSM. As a result, the comparison showed that the SSM and other model have different cost and with different effects on service time. The SSM has more features than other models, but one of the implications that have been founded is the SSM does not allow more than one Resource in the same Security Level. This can affect the total service time and it might cause a delay to execute other Tasks in the same Resource.

However, there is a lack of similar work with security as main feature for scheduling Tasks over allocated Resources. Table V. shows what the SSM provides against other Cloud Models. Also, it shows that there are shared features but there are for different purpose. For example, the Cloud Trust Model [30] is including security but it serves DaaS. So, the SSM adds to Scheduling and QoS the features Security, Cost, Service Availability, and IaaS all together to improve the cloud service.

V. Conclusion

This paper provided a discussion of the results produced from the SSM, which helped to discuss the evaluation questions to give better understanding to the SSM. It presented how the SSM improves the security aspect of the Cloud service by implementing the security as a main feature for executing Tasks and the effects on the Cost. Then it showed the differences in time and cost before and after establishing the service.

Acknowledgments

Thanks to Taif University in Kingdom of Saudi Arabia for the funding.

References

[1] H. Ramadan, and D. Kashyap, *Quality of Service (QoS) in Cloud Computing*, International Journal of Computer Science and Information Technologies (IJCSIT), vol. 8, No. 3, pp. 318–320, 2017.

[2] A. Sheikh, M. Munro and D. Budgen, *Systematic Literature Review (SLR) of Resource Scheduling and Security in Cloud Computing*, International Journal of Advanced Computer Science and Applications (IJCSA), IEEE, vol. 10, no. 4, pp. 35–44, 2019.

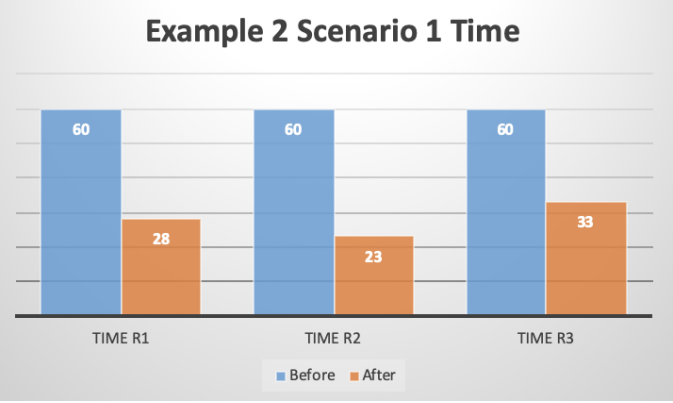


Fig. 8. Example 2 Scenario 1: Change in Service Time Before and After SSM Applied

[3] A. Sheikh, M. Munro and D. Budgen, *Scheduling Security Model (SSM) for a Cloud Environment*, Conference of Cloud Computing, ACM, vol. 2, no. 1, pp. 1–15, 2018.

[4] CS. Pabla, *Completely fair scheduler*, Linux Journal, ACM, vol. 1, no. 184, pp. 68–72, 2009.

[5] M. Pinedo, *Scheduling: Theory, Algorithms, and Systems*, Springer, pp. 1–10, 2008.

[6] RK. Yadav and A. Upadhayay, *A fresh loom for multilevel feedback queue scheduling algorithm*, International Journal of Advances in Engineering Sciences (IJAES), vol. 2, no. 3, pp. 21–23, 2012.

[7] CP. Pfleeger and SL. Pfleeger, *Security in computing*, Prentice Hall Professional Technical Reference, 2002.

[8] Tutorials Point,*Cloud Computing Quick Guide*, http://www.tutorialspoint.com/cloud_computing/cloud_computing_quick_guide.htm [Accessed in May 2019].

[9] P. Mell and T. Grance, *The NIST definition of cloud computing*, Computer Security Division, Information Technology, Laboratory, National Institute of Standards and Technology, Gaithersburg, 2011.

[10] P. Patel, A. Ranabahu and A. Sheth, *Service level agreement in cloud computing*, 2009.

[11] F. Panzieri,O. Babaoglu, S. Ferretti, V. Ghini, and M. Marzolla, *Distributed computing in the 21st century: Some aspects of cloud computing*, Springer, 2011.

[12] R. Shelke and R. Rajani, *Dynamic resource allocation in cloud computing*, International Journal of Engineering Research and Technology, ESRSA, vol. 2, no. 10, 2013.

[13] P. Watson, *A multi-level security model for partitioning workflows over federated clouds*, Journal of Cloud Computing, Springer, vol. 1, no. 1, pp. 1–15, 2012.

[14] A. Sheikh, M. Munro and D. Budgen, *Cost and Effect of Using Scheduling Security Model in a Cloud Environment*, International Conference on Cyber Security and Cloud Computing and Edge Computing and Scalable Cloud (CSCloud/EdgeCom), IEEE, pp. 95–101, 2019.

[15] A. Bessani, M. Correia, B. Quaresma, F. André and P. Sousa, *DepSky: dependable and secure storage in a cloud-of-clouds*, ACM Transactions on Storage (TOS), ACM, vol. 9, no. 4, pp. 12–33, 2013.

[16] M. Vrable, S. Savage, GM. Voelker, *BlueSky: a Cloud-Backed File System for the Enterprise*, Proceedings of the 10th USENIX Conference on File and Storage Technologies, USENIX Association, vol. 12, no. 10, pp. 237–250, 2012.

[17] R. Kotla, L. Alvisi and M. Dahlin, *SafeStore: a durable and practical storage system*, USENIX Annual Technical Conference, pp. 129–142, 2007.

[18] M. Alzain, B. Soh and E. Pardede, *A new model to ensure security in cloud computing services*, Journal of Service Science Research, Springer, vol. 4, no. 1, pp. 49–70, 2012.

[19] Tu. Hu, HCH. Chen,P. Lee and Y. Tang, *NCCloud: Applying Network Coding for the Storage Repair in a Cloud-of-Clouds*, FAST, vol. 12, no. 10, pp. 265–272, 2012.

[20] K. Bowers, A. Juels and A. Oprea, *HAIL: a high-availability and integrity layer for cloud storage*, Proceedings of the 16th ACM conference on Computer and communications security, ACM, pp. 187–198, 2009

[21] C. Cachin, R. Haas and M. Vukolic, *Dependable storage in the intercloud*, IBM research, 3783, pp. 1–6, 2010.

[22] AJ. Feldman, WP. Zeller, MJ. Freedman and EW. Felten, *SPORC: Group Collaboration using Untrusted Cloud Resources*, OSDI, vol. 10, pp. 337–350, 2010.

[23] P. Mahajan, S. Setty, S. Lee, A. Clement, L. Alvisi, M. Dahlin, M. Walfish, *Depot: Cloud storage with minimal trust*, Transactions on Computer Systems (TOCS), ACM, vol. 29, no. 4, pp. 79–117, 2011.

[24] W. Wongthai, F. Rocha, and A. Van Moorsel, *Logging Solutions to Mitigate Risks Associated with Threats in Infrastructure as a Service Cloud*, International Conference on Cloud Computing and Big Data (CloudCom-Asia), IEEE, 163–170, 2013.

[25] A. Shraer, C. Cachin, A. Cidon, I. Keidar, Y. Michalevsky, and D. Shaket, *Venus: Verification for Untrusted Cloud Storage*, Proceedings of the 2010 ACM workshop on Cloud Computing Security Workshop, ACM, pp. 19–30, 2010.

TABLE V. THE SSM AND OTHER CLOUD MODELS

Models	Category				Main Focus													
	DaaS	SaaS	IaaS	Cloud storage	Availability	Confidentiality	Reliability	Intrusion	Integrity	Fault tolerance	Recovery fail	Cost	Scalability	Performance	Accountability	Latency	Security	Authentication
DepSky [15]	√				√	√												
Bluesky [16]	√																	
SafeStore [17]	√					√												
NetDB2-MS [18]	√				√			√	√									
NCCloud [19]				√						√	√	√						
HAIL [20]				√	√				√									
ICStore [21]				√				√										
SPORC [22]				√	√													
Depot [23]				√	√						√					√		
Logging Solutions [24]			√										√	√	√			
Venus [25]				√					√									
TCCP [26]			√		√				√									
CCM [27]																	√	
Hexagon Model [27]																	√	
MTCM [27]																	√	
CSA [27]																	√	
Mapping model[27]																	√	
Separation Model [28]										√								
Migration Model [28]									√								√	
Availability Model [28]					√												√	
Tunnel Model [28]									√								√	
Cryptography Model [28]						√											√	
NDSM [29]	√			√													√	
Cloud Trust Model [30]	√																√	
DSM [31]	√					√											√	
DSSM [32]	√			√													√	√
SC [33]														√				
SSM [3]			√		√							√					√	

[26] N. Santos, KP. Gummadi and R. Rodrigues, *Towards Trusted Cloud Computing*, HotCloud, vol. 9, no. 9, pp. 3–8, 2009.

[27] V. Chang,D. Bacigalupo, G. Wills and D. De Roure, *A categorisation of cloud computing business models*, Proceedings of the IEEE/ACM International Conference on Cluster, Cloud and Grid Computing, IEEE Computer Society, pp. 509–512, 2010.

[28] G. Zhao, C. Rong, MG. Jaatun, FE. Sandnes, *Deployment models: Towards eliminating security concerns from cloud computing*, International Conference on High Performance Computing and Simulation (HPCS), IEEE, pp. 189–195, 2010.

[29] Sh. Ajoudanian and Mr. Ahmadi, *A novel data security model for cloud computing*, International Journal of Engineering and Technology, IACSIT Press, vol. 4, no. 3, pp. 326–329, 2012.

[30] H. Sato, A. Kanai and S. Tanimoto, *A cloud trust model in a security aware cloud*, International Symposium on Applications and the Internet (SAINT), IEEE, vol. 10, pp. 121–124, 2010.

[31] Z. Xin, L. Song-qing and L. Nai-wen, *Research on cloud computing data security model based on multi-dimension*, International Symposium on Information Technology in Medicine and Education (ITME), IEEE, vol. 2, pp. 897–900, 2012.

[32] HB. Patel, DR. Patel, B. Borisaniya and A. Patel, *Data storage security model for cloud computing*, International Conference on Advances in Communication, Network, and Computing, Springer, pp. 37–45, 2012.

[33] L. Tripathy and R.R. Patra, *Scheduling in cloud computing*, International Journal on Cloud Computing: Services and Architecture (IJCCSA), vol 4, no. 5, pp.21–27, 2014.

[34] M. Mathirajan and AI. Sivakumar, *A literature review, classification and simple meta-analysis on scheduling of batch processors in semiconductor*, The International Journal of Advanced Manufacturing Technology, Springer, vol. 29, no. 9, pp. 990–1001, 2006.

Statistical Analysis and Security Evaluation of Chaotic RC5-CBC Symmetric Key Block Cipher Algorithm

Abdessalem Abidi[1], Anissa Sghaier[2], Mohsen Machhout[5]
Electronics and Microelectronics Lab.
Faculty of Sciences of Monastir
University of Monastir
Tunisia

Mohammed Bakiri[3]
Centre de Développement des Technologies
Avancées ASM/DMN Department
Cité 20 août 1956 Baba Hassen, B. P 17, 16303
Alger, Algeria

Christophe Guyeux[4]
FEMTO-ST Institute, UMR 6174 CNRS,
University of Franche-Comté, France

***Abstract*—In some previous research works, it has been theoretically proven that RC5-CBC encryption algorithm behaves as a Devaney topological chaos dynamical system. This unpredictable behavior has been experimentally illustrated through such sensitivity tests analyses encompassing the avalanche effect phenomenon evaluation. In this paper, which is an extension of our previous work, we aim to prove that RC5 algorithm can guarantee a much better level of security and randomness while behaving chaotically, namely when embedded with CBC mode of encryption. To do this, we have began by evaluating the quality of such images encrypted under chaotic RC5-CBC symmetric key encryption algorithm. Then, we have presented the synthesis results of an hardware architecture that implements this chaotic algorithm in FPGA circuits.**

***Keywords*—Cipher Block Chaining (CBC); Rivest Cipher 5 (RC5); chaotic dynamical system; sensibility; security; randomness**

I. Introduction

The main types of symmetric cryptosystems used nowadays fall into two broad categories: block cipher algorithms which consists of processing a data blocks of fixed size and the stream cipher algorithms operating on a continuous stream of data [19], [5]. In this article, we focus on the study of one of the most famous symmetric key block cipher algorithms, namely the Rivest Cipher 5 (RC5) [16]. This encryption algorithm has been designed by Ronald Rivest and it first appeared in December 1994 [7]. Unlike DES [15] for instance, where the block size and the key size must be respectively 64 and 56 bits, in RC5, the block size, the number of rounds and the length of the secret key all can be of variable length. This provides the opportunity for great flexibility in both performance characteristics and the level of security.

As any block cipher algorithm, it is not sufficient to put anyhow the RC5 block cipher algorithm in a program. Hence, various modes of operation have been standardized in order to allow those ciphers to work with large data streams, without the risk of compromising the provided security. In our previous research work, the RC5 algorithm has been used inside the CBC mode of operation in order to form the so-called RC5-CBC. Indeed, the chaotic behavior of this algorithm has been theoretically proven according to the reputed definition of Devaney [9] and then experimentally evaluated through sensitivity tests involving the avalanche effect phenomenon [2].

The mathematical theory of chaos is fully legitimate for iterations over discrete infinite sets. The chaos theory that has been considered in our previous articles is the Devaney's topological one [9]. This theory does not only provide one of the best mathematical definition of chaos, but it also offers a framework with qualitative and quantitative tools to evaluate how unpredictable a recurrent system is [13].

The main purpose of this paper is to evaluate the influence of the chaotic behavior of an encryption system on its security level. Precisely, we have demonstrated that Rivest Cipher 5 algorithm can offer a much better level of security and randomness when behaving chaotically, that is to say, when embedded with CBC mode of operation. To this end, we have began by making a comparison between the quality of such selected images encrypted by chaotic RC5-CBC and the same images encrypted with the standalone RC5. In addition, we have interpreted the synthesis results of an hardware architecture that implements the chaotic RC5-CBC in FPGA circuits.

The remainder of this paper is organized as follows. In Section 2, we will recall some basic definitions concerning cipher block chaining mode of operation and RC5 encryption algorithm. Section 3 is devoted to sum up our various obtained results that have been detailed in [2]. Sections 4 and 5 are devoted to experimental evaluations that put in evidence RC5 presents a much better level of security and randomness when behaving chaotically namely while working with CBC mode of operation. In Section 6, we will discuss our contribution. This research work ends by conclusion section, in which contributions are recalled and summarized.

II. Literature Review

A. Rivest Cipher 5 Symmetric Key Encryption Algorithm

The RC5 encryption algorithm is a symmetric key block cipher algorithm designed by Ronald Rivest of Massachusetts Institute of technology (MIT) and it first appeared in December 1994 [12], [1]. Unlike DES [8] for instance, where the block size and the key size must be respectively 64 and 56 bits, in RC5, the block size, the number of rounds and the length of the secret key all can be of variable length. This provides the opportunity for great flexibility in both performance characteristics and the level of security.

As mentioned in Algorithm 1 and Fig. 1, the encryption using RC5 is based on only three operations: addition, exclusive-OR, and rotation. This makes RC5 both easy to implement for software and hardware applications, and more amenable to analysis than many other block ciphers. The connection between simplicity of design and simplicity of analysis was indeed one of Rivest main goals [3].

Algorithm 1 Encryption using RC5 Algorithm

Require: The input block to RC5 consists of two w-bits words given in two registers A and B.
Ensure: The output is also placed in the registers A and B.
First, divide the original plain text into two blocks of equal sizes called A and B
for $i = 1$ to r do **do**
$A \leftarrow ((A \oplus B) <<< B) + S[2i]$
$B \leftarrow ((B \oplus A) <<< B) + S[2i + 1]$
end for

B. Description of RC5 Block Cipher Operating with CBC Mode

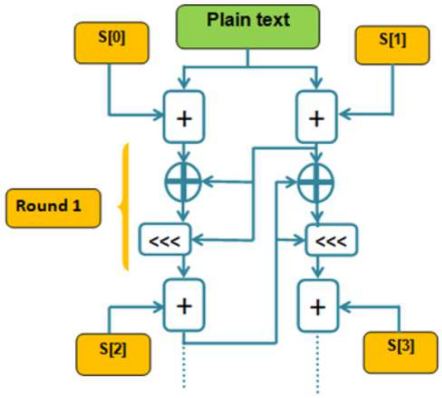
Fig. 2 depicts how RC5 algorithm is embedded with CBC mode of encryption in order to form the so-called RC5-CBC. In this algorithm, the input data is firstly divided into 16 bits blocks $(m_0, m_1, ..., m_n)$. The XOR function is applied between each m_i block and its corresponding previously encrypted C_{i-1} block to give CBC_Result_i block as output which, in turn, will be Xored with m_{i+1} block forming the input of the RC5 algorithm which provides as a result the C_i encrypted block and so on. For the first block, the initialization vector acts as the previous encrypted one. Finally, all blocks that have been encrypted separately are then gathered in a particular way, to obtain the complete encrypted message. For decryption, the path remains the same but this time starting from the encrypted block to obtain the original one using the decryption algorithm instead of the encryption function.

III. Previously Obtained Results

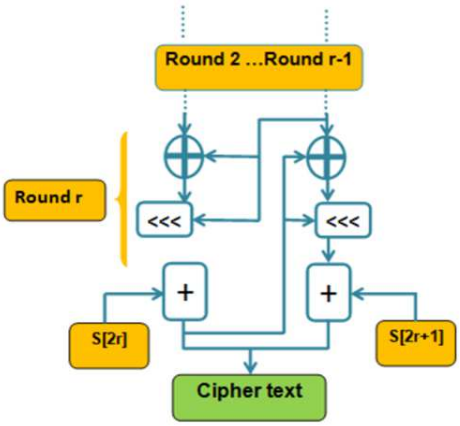
In this section we will summarize our previous results that have been detailed in [2].

A. Proving of Chaotic Behavior of RC5-CBC Block Cipher

In favor of evaluating the chaotic behavior of RC5-CBC block cipher according to the reputed definition of Devaney, it is indispensable to investigate the connectivity of its corresponding directed graph. Let us recall that:



(a) Description of the first round



(b) Description of the final round

Fig. 1. Encryption phase using RC5 block cipher algorithm

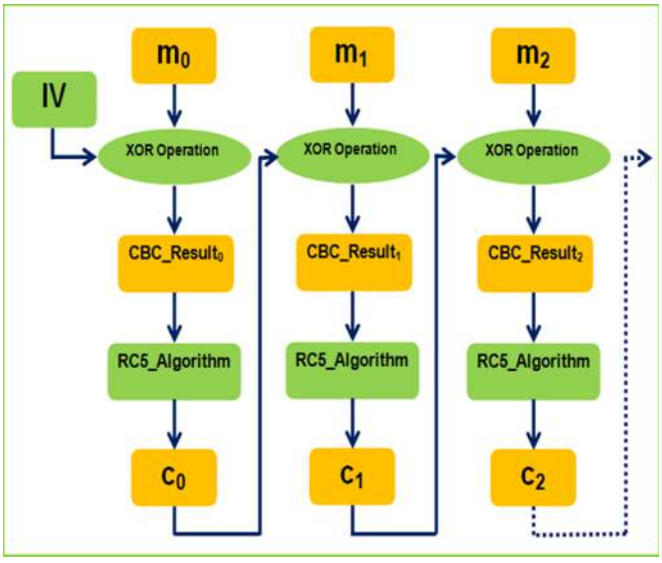


Fig. 2. CBC mode of encryption embedded with RC5 block cipher Algorithm

Definition 1: Devaney's formulation of chaos [9]: The function f is chaotic on a metric space $(\mathcal{X}, d)$ if f is regular, topologically transitive, and has sensitive dependence on initial conditions. Banks et al. have proven that when f is regular and transitive on a metric space $(\mathcal{X}, d)$, then f has the property of sensitive dependence on initial conditions. This is why chaos can be formulated too in a topological space $(\mathcal{X}, \tau)$: in that situation, chaos is obtained when f is regular and topologically transitive [11]. Note that the transitivity property is often obtained as a consequence of the strong transitivity one, which is defined below.

Definition 2: f is strongly transitive on $(\mathcal{X}, d)$ if, for all point $x, y \in \mathcal{X}$ and for all neighborhood $\mathcal{V}$ of x, it exists $n \in \mathbb{N}$ and $x' \in \mathcal{V}$ such that $f^n(x') = y$. Therefore, the sole condition to put in evidence that RC5-CBC block cipher is chaotic according to Devaney consists of proving the strong connectivity of its corresponding directed graph $\mathcal{G}_g$.

In fact, there are different methods to check the connectivity of a given directed graph. In our previous research work, we have chosen to use the optimized method referred as Kosaraju's Depth First Traversal (DFS) algorithm [6], [10]. For the sake of completeness, its steps are recalled hereafter:

- All vertices are initialized as not been visited.
- Do a Depth First Search (DFS) traversal of graph starting from any arbitrary vertex v. Return False if DFS traversal does not visit all vertices.
- Reverse all edges (or find transpose or reverse of graph).
- Mark all vertices as not visited in reversed graph.
- Again do a DFS traversal of reversed graph starting from same vertex v (same as Step 2). If DFS traversal does not visit all vertices, then return False. Otherwise, return True.

Thanks to this technique, we have succeeded to prove the strong connectivity of the directed graph G_g. So, we have concluded that:

Theorem 1: The CBC mode of operation is chaotic according to Devaney when the embedded block cipher is the symmetric key encryption algorithm RC5.

To put a nutshell, our work that has been detailed in [2] consists primarily in constructing an ad hoc directed graph related to the RC5-CBC and then confirming its strong connectivity using the optimized method referred as Kosaraju's Depth First Traversal (DFS) algorithm [10], [14].

B. Sensitivity Tests

There are several attacks on symmetric ciphers based on the study of the relation between two encrypted blocks obtained by a small change either on their original blocks, or in the secret key used. To evaluate the risks against such attacks, some sensitivity tests have been introduced. Passing such a test shows on how much a slight change in the original block or in the key will affect the resulted encrypted block: higher is the change in the resulted block, better is the sensitivity of the encryption algorithm.

TABLE I. COMPARISON BETWEEN RC5 AND CHAOTIC RC5-CBC CORRELATION COEFFICIENT VALUES

Image	Correlation Coefficient for RC5	Correlation Coefficient for RC5-CBC
Lena	-0.02894	0.00509
Mandrill	-0.06669	-0.00052
Airplane	-0.00789	-0.00161
Boat	-0.0709	-0.0006

To measure the "avalanche effect in a block", the arithmetic average of Hamming distances has been used [20], and the following method has been applied. Two different original messages M_1 and M_2 which have only one bit of difference (namely, their Least Significant Bit LSB) are encrypted under RC5-CBC using the key K, to produce respectively two encrypted messages C_1 and C_2. Then, the Hamming distance (in bits) between these two encrypted messages is calculated using the following equation:

$$\begin{aligned} \text{Avalanche Effect}(\%) &= \frac{\text{changed bits in cipher text}}{\text{Total number of bits in cipher text}} \cdot 100\% \\ &= \frac{\text{RC5}_k(M_1) \oplus \text{RC5}_k(M_2)}{N} \cdot 100\% \\ &= \frac{C_{1,k} \oplus C_{2,k}}{N} \cdot 100\%, \end{aligned} \tag{1}$$

where N is the block size.

After having proved that RC5-CBC algorithm can exhibit a Devaney's chaotic behavior, this unpredictability is then illustrated and evaluated through hardware simulations, encompassing the analyzes of uniformity, sensitivity and degree of randomness. Through sensitivity tests, we have verified that, at each time, the cipher block chaining exhibits the sensitivity to the initial conditions, an aspect of chaos. Consequently, and due to the theoretical proofs, we can guarantee that any error on the IV (starting state) or on the message to encrypt (edges to browse) may potentially lead to a completely different list of visited states, that is, of a completely different cipher text. To sum up, thorough sensitivity test results, developed in [2], we have succeeded to confirm that RC5-CBC algorithm exhibits a high degree of randomness, key and plain sensitivity, in addition to satisfying the so-called avalanche effect. These experimental results confirm its theoretical chaotic behavior, which has been already proven through computations.

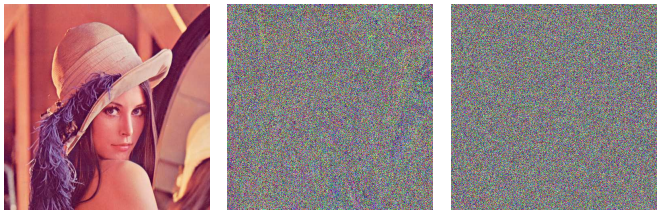
IV. SECURITY EVALUATION OF IMAGES ENCRYPTED UNDER CHAOTIC RC5-CBC ALGORITHM

The sensitivity of encryption methods applied to images can be measured using the linear correlation coefficient [17]. This coefficient can compute the degree of similarity between two adjacent pixels. Due to the meaning and content, this correlation is usually high (close to 1) in the case of a natural image. However, this correlation must be broken (close to 0) when encrypting the image [4], [18].

By examining Fig. 3, 4, and 5, in which the RC5 has been configured with a low number of bits, we can clearly remark that chaotic CBC mode improves the confusion of RC5 alone, enlarging the differences between the original and the

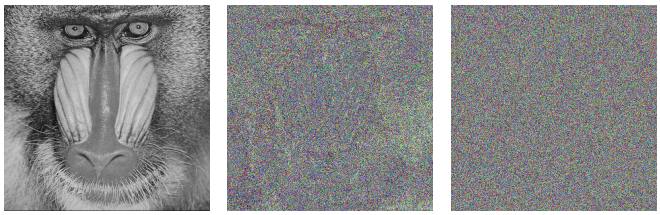
encrypted images. We obtain indeed a real visual degradation, in which no useful information seems to be revealed by the ciphered image about the contents of the original one.

To measure this degradation, the correlation coefficient has been computed between original and RC5-encrypted images on the one hand, and between original and RC5-CBC encrypted images on the other hand. Obtained results, provided in Table I, allowed us to consider that a better confusion is achieved by RC5-CBC. This is due to the addition of chaotic CBC mode to be embedded with RC5 during the encryption operation.



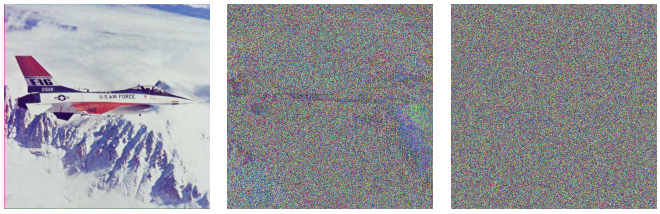
(a) Original Lena (b) Lena encrypted with RC5 standalone (c) Lena encrypted with Chaotic RC5-CBC

Fig. 3. Original and encrypted Lena



(a) Original Mandrill (b) Mandrill encrypted with RC5 standalone (c) Mandrill encrypted with Chaotic RC5-CBC

Fig. 4. Original and encrypted Mandrill



(a) Original airplane (b) airplane encrypted with RC5 standalone (c) airplane encrypted with Chaotic RC5-CBC

Fig. 5. Original and encrypted airplane

V. Hardware Implementation of Chaotic RC5-CBC

A. Proposed Architecture Design

In this section, we describe the hardware architecture of the proposed block cipher based on the RC5 standalone on the one hand, and on RC5 with CBC (chaotic) mode on the other hand. Hardware implementation encompasses the block ciphers in encryption and decryption modes, its embedding in Xilinx ISE 13.1, and its simulation with ModelSim, while experiments are validated using the Virtex6 FPGA device from Xilinx (xc6vlx75t-1ff484).

Fig. 6 illustrates the RC5 architecture data-path, which is mainly based on two parts. The first part performs the key expansion algorithm as defined in Section 2.2.1, which is based on three components named Simple Algorithmic Parts (SAP1, SAP2, SAP3); the second one is the encryption block as described in Section 2.2.2.

Let us firstly present the different blocks of key-expansion SAP1, SAP2, and SAP3. In the first part of the key expansion algorithm, RC5-CBC uses an expanded key table of w-bit words $S[0 \dots t-1]$, such that $t = 2(r+1)$. The S table is initialized by a secret key K given by the user, which is represented by the SAP1 block. SPA1 converts K from bytes to words by directly copying the u $(w/8)$ consecutive key bytes into the c $(c = \lceil b/u \rceil)$ positions of the L memory. SAP2 initializes S memory to a particular fixed pseudo-random bit pattern determined by the "magic constants" P_8 and Q_8. The associated hexadecimal values of P_8 and Q_8 are respectively 0xB7 and 0x9E. SPA2 block contains a bit-wise $\oplus$ primitive operation to add P_8 and Q_8. SAP3, for its part, is based on a scheduling loop in order to mix in the secret key K using S and L. This block contains three bit-wise $+$ primitive operations and two left-rotations of words denoted by $\lll$ (for example, $x \lll dec$ is a rotation left of word x by dec bits).

The encryption RC5-CBC block inputs are the two words A and B composing the block of plain text (m_0 XOR IV) and the resulting S table of the key-expansion parts. It is based on one XOR (A$\oplus$B), two left-rotation of words ($\lll A$ or $\lll B$) and four bit-wise $+$ primitive operations (to add shifted result to S[2*i] or S[2*i+1]). In each RC5 round, both registers A and B are updated to be used in the next round. The decryption algorithm can be easily derived from the encryption algorithm: it is based on two XORs (A$\oplus$B), two right-rotation of words (by $\ggg A$ or $\ggg B$), and four bit-wise $-$ primitive operations (to subtract S[2*i] from A and S[2*i+1] from B).

B. Synthesis Results

In this section, we present the hardware implementation results of both the RC5 and the RC5-CBC algorithms in encryption and decryption mode. Table II presents the implementation results of the RC5 and the RC5-CBC architectures in terms of area and execution time.

TABLE II. Synthesis Results.

	RC5	(Chaotic) RC5-CBC
Nbr of Slice Registers	617	731
Nbr of Slice LUTs	461	534
Frequency(MHz)	134.691	130.570
Execution Time (μs)	0,59	0,68
Throughput ($\frac{Mbit}{s}$)	27,28	23,47
Efficiency ($\frac{Mbit/s}{slices}$)	0,059	0,044

As a first conclusion, from this table, we can conclude the performance of chaotic RC5-CBC in terms of slices LUTs and execution time. Hence, RC5 can be both easy to implement for software and hardware applications, and more amenable to analysis than many other block ciphers. Being compared to RC5 design, the area occupancy and the execution time of the chaotic RC5-CBC are slightly bigger by about 26.65 % and 13.23 %, respectively. This can be justified by the fact that we have added the XOR block in the RC5-CBC architecture when compared with the RC5 only.

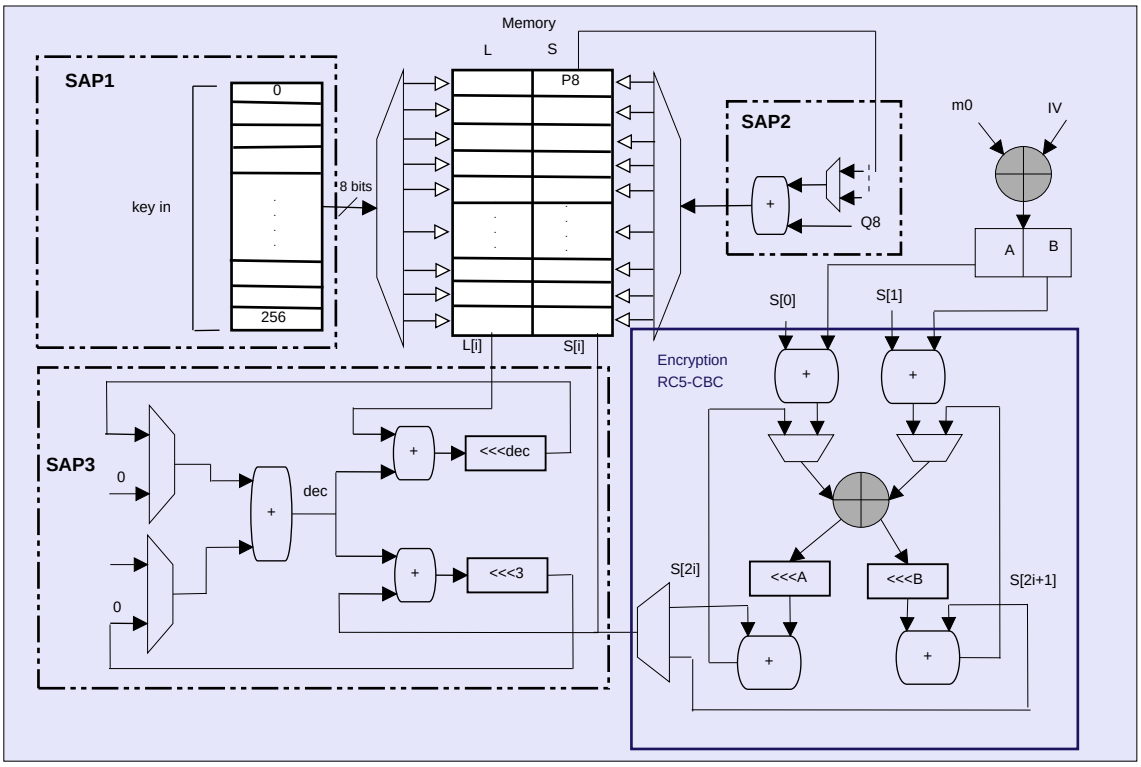


Fig. 6. RC5-CBC architecture design based on key expansion algorithm divided by three Simple Algorithmic Parts (SAP1, SAP2, SAP3) and a chaotic encryption block

In order to compare the efficiency of the RC5 and the chaotic RC5-CBC designs, we calculated the throughput and the efficiency of each approach as follows:

$$\text{Throughput} = \frac{\text{Frequency} \times \text{Number of Bits}}{\text{Cycles Number}} \quad \frac{Mbit}{s} \tag{2}$$

$$\text{Efficiency} = \frac{\text{Throughput}}{\text{Area}} \quad \frac{Mbit/s}{slices} \tag{3}$$

From Table II, we note that RC5 achieves a 16.23% higher throughput than RC5-CBC and it is 25% more efficient. It is obvious from the previous results that RC5 without CBC is slightly faster and occupied less memory space than CBC embedding RC5 algorithm. On the other hand, this later encryption technique presents a much better level of security and randomness while behaving chaotically, which has been verified in [2]. This better aimed level is caused by the adding of CBC block, which makes the loss of memory and speed strongly negligible in front of this performance presented by the chaotic RC5-CBC architecture.

VI. Discussion

The originality of our work is that we consider discrete infinite sets: we consider machine numbers (discrete aspect) and media of unbounded size (infinite set). While it is true that the machine's memory is infinite, the set of media that can be provided to the machine or that it can produce is infinite (discrete). And so, if we consider an algorithm iterating on a media stream, for example the RC5-CBC iterating on a video stream, then we are dealing with an algorithm iterating on the discrete infinite space of the Cartesian product between the finite memory of the machine and the infinite set of finite unbounded size binary sequences, corresponding to the input-output media of the machine. The main objective of our series of articles, regarding the chaotic topological behavior of the CBC mode of operation, is to understand in which extent this mode depends on its inputs. More precisely, is it possible to understand this dependence, in such a way that the effects of a modification of the IV and/or the message can be predicted. If so, this kind of weakness could be considered in the design of specific attacks, while if the converse is proven, that is to say, if the mid-to-long term effects of a slight modification of the input cannot be predicted, that chaotic dependence will make such attacks inefficient.

VII. Conclusions

In some previous research works, we have proven that RC5-CBC algorithm is chaotic according to Devaney. In this paper, we aimed to prove that this chaotic behavior can ensure a better level of randomness and security. This result has been illustrated through the analysis of the quality of such images encrypted under chaotic algorithm and the synthesis results of its hardware implementation in FPGA circuits.

References

[1] Abdullah, K.M., Houssein, E.H., Zayed, H.H.: Extended spins framework for security wireless sensor network. Int. J. Comput. Sci (2017), 14 (2017)

[2] Abidi, A., Guyeux, C., Machhout, M.: Evaluation of chaotic properties of CBC mode of encryption embedded with RC5 block cipher algorithm. Discontinuity, Nonlinearity, and Complexity (in press)

[3] Advani, N., Rathod, C., Gonsai, A.M.: Comparative study of various cryptographic algorithms used for text, image, and video. In: Emerging Trends in Expert Applications and Security, pp. 393–399. Springer (2019)

[4] AlZain, M.A., Faragallah, O.S.: Efficient chaotic tent map-based image cryptosystem. International Journal of Computer Applications **975**, 8887 (2017)

[5] Arora, M., Sharma, S., Engles, D.: Parametric comparison of emds algorithm with some symmetric cryptosystems. Egyptian informatics journal **18**(2), 141–149 (2017)

[6] Asadi, M.M., Mahboubi, H., Habibi, J., Aghdam, A.G., Blouin, S.: Connectivity assessment of random directed graphs with application to underwater sensor networks. IEEE Transactions on Control Systems Technology **25**(4), 1457–1464 (2017)

[7] Chandra, C.S., Lal, S.S., Saranya, A.: Evolution of cryptographic algorithms and performance parameters. Evolution **5**(01) (2016)

[8] Cygan, M., Fomin, F.V., Kowalik, Ł., Lokshtanov, D., Marx, D., Pilipczuk, M., Pilipczuk, M., Saurabh, S.: Parameterized algorithms, vol. 4. Springer (2015)

[9] Devaney, R.: An introduction to chaotic dynamical systems. CRC Press (2018)

[10] Dhingra, S., Dodwad, P.S., Madan, M.: Finding strongly connected components in a social network graph. International Journal of Computer Applications **136**(7), 1–5 (2016)

[11] Fadel, A., Dzul-Kifli, S.C.: Some chaos notions on dendrites. Symmetry **11**(10), 1309 (2019)

[12] Faragallah, O.S.: Digital image encryption based on the rc5 block cipher algorithm. Sensing and Imaging: An International Journal **12**(3-4), 73–94 (2011)

[13] Guyeux, C., Couturier, R., Héam, P.C., Bahi, J.M.: Efficient and cryptographically secure generation of chaotic pseudorandom numbers on gpu. The Journal of Supercomputing **71**(10), 3877–3903 (2015)

[14] Hsu, D.F., Lan, X., Miller, G., Baird, D.: A comparative study of algorithm for computing strongly connected components. In: 2017 IEEE 15th Intl Conf on Dependable, Autonomic and Secure Computing, 15th Intl Conf on Pervasive Intelligence and Computing, 3rd Intl Conf on Big Data Intelligence and Computing and Cyber Science and Technology Congress (DASC/PiCom/DataCom/CyberSciTech), pp. 431–437. IEEE (2017)

[15] Kouser, Z., Singhal, M., Joshi, A.M.: Fpga implementation of advanced encryption standard algorithm. In: 2016 International Conference on Recent Advances and Innovations in Engineering (ICRAIE), pp. 1–5. IEEE (2016)

[16] Kumar, S., Patidar, K., Kushwah, R., Chouhan, S.: Text data partitioning and image based rc5 encryption with block based key generation. International Journal of Advanced Technology and Engineering Exploration **4**(31), 101 (2017)

[17] Liu, W., Sun, K., Zhu, C.: A fast image encryption algorithm based on chaotic map. Optics and Lasers in Engineering **84**, 26–36 (2016)

[18] Noura, H., Sleem, L., Noura, M., Mansour, M.M., Chehab, A., Couturier, R.: A new efficient lightweight and secure image cipher scheme. Multimedia Tools and Applications **77**(12), 15457–15484 (2018)

[19] Santhi, H., Gayathri, P., Katiyar, S., Gopichand, G., Shreevastava, S.: Study of symmetric-key cryptosystems and implementing a secure cryptosystem with des. In: Information Systems Design and Intelligent Applications, pp. 299–313. Springer (2019)

[20] Vibar, J.C.N., Medina, R.P., Sison, A.M.: Erc5a–an enhanced rc5 algorithm on bit propagation in the encryption function. In: 2019 IEEE 4th International Conference on Computer and Communication Systems (ICCCS), pp. 479–482. IEEE (2019)

Hybrid Control of PV-FC Electric Vehicle using Lyapunov based Theory

Saad Hayat[1]
SEECS,NUST
Islamabad,Pakistan

Sheeraz Ahmed[2]
Iqra National University
Peshawar, Pakistan

Tanveer-ul-Haq[3]
University of Science and Technology
Bannu, Pakistan

Sadeeq Jan[4]
Department of CS and IT, UET
Peshawar, Pakistan

Mehtab Qureshi[5]
Hajvery University
Lahore, Pakistan

Zeeshan Najam[6]
Ultimate Consultancy
Peshawar, Pakistan

Zahid Wadud[7]
Department of Computer System Engg
UET Peshawar, Pakistan

***Abstract*—Lyapunov based control is used to test whether a dynamical system is asymptotically stable or not. The control strategy is based on linearization of system. A Lyapunov function is constructed to obtain a stabilizing feedback controller. This paper deals with Lyapunov based control of multiple input single output system for hybrid electric vehicles (HEVs). Generally, an electric vehicle has an energy management system (EMS), an inverter, a DC-DC converter and a traction motor for the operation of its wheels. The control action is applied on the DC-DC converter, which works side-by-side with the EMS of the electric vehicle. The input sources considered in this study are: photo-voltaic (PV) panel, fuel cell and high voltage lithium-ion (Li-ion) battery. PV cell and fuel cell are considered as the primary sources of energy and the battery is considered as the secondary source. The converter used is a DC-DC boost converter which is connected with all the three sources. The idea follows the basic HEV principle in which multiple sources are incorporated to satisfy the power demands of the vehicle, using a DC-DC converter and an inverter, to operate its traction motor. The target is to achieve necessary tracking of all input source currents and output voltage, and fulfill the power demand of the HEV under severe load transients. The operations of the DC-DC converter are divided into three stages, each representing a different combination of the input sources. The analysis and proof of the stability of the HEV system is done using the Lyapunov stability theory.The results are discussed in the conclusion.**

***Keywords*—Energy Management System (EMS); Hybrid Electric Vehicle (HEV); DC-DC converter; Multiple Input-Multiple Output (MIMO) system**

I. Introduction

Renewable energy has been the center of attraction for past three decades. Nowadays, HEVs are being considered as a great tool for transportation, which can utilize the renewable energy, coming in from many different sources. Thus, a new form of automobile industry revolution is taking place. Hybrid Electric vehicles (HEVs) have been already adapted and have presented encouraging results [1], [2].

Although at present, commercial electric vehicles are using a hybrid of a renewable energy source (such as a fuel cell or PV cell) with an internal combustion engine (ICE), but recently a more hybridized form of HEVs has taken place. This new form of HEV incorporates several sources at the same time. Fuel Cell, battery, super capacitor and PV cells are such examples which can simultaneously provide energy to the HEV.

Today, HEVs are using the fuel cell and a battery as its sources to save energy. Energy savings benefit both the consumers and grid. There is less burden on grid, electric vehicles range is increased and maintenance of fuel cell is reduced [3], [4]. It has been found that an electric vehicle which interconnects FC and battery, with or without any other kind of other source, is the most effective way to cater demand [5]. Solar energy is best alternative energy source for this scenario. With PV cell, fuel cell and battery, we can be more effective with fuel savings, alleviating noise and providing a pollutant free environment, and at the same time, fulfilling the limitations of both fuel cell and battery [6]. For such a system where more than one source is providing energy, DC-DC converters are necessary for its operation [7]. A lot of work done has been done in improving the performance and efficiency of the DC-DC converters for electric vehicles.

Fuel cell based electric vehicles (FCEVs) are environmentally friendlier than the conventional ICE based HEVs because they have zero carbon emission as FCEVs use hydrogen fuel and oxygen (from air) to produce only electricity and water as a by-product. Proton Exchange Membrane Fuel Cell (PEMFC) is a type of FC, which has a high efficiency and low operating temperature. Therefore, they are mostly used in HEVs nowadays [8], [9]. Although fuel cells are a good candidate for an HEV's energy source, they don't have fast standby operation i.e. they have a lesser power density than other electrical sources like battery or super capacitor [10]. In other terms, it means that PEMFC cannot provide sufficient energy during load transients. Another flaw in using PEMFCs in HEVs is the manufacturing costs and durability issues which are inevitable when one deals with fuel cells [11]. Hence a battery has to be used with fuel cell to overcome these problems.

Recently, solar photo voltaic energy is introduced in automobile industry due to many reasons such as being cost effective, pollution free and durable in the long run [12]. The lifetime of PV cells (or modules) are commonly up to 20 years, which is far better than other electrical sources like battery. Furthermore, solar energy can be easily converted to electrical energy using DC-DC converters. However, when

using PV cells, factors such as unreliability and cost of solar cells, should always be considered. Another important factor is the maximum power that can only be obtained from PV cell when it is operating at its maximum power point (MPP). A number of strategies have been used in various studies to evaluate the MPP of the PV [13].

HEVs also require rechargeable batteries to aid the driving mechanism and store energy, obtained from regenerative braking. Therefore high capacity batteries and higher capacity power converters are needed for this operation [14]. Another important use of batteries, installed in an FCEV, is the support they provide to the primary power source: FC. In an FCEV, fuel cells (FCs) require batteries or super capacitor whenever there is a sudden load transient. In case of high power demand, batteries and FC simultaneously provide power to the load and during regenerative braking, the extra power can be used to recharge the batteries. The main reason is that FCs have poor transient response to these sudden spikes; But they have more driving range than battery electric vehicles (BEVs) because BEVs only contain batteries as their power source. Since, batteries have a limited amount of charge in them, they require recharging after some time. In FCEVs, FC has a greater energy density (amount of energy stored) than a battery pack, hence they can provide energy as long as they are provided with the hydrogen fuel.

In an HEV, multiple input sources require a power unification scheme of at least two or three power sources at the same time [15]. The combination of the active sources solely depends on the HEV's load demand and our control strategy which is operated through the EMS. The reason is that the solar energy is not available at all times and FC's slow response time to transients require a battery. The battery has disadvantages like less driving range and slow charging time as compared to FC. Hence we need collaboration of two or more than two sources for a complete and successful operation of the HEV [16].

The DC-DC converter acts as an interface between PV source, fuel cell and battery. DC-DC converter is used in electric vehicle for regulating the output voltage and sources current [17]. A system where sources of different kinds interact with each other and the load, is called a hybrid energy storage system (HESS). A HESS requires the EMS for its operation. The EMS usually contains an algorithm for providing different reference values to the controller and decide which stage or mode should be operated. However, in this study our primary focus is on the working and control of the HESS. This includes the selection of the DC-DC converter topology and its benefits and the selection of suitable power sources for the HEV.

a) Literature Review: In [18], a control technique has been applied on the HEV to design observers for estimating the values of speed and torque. Several control strategies have been developed for fast charging of electric vehicles in [19]. An optical isolation is introduced between the three sources in [20]. It uses a battery charger and a DC-DC converter as the combined charger. This scheme ensures unified power transmission between the sources. The HESS of an HEV requires power factor correction [21], getting high voltage gain and regulating the current flow inside the battery [22]. Model Predictive Control is another form of advanced control technique which is extensively applied on converters [23]–[25]. The problem with MPC is that it causes a lot of computational burden and it can't be applied on all systems. A number of control techniques, both linear and non-linear, have been applied to HESS since its first introduction. Linear control techniques include fuzzy and PI based control [26], [27]. In [28], a PI controlled bi-directional DC-DC converter has been used to drive DC motor of a BEV. Although the PI control provides a simple control approach, it fails to provide a steady, ripple-free output. In [29], a closed loop controller using decoupling method has been introduced to design a closed loop compensator. Battery balancing is also an important aspect for EVs which is achieved by constant current flow, described in [30]. This study uses a battery balancing circuit for Li-ion battery, using a single inductor based circuit for HEVs. PI control is also used in this study. For control of capacitor and battery currents PID control is used in [31]. The unwanted noise can be found in tracking of all these strategies.

As we know that most dynamic systems in real world exhibit nonlinear characteristics. This fact also extends to DC-DC converters, fuel cells [32], [33] and PV cells [34]. Linear systems are usually constructed by linearization of the system dynamics around one equilibrium point. It is obvious that this linear mathematical model is not rich enough to describe many commonly observed phenomena of non-linear systems. This is why when linear control is applied to a nonlinear control system it results in very limited operating range [35] and sometimes poor performance.

The formulation of paper is as follows: In Section III working principle of HESS is explained. Controller analysis is presented in Section IV. In Section V, the stability analysis of the closed loop system is done. In Section VI, simulation results are presented and analyzed. In Section VII, the proposed controller is compared with PI-based controller on the same HESS, and lastly, the conclusion of paper is presented in Section VIII.

II. Motivation

The sale of Electric Vehicles have been moderate due to consumers not acknowledging the benefits provided to them. Conventional electric vehicles offer more interesting package and have less uncertainty such as battery life, range of vehicle and speed of technological improvement [2].
The only method of tackling this issue is by combining power electronics with a well devised control system which will guarantee long range, longer battery life and performance optimization.
Control system designed in [29] has overshoot and ripple of large magnitude found in output voltage response and inductor current which impacts the battery life and performance causing considerable power loss. If a control system is devised such that there is perfect tracking of required output voltage at load side and current flowing through the inductors with little to no ripple, this will help the cause. The power electronics

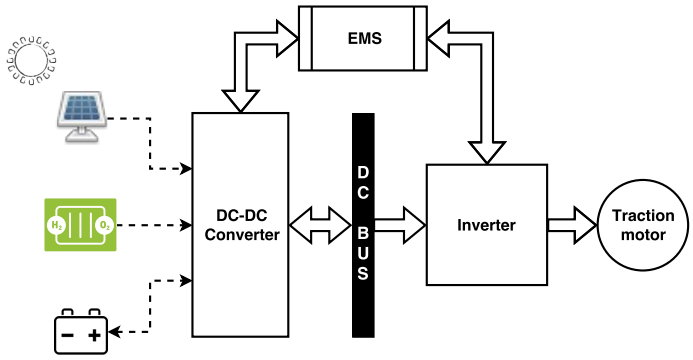


Fig. 1. General structure of HEV

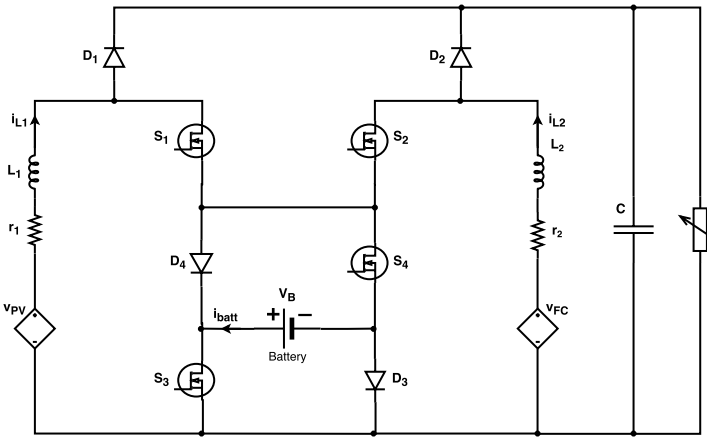


Fig. 2. Selected DC-DC converter schematic

circuitry in [15] is complicated due the adoption of two power converters at a some time which makes management from control side difficult, added cost due to increased number of elements and package bulky.

III. Demonstration of HESS and Converter Topology

Fig. 1 shows the selected HEV which includes EMS, traction motor, inverter, DC-bus, DC-DC converter and the three sources. Input sources include PV cells, high voltage battery and PEMFC. Energy direction is planned such that the energy transfer is uni-directional between PEMFC and load i.e. from PEMFC to load, because PEMFC cannot be recharged by conventional means. Similar is the case beween PV source and load. For batteries, the transfer of energy is selected as bi-directional because in case of load transients, the battery pack has to be charged and discharged. These energy transfers are later explained in subsection III-A.

Fig. 2 shows the considered HESS for the HEV. The converter used is three input DC-DC boost type. The two input sources, PV and FC, have voltages v_{PV} and v_{FC} respectively. The battery voltage is taken as V_B. Both v_{PV} and v_{FC} are shown as dependent voltage sources because the PV source voltage depends on the PV current, light intensity and ambient temperature of the PV panel, whereas, the fuel cell (FC) voltage depends on the FC current. Since both the input sources are in series with the inductors L_1 & L_2, the current in i_{L_1} is i_{PV} and the current in i_{L_2} is i_{FC}. Hence, the voltage sources indirectly depend on the inductor currents. Capacitor C is output filtering capacitor and R_L is the variable load representing the inverter and the traction motor load. Four switches S_1, S_2, S_3 and S_4 are used in this converter. All of them are independently controlled by duty cycles d_1, d_2, d_3 and d_4 respectively.

The combination of the duty ratios are set in such a way that ensures the converter always works in continuous conduction mode (CCM). This is done to minimize the current ripples as much as possible. The converter topology used in this paper is taken from [29] in which a PI control technique has been applied.

A. Hybrid Energy Storage System (HESS)

As stated earlier, the HESS is a power conditioning unit in an HEV, which ensures a unified power flow between the energy sources and synchronization of the power sources with the DC-DC converter and load. Usually, the HESS comprises of a DC-DC converter and/or a DC-AC converter, and an EMS, that contains a set of rules that are necessary to operate the HEV. A mathematical model of the selected HESS is developed in this section. Also, the highlights of the EMS operation are described in detail.

1) DC-DC Converter Mathematical Modeling: The converter structure is shown in Fig. 2. The converter operates in three stages. In the first stage, only v_{PV} and v_{FC} power up the load while the battery v_B is disconnected i.e. it neither charges or discharges. In the second stage, all three energy sources provide power to the load. In the third stage, v_{PV} and v_{FC} supply the power to the load while battery v_B is recharged. For simplicity, all switches are considered ideal and the equivalent series resistance (ESR) of the capacitor (C) is considered negligible. Dynamic equations for each stage are evaluated using volt-second and charge-second balance. For the derivation of the mathematical model for this DC-DC converter, the large-signal model is being considered.

The three stages of the DC-DC converter, described above, can be represented by the state of the battery current i_{batt} in each stage. It can be given as:

$$i_{batt} = \begin{cases} 0, & \text{(Stage 1)} \\ +ve, & \text{(Stage 2)} \\ -ve, & \text{(Stage 3)} \end{cases} \tag{3-a}$$

Since, there are three energy storing elements in the DC-DC converter, there would be three state variables for this system:

$$[x_1 \quad x_2 \quad x_3]^T = [< i_{L_1} > \quad < i_{L_2} > \quad < V_o >]^T$$

These state variables are respectively, inductor 1 current i_{L_1}, inductor 2 current i_{L_1} and output voltage V_o. The state

variables are taken in their state-averaged form because the mathematical model is also state-averaged.

2) STAGE 1 ($i_{batt} = 0$): From Fig. 3, it can be seen that there are 3 modes of the converter in this stage. Since the system is operating without battery, the inductors L_1 & L_2 are powered-up by v_{PV} and v_{FC}, through paths S_1-S_4-D_3 & S_2-S_4-D_3 respectively. In the next mode, switch S_1 is turned off and the diode D_1 becomes forward-biased. Therefore, v_{PV} provides power to the load along with i_{L_1}. In the third mode, switch S_2 is turned off and both sources v_{FC} & v_{PV} simultaneously provide power to the load. By applying volt-second and charge-second balance, the converter equations for a single switching cycle would be:

$$\begin{aligned}
\frac{di_{L_1}}{dt} &= \frac{1}{L_1}[d_1 v_{PV} + (1-d_1)(v_{PV} - V_o) - r_1 i_{L_1}] \\
\frac{di_{L_2}}{dt} &= \frac{1}{L_2}[d_2 v_{FC} + (1-d_2)(v_{FC} - V_o) - r_2 i_{L_2}] \\
\frac{dV_o}{dt} &= \frac{1}{C}[(1-d_1) i_{L_1} + (1-d_2) i_{L_2} - \frac{V_o}{R_L}]
\end{aligned} \tag{3-b}$$

3) STAGE 2 ($i_{batt} > 0$): In this stage, all the sources: v_{PV}, v_{FC} & V_B power up the load. By inspecting the circuit in Fig. 4, it can be seen that there are 4 operating modes of the converter in this stage. In the first mode, the battery V_B first discharges and together with the sources v_{PV} and v_{FC}, power-up the inductors L_1 & L_2. Since, the battery charge is depleted at the end of this mode, the next modes are almost similar to the three modes of stage 1 because i_{batt} remains zero after the first mode. By applying volt-second and charge-second balance, the converter equations for a single switching cycle would be:

$$\begin{aligned}
\frac{di_{L_1}}{dt} &= \frac{1}{L_1}[(d_1 - d_4) v_{PV} + d_4 (v_{PV} + V_B) \\
&\quad + (1-d_1)(v_{PV} - V_o) - r_1 i_{L_1}] \\
\frac{di_{L_2}}{dt} &= \frac{1}{L_2}[(d_2 - d_4) v_{PV} + d_4 (v_{FC} + V_B) \\
&\quad + (1-d_2)(v_{FC} - V_o) - r_2 i_{L_2}] \\
\frac{dV_o}{dt} &= \frac{1}{C}[(1-d_1) i_{L_1} + (1-d_2) i_{L_2} - \frac{V_o}{R_L}]
\end{aligned} \tag{3-c}$$

4) STAGE 3 ($i_{batt} < 0$): In this stage, v_{PV}, v_{FC} power-up the load and also charge the battery V_B. There are 4 modes of converter operation in this stage, which can be seen in Fig. 5. In this mode, V_{PV} and V_{FC} are charging the inductors and the output capacitor C is providing power to the load. In the second mode, the sources v_{PV} and v_{FC} are charging the battery source V_B through the common path D_4-V_B-D_3. In the third mode, the source v_{PV} provides power to the load and replenish the charge of output capacitor (C), whereas the source v_{FC} keeps charging the battery V_B. Once the battery V_B is recharged, the two input sources v_{PV} and v_{FC} start delivering power directly to the load. By applying volt-second and charge-second balance, the converter equations for a single switching cycle would be:

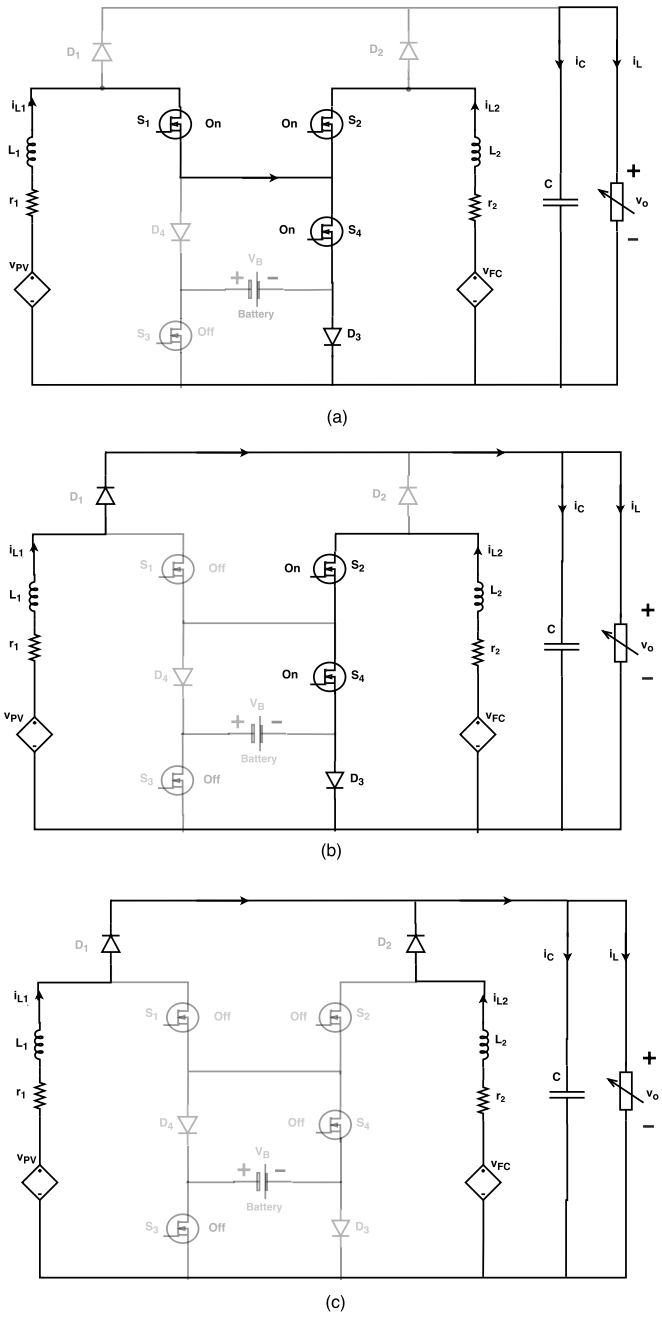


Fig. 3. Stage 1 of the DC-DC converter

$$\begin{aligned}
\frac{di_{L_1}}{dt} &= \frac{1}{L_1}[(d_1 - d_4) v_{PV} + d_4 (v_{PV} + V_B) \\
&\quad + (1-d_1)(v_{PV} - V_o) - r_1 i_{L_1}] \\
\frac{di_{L_2}}{dt} &= \frac{1}{L_2}[(d_2 - d_4) v_{PV} + d_4 (v_{FC} + V_B) \\
&\quad + (1-d_2)(v_{FC} - V_o) - r_2 i_{L_2}] \\
\frac{dV_o}{dt} &= \frac{1}{C}[(1-d_1) i_{L_1} + (1-d_2) i_{L_2} - \frac{V_o}{R_L}]
\end{aligned} \tag{3-d}$$

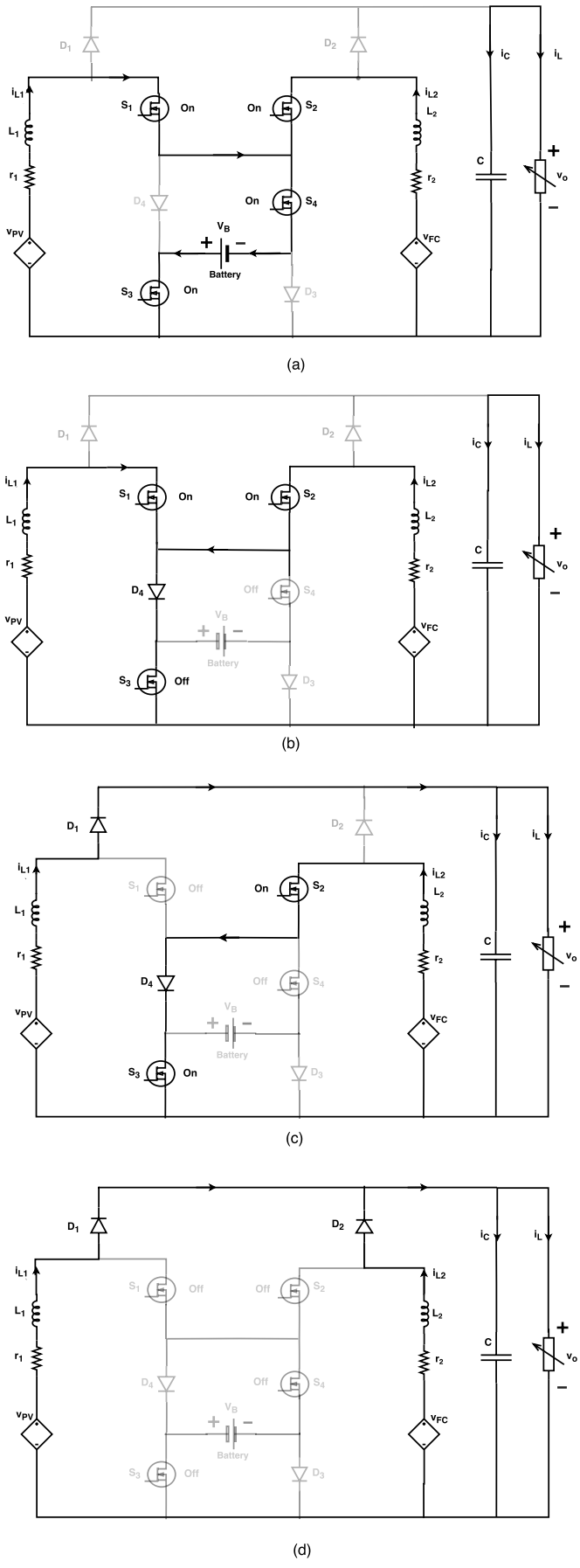


Fig. 4. Stage 2 of the DC-DC converter

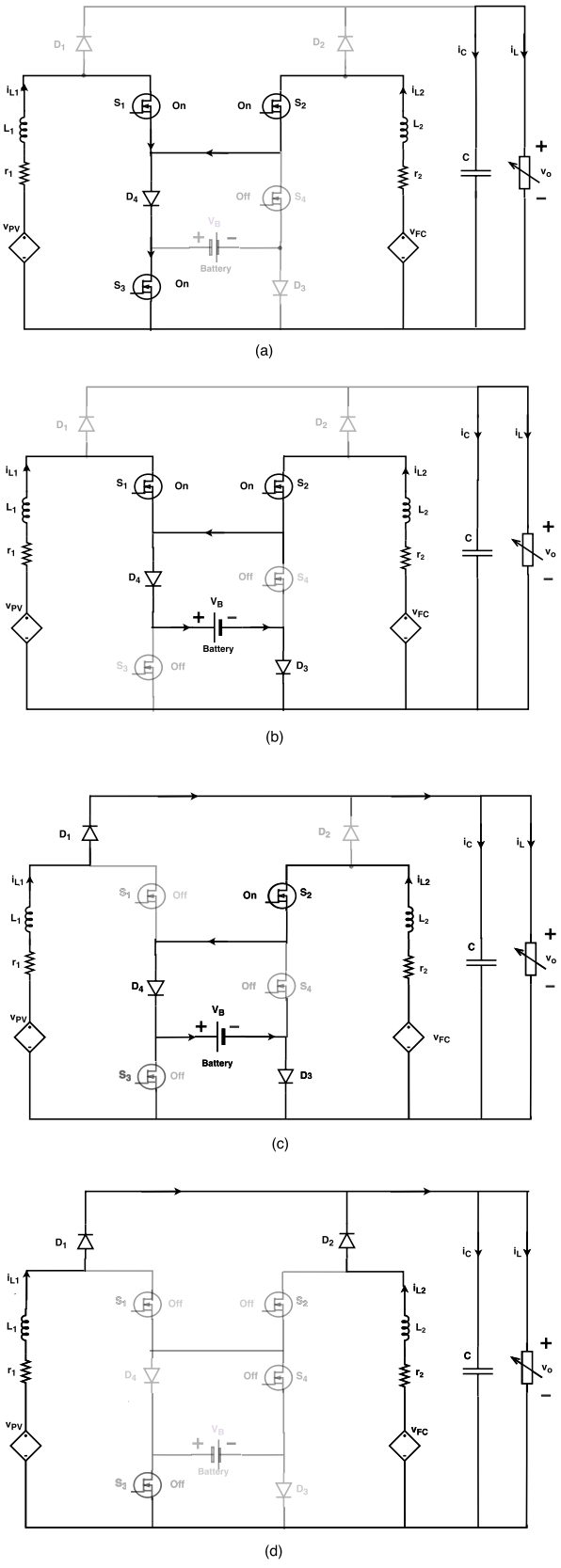


Fig. 5. Stage 3 of the DC-DC converter

From the dynamic equations 3-b, 3-c & 3-d and the state variables taken as $i_{L_1} = x_1$, $i_{L_2} = x_2$ and $V_o = x_3$, the mathematical model for each stage is given as follows:

FIRST STAGE:

$$\begin{aligned}\dot{x}_1 &= \frac{1}{L_1}[d_1 v_{PV} + (1-d_1)(v_{PV} - x_3) - r_1 x_1] \\ \dot{x}_2 &= \frac{1}{L_2}[d_2 v_{FC} + (1-d_2)(v_{FC} - x_3) - r_2 x_2] \\ \dot{x}_3 &= \frac{1}{C}[(1-d_1)x_1 + (1-d_2)x_2 - \frac{x_3}{R_L}]\end{aligned} \tag{3-e}$$

SECOND STAGE:

$$\begin{aligned}\dot{x}_1 &= \frac{1}{L_1}[(d_1 - d_4)v_{PV} + d_4(v_{PV} + V_B) \\ &\quad + (1-d_1)(v_{PV} - x_3) - r_1 x_1] \\ \dot{x}_2 &= \frac{1}{L_2}[(d_2 - d_4)v_{PV} + d_4(v_{FC} + V_B) \\ &\quad + (1-d_2)(v_{FC} - x_3) - r_2 x_2] \\ \dot{x}_3 &= \frac{1}{C}[(1-d_1)x_1 + (1-d_2)x_2 - \frac{x_3}{R_L}]\end{aligned} \tag{3-f}$$

THIRD STAGE:

$$\begin{aligned}\dot{x}_1 &= \frac{1}{L_1}[(d_1 - d_4)v_{PV} + d_4(v_{PV} + V_B) \\ &\quad + (1-d_1)(v_{PV} - x_3) - r_1 x_1] \\ \dot{x}_2 &= \frac{1}{L_2}[(d_2 - d_4)v_{PV} + d_4(v_{FC} + V_B) \\ &\quad + (1-d_2)(v_{FC} - x_3) - r_2 x_2] \\ \dot{x}_3 &= \frac{1}{C}[(1-d_1)x_1 + (1-d_2)x_2 - \frac{x_3}{R_L}]\end{aligned} \tag{3-g}$$

B. Energy Management Strategy (EMS)

The EMS ensures that the HEV operates correctly and according to our objectives. The EMS is a vital part of every HEV because it generates various current and voltage references according to varying conditions and requirements. The controller only tracks the references it is given by the EMS. Hence it is very important that the EMS generates correct values of current and voltage references. The EMS must be designed to achieves the following objectives:

1) Generates PV source current reference value i_{PV}^{ref} according to the load demands.
2) Generates FC source current reference value i_{FC}^{ref} according to the load demands.
3) Generates output voltage reference value V_o^{ref} according to the requirements.
4) The converter operates in the correct mode according to the state of the battery and the load demands.
5) Load demand is fulfilled by the three sources.

However, the focus of this study is on the nonlinear control design of the selected HEV and that whether the HESS tracks the reference values set by EMS or not.

IV. Controller Design

The mathematical model for each stage (3-e), (3-f), (3-g) is clearly a nonlinear model, as the model contains some terms in which the state variables (x_1, x_2, x_3) are in product with the control inputs (d_1, d_2, d_3, d_4). Since the control inputs are actually functions of the state variables, the resulting model is a nonlinear mathematical model. The dynamics and control of a nonlinear mathematical model are fully defined using a nonlinear control strategy. The control scheme used in this study is Lyapunov based control strategy. The nonlinear Lyapunov based control uses an energy like function called Lyapunov function candidate (LFC). The system is considered stable if the energy of the system is decreasing over time. In other words, if $V(x)$ is the LFC of a system, it is considered to be stable if,

$$\dot{V}(x) \leq 0$$

Since the control objectives for each stage are different, the control expression for each stage is also different and must be derived separately.

A. For Stage 1

In this stage only PV source and FC source operates whereas the battery is disconnected i.e. $i_{batt} = 0$. The control objectives for stage 1 are as follows:

1) Minimize the error between input PV current i.e $i_{PV} = i_{L_1} = x_1$ & the reference I_{PV}^{ref}.
2) Minimize the error between output voltage i.e V_o & the reference V_o^{ref}.

According to our first objective, let's define the error (e_1) as:

$$e_1 = x_1 - I_{PV}^{ref} \tag{4-a}$$

Now regulating PV current means that the error e_1 should exponentially decay to zero. For this purpose we define its dynamics as follows:

$$\dot{e}_1 = -k_1 e_1 \tag{4-b}$$

Where k_1 is a positive constant. Taking time derivative of (4-a) gives:

$$\dot{e}_1 = \dot{x}_1 - \dot{I}_{PV}^{ref} \tag{4-c}$$

From the equations (3-e), we can write eq. (4-c) as:

$$\dot{e}_1 = \frac{1}{L_1}[d_1 v_{PV} + (1-d_1)(v_{PV} - x_3) - r_1 x_1] - \dot{I}_{PV}^{ref}$$

Using equation (4-b):

$$-k_1 e_1 = \frac{1}{L_1}[d_1 v_{PV} + (1-d_1)(v_{PV} - x_3) - r_1 x_1] - \dot{I}_{PV}^{ref}$$

Solving for d_1 we get,

$$d_1 = \frac{1}{x_3}[-L_1 k_1 e_1 - v_{PV} + r_1 x_1 + x_3 + L_1 \dot{I}_{PV}^{ref}] \tag{4-d}$$

Now, to complete the second objective, DC BUS voltage V_o should track the reference V_o^{ref}. Hence error e_3 is introduced as:

$$e_3 = x_3 - V_o^{ref} \tag{4-e}$$

As we know that regulating PV current means that the error e_3 should exponentially decay to zero. For this purpose we define its dynamics as follows:

$$\dot{e}_3 = -k_3 e_3 \tag{4-f}$$

Where k_3 is a positive constant. Taking time derivative of (4-f), and substituting the expression of $\dot{x}_3$ from (3-e)

$$\dot{e}_3 = \frac{1}{C}[(1-d_1)x_1 + (1-d_2)x_2 - \frac{x_3}{R_L}] - \dot{V}_o^{ref}$$

Since the reference voltage is a constant value, its derivative $\dot{V}_o^{ref} = 0$. Therefore, using eq. (4-f), we get:

$$-k_3 e_3 = \frac{1}{C}[(1-d_1)x_1 + (1-d_2)x_2 - \frac{x_3}{R_L}]$$

Now, solving for the control input d_2, we can obtain the control law for this stage as:

$$d_2 = \frac{1}{x_2}[Ck_3 e_3 + (1-d_1)x_1 + x_2 - \frac{x_3}{R_L}] \tag{4-g}$$

B. For Stage 2

In this stage all the sources: PV, FC and battery are providing power to the load. Therefore, $i_{batt} > 0$. The control objectives for this stage can be given as:

1) Minimize the PV current error e_1 (eq. 4-a).
2) Minimize the error between input FC current i.e. $i_{FC} = i_{L_2} = x_2$ & the reference I_{FC}^{ref}.
3) Minimize the output voltage error e_3 (eq. 4-e).

According to our first objective, we have to eliminate the error between PV current and its reference. Using equations (4-a), (4-c) & (4-b), but only this time we substitute the expression of $\dot{x}_1$ from stage 2 mathematical model equation (3-f), to get:

$$\begin{aligned} -L_1 k_1 e_1 = {} & (d_1 - d_4)v_{PV} + d_4(v_{PV} + V_B) \\ & + (1-d_1)(v_{PV} - x_3) - r_1 x_1 - \dot{I}_{PV}^{ref} \end{aligned}$$

Further simplifying, we get:

$$d_1 x_3 + d_4 V_B = -k_1 e_1 L_1 - v_{PV} + x_3 + r_1 x_1 \tag{4-h}$$

Now to complete the second objective, let us define an error e_2 as:

$$e_2 = x_2 - I_{FC}^{ref} \tag{4-i}$$

To minimize the error e_2, the time derivative $\dot{e}_2$ should be negative. For this purpose we must define its dynamics so that e_2 would exponentially decay to zero with time. Therefore,

$$\dot{e_2} = -k_2 e_2 \tag{4-j}$$

Where k_2 is also a positive constant. Taking time derivative of (4-i) and using (3-f), we get:

$$\begin{aligned} \dot{e}_2 = \frac{1}{L_2}[{} & (d_2 - d_4)v_{PV} + d_4(v_{FC} + V_B) \\ & + (1-d_2)(v_{FC} - x_3) - r_2 x_2] - I_{FC}^{ref} \end{aligned}$$

Using equation (4-j), it can be simplified as:

$$d_2 x_3 + d_4 V_B = -L_2 k_2 e_2 - v_{FC} + x_3 + r_2 x_2 \tag{4-k}$$

For our third objective of stage 2, we have to eliminate the error between output voltage x_3 and its reference V_o^{ref}. Taking time derivative of (4-e) and using (4-f) we can write:

$$-k_3 e_3 = \dot{x}_3 - \dot{V}_o^{ref}$$

Since the output voltage reference V_o^{ref} is a constant, its derivative would be zero. Now substituting the expression of $\dot{x}_3$ from (3-f), we get:

$$-k_3 e_3 = \frac{1}{C}[(1-d_1)x_1 + (1-d_2)x_2 - \frac{x_3}{R_L}]$$

On further simplification, we get:

$$-d_1 x_1 - d_2 x_2 = -k_3 e_3 C - x_1 - x_2 + \frac{x_3}{R_L} \tag{4-l}$$

Considering equations (4-h), (4-k) and (4-l), we have a system of equations of three variables. It is further simplified to obtain the following control laws:

$$\begin{aligned} d_2 = {} & \frac{k_1 e_1 L_1 x_1 + k_2 e_2 L_2 x_2 - v_{PV} x_1 + v_{FC} x_1 + r x_1^2}{-(x_1 + x_2)(x_3)} \\ & + \frac{r x_1 x_2 - k_3 e_3 C x_3 - x_1 x_3 - x_2 x_3 + \frac{x_3^2}{R_L}}{-(x_1 + x_2)(x_3)} \\ d_1 = {} & \frac{d_2 x_3 - k_1 e_1 L_1 + k_2 e_2 L_2 - v_{PV} + v_{FC} + r x_1 - r x_2}{x_3} \\ d_4 = {} & \frac{-k_1 e_1 L_1 - v_{PV} + x_3 - d_1 x_3}{V_B} \end{aligned} \tag{4-m}$$

C. For Stage 3

The control objectives for this stage are similar to those for stage 2. Hence to achieve our first objective the first error e_1 is defined the same as defined in (4-a). Taking the time derivative of (4-a) and using the dynamic equations of stage 3 (eq. 3-g), we can write the resulting expression as:

$$\begin{aligned} -k_1 e_1 = {} & (\frac{1}{L_1})(d_3 v_{PV} + (d_1 - d_3)(v_{PV} - V_B) \\ & + (1-d_1)(v_{PV} - x_3) - r_2 x_2) - \dot{I}_{PV}^{ref} \end{aligned} \tag{4-n}$$

Further simplification leads to:

$$d_1 V_B + d_3 V_B + d_1 x_3 = -k_1 e_1 L_1 - v_{PV} + x_3 + r_1 x_1 \tag{4-o}$$

Following the same procedure as done in the formulation of control laws for stage 2, the errors e_2 (eq. 4-i) and e_3 (eq. 4-e) are handled using the dynamic equations from stage 3 mathematical model (eq. 3-g). Therefore, the expression for e_2 is obtained using equations (4-i), (4-j) and (3-g) as:

$$-d_2 V_B + d_3 V_B + d_2 x_3 = -k_2 e_2 L_2 - v_{FC} + x_3 + r_2 x_2 \tag{4-p}$$

Similarly, using equations of error e_3 i.e. equations (4-e), (4-f) and using (3-g), the following expression is obtained:

$$-d_1 x_1 - d_2 x_2 = -k_3 e_3 C - x_1 - x_2 + \frac{x_3}{R_L} \tag{4-q}$$

Again following the steps done in the derivation of stage 2, the system of equations, comprising of equations (4-o), (4-p)

and (4-q) is further simplified to obtain the control laws for stage 3, given as:

$$d_2 = \frac{-k_1e_1L_1x_1 + k_2e_2L_2x_2 - v_{PV}x_1 + v_{FC}x_1 + rx_1^2}{V_Bx_1 + x_2V_B - x_2x_3 - x_1x_3} + \frac{-rx_1x_2 + V_Bk_3e_3Cx_3 + V_Bx_1 + V_Bx_2 - x_1x_3 - x_2x_3}{V_Bx_1 + x_2V_B - x_2x_3 - x_1x_3} + \frac{-V_B + k_3e_3Cx_3}{V_Bx_1 + x_2V_B - x_2x_3 - x_1x_3}$$

$$d_1 = \frac{d_2x_3 - k_1e_1L_1 + k_2e_2L_2 - v_{PV}}{-V_B + x_3} + \frac{v_{FC} + rx_1 - rx_2 - d_2V_B}{-V_B + x_3}$$

$$d_4 = \frac{-k_1e_1L_1 - v_{PV} + x_3 + r_1x_1 + d_1V_B - d1_x3}{V_B} \tag{4-r}$$

V. Stability Analysis

As discussed earlier in section IV, the stability of the system, operating in stage 1, can be proved LFC, given as:

$$V = \frac{1}{2}e_1^2 + \frac{1}{2}e_3^2 \tag{5-a}$$

We need to make the $\dot{V}$ negative definite, in order to make the system asymptotically stable. Taking derivative of (5-a), we get

$$\dot{V} = e_1\dot{e}_1 + e_3\dot{e}_3$$

Using (4-b) and (4-f), we get

$$\dot{V} = -k_1e_1^2 - k_3e_3^2$$

Since constants k_1 and k_2 are positive, which proves that:

$$\dot{V} \leq 0, \forall\, x \in \mathbb{R}^3$$

Hence for stage 1, the closed loop system is globally asymptotically stable.
For stage 2 and 3, the LFC can be given as:

$$V = \frac{1}{2}e_1^2 + \frac{1}{2}e_2^2 + \frac{1}{2}e_3^2 \tag{5-b}$$

Taking the time derivative of (5-b), we get:

$$\dot{V} = e_1\dot{e}_1 + e_2\dot{e}_2 + e_3\dot{e}_3$$

From (4-b), (4-j) and (4-f), we get:

$$\dot{V} = -k_1e_1^2 - k_2e_2^2 - k_3e_3^2 \tag{5-c}$$

Since k_1, k_2 & k_3 are positive constants, $\dot{V}$ is negative definite. Hence the closed loop system is globally asymptotically stable for stages 2 & 3.

VI. Simulation Results

The HEV system is simulated to validate the performance of the proposed nonlinear controller. The DC reference voltage (V_o^{ref}) is taken as 350V. Therefore one of the controller objectives is to regulate the DC bus to 350V. PV and FC sources are modeled as current dependent sources. The current references i_{PV}^{ref} & i_{FC}^{ref} are taken different in each stages. In stage 1, there is only one current reference: i_{PV}^{ref} because as explained in IV-A, our objectives are to control only the i_{PV}^{ref} and V_o^{ref}. The reference values for each stage is given in Table I. The DC-DC converter parameters are listed in Table II. The controller gains for each stage are evaluated using hit-and-trial method and are listed in Table III. The control laws for each stage are built in separate blocks. The stages are differentiated by the battery current state (i_{batt}) as shown in (3-a).

TABLE I. Set Reference Values

Reference values	Stage 1	Stage 2	Stage 3
i_{PV}^{ref} (A)	16.25	21	5.3
i_{FC}^{ref} (A)	NIL	7.5	23
V_o^{ref} (V)	350	350	350

TABLE II. Components Values

Parameter	Notation	Value
Inductor	L_1,L_2	4e-3
Capacitor	C	200e-6

TABLE III. Control Design Parameters

Stage	k_1	k_2	k_3
Stage 1	100	100000	100000
Stage 2	NIL	10	10
Stage 3	10	100	100

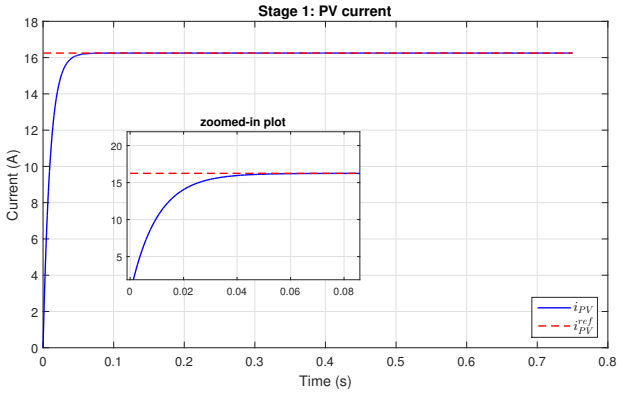


Fig. 6. Plot of i_{PV} for stage 1, with $i_{PV}^{ref} = 16.25A$

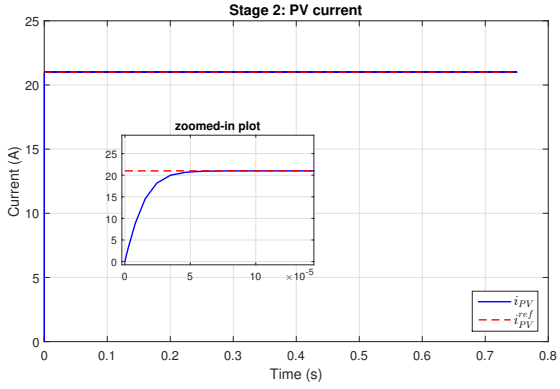


Fig. 7. Plot of i_{PV} for stage 2, with $i_{PV}^{ref} = 21A$

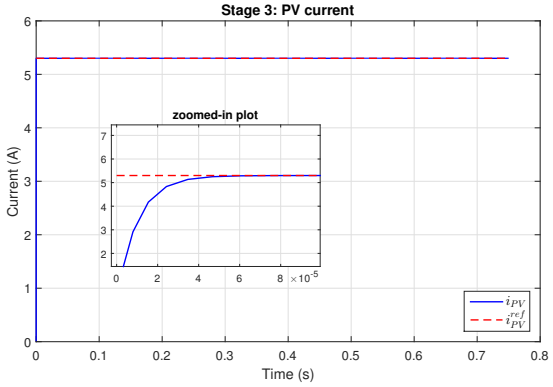


Fig. 8. Plot of i_{PV} for stage 3, with $i_{PV}^{ref} = 5.3A$

The HESS and the proposed controller are simulated for a total time of 0.75 seconds. As one can see, the PV current (i_{PV}) tracks its reference value perfectly for all the three stages that is 16.25A for stage 1 in Fig. 6, 21A for stage 2 in Fig. 7 and 5.3A for stage 3 in Fig. 8 . A slight deviation is observed in the transient response, however, the response settled down very quickly. Same behavior is observed in the FC current i.e. the Fuel Cell current is perfectly tracked that is 7.5A for stage 2 in Fig. 9 and 23A for stage 3 in Fig. 10 and output voltage (V_o) waveform (Fig. 11), where the response took a little time to settle down. The transient time for the i_{FC} is observed to be around 0.4 seconds, which is sufficient for the vehicular operation. Since the output voltage (V_o) has been set to track a constant reference value, in all the stages (see Table I), a constant output voltage of 350V has been observed in all the converter stages. It is important to note here that the output load value is not constant in this simulation. From Fig. 12, it can be seen that the output load is set to vary from 10Ω to 80Ω with a linear change of $35\Omega/s$. Hence it can be concluded that the proposed system is performing correctly under varying load conditions, which is the primary objective of our control scheme. To quantify the controller's performance, the settling time is recorded for each operating stage. The settling time is the time, the response of a system takes to reach 90% of its final value. It is an important, quantifiable performance measure for a controller. Following values of settling time has been recorded for each stage of the converter:

1) Stage 1 :

- 0.107s for PV current.
- 1.363s for DC-link voltage.

2) Stage 2 :

- 0.002s for PV current.
- 0.926s for FC current.
- 0.135s for DC-link voltage.

3) Stage 3 :

- 0.002s for PV current.
- 0.941s for FC current.
- 0.135s for DC-link voltage.

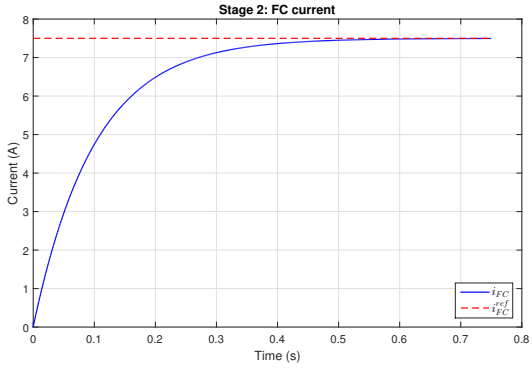


Fig. 9. Plot of i_{FC} for stage 2, with $i_{FC}^{ref} = 7.5A$

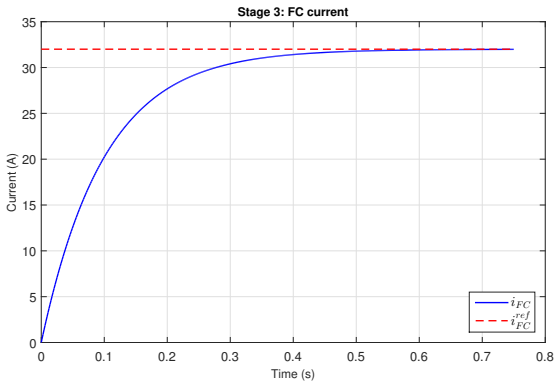


Fig. 10. Plot of i_{FC} for stage 3, with $i_{FC}^{ref} = 32A$

VII. Comparison with PI-Control

PI-control has been applied on the same HESS in [29]. The technique was based on decoupling network. Two types of decoupling networks have been utilized to design a feedback converter. For proper comparison, reference values and converter parameters are kept the same. The only change in parameters from previous simulation in the load resistance

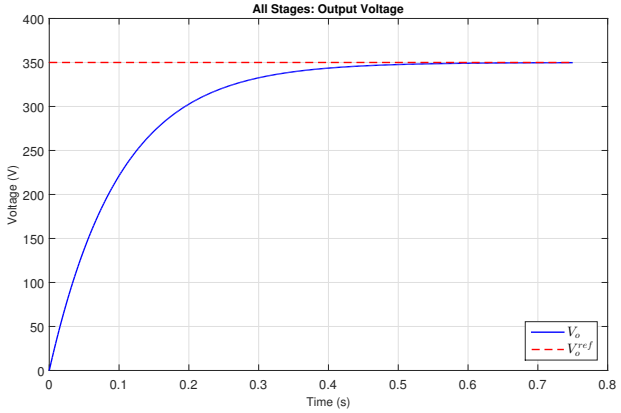


Fig. 11. Plot of Output Voltage V_o tracking $V_o^{ref} = 350V$, constant for all the stages

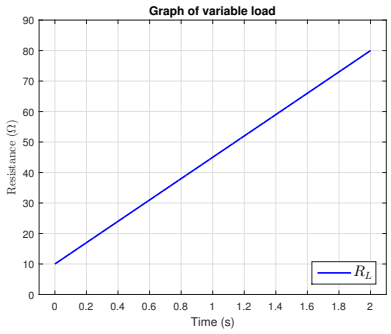


Fig. 12. Plot of Variable load R_L

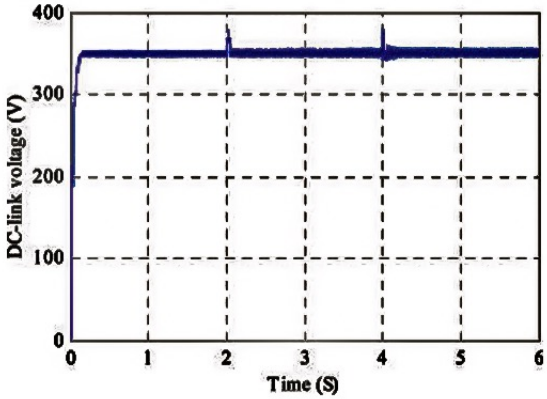


Fig. 13. Output voltage V_o with PI control

value, which is a constant: $R_L = 49\Omega$.

Fig. 13 and 14 show the PI-control based HESS [29]. Overshoot and ripples of large magnitudes can be observed at the times when the reference currents are changed (see Fig. 14). Therefore, the advantages of the proposed control scheme over the PI-control, can be summarized in the following points:

1) No overshoot was observed even when the reference and load varied.
2) No steady state error was found in PV current and FC current in all the stages.
3) No steady state error in output voltage was observed.
4) Very small current ripples were observed in all the source currents (PV, FC & battery).

VIII. Conclusion

A Lypunov based nonlinear control technique is applied on a MIMO HEV system. The input sources are PV module, PEMFC and high voltage lithium-ion battery. The converter topology has four switches which are independently controlled. The DC-DC converter operation is divided into three stages, differentiated by the state of battery current. A state-averaged nonlinear mathematical model of the HEV has been developed and a Lyapunov-based non-linear control scheme has been applied to achieve current and voltage regulation of each source in each stage. The proposed system is simulated on

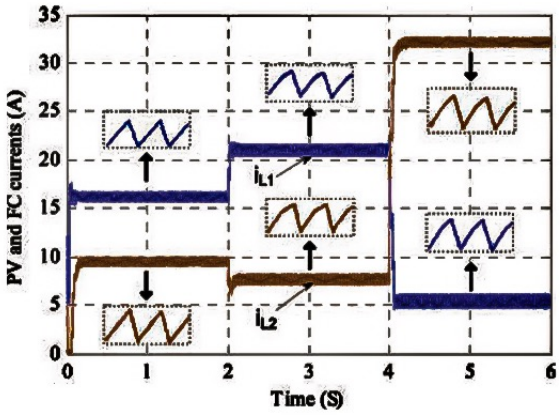


Fig. 14. Plot of source currents with PI control

MATLAB/Simulink to observe the controller's performance. The proposed nonlinear controller is found to be better in terms of current tracking, DC-bus voltage and load regulation, when compared with a PI-based controller. Therefore, by observing its performance and its effectiveness, one can conclude that the proposed controller is a better choice for applications such as HEVs, where multiple energy sources are involved.

References

[1] Haifeng Wang. A boost converter design with low output ripple based on harmonics feedback. *arXiv preprint arXiv:1901.10020*, 2019.

[2] Fanchao Liao, Eric Molin, Harry Timmermans, and Bert van Wee. Consumer preferences for business models in electric vehicle adoption. *Transport Policy*, 73:12–24, 2019.

[3] JA Domínguez-Navarro, R Dufo-López, JM Yusta-Loyo, JS Artal-Sevil, and JL Bernal-Agustín. Design of an electric vehicle fast-charging station with integration of renewable energy and storage systems. *International Journal of Electrical Power & Energy Systems*, 105:46–58, 2019.

[4] M. S. A. Chowdhury, K. A. A. Mamun, and A. M. Rahman. Modelling and simulation of power system of battery, solar and fuel cell powered hybrid electric vehicle. In *2016 3rd International Conference on Electrical Engineering and Information Communication Technology (ICEEICT)*, pages 1–6, Sept 2016.

[5] Khalil Amine. E-fuel system: a conceptual breakthrough for energy storage. *Science Bulletin*, 64(4):227–228, 2019.

[6] Y. T. Teng and F. C. Wang. Cost analyses and optimization of a pemfc electric vehicle model. In *2016 IEEE/SICE International Symposium on System Integration (SII)*, pages 887–892, Dec 2016.

[7] Dragan W Maksimovic, Khurram K Afridi, Regan A Zane, Gregory L Plett, and Michael Scott Trimboli. Heterogeneous energy storage system and method of controlling a heterogeneous energy storage system, February 28 2019. US Patent App. 16/079,957.

[8] Hassan Fathabadi. Combining a proton exchange membrane fuel cell (pemfc) stack with a li-ion battery to supply the power needs of a hybrid electric vehicle. *Renewable energy*, 130:714–724, 2019.

[9] Hanqing Wang, Arnaud Gaillard, and Daniel Hissel. A review of dc/dc converter-based electrochemical impedance spectroscopy for fuel cell electric vehicles. *Renewable Energy*, 2019.

[10] Ahmed Fathy, Hegazy Rezk, and Ahmed M Nassef. Robust hydrogen-consumption-minimization strategy based salp swarm algorithm for energy management of fuel cell/supercapacitor/batteries in highly fluctuated load condition. *Renewable Energy*, 139:147–160, 2019.

[11] J. Chen, C. Xu, C. Wu, and W. Xu. Adaptive fuzzy logic control of fuel-cell-battery hybrid systems for electric vehicles. *IEEE Transactions on Industrial Informatics*, 14(1):292–300, Jan 2018.

[12] Kathleen Araújo, Jean Léon Boucher, and Omkar Aphale. A clean energy assessment of early adopters in electric vehicle and solar photovoltaic technology: Geospatial, political and socio-demographic trends in new york. *Journal of Cleaner Production*, 216:99–116, 2019.

[13] Ankit Gupta, Yogesh K Chauhan, and Rupendra Kumar Pachauri. A comparative investigation of maximum power point tracking methods for solar pv system. *Solar energy*, 136:236–253, 2016.

[14] Jisun Kim, Chih-Jen Yu, M. Khammuang, J. Lui, A. Almujahid, and T. Daim. Forecasting battery electric vehicles. In *2017 IEEE Technology Engineering Management Conference (TEMSCON)*, pages 199–208, June 2017.

[15] Hammad Armghan, Iftikhar Ahmad, Naghmash Ali, Muhammad Faizan Munir, Saud Khan, and Ammar Armghan. Nonlinear controller analysis of fuel cell–battery–ultracapacitor-based hybrid energy storage systems in electric vehicles. *Arabian Journal for Science and Engineering*, 43(6):3123–3133, 2018.

[16] Lia Kouchachvili, Wahiba Yaïci, and Evgueniy Entchev. Hybrid battery/supercapacitor energy storage system for the electric vehicles. *Journal of Power Sources*, 374:237–248, 2018.

[17] BM Sanghavi, C Tejaswini, and Venkateshappa Venkateshappa. Dc/dc boost converter using dsp controller for fuel cell. *Perspectives in Communication, Embedded-systems and Signal-processing-PiCES*, 2(10):248–251, 2019.

[18] D. Foito, M. Gaspar, and V. F. Pires. Road motion control electric vehicle with speed and torque observer. In *2013 International Conference on New Concepts in Smart Cities: Fostering Public and Private Alliances (SmartMILE)*, pages 1–6, Dec 2013.

[19] Ottorino Veneri, Clemente Capasso, and Stanislao Patalano. Experimental investigation into the effectiveness of a super-capacitor based hybrid energy storage system for urban commercial vehicles. *Applied Energy*, 227:312–323, 2018.

[20] H. Yin, C. Liu, D. You, J. Zhao, Y. Wu, and Z. Ling. A new isolation control of three-port active converters for electric vehicles. In *2017 IEEE Conference on Energy Internet and Energy System Integration (EI2)*, pages 1–4, Nov 2017.

[21] S. Das, K. M. Salim, and D. Chowdhury. A novel variable width pwm switching based buck converter to control power factor correction phenomenon for an efficacious grid integrated electric vehicle battery charger. In *TENCON 2017 - 2017 IEEE Region 10 Conference*, pages 262–267, Nov 2017.

[22] K. C. Manjunatha and Manjesh. Design and development of flyback converter with buck-boost regulator for dc motor used in electric vehicle for the application of renewable energy. In *2017 International Conference on Circuit ,Power and Computing Technologies (ICCPCT)*, pages 1–4, April 2017.

[23] Martin Batliner, Oliver König, Stefan Jakubek, and Günter Prochart. Method and controller for model predictive control of a multi-phase dc/dc converter, February 26 2019. US Patent App. 10/216,153.

[24] Xinan Zhang, Benfei Wang, Ujjal Manandhar, Hoay Beng Gooi, and Gilbert Foo. A model predictive current controlled bidirectional three-level dc/dc converter for hybrid energy storage system in dc microgrids. *IEEE Transactions on Power Electronics*, 34(5):4025–4030, 2019.

[25] Apparao Dekka, Bin Wu, Venkata Yaramasu, Ricardo Lizana Fuentes, and Navid R Zargari. Model predictive control of high-power modular multilevel convertersan overview. *IEEE Journal of Emerging and Selected Topics in Power Electronics*, 7(1):168–183, 2019.

[26] B. N. Kommula and V. R. Kota. Performance evaluation of hybrid fuzzy pi speed controller for brushless dc motor for electric vehicle application. In *2015 Conference on Power, Control, Communication and Computational Technologies for Sustainable Growth (PCCCTSG)*, pages 266–270, Dec 2015.

[27] Tapas Kumar Mohapatra, Asim Kumar Dey, Krushna Keshab Mohapatra, and Binod Sahu. A novel non-isolated positive output voltage buck-boost converter. *World Journal of Engineering*, 2019.

[28] R. Das and M. A. UddinChowdhury. Pi controlled bi-directional dc-dc converter (bdddc) and highly efficient boost converter for electric vehicles. In *2016 3rd International Conference on Electrical Engineering and Information Communication Technology (ICEEICT)*, pages 1–5, Sept 2016.

[29] R. R. Ahrabi, H. Ardi, M. Elmi, and A. Ajami. A novel step-up multiinput dc x2013;dc converter for hybrid electric vehicles application. *IEEE Transactions on Power Electronics*, 32(5):3549–3561, May 2017.

[30] R. K. Vardhan, T. Selvathai, R. Reginald, P. Sivakumar, and S. Sundaresh. Modeling of single inductor based battery balancing circuit for hybrid electric vehicles. In *IECON 2017 - 43rd Annual Conference of the IEEE Industrial Electronics Society*, pages 2293–2298, Oct 2017.

[31] Hui Peng, Junzheng Wang, Wei Shen, Dawei Shi, and Yuan Huang. Compound control for energy management of the hybrid ultracapacitor-battery electric drive systems. *Energy*, 2019.

[32] P. Swain and D. Jena. Modeling, simulation amp; optimal control of non-linear pem fuel cell with disturbance input. In *2015 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS)*, pages 1–7, March 2015.

[33] Yu Wu, Yigeng Huangfu, Rui Ma, Alexandre Ravey, and Daniela Chrenko. A strong robust dc-dc converter of all-digital high-order sliding mode control for fuel cell power applications. *Journal of Power Sources*, 413:222–232, 2019.

[34] A. K. Gupta and R. Saxena. Review on widely-used mppt techniques for pv applications. In *2016 International Conference on Innovation and Challenges in Cyber Security (ICICCS-INBUSH)*, pages 270–273, Feb 2016.

[35] H. El Fadil, F. Giri, J. M. Guerrero, and A. Tahri. Modeling and nonlinear control of a fuel cell/supercapacitor hybrid energy storage system for electric vehicles. *IEEE Transactions on Vehicular Technology*, 63(7):3011–3018, Sept 2014.

Automatic Classification of Academic and Vocational Guidance Questions using Multiclass Neural Network

Omar Zahour[1], El Habib Benlahmar[2], Ahmed Eddaoui[3], Oumaima Hourrane[4]
Laboratory of Information Technology and Modeling
Hassan II University, Faculty of Sciences Ben M'SIK, Casablanca, Morocco

***Abstract*—The educational and professional orientation is an essential phase for each student to succeed in his life and his curriculum. In this context, it is very important to take into account the interests, occupations, skills, and the type of each student's personalities to make the right choice of training and to build a solid professional outline. This article deals with the problematic of educational and vocational orientation and we have developed a model for automatic classification of orientation questions. "E-Orientation Data" is a machine learning method based on John L. Holland's Theory of RIASEC typology that uses a multiclass neural network algorithm. This model allows us to classify the questions of academic and professional orientation according to their four categories, thus allows automatic generation of questions in this area. This model can serve E-Orientation practitioners and researchers for further research as the algorithm gives us good results.**

Keywords*—Academic and vocational guidance; multiclass neural network; e-orientation; machine learning; Holland's theory

I. INTRODUCTION

The classification of questions is a problem that has already been studied by several researchers in this field, but most of the work is domain-specific or limited to a high-level classification.

Anbuselvan and R.Ahmed [1] proposed an SVM-based method for the same task. The question is first analyzed and numbered, the parts of the speech are labeled, the stop words are deleted, the data is truncated and many features are extracted. The feature selection steps are performed prior to transmitting the data to a carrier vector machine for training. The same treatment is also done for test questions, which can take a long time to get results in real-time.

Marco Pota [2] propose a feature-based method, in which features related to a subset of questions such as keywords, how - all / some words, leading verbs and various other such features were extracted from the texts a classifier.

For Natural Language Processing (NLP) Convolutional neural networks (CNNs) have already been used in some works. Collobert and J.Weston [3] first proposed the idea of a convolutional neural network architecture, which includes lookup tables and hyperbolic hard tangents. Kalchbrenner and P.Blunson [4] proposed a simplified version of Collobert's network, which was used to classify Twitter's questions and opinions. They used the concept of k-max pooling. Yoon Kim [5] developed Kalchbrenner's work to add various machine learning strategies, such as regularization, to improve network performance.

For the time, the question classification has mainly been studied in the context of open-domain TREC (Text REtrieval Conference) questions [6], with smaller recent datasets available in biomedical [7] [8] and education [9]. The TREC corpus of questions from the open-domain is a set of questions associated with a taxonomy developed by Li and Roth [10] that includes 6 types of coarse responses (such as entities, locations and numbers) and 50 fine-grained types (for example, specific types of entities, such as animals or vehicles). While a wide variety of syntactic, semantic and other features and classification methods have been applied to this task, culminating in an almost perfect classification performance [11], recent work has shown that QC methods developed on TREC issues usually fail to transfer to datasets with more complex issues such as those in the biomedical field [7], probably due in part to the simplicity and syntactic regularity of questions and the possibility of simpler term frequency models achieve near-ceiling performance [12].

In this world, the educational and guidance system of each country seeks to help the students or the laureates of higher education institutions and vocational training institutes to make their choice.

According to Ali Boulahcen [13] and through his analysis, he noticed that there is no real process of educational guidance in Morocco, but there is only a summary process in the context, within a few seconds, one decides on the fate of the pupil that based solely on his academic value then translated by a numerical note.

This means that the Moroccan school institution is based at least on selection criteria and not on orientation [13].In this context, our goal is to set up an E-Orientation system that is interested in the automation of the orientation task, thanks to the evolution of information technologies. The realization of this electronic guidance system requires the classification then modeling and integration of user preferences in this system. In this paper, we used the Multi-Class Neural Networks algorithm to classify the different questions according to John L. Holland's RIASEC topology.

This document is organized as follows:

Section 2 provides a literature review of the various theories of educational and vocational guidance, including the theory of John L. Holland, Section 3 deals with the different automatic classification algorithms of the text, Section 4 deals

with the experimental evaluation of the classification, and Section 5 covers the results obtained and the conclusion with research perspectives.

II. HOLLAND'S THEORY AND RIASEC TYPES

A. Holland's Theory

The guiding approach is based on theories and studies related to career choice and career development. These include Hoyt's concept of career education, Gardner's theory of multiple intelligences and Holland's typology of professional interests [14]. Holland's theory of vocational choice (1997) [15], is the result of the work of American psychologist and researcher "John Holland (1919-2008)". The results of his research argue that the association of workers to one type of career would be determined by their skills, interests, and personality.

Some activities would be better suited to one type of person than another. It constitutes the theoretical anchoring of our classification model and serves as a basis for many psychometric tools, including the Hexa 3d professional interest's questionnaire.

Although this theory, dating from the mid-1960s is still widely used [16] and has been the subject of numerous studies [17] - [18].

To briefly explain his theory, Holland (1997) [15] formulates several hypotheses according to professional interests that are a mode of expression of personality. Therefore, he considers the choices of orientation as a mode of expression of this personality and distinguishes six types of personality (RIASEC), according to aptitudes, personality traits, values, and beliefs.

Of all the models related to career development, the Holland model has been the subject of the greatest number of analyzes and studies.[19].Among those conducted on the structure of interests across gender and ethnic populations, a number demonstrates the consistency of the arrangement of types and their proximity on a hexagonal and spherical model [18], [20], [21]. This debate focuses more on the geometric regularity of the hexagon and on the correspondence distances between the different types. Vrignaud and Bernaud (1994) validated other things such as the structure of the Holland model in France [22].

Professional activities, as well as work environments, tend to bring together people who share common interests to a certain extent. The choice of a profession or trade is a form of expression of the personality of an individual; it is the theory of vocational interests.

The person-work environment combination is the most widely used method in the world of educational and vocational guidance.

B. Holland's RIASEC Types

The theory of vocational choice distinguishes six categories of professional interest (realistic, investigative, artistic, social, enterprising, and conventional) corresponding to different personality profiles. Holland represents them according to a hexagonal model illustrated in Fig. 1 [23].

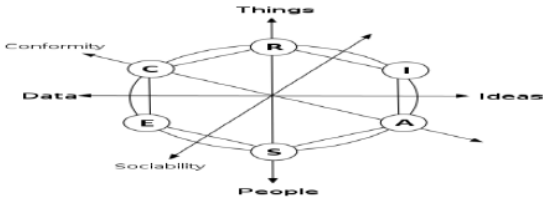


Fig. 1. Representation of Holland's Circular Model (RIASEC).

According to Holland - and many research, they have confirmed the profession or trade chosen by a person which is a form of expression of his personality. Therefore, it is related to the type to which he belongs.

The affiliation of a worker to one of the six types would be determined by his aptitudes, by certain traits of his personality and interests. So, according to Holland, people of the same type would be attracted to the same kind of work. Why? Because these people are similar in their personality, in the fact they pursue similar objectives and have the same physical or psychological dispositions with regard to their work. All persons can be divided into six professional types.

The typology of a person is established by measuring his degree of affinity with each of the six types, to place them in order of importance, of the type that corresponds most to him. For most people, it is mostly the first two or three types of personal classification that determine their way of being and acting in their personal and professional lives. For example, a person whose dominant type is "Investigator" and who has affinities with the "Realist" type; we will say that he has an "IR" profile. To further characterize this person's typology, it is possible to consider the third type which it most closely resembles and to say the case where it is of the "Social" type and is this person has an "IRS" profile?

These types can be combined in all sorts of ways and their combination determines the personality.

THE REALISTIC TYPE – People exercise mainly concrete tasks. With their hands, they know how to coordinate their actions. They use tools; operate appliances, machines, vehicles. Realists have a sense of mechanics which is a concern for precision. Many people practice their profession outdoors rather than indoors. Their work often requires good physical stamina and even athletic abilities. These people are patient, meticulous, consistent, sensible, natural, frank, practical, concrete and simple.

TYPE INVESTIGATOR - Most people of this type have theoretical knowledge which uses it to act. They have specialized information that they use to solve problems. They are observers. Their main competence lies in their understanding of phenomena. They like to be absorbed in their reflections. They like to play with ideas. They value knowledge. These people are critical, curious, anxious to learn, calm, reserved, persevering, tolerant, cautious in their judgments, logical, objective, rigorous and intellectual.

THE ARTISTIC TYPE - People of this type like activities that allow them to express themselves freely based on their perceptions, their sensitivity, and their intuition. They are interested in creative work, visual art, literature, music, and

advertising or entertainment. With an independent and unconventional spirit, they are comfortable in situations that are out of the ordinary. They have great sensitivity and a lot of imagination. Although discouraged by methodical and routine tasks, they are nevertheless able to work with discipline. These people are spontaneous, expressive, imaginative, emotional, independent, original, intuitive, passionate, proud, flexible, and disciplined.

THE SOCIAL TYPE - People of this type like to be in contact with others in order to help them, to inform them, to educate them, to entertain them, to treat them or to promote their growth. They are interested in human behavior and care about the quality of their relationships with others. They use their knowledge and their feelings and emotions to act and interact with others. They like to communicate and express themselves easily. These people are attentive to others, cooperative, collaborating, understanding, dedicated, sensitive, friendly, insightful, caring, communicative, and encouraging.

THE ENTREPRENEURIAL TYPE - People of this type like to influence their surroundings. Their decisions make ability; a sense of organization and a particular ability to communicate their enthusiasm to support them in their goals. They know how to sell ideas as much as material goods. They have a sense of organization, planning, initiative, and know-how to carry out their projects. They know how to be bold and efficient. These people are persuasive, energetic, optimistic, audacious, self-confident, ambitious, determined, diplomatic, resourceful, and sociable.

THE CONVENTIONAL TYPE - People of this type have a preference for specific, methodical activities that focused on a predictable outcome. They are concerned about the order and the good material organization of their environment. They prefer to abide by well-established conventions and clear instructions rather than acting in improvisation. They like to calculate, classify, and maintain records or records. They are effective in any job that requires accuracy and ease in routine tasks. These people are loyal, organized, efficient, and respectful of authority, perfectionist, reasonable, conscientious, punctual, discreet, and strict [24].

III. Related Work

Classification systems for the best-performing questions tend to use a rule-based custom template matching [25] [11], or a combination of basic learning approaches. of rules and machine learning [26], to the detriment of model construction time.

Recent research on the methods learned has shown that a large number of CNN variants [27] and LSTM [12] achieve similar precision on the TREC question classification; these models presenting at best small gains compared to simple models term frequency models. These recent developments echo the observations of Roberts and M.Fiszman [7], who have shown that existing methods beyond term frequency models fail to generalize to questions in the medical field.

In the education sector, researchers Godea.A and Nielsen.R [9] collected 1,155 questions in class and classified them into 16 categories. To allow a detailed study of the classification of questions in the scientific field, the process of classifying a text collection is to label each text with one or more predefined classes (Categories). In this process, an algorithm is first designed then it is driven with a set of specific characteristics, for example, word occurrences or even theme distributions in a document. Once trained, the algorithm is used to label new texts, but these are different from the texts used during training. The algorithm is evaluated on the number of classification errors obtained during the learning phase and during the test phase.

When we are training the classification algorithm, the extraction phase of the characteristics is used for learning crucial. These Characteristics extracted from texts that are typically derived from a large vector space. This space is constructed with vector modeling of words using distributional semantics [28].

Data science or statistical algorithms are further classified into multiple machines learning specific algorithmic categories:

- Supervised learning algorithms (label and output known).
- Unsupervised learning algorithms (label and output not known).
- Reinforced learning algorithms (reward-based agent action).
- Semi-supervised learning algorithms (mix of supervised and unsupervised).

These algorithms, in turn, contain multiple sub-algorithms and types (see Table I). For example, a few algorithms fall under the category of parametric, whereas others are non-parametric. In parametric algorithms, information about the population is completely known which not the case with non-parametric algorithms is. Typically, parametric models deal with a finite number of parameters, whereas non-parametric learning models are capable of dealing with an infinite number of parameters. Therefore, the training data grows the complexity of nonparametric models increases. Linear regression, logistic regression, and Support vector machines are examples of parametric algorithms. K-nearest neighbor and decision trees are non-parametric learning algorithms. These algorithms are computationally faster in comparison to their nonparametric companions.

As Table I depicts, the machine learning algorithms are large in number [29].

In this section, we briefly describe various machine-learning algorithms used for forecasting.

A. Support Vector Machine (SVM)

SVM Classifiers attempt to partition the data space with the use of linear or non-linear delineations between the different classes. The key in such classifiers is to determine the optimal boundaries between the different classes and use them for the purposes of classification.

TABLE. I. MACHINE LEARNING ALGORITHMS

Supervised Learning	Unsupervised Learning	Reinforcement Learning
Artificial neural network	Artificial neural network	
Bayesian statistics	Association rule learning	Q-learning
Case-based reasoning	Hierarchical clustering	Learning automata
Decision trees	Partitioned clustering	
Learning automata		
Instance-based learning		
Regression analysis		
Linear classifiers Decision trees		
Bayesian networks		
Hidden Markov models		

B. Naïve Bayes Classifier

Naïve Bayes classifier is statistical classifiers, which predict class membership based on probabilities. Naive Bayes classifiers make use of class conditional independence, which makes it computationally faster. Class conditional independence means every attribute in the given class independent of other attributes. Naive Bayes classifier works as follows:

Let us suppose T represents a training set of samples. There are k classes, so class labels would be $C_1, C_2, ..., C_k$. Each record is represented by an n-dimensional vector, $X = \{X_1, X_2, ..., X_n\}$. It represents n measured values of the n attributes $A_1, A_2, ..., A_n$ respectively. Classifier will predict the class of X based on highest a posteriori probability. Thus we find the class that maximizes $(C_i \mid X)$ By Bayes Theorem, we have k :

$$P(C_i / X) = P(X \mid C_i) P(C_i) / P(X) \tag{1}$$

As $P(X)$ has same value for all classes, we can ignore it. Naïve Bayes makes class conditional independence assumption mathematically:

$$P(X \mid C_i) = \prod_{k=1}^{n} P(x_k \mid C_i) \tag{2}$$

The probabilities $(x_1 \mid C_i), (x_2 \mid C_i), ..., (x_n \mid C_i)$ are computed from the training set. In (2), the term x_k denotes the value of attribute A_k for the given sample.

C. K-Nearest Neighbors

K-Nearest Neighbor (KNN) is a simple to implement machine learning classifier. The decision is taken on the basis of similarity parameters such as Euclidean distance. The KNN classifier works as follows:

1) Compute k number of nearest neighbors.

2) Determine the distance between the test samples and the training samples by using metrics such as Euclidean distance.

3) Perform sorting on all the training data is on the basis of distances.

4) Decide class labels of k nearest neighbors on the basis of majority vote and assign it as a prediction value of the query record.

D. Multiclass Logistic Regression

Multinomial logistic regression is a form of logistic regression which used to predict a target variable; it has more than two classes. It is a modification of logistic regression using the softmax function instead of the sigmoid function, and the cross-entropy loss function. The softmax function squashes all values to the range [0,1] and the sum of the elements is 1.

$$soft\max(x)_i = \frac{e^{x_i}}{\sum_{j=1}^{n} e^{x_j}} \tag{3}$$

Cross entropy is a measure of how different two probability distributions are near to each other. If p and q are discrete we have:

$$H(p,q) = -\sum_x p(x) Log\, q(x) \tag{4}$$

This function has a range of [0, inf], it is equal to 0 when p=q and infinity then p is very small compared to q or vice versa. For example x, the class scores are given by vector z=Wx+b, where W is a C×M matrix and b is a length C vector of biases. We define the label y as a one-hot vector equal to 1 for the correct class c and 0 everywhere else. The loss for a training example x with predicted class distribution y and correct class c will be:

$$\hat{y} = softmax(z) \tag{5}$$

$$\begin{aligned} loss &= H(y, \hat{y}) \\ &= -\sum_i y_i \; Log \; \hat{y}_i \\ &= -Log \; \hat{y}_c \end{aligned} \tag{6}$$

As in the binary case, the loss value is exactly the negative log probability of a single example x having true class label c. Thus, minimizing the sum of the loss over our training example is equivalent to maximizing the log-likelihood. We can learn the model parameters W and b by performing gradient descent on the loss function with respect to these parameters. There are two common methods to perform multi-class classification using the binary classification logistic regression algorithm: one-vs-all and one-vs-one. In one-vs-all, we train C separate binary classifier for each class and run all those classifiers on any new example x, we want to predict

and take the class with the maximum score. In one-vs-one, we train C to choose 2 classifiers = C(C-1)/2 one for each possible pair of class and choose the class with maximum votes while predicting for a new example.

E. Multiclass Neural Network

A neural network is a set of interconnected layers. The inputs are the first layer and are connected to an output layer by an acyclic graph composed of weighted edges and nodes. We can insert multiple hidden layers between the input and output layers. Most predictive tasks can be accomplished easily with one or more hidden layers. However, Deep Neural Networks (DNNs) [30], [31] with many layers can be very effective for complex tasks such as image recognition or speech. Successive layers are used to model increasing levels of semantic depth. The relationship between inputs and outputs is learned during the formation of the neural network on the input data. The chart direction passes inputs to the hidden layer and the output layer. All the nodes of a layer are connected by the weighted edges to the nodes of the next layer.

To calculate the network output for a particular input, a value is calculated at each node of the masked layers and the output layer. The value is defined by calculating the weighted sum of the values of the nodes of the previous layer. An activation function is then applied to this weighted sum.

We use a multiclass neural network module to predict a multi-valued target knowing that neural networks of this type could be used in complex computer vision tasks, such as recognition of numbers or letters, classification of documents, of text (Questions ...) and also for pattern recognition. In this sense classification using neural networks is a supervised learning method. It, therefore, requires a tagged data set comprising a label column.

IV. Experimental Evaluation and Results

A. Proposed Method

Our proposed system is based on the multi-class neural network algorithm which follows supervised learning. The goal of this is to discover an underlying structure of the data. This algorithm requires a tagged dataset. The data set on orientation questions "E-Orientation Data" is divided into two series, such as training data and test data. The classification performed by the algorithm used in our model is based on the knowledge acquired by the learning data during the learning process.

Our dataset was collected from the RIASEC test based on Holland's theory [32], [33], [34], it contains two columns namely:

Question: It contains questions and statements that measure either the occupations or the activities or abilities or the personality of the users.

Categories: we have four classes (labels) of categories namely:

1) Activity
2) Occupations
3) Abilities
4) Personality

In our research work on Guidance Classification, we used the Azure Machine Learning Studio [35] tool which is a collaborative drag-and-drop tool that we can use to create, test, and deploy predictive analytics solutions on our data. Machine Learning Studio publishes templates as a web of services that can be easily consumed by custom applications. Machine Learning Studio is the meeting place of data science, predictive analytics, cloud resources, and our data.

B. Experiment Steps

The experimental steps described and illustrated in Fig. 4. They are explained below:

1) Importing the Dataset: We import our dataset entitled "E-Orientation Data" that we collected from several websites from our local disk on Azure ML Studio to be used for the experiment and Category names that we have been used as a class tag or attribute to predict.

2) Preprocessing and Preparing the Dataset: The dummy column headers have been replaced by meaningful column names by using the metadata editor. Also, missing values have been cleared by deleting the entire line containing the missing value.

3) Feature engineering: After the processing phase of the dataset, we will use the feature hashing module to convert the raw text of the questions into integers; and use the integer values as input entities of the model. Fig. 3 represents our model.

4) Split the Data and Parameter Settings: We have divided the data of "E-Orientation Data" as 70% of the data for training and 30% for the test. Then we applied the Multiclass Neural Networks algorithm with the default settings for model formation. The parameters have been set by using the "Tune model hyperparameters".

5) The Model: We used the Multiclass neural network algorithm. A neural network is a set of layers that are interconnected. The first layer is the inputs which are connected to an output layer by an acyclic graph; it is comprised of weighted edges and nodes. Multiple hidden layers are present between the input and output layers. The relationship between inputs and outputs is obtained for training input data of the neural network. All the nodes in a layer are associated with the weighted edges to the nodes in the successive layer.

6) Score and evaluate the Model: The Evaluate model also visualizes the results through the confusion matrix.

C. The Results

We used the Multiclass Neural Network algorithm to classify the category of academic and professional guidance questions according to Holland's RIASEC typology. The graphic representation of the Multiclass classification is given in Fig. 2.

Fig. 4 shows the overall implementation of our model.

The classification is carried out as shown in Fig. 5.

Prediction accuracy for each class is shown in Fig. 6.

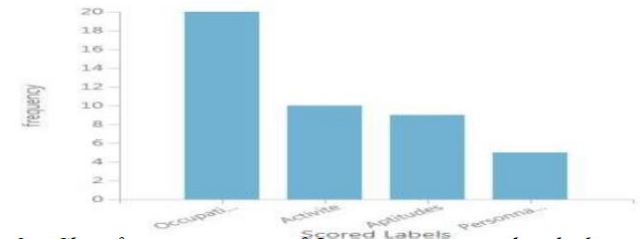


Fig. 2. Classification Category of Question Represented in the Histogram.

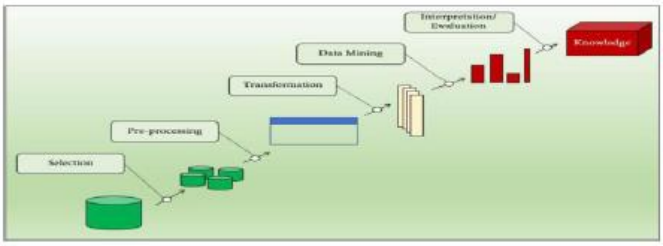


Fig. 3. Schema of Model.

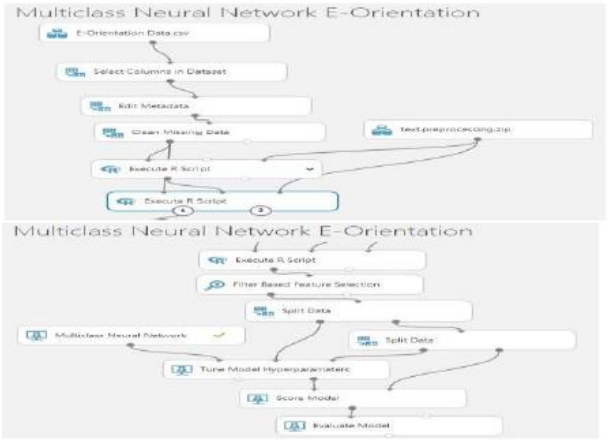


Fig. 4. Classification using Multiclass Neural Network.

Scored Probabilities for Class "Activite"	Scored Probabilities for Class "Aptitudes"	Scored Probabilities for Class "Occupations"	Scored Probabilities for Class "Personnalite"	Scored Labels
0.208896	0.014198	0.644117	0.10673	Occupations
0.000097	0.999752	0.001055	0.000814	Aptitudes
0.001762	0.016079	0.999992	0.002484	Occupations
0.000088	0.999334	0.006043	0.00104	Aptitudes
0.004054	0.011152	0.018266	0.997337	Personnalite
0.949081	0.024299	0.003832	0.060052	Activite

Fig. 5. Snapshot of the Classification.

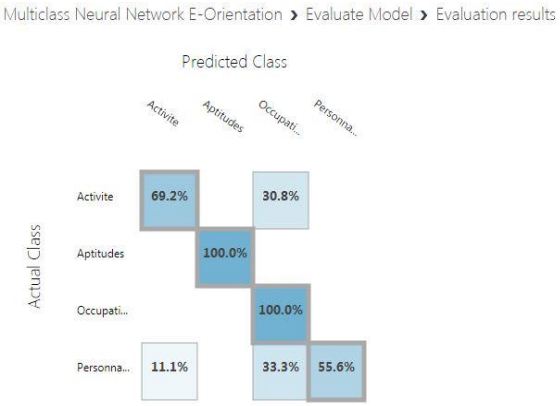


Fig. 6. Confusion Matrix.

V. Conclusion

In this paper, we defined the different Machine Learning algorithms used for text classification. We conclude that multiclass neural networks perform better than other algorithms of machine learning.

The Multiclass Neural Network algorithm used in our classification model of academic and professional orientation questions by category are implemented by using Azure Machine Learning Studio. In fact, we found that the supervised method gives very good precision. This method can also be used to automatically generate academic and vocational orientation questionnaires by knowing in advance the class of these new questions proposed, and we can see this research question as a perspective. This model can also help the researchers of e-Orientation in the development process in this area.

As future work, we focus on using social network analysis, for example, using Twitter sentiment analysis as a feature to determine the class of questions and the interests of students and faculties of educational institutions.

VI. Conflict of Interest

The authors declare no conflict of interest.

References

[1] Sangodiah, R. Ahmad, and W. F. W. Ahmad, "A review in feature extraction approach in question classification using Support Vector Machine," in Proceedings - 4th IEEE International Conference on Control System, Computing and Engineering, ICCSCE 2014, 2014.

[2] G. D. Pietro Marco Pota, Angela Fuggi, Massimo Esposito, "Extracting Compact Sets of Features for Question Classification in Cognitive Systems: A Comparative Study," in 2015 ,10th International Conference on P2P, Parallel, Grid, Cloud and Internet Computing, pp. 551–556.

[3] R. Collobert, J. Weston, L. Bottou, M. Karlen, K. Kavukcuoglu, and P. Kuksa, "Natural language processing (almost) from scratch," J. Mach. Learn. Res., 2011.

[4] N. Kalchbrenner, E. Grefenstette, and P. Blunsom, "A convolutional neural network for modelling sentences," in 52nd Annual Meeting of the Association for Computational Linguistics, ACL 2014 - Proceedings of the Conference, 2014.

[5] Y. Kim, "Convolutional neural networks for sentence classification," in EMNLP 2014 - 2014 Conference on Empirical Methods in Natural Language Processing, Proceedings of the Conference, 2014.

[6] E. M. Voorhees and D. M. Tice, "Building a question answering test collection," SIGIR Forum (ACM Spec. Interes. Gr. Inf. Retrieval), 2000.

[7] K. Roberts, H. Kilicoglu, M. Fiszman, and D. Demner-Fushman, "Automatically classifying question types for consumer health questions," AMIA Annu. Symp. Proc., 2014.

[8] M. Wasim, M. N. Asim, M. U. Ghani Khan, and W. Mahmood, "Multi-label biomedical question classification for lexical answer type prediction," J. Biomed. Inform., 2019.

[9] A. Godea and R. Nielsen, "Annotating educational questions for student response analysis," in LREC 2018 - 11th International Conference on Language Resources and Evaluation, 2019.

[10] X. Li and D. Roth, "Learning question classifiers," 2002.

[11] H. T. Madabushi and M. Lee, "High accuracy rule-based question classification using question syntax and semantics," in COLING 2016 - 26th International Conference on Computational Linguistics, Proceedings of COLING 2016: Technical Papers, 2016.

[12] W. Xia, W. Zhu, B. Liao, M. Chen, L. Cai, and L. Huang, "Novel architecture for long short-term memory used in question classification," Neurocomputing, 2018.

[13] A. Boulahcen, "Le processus d'orientation scolaire au MarocA Sociological Analysis of the Careers Advice Process in Moroccan SchoolsUn análisis sociológico del proceso de orientación escolar en Marruecos," Rev. Int. d'éducation Sèvres, 2005.

[14] G. . & M. . D. Dupont.P, "Guide for Educational and Vocational Information and Guidance: Elementary and Secondary Cycle Three, Youth Sector," Prov. Support Gr. Youth Orientat. approach to Sch. Univ. Sherbrook, Sherbrook, Canada., 2002.

[15] J. L. Holland, "Making vocational choices: A theory of vocational personalities and work environments," Englewood Cliffs NJ PrenticeHall, 1997.

[16] M. M. Nauta, "The Development, Evolution, and Status of Holland's Theory of Vocational Personalities: Reflections and Future Directions for Counseling Psychology," J. Couns. Psychol., 2010.

[17] R. Du Toit and G. P. De Bruin, "The structural validity of Holland's R-I-A-S-E-C model of vocational personality types for young black South African men and women," J. Career Assess., 2002.

[18] D. Guglielmi, F. Fraccaroli, and M. L. Pombeni, "Les intérêts professionnels selon le modèle hexagonal de Holland," L'orientation Sc. Prof., 2004.

[19] A. R. Spokane, E. J. Luchetta, and M. H. Richwine, "Holland's theory of personality in work enviornments," in Career choice and development, 2002.

[20] A. R. Spokane and M. C. Cruza-Guet, "Holland's Theory of Vocational Personalities in Work Environments," in Career development and counseling: Putting theory and research to work, 2005.

[21] Tetreau.B, "The rise of a psychology of professional interests," Carrierology, vol. 10, no. 1, pp. 77–118, 2005.

[22] V. P. & Bernaud.J, "The interests of the French People are they hexagonal?" 1. Elements for the validation of the model of the interests of Holland (RIASEC) in France," Quest. Orientat., vol. 49, no. 1, pp. 17–39, 1994.

[23] "Holland's Codes," https://en.wikipedia.org/wiki/Holland_Codes. [Online]. Available: https://en.wikipedia.org/wiki/Holland_Codes.

[24] "Dictionnaire septembre des métiers et professions; suivi du guide Cléo, des clés pour s'orienter.," Septembre editeur S.E.N.C. pp. 256–257, 2005.

[25] A. Lally et al., "Question analysis: How Watson reads a clue," IBM Journal of Research and Development. 2012.

[26] J. Silva, L. Coheur, A. C. Mendes, and A. Wichert, "From symbolic to sub-symbolic information in question classification," Artif. Intell. Rev., 2011.

[27] T. Lei, Z. Shi, D. Liu, L. Yang, and F. Zhu, "A novel CNN-based method for question classification in intelligent question answering," in ACAI 2018 Proceedings of the 2018 International Conference on Algorithms, Computing and Artificial Intelligence, p. 54.

[28] Z. S. Harris, "Distributional Structure," WORD, 1954.

[29] P. Kashyap and P. Kashyap, "Machine Learning Algorithms and Their Relationship with Modern Technologies," in Machine Learning for Decision Makers, 2017.

[30] Hourrane, Oumaima, and El Habib Benlahmar. "Survey of plagiarism detection approaches and big data techniques related to plagiarism candidate retrieval." Proceedings of the 2nd International Conference on Big Data, Cloud and Applications. ACM, 2017.

[31] Hourrane, Oumaima, et al. "Using Deep Learning Word Embeddings for Citations Similarity in Academic Papers." International Conference on Big Data, Cloud and Applications. Springer, Cham, 2018.

[32] Omar Zahour,El Habib Benlahmar,Ahmed Eddaoui " E-orientation : entre prescription des théories et prise de décision " Conference TIM'16 ,2016.

[33] Omar Zahour,El Habib Benlahmar,Ahmed Eddaoui " E-Orientation: Between prescription of theories and decision-making " Conference SITA'16 , October 2016.

[34] Omar Zahour,El Habib Benlahmar,Ahmed Eddaoui "E-orientation : Vers une modélisation des facteurs d'orientation scolaire " Conference TIM'18 , 2018.

[35] Team, Azureml,Dorard, Louis,Reid, Mark D,Martin, Francisco J, "AzureML: Anatomy of a machine learning servicein" JMLR: Workshop and Conference Proceedings 50:1–13, 2016.

Software Architecture Solutions for the Internet of Things: A Taxonomy of Existing Solutions and Vision for the Emerging Research

Aakash Ahmad[1], Sultan Abdulaziz[2], Adwan Alanazi[3], Mohammed Nazel Alshammari[4], Mohammad Alhumaid[5]
College of Computer Science and Engineering
University of Ha'il, Ha'il, Saudi Arabia

***Abstract*—Recently, Internet of Thing (IoT) systems enable an interconnection between systems, humans, and services to create an (autonomous) ecosystem of various computation-intensive things. Software architecture supports an effective modeling, specification, implementation, deployment, and maintenance of software-intensive things to engineer and operationalize IoT systems. In order to conceptualize and optimize the role of software architectures for IoTs, there is a dire need for research efforts to analyse the existing research and solutions to formulate the vision for futuristic research and development. In this research, we propose to empirically analyse and taxonomically classify the impacts of research on designing, architecting, and developing IoT-driven software systems. We have conducted a survey-based study of the existing research – investigating challenges, solutions and required futuristic efforts – on architecting IoT systems. The results of survey highlight that software architecture solutions support various research themes for IoT systems such as (i) cloud-based ecosystems, (ii) reference architectures, (ii) autonomous systems, and (iv) agent-based systems for IoT-based software. The results also indicate that any futuristic vision to architect IoT software should incorporate architectural processes, patterns, models and languages to support reusable, automated, and efficient development of IoTs. The proposed research documents structured and systemised knowledge about software architecture to develop IoT systems. Such knowledge can facilitate the researchers and developers to identify the key areas, understand the existing solution and their limitations to conceptualize and propose innovation solutions for existing and emerging challenges related to the development of IoT software.**

Keywords*—*Software and system architecture; Internet of Things; software engineering; software engineering for IoT

I. INTRODUCTION

Internets of Things (IoTs) provide a set of technologies and their underlying infrastructure(s) that connect systems, services, human, devices and things to establish the foundation of interconnected and autonomous computing systems [1, 2]. IoT-based computing systems provide the foundation for smart cities and societies with diverse services such as smart health, autonomous transportation, home service robots and industrial automation [2]. From an implementation point of view, IoT systems represent a complex integration of software with hardware complemented by networking components that enable interconnected devices and services that collect data and later process, manage and exploit useful data for automation [1]. As a typical example, consider a robotic agent as a hardware component that interacts with different home appliances (coffee maker, wash/cleaning machine), and it can be monitored and controlled through mobile application to enable housekeeping activities such as cleaning, entertaining and home security activities [3]. One of the recent studies performed by CISCO has indicated that the role of IoTs is increasing in industry scale systems and 25 billion heterogeneous devices (approximately) are expected to be part of the IoTs by the year 2020 and further growth beyond that [4]. In the current age, IoT systems represent the potential to connect, automate and operationalize health, transportation, urban servicing, to accelerate the implementation of smart cities. To realize such potential that lies with the IoT systems, a number of challenges such as engineering, implementation, maintenance, deployment and operationalization of the IoTs must be addressed for wide spread and trustworthy adoption of IoTs [5].

From software or systems development point of view, software design and architecture provides useful abstraction to engineer and develop complex systems effectively and efficiently [6]. In the context of the IoTs, software architecture can abstract the complex and implementation specific details of hardware component and software modules with high-level system view that facilitates engineers and developers for designing, developing and evaluating IoT systems in an automated way with required human decision support [8, 9]. Specifically, the autonomous robot for service and appliances operating in a domestic environment that interact with each other (robot making the coffee or perform cleaning services) can be represented as architectural components and connectors that support programmable implementation of an IoT system that enables humans to exploit automation and home servicing based on interconnected things (i.e., service robot and appliances). This implies that existing processes, practices, patterns, languages and tools for architecture-centric development of software and systems can be effectively leveraged to architect IoT-based software [7, 8]. To support sustainable design and development of IoT software, there is a need to extend the existing solutions that address the challenges for existing and emerging solutions for IoT software [10, 11, 12].

Scope and Contributions of Survey-based Study: In the most recent decade, lot of research and development efforts started and progressed on streamlining and leveraging

This research is supported by the Deanship of Scientific Research at the University of Ha'il, Saudi Arabia under the project number '160595' (Project Code: 160595)

architecture-centric principle, practices and solutions to tackle a diverse set of challenges such as implementation, deployment, standardization and compliance issue pertaining to IoT software and systems [10]. In recent years, some architectural models and reference architectures have also been proposed and implemented to unify the practices to develop IoT systems [3]. In the existing research and development, there is a gap in terms of investigating (i) what is the contribution and impact of existing research?, and (ii) what futuristic challenges are shaping up for the next generation of IoT software. In order to bridge this gap, we have used the principal of empirical research and practices of empirical software engineering for qualitative analysis of 88 that have been published in the last decade [5]. These studies represent a body of knowledge – as a catalogue of existing solutions – on architecting IoT intensive systems. We outline the primary objectives of the proposed research as:

1) Analysing the existing architectural solutions for IoTs and investigating the role of software architecture in the development of IoT-based software.

2) Classifying and comparing the existing solutions and their impacts to identify the trends of research for next generation of IoTs.

The proposed survey-based study mainly focuses on the taxonomical classification of existing research as themes to identify the prominent challenges, their recurring architectural solutions and patterns (as reusable knowledge) knowledge for IoTs.

Streamlining the past, present and futuristic research efforts that are required to develop innovative IoT solutions.

Summary of Results: The results of the study indicate a continuous growth of published research that exploits architectural models to develop IoT based software. Mobile and cloud computing technologies represent the technical backbone to implement the IoTs [19]. The analysis suggest that futuristic research and development depends on the provisioning of architectural principle, patterns, languages, tools and frameworks to effectively and efficiently develop the next generation of IoT systems. We believe that the proposed research and its results (presented as structured tables and illustrative figures) can be beneficial for (i) researchers who would like to conceptualize the state of existing research and understand needs for futuristic solutions, and (ii) practitioners who may be interested in leveraging the academic research and understanding the existing solutions and their application to industrial IoTs [9].

Section 2 provides background of software architecture in the context of IoTs. Section 3 presents research methodology. Section 4 to Section 6 present the results as research taxonomy, architectural solutions, and vision for emerging research on architecting software for IoTs. Section 7 concludes this paper.

II. Background: Software Architecture for IoTs

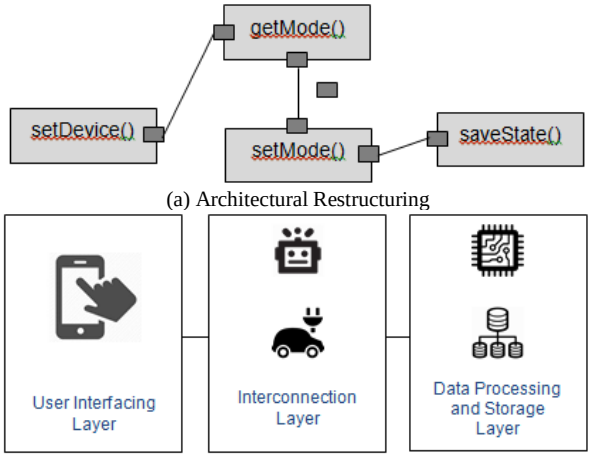
Software architecture for the IoT based systems represents a blue-print or abstraction to develop, operationalise and manage distributed and heterogeneous devices and things that communicate with each other [8, 9]. Specifically, architectural components represent the modules of source code to support the processing and data storage of the devices. Architectural connectors that interconnect the components represent interaction or message passing between the devices [6, 13]. In the following, we present Fig. 1 to show (i) a high-level structural view and (ii) operations of the software architecture for IoT systems. The notations and visualization introduced in this section helps us to discuss architectural aspects of IoT systems throughout the paper.

A. Architectural Strucure for IoT based Software Systems

To discuss architectural structuring for IoTs, Fig. 1 presents a side by side comparative view of (i) devices and their interactions in an IoT system (Fig. 1(a)) and (ii) architectural view of the software that manages and operationalises IoT devices. The view in Fig. 1 is consistent with the presentation of software architecture in [10]. Specifically, Fig. 1(a) highlights the structure of the IoTs and their interconnections at different levels. Specifically, Fig. 1(b) presents the corresponding software architecture (components and connectors) corresponding to the IoT structure in Fig. 1(a). First, in Fig. 1(a) an IoT system is structurally divided into three distinct layers namely, *User Interfacing*, *Interconnection*, and *Data Processing and Storage* layers. Second, different architectural components and their connectors are distributed among different layers to support the IoT systems that are detailed in the next subsection. We conclude that to develop, manage, and operationalise IoT architecture, layered architecture patterns represents a suitable abstraction that can be extended and customized as per the needs of the system [11, 12].

B. Operations of the Software Architecture for IoT Systems

After the discussion about architectural structure, we now present the operations of IoTs that are supported by software architecture. Operational aspects of the IoT systems refer to the functionality performed and tasks completed by the devices (and things) that are part of an IoT system. For example, a robot that is used for home servicing is an IoT device that can interact with other IoT devices such as coffee maker or refrigerator to autonomously perform home automation services [18]. In the context of Fig. 1(a), at the User Interfacing layer the user is able to control and manipulate any IoT devices by means of their computers or portable devices. Based on user control, the IoT devices at the interconnection layer communicate with each other to perform the required tasks. Finally, at the Data Processing and Storage Layer, the data produced or consumed by IoT devices is processed and stored. Fig. 2(b) highlights the required architectural components and their interconnections that support software modules to manage and operationalise IoT system. For example, in Fig. 1(b) the architectural component named *DeviceMode* helps to configure the mode of a device such as *Start*, *Pause*, and *Shutdown*. For example, a typical scenario includes the user at home starting the home service robot (that is controlled though a mobile device) to make a cup of coffee for the user.



(a) Architectural Restructuring

(b) Layered View of the IoTs

Fig. 1. High-Level view of the Software Architecture and Components of IoT Systems.

The discussion in this section, based on the illustrations in Fig. 1 highlight that architectural components, connectors and layers (i.e., layered architecture pattern) can abstract the source code and implementation level complexities to develop, operationalise and maintain IoT-based software systems effectively. In this paper, our focus is to identify, analyse and synthesise state-of-the-art for architecting software for IoT-based systems. By presenting the architectural structure and its operationalisation helps us to discuss the effective role of software architecture and architectural notations for IoT-based systems [13, 16].

III. Research Method

In order to conduct this research, we have used the principle and procedures of the systematic literature reviews and systematic mapping studies that provides guidelines as a systematised method for collecting, analysing and reporting the data [5]. Fig. 2 presents an overview of the research methodology that is divided into three different phases namely (i) Planning the Research Study, (ii) Identifying and Synthesising the Data, (iii) Reporting the Results. In the remainder of this section, we present the research methodology, briefly summarizing each phase of Fig. 2, as detailed below. Additional information about the methodology are presented as a dedicate report in [14].

A. Phase I – Planning the Research Study

The first phase relates to planning the research study before proceeding further that comprises of following two steps.

Step 1. Identify the Needs for the Study: We need to identify and justify the needs for the proposed research study. The rationale, justification, and proposed contributions of this research study have already been detailed earlier (see Section 1). The study aims to analyse and highlight the use and effectiveness of software architecture solutions to design, engineer IoT software and systems.

Step 2. Specify the Research Questions: After defining the scope and outlining the needs, one of the most important steps is to outline the Research Questions (RQs) for the study. The RQs help to objectively assess the data and systematically present the outcomes and results of the proposed research study. Below, we outline three RQs that need to be investigated. Answers to these RQs provide the findings and results of this research study.

RQ-1: What are the existing research areas, their classification, and categorisation that support architecture-centric solutions for IoT-driven systems?

RQ-2: What challenges exist and what solutions are provided to architect software for IoT-based systems?

RQ-3: What the existing and emerging research trends and focus on architecting software for IoT-based systems?

B. Phase II – Collecting the Data for Study

After the planning, the next phase relates to collecting the data that can be analyzed to conduct the study and interpret its results. Specifically with RQs outlined, we now need to identify and synthesis the data to answer these RQs. This phase comprises of 2 steps that include identification of primary studies and collecting data from these studies. Both these steps are detailed below.

Step 1. Identification of Primary Studies: The first step in this phase relates to identification of the primary studies (as published literature). In order to identify the studies, we derive a search strategy as illustrated in Fig. 3. As in Fig. 3, we derived specific search strings to identify a total of 12390 potentially relevant studies to be reviewed. However, based on the screening (analyzing the titles and abstracts of the studies), a total of 7682 studies were short listed. Finally, based on further qualitative analysis a total of 88 studies have been selected for reviewing to support the proposed research. The list of 88 studies selected for review in this research is presented in Appendix A.

Step 2. Collection of Data for Reporting Results: After the studies have been identified (see Fig. 3), the next step involves a systematic and objective collection of the relevant data. To do so, Table I provides a structured format having multiple Data Points (DPs) to precisely capture the relevant data. The DPs have been derives based on the specified RQs. For example, in the context of RQ-1, DP-6 documents data about the challenges for architecting software IoT systems as in Table I. Table I presents a simplified view of structured data collection comprising of a total of 13 DPs.

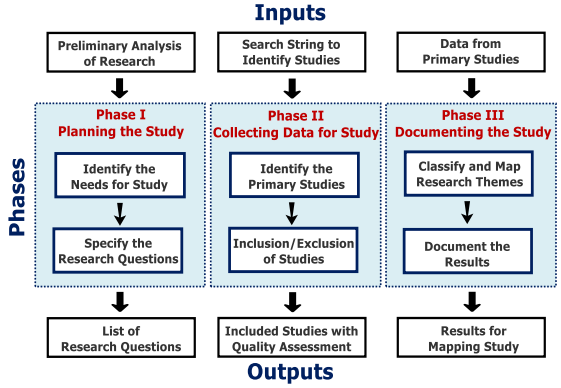


Fig. 2. Overview of the Research Method.

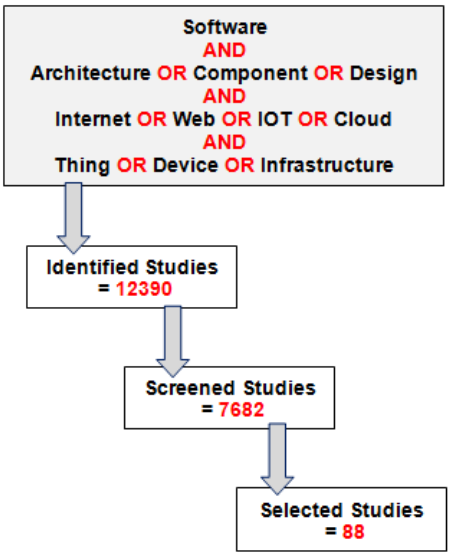


Fig. 3. Overview of the Strategy for Literature Search.

TABLE. I. STRUCTURED TEMPLATE TO DOCUMENT RELEVANT DATA

Data Point (DP)	Description
Generic Information	
DP-1. Study ID	Unique identification of the study
DP-2. Title	Title of the study
DP-3. Authors	List of authors
DP-4. Year of Publication	Year of publication for the study
DP-5. Study Focus	Research focus of the study
Challenges and Solutions	
DP-6. Challenge	Challenges highlighted in the study
DP-7. Proposed Solution	Proposed solution for the challenge
DP-8. Usage of Solution	Application or usage of the proposed solution
Architectural Patterns	
DP-9. Pattern Name	Name of the identified pattern
DP-10. Pattern Usage	Usage or applicability of the pattern
DP-11. Pattern View	Visual representation of the pattern
Existing and Emerging Trend	
DP-12. Existing Trends	Existing trend of research in the study
DP-13. Emerging Trend	Emerging or futuristic trend of research in study

C. Phase III – Documenting the Study to Report the Results

Finally, the last step involves documenting or reporting the results of the study. The results have been reported in dedicated sections (Section 4 to Section 6, answering RQ-1 to RQ-3) in the remainder of this paper. We conclude the discussion about research method by presenting some threats as potential issues that can affect the validity of proposed research.

Threat I – Bias in Study Identification: It relates to the inherent potential bias in the identification of most relevant studies to conduct the research. This means that relevant studies with misleading title or contents could be selected for data collection. Such bias can pose threats to the credibility of the results. In order to avoid this bias, we have tried to define relevant search strings to search and identify the most relevant studies and devised a three step criteria for the identification of the relevant studies, as in Fig. 3.

Threat II – Objective Reporting of the Results: Another threat is about objectivity of reporting the results as part of documenting the findings of the research study. This can relate to potential ambiguity in reporting the results that may lead to wrong conclusions of the research. In order minimise this threat, we have used a structured format (Table I) with defined data points to capture the relevant data. These data points are derives based on the RQs and help us to document the relevant data for each RQ individually and objectively.

The results of this research study – by answering RQ-1 to RQ-3 – are presented from Section IV to Section VI.

IV. A TAXONOMY OF SOFTWARE ARCHITECTURES FOR IOTS

We present the results for RQ-1 that focuses on outlining taxonomy and discuss the classification and categorisation of various architectural solutions for IoT software. We answer RQ-1 based on research taxonomy as illustrated in Fig. 4. Table I extends the taxonomy in Fig. 4 by presenting structured themes and sub-themes. The research taxonomy (in Fig. 4, Table I) is created by means of applying the thematic analysis and ACM classification scheme as in [17]. The taxonomy is defined as naming and hierarchical organization of existing topics and their sub-topics to outline and investigate the contributions of existing research. Both Fig. 4 and Table II support each other for a comprehensive presentation of the research taxonomy. Fig. 4 provides a blue-print as a generic view of various research themes of software architecture for IoTs.

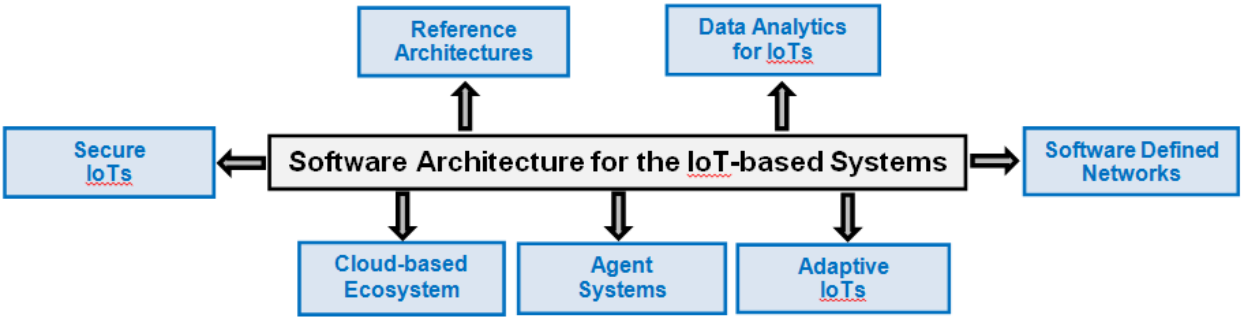


Fig. 4. A Taxonomy of Research Areas on Architecting Software for IoTs.

TABLE. II. RESEARCH AREAS, RESEARCH THEMES, NUMBER OF STUDIES AND AVAILABLE EVIDENCE

Research Area and Themes (as per Fig. 4 and Fig. 5)	**Number of Studies**	**Available Evidence (Published Studies as in Appendix A)**
1. Cloud-based Ecosystems		
2. 1.A	3	[RS-29, RS-47, RS-53]
3. 1.B	**7**	[RS-1, RS-64, RS-5, RS-9, S40, RS-42, RS-44]
4. 1.C	**5**	[RS-8, RS-18, RS-32, RS-46, RS-54]
5. 1.D	**6**	[RS-15, RS-17, RS-19, RS-34, RS-70, RS-75]
6. Software Defined Networks		
7. 2.A	**2**	[RS-12, RS-86]
8. 2.B	**3**	[RS-4, RS-23, RS-45]
9. 2.C	**2**	[RS-81, RS-25]
10. 2.D	**3**	[RS-33, RS-84, RS-88]
11. Data Analytics for IoTs		
12. 3.A	**3**	[RS-43, RS-51, RS-85]
13. 3.B	**2**	[RS-77, RS-80]
14. 3.C	**2**	[RS-66, RS-71]
15. Reference Architectures		
16. 4.A	**2**	[RS-16, RS-74]
17. 4.B	**8**	[RS-7, RS-26, RS-27, RS-28, RS-30, RS-41, RS-76, RS-87]
18. 4.C	**7**	[RS-31, RS-60, RS-63, RS-72, RS-11, RS-39, RS-73]
19. 4.D	**4**	[RS-22, RS-48, RS-62, RS-82]
20. Adaptive IoTs		
21. 5.A	**2**	[RS-38, RS-56]
22. 5.B	**5**	[RS-3, RS-13, RS-49, RS-50, RS-52]
23. 5.C	**3**	[RS-58, RS-69, RS-79]
24. 5.D	**9**	[RS-6, RS-21, RS-35, RS-36, RS-55, RS-57, RS-67, RS-68, RS-83]
25. Agents Systems		
26. 6.A	**3**	RS-10, RS-20, RS-65]
27. Secure IoTs		
28. 7.A	**2**	[RS-2, RS-78]
29. 7.B	**1**	[RS-61]
30. 7.C	**4**	[RS-14, RS-24, RS-37, RS-59]

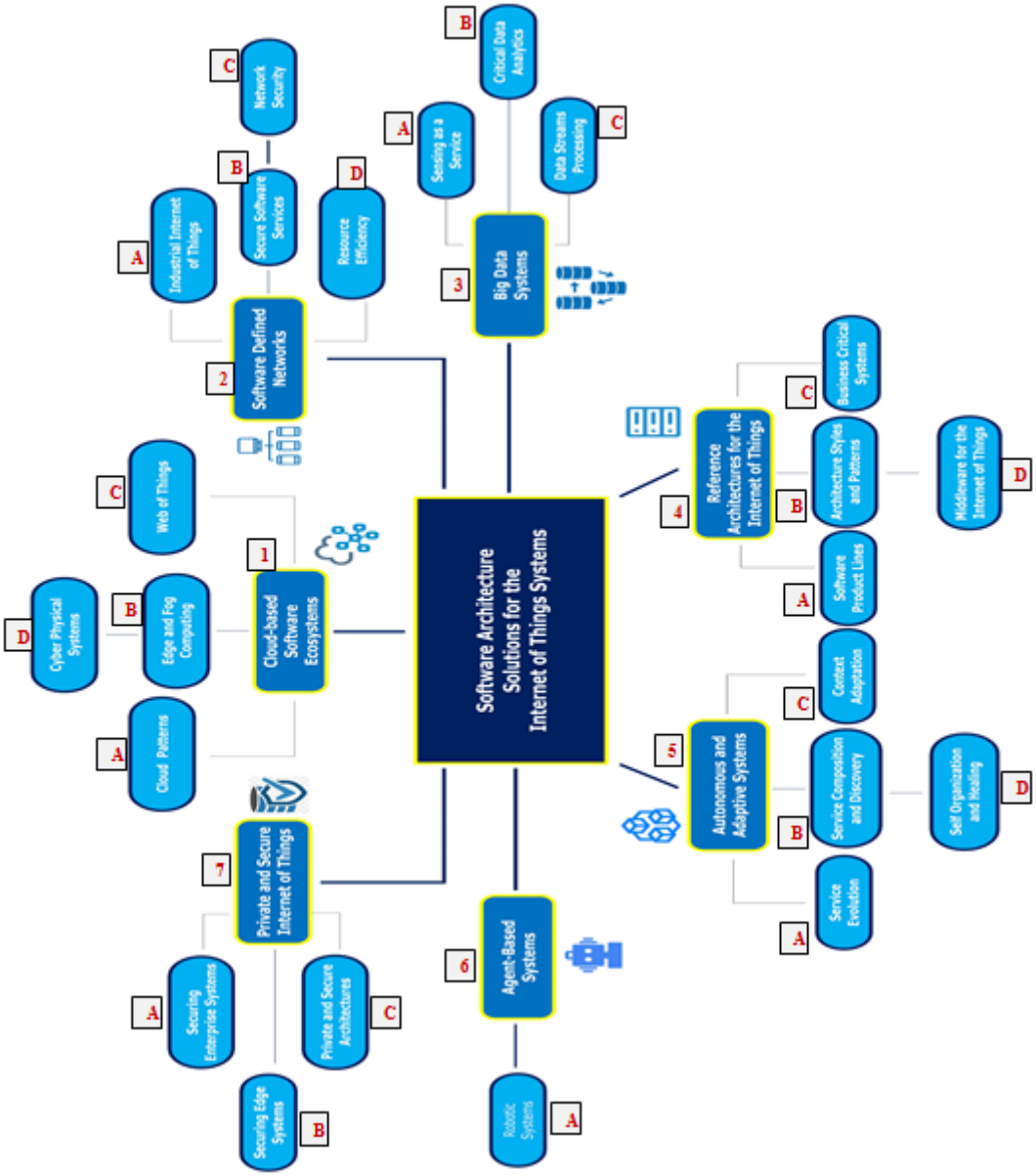


Fig. 5. Thematic Classification of Research Areas and their Research Themes.

In comparison, Table II provides structured information about the high-level research themes, sub-themes along with the references to the published studies as available evidence for each research theme and sub-theme. In Table II, we have two level organisation of the existing research named as (i) Area of Research and (ii) Research Themes. For example, as in Table I, the research study [RS-6][1] falls under the area Adaptive IoTs (i.e., Area of Research), specifically [RS-6] supports software architecture for Self-healing IoTs (i.e., Research Theme). In the remainder of these sections, based on Fig. 3 and Table II, we discuss the existing areas of research and research themes that provides us the foundation to discuss challenges and proposed architecture-centric solutions along with the emerging research discussed later in the paper.

A. Area of Research overviews a broader focus of the existing research and its contribution(s) in a defined scope. Fig. 4 shows that based on our thematic analysis process, we have discovered a seven areas of research (along with their sub-areas/research classification) that highlights the prominent challenges for IoTs and frequently used software architecture solutions to address the challenges for IoT systems.

B. Research Classification represents an extension and specific contributions of existing research in Table II under the generic area of research that are derived in Fig. 4. As an example, in Table II, the research studies [RS-6, RS-21, RS-35] that support software architecture for IoTs are under the research area of Adaptive IoTs. The research area of Adaptive IoTs support specific research themes such as of Self-healing IoT Systems. Our analyses have discovered 25 research themes classified under 07 areas of research to support

[1] The reference [RS-n] (RS: Research Study and n is a number from 1 to 88) reflects referencing to research studies for the review as in Appendix.

software architecture for IoTs as detailed below. In **Table II**, the research area Cloud-based Ecosystem having 04 research themes (i) Web of Devices, (ii) Patterns for IoT Cloud, (iii) Cyber Physical Systems, and (iv) Edge Commuting.

V. Software Architecture-Centric Solutions for IoT Systems

We present the results for RQ-2 that focuses on presenting architectural solution for challenges relating to IoT systems. We have used the taxonomy of existing research (Fig. 4, RQ-1) to present the architectural solutions presented in Table III. Table III helps us to objectively present the challenges and their corresponding architecture solutions for IoTs [21]. Table III focuses on presenting (a) Challenges for IoT Systems, (b) Solutions to Challenges for Architecting IoT Systems, (c) Research Themes that support Architectural Solutions, (d) Generic View of the Software Architecture. To collect the data mentioned above, we used Table II (see Section 3) to capture the required information (Challenges and Solution (DP-6 to DP-8). We exemplify one of the challenges and solutions as detailed in Table III.

1) Challenges: How to engineer and develop a heterogeneous eco-system of cloud computing systems to support as a service model for infrastructure/platform/ software?

2) Architectural solutions for IoTs: The architectural solution provides a mediator that helps a seamless integration between various heterogeneous cloud providers to support an eco-system of clouds. However, the communication between the clouds is maintained through a mediator that involves communication latency in the ecosystem.

3) Research themes: The research themes include (a) Edge Computing [RS-1, RS-5, RS-64,], (b) Web of Devices [RS-8, RS-18, RS-32], (c) Cyber Physical System [RS-15, RS-17, RS-19], (d) Patterns for IoT Cloud [RS-29, RS-47, RS-53]

4) Architectural view: It is presented as '*Software Architecture for Cloud Ecosystem*' in Fig. 6(a).

VI. Emerging Research on Architecture-Based Solutions for IoT Software

The answer to RQ-3 focuses on streamlining the emerging trends of research as potential areas of emerging research for IoT systems and software. We summarise the most relevant emerging trends that could be further explored and researched to devise state-of-the-art solutions for architecting IoT software. Based on the published research in the last 03 years (2017 to 2019), we have identified the following research themes as emerging topics with their potential as futuristic challenges and innovative solutions to engineer IoT-intensive systems.

Trend I: Architecture-centric Languages and Reusable Patterns.

In the architectural context, architectural languages and reusable patterns they support provide the necessary structure, semantics, and reusable knowledge for architecture-based modeling, development and management of software systems. Our analysis suggests that in recent years, architectural languages are being investigated as structured mechanism to exploit reusable specification and knowledge for architecture-centric development of the IoT systems. The primary challenge with architectural languages and patterns is that they are derived from empirical knowledge that needs to be systematically discovered, structurally documented, and frequently reused for system wide usage. As part of future solution for architecting IoTs, there is a growing need for research and development to exploit the existing foundations to develop solutions such as meta-models, ontologies and pattern catalogues for architecting IoT software. Such initiatives can support innovative solutions to model, develop, evolve, operate, and manage IoT-driven systems in an effective and efficient manner [22, 23, 25].

Trend II: Context-aware IoT Architectures

Context-aware computing support adaptive systems can evolve the operations and functionality of a system under changing requirements. Mobile computing is fast becoming an integrated part of the IoT systems. Mobile systems that support portability are regarded as context-aware computing nodes that can sense contextual information such as current location, time etc. to adapt a system as per contextual requirements. By means of integrating mobile computing with IoTs, we could exploit mobile-driven IoTs that are portable and context-sensitive. Specifically, context-aware IoTs can gather and process contextual information (such as geo-location, temperatures, time of the day) to adapt IoT systems in the field of robotics. The applications of context-aware IoTs can range from agent-based systems for smart city systems including but not limited to smart traffic management, smart healthcare, recommender systems and home service autonomous and adaptive agents [24]. However, in the context of mobile-driven context-aware systems, security and privacy of user data and device information are of prime importance [20].

Trend III: Reference Architectures for Industrial IoTs

In recent years, IoT systems are being increasingly adopted in industrial context ranging from industrial automation to manufacturing and supply chain. Reference architectures have proven to be useful to provide a blue-print and high-level view for the system under consideration [9, 10]. For example, the reference architecture named RAMI 4.0 supports industrial automation based on IoTs. Future research and development requires more diverse reference architectures and their standardization that could be used across industries such as manufacturing, transportation and logistics [15]. For such systems, the role of reference architectures and models become fundamental to design, develop, and manage complex IoT systems.

TABLE. III. A MAPPING EXISTING CHALLENGES AND CORRESPONDING SOLUTIONS FOR ARCHITECTING IOTS

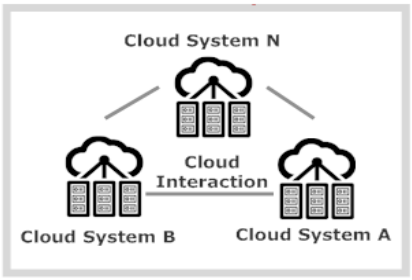
<table>
<tr><th>Challenges for IoT-based Software Systems</th><th>Solutions for Architecting IoT-based Software Systems</th></tr>
<tr><td colspan="2">Challenge A: Cloud-based Ecosystem</td></tr>
<tr><td>Primary Challenge: How to support a (heterogeneous) eco-system of cloud-based software that supports (infrastructure/platform/software) as a service model offered by various cloud providers to third party cloud service subscribers?</td><td>Proposed Solution: The IoT based solution supports the communication among multi-clouds - the interconnected things that produce ad consume data - using a central Cloud Hub. The Cloud Hub facilitates the interaction among the different clouds to collaborate and connect as part of the ecosystem.</td></tr>
<tr><td>Research Themes with Published Evidences</td><td>Generic View of Software Architecture</td></tr>
<tr><td>1-a. Edge Computing Systems exploits architectural configurations to push the computation and storage of devices to the edge of the network to improve performance of the IoTs.
Available Evidence(s): [S1, S64, S5, S9, S40, S42, S44]
1-b. Web of Things (WoT) support potently connected web of devices and things to support universally accessible IoTs
Available Evidence(s): [S8, S18, S32, S46, S54]
1-c. Cyber Physical Systems represent heterogeneous and massively distributed systems to support IoTs for cyber physical systems.
Available Evidence(s): [S15, S17, S19, S34, S70, S75]
1-d. Cloud Computing Patterns represent generic and reusable knowledge and practices that supports reuse-driven development, maintenance and evolution of software architectures for IoT-based cloud-ecosystems.
Available Evidence(s): [S29, S47, S53]</td><td>The architectural view presents a generic view in terms of highlighting the Cloud Hub as a mediator that helps various cloud providers to bind with each other using the mediator as illustrated in Figure 6 a.
 

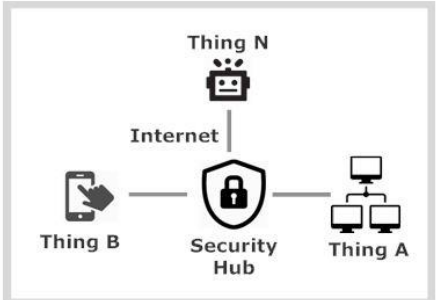
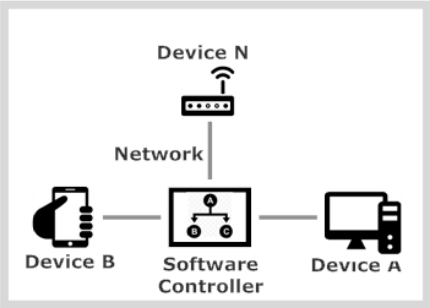
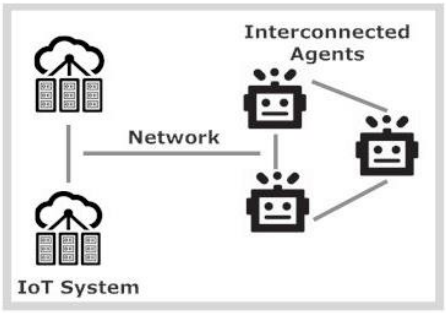
Figure. 6 a. Overview of Generic Software Architecture for Cloud Ecosystem.</td></tr>
<tr><td colspan="2">Challenge B: Secure Internet of Things</td></tr>
<tr><td>Primary Challenge: How to enable the security and privacy of data that is produced, consumed or shared by the interconnected things (i.e., heterogeneous devices) in the IoT systems?</td><td>Proposed Solution: The solution introduces a Security Hub that exploits the mediator architectural pattern to mediate the communication between the connected devices/things and ensure the security of the IoT system.</td></tr>
<tr><td>Research Themes with Published Evidences</td><td>Generic View of Software Architecture</td></tr>
<tr><td>2-a. Security of Edge Computing supports secure communication, computation and storage of the nodes deployed as edges in IoT based architectural configurations.
Available Evidence(s): [S61]
2-b. Secure and Private Enterprise Software supports the security of computation infrastructures and privacy of data in industry scale enterprise software based on IoTs.
Available Evidence(s): [S2, S78]
2-c. Reference Architecture for Secure IoT Systems provides a reference architecture and a framework as guidelines and enabling methods to design and develop secures IoTs.
Available Evidence(s): [S14, S24, S37, S59]</td><td>The architectural view presents the mediator, i.e., Security Hub that monitors and manages the data communication between the devices that may introduce the communication latency as illustrated in Figure. 6 b.
 

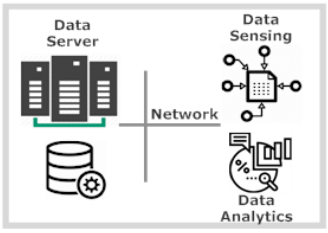
Figure 6.b. Overview of the Software Architecture for Secure IoTs.</td></tr>
</table>

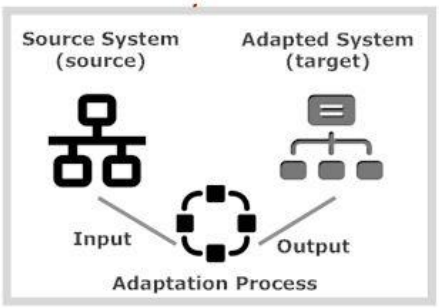
(CONTD.)

Challenge C: Software Defined Networks for IoTs	
Primary Challenge: How to enable software-driven (logic-based) dynamic interconnection and coordination of the things in IoT based systems?	*Proposed Solution* The proposed solutions integrate a software controller that monitors and manages the necessary logic for runtime manipulation of the interconnections in IoT systems.
Research Themes with Published Evidences	**Generic View of Software Architecture**
3-a. Software Services in IoTs supports the runtime coordination and security of software as a service in IoT based systems. **Available Evidence(s):** [S4, S23, S45] *3-b. Software Defined Security* enables software-driven monitoring and management of security for the IoT systems. **Available Evidence(s):** [S81, S25] *3-c. Resource Efficient IoT* enables software systems to support the computation, storage, energy, and communication efficiency for IoT networks. **Available Evidence(s):** [S33, S84, S88] *3-d. Industrial IoTs* is supported with dynamically configured software services that can manipulate and automate the devices in industrial IoTs. **Available Evidence(s):** [S12, S86]	The architectural view presents a Software Controller that acts as an orchestrator for runtime management and configuration of the devices to support software and logic-driven networking of the IoTs as illustrated in Figure. 6 c.  Figure. 6 c. Overview of Generic Software Architecture for Software Defined Networking of IoTs

Challenge D: Software Agents for IoTs	
Primary Challenge: How to exploit the devices and things in the IoT systems to engineer and develop autonomous and adaptive agents that are interconnected and web accessible?	*Proposed Solution:* The proposed solutions consist of two parts, i.e., IoT System and the Interconnected Software Agents. The agents (i.e., autonomous, adaptive and distributed components) can be connected to the IoT systems to perform their tasks.
Research Themes with Published Evidences	**Generic View of Software Architecture**
4-a. Software Agents can support a collaborative network of agents that actively coordinate to complete the assigned tasks in an IoT system. **Available Evidence(s): [S10, S20, S65]**	The architectural view presents network-based coordination between the IoT system and software agents as illustrated in Figure 6 d.  Figure. 6 d. Overview of Generic Software Architecture for Software Agents of IoTs.

(CONTD.)

Challenge E: Supporting IoT based Big Data Systems	
Primary Challenge: How to exploit the interconnected and distributed devices in an IoT system to sense (collect real-world) data and analyze it (process in real-time) for decision support systems?	*Proposed Solution:* The proposed solution exploits 'on the edge' deployed devices that acts as context-aware data sensors and communicate it with the backend server. The backend cloud-based servers can store and process the data with back and forth communication between front-end devices and back-end servers.
Research Themes with Published Evidences	**Generic View of Software Architecture**
5-a. Sensing as a Service: support loosely coupled and autonomous (web-) services that exploit the devices and sensors to collect the data. **Available Evidence(s):** [S43, S51, S85]	The architectural view presents the front-end (on the edge) IoT devices that sense data and communicates it with the backend server that process the data as illustrated in Figure. 6 e.
5-b. Data Stream Processing: is managed by IoT sensors that can be deployed at different network locations to collect and process live streams of data as part of real-time data analytics. **Available Evidence(s):** [S66, S71]	
5-c. Critical Data Analytics: is managed by IoT devices that are deployed 'on the edge' to sense and process critical data that includes health, context and urban analytics. **Available Evidence(s):** [S77, S80]	 Figure. 6 e. Overview of Generic Software Architecture for IoT based Big Data Systems.

Challenge F: Adaptive IoTs	
Primary Challenges: How to support architectural models that enable autonomous and adaptive IoTs that dynamically adapts the structure and behavior of the IoT systems at runtime?	*Proposed Solution:* The solution supports an adaptation process based on IBM'S framework for autonomic computing that takes a (source/existing) IoT systems and then adjusts its structure and behavior to enable an adapted (target/new) IoT system.
Research Themes with Published Evidences	**Generic View of Software Architecture**
6-a. Service Composition: supports dynamic discovery and composition of the IoT software services to enable dynamic systems as per the contextual requirements. **Available Evidence(s):** [S3, S13, S49, S50, S52]	The architecture presents an adaptation process that contains the adaptation context and logic to dynamically reconfigure/adapts a source system to a target system at runtime in Figure. 6 f.
6-b. Self Healing: enables IoT software that is fault-tolerant and it can self-organize to continue its operations under continuously varying requirements and frequent maintenance and evolution. **Available Evidence(s):** [S6, S21, S35, S36, S55, S57, S67, S68, S83]	
6-c. Service Evolution: is supported with dynamically reconfigured services in the IoTs systems that evolve over-time as per changes in the business and technical requirements and operational environments. **Available Evidence(s):** [S38, S56]	 Figure. 6 f. Overview of Generic Software Architecture for Adaptive IoTs.

(CONTD.)

<table>
<tr><th colspan="2">Challenge G: Reference Architectures for IoTs</th></tr>
<tr><td><u>Primary Challenge:</u> How to establish guidelines and frameworks that provides the templates and blue-print to design and develop IoT systems for real world applications?</td><td><u>Proposed Solution:</u> The solutions provide reference architectures as generic and high-level (abstract) solutions that can be instantiated with specialized architectures as (concrete) solutions for IoTs.</td></tr>
<tr><th>Research Themes with Published Evidences</th><th>Generic View of Software Architecture</th></tr>
<tr><td>7-a. <u>Enterprise and Business Critical Systems:</u> are developed based on reference architectures and process automation that support enterprise systems and production/assembly lines to enable industrial IoTs.

Available Evidence(s): [S31, S60, S63, S72]</td><td rowspan="6">The architectural views present reference architectures as a reference framework that serves as a template and a collection of documented guidelines to architect and design IoT systems as in Figure 6. g.

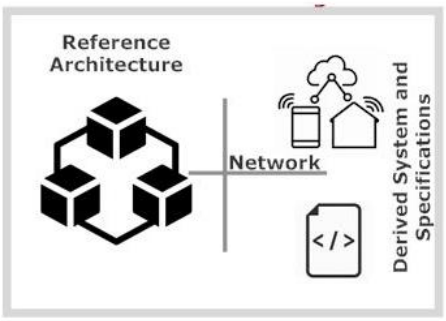
 

Figure. 6 g. Overview of Generic Reference Architecture for IoTs</td></tr>
<tr><td>7-b. <u>IoT for Ecommerce Solutions:</u> are supported by business process automation and reference architectures that automate those business processes to support the development and operations of IoT based e-commerce systems.

Available Evidence(s): [S11, S39, S73]</td></tr>
<tr><td>7-c. <u>Architectural Styles and Patterns for IoTs</u>: represent generic knowledge and best practices to model, develop, and evolve IoT architectures with enhanced reusability and efficiency.

Available Evidence(s): [S7, S26, S27,S 28, S30, S41, S76, S87]</td></tr>
<tr><td>7-d. <u>IoT-based Software Product Lines</u>: are supported by reference architectures that represent a generic solution to derive specialized product lines that enable Industrial IoT systems.

Available Evidence(s): [S16, S74]</td></tr>
<tr><td>7-e. <u>Smart City Architecture:</u> are enabled by interconnected IoT devices that act as backbones for smart and autonomous infrastructures for digitized urban services.

Available Evidence(s): [S82]</td></tr>
<tr><td>7-f. <u>IoT Middleware:</u> provides a technological layer that abstracts the hardware and software complexities to support IoT devices (hardware) and their corresponding (software) applications to support IoT systems.

Available Evidence(s): [S22, S48, S62]</td></tr>
</table>

VII. Conclusions of the Study

The research and development on architecting software-driven IoTs have progressed and matured for more than a decade to address challenges and proposed architectural solutions for IoTs. In this research study, we have used EBSE method to systematically identify the state of existing research and areas of future interests on software architectures in developing IoT-driven software systems. The result of our study highlights that existing research has focused on research areas such as cloud ecosystems, adaptive IoTs, secure IoTs, software defined networks, reference architectural models, agent systems and data analytics for IoTs. The trends suggest that emerging and future research needs to focus on architectural languages and reuse-based patterns, context-aware IoTs and reference architectures for IoTs in the context of industrial systems. The results of study can be beneficial for:

Researchers interesting in assessing the state of existing research and identify the areas of future research. By presenting research taxonomy of themes and a view of architectural solutions, the proposed study can support new research ideas and development. The study could help to understand: (i) challenges and architectural solution, along with (ii) emerging research to design new generation of architectural solutions for IoT software.

Practitioners could be interested in knowing the architectural artifacts in the development of industrial solutions for IoTs. Specifically, the discussion about reference models and architectures provide a foundation for solutions that could be applied to industrial IoTs.

Acknowledgment

This research is supported by the Deanship of Scientific Research at the University of Ha'il, Saudi Arabia under the project number '160595' (Project Code: 160595)

REFERENCES

[1] Al-Fuqaha , M. Guizani , M. Mohammadi ; M. Aledhari ; M. Ayyash. "Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications", IEEE Communications Surveys & Tutorials, vol. 17, no. 4, pp: 2347 – 2376, 2015.

[2] Andrea Zanella, Nicola Bui , Angelo Castellani, Lorenzo, Vangelista, Michele Zorzi. "Internet of Things for Smart Cities", IEEE Internet of Things Journal, vol. 1 , no. 1, pp. 22 – 32, 2014.

[3] J. O. Hamblen, G.M.E van Bekkum. "An Embedded Systems Laboratory to Support Rapid Prototyping of Robotics and the Internet of Things", IEEE Transactions on Education, vol. 56, no.1, pp. 121-128, 2013.

[4] D. Evans. "The Internet of Things How the Next Evolution of the Internet Is Changing Everything", CISCO White Paper, San Jose, USA, , 2011.13/11/2018/

[5] K. Petersen, R. Feldt, S. Mujtaba, and M. Mattsson. "Systematic Mapping Studies in Software Engineering", 12th International Conference on Evaluation and Assessment in Software Engineering, vol. 8, pp. 68–77, 2008.

[6] R. Capilla, A. Jansen, A. Tang, P. Avgeriou, M. A. Babar. "10 Years of Software Architecture Knowledge Management: Practice and Future", Journal of Systems and Software, vol 116, pp. 191–205, 2016.

[7] J. Wan, S. Tang, Z. Shu, D. Li, S. Wang, M. Imran, and A. V. Vasilakos. "Software-defined Industrial Internet of Things in the Context of Industry 4.0", IEEE Sensors Journal, vol. 16, no. 20, pp. 7373–7380, 2016.

[8] P. Fremantle, "A Reference Architecture for the Internet of Things", WSO2, White Paper, [Online]. Available: http://wso2.com, 2014

[9] E. Cavalcante, M.P. Alves, T. Batista, F.C. Delicato, P.F. Pires. "An Analysis of Reference Architectures for the Internet of Things", 1st International Workshop on Exploring Component based Techniques for Constructing Reference Architectures, 2015.

[10] M. Weyrich and C. Ebert. Reference Architectures for the Internet of Things. In IEEE Software, vol. 33, no. 1, pp. 112–116, 2016.

[11] G. Campeanu. "A Mapping Study on Microservice Architectures of Internet of Things and Cloud Computing Solutions", 7th Mediterranean Conference on Embedded Computing (MECO). IEEE, 2018.

[12] M. Henry, and M. T. Moghaddam. "IoT Architectural Styles". European Conference on Software Architecture. Springer, 2018.

[13] E. Croes. "Software Architectural Styles in the Internet of Things", MS Thesis, Radboud University Nijmegen, August 2015.

[14] A. Alreshidi, A. Ahmad. "Protocol for Systematic Mapping Study on Software Architecture for the Internet of Things", Technical Report, College of Computer Science and Engineering, University of Ha'il, pp. 1 – 13, 2019. https://ahmadaakash.wixsite.com/aakash/sa4iot-ressearchprotocol

[15] Internet of Things Related Standards. IEEE Standards Association [Online:] https://standards.ieee.org/initiatives/iot/stds.html, Accessed 02/02/2019

[16] F. Ciccozzi, R. Spalazzese. "MDE4IoT: Supporting the Internet of Things with Model-Driven Engineering", International Symposium on Intelligent and Distributed Computing. Springer, 2016.

[17] R. E. Boyatzis. "Transforming Qualitative Information: Thematic Analysis and Code Development". Sage, 1998.

[18] A. Ahmad, M. A. Babar. Software Architectures for Robotic Systems: A Systematic Mapping Study. In the Journal of Systems and Software, vol. 122, pp: 16 – 39, 2016.

[19] I. Alseadon, A. Ahmad, A. Alkhalil, K. Sultan. Migration of Existing Software Systems to Mobile Computing Platforms: A Systematic Mapping Study. In Frontiers of Computer Science, Springer, 2019. https://doi.org/10.1007/s11704-019-8166-5

[20] M. Sajjad, A. A. Abbasi, A. Malik, A. B. Altamimi, and I. M. Alseadoon. Classification and Mapping of Adaptive Security for Mobile Computing. In IEEE Transactions on Emerging Topics in Computing, IEEE, 2018. 10.1109/TETC.2018.2791459

[21] A. Alreshidi, A. Ahmad. Architecting Software for the Internet of Thing Based Systems. In Future Internet, MDPI. Future Internet 2019, vol. 11, no. 7), 153; https://doi.org/10.3390/fi11070153

[22] A. Ahmad, A. W. Malik, A. Alreshidi, W. Khan, and M. Sajjad. Adaptive Security for Self-Protection of Mobile Computing Devices. In Mobile Networks and Applications (2019), Springer, 2019.

[23] A. Ahmad and M. A. Babar, "A framework for architecture-driven migration of legacy systems to cloud-enabled software," in Proceedings of the WICSA 2014 Companion Volume. ACM, 2014.

[24] A. Khan, A. Ahmad, A. Rahman, A. Alkhalil . A Framework for the A Mobile Cloud Framework for Context-Aware and Portable Recommender System for Smart Markets. In Smart Infrastructure and Applications. EAI/Springer Innovations in Communication and Computing. Springer, 2019.

[25] A. Ahmad, I. Alseadoon, A. Alkhalil, K. Sultan. Evolution of Legacy Software Towards Context-aware and Portable Mobile Computing Applications. In Proceedings of the International Conference on Software Engineering Research and Practice (SERP), pp. 3-9, 2019.

APPENDIX A. LIST OF STUDIES REVIEWED FOR DATA COLLECTION

Study ID	Title of the Study	Publication Type	Publication Year
[RS-1]	Cloud Ecosystems Support for Internet of Things and DevOps Using Patterns	Conference	2016
[RS-2]	Internet of Things (IoT): Security challenges, business opportunities & reference architecture for E-commerce	Conference	2015
[RS-3]	A Taxonomy of IoT Client Architectures	Journal	2018
[RS-4]	An Open Internet of Things System Architecture based on Software-defined Device	Journal	2018
[RS-5]	Responsive Data Architecture for the Internet of Things	Journal	2016
[RS-6]	Architecting Emergent Configurations in the Internet of Things	Conference	2017
[RS-7]	Software architecture pattern selection model for Internet of Things based systems	Journal	2018
[RS-8]	A Software Architecture Enabling the Web of Things	Journal	2015
[RS-9]	Application of cloud computing in the emergency scheduling architecture of the Internet of Things	Conference	2015
[RS-10]	Modeling landing control system of carrier-based aircraft on Internet of Things	Conference	2014
[RS-11]	Digital Enterprise Architecture - Transformation for the Internet of Things	Conference	2015
[RS-12]	Adaptive Transmission Optimization in SDN-Based Industrial Internet of Things With Edge Computing	Journal	2018
[RS-13]	A Scalable and Self-Configuring Architecture for Service Discovery in the Internet of Things	Journal	2014
[RS-14]	A Novel Secure Architecture for the Internet of Things	Conference	2011
[RS-15]	Designing a Cyber-Physical Cloud Computing Architecture	Journal	2015
[RS-16]	Building a Framework for Internet of Things and Cloud Computing	Conference	2014
[RS-17]	Software Abstractions for Component Interaction in the Internet of Things	Journal	2016
[RS-18]	From the Internet of Things to the web of things — enabling by sensing as-a service	Conference	2016
[RS-19]	A Component Architecture for the Internet of Things	Journal	2018
[RS-20]	Infrastructure Management Support in a Multi-agent Architecture for Internet of Things	Symposium	2014
[RS-21]	Software architecture of self-organizing systems-of-systems for the Internet-of-Things with SosADL	Conference	2017
[RS-22]	A Reference Model for Internet of Things Middleware	Journal	2018
[RS-23]	A SDN-based architecture for horizontal Internet of Things services	Conference	2016
[RS-24]	A Multiple Layer Sercurity Architecture for Internet of Things into MVC Design	Conference	2018
[RS-25]	An hybrid and proactive architecture based on SDN for Internet of Things	Conference	2017
[RS-26]	Design and Implementation of a Hardware Versatile Publish-Subscribe Architecture for the Internet of Things	Journal	2018
[RS-27]	T-REST: An Open-Enabled Architectural Style for the Internet of Things	Journal	2018
[RS-28]	A Layered Protocol Architecture for Scalable Innovation and Identification of Network Economic Synergies in the Internet of Things	Conference	2016
[RS-29]	IoT gateway for smart metering in electrical power systems - software architecture	Conference	2017
[RS-30]	The Internet of Things (IoT): A Study of Architectural Elements	Conference	2017
[RS-31]	Research and Application of Manufacturing Recourse Management in Manufacturing Enterprise Based on Internet of Things	Conference	2017
[RS-32]	An Avatar Architecture for the Web of Things	Journal	2015
[RS-33]	Graph Based Clustering for Two-Tier Architecture in Internet of Things	Conference	2016
[RS-34]	A novel clock synchronization architecture for IoT access system	Conference	2016
[RS-35]	Self-Organised Middleware Architecture for the Internet-of-Things	Conference	2013
[RS-36]	A Commitment-Based Approach to Realize Emergent Configurations in the Internet of Things	Workshop	2017
[RS-37]	A Reference Architecture for Improving Security and Privacy in Internet of Things Applications	Conference	2014
[RS-38]	Complex Event Recognition Notification Methodology for Uncertain IoT Systems Based on Micro-Service Architecture	Conference	2018
[RS-39]	Research on intelligent supermarket architecture based on the Internet of Things technology	Symposium	2014
[RS-40]	CEFIoT: A fault-tolerant IoT architecture for edge and cloud	Forum	2018
[RS-41]	Microservices approach for the internet of things	Conference	2016
[RS-42]	Moving Application Logic from the Firmware to the Cloud: Towards the Thin Server Architecture for the Internet of Things	Conference	2012
[RS-43]	An Architecture to Support the Collection of Big Data in the Internet of Things	Conference	2014
[RS-44]	Edge computing enabling the Internet of Things	Forum	2015
[RS-45]	A distributed software-defined multi-agent architecture for unifying IoT applications	Conference	2017
[RS-46]	A resource oriented architecture for the Web of Things	Conference	2012

[RS-47]	IoT Mashup as a Service: Cloud-Based Mashup Service for the Internet of Things	Conference	2013
[RS-48]	A Reference Architecture for federating IoT infrastructures supporting semantic interoperability	Conference	2017
[RS-49]	Automatic Generation of Distributed Run-Time Infrastructure for Internet of Things	Workshop	2017
[RS-50]	Event-Aware Framework for Dynamic Services Discovery and Selection in the Context of Ambient Intelligence and Internet of Things	Journal	2016
[RS-51]	A Holistic Architecture for the Internet of Things, Sensing Services and Big Data	Conference	2013
[RS-52]	A Decentralized Locality-Preserving Context-Aware Service Discovery Framework for Internet of Things	Conference	2015
[RS-53]	Architecture and measured characteristics of a cloud based internet of things	Conference	2012
[RS-54]	CoTWare: A Cloud of Things Middleware	Workshop	2017
[RS-55]	Self-Healing for Distributed Workflows in the Internet of Things	Workshop	2017
[RS-56]	A Notification Management Architecture for Service Co-evolution in the Internet of Things	Symposium	2016
[RS-57]	A management architectural pattern for adaptation system in Internet of Things	Conference	2016
[RS-58]	A message broker based architecture for context aware IoT application development	Conference	2017
[RS-59]	Thingtegrity: A Scalable Trusted Computing Architecture for the Internet of Things	Conference	2016
[RS-60]	A Reference Separation Architecture for Mixed-Criticality Medical and IoT Devices	Conference	2017
[RS-61]	An Architectural Mechanism for Resilient IoT Services	Workshop	2017
[RS-62]	A policy-based coordination architecture for distributed complex event processing in the internet of things: doctoral symposium	Conference	2016
[RS-63]	The design and development of an intelligent tutoring system as a part of the architecture of internet of things (IoT)	Conference	2017
[RS-64]	A new security middleware architecture based on fog computing and cloud to support IoT constrained devices	Conference	2017
[RS-65]	Towards a Reference Architecture for Swarm Intelligence-Based Internet of Things	Conference	2017
[RS-66]	A Graph-Based Cloud Architecture for Big Stream Real-Time Applications in the Internet of Things	Conference	2014
[RS-67]	Applying Architecture-Based Adaptation to Automate the Management of Internet-of-Things	Conference	2018
[RS-68]	Formally Describing Self-organizing Architectures for Systems-of-Systems on the Internet-of-Things	Conference	2018
[RS-69]	A Framework of Adaptive Interaction Support in Cloud-Based Internet of Things (IoT) Environment	Conference	2014
[RS-70]	An Architecture for Interoperable IoT Ecosystems	Workshop	2016
[RS-71]	An Open-Source Cloud Architecture for Big Stream IoT Applications	Conference	2015
[RS-72]	An Integrated Architecture for IoT-Aware Business Process Execution	Conference	2018
[RS-73]	Integrating Traditional Stores and e-Commerce into a Multi-tiered Recommender System Architecture Supported by IoT	Conference	2017
[RS-74]	Towards Defining Families of Systems in IoT: Logical Architectures with Variation Points	Summit	2015
[RS-75]	Architecture and Scheduling Method of Cloud Video Surveillance System Based on IoT	Conference	2015
[RS-76]	The Internet of Things: Insights into the building blocks, component interactions, and architecture layers	Conference	2018
[RS-77]	An energy-efficient internet of things (IoT) architecture for preventive conservation of cultural heritage	Journal	2018
[RS-78]	SecureSense: End-to-end secure communication architecture for the cloud-connected Internet of Things	Journal	2017
[RS-79]	COLLECT: COLLaborativE ConText-aware service oriented architecture for intelligent decision-making in the Internet of Things	Journal	2017
[RS-80]	A new architecture of Internet of Things and big data ecosystem for secured smart healthcare monitoring and alerting system	Journal	2018
[RS-81]	New Security Architecture for IoT Network	Workshop	2015
[RS-82]	Smart City Architecture and its Applications Based on IoT	Journal	2018
[RS-83]	Software architecture of self-organizing systems-of-systems for the Internet-of-Things with SosADL	Journal	2017
[RS-84]	Evaluating energy efficiency of Internet of Things software architecture based on reusable software components	Journal	2017
[RS-85]	Software-defined wireless network architectures for the Internet-of-Things	Conference	2015
[RS-86]	A System Architecture for Software-Defined Industrial Internet of Things	Conference	2015
[RS-87]	PMDA: A physical model driven software architecture for Internet of Things	Journal	2013
[RS-88]	EfiIoT: An efficient software architecture for internet of things	Conference	2012

Data Augmentation to Stabilize Image Caption Generation Models in Deep Learning

Hamza Aldabbas[1], Muhammad Asad[2], Mohammad Hashem Ryalat[3],
Kaleem Razzaq Malik[4], Muhammad Zubair Akbar Qureshi[5]
Prince Abdullah bin Ghazi Faculty of Information and Communication Technology,
Al-Balqa Applied University, Salt 19117. Jordan[1,3]
Department of Computer Science
Air University, Multan Campus Multan, Pakistan[2,4,5]

***Abstract*—Automatic image caption generation is a challenging AI problem since it requires utilization of several techniques from different computer science domains such as computer vision and natural language processing. Deep learning techniques have demonstrated outstanding results in many different applications. However, data augmentation in deep learning, which replicates the amount and the variety of training data available for learning models without the burden of collecting new data, is a promising field in machine learning. Generating textual description for a given image is a challenging task for computers. Nowadays, deep learning performs a significant role in the manipulation of visual data with the help of Convolutional Neural Networks (CNN). In this study, CNNs are employed to train prediction models which will help in automatic image caption generation. The proposed method utilizes the concept of data augmentation to overcome the fuzziness of well-known image caption generation models. Flickr8k dataset is used in the experimental work of this study and the BLEU score is applied to evaluate the reliability of the proposed method. The results clearly show the stability of the outcomes generated through the proposed method when compared to others.**

***Keywords*—Convolutional Neural Networks (CNN); image caption generation; data augmentation; deep learning**

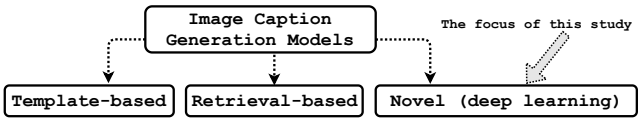


Fig. 1. The main categories of Image Caption generation models

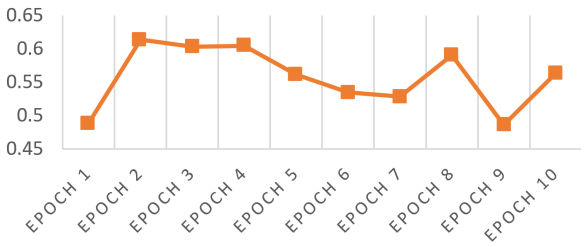


Fig. 2. The BLEU-evaluation-score vs. ten generated epochs where data augmentation is never used.

I. Introduction

Auto Generation of Captions for images is quite a complex task for computers. Many big names like Google, Microsoft, Apple, etc. are working on the improvement of scene understanding by computers. Understanding the objects in images is not the only task for computers but also understanding the relation of these objects in order to to translate this relation in natural language to mimic like a human. This task is quite expensive in terms of computational cost. The story began in 2010 when [1] proposed a method to describe an image into a sentence. By 2011, the GPU speed becomes super fast due to enhancement in technology. That enables to dive into Deep Learning capabilities.

There are three main approaches to generate image captions as displayed in Fig. 1. The first approach is the template-based image caption generation method. In this type we have some templates of captions with missing words, and those missing words are filled according to the objects in an image. For example, [1] use triplet of the scene to fill blank spaces in a template and [2] extract phrases related to the objects detected in an image and define a relationship among objects to create a sentence. The generated sentence in this approach is not a variable length. The second approach is called retrieval-based, in which we have an existing set of captions, which are called candidate captions. In this approach, the query image is matched with a visually similar image in training dataset to produce a caption [3], [4]. The third approach, which is deeply investigated in this paper, is known as novel caption generation, in which the deep learning techniques are utilized to automatically generate image captions. This approach implies the analysis of the objects in images and mapping the analyzed data on the language model to generate captions [5], [6]. This approach produces unique captions in a variable length.

In deep learning based image caption generation models, we extract image features and feed them to a neural network. A CNN (Convolutional Neural Network) is used in this approach to extract features as presented in [7]. After getting features of a dataset, we train a model of neural network and then use it for further prediction tasks. The initial configuration in this process includes specifying the number of epochs, and the loss function. The loss function is an integral part of ANNs which is used to measure the inconsistency between predicted label ($\hat{y}$) and the actual label (y). The models created could be variant and lose stability.

Fig. 2 shows to which extent the outcomes normally differ

from epoch to the other. The BLEU score [8] is employed for evaluation in this study. Fig. 2 asserts the fact that there are obvious variations and instability in the outcomes when data augmentation is never used. However, this research presents a methodology by which we can create stable image caption generation model.

The remaining of this paper is organized as follows. Section II presents literature review and background information. The details of the proposed method are provided in Section III. The experimental work is presented in Section IV and the results is discussed in Section V. The conclusion together with some suggested future work are drawn in Section VI and Section VII respectively.

II. Literature Review

This section presents an overview on the research papers that are related to the image caption generation models. The authors of [3] adopts the retrieval based protocol in which image query is checked to get a sentence from a pool of reference sentences associated with the image. This technique can be used in any system that stores both, images and sentences. The main idea in that study is the retrieval of image-to-sentence. To establish the results, they use the Kernel Canonicals Correlation Analysis along with many linguistic and visual Kernels to map images and sentence into space where the similarity between them can be computed directly. They train the model using 6,000 images with real-world captions. For further enhancements in the results, they introduce an algorithm which is called Stacked Auxiliary Embedding that can transfer tens of thousands of annotated images every week to improve the accuracy of the retrieval-based Image caption.

In [5], they use the encoder-decoder pipeline to learn based on the work of generating the descriptions of the images using the Multimodal. A multimodal is based on the embedding space of the images and text and a novel language modal that matches distributed representation of the text and images. This multimodal consists of two trained models, which are as follows.

- Neural Language Modal
- Image-Text Modal

The function of the encoder in their pipeline is to rank the images and sentences. On the other hand, the function of the decoder is generating the description for images from scratch. They use LSTM [9] to encode the sentence, and match their results with Flickr8K and Flickr30K without using object detection techniques. They get their best result using the convolution neural network with 19x layers. However, they use three different methods to generate descriptions of the images.

- Template-based method
- Composition-based method
- Neural-network-based method

The following methods are used in their pipeline to enable the encoder and the decoder to rank generation:

- Long short term memory RNNs
- Multimodal distributed representation
- Log-bilinear NL models
- Multiplicative NL models
- Structure-content NL models

Long-term Recurrent Convolution Network (LRCNs) is applied in [10]. LRCNs consists of the convolution layers, and temporal recursion with long-range. It is considered as end to end trainable method. They train their modal for the specific video activity recognition and image caption generation. The LRCNs modal is both spatially and temporally deep and flexible enough to be applied in vision-based tasks. Their results consistently demonstrate learning sequential dynamics with a deep sequence modal. They use the deep neural network like (CNN) for capturing the features from the images, and then they add another model LSTM, which is used to generate the sequence of words based on the natural language. They combined both CNN and RNN, and under these, they use LSTM to generate the description of images and videos. The whole system contains the features of CNN and RNN and also a sequence generator.

In [11], they use CNN modal instead of traditional RNN modal. They use CNN as image "encoder" and then they use the last hidden layer of the network as an input to the RNN "decoder" that generate the sentence. They call this model natural image caption (NIC). It is a neural network which is fully trainable using well-known techniques such as stochastic gradient decent (SGD) [12]. Modal also combines the state of the art sub-networks that perform subtasks like vision and natural language processing. Using these sub-modals, they take advantages of pre-training these modal on large datasets. The performance of their system compared to the state of the art modals is very good. For example, on the Pascal dataset, NIC BLUE score is 59%, and the current state of the art modal score is 25%, while human performance reaches 69%. On Flickr30k they improve from 56% to 66%.

The authors of [13] describe a new approach to the image caption generation that tries to generate the caption using a form of attention with two variants.

- A mechanism of hard attention
- A mechanism of soft attention

They generate two attention based modal for the image caption generator under a common framework. The first one is a soft deterministic attention-based model which is trained through the back-propagation method, and the second one is a hard attention-based model which is trained by maximizing the lower bound. Flickr8k [14], Flickr30k and the MS COCO [15] dataset are used in their study. For evaluation, they use BLEU as well as METEOR metrics. They also present how the learned attention can be used into modal generation process and demonstrate that learned alignments correspond very well to the human intuition. This model is not very simple, but the result of this model is satisfying.

In [16], the authors use a different method for caption generation. This technique is different from the previous approaches. They suppose in their work that description can be represented by collections of nouns, verbs, and prepositional

phrases. The object in the image is described as a Noun phrase. The interaction between the object in the image is encoded as a verb phrase or maybe a preposition. Flickr30k and MS COCO are used as dataset in their experiments. In both datasets, every image has a five (or six) sentence descriptions. When combining both datasets they can have 559,113 sentences so they propose the simplest model that can infer different phrases from image samples. From the phrases predicted, their model can automatically generate sentences using a statistical language model. Their algorithm, despite being simpler than state-of-the-art models, achieves similar results on this task. Also, their model generates some new sentences which are not generally present in the dataset. They measure the quality of the generated sentences using BLEU score.

The authors of [17] use a new method of embedding the visual and language data. Their proposed modal is trained using the following parameters:

- **Learning and inference**: they try to retrieve images based on the given query sentence. They train the model on a set of N Images and N correspondent statements that describe their content. After the completion of training process, they discard the training data and evaluate the results of the modal on the unseen data.
- **Fragment Embedding**: it is another variant they use in their work. They break down the image and sentence into fragments and embed these fragments into a vector for validation.

Their modal has some limitations when it assigns a simple phrase like "A cat is black and white" into multiple relations; it fails to relate them together. On the other hand, from the image side, it counts many persons in the picture as one person. However, the overall results are satisfying.

In [14] authors focus on the work of associating images with sentences drawn from a big predefined pool of the images' descriptions. These descriptions are written by people who were asked to describe the images. They provide an alternate method for describing the image which is best suitable to that image. They use a rank system rather than generating the description for the image. The new Rank system works based on the nearest-neighbour search for the image description. The representation in this paper is straightforward. They only rely on three types of low-level pixels perceptual features that capture shape, colour and text in the form of SIFT descriptor. They use two different kernels, the histogram kernel and the pyramid kernel. In both cases, they compute separate kernel for each of three types of images feature and average their results. They then draw similarities between these kernels. These kernels are string kernels with lexical similarities, the Lin similarity kernel, and the distributional similarity kernel.

In [18], the authors propose a new query expansion approach, which is used in auto image captioning. The main idea behind this is just to convert the visual query into distributed semantics. It is generated by the average of sentence vectors that are generated from the captions of the visual images that are similar to the input images. In their study, they use three image captioning standard datasets and show that their technique leads to more accurate results. Automatic image captioning is very popular in computer vision and language processing. The data-driven method, automatic metrics, and subjective evaluation are the techniques which are discussed and compared in this research paper. The first approach generates novel captions from images directly. In this approach, computer vision techniques like object detection and classification use output to extract the visual contents of the input image and generate captions. These studies combine CNN with RNN to generate captions for images. The second approach uses joint representations of images and captions. They use ML techniques to form a common embedding space for textual as well as visual data and accomplish image to sentence in that intermediate space to find the most appropriate captions for a query image. The third technique is to use data-driven approach, by this all image can be treated for captions as a caption transfer problem [19].

In [20], the author presents a model that generates a description of images in natural language. Their proposed model is based on a novel combination of CNNs over image regions and bidirectional-RNN over sentences. The authors also describe the Multi-modal RNN architecture that uses the inferred alignments to generate novel descriptions of images. Flickr8K, Flickr30K, and MSCOCO are used in their experiments. The previous work in visual recognition was labeling images with visual categories. They evaluate the output of Multimodal RNN architecture on both full-frame and region-level experiments and show that in both cases, Multimodal RNN output forms the retrieval baselines.

III. Data Augmentation to Stabilize Image Caption Generation Models

As presented in VGG16 [7], our proposed method skips the last layer in the pre-trained model in order to utilize that layer for feature extraction. We remove the last layer of the model which gives the raw output in the form of 4096 vector size (i.e. the raw features of the image). After feature extraction, we feed these features to train our neural network. The network, which is shown in Fig. 3, is implemented using Keras API under Tensorflow back-end environment. The contribution that this research presents is the employing of data augmentation to generate models in more stable manners. We generate 10 models from both techniques, the augmented-images technique and non-augmented-images technique. After that, we pick a picture and generate a description with all 20 models (10 from augmented-images and 10 from non-augmented-images). Finally, we accept the best description generated by both categories and make a reference description to calculate BLEU score [8] as shown in Fig. 4.

The following represents the relation between P, m, and W_t where m is a number of words which belongs to the candidate text which exists in the reference text, and W_t represents the total words in the candidate text. r is the effective length of the reference corpus, and c is the total length of the translation corpus.

$$P = \frac{m}{w_t}$$

$$\exists p = \begin{cases} 1 & if\, c > r \\ e^{(1-\frac{r}{c})} & if\, c \leq r \end{cases}$$

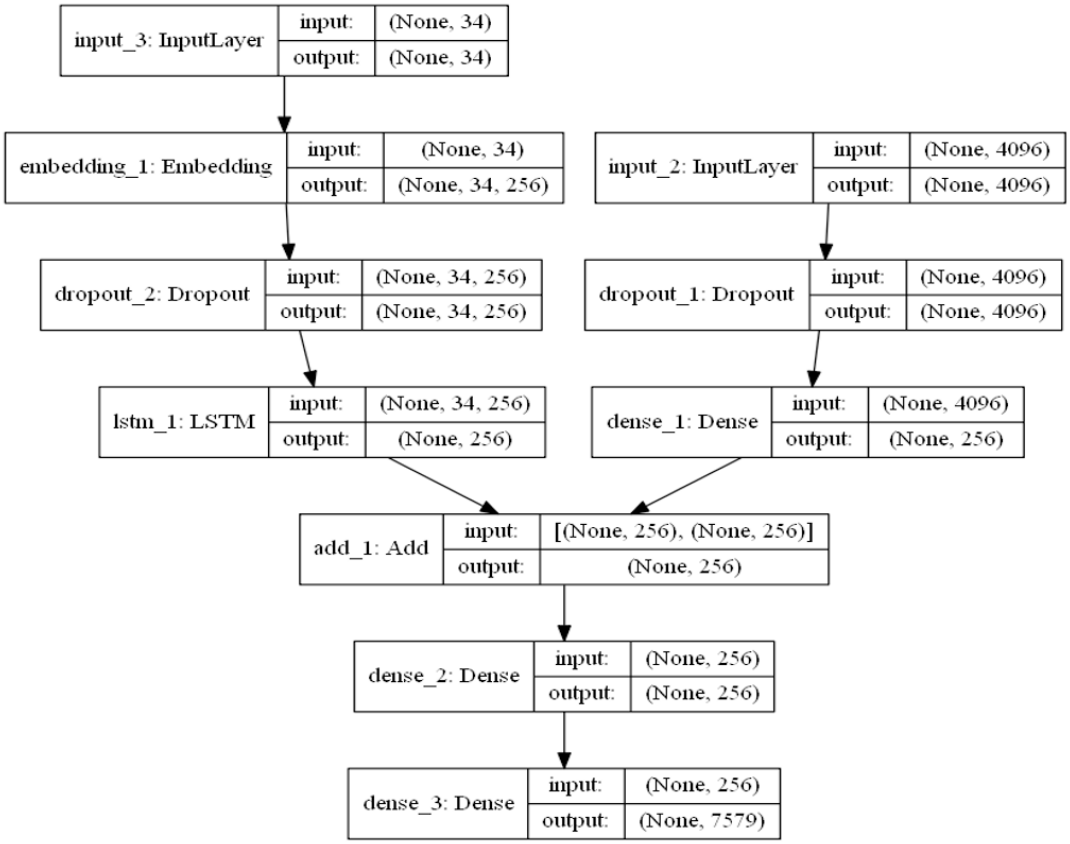


Fig. 3. Proposed Network Diagram to Generate Image Caption Models

$$BLEU = p.e^{\sum_{n=1}^{N} (\frac{1}{n} * \log Pn)} \quad (1)$$

In (1), P_n is the geometric average of the modified n-gram precision, and N is the length of n-grams used to compute P_n. The BLEU score, which is used in this paper to evaluate the results, is calculated using the formula in (1).

$$Avg\_BLEU\_\mathrm{Im}_k = \frac{\sum_{n=1}^{n=10} BLUE(j)}{n} \quad (2)$$

By using (1), we develop a formula represented in (2) where n is the number of epochs (every epoch have its model), k is the ID of the image, j is to identify the BLEU score grams, and j follows the following inequality $1 \leq j \leq 4$.

IV. Experiments

This section presents the experimental work that is designed to evaluate the proposed approach in this study. We apply data augmentation technique on Flickr8k dataset [14]. Flickr8k dataset consists of 8,000 photos and up to 5 captions for each photo. The VGG16 technique presented in [7] is implemented and used as a base reference model to extract features, but we did not classify the output of the VGG16 model into 1000 categories. We use transfer learning concept and remove the prediction layer in VGG16 and save the raw output. Then we implement the proposed model on the raw output of VGG16 model, and present the impact of data augmentation obtained on our dataset using the VGG16 and our Network Diagram along with the proposed methodology. One hundred images were selected from Flickr8k dataset and divided into two groups. The evaluation in this section is evaluated over these two groups. Fig. 5 represents a sample reference image from the first group and Fig. 7 from the second group.

We trained 10 models with the augmented and non-augmented images and tested the reference images shown in Fig. 5 and Fig. 7 from the first and the second group respectively to all 10 models of both types. We picked the highlighted definitions shown in Table I and Table II. To avoid biases, we picked more accurate generated description equals the other generated description and took this description as a candidate text to perform BLEU. The bar chart in Fig. 6 and Fig. 8 confirm that image caption models generated using augmented data are more stable and steady than those generated without augmentation.

Table I presents the BLEU scores for the first group of images, where the image in Fig. 5 is a reference image and Table II presents the BLEU scores for the second group of images, where the image in Fig. 7 is a reference image. The

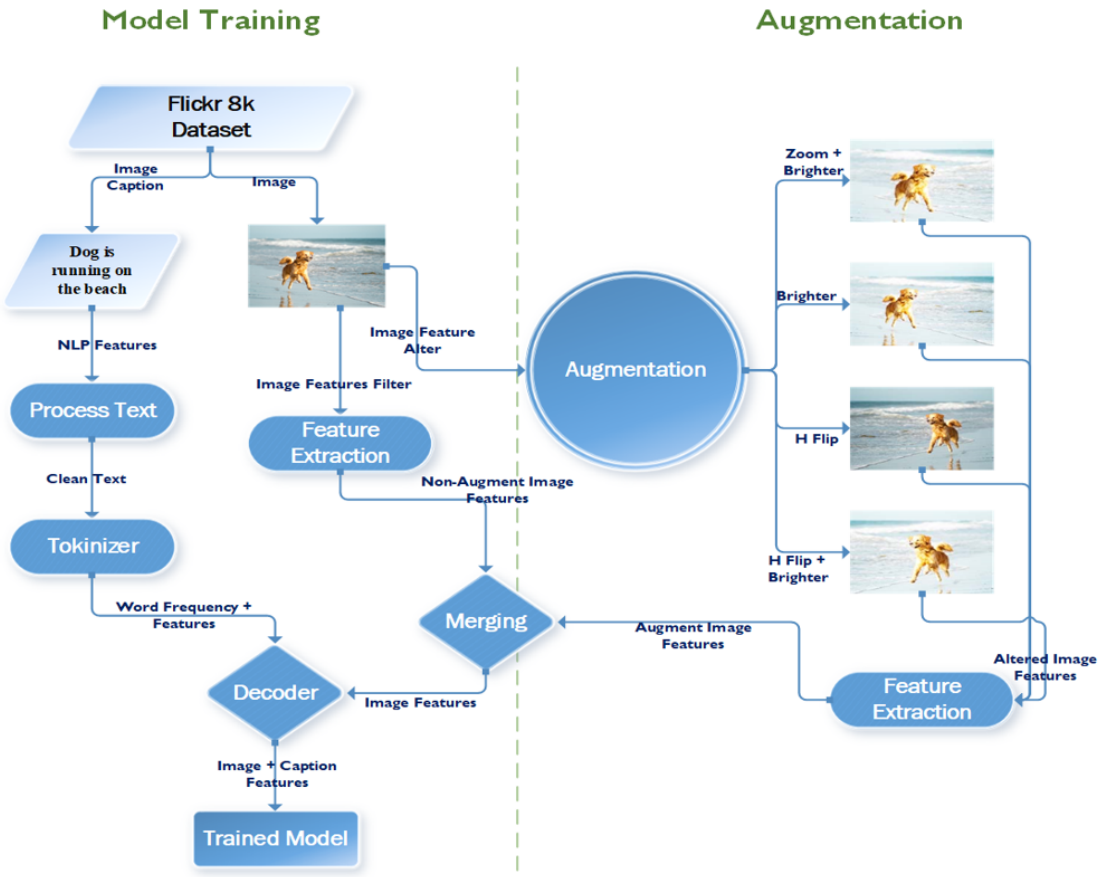


Fig. 4. The Proposed Methodology

TABLE I. BLEU SCORES FOR THE FIRST GROUP, WHERE THE IMAGE IN FIG. 5 IS A REFERENCE IMAGE (AUGMENTED VS. NON-AUGMENTED).

Models	Augmentation	BLEU 1	BLEU 2	BLEU 3	BLEU 4	No Augmentation	BLEU 1	BLEU 2	BLEU 3	BLEU 4
epoch1	dog is running through the grass	0.846	0.846	0.846	0.846	dog is running	0.5643	0.5079	0.4232	0.2822
epoch2	dog is running through the grass	0.846	0.846	0.846	0.846	dog is running	0.5643	0.5079	0.4232	0.2822
epoch3	white dog is running through the grass	1	1	1	1	dog is running	0.5643	0.5079	0.4232	0.2822
epoch4	dog runs through the grass	0.536	0.335	0.223	0	white dog is running	0.5714	0.5	0.4	0.25
epoch5	white dog is running through the grass	1	1	1	1	dog is running	0.5643	0.5079	0.4232	0.2822
epoch6	white dog runs through the grass	0.705	0.508	0.212	0	two dogs are running	1	1	1	1
epoch7	dog runs through the grass	0.536	0.335	0.223	0	the brown dog is running	0.5	0.4286	0.3333	0.2
epoch8	white dog is running through the grass	1	1	1	1	white dog running	0.5643	0.5079	0.4232	0.2822
epoch9	white dog is running through the grass	1	1	1	1	dog running	0.5363	0.5027	0.4469	0.3352
epoch10	white dog is running through the grass	1	1	1	1	dog running	0.5363	0.5027	0.4469	0.3352
	Average	**0.847**	**0.787**	**0.735**	**0.669**	**Average**	**0.5966**	**0.5473**	**0.4743**	**0.3531**

Fig. 5. Sample reference image from the first group

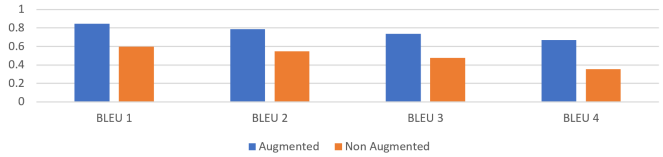


Fig. 6. Bar Chart shows the average BLEU Score of the 10 Models on reference image in Fig. 5

Fig. 7. Sample reference image from the second group

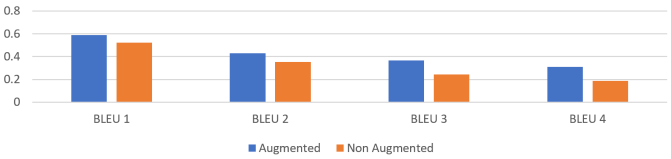


Fig. 8. Bar Chart shows the average BLEU Score of the 10 Models on reference image in Fig. 7

BLEU scores in both tables are calculated for the augmented and the non-augmented dataset. The numbers displayed in Table I and Table II are evaluated using the equation presented in (2) in Section III.

V. Results and Discussions

The results indicate clearly that proposed method outperforms the other approaches in experiments carried out at benchmark subsets. The introduced method reports a stable prediction model generation.

Fig. 9, Fig. 10, Fig. 11, and Fig. 12 display the values of BLEU1, BLEU2, BLEU3, and BLEU4 scores, respectively. The blue line in these figures shows the value of BLEU score of the generated models when data augmentation is used, whereas the orange line shows the value of BLEU score when data augmentation is never used. The stability of generating captions can be seen clearly in these figures.

The settings which are used to perform data augmentation in this study are:

- zoom + brighter
- brighter
- H-flip
- H-flip + brighter

The BLEU-2, BLEU-3, and BLEU-4 are evaluated using the settings displayed in Fig. 13, Fig. 14, and Fig. 15, respectively. It is obvious that our generated model keeps a stable results regardless using different setting in data augmentation.

VI. Conclusion

This paper presented a new methodology in the form of a pipeline to automatically generate image captions. The proposed method in this study employed the deep learning techniques to enhance and stabilize the generated model. By utilizing the power of data augmentation, our method applied CNNs over a set of augmented images to extract their features. Those extracted features are merged with the features which are extracted from a set of non-augmented images and the resulting combination underwent several phases of our proposed pipeline including text processing, tokinizer, decoder, and training model.

This study used the Flickr8k dataset which consists of 8,000 photos and up to 5 captions for each photo, and the VGG16 technique is implemented and used as a base reference model. In order to evaluate the robustness and stability of the proposed method, the BLEU score metric is applied. The outcomes asserted the significant stability of achieved results when data augmentation is used which emphasizes the correctness of the basic contribution of this study.

VII. Future Work

The future directions of this research are exploring the effects of changing data augmentation settings over the stability of the generated image cation, as well as producing a mobile application which automatically generates image captions.

TABLE II. BLEU SCORES FOR THE SECOND GROUP, WHERE THE IMAGE IN FIG. 7 IS A REFERENCE IMAGE (AUGMENTED VS. NON-AUGMENTED).

Models	Augmentation	BLEU 1	BLEU 2	BLEU 3	BLEU 4	No Augmentation	BLEU 1	BLEU 2	BLEU 3	BLEU 4
epoch1	man in green shirt	0.778	0.63	0.571	0.5	man in green shirt	0.67	0.375	0	0
epoch2	man in green shirt is standing beside the river	0.636	0.4	0.333	0.25	man in black hat is sitting beside table	1	1	1	1
epoch3	man in red shirt is wearing red shirt and black hair	0.455	0.4	0.333	0.25	man in black and black and man are sitting on the camera	0.54	0.417	0.273	0.1
epoch4	man in green shirt is wearing green hat	0.552	0.5	0.441	0.35	man in black and black and black and black hair are sitting on the camera	0.47	0.357	0.231	0.08
epoch5	man in green hat is sitting beside river	0.7	0.44	0.375	0.29	man is standing on the beach	0.4	0.121	0	0
epoch6	the man is wearing red shirt and is wearing green hat	0.455	0.1	0	0	two people are playing in the water	0.21	0	0	0
epoch7	man in red shirt is wearing red shirt and black hat	0.455	0.4	0.333	0.25	man is sitting on the beach	0.51	0.364	0.303	0.2
epoch8	man in red shirt is wearing red shirt and black hair	0.385	0.33	0.273	0.2	man wearing black hat and black hat is sitting on the camera	0.58	0.364	0.3	0.22
epoch9	man in green shirt is sitting in the street	1	1	1	1	two people are standing on the river	0.21	0.125	0	0
epoch10	the man is wearing green hat and is wearing green shirt	0.455	0.1	0	0	man wearing black and black hat is sitting on the camera	0.64	0.4	0.333	0.25
	Average	**0.587**	**0.43**	**0.366**	**0.31**	**Average**	**0.52**	**0.352**	**0.244**	**0.19**

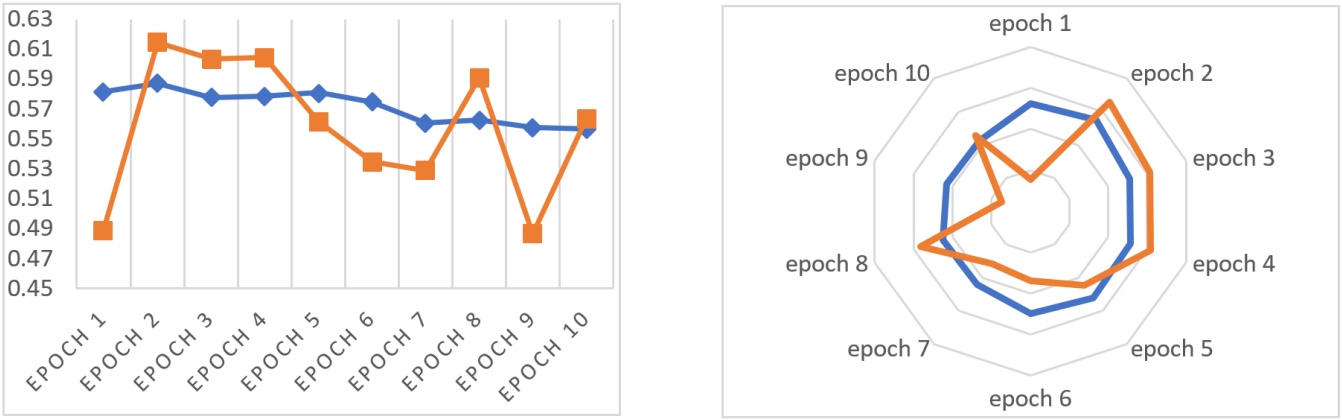


Fig. 9. Impact of Augmentation on Caption Generation Models Evaluated on BLEU-1 Score

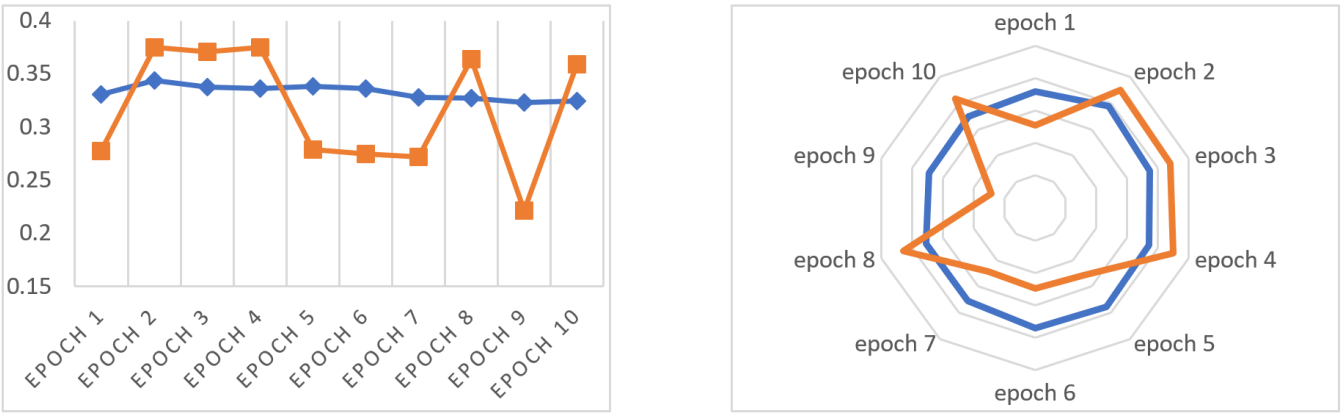


Fig. 10. Impact of Augmentation on Caption Generation Models Evaluated on BLEU-2 Score

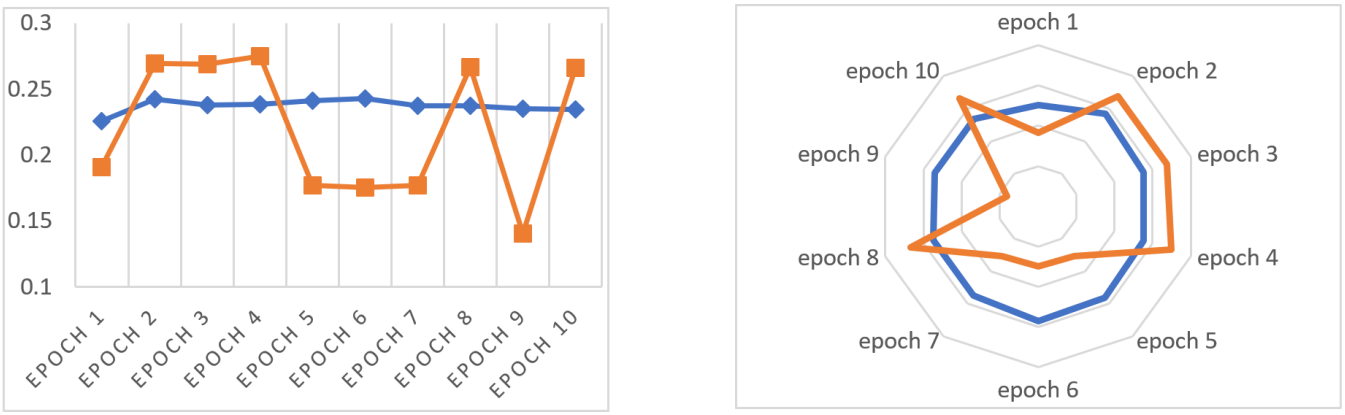


Fig. 11. Impact of Augmentation on Caption Generation Models Evaluated on BLEU-3 Score

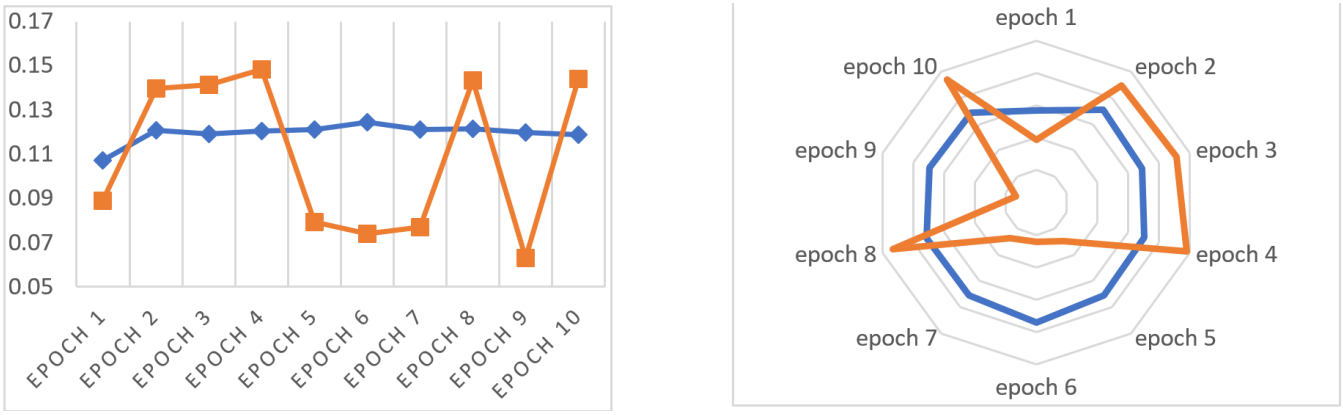


Fig. 12. Impact of Augmentation on Caption Generation Models Evaluated on BLEU-4 Score

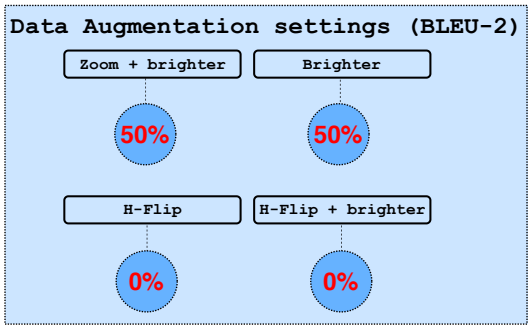


Fig. 13. Data augmentation settings (BLEU-2 Score)

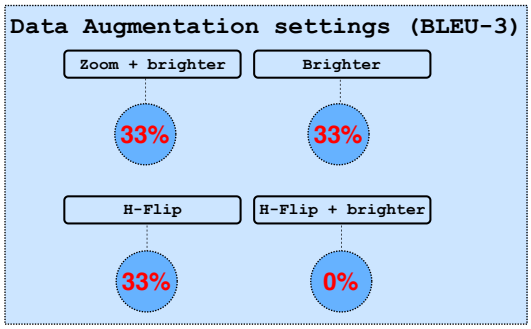


Fig. 14. Data augmentation settings (BLEU-3 Score)

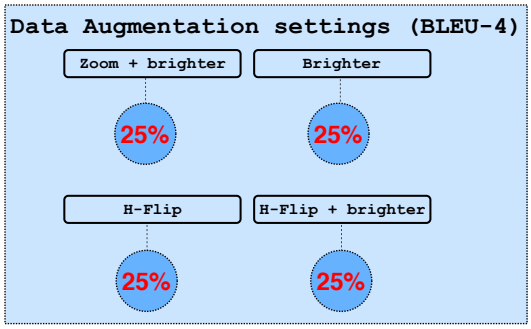


Fig. 15. Data augmentation settings (BLEU-4 Score)

REFERENCES

[1] A. Farhadi, M. Hejrati, M. A. Sadeghi, P. Young, C. Rashtchian, J. Hockenmaier, and D. Forsyth, "Every picture tells a story: Generating sentences from images," in *European conference on computer vision*. Springer, 2010, Conference Proceedings, pp. 15–29.

[2] S. Li, G. Kulkarni, T. L. Berg, A. C. Berg, and Y. Choi, "Composing simple image descriptions using web-scale n-grams," in *Proceedings of the Fifteenth Conference on Computational Natural Language Learning*. Association for Computational Linguistics, 2011, Conference Proceedings, pp. 220–228.

[3] Y. Gong, L. Wang, M. Hodosh, J. Hockenmaier, and S. Lazebnik, "Improving image-sentence embeddings using large weakly annotated photo collections," in *European conference on computer vision*. Springer, 2014, Conference Proceedings, pp. 529–545.

[4] C. Sun, C. Gan, and R. Nevatia, "Automatic concept discovery from parallel text and visual corpora," in *Proceedings of the IEEE international conference on computer vision*, 2015, Conference Proceedings, pp. 2596–2604.

[5] R. Kiros, R. Salakhutdinov, and R. S. Zemel, "Unifying visual-semantic embeddings with multimodal neural language models," *arXiv preprint arXiv:1411.2539*, 2014.

[6] S. Jabbar, K. R. Malik, M. Ahmad, O. Aldabbas, M. Asif, S. Khalid, K. Han, and S. H. Ahmed, "A methodology of real-time data fusion for localized big data analytics," *IEEE Access*, vol. 6, pp. 24 510–24 520, 2018.

[7] K. Simonyan and A. Zisserman, "Very deep convolutional networks for large-scale image recognition," 2014.

[8] K. Papineni, S. Roukos, T. Ward, and W.-J. Zhu, "Bleu: a method for automatic evaluation of machine translation," in *Proceedings of the 40th annual meeting on association for computational linguistics*. Association for Computational Linguistics, 2002, Conference Proceedings, pp. 311–318.

[9] F. Gers, "Long short-term memory in recurrent neural networks," Thesis, 2001.

[10] J. Donahue, L. Anne Hendricks, S. Guadarrama, M. Rohrbach, S. Venugopalan, K. Saenko, and T. Darrell, "Long-term recurrent convolutional networks for visual recognition and description," in *Proceedings of the IEEE conference on computer vision and pattern recognition*, 2015, Conference Proceedings, pp. 2625–2634.

[11] O. Vinyals, A. Toshev, S. Bengio, and D. Erhan, "Show and tell: A neural image caption generator," in *Proceedings of the IEEE conference on computer vision and pattern recognition*, 2015, Conference Proceedings, pp. 3156–3164.

[12] O. Bousquet, U. von Luxburg, and G. Rätsch, *Advanced Lectures on Machine Learning: ML Summer Schools 2003, Canberra, Australia, February 2-14, 2003, Tübingen, Germany, August 4-16, 2003, Revised Lectures*. Springer, 2011, vol. 3176.

[13] K. Xu, J. Ba, R. Kiros, K. Cho, A. Courville, R. Salakhudinov, R. Zemel, and Y. Bengio, "Show, attend and tell: Neural image caption generation with visual attention," in *International conference on machine learning*, 2015, Conference Proceedings, pp. 2048–2057.

[14] M. Hodosh, P. Young, and J. Hockenmaier, "Framing image description as a ranking task: Data, models and evaluation metrics," *Journal of Artificial Intelligence Research*, vol. 47, pp. 853–899, 2013.

[15] T.-Y. Lin, M. Maire, S. Belongie, J. Hays, P. Perona, D. Ramanan, P. Dollár, and C. L. Zitnick, "Microsoft coco: Common objects in context," in *European conference on computer vision*. Springer, 2014, Conference Proceedings, pp. 740–755.

[16] R. Lebret, P. O. Pinheiro, and R. Collobert, "Phrase-based image captioning," 2015.

[17] A. Karpathy, A. Joulin, and L. F. Fei-Fei, "Deep fragment embeddings for bidirectional image sentence mapping," in *Advances in neural information processing systems*, 2014, Conference Proceedings, pp. 1889–1897.

[18] S. Yagcioglu, E. Erdem, A. Erdem, and R. Cakici, "A distributed representation based query expansion approach for image captioning," in *Proceedings of the 53rd Annual Meeting of the Association for Computational Linguistics and the 7th International Joint Conference on Natural Language Processing (Volume 2: Short Papers)*, vol. 2, 2015, Conference Proceedings, pp. 106–111.

[19] K. Z. Haider, K. R. Malik, S. Khalid, T. Nawaz, and S. Jabbar, "Deepgender: real-time gender classification using deep learning for smartphones," *Journal of Real-Time Image Processing*, vol. 16, no. 1, pp. 15–29, 2019.

[20] A. Karpathy and L. Fei-Fei, "Deep visual-semantic alignments for generating image descriptions," in *Proceedings of the IEEE conference on computer vision and pattern recognition*, 2015, Conference Proceedings, pp. 3128–3137.

From Poster to Mobile Calendar: An Event Reminder using Mobile OCR

Fatiha Bousbahi
Information Technology Department
College of Computer and Information Science, King Saud University, Riyadh, Saudi Arabia

***Abstract*—Technological innovations are the foundation of new services today. Successful services address real-life issues that help people manage life more conveniently using relevant technologies. Currently, images are a part of daily life. People are often taking pictures of different posters for different events as exhibitions, workshops, conferences, etc., with their mobile. Unfortunately, sometimes these pictures are forgotten and events' dates expire. As consequence, people miss events they were interested in. Hence, with the vision to provide technology-powered services, affordable and turnkey applications, this paper presents Event-Reminder, a fully automated lightweight reminder system builds upon a mobile offline OCR (Optical Character Recognition) with touch interaction making some daily tasks easier. Event-Reminder is a mobile application that would recognize the images' text content, extract event's date and venue and upload this event information automatically to mobile calendar in order to remind the user about the event at proper time. A prototype system is introduced in this paper.**

***Keywords*—OCR; API; mobile apps; reminder systems**

I. Introduction

With the proliferation of mobiles, images become part of daily life. Indeed, people are often taking pictures of different posters for different events as concert, exhibitions, workshops etc., with their mobile. This results in many images hard to manage, to search and remember. People may miss their events they were interested in. A reminder application that would recognize the images' text content, extract date and venue and upload this event's information automatically to mobile calendar in order to remind the user about the event at proper time would be excellent help. Another audience who can benefit from this reminder system is patients that want to remind their physician appointments. The patient takes an image of her/his appointment and the system will save it in the user's mobile calendar.

Reminder systems were developed for many purposes such personal task reminder [1], location reminder [2,3] medication reminder [4], activities reminder for memory impairment [5], etc. But most of them require input fields which can be tedious for mobile owners expecting intuitive navigation and easy applications. Thanks to smartphones which become more and more efficient and consequently promote ease and efficiency of applications' design by including new technologies. Most of these new technologies and technical innovations hold big promise for businesses and their customers. Indeed, the challenge consists to convert the potential into actual capability by delivering working services into the market. Yet, new technologies, however exciting they are, could be too complex to be adopted by people in their daily live because people prefer simple and relevant technologies that help them manage life more conveniently. Indeed, 14% of smartphone owners reported deleting an app that was difficult to use [6]. Hence, an intuitive and easy smart phone application has been proposed in this paper, which will help people attend their medical appointments or events they are interested in at proper time.

Actually, there are many expiry date reminder applications available but what makes this special, we focus on reminder based on print media describing event or appointment which will be elapsed in due time while integrating new technologies. Everything in this application is done automatically with no need of internet. The application is developed with a consideration that it does not take up significant time or effort. Furthermore, the application is developed with low cost software.

In this article, we describe an android application that builds upon the latest mobile OCR, touch interaction and leads to a new portable tool. We have implemented a prototype system.

The remainder of this paper is organized as follows. Section 2 describes background and work related to the tools of OCR. The proposed system is presented in Section 3. The system design and evaluation are reported and discussed in Sections 4 and 5, respectively. Section 6 concludes the paper and presents a number of directions for future work.

II. Background and Related Work

A. OCR Technology: An Overviw

Nowadays, documents are more and more scanned allowing for the convenient access and sharing of files. Yet, these scanned documents are simply images of the original files which impede editing and searching. Thanks to OCR (Optical Character Recognition) technology, the text of these documents is made more accessible [7]. OCR technology enables users to convert paper content into electronic files thus transforming physical paper into searchable and editable digitized documentation. In the early 2000's, OCR began appearing in modern technology, as it was promoted as an online software service, a cloud computing solution, and recently, began to appear in mobile software such as postal processing, banking, healthcare, assistive technology for visually impaired people and language translation applications [8].

Since its inception, OCR technology has expanded from simple character recognition tool into plenty used and specialized technologies, able to boost large business process. Indeed, today, OCR has become trending with the use of new technologies. OCR has become a way for developers to develop a different use-case with the integration of it.

B. Mobile OCR

Mobile Optical Character Recognition describes an OCR process which is entirely executed on a mobile device. All image pre-processing and text recognition algorithms work without a server connection and only use the mobile device's camera solution and processor power.

There are several Text Recognition SDK provided by major technology companies such Mobile vision API [9], Tesseract [10], ABBYY Mobile OCR [11], Anyline [12] to name few. To choose an OCR SDK for our application, we took into account four factors: accuracy, free licence, offline, real-time recognition and simple coding. Indeed, we chose Mobile Vision API since it meets our requirements.

C. Mobile Vision Text API

Google's Mobile Vision detects faces, barcodes, and text in image or video by having API installed on a device. It works without cloud. Its biggest advantage, no network call is required to detect text. It works in real time on the device as well as on live camera. The identified text could be in any sequence. This API gives an application the ability to read text that appears in an image by transforming electronic images of printed documents into searchable electronic records. It recognizes text in any Latin based language. It also represents the structure of recognized text, including paragraphs and lines.

D. Reminder Systems

The idea of using expiry date reminder system is not new. Much work has been done in the past. More, the idea of using a smart phone application expiry date reminder has been developed in Android [13] as well in iOS [14]. To reduce manual entries, some application used RFID technology which bring some improvements.

As example, [15] is using RFID technology to detect the objects the user s/he might have forgotten when s/he is leaving home. Each object is identified with its name, RFID number and its class. The system uses taxonomy with two levels: classes and objects. The reminder system is connected to the user's calendar. An event object list can be built by the user or automatically detected and recorded by the system. The reminder system checks the objects carried in the user's bag when s/he is leaving home. This means the system shall detect the user's exit from house. An RFID reader is installed near the front door which can be very inconvenient to the user. More, although the RFID tags deployed in the public areas can help reach the goal, the tag price is still too high to make it feasible in real applications. In addition, this kind of reminder system needs internet connection to the server where the objects information is recorded in a database.

ShotVis [16] is a prototype of android mobile application that permits to take images of text captured from mobile devices and extracts information for visualization. Before data visualization, users must clean, select, and label dimensions from data extracted by an OCR through a series of sketching gestures. Then it automatically manipulates the data according to the supported gestures. The OCR software used in this prototype is not indicated. But we understood from the article, that the prototype needs a net connection to send the image to be processed by the OCR on a server.

Several existing reminder systems using OCR are focusing on medication. The most interesting we could find in the literature is an android application which consists to extract medicine bag information, reminder patient to take medicine as well as information regarding potential interactions [17]. The application uses online Tesseract OCR to recognize characters after performing image pre-processing involving binarization, denoising, skew correction, layout analysis, and character cut. The researchers needed to use also Median filter to remove noise from images and Affine Transform to accomplish skew correction before sending the data to the OCR. The application development is somewhat costly. It necessitates a database, an online OCR and other software.

Another interesting medication reminder system was developed by [18]. The researchers tried to automate more tasks such setting the medicine time automatically in the mobile calendar. But there is no explanation in their article about how medicine information is extracted from the recognized prescription and embedded in the calendar. Other prototypes are focusing on expiry food products [19].

E. Released Applications

There are some expiry date applications which are released in the market [20]. We cite among others, CozZo, a free fridge & pantry manager app. It helps to avoid food waste by checking the expiry date. Another one, Pharmaceutical Track &Trace is a mobile application which permits users to check if the medicines are counterfeit and or expired.

After analysis, we noticed that the existing reminder systems are not fully automatic. They have lots of manual work and they are much time consuming since they are using online OCR added to other software. More, there is possibility of hanging down of the existing systems due to the manual work or net disconnection. Table I shows a comparison between the existing reminder systems and the proposed system Event-Reminder.

In the present work, an attempt has been made to implement fully automatic reminder system based on mobile Optical character recognition. Low cost software was used to develop this event reminder application.

TABLE. I. COMPARISON OF EXISTING SYSTEMS AND PROPOSED SYSTEM

Features	***Existing System***	***Proposed System***
Method	Manual/Partial automatic	Fully automatic
Time	More time consuming	Less time consuming
Database	Yes	No
Net Connection	Yes	No
Identification	RFID+OCR/barcode + OCR	OCR only

III. System Overview

As it was mentioned in the previous section, the existing reminder systems are useful but they are not fully automated. They are providing quit functionalities manually which can be automated nowadays with the new available technologies.

Event-Reminder is an android mobile application (Fig. 1). Its goal is to provide an efficient technical solution that can serve people with different ages and level of education. It enables users to make use of advanced technologies to facilitate their live by saving time, effort and money.

Event-Reminder focuses on three automated tasks: the first one is getting text from a paper document describing an event into the user's mobile; the second one is to extract relevant information about this event and finally embed the event in the built-in calendar of user's mobile.

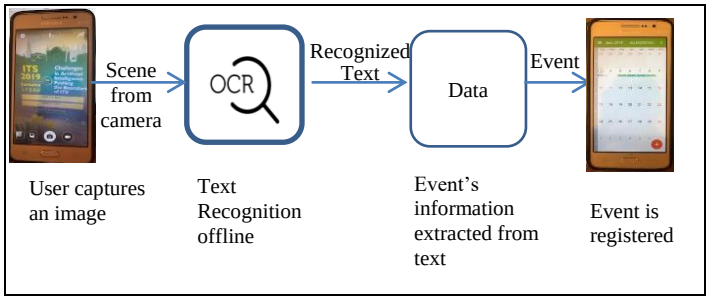


Fig. 1. Event-Reminder Architecture.

Event-Reminder recognizes the image's text content, extract date, title and venue then embeds it automatically to mobile calendar. A notification is sent on time to the user as a reminder about her/his event.

IV. System Design and Implementation

When designing Event-Reminder, we were keen to include the basic requirements that users want and expect in any mobile application. We included, the following most important ones:

- Utility: The proposed application enhances efficiency for tasks that are performed often by people.
- Intuitive: A full automated application where the number of clicks is reduced to an absolute maximum and no entry fields exist, all without limiting functionality of the application.
- Simplicity: A usable and simple design which focuses on tasks at hands and avoid any other features that aren't actually essential to what the user wants to perform.

The proposed application is composed of three components which are Text Recognition API representing the OCR module, Pattern Extraction algorithm and the mobile application. In the proposed application we use Mobile Vision API. By integrating Mobile Vision API and Pattern Extraction algorithm with the mobile application we will have the whole complete Event-Reminder application as shown in Fig. 1. The application components are described in the following sections:

A. The Application's Interfaces

When the application is launched, the initial interface allows the user to capture a scene (see Fig. 2(a)).

Application's functions:

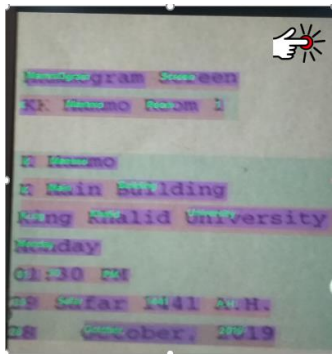
- The user is able to focus her/his camera on some regions of the image to be captured
- The user is able to see the captured text.
- The user is able to save the relevant information in her/his mobile calendar.

Event-Reminder is very easy to use and could be used by a wide range of people. Fig. 2 illustrates the application's interfaces and how to use them.

B. OCR Module

The proposed application deals mainly, with events' posters and medical appointment which have few text and more contrast between text and background (see Fig. 3(a)). We do not need pre-process such images, which save time while executing the application.

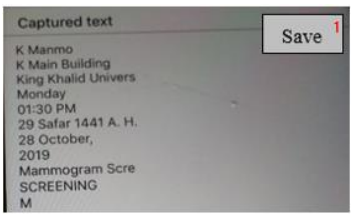
As shown in Fig. 1, the system is an android mobile application which captures a real-world scene from a printed data of an event with the user's smart device camera. While scanning the printed document, the user is able to focus regions in the image to be taken as input to recognize and produce the corresponding editable text as output. It overlays a selectable region in the view so that the required fields can be conveniently scanned within the region (see Fig. 3(b)). Once the required relevant information is in the small region, the capture button on the interface can be clicked to scan it. The output is an editable and searchable text (Fig. 3(c)).



(a) The scene as it is viewed from the mobile camera.

After the application is launched, the camera view is displayed.
The user points the camera on the interested regions of the real scene of the printed document to perform OCR.

1 This button permits the user to capture the text.

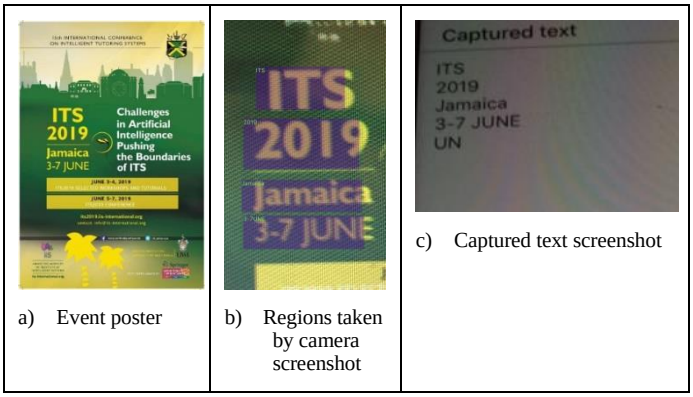


(b) The captured text from the scene.

The captured text is displayed.

1 This button permits the user to save the relevant information in the mobile calendar.

Fig. 2. Application's Interfaces.



a) Event poster

b) Regions taken by camera screenshot

c) Captured text screenshot

Fig. 3. OCR Modules Process.

Before, integration with the mobile application, we implemented the OCR module with Mobile Vision Text API which is an android offline image recognition library. To recognize text, we implemented three important parts: a detector object named TextRecognizer which processes images and determines what text appears within them; a camera manager pre-configured for vision processing named CameraSource. This is set to use rear camera by default. And to read text straight from the camera, a Detector Processor, which will handle detections as often as they become available. To accurately display the scanned text, we defined a layout using a specific method from the library.

C. Data Extraction from Captured Text

The pattern extraction work in the proposed system deals with sources such as events' posters and printed appointments forms as those for hospital. These sources are usually small and semi-structured. For instance, an event poster or hospital appointment are never more than a page's worth of information and are organized in such a way to make it easier to find dates, names and venue. The text (Fig. 3(c)) obtained from OCR module is made editable so that the edited text is searched and parsed to extract entities of interests. In this module, two functions are utilized. The first one searches keywords, such as: visit type, visit place, visit day, visit date to mine the needed information (case of hospital appointments) and regular expressions to extract date. When the document scanned is not a hospital appointment, the output of the search is null. In this case, the second function executes a date pattern recognition algorithm using Java regular expressions to mine matching pattern from strings. Indeed, Java 4 and later includes an excellent regular expressions library in the java.util.regex package [21]. Each line in the editable text is inspected to find the date first. The information surrounding the date is considered as the remaining information about the event. Since, only the fields of interest are scanned, the parsing is very fast. Once the relevant information is extracted, the user can click on the save button and the event is registered automatically in the mobile calendar.

We utilize Android Studio to implement user interfaces using XML and to implement all classes using Java programming language.

V. Experimentation and Evaluation

To test the performance, utility and the usability of the proposed system, we conducted some tests in real world with two android devices having versions 4.1 and 4.2.

A. Dataset

Experiments have been carried out with our prototype system to evaluate its performance and usability. We created a dataset with different posters and appointments collected from real-world events and medical appointments. The images have mostly not more than ten lines of text with different background colors/images, font types, font sizes, font colors, quality, etc. All images were of printed materials. 100 images were collected. Table II shows samples of dataset used. Some of them described past events.

B. Performance Testing

Each succeed case which embedded the correct relevant information in the right date of mobile's calendar is counted as correct counter (r) and each case was incorrectly embedded is counted as incorrect case. The accuracy rate can be calculated by = R/ number of testing cases.

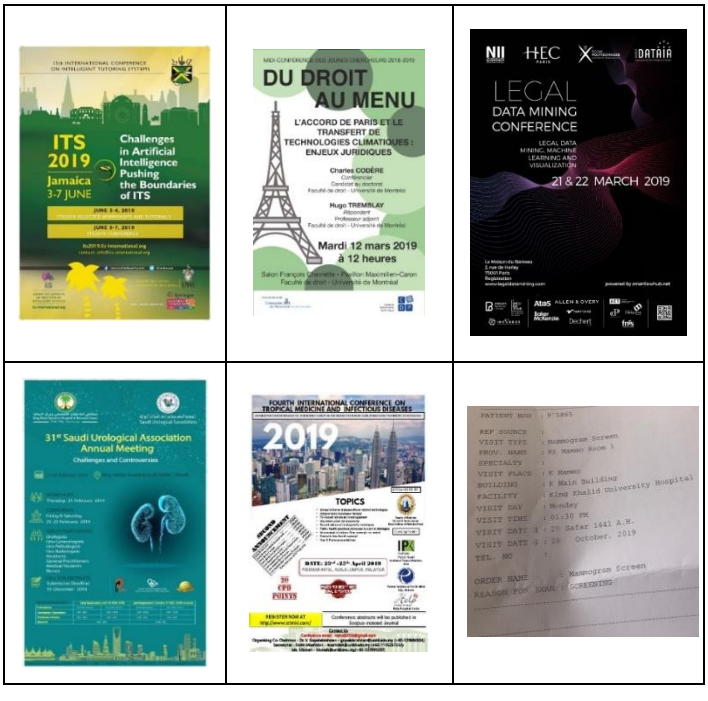
To assess the accuracy of the Event-Reminder, we used the following accuracy formula:

$$\text{Accuracy} = \frac{number\ of\ images\ correctly\ processed}{total\ number\ of\ images} * 100$$

The average time was calculated as follow:

$$Average\ time \quad = \frac{\sum xi}{n} * 100 \quad where\ x = time\ for\ each\ image\ and\ n = number\ of\ images.$$

TABLE. II. Dataset's Samples



The error rate is calculated by:

$$= \frac{\sum f/n}{4} * 100$$

where f=number of failed images and n = number of images.

The experimental results pointed to the effectiveness of our proposed system. As shown in Table III the application fails with only four images among one hundred. Only six images among one hundred were partially recognized, but the application succeeds to find the relevant information and save the corresponding event. As shown in Table IV, the accuracy of the proposed application was found to be 90% with an average time to perform the whole tasks less than 4 seconds. The error rate was found to be less than 1%. This implies that our system is beneficial to users.

C. Usability and Utility Testing

Most important function of a mobile application is to provide utility or value to users. Utility can come in many forms, entertainment value, a solution to a problem, or enhanced efficiency for tasks that are performed often by smartphones' owners as the case in the proposed application in this paper.

To determine utility and usability of the proposed system, experiments were conducted. Event-Reminder was tested by ten female participants aged from 18-60 years including five university teachers, two students and three patients having medical appointments in the university hospital. All of the participants are used to utilize mobile apps. The test was conducted individually within participant's free time at King Saud University. The session test, took no more than twenty minutes with each participant. After using the application, each participant evaluates it according to six factors: utility, functionality, simplicity, intuitive navigation, easy navigation, timing using five-point scales: Excellent, Very Good, Good, Fair, Poor and then replies to one open question - "Will you use it, if it is available?".

TABLE. III. EVENTS' POSTERS AND APPOINTMENTS RECOGNIZED AND EMBEDDED IN THE CALENDAR

Type of printed data	Success	Failed	Partial
Text recognition	80/100	8/100	12/100
Fields of interest extraction	80/80	-	10/100
Events embedded in calendar	80/80	-	10/10
Events out of date	5/80	-	-

TABLE. IV. EFFECTIVENESS OF THE PROPOSED SYSTEM

Type of printed data	Image background	Number of samples	Avg. time taken	Accuracy
Events' posters	Non-uniform	80	<4s	90%
Medical Appointment	Uniform	20	<3s	100%

D. Results and Discussion

After trying the application, all of the participants found the applications idea excellent. Most of the participants also, found the application very useful and usable. Indeed, the participants observed that there are no field entries, more, the number of clicks is reduced to an absolute maximum, all without limiting functionality of the application. Hence, all of them agree that the proposed application fall in the technology satisfying users daily life needs in simple manner. All the participants appreciate that the application is easy, fast and does not need internet connection. In addition, most of them will use this application if it is available in their phones.

VI. CONCLUSION

We witness an era where technology advancements increase efficiency and reduce cost to develop smart applications. In other hand, smartphones' owners are always looking for services and applications to perform numerous daily tasks to save money, effort and time. In this paper we present an intuitive and easy reminder application developed with low cost using technologies namely OCR and smartphone to facilitate certain tasks for people. Unlike other reminder applications, the proposed application is a full offline application which permits to use it anytime and anywhere. More, it is a fully automatic application which performs without typing on smartphone keyboard. The proposed system automatically extracts relevant information from images of event posters or medical appointments, making use OCR technology within a smartphone. This information includes the name of the event, its date, time and venue to be embedded in the smartphone calendar. The usability and utility tests show that the application satisfies highly mobile users' needs. Finally, the system can be easily used on any Android smartphone.

One of the limitations of this application is that it can only extract text in English or French as it cannot recognize characters in any other language. Other languages will be added in future work as well an iOS version will be developed.

ACKNOWLEDGMENT

This research project was supported by a grant from the "Research Center of the Female Scientific and Medical Colleges", Deanship of Scientific Research, King Saud University.

REFERENCES

[1] Chi-Yi Lin and Ming-Tze Hung (2013) "A location-based personal task reminder for mobile users", Springer-Verlag London.

[2] Timothy Sohn et al. (2005) "Place-Its: A Study of Location-Based Reminders on Mobile Phones" in M. Beigl et al. (Eds.): UbiComp, LNCS 3660, pp. 232-250. Springer-Verlag Berlin Heidelberg.

[3] Mohammed Abdul Qadeer, Ankur Chandra and Shashank Jain (2012) "Design and Implementation of Location Awareness and Sharing System using GPS and 3G/GPRS" in International Journal of Multimedia and Ubiquitous Engineering Vol. 7, No. 4.

[4] Katarzyna Stawarz, Anna L Cox and Ann Blandford (2014) "Don't Forget Your Pill! Designing Effective Medication Reminder Apps That Support Users' Daily Routines". Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Pages 2269-2278.

[5] Martha E. Pollack et al. (2003). “Autominder: an intelligent cognitive orthotic system for people with memory impairment”. Robotics and Autonomous Systems 44, 273–282.

[6] https://www.emarketer.com/.

[7] https://www.nla.gov.au/content/ocr-overview accessed on May 2019.

[8] https://www.k-international.com/blog/translation-apps-2016/ accessed on May 2019.

[9] Mobile vision. Available: https://developers.google.com/vision/text-overview.

[10] Tesseract Ocr Engine Cube mode - Training Tesseract. Available: https://stackoverflow.com/questions/16590259/tesseract-ocr-engine-cube-mode-training-tesseract.

[11] ABBYY Mobile Imagining SDK. Available: https://www.abbyy.com/en-eu/mobile-imaging-sdk/.

[12] https://documentation.anyline.com/toc/platforms/android/index.html.

[13] "Best Before". https://play.google.com/store/apps/details?id=com.nicedistractions.bestbefore&hl=en.

[14] "Fridge Police". https://itunes.apple.com/us/app/fridge-police-foodexpiratio/id394119420?mt=8&ign-mpt=uo%3D4.

[15] K. Jeevan Reedy, M.Veda Chary (2013) “An RFID-Based Reminder System for Smart Home.” International Journal of Scientific Engineering and Technology Research Volume. 02, Issue No.05, pages:318-324.

[16] Biao Zhu, Hongxin Zhang, and Wei Chen (2015) “ShotVis: Smartphone-Based Visualization of OCR Information from Images” ACM Trans. Multimedia Comput. Commun. Appl., Vol. 12, No. 1s, Article 12.

[17] Yu-Liang Kuo, Chiun-Li Chin, Cheng-Che Lu, Yi-Ju Wu (2015) “Intelligent reminder system for taking of medicine and potential interactions” Chung Shan Medical Journal, Vol 26, 15-22.

[18] Bhadane Ashwini, Kale Sapna, Bhuse Ishwari, Pawar Pallavi, P. N. Achaliya (2013) “An Android Based Medication Reminder System Based on OCR Using ANN”. International Conference on Recent Trends in engineering & Technology (ICRTET'2013).

[19] James, R. P (2013). An Application for Keeping Track of Food Item Expiration. (Master's thesis). Retrieved from https://scholarcommons.sc.edu/etd/2463.

[20] https://en.softonic.com/solutions/what-are-the-best-expiration-date-trackers.

[21] https://www.tutorialspoint.com/java/java_regular_expressions.htm. Accessed on April, 30.