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Editorial Preface

From the Desk of Managing Editor…

It is our pleasure to present to you the February 2013 Issue of International Journal of Advanced Computer Science and Applications.

Today, it is incredible to consider that in 1969 men landed on the moon using a computer with a 32-kilobyte memory that was only programmable by the use of punch cards. In 1973, Astronaut Alan Shepherd participated in the first computer "hack" while orbiting the moon in his landing vehicle, as two programmers back on Earth attempted to "hack" into the duplicate computer, to find a way for Shepherd to convince his computer that a catastrophe requiring a mission abort was not happening; the successful hack took 45 minutes to accomplish, and Shepherd went on to hit his golf ball on the moon. Today, the average computer sitting on the desk of a suburban home office has more computing power than the entire U.S. space program that put humans on another world!!

Computer science has affected the human condition in many radical ways. Throughout its history, its developers have striven to make calculation and computation easier, as well as to offer new means by which the other sciences can be advanced. Modern massively-paralleled super-computers help scientists with previously unfeasible problems such as fluid dynamics, complex function convergence, finite element analysis and real-time weather dynamics.

At IJACSA we believe in spreading the subject knowledge with effectiveness in all classes of audience. Nevertheless, the promise of increased engagement requires that we consider how this might be accomplished, delivering up-to-date and authoritative coverage of advanced computer science and applications.

Throughout our archives, new ideas and technologies have been welcomed, carefully critiqued, and discarded or accepted by qualified reviewers and associate editors. Our efforts to improve the quality of the articles published and expand their reach to the interested audience will continue, and these efforts will require critical minds and careful consideration to assess the quality, relevance, and readability of individual articles.

To summarise, the journal has offered its readership thought provoking theoretical, philosophical, and empirical ideas from some of the finest minds worldwide. We thank all our readers for their continued support and goodwill for IJACSA. We will keep you posted on updates about the new programmes launched in collaboration.

Lastly, 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.

We hope that materials contained in this volume will satisfy your expectations and entice you to submit your own contributions in upcoming issues of IJACSA

Thank you for Sharing Wisdom!

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Machine Learning for Bioclimatic Modelling

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***Abstract*—Many machine learning (ML) approaches are widely used to generate bioclimatic models for prediction of geographic range of organism as a function of climate. Applications such as prediction of range shift in organism, range of invasive species influenced by climate change are important parameters in understanding the impact of climate change. However, success of machine learning-based approaches depends on a number of factors. While it can be safely said that no particular ML technique can be effective in all applications and success of a technique is predominantly dependent on the application or the type of the problem, it is useful to understand their behavior to ensure informed choice of techniques. This paper presents a comprehensive review of machine learning-based bioclimatic model generation and analyses the factors influencing success of such models. Considering the wide use of statistical techniques, in our discussion we also include conventional statistical techniques used in bioclimatic modelling.**

Keywords—Machine Learning; Bioclimatic Modelling; Geographic Range; Artificial Neural Network; Evolutionary Algorithm

I. INTRODUCTION

Understanding species' geographic range has become all the more important with concerns over global climatic changes and possible consequential range shifts, spread of invasive species and impact on endangered species. The key methods used to study geographic range are bioclimatic models, alternatively known as envelope models (Kadmon et al., 2003), climate response surface models (Huntley, 1995), ecological niche models (Peterson & Vieglais, 2001) or species distribution models (Loiselle et al., 2003). Predictive ability lies at the core of such methods as it is the ultimate goal of ecology (Peters, 1991).

Machine Learning (ML) as a research discipline has roots in Artificial Intelligence and Statistics and the ML techniques focus on extracting knowledge from datasets (Mitchell, 1997). This knowledge is represented in the form of a model which provides description of the given data and allows predictions for new data. This predictive ability makes ML a worthy candidate for bioclimatic modelling. Many ML algorithms are showing promising results in bioclimatic modelling including modelling and prediction of species distribution (Elith et al., 2006).

There are diverse applications of ML algorithms in ecology. They range from experimenting bio-geographical, ecological, and also evolutionary hypotheses to modelling species distributions for conservation, management and future planning (e.g., Fielding, 1999; Recknagel, 2001, 2003; Cushing and Wilson, 2005; Ferrier and Guisan, 2006; Park and Chon, 2007). Under the broad umbrella of Eco-informatics (Green et al., 2005) machine learning (ML) is a fast growing area which is concerned with finding patterns in complex, often nonlinear and noisy data and generating predictive models of relatively high accuracy. The increase in use of the ML techniques in ecological modelling in recent years is justified by the fact that this ability to produce predictive models of high accuracy does not involve the restrictive assumptions required by conventional, parametric approaches (Guisan and Zimmermann, 2000; Peterson and Vieglais, 2001; Olden and Jackson, 2002a; Elith et al., 2006).

It may be noted that there is no universally best ML method; choice of a particular method or a combination of such methods is largely dependent on the particular application and requires human intervention to decide about the suitability of a method. However, concrete understanding of their behavior while applied to bioclimatic modelling can assist selection of appropriate ML technique for specific bioclimatic modelling applications.

In this paper we present a concise review of application of machine learning approaches to bioclimatic modelling and attempt to identify the factors that influence success or failure of such applications. In our discussion we have also included popular applications of statistical techniques to bioclimatic modelling.

The rest of the paper is organized as follows: Section II provides an overview of the Machine Learning and statistical methods commonly used in bioclimatic modelling and their applications to bioclimatic modelling; Section III presents an investigation on factors which influence success of such applications; finally in Section IV, we present some concluding remarks.

II. ML & STATISTICAL TECHNIQUES AND THEIR APPLICATION TO BIOCLIMATIC MODELLING

The inference mechanisms employed by Machine Learning (ML) techniques involve drawing conclusions from a set of examples. Supervised learning is one of the key ML inference mechanisms and is of particular interest in prediction of geographic ranges. In supervised learning the information about the problem being modeled is presented by datasets comprising of input and desired output pairs (Mitchell, 1997). The ML inference mechanism extracts knowledge representation from these examples to predict outputs for new inputs. The ML inference mechanism is depicted in Fig. 1.

The relatively more popular bioclimatic modelling applications of statistical and machine learning techniques and features of the relevant techniques are discussed next.

A. Statistical Approaches

1) Generalised Linear Model (GLM)

Generalised linear models (GLM) (McCullagh and Nelder, 1989) are probably the most commonly used statistical method in the bioclimatic modelling community and have proven ability to predict current species distribution (Bakkenes et al., 2002).

Generalised linear model (GLM) is a flexible generalization of regular linear regression. In GLM the response variable is normally modeled as a linear function of the independent variables. The degree of the variance of each measurement is a function of its predicted value.

Logistic regression analysis has been widely used in many disciplines including medical, social and biological sciences (Hosmer and Lemeshow, 2000). Its bioclimatic modelling application is relatively straightforward where a binary response variable is regressed against a set of climate variables as independent variables.

2) Generalised Additive Model (GAM)

Considering the limitations of Generalised Linear Models in capturing complex response curves, application of Generalised Additive Models is being proposed for species suitability modelling (Austin and Meyers, 1996; Seone et al., 2004; Austin, 2007).

The Generalised Additive Model (GAM) blends the properties of the Generalised Linear Models and Additive models (Friedman et al., 1981). GAM is based on non-parametric regression and unlike GLM does not impose the assumption that the data supports a particular functional form (normally linear) (Hastie and Tibshirani, 1990). Here the response variable is the additive combination of the independent variables' functions. However, transparency and interpretability are compromised to accommodate this greater flexibility.

GAM can be used to estimate a non-constant species' response function, where the function depends on the location of the independent variables in the environmental space.

3) Climate Envelope Techniques

There are a number of specialized statistics-based tools developed for the purpose of bioclimatic modelling. Climate envelope techniques such as ANUCLAM, BIOCLIM, DOMAIN, FEM and HABITAT are popular and specialized bioclimatic modelling tools and thus deserve mention here. These tools usually fit a minimal envelope in a multidimensional climate space. Also, they use presence-only data instead of presence-absence data. This is highly beneficial as many data sets contain presence-only data.

Other statistical methods gaining popularity includes the Multivariate Adaptive Regression Splines (Elith et al., 2007).

B. Machine Learning Approaches

1) Evolutionary Algorithms (EA)

Evolutionary Algorithms are basically stochastic and iterative optimisation techniques with metaphor in natural evolution and biological sexual reproduction (Holland, 1975; Goldberg, 1989). Over the years several algorithms have been developed which fall in this category; some of the more popular ones being Genetic Algorithm, Evolutionary Programming, Genetic Programming, Evolution Strategy, Differential Evolution and so on. The most popular and extensive application of Evolutionary Algorithm and more specifically Genetic Algorithm (GA) to bioclimatic modelling has been through the software Genetic Algorithm for Rule-set Production (GARP) (Anderson et al., 2003; Peterson et al., 2001, 2002). Here, we shall restrict our discussion on application of Evolutionary Algorithm to bioclimatic modelling primarily to GARP.

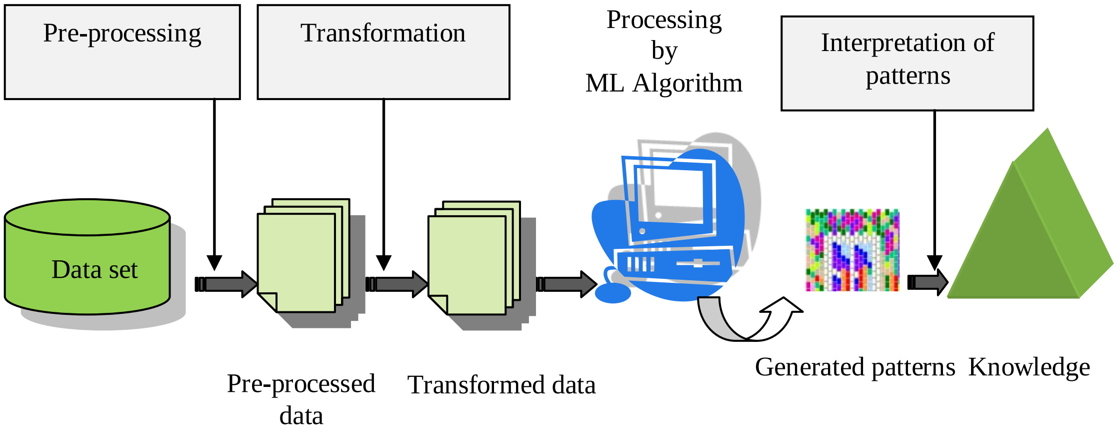
Genetic Algorithm for Rule Set Production (Stockwell and Peters, 1999) is a specialised software based on Genetic Algorithm (Mitchell, 1999) for ecological niche modelling. The GARP model is represented by a set of mathematical rules based on environmental conditions. Each set of rules is an individual in the GA population. These rule sets are evolved through GA iterations. The model predicts presence of a species if all rules are satisfied for a specific environmental condition. The four sets of rules which are possible are: atomic, logistic regression, bio-climatic envelope and negated bio-climatic envelope (Lorena et al., 2011).

GARP is essentially a non-deterministic approach that produces Boolean responses (presence/absence) for each environmental condition. As in case of the climate envelope techniques, GARP also does not require presence/absence data and can handle presence-only data. However, as the "learning" in GARP is based on optimisation of a combination of several types of models and not of one particular type of model, ecological interpretability may be difficult.

Examples of applications of GARP for bioclimatic modelling include: the habitat suitability modelling of threatened species (Anderson and Martı´nez-Meyer, 2004) and that of invasive species (Peterson and Vieglais, 2001; Peterson, 2003; Drake and Lodge, 2006), and the geography of disease transmission (Peterson, 2001).

Other applications of Ganetic Algorithm to ecological modelling include: modelling of the distribution of cutthroat and rainbow trout as a function of stream habitat characteristics in the Pacific Northwest of the USA (D'Angelo et al., 1995) and modelling of plant species distributions as a function of both climate and land use variables (Termansen et al., 2006). McKay (2001) used Genetic Programming (GP) to develop spatial models for marsupial density. Chen et al. (2000) used GP to analyse fish stock-recruitment relationship, and Muttil and Lee (2005) used this technique to model nuisance algal blooms in coastal ecosystems. Newer approaches to use Evolutionary Algorithms for ecological niche modelling are being proposed such as the WhyWhere algorithm advocated by Stockwell (2006). EC has also been applied in conservation planning for biodiversity (Sarkar et al., 2006).

Fig. 1. Steps Involved In The Machine Learning Inference Process



2) Artificial Neural Network (ANN)

A relatively later introduction to species distribution modelling is that of the Artificial Neural Network (ANN) (Manel et al., 1999; Olden et al., 2002b; Pearson et al., 2002; Thuiller, 2003).

Artificial Neural Networks are computational techniques with metaphor in the structure, processing mechanism and learning ability of the brain (Haykin, 1998). The processing units in ANN simulate biological neurons and are known as nodes.

These artificial neurons or nodes are organised in one or more layers. Simulating the biological synapses, each node is connected to one or more nodes through weighted connections. These weights are adjusted to acquire and store knowledge about data. There are many algorithms available to train the ANN.

Some of the noteworthy applications of ANN are as follows: species distribution modelling (Mastrorillo et al., 1997; O¨zesmi and O¨zesmi, 1999), species diversity modelling (Gue´gan et al., 1998; Brosse et al. 2001; Olden et al. 2006b), community composition modelling (Olden et al. 2006a), aquatic primary and secondary production modelling (Scardi and Harding 1999; McKenna 2005), species classification in appropriate taxonomic groups using multi-locus genotypes (Cornuet et al., 1996), modelling of wildlife damage to farmlands (Spitz and Lek , 1999), assessment of potential impacts of climate change on distribution of tree species in Europe (Thuiller, 2003), invasive species modelling (Vander Zanden et al. 2004), and pest management (Worner and Gevrey, 2006). Please see Olden et al. (2008) for further details.

The main advantages of ANNs are that they are robust, perform well with noisy data and can represent both linear and non-linear functions of different forms and complexity levels. Their ability to handle non-linear responses to environmental variables is an advantage.

However, they are less transparent and difficult to interpret. Inability to identify the relative importance and effect of the individual environmental variables is a limitation (Thuiller, 2003).

3) Decision Trees (DT)

Decision Trees have also found numerous applications in bioclimatic modelling. Decision Trees represent the knowledge extracted from data in a recursive, hierarchical structure comprising of nodes and branches (Quinlan, 1986). Each internal node represents an input variable or attribute. They are associated with a test or decision rule relevant to data classification. Each leaf node represents a classification or a decision i.e. the value of the target variable conditional to the value of the input variables represented by the root to leaf path. Predictions derived from a Decision Tree generally involve determination of a series of 'if-then-else' conditions (Breiman et al., 1984).

The two main types of Decision Trees used for predictions are: Classification Tree analysis and Regression Tree Analysis. The term Classification and Regression Tree (CART) analysis is the umbrella term used to refer to both Classification Tree analysis and Regression Tree analysis (Breiman et al., 1984).

Some of the relevant and relatively recent applications of Decision Trees are as follows: habitat models for tortoise species (Anderson et al. 2000), and endangered crayfishes (Usio, 2007); quantification of the relationship between frequency and severity of forest fires and landscape structure by Rollins et al. (2004); prediction of fish species invasions in the Laurentian Great Lakes by Mercado-Silva et al. (2006); species distribution modelling of bottlenose dolphin (Torres et al., 2003);development of models to assess the vulnerability of the landscape to tsunami damage (Iverson and Prasad, 2007). Olden et al. (2008) provides a more complete list.

The obvious advantage of the Decision Trees is that the ecological interpretability of the results derived from them is simple. Also there are no assumed functional relationships between the environmental variables and species suitability

TABLE I. COMPARISON OF SOME OF THE RELEVANT CHARACTERISTICS OF ML TECHNIQUES

Characteristic	GLM	DT	ANN	EA
Mixed data handling ability	Low	High	Low	Moderate
Outlier handling ability	Low	Moderate	Moderate	Moderate
Non-linear relationship modelling	Low	Moderate	High	High
Transparency of modelling process	High	Moderate	Low	Low
Predictive ability	Low	Moderate	High	High

(De'Ath and Fabricius, 2000; Roguet et al., 2001; Vayssieres et al., 2000).

Despite their ease of interpretability, Decision Trees may suffer from over-fitting (Breiman et al., 1984; Thuiller, 2003).

Some relevant characteristics of different ML techniques are depicted in Table 1. Also see Olden et al. (2008).

III. FACTORS INFLUENCING SUCCESS OF ML APPROACHES TO BIOCLIMATIC MODELLING

While it is not that straightforward to identify the causes of success or failure of applications of the Machine Learning techniques to bioclimatic modeling, in this section we attempt to outline some of the factors which may impact their performance broadly. However, this is not to undermine the fact that success or failure of any machine learning application is predominantly dependent on the specific application.

A. *Very large data sets*

Data sets with hundreds of fields and tables and millions of records are commonplace and may pose challenge to the ML processors. However, enhanced algorithms, effective sampling, approximation and massively parallel processing offer solution to this problem.

B. *High dimensionality*

Many bioclimatic modeling problems may require a large number of attributes to define the problem. Machine learning algorithms struggle when they are to deal with not just large data sets with millions of records, but with a large number of fields or attributes, increasing the dimensionality of the problem. A high dimensional data set pose challenges by increasing the search space for model induction. This also increases the chances of the ML algorithm finding invalid patterns. Solution to this problem includes reducing dimensionality and using prior knowledge to identify irrelevant attributes.

C. *Over-fitting*

Over-fitting occurs when the algorithm can model not only the valid patterns in the data but also any noise specific to the data set. This leads to poor performance as it can exaggerate minor fluctuations in the data. Decision Tress and also some of the Artificial Neural Networks may suffer from over-fitting. Cross-validation and regularization are some of the possible solutions to this problem.

D. *Dynamic environment*

Rapidly changing or dynamic data makes it hard to discover patterns as previously discovered patterns may become invalid. Values of the defining variables may become unstable. Incremental methods that are capable of updating the patterns and identifying the patterns of changes hold the solution.

E. *Noisy and missing data*

This problem is not uncommon in ecological data sets. Data smoothing techniques may be used for noisy data. Statistical strategies to identify hidden variables and dependencies may also be used.

F. *Complex dependencies among attributes*

The traditional Machine Learning techniques are not necessarily geared to handle complex dependencies among the attributes. Techniques which are capable of deriving dependencies between variables have also been experimented in the context of data mining (Dzeroski, 1996; Djoko et al., 1995).

G. *Interpretability of the generated patterns*

Ecological interpretability of the generated patterns is a major issue in many of the ML applications to bioclimatic modeling. Applications of Evolutionary Algorithm and Artificial Neural Networks may suffer from poor interpretability. Decision Trees on the other hand scores high in terms of interpretability.

Other influencing factors, which are not directly related to the characteristic of Machine Learning techniques, are as below.

H. *Choice of test and training data*

Various reported applications of ML used the following three different means to choose test and training data: *re-substitution* – the same data set is used for both training and testing; *data splitting* – the data set is split into a training set and a test set; independent validation – the model is fitted with a data set independent of the test data set. Naturally, independent validation is the preferred method in most cases, followed by data splitting and then re-substitution. The results obtained by data splitting and re-substitution may be overly optimistic due to over-fitting (Jeschke and Strayer, 2008). However, the choice of one technique over the other is also problem dependent. Only a small segment of the reported studies seems to use independent validation.

I. *Model evaluation metrics*

The measure of model performance or the model evaluation technique should ideally be chosen based on the purpose of the study or the modeling exercise. It is thus perfectly understandable that different authors have used different evaluation metric for their specific studies. Pease see the following literature for further discussions on choice of evaluation metrics: Fielding & Bell (1997); Guisan & Zimmermann (2000); Pearce & Ferrier (2000); Manel et al. (2001); Fielding (2002); Liu et al. (2005); Vaughan &

TABLE II. FACTORS INFLUENCING APPLICATION OF ML TECHNIQUES TO ECOLOGICAL MODELLING

Factor	Impact on ML technique	Possible solution
Very large data sets	EC, ANN and DT all are adversely effected	Enhanced algorithms, effective sampling, approximation; massively parallel processing
High dimensionality	EC, ANN and DT all are adversely effected	Reducing dimensionality; using prior knowledge to identify irrelevant attributes
Over-fitting	DT and some of the ANNs are adversely effected	Cross-validation; regularization
Dynamic environment	EC, ANN and DT all are adversely effected	Incremental methods capable of updating the patterns and identifying the patterns of changes
Noisy and missing data	DT is better equipped to handle this problem compared to others	Data smoothing; Statistical strategies to identify hidden variables and dependencies
Complex dependencies among attributes	EC, ANN and DT all are effected; however, handles better than traditional techniques such as GLM	
Interpretability of the generated patterns	EC = poor interpretability; DT and ANN= moderate to high interpretability	
Choice of test and training data	Effects EC, ANN and DT	Depends on goal of the study; however, generally independent validation is better than others
Model evaluation metrics	Effects EC, ANN and DT	Depends on goal of the study

Ormerod (2005); Allouche et al. (2006).

Table 2 summarises the factors influencing application of ML techniques to ecological modelling. Also see Jeschke et. al. (Jeschke and Strayer, 2008) for a list on comparative performances of ecological modelling techniques as observed in some of the selected studies found in the literature.

As can be seen, none of the modeling techniques is universally superior compared to other techniques across all applications. Comparative performances of the three traditional methods, namely, GLM, GAM and climate envelope model, shows GAM and GLM have comparable performances. Among the Machine Learning methods, the popular GARP technique produces moderate performance, while CART and ANN have shown mixed results. It may be noted that these examples did not include adequate number of applications of ANN. Jeschke and Strayer (2008) have reported, overall, ANN performs better among the ML techniques applied to this problem domain. Robustness is a characteristic often attributed to ANN. The findings by Jeschke and Strayer (2008) also validate this claim. The specialized climate envelope techniques such as BIOCLIM, FEM and DOMAIN show only moderate performance in general and often perform worse than the Machine Learning techniques. However, some of the relatively recent comparisons have claimed that newer techniques are likely to outperform more established techniques (e.g. the model-averaging random forests by Lawler et al. (2006) and Broennimann et al. (2007); the Bayesian weights-of-evidence model by Zeman & Lynen (2006)). However, as these methods have been used only in a handful of studies, claims about their predictive power is premature (Jeschke and Strayer, 2008). Finally, this comparative study reiterates the fact that success and failure of inductive, data-driven techniques such as the machine learning techniques are primarily dependent on the application, including the complexity and representativeness of the data set and the goal of study.

IV. CONCLUSION

This paper presented a comprehensive review of applications of various Machine Learning techniques to bioclimatic modelling and broadly to ecological modelling. Some of the statistical techniques popular in this application domain have also been discussed. Factors influencing the performance of such techniques have been identified. It has been concluded that success or failure of application of the Machine Learning techniques to ecological modeling is primarily application dependent and none of techniques can claim superior performance as against other techniques universally. However, the identified factors or characteristics can be used as a guideline to select the ML techniques for such modeling exercises.

Some of the issues that future researches may consider are as follows:

- Hybrid ML techniques have been successfully tried in various applications; this is still underutilized in bioclimatic modelling. Suitable hybrid methods may be useful in handling complexities such as the extreme variability, intermittence and long range correlation involved with the hydro-meteorological fields.

- Goal of the research should be a key driver influencing the choice of the ML technique. For example: ANN would be a good choice where visualization is important; ANN also works well where the intent is to reveal the nature of relationships between the input (driver) and the output variables in the ecosystem; Adaptive agents can be used to predict the structure and behavior of emergent ecosystems in response to environmental changes.

- Machine learning techniques are essentially data-driven techniques. It is important that the dataset is representative of the problem. This includes both the variables considered and the source of data. For example, modelling of species distribution may sometime require pooling of data from populations with very different demographic and ecological history.

- Further research is required about transparency of the modelling process and more importantly the interpretability of the models for ML–based bioclimatic modelling.

Finally, in the bio-climatic modelling context, it is important to remember that the ML techniques are not meant to replace the human experts, but to provide them with powerful tools for prediction, explanation and interpretation of bio-climatic phenomena.

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Toward the Integration of Traditional and Agile Approaches

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Abstract—**The agile approach uses continuous delivery, instead of distinct procedure, to work closer with customers and to respond faster requirement changes. All of these are against the traditional plan driven approach. Due to agile method's characteristics and its success in the real world practices, a number of discussions regarding the differences between agile and traditional approaches emerged recently and many studies intended to integrate both methods to synthesize the benefits from these two sides. However, this type of research often concludes from observations of a development activity or surveys after a project. To provide a more objective supportive evidence of comparing these two approaches, our research analyzes the source codes, logs, and notes. We argue that the agile and traditional approaches share common characteristics, which can be considered as the glue for integrating both methods. In our study, we collect all the submissions from the version control repository, and meeting notes and discussions. By applying our suggested analysis method, we illustrate the shared properties between agile and traditional approaches; thus, different development phases, like implementation and test, can still be identified in agile development history. This result not only provides a positive result for our hypothesis but also offers a suggestion for a better integration.**

Keywords—Source Code Analysis; Software Data Mining; Agile Development

I. Introduction

Developing a modern software system becomes very challenging due to the increasing customer demands on more functions and higher quality. Especially, when software engineers face this challenge under very dynamic market, how to change their software or service in order to satisfy the need of faster delivery, better quality and lower cost rises many discussions [1, 2].

Recently, many suggestions for improving software development methods have come from real world practitioners. The main trend is the agile method. Unlike traditional development method, which requires a disciplined and distinct procedure, the agile development places the highest priority on satisfying the customer needs through continuous delivery [3, 4]. It emphasizes on rapidly iterations with the focus on working software so it can embrace closely customer collaboration by using faster responses to changing needs.

In addition, the theory behind the traditional methods is that all the requirements can be defined at the beginning of the system building process and a sequence of well-articulated tasks like systems planning, analysis, architecture, design, development, and testing can be explicitly defined [5]. Therefore, the development process is systematic, and the boundary of each task can be clearly identified. On the other hand, the agile method is more chaotic. It contains the evolutionary delivery through short iterative cycles that blending planning, action, and testing activities within intense human collaboration.

Software industry found that agile process fits small and stand-alone projects better. Developers and managers have difficulties to scale up and to integrate agile practices into the organization that already has well-defined traditional process. Therefore, industry seeks a solution of integrating agile and traditional methods so their benefits can be synthesized [18].Past studies have discussed the agile method in the area of focusing on the integration of both traditional and agile developments or comparison of these two different methods [6]. Those suggested integration methods and the comparison studies are mostly inferred from the description of development activities or the review of the process. But, there are not any comparison research or any integration method, which has previously been published in the aspect of source code and design artifact's data analysis. Therefore, one shortcoming of these studies is lacking of supportive evidences from scientific data analysis. To remedy this, we would like to investigate how the agile method is executed in practices and what their results or effects look like. We argued that agile and traditional developments should still share many similar characteristics although the whole agile development could be chaotic due to putting various tasks together in a single iteration. Once we identify different phases, such as requirement defining, implementation, and testing in the whole agile development history, how to integrate traditional and agile methods or how to compare them can be further developed.

In this paper, we investigate the history of a software project, which is developed by the agile approach. By cross-referencing the source code and analysis of development log and meeting notes, we identify several characteristics of the agile development. We find that agile project development is not so chaotic. It still demonstrates systematic aspects, like the traditional software development.

The rest of this paper will be organized as follows. Section 2 will explore the related research. Section 3 will discuss the detailed differences between agile and traditional software developments. Section 4 will explain the analysis method.

Section 5 will show the analysis results and then discuss them. Finally, we will conclude our research and explain our future research.

II. Related Work

Many past studies reveal the differences or contradictions between traditional and agile developments, tried to integrate both methods by applying the agile method to traditional approach. Parsons and Lai [7] discussed the hybrid approaches in the software quality perspective and argued the differences based on the statistics. Manhart and Schneider [8] showed the integration of agile and traditional methods an industrial case study. They claimed that both approaches shared the common developing goal but had different kinds of emphases. Armitage [9] described another hybrid approach that overlays the agile process with higher level design approaches in order to assist refactoring. Turner and Jain [10] researched the culture clash between the agile and Capability Maturity Model Integration (CMMI) processes. Lycett et al [11] suggested a situated process framework, in which, patterns are developed through a situated examination of contextual characteristics (e.g., project, product, or team)and expressed as Rational Unified Process (RUP) development cases. Alegria and Bastarrica [12] discussed the way to reach CMMI level 2's certification by implementing agile methods like Scrum and Extreme Programming (XP).

Several previous reviews were also published to introduce characteristics of the agile method by comparing both agile and traditional approaches. Cohen et al.'s [13] explored the history of agile development, and particularly discusses relations between agile development and the Capability Maturity Model (CMM). Wang et al. introduced the contradictions in the agile development and used a paradoxical perspective to deal with them. Nerur et al. explored the differences and pointed out the challenges of changing to the agile method.

Most past research proposed their integrated approach by inserting the agile method into traditional development because their assumption is that the developer can treat traditional approach as an outline and then add the agile activities inside each major phase. However, the validation of this type of study lacks of the perspective of the data analysis about the delivered artifacts. With the implementation data analysis supports, the differences between agile and traditional development can become clearer and both methods' benefits can be synthesized seamlessly.

III. Agile And Traditional Software Development

A. Agile vs Traditional software Development

One major reason to cause the failure of a software project is that the built software system cannot be delivered on time. Even if the software can be delivered on time, it may not satisfy all the customer's expectations. As a result, agile software development is created to solve these problems. However, agile methods also face some critics, for example, insufficient architecture planning, over-emphasis on early results, and low levels of test coverage. These shortages can also be explicitly observed and understood while two development process models are compared.

In the traditional software development, each step in the process is clear. One must start only after the previous step is completed. On the other hand, software engineers who use the agile development do not wait for prior procedure to complete (see Fig. 1). Each iteration, engineers review their results, and then modify and test the product in the next iteration.

B. Observation of Source Code Changes

The implementation in traditional software process usually starts after a thought-through design. The amount of source codes usually increases largely during the early phase of development because most function has been implemented. After the main structure of the system becomes steady, the lines of source codes gradually increase or decrease. Thus, the source codes in the traditional method do not have dramatic dynamic changes (i.e., rapidly increase or decrease in a large amount) at anytime in the whole development.

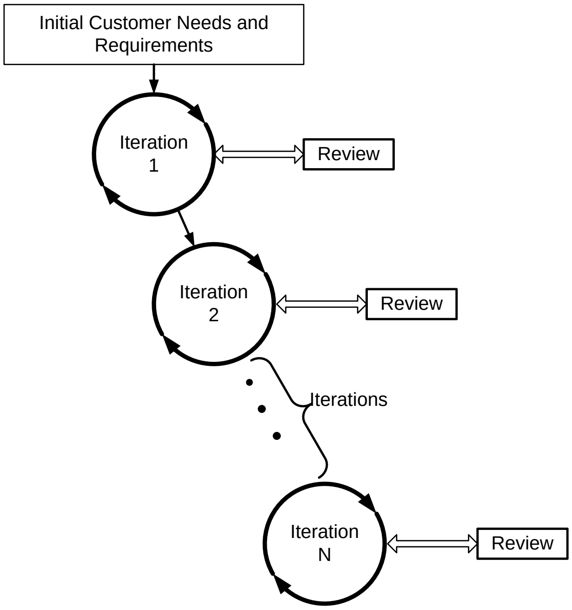

Fig. 1. Agile Software Development Process

However, the agile method shows very differently. The key characteristic of the agile method is rapid iteration. After every time's iteration, the release tries to meet customer's requirements. If not, changes should immediately happen in the next iteration. The amount of source code change depends on customer's review result. Due to no solid development planning, it is very possible to have changes about major structure adjustment. In addition, requirements during the whole development could change very often. As a result, the source codes change largely. However, we argue that the agile development can also demonstrate certain similar characteristics as traditional development. In our analysis, we would like to investigate this observation.

IV. Analysis

A. Scope of Application

Our method targets the analysis of agile development project. The agile development team's software release and team meeting is weekly. Although primary software releases and weekly meetings are stored, between two weekly releases, there may still many development versions committed in the repository as well as many discussions, and documents are saved. Therefore, our analysis method will be applied to these data.

B. Data Analysis Method

There are three major stages in our analysis. We firstly collect data from the agile development project. In second stage, we eliminate insignificant versions from our collected dataset in order to reduce the efforts of the analysis. Lastly, we identify those phases, such as requirement, software architecture, implementation, or testing, as we define in the traditional development. Finding these phases is the key step in our justification of our source analysis hypothesis.

1) Data collection and engineering

Three types of data are collected from the project: meeting notes, source codes, and version logs. Two programs are written for collecting those data. The first program extracts all the source codes and version logs from Subversion (SVN) version control repository. Since the weekly meeting notes are written in the MS Power Point or Word formats and discussions are posted the internal wiki website. These textual data are first extracted by the other program and then are reorganized in to a time series structure. Using this time series structure can help us to specify various phases according to the project's development timeline.

2) Identify key versions and development task

Because many versions are only saved for records, their modifications are small and cannot reflect structure altering, important designer's decisions, or requirement changes. To avoid analyzing these trivial versions, one of our jobs is to identify the key versions in the development history. We use two ways to identify key versions - source code and text analyses.

a) Source code analysis

One characteristic of key versions in the source code analysis is that the amount of code change is substantial. Therefore, by comparing the number of source line of code (SLOC) in two sequential versions, those key versions can be identified. More importantly, in a source analysis diagram (e.g., SLOC VS version), the key version points can match the shape of the curve and capture the turning points.

To determine the key versions, we develop three methods to extract those versions that match significant changes. The first method calculates the slop change (*SC*) against three consecutive versions (see Fig. 2).

$$SC = (Vn+1 - Vn) / (Vn - Vn-1) \qquad (1)$$

Vn is the measured value (e.g., SLOC in the SLOC VS version diagram) at version n, *Vn+1* represents is the measured value at version *n+1*, and *Vn-1* represents is the measured value at version *n-1*.

This *SC* represents the angle between two tangents from two sequential versions. Once the *SC* exceeds the threshold, the key versions can be extracted.

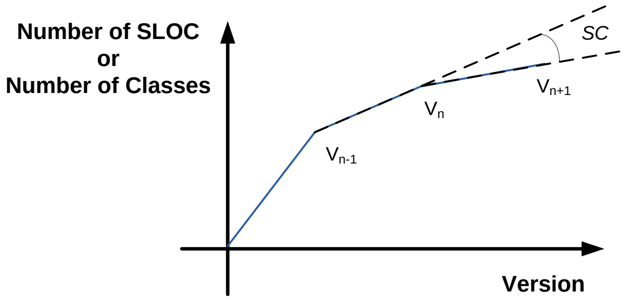

Fig. 2. The Calculation of the Slope Change

The second method extracts key versions based on the calculation of the relative difference *RC* between two sequential versions (see Fig. 3).We can also setup a threshold to determine if a version is the key version. The equation below is to calculate the relative changes *RC*.

$$RC = (Vn - Vn-1) / Vn-1 \qquad (□2)$$

Vn is the measured value at version *n* (e.g., SLOC in the SLOC VS version diagram), and *Vn-1* represents is the measured value at version *n-1*.

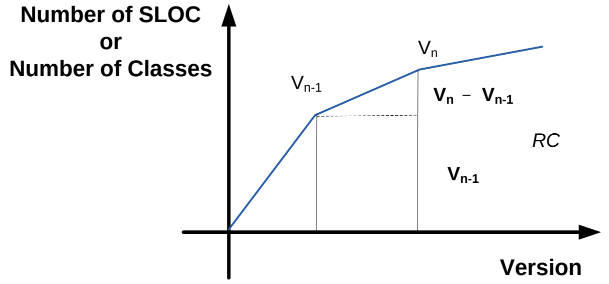

Fig. 3. The Calculation of the Relative Change

The third method is very similar to the second one. Instead of calculating the relative change, we compute the direct difference based on a normalized curve. The normalized values are calculated based on the measured value divided by the maximum value; for example, each number of SLOC divided by maximum number of SLOC. After we get the normalized values, we can direct calculate the difference using the formula below.

$$DC = (Vn - Vn-1) \qquad (3)$$

DC is direct change, *Vn* is the normalized value at version *n*, and *Vn-1* represents the normalized value at version *n-1*.

To avoid missing any significant modifications or possible key version, the union of all the above three method's results is the entire key version set.

b) Text analysis

We applied text analysis in the developer's meeting notes and version logs. Since text analysis could be very time consuming, rather than analyzing every version's log, only key version's log is used.

This method firstly detects the keywords according to its frequency, developer's descriptive guideline, or common terminologies. For example, in the log "fixed the bug no 23", "bug" and "fix" can be two keywords which represent correcting the program to satisfy the functional requirement. Then, we manually identify the description about requirements or development planning from meeting notes. After we analyze the meeting notes and version logs, we can decide which type of development task, such as debugging, building new function, or testing, is the major activity between two versions.

3) *Identify different phases*

To identify different phases, we need to do cross-referencing between the result of source code and text analysis. The source code analysis tells us that which versions are representative in the whole version history. The text analysis shows the type of development activity between two versions. With combining these two kinds of outcomes, we can further understand the major development activity within a period of time. In addition, the meeting note analysis result can also be used to verify if the phase that we identify is valid or not.

V. Results And Discussions

A. *Case Study Project Background*

The agile project that we investigate is called Visualization of Attack Surfaces for Targeting (VAST). This is a tool that is developed based on the Eclipse plug-in framework. The VAST tool provides multi-column code viewer with bread crumb trail so that it helps code auditors to retrace their thought processes and shows source code overview in context of the software vulnerability. The tool is developed by a five developer's product team in the Information Sciences Institute. The entire developing time is 18 months, and 841 versions are committed.

The team follows many methods that the agile practices proposed during entire development. First, their customer worked closely with the team, like one of the team members. The customer immediately clarifies their needs and identifies the priority. The team does not hold any meetings to layout the whole system structure; instead, customers reveal the expected user interfaces. Second, the tool is released weekly, an acceptance test is applied, and the customer discusses the expectation in the next release. Third, the team has daily meet like scrum to know each member's obstacles and status. Lastly, the team keeps refactoring the code. In addition, team members also use an internal wiki site to maintain all the documents, discussions, learning, and meeting notes. Since there is a software release every week, in the initial stage of the project, the VAST team does not spend much time to work on the software architecture; instead, they quickly divide the task and start to build the software. The team expects the software will finally change while they have better understanding on design and customer's needs after several iterations.

B. *Key Version Extraction*

We apply equation (1), (2), and (3) to all the version history in order to identify those key versions. In equation (1), (2), and (3), we use 0.2, 0.2, and 0.15 as thresholds, respectively. The entire key version is the union set of the results of all these three equations. In Fig. 3 and 4, we pick those key version points on the both original SLOC and Number of Classes curves, respectively Then, we connect all the points to form a curve that matches the original graph. The matching curves in both Fig. 4 and 5 obviously still reserve the characteristics of the original curves. This shows that the matching curves should be able to have enough significance to represent the original curves. Therefore, we have confidence to use these key versions to do our next step analysis.

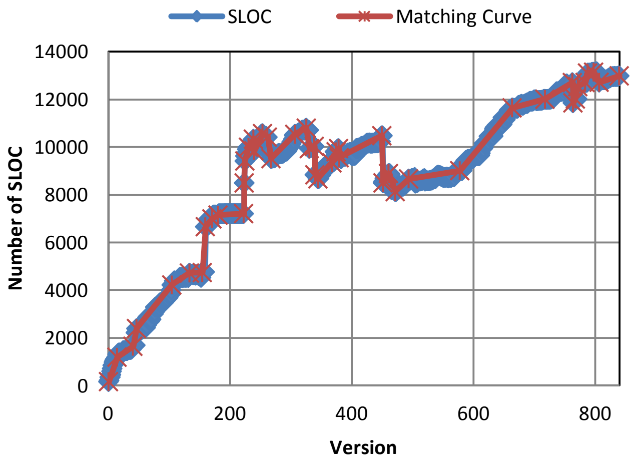

Fig. 4. Version VS SLOC and Its Matching Curve

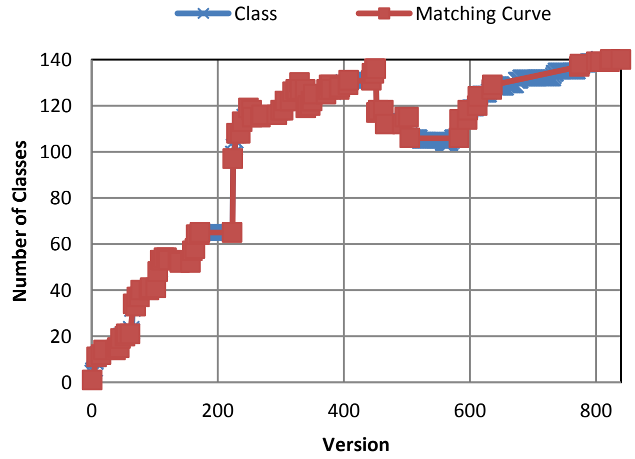

Fig. 5. Version VS Number of Classes and Its Matching Curve

Fig. 6 shows the normalized matching curves of Number of Classes and Number of SLOC. All the versions in Fig. 6 are potentially the points that separate two different phases. Therefore, by investigating the meeting notes, documents, and discussions, we can validate separation points and detect different type of development stage. In our text analysis, except the logs of task assignment (e.g., developer X should work on task 1), three kinds of descriptions can be identified. They are functional, modification and testing or debugging descriptions. The log also tells the re-factored versions that are those sharp change points in matching curve. As well, in the meeting notes, we can find when customers stop to request modification of the system due to the stabilized needs. By knowing this time points and various types of descriptions in the logs, through a cross-reference between discussion, logs, and meeting notes, we can be divided the whole development history into four phases: (1) customer needs to requirements (from version 1 to 173) (2) developer's learning and research (from version 174 to 264) (3) implementation and testing (from version 264 to 625) (4) debugging (from version 626 to the end of development - version 841).

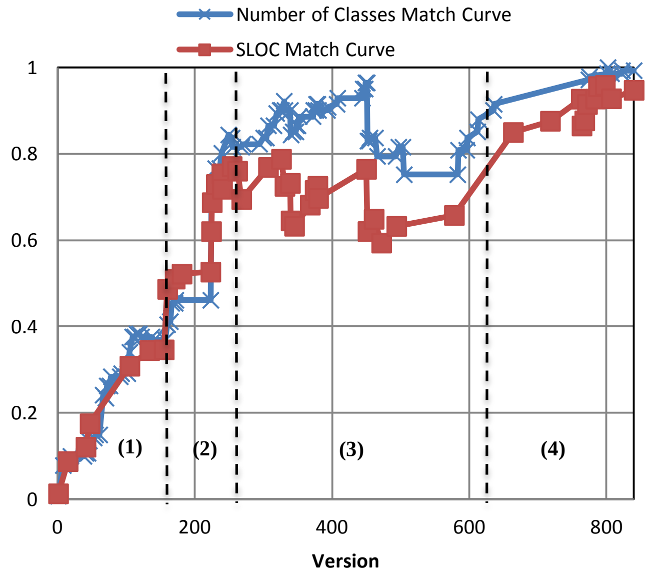

Fig. 6. Normalized Matching Curves of Version VS Number of Classes and Version VS SLOC

Moreover, Fig. 6 also implies that the functional change should be less or adding function is completed when the development reaches a point where the whole system and requirements are more stable (i.e., the end of the second phase). After this point, the development activities turn to be focusing on testing and debugging.

VI. Conclusion And Future Research

The agile approach recently becomes a main trend in both industry and academia. Due to this, many studies try to understand the differences between this new and old development approaches to gain a balance between them, and then the benefits of these two methods can be synthesized. While there is no concrete data analysis of the implementation to support the integration of both methods from past research, our research particularly uses source code and design artifact analysis to complement the type of study.

In our source analysis method, we capture the characteristics of the SLOC VS version curve and then using this normalized skeleton curve to specify each development phase as traditional plan driven approach. From our case study result, we find that agile and traditional approaches share common features. The agile development has distinguished each phase like traditional process. This provides a data analysis evidence of the integration. We discover that the agile activities can be treated as the sub-activities in primary development phase. Our research may lack of the suggestion from management's point of view but we do provide another perspective to the agile approach.

Since our paper only contains one project data analysis, in the future, we should collect multiple projects' data in order to strengthen our conclusion. In addition, we may also apply our source code analysis to enhance the software process improvement so that the integration can be more precise and seamless. Particularly, we would like to further research about offering good advices for managing a software project that could adopt the agile method.

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Universal Learning System for Embedded System Education and Promotion

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Abstract—**In this article, the idea of the universal learning system for embedded systems is presented. The proposed system provides a complete learning environment consisting of the information collection center, preference estimation system, Q&A center, forum, and virtual classroom. The skeleton of the proposed system is a preference estimation system, which helps users know the relationship between different hardware kits and suggests suitable hardware kits to users to learn embedded systems. Then, the proposed system provides the virtual classroom and Q&A service for users to start their classes. Besides, users can share design samples and experience, and join discussions through the forum of the proposed system. For demonstration, three embedded hardware platforms are introduced and applied by the proposed learning system. The results show that most students feel the proposed learning system can effectively help with their embedded software design.**

Keywords—Embedded system; Distance learning; Computer science education

I. Introduction

Due to the rapid development of electronic technology and requirements of electronic markets, electronic products tend to become smaller, faster, and more popular. In Europe, nearly 50% of the 100 biggest companies have invested in embedded systems research [1]. This implies the increasing requirements of the talents of embedded systems. More and more educators put emphasize on this area [2]-[9] as well. However, the great diversity of electronic products and applications also lead to inconvenience in education of embedded systems because it is difficult to learn all software design skills from the same embedded hardware platform.

Therefore, more and more embedded hardware platforms are developed and used in different courses for various applications, such as data sensing or video compression. When learning embedded software design, students usually encounter three difficulties. First, software resources are dispersive or unavailable on the Internet, so it is difficult for students to search for these resources. Second, the selection of embedded hardware platforms might not only confuse students but also educators. Third, time and locations for learning are confined. This might cause great inconvenience to students and thus restrict the growth of manpower.

Considering the above problems, the idea of the universal learning system is proposed in this article. The proposed system is constructed and maintained by National Chip Implementation Center (CIC) [10] in Taiwan, a national research and service center supported by Taiwan government for IC education and promotion. The universal learning system contains five parts, the information collection center, preference estimation system, Q&A center, forum, and virtual classroom. The skeleton of the universal learning system is the preference estimation system, which helps users make comparisons and selections among different hardware kits. In the preference estimation system, the features of hardware kits are visualized and personalized according to the user preference. These features are mapped to points in a low-dimensional coordinate system, so a user can easily tell the relationship between the user preference and hardware kits. Finally the proposed system can suggest the most suitable hardware kit for the user. After a user selects the hardware kit to learn, he can take courses in the virtual classroom and search for relevant resources such as documents and design samples in the information collection center. Besides, the user can join discussions and share experience or resources in the forum. Moreover, the Q&A center in the proposed system can be viewed as a unified window between users and vendors. The experts in CIC help users answer questions or forward questions to the vendor. Therefore, the preference estimation system can provide a solution to let users learn embedded systems anytime and anywhere.

A case study is presented to demonstrate the performance of the universal learning system. Three embedded hardware platforms [11]-[13] are imported into the proposed system. For each hardware platform, a short course is carefully designed according to the features of this hardware platform. A user can choose the hardware platform and take the course according to the suggestion of the preference estimation system. The student feedback shows that most students agreed the proposed system could help their study in embedded software design.

This article is organized as follows. In the next section, we give an overview of the universal learning system. Then the preference estimation system is presented in Section 3. In Section 4, a case study is described. In the case study, three embedded hardware platforms are introduced and imported to the proposed system. Some discussions and student feedback are also given in the same section. In the last section, a summarization and future works are presented.

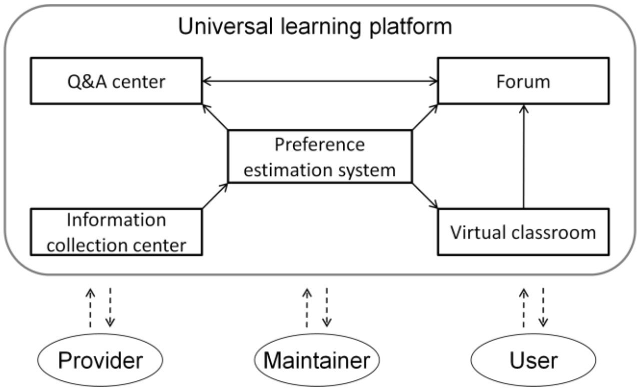

Universal learning platform
Q&A center
Forum
Preference estimation system
Information collection center
Virtual classroom
Provider
Maintainer
User

Fig. 1. The Architecture of the Universal Learning System

II. Overview of the Universal Learning System

There are three kinds of participants in the universal learning system, Provider, Maintainer, and User. These participants share information together, such that the proposed system can work correctly. The role of each kind of participant is described as follows:

1) Provider: A provider provides information of hardware kits to the universal learning system, and gets feedback from users. A provider is usually the vendor providing hardware kits, documents, design samples, and consulting. Besides, a provider can be also an educator or learner that provides experience and design samples.

2) Maintainer: The maintainer is in charge of maintenance and update of the universal learning system, and transforms information from the provider to helpful statistics for users. For example, the maintainer delivers courses and evaluates hardware kits in the universal learning system. Besides, the maintainer also forward questions or suggestions of users to the provider, so this role can be viewed as a unified window between the provider and users. Therefore, the experts, rich resources, and a good relationship with the provider are three necessary conditions of the maintainer. As an IC research and service center in Taiwan, CIC has sufficient resources and enough experts supported by Taiwan government. Besides, CIC also has a close relationship with both vendors and universities. Thus CIC is very suitable for the role of the maintainer.

3) User: A user is able to access information and get suggestions of the universal learning system, take courses, join discussions, ask questions, and share experience and design samples. Besides, it is also important that the provider and maintainer can get feedback from users. Students and teachers are major users of the proposed system.

The purpose of the universal learning system is to help users select a suitable embedded hardware kits according to the requirements, and then provide a friendly learning environment to users. Based on the objective, the proposed system is categorized to five parts, as described below:

1) The information center collecting dispersed resources together: While surveying hardware kits, a user usually faces a problem: requested resources (i.e., documents, samples, etc.) are unavailable or dispersed. This is because the resource providers could be different organizations or users, so the user must search for resources through different manners, such as official website, attached CD of the hardware kits, forums, classmates, etc. The universal learning system collects these resources together, so every user can easily get required resources and information on the proposed system.

2) The preference estimation system for hardware kits: Another key problem that might be encountered by users is the selection of hardware kits. Since there are numerous hardware kits designed by different vendors for various purposes, the wide diversity usually confuses users. Therefore, the preference estimation system is proposed here to analyze the user preference, compare the features of different hardware kits, and then visualize the relationship between user preference and features of hardware kits. Thus a user can easily understand which hardware kits fulfill his requirements.

3) The Q&A center for responses of queries: Frequently asked questions are collected in the question center. Besides, the Q&A service is provided for users. Questions from users will be answered by CIC experts or forwarded to the vendors. Trough the universal learning system, a user can search for the answer of questions and query anytime.

4) The forum sharing experience and feedback: The proposed system also provides a forum for users to share their learning experience and report bugs. Vendors can get user responses as their reference to improve their products.

5) The virtual classroom for online learning: CIC experts deliver embedded system courses every summer and winter vacation. All video recorded courses can be accessed by users from the universal learning system. Besides, virtual laboratory such as virtual platforms or remote laboratory will be provided in the virtual classroom as well, so that a user can learn both knowledge and practical design experience in the virtual classroom anytime and anywhere. In the future, every user can register on-line as a lecturer or student. A lecturer could give courses and recruit students. CIC will be responsible for the quality of every course.

The architecture of the universal learning system is illustrated in Figure 1. From the selection of hardware kits, learning, laboratory, query, till discussion and sharing experience, the proposed system provides a complete learning environment to users. The arrows shown in Figure 1 represent several possible learning orders of users. For example, a user can have a survey in the information collection center first. Next, the preference estimation center help the user compare the relationship between user preference and hardware features, and then give a suggestion about suitable hardware kits for the user. After the user decides which hardware kit to use, he can take relevant courses in the virtual classroom and join discussion in the forum. The user can also ask questions in the Q&A center if he cannot get required information in the forum.

When a hardware kit and relevant resources are sent to CIC, CIC will start analyzing and evaluating the hardware kit. In the first step, experts of CIC have to understand how to use the hardware kit in depth. Then according to specifications and

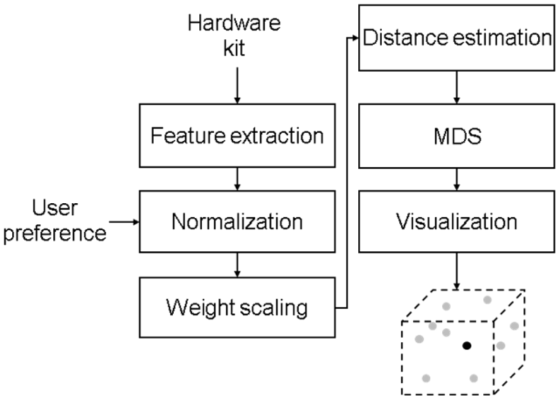


Fig. 2. The Steps To Visualize The Relationship Between Hardware Kits

user experience, the hardware features are extracted into the preference estimation system. After that, design samples will be collected or created by CIC experts in the information collection center. Next, CIC lecturers will deliver related courses. The courses content including lectures and teaching materials will be uploaded to the virtual classroom. The virtual platform is also going to be built up if the vendor is willing to provide detailed specification of the hardware kit to CIC. Meanwhile, an exclusive discussion board will be provided in the forum and question center, such that users can share experience and ask questions. In this article, we put emphasis on description of the preference estimation system because it is the most important part in the universal learning system.

III. Preference Estimation System

The spirit of the universal learning system is the preference estimation system. Before learning embedded systems, the most important thing is selecting a correct hardware kit that corresponds to the user requirements. In this section, we describe the components of the preference estimation system, which has several features:

- Extraction of features from a hardware kit for users.
- Visualization of the relationship between hardware kits.
- Visualization of the user preference.
- Suggestion of suitable hardware kits for users.

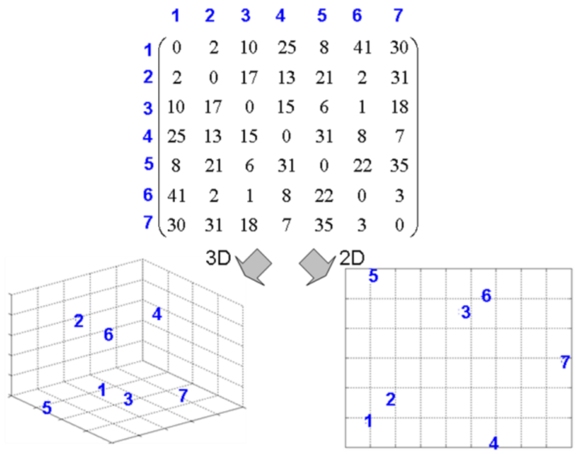
Figure 2 illustrates the flow chart of visualizing the hardware features and user preference. In the proposed system, every hardware kit is mapped to a point in a low dimensional coordinate system, such as a 3D cube, 2D plane, or even a 1D line, where the distance between two points illustrates how similar they are. For this purpose, we have to extract the features of every hardware kit first, and then transform these features to a feature vector. After normalization and weight scaling, these feature vectors are used to measure the distance between each other. Here the Euclidean distance is applied to represent the degree of similarity between two feature vectors. Then we can get a dissimilarity matrix describing the relationship between each pair of feature vectors. However, it is still inconvenient for users to search for relationship in this big matrix, so we use multidimensional scaling [14] to transform the relationship to a low dimensional point, so that users can easily understand this relationship. In the following sub-sections, the details of every step are described.

A. Feature Extraction

In order to select a suitable hardware kit, a user may need to collect the specifications and spend much time comparing different hardware kits. It is a difficult task especially for a beginner. To help users make comparisons and decisions, the proposed system collects useful information and extract features for every hardware kit. These features can be classified as three categories, indicating the general information, complexity, and user experience of a hardware kit, respectively. Several objective and subjective feature factors are included to form a feature vector, listed as follows:

1) General Information: The general information shows the brief specification of a hardware kit. This information let users understand the global view and applicable area of a hardware kit, such as the appearance, size, processor type, peripheral information, etc. Thus the difference between hardware kits becomes clearer and more transparent.

2) Complexity: The complexity includes several factors that could influence the learning performance. Basically we consider five factors in this category, but the factors could be inserted, removed, or updated in practice according to the user feedback. These factors are (1) degree of design transparency, (2) number of design samples, (3) processor core speed, (4) depth of Instruction Set Architecture (ISA), and (5) ease of use of Board-level Support Package (BSP). The first factor “degree of design transparency” means if the design of hardware/software components provided by the vendor is visible. For example, the codec inside a design sample is released to all users without charge. Transparent design benefits deep understanding of the foundational concepts behind design ideas and also helps freeware development. The second factor “number of design samples” means if enough design references can be found. These design references can be provided by vendors, CIC, or common users. More design references means a user can be familiar with the hardware kit more deeply and widely. The third and forth factors are related to the core processor of the hardware kit because many users select hardware kits depending only on the characteristic of a core processor. The factor “core speed” denotes the processor speed, which has significant impact on programming strategies. High-speed cores can be used for complex and general-purposed programming, but low-speed cores are only suitable for simple programming or controlling. On the other hand, high-speed cores usually cost more energy than low-speed ones. In addition to the core speed, “ISA depth” indicating the bit-depth of the instruction set is also important. A long instruction set is usually more complex than a short instruction set. The last factor “ease of use of BSP” means if the board-level support package (BSP) is easy to use. The rating of this factor is evaluated by CIC experts based on their experience. The rated score depends on the user interface, function supports, and integrity of BSP. Note that high complexity does



$$\begin{array}{c|ccccccc} & 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ \hline 1 & 0 & 2 & 10 & 25 & 8 & 41 & 30 \\ 2 & 2 & 0 & 17 & 13 & 21 & 2 & 31 \\ 3 & 10 & 17 & 0 & 15 & 6 & 1 & 18 \\ 4 & 25 & 13 & 15 & 0 & 31 & 8 & 7 \\ 5 & 8 & 21 & 6 & 31 & 0 & 22 & 35 \\ 6 & 41 & 2 & 1 & 8 & 22 & 0 & 3 \\ 7 & 30 & 31 & 18 & 7 & 35 & 3 & 0 \end{array}$$

Fig. 3. An Example Of MDS From 7×7 Dissimilarity Matrix To 3D And 2D Coordinating System

not always imply high difficulty to learn this hardware kits. They are just references for users to select a hardware kit corresponding to the requirements.

3) User Experience: The above two categories are considered from the view of the hardware kit, but it is also important to consider the view of users, so that users can realize how others think about the hardware kit. Therefore, the proposed system allows users voting on-line and leaves comments about every hardware kit.

In fact, the user preference can be expressed by the above factors as well. A user just needs to fill out the requirements of every feature factor. Then the proposed system will estimate the relationship between the user preference and hardware features. Our goal is to visualize this relationship, so that users can easily read the relationship.

In order to construct the relationship between hardware kits, how to represent these feature factors is very important. Since a hardware kit can be described by a feature vector consisting of the feature factors as mentioned above, we quantify these feature factors with numbers. For example, (core number, core speed, number of examples, user rating) can be treated as a feature vector with four feature factors. However, not every feature factor can be quantified. Some factors such as CPU type or peripheral type are only meaningful when they are expressed by text. This kind of feature factors will be excluded during the estimating process.

B. Dissimilarity Matrix

After the extraction of features, we can use a feature vector to describe a hardware kit. With these feature vectors, the relationship between hardware kits can be constructed. Here the relationship can be interpreted as the degree of similarity. Thus, if we let $V_1 = (v_{11}, v_{12}, \ldots, v_{1n})^T$ and $V_2 = (v_{21}, v_{22}, \ldots v_{2n})^T$ be two feature vectors, the simplest way to represent the relationship between V_1 and V_2 is the Euclidean Distance, as shown below:

$$D(V_1,V_2) = \sqrt{(v_{11}-v_{21})^2 + (v_{12}-v_{22})^2 + \ldots + (v_{1n}-v_{2n})^2} \qquad (1)$$

The sub-index n indicates the number of learning indices. Apparently, a smaller $D(V_1,V_2)$ means a higher degree of similarity between V_1 and V_2. However, the range of every feature factor v_{ij} is different. For example, “user rating” might be scored from 1 to 100, but “the number of design samples” might have only 30 levels. Due to this reason, we have to normalize each feature vector V_i to $V'_i = (v'_{i1}, v'_{i2}, \ldots, v'_{in})$ before the measurement of the Euclidean Distance, such that each V'_i for $i \in [1, n]$ has the same range. Therefore, the above formula becomes:

$$D'(V'_1,V'_2) = \sqrt{w_1(v'_{11}-v'_{21})^2 + w_2(v'_{12}-v'_{22})^2 + \ldots + w_n(v'_{1n}-v'_{2n})^2} \quad (2)$$

In (2), w_i is the weighting value indicating the importance of the i-th feature factor. It is configurable when a user prefers one feature factor to others. In general cases, w_i is set to 1 $\forall\, i \in [1, n]$.

Suppose the number of feature vectors is k. After (2) is applied to all pairs of feature vectors, the dissimilarity matrix D can be obtained as follows:

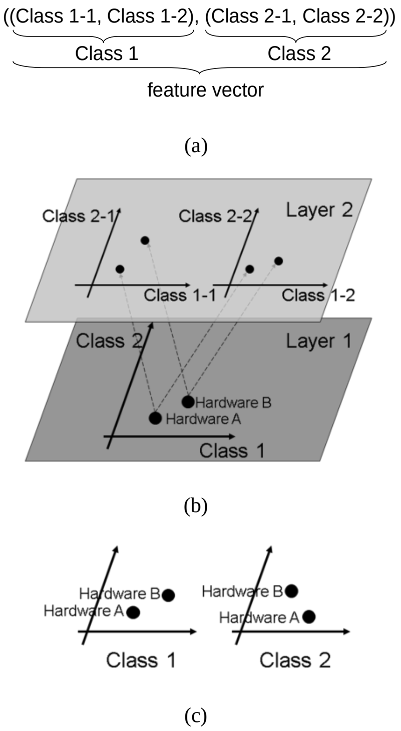
$$D = \begin{pmatrix} D'(V'_1,V'_1) & D'(V'_1,V'_2) & \cdots & D'(V'_1,V'_k) \\ D'(V'_2,V'_1) & \ddots & & \\ \vdots & & & \\ D'(V'_k,V'_1) & & & D'(V'_k,V'_k) \end{pmatrix} \qquad (3)$$

As mentioned before, the dissimilarity matrix D consists of the degree of similarity between each pair of hardware kits. Through the dissimilarity matrix, the relationship among hardware kits becomes obvious.

C. Multidimensional Scaling

In the previous section, we use quantified feature vectors to construct the dissimilarity matrix, which shows the degree of similarity among different hardware kits. Nevertheless, a user still has to spend lots of time searching for the relationship from this $k \times k$ matrix, so a friendly interface to present this relationship is necessary, such that users can read this dissimilarity matrix with ease.

Multidimensional scaling (MDS) is a mathematical tool that uses proximities between objects, subjects, or stimuli to produce a spatial representation of these items. The proximities are defined as any set of numbers that express the amount of similarity or dissimilarity between pairs of objects, subjects or stimuli. It is a data reduction technique because it is concerned with the problem of finding a set of points in low dimension that represents the “configuration” of data in high dimension. Here the “configuration” can be viewed as our dissimilarity matrix D. Then D can be visualized in a low dimensional coordinate system, such as a 2D plane or a 3D cube. Figure 3 shows an example of multidimensional scaling from a dissimilarity matrix to 2D and 3D representation. Suppose there are seven items, noted as item 1 to item 7. In Figure 3, the distance between item i and item j is shown at location (i, j) of the dissimilarity matrix. After multidimensional scaling, the relative position of each item can be visualized in any low-dimensional coordinate systems. Figure 3 illustrates an example of 2D and 3D visualization of a dissimilarity matrix.



(a)

(b)

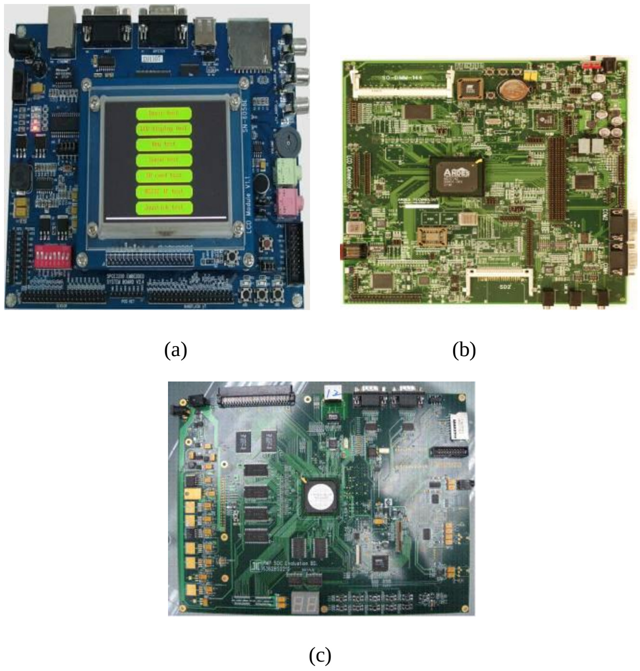
(c)

Fig. 4. An example of the preference estimation system

In practice, there are many ways to implement the preference estimation system. For example, the feature factors could be divided to several classes, where each class is visualized by either an entire coordinate system or just an axis. In Figure 4 (a), a feature vector is divided to class 1 consisting of class 1-1 and class 1-2 as well as class 2 consisting of class 2-1 and class 2-2. Figure 4 (b) shows a hierarchical representation to visualize the features of all classes (Layer 1) and subclasses (Layer 2). Here a class or subclass is represented by an axis. Figure 4 (c) is another representation to illustrate class 1 and class 2. In this case, a class is represented by an entire coordinate system. The advantage of this kind of representation is that difference between classes or relationship in a class can be more easily compared. A detailed case study will be described in the next section.

IV. Case Study

As mentioned before, more and more embedded hardware platforms have been developed and used in different courses for various applications. Thus it is unlikely to learn all design skills using one embedded hardware platform. In this case study, three hardware platforms with different features are adopted for embedded system curriculums. The three hardware platforms are imported into the universal learning system, so students can use the proposed system to understand the relationship between the user preference and other feature vectors. For each hardware platform, CIC lecturers deliver a short course, which has been carefully designed, such that the skills required for designing most popular electronic products can be covered in the course. Once a student decides the hardware platform according to the preference, he can take the course either in the CIC classroom or in the virtual classroom.



(a)

(b)

(c)

Fig. 5. Three hardware platforms used in the courses: (a) Sunplus SPCE3200, (b) ANDES Leopard, and (c) ITRI PAC-PMP

Besides, he can also join discussion in the forum and ask questions in the Q&A center.

In this section, the three embedded hardware platforms are first introduced. Then the steps to visualize features of the hardware platforms and the user preference are illustrated. Besides, for each hardware platform the course design strategy is described. Finally, student feedback is given for demonstration of the performance of the proposed system.

A. Hardware Platforms

The first hardware platform used in the system is Sunplus SPCE3200 [11], which is a highly integrated platform designed by Sunplus for multimedia applications, as shown in Figure 5 (a). The platform is composed of a domestic 32-bit SoC (S+Core), 128MB SDRAM, 64Mb NOR Flash, 128Mb NAN Flash, QVGA 3.5" TFT LCD, and rich peripherals. The SoC chip of SPCE3200 contains S+core CPU, Advanced High-Performance Bus (AHB) connecting with high-performance modules, and Advanced Peripheral Bus (APB) connecting with low-speed peripheral modules. High-performance modules include CMOS sensor interface (CSI), MPEG-4/JPEG encoding and decoding modules, LCD controller, TV signal encoding module, 2-channel 16-bit D/A converter, embedded 8KB RAM (LDM) and 32KB ROM, and memory interface controller. Low-speed peripheral modules include GPIO controller, SPI serial bus controller, SIO serial bus controller, I2C serial bus controller, I2S master/slave controller, UART controller, USB master/slave controller, Watchdog, SD controller, NAND flash controller, and 9-channel 12-bit A/D converter. A well-integrated development and debugging IDE environment as well as a ported eCOS system is offered with the platform, helpful for the Hardware-Dependent Software (HDS) and application developing. The core of SPCE3200 is S+Core7, a 32-bit and 7-stage pipeline RISC CPU, supporting

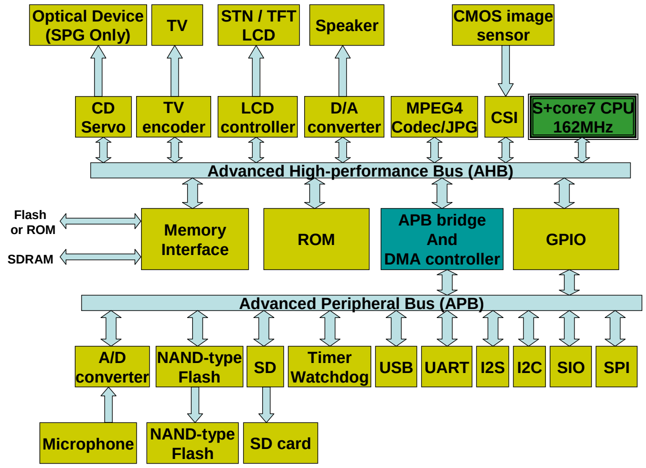


Fig. 6. The Architecture Of Sunplus SPCE3200

16/32-bit mixed instruction set and working at 27~162 MHz. Since many applications can be implemented by hardware, it saves execution time of software programs, and thus achieves low energy cost and high efficiency. Therefore, SPCE3200 is suitable for low-power devices or the controller of devices, such as handheld devices, small household appliances, sensors, or controllers of robots. The architecture of SPCE3200 is shown in Figure 6.

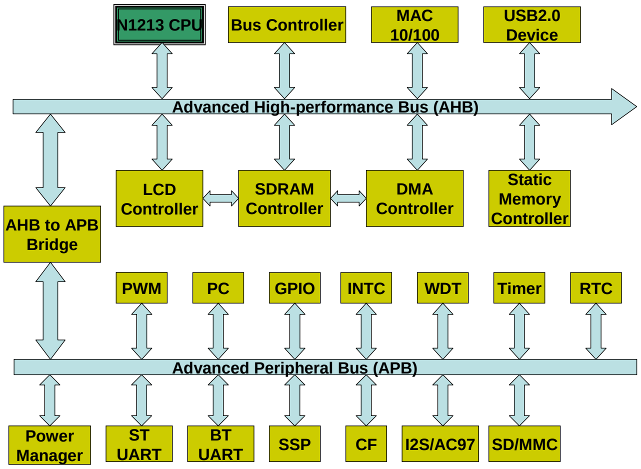


Fig. 7. The Architecture Of ANDES Leopard

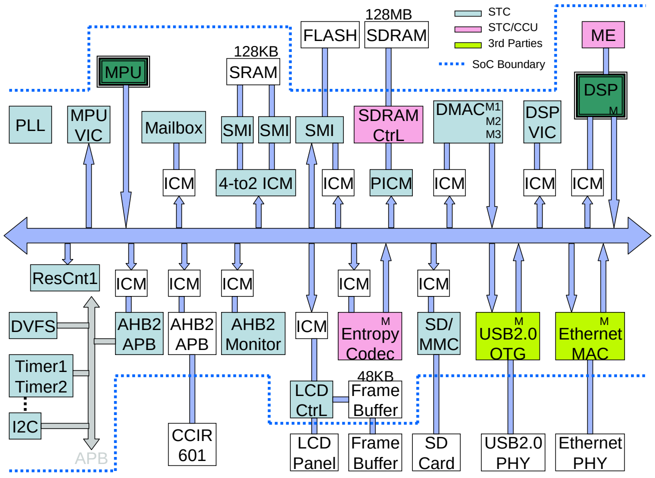


Fig. 8. The Architecture Of ITRI PAC-PMP

The second hardware platform is ANDES Leopard [12], consisting of a 32-bit SoC, a SODIMM slot of SDRAM, 32MB Flash, QVGA 3.5" TFT LCD, Ethernet, UART, IIC, AC97, SD card, LED, LEDs, buttons, ICE port for on-line debug, and so on, as shown in Figure 5(b). Just like SPCE3200, there are AHB connecting with high-performance modules and APB connecting with low-speed peripheral modules. The core of ANDES Leopard is a 32-bit and 5-stage pipeline SoC, supporting 16/32-bit mixed instruction set. The maximum working frequency of the core can reach 500 MHz. Besides, the chip also contains controller of LCD, Flash, AHB, SDRAM, DMA, and so on. Moreover, Leopard offers a well-integrated development and debugging IDE environment and a well-ported Linux kernel. Since Leopard has a well-ported Linux and a powerful CPU, it is suitable for developing general-purposed applications or applications that requires complex computations, such as Netbooks, mini-computers, or E-books. The architecture of Leopard is shown in Figure 7.

The third hardware platform is ITRI PAC-PMP [13] (Figure 5(c)). PAC (Parallel Architecture Core) is a high performance and low energy cost DSP developed by ITRI (Industrial Technology Research Institute of Taiwan). PAC-PMP (Parallel Architecture Core Portable Multimedia Player) is a heterogeneous dual-core hardware platform designed mainly for multimedia and parallel applications. The structure of PAC-PMP is shown in Figure 8. PAC-PMP has a dual-core SoC, 128MB SDRAM, 32MB Flash, VGA TFT LCD, and several interfaces, such as UART, Ethernet, USB, IIC, UART, IrDA, LEDs, IIS, SD card, ICE port for on-line debug, and so on. The core of PAC-PMP adopts the heterogeneous dual-core structure, consisting of ARM926EJ-S and a domestic DSP with 5-way VLIW for multimedia applications. Besides dual-core architecture, the other feature of PAC-PMP is multimedia hardware codec, supporting H.264/AVC hardware accelerator (motion estimation and entropy coding) and multimedia DMA and SDRAM controller. In addition, the SoC also includes the newest Dynamic Voltage Frequency Scaling (DVFS) technique, which can dynamically adjust voltage frequency to efficiently reduce energy cost. Due to the sufficient hardware supports and powerful computational ability, PAC-PMP focuses on high-quality multimedia applications and parallel computing, such as recording video and answering the phone simultaneously. However, the high complexity of its structure also increases the threshold to learn this platform, so PAC-PMP is more suitable for advanced software designer. The applicable area includes PDAs, smart phones, high-definition DVRs, and so on.

B. *Preference Estimation*

Before taking the courses, a student could provide his requirements (or preference) to the system, and give a weighting value to each feature factor. The requirements of students were treated as a feature vector, just like other hardware platforms. Then we extracted feature factors for each hardware platform. After that, the feature factors were divided into two parts, the ones that can be quantified or not.

TABLE I. UNQUANTIFIED FEATURE FACTORS

	SPCE3200	Leopard	PAC-PMP
Processor	Sunplus S+score	ANDES N1213	PAC DSP + ARM926EJ-S
Memory	128Mb SDRAM, 192Mb Flash	256MB SDRAM SO-DIMM, 32MB NOR Flash	128MB SDRAM, 32MB NOR Flash
Communication Interface	SPI, SIO, IIC, UART, USB, Ethernet, GPRS	Ethernet, UART, IIC	Ethernet, USB, IIC, UART, IrDA
Interaction Interface	Joystick, Touch panel, buttons, LEDs	Touch panel, buttons, LEDs	Touch panel, buttons, LEDs
Multimedia Interface	TV Out, LCD, CMOS camera, IIS	LCD, AC97	LCD, IIS
Other Interface	SD card, SJTAG, GPS	SD card, AHB, X-Bus, MII	SD card, AHB
Applicable area	Peripheral controlling, non-OS programming	OS kernel programming, general-purposed programming	DSP programming, multi-thread programming

Quantified factors were added into the feature vector, and others were listed by a table, as shown in TABLE I. Since the range of every feature factor is different, each factor is normalized to [1, 100] first. Next, every feature vector was adjusted according to the weighting values given by the user, so the result could more approximate the user requirements.

After all feature vectors were extracted and quantified, we categorized the feature vector into three classes, software information, hardware information, and user experience. Each class contains several feature factors. For example, the class of software information contains complexity of BSP, number of design examples, completeness of documents, and so on. The class of hardware information contains the core speed, core size, and some quantified hardware specifications. As for the user experience, it includes user ratings, ease of use, readability of documents, etc. Next, the Euclidean Distance between each pair of feature vectors is calculated to obtain the dissimilarity matrix. After multidimensional scaling of feature vectors in each class, the features of a hardware platform was reduced to three values, standing for software information, hardware information, and user experience, respectively. The three values are expressed by *x*, *y*, and *z* axis of a coordinate system, respectively. Eventually, there will be four points shown in a 3D coordinate system, standing for the feature of each platform and the preference of the user, respectively. Figure 9 shows an example of the preference of a student (U) and the corresponding visualized feature points of the three platforms (S, A, and P).

The distance between two points represents the degree of similarity. Since the distance between 'S' and 'U' is the shortest, the system suggests the student select SPCE3200. On the other hand, the user could consider from only one dimension (such as the hardware information dimension), so different suggestion might be provided.

C. Course Design

Since every selected hardware platform has different features and applicable areas, we design three short courses to teach these platforms so that students can learn different types of design skills in different courses. Students could choose courses according to the suggestion of the user preference system.

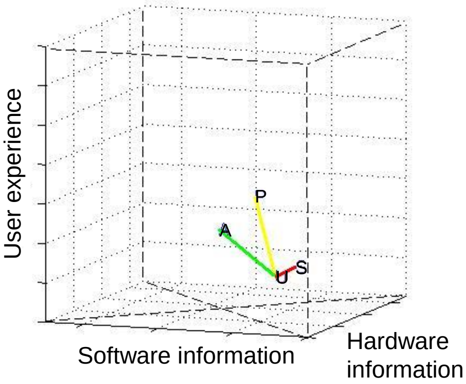


Fig. 9. MDS From Three Hardware Platforms To A 3D Coordinating System, Where S Means Sunplus SPCE3200, A Means ANDES Leopard, P Means ITRI PAC-PMP, And U Means User

The design strategy of courses basically follows ADDIE process [15], which is a systematic framework used for instructional design, and it is also used for helping create new research topics in learning technology. There are five phases in ADDIE process, analysis, design, development, implementation, and evaluation. We simplify these five phases to three steps, instructional objective, instructional strategy, and evaluation, as described in the following subsections.

First, we use ABCD model proposed by Mager [16] to describe our instructional objectives. In ABCD model, useful instructional objectives consist of four necessary components: Audience, Behavior, Conditions, and Degree. According to ABCD model, our instructional objective is defined as: Students (Audience) can learn embedded software design skills (Behavior) and finish 70% lab assignments (Degree) using the simulator and the hardware platform provided in the course (Condition). The details are described as follows:

1) *Audience:* Students are mainly graduated students with basic knowledge of embedded systems, but the community is also accepted to take the course.

2) *Behavior:* Students can learn skills of embedded software design according to their requirements or abilities.

3) *Condition:* Students have to program using the simulator and the hardware platform provided in the class.

4) *Degree:* Students have to finish 70% lab assignments in the course, so that we can make sure how much the students have learned.

The position of the proposed courses is advanced learning of embedded software design, so students are requested to have basic knowledge of embedded systems, operating systems, computer architecture, and C programming. All of the preliminary knowledge can be learned in the university.

Since teaching basic knowledge is omitted, the length of every short course can be curtailed to 15 hours. At beginning of every short course, the basic information of the platform is introduced, including specification of the hardware platform, development tools, peripheral devices and connectors, and

TABLE II. COURSE OVERVIEW

Course Outline		
SPCE3200	***Leopard***	***PAC-PMP***
S+core introduction	ANDES introduction	PAC-PMP SoC overview
IDE tools introduction	Software development using AndesLive	Parallel architecture core - PAC DSP + PAC platform
SPCE3200 platform introduction	AndesStar ISA	Development tools of ARM
SPCE3200 GPIO	ANDES GPIO	Development tools of PAC DSP
SPCE3200 timer	ANDES memory controller	
SPCE3200 interrupt	ANDES timer and interrupt	
	ANDES LCD and DMA	

TABLE III. SPECIFIC TOPICS OF THE COURSES

Specific Topics		
SPCE3200	***Leopard***	***PAC-PMP***
Programming of peripheral controller	Programming of general purposed applications	DSP programming
Programming of non-OS device driver	Program profiling and optimization techniques	Dual-core project design flow
Programming of tiny-OS applications	Final Lab: Development of applications on Linux	Dual-core project execution flow
Final Lab: Development of applications on eCos or non-OS environments		Final Lab: Usage of AAC, JPEG, and H.264/AVC accelerators

installation. After the introduction, there are specific topics for different applications in each class. TABLE II illustrates the overview of each course, and TABLE III shows specific topics in each course. For SPCE3200, we focus on design of controller to peripheral programming and low level non-OS device driver programming. For Leopard, the main topic is general purposed software development on Linux. For PAC-PMP, DSP programming and development of dual-core communications and applications are emphasized. Note that the difficulty to learn PAC-PMP is considered as the highest because many students are not familiar with the skills of parallel design and inter-process communication. Therefore, students are suggested to learn parallel programming design before PAC-PMP.

D. Evaluation

Dave addressed five stages composing Psychomotor Domain of Bloom’s Taxonomy [17]. The five stages are Imitation, Manipulation, Precision, Articulation, and Naturalization. These stages explained the importance of exercises. Besides, lab exercise is also one of the best ways to evaluate the learning efficiency of a student, so we emphasize on lab exercises in the courses. There are lab exercises assigned after the introduction of every topic. The assignments are designed in order to let students review the topics they just learned. In the first assignment, the teacher shows how to use IDE tools and simple programming skills, and students have to repeat these actions. As for the remaining assignments, the teacher just gives hints, and students have to finish assignments themselves.

In the final lab exercise, students design their own projects according to the given direction. The knowledge they have learned in the courses must be applied in their projects. In the summer courses of 2012, some students integrated their majors into the projects, such as a non-OS MP3 player using SPCE3200, a digital photo frame using ANDES Leopard, and a motion estimation accelerator using PAC-PMP.

As for the students taking the course in the virtual classroom, several virtual platforms are provided for lab exercise. Most functions on the hardware platform can be simulated by its virtual platform, although the performance might decrease significantly. Another problem is that the student cannot ask question during the lab exercise, but he can join discussion in the forum or query in the Q&A center by email or hotline.

E. Student Feedback

At the end of the courses, we collected 69 questionnaires from students. Before the courses, only 57% students have basic knowledge of embedded systems. There are even 7% students had never touched embedded systems. This means about half of students did not really know their learning objective. After the courses, 98% students agreed the proposed system could more or less help their embedded software design in the future. Among these 98% students, 76% of them felt the proposed system is very helpful. Besides, 88% students believed the courses met their expectation. In ease of use, 100%, 90%, and 65% students agreed that it is easy to use SPCE3200, Leopard, and PAC-PMP, respectively. This result corresponds to our expectation because the preference estimation system reveals that the complex rank of the three hardware platforms is PAC-PMP > Leopard > SPCE3200. A complex hardware platform usually needs more effort to learn. Therefore, from the feedback, it can be concluded the proposed system helped students to select correct hardware platform. In addition, the proposed short courses also helped students to learn embedded software design for different applications.

We also collected the comments from the teachers after the courses. Some comments are quoted as follows:

1) *The visualized interface might attract more students to use the proposed suggesting system. The relation map looks instinctive and easy.*

2) *The proposed system also helps teachers to determine the instructional objectives. The teacher, for example, can map the requirements of all students to coordinate points, and classify students into groups by similarity. For different groups, different assignments or objectives might be given, so that every student could learn according to their requirements and levels. However, the proposed system works only when the student keys in correct user preference. If some students do not really know what they need, the system output will lose accuracy in this situation.*

The main problem from the teachers is inaccurate user input. This error is unavoidable if the user input is inaccurate. Therefore, we suggest the user preference is determined by the feature vector of a platform that the user has used before. For example, in this case study, a user can use the feature vector of SPCE3200 as his preference if he used to use this hardware platform before. Then the system will suggest ANDES to the user because ANDES is more like SPCE3200 than PAC-PMP.

V. Conclusion

In this article, the idea of the universal learning system is proposed. The visualization of the dissimilarity matrix let users intuitively understand the relationship between the hardware platforms and user preference, and helps users select the most suitable hardware platform to learn embedded systems on-line. In addition to online courses and virtual platforms, users can also join discussion and ask questions using the proposed system. In the demonstration, we applied three hardware platforms used for embedded system education in Taiwan. The results show that users can easily select the most suitable hardware platform and take courses according to requirements. Therefore, the proposed system can help users learn embedded system anytime and anywhere.

However, there are still some problems in the proposed system. For example, there should be a well-organized management for the forum. Also, it is difficult to build up the virtual platform for each hardware platform. In the future, these issues will be taken into account gradually, such that the universal learning system can be more practical.

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Diabetes Monitoring System Using Mobile Computing Technologies

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***Abstract*—Diabetes is a chronic disease that needs to regularly be monitored to keep the blood sugar levels within normal ranges. This monitoring depends on the diabetic treatment plan that is periodically reviewed by the endocrinologist. The frequent visit to the main hospital seems to be tiring and time consuming for both endocrinologist and diabetes patients. The patient may have to travel to the main city, paying a ticket and reserving a place to stay. Those expenses can be reduced by remotely monitoring the diabetes patients with the help of mobile devices. In this paper, we introduce our implementation of an integrated monitoring tool for the diabetes patients.**

The designed system provides a daily monitoring and monthly services. The daily monitoring includes recording the result of daily analysis and activates to be transmitted from a patient's mobile device to a central database. The monthly services require the patient to visit a nearby care center in the patient home town to do the medical examination and checkups. The result of this visit entered into the system and then synchronized with the central database. Finally, the endocrinologist can remotely monitor the patient record and adjust the treatment plan and the insulin doses if need.

***Keywords*—Diabetes; Electronic Monitoring; Remote Monitoring, Ubiquities Healthcare; T1DM, T2DM; Android Monitoring System.**

I. Introduction

Diabetes Mellitus (DM) is a chronic disease that is considered to be a metabolic disorder [1]. Diabetes is caused by either the absent of insulin or inability to utilize the produced insulin. Age, family history, body weight, and having previous gestational diabetes are some factors which make the person exhibition for diabetes. Diabetes classified within three categories: Type1 diabetes mellitus (T1DM); which is the result of not producing insulin, Type2 diabetes mellitus (T2DM); which is the result of ignoring insulin by the cells, and gestational diabetes which diagnosed in some pregnancies.

In fact, diabetes needs to be treated either by just modifying life style, or by medications and injections. This treatment is very important to prevent fatal complications. Also, patients who have diabetes need to measure their blood level daily using a glucose meter. In addition, they have to do the HA1c test every three to six months to guide the endocrinologist when evaluating the treatment plan.

Mobile computing can improve the quality of the patients' life by providing systems that help diabetes patients to monitor and control their diseases [2]. These applications can help the endocrinologist by providing a remote monitoring to the patient. Database technologies can be combined with communication technologies to present an integrated diabetes monitoring tool.

Nowadays, many researches are proposing different architectures and system designs for diabetes monitoring system. One of these proposed systems is SMARTDIAB [1] which is proposed by S.G. Mougiakakou et al. in 2010. They combine state of the art approaches in database technologies, communications, simulation algorithm and data mining. SMARTDIAB was consisting of two units: patient unit and patient management unit. The patient unit feed the system by passing information and gets a response regarding to that information.

In this paper, we will improve the SMARTDIAB by building a system of three units: patient unit, endocrinologist unit, and general physician unit. In addition, we increase the strength of our proposed system by concerning the HA1c test's result which helps the endocrinologist to efficiently evaluate the treatment plan. The accuracy of the data is achieved by depending on electronic data input for blood glucose levels' readings. And since the authority is a sensitive criterion in any health care monitoring system, we define three actors in the system with three associated access rights.

This paper is organized as the following: Section 2 discusses the existing work and shows the literature review. Then section 3 presents the problem statement and discusses the proposed system architecture. In Section 4, Patient side solution is presented. After that, in Section 5, we present the doctor side solution followed by discussion about the central database in section 6. In section 7, we show the system evaluation. And then, we show the system strength in section 8. Finally, we summarize our work and highlight some future works in section 9.

II. Literature review

Diabetes is known as one of the most common diseases that has significant burden on patients and healthcare systems. Nowadays, there are lots of researches in the field of diabetes monitoring. These researches are coming as a sequence of evolutions. The first evolution in diabetes monitoring was the use the computers to manage patient data and save their records which include personal information, treatment progress and historical information. Then, these monitoring systems were developed and become as dual sides systems. In this type of systems, diabetes can be controlled remotely by which called tele-monitoring and tele-medication. In such systems, the health care providers offer tele-support and monitoring services to patients through a desktop computer at home. Patient also can enter data about his daily intake food, activities, and medication and get a right advice about his condition. Later, with the huge growth in technology, a tele-monitoring system built for mobile phones and PDAs have appeared. These systems can support the patient while he is in move, and supply him with interactive conversation with the healthcare providers. This last type of evolution is now taking a considerable place in researches and markets. And if they well designed, they can provide a really prevention or improvement of diabetes.

In this section, we study the literature and application of diabetes monitoring systems with more details in the last evolution that is related to our work.

A. One-Side Desktop Diabetes Monitoring System

A system was developed by S. Pruna et al. to enable the monitoring of clinical care in the countries of the black sea[3]. The system improves the quality of diabetes services by providing the clinicians with a computerized diabetes registry. The clinicians have many options for the management of the creation, correction, and visualization of patients' records. The system was developed using a modular design and object oriented method approach and its architecture was based on the Good European Health Care Record (GEHR). They use a MS access related tables to store information in the database. Black Sea Tele Diab has two security levels: function level, which assigns specific functions to the user depending on his access right, and data level which restrict the access to the items depending on the user rights.

B. Dual-Side Desktop Diabetes Monitoring System

H. kwon et al. designed new diabetes monitoring system model online using the internet[4]. By using this system patients can contact physicians online, to provide them with information and receive recommendations. In this study, a randomized clinical trial involving 110 patients were conducted to do a comparison between patients who used the internet based blood glucose monitoring system and usual out patient who received the traditional out patient management system for the same period. They call these two groups intervention and control group respectively. Patients at intervention group could access the system via the internet and sent information about blood glucose level, drug information, medication intake, blood pressure and weight. Also, they could ask questions and post comments (e.g. diet exercise, hypoglycemic event). On the other hand, patients were able to see recommendations as well as laboratory data.

C. Mobile and PDA Diabetes Monitoring System

A study and a pilot testing of mobile based remote patient monitoring system was developed to improve blood-pressure (BP) control of hypertensive patient with diabetes [5]. The system was developed within two phases. The first one was to design a home BP tele-management system. This involved a series of focus group meetings with patients and care providers to guide the development of the system. In the second phase, a pilot study of the system was done. Thirty three patients with type2 diabetes and uncontrolled ambulatory BP were chosen to be under the pilot test. The system was architected into the patient component, a data center and decision support system, and the care provider for physician for reporting and alerting components. Data from the BP monitor device were transmitted via Bluetooth to a programmed mobile phone. The phone securely transmits this data to sever to be stored in a central database. The system applies a set of clinical rules on the data then sends secure written progress messages automatically to the mobile phone.

A. Kollmann et al. [6] find that mobile phone can be used to provide a ubiquitous, easy-to-use, and cost efficient solution for management of diabetes mellitus type1 (T1DM). They do a feasibility study to see how much mobile phone-based data service could be accepted with diabetes mellitus type1 patients, and how much the services can assist T1DM patient on intensive insulin treatment. For this study, researchers had developed software called Diab-memory to support patients entering their information such as: blood-glucose level, injected insulin doses, food intake, well-being and physical activities. Then, data were remotely synchronized to a central database. The system was based on Java2 Mobile edition (J2ME) and built using state of the art internet technology. The study sample was 10 patients with T1DM. Mean age was 36.6 years (±11.0 years) being in the trail study for three months. The result was focused on patients' adherence to the therapy, availability of the monitoring system and the effects on metabolic status. As questionnaire shows, the system was accepted in general.

Another study was focusing on the difficulty of managing diabetes [6]. In this study, an appropriate diabetic treatment is needed to manage the diabetic's blood sugar level and prevent the future complications. Diabetes patients can send their information such as blood sugar level; blood pressure, food consumption, exercise and then the system manage the treatment by recommending food intake, physical activities, insulin dosage…etc. In order to have the best treatment recommendation, the system is based on rules and the k-Nearest Neighbor (KNN) classifier algorithm. Rule based interface select the knowledge similar to the human experts and it needs pervious knowledge to make rules. The KNN is a machine learning algorithm used in the system to classify results using given data by evaluate time, blood sugar, blood pressure, number of meals, amount of exercise and target caloric consumption. The system integrates the KKN and rule-based inference to generate decisions outside the strict rules. Also, a blood sugar monitoring system for diabetes patient is implemented using web services and Personal Digital Assistant (PDA) programmed in java.

A platform was designed to support the monitoring, management and treatment of Type1 Diabetes Mellitus (T1DM) patients. They call this platform "SMART DIAB" [1]. In order to provide the intelligent monitoring and management, "SMART DIAB" combine many approaches in the field of database and data mining technologies for management of diabetes data, simulation algorithm for insulin treatment optimization, and communication technologies to implement a tele medicine platform either with wired or wireless capabilities. By combining the previous technologies, SMART DIAB allows intensive monitoring of glucose levels, diabetes treatment optimization, continuous medical care, and improvement of quality of life individuals with T1DM.

D.L. Katz and B. Nordwall state that self-care is efficient to controlling in chronic disease through patient empowerment and timely feedback [7]. They have built wireless system which provides a remote patient monitoring. The system was based on mobile phone technology. Patients are allowed to submit a new data daily and upon these data the server will generate and send feedback messages to the patients' cell phones. The data accuracy ensured by reducing manual data input by integrating the phone with the glucose meter, blood pressure and weight measurement. This platform has some disadvantages as mentioned in [8] such as the limited scope to manually enter data about physical activities and intake food.

Pilot controlled trail were selected to evaluate the feasibility and efficiency of the system to manage type2 diabetes. The selected patients were divided into two groups; 15 patients were using the cell phone technology and 15 patients were in a control group. The study lasts for three months and the researchers collected some improvement feedbacks from the patient in order to apply these modifications to the system. All necessary improvements were done to the system.

III. Problem Statement And Proposed Schema

In this section we present the problem statement and the proposed scheme. First, we define the problem and present the real impact of diabetes on the human beings. We emphasize on the effort that rise from the regular medical examinations and tests. Next, we present our proposed scheme in details.

A. Problem Definition

Since diabetes mellitus is a chronic disease, it needs a regular monitoring to control blood sugar level. Seriously, this monitoring is very critical to prevent many fatal complications. According to the World Health Organization (WHO) [9], there are more than 220 million people worldwide having diabetes. In 2004, about 3.4 million people died from complications and consequences of high blood sugar. WHO expected that diabetes deaths will double between 2005-2030. For the economic side, diabetes mellitus economically has an impact on individuals, families, health systems, and countries.

Diabetes mellitus monitoring includes maintain healthy weight, physical activates, and regular medical examinations and tests. In fact, regular medical examinations and tests seem to be time consuming for both doctors and patients. Patients who live in neighboring villages face some difficulties to go down to the hospital in the city. They have to reserve a ticket or pass a road, reserve a place to stay in addition to the cost of the treatment if any.

Our proposed framework is to produce a diabetes monitoring system based on mobile platform. This system can assist diabetes mellitus patients to monitor their glucose level according to the glucose level readings, intake food, medication, and physical activities. Our system based on electronic data input, as well as manual data input. This is for accomplish data accuracy and follow-up daily activities at the same time. In addition, clinician-to-patient interaction is allowed by exchanging messages.

The greatest achievement in our proposed system is Arabization. Most of the diabetes monitoring systems was available in English language only, where D.L. Katz and B. Nordwall were translated their system in Spanish [7]. Also we will allow an effective functionality to control the change in HbA1c Levels. Black sea tele Diab [3] was caring about this point, but it was a desktop based system specific for physicians.

B. Proposed System Architecture

The specification of our project is to deliver a smart medical system for diabetes monitoring based on mobile platform. The proposed architecture is consisting of three main units: *the Patient Unit, the Center care Unit and the Hospital Unit*. The *Patient Unit* is the starting point in the system. It contains the patient, the glucose meter, and the mobile device. The glucose level readings are electronically transmitted to the mobile device. Also, the patient can manually enter daily food intake, physical activities and information about some medications and injection. The system may alert the patient about injection time, special medicine reminder, date for medical examination and tests. The patient is able to do a conversation with his/her endocrinologist in emergency cases or for inquiries. These conversations are done via exchanging messages.

The *Care Center Unit* represents the medical center in the patient hometown where the patient can visit instead of the hospital in the main city to do regular checks and medical tests and examinations. The general physician in the medical center is allowed to enter results of the HA1c test.

The *Hospital Unit* is controlled by the endocrinologist who can remotely monitor the patients' status, send advises, and take an action in urgent cases. The endocrinologist is the only actor who allowed modifying the insulin doses regarding to the daily glucose reading and the result of the HA1c test. These three units are integrated together forming a whole Diabetes Monitoring System. The interacting between these units is done by exchanging data. These three units are integrated together forming a whole Diabetes Monitoring System. The interacting between these units is done by exchanging data.

Our proposed system is consisting of three layers: *Presentation Layer, Service Layer, and Data Repository Layer* as shown in Figure 1. The *Presentation Layer* presents the system units' interface. The system user can access the system interface by logging to the system and assigned an access rights. The patient unit is provided by a patient's interface which can be accessed using a mobile device. The glucose readings are transmitted via Bluetooth adaptor to this interface. This patient's interface is presented to the patient by using a micro browser. The endocrinologist and the general physician are provided with a desktop interface. The interface for these two system units will be presented by using an internet browser.

The *Service Layer* is the core of our system. It performs the services to the system units. It contains two main components: Report Extractor and Smart Analyzer. The Report Extractor service is inquired by the endocrinologist or the general physician. It accesses the Resource Layer and collect information from the requested database. Then, it formats this information and presents it to the requestor. The Smart Analyzer analyzes incoming data before sending it to the database. This Smart Analyzer is depending on some values such as: MIN_Glucose_LEVEL, MAX_Glucose_Level, and MAX_A1c. The analysis in this component is work as the following:

- Once the glucose readings are transmitted from the glucose meter to the mobile phone, they will be compared with MIN_Glucose_LEVEL and MAX_Glucose_Level values. Then, the patient will be advised by the system to do something like: eat more, have a walk, take insulin injection and so on.

When the general physician enters the test result of HA1c test, it will be compared with A1c critical value. If it is above the range, or below it, the endocrinologist will be alerted to make a decision and modify the insulin doses or the treatment plan if needed. His information and presents it to the requestor. The Smart Analyzer is responsible to analyze incoming data before send it to the database. This Smart Analyzer is depending on some values such as: MIN_Glucose_LEVEL, MAX_Glucose_Level, and HA1c value. Resource Layer contains the databases for the system. The system is connected on many databases such as: medical information's database, patients' database, and users' database.

Finally is the ***Resource Layer***. It contains the databases for the system. The system is depends on four databases: knowledge database, medical information's database, patients' database, and users' database. The Knowledge database is used by the Smart Analyzer service. It will contain the information needed by this service to perform the analyses such as: MAX_Glucose_Level, MIN_Glucose_LEVEL and A1c. The Smart Analyzer uses this information to compare incoming reading and alert the endocrinologist about up normal or subnormal values. The patients' database holds the patients' personal information such as: patient name, Birth of date, address, telephone number and so on. The Medical Information database is designed to hold medical information for each patient. This medical information include: daily glucose levels, intake food and amount of activities in calories, insulin doses, medical checkups and examinations' results, and information about glucose injection. Finally, the users' database is needed for handling system users' accounts and access rights. The database server is interacting with the web application server.

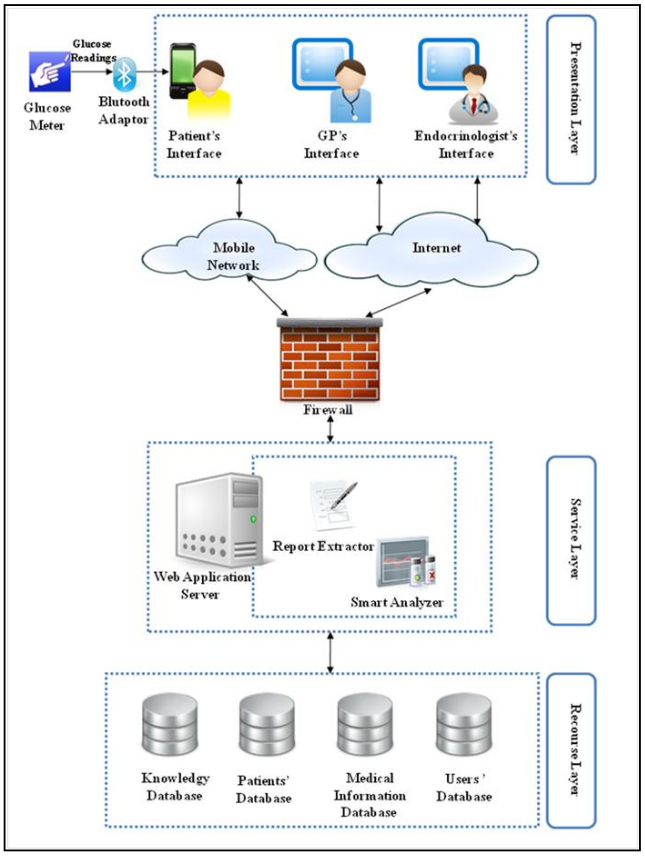

Fig. 1. Proposed System Architecture

IV. Patient Side Implementation

The Patient –Side Environment was implemented on the android using java programming language. Android SDK was used to setup the development tool and SDK add-ons. There are many reasons behind choosing android OS for the patient-side in our integrated system. We needed to develop a mobile application that can easily communicate with a central database without slowing down the application performance. Also, we needed the mobile to have ability that makes the patient implicitly sends SMS to another phone number and communicates with an external device via a Bluetooth adapter. Moreover, Android supports many libraries that contribute to the implementation process with our integrated environment such as, org.apache.http, org.json, android.bluetooth, android.telephony.SmsManager and java.util.Locale. In the following subsections we will overview some of the used android and java technologies and describe them in more details.

A. Patient side technologies

The first technology is the use of the virtual device configuration. We chose HTC Desire as a target platform and we set the virtual device configuration as SDK Platform Android 2.2, API8. After that, we were able to use the emulator as a virtual device to run our application. Second technology is Dual Language Support.

Our project implementation was designed to support two languages; English language and Arabic Language. Each Patient can set their preferred language. This preferred selection is saved in the database. Once the patient logged in to the system, the preferred language will be retrieved, and according to the preferred language the application will be launched with that language. The design of our system is flexible so it can support more languages in the future. In the database there may be two values for the language: "en" for English language support and "ar" for Arabic language support. After the patient logged in to the system, the Locale will set and configured with the language value. At any time the patient can go to the setting and change the preferred language. This will be updated in the database and the system will launched with the updated preferred language immediately. We built the interfaces labels and user prompt messages as an XML dictionary for each language. In this dictionary we declare the system interfaces variables and assign the value of this variable according to the target language. For example:

<string name="mysevices">My Services</string>

"myservices" is a variable for the Button led to patient services screen. Here we set the value as (My Services) for the English language support dictionary and (خدماتي) for the Arabic language support dictionary. This is done for all application interfaces' variables. This led to two dictionaries: en-value and ar-value with more than 27 variables for each.

Bluetooth Connectivity is another technology has been used in our system. The Android platform support exchanging data over a Bluetooth network stack. The Android application access the Bluetooth functionality through the Android Bluetooth APIs. These APIs allow point-to-point feature by performing the following: Query local Bluetooth adaptor, scan for neighbor Bluetooth devices, establish Radio Frequency channels between the local adapter and the selected device, and transfer data to and from other device [10]. Our selected glucose meter has an embedded Bluetooth sensor. It connects to the android application over a Synchronous Serial Port (SSP) profile with a well known Universally Unique Identifier (UUID). The SSP profile is a serial interface used for communication between two devices [11]. The android application communicates with the glucose meter by creating a Radio Frequency Communication (RFCOMM) socket using a well known UUID. And according to the UUID specification for the serial port, the used UUID is 00001101-0000-1000-8000-00805F9B34FB [12]. After RFCOMM socket is connected, the glucose meter is set in pair mode and the android application starts to get the glucose reading by exchanging commands with glucose meter. The outgoing command is written in a created output stream form the connected RFCOMM socket and the responses is read from an input stream created from the same RFCOMM socket.

Also, our system use remote communication with central database. The android application can handle communication with a remote MySQL database to authenticate patient log in information and also to retrieve/ update patient medical information in the database. The communication process with MySQL database is done by posting data using HttpRequest. First, the application has to make a connection with a PHP script which located in the server. This is done by use HTTP protocol from the android application. PHP scripts are in the middle between the android application and MySQL database. There are many PHP files, each associated with a specific task in the android application such as: authenticate, inter glucose reading, change language…etc. These PHP files are used to call the remote server and POST/GET data to/from it. On the other hand, JSON object is used to handle incoming data from the MySQL database. JSON is Java Script Object Notation used as a data interchange language [13]. Once the query is executed in the PHP file, the result is encoded in string as a JSON representation format. Later, in the Android script, the returned value is handled in JSON array to be decoded and to extract the values from it. These values are used later in the Android application.

Finally, our system can send SMS. The patient can send SMS message to the endocrinologist through the Android application. This can be done by using SMS Manager that manages sending a text message. In the Android script, the endocrinologist's phone number will be retrieved from the MySQL database. Then, the SMS Manger will be called to get the default instance. After that, the function sendTextMessage will be called to send the SMS message.

B. *Android Application Activities*

In this section, we will preview the features of our implemented Android Application. Android deals with the project interfaces as Activities. The activity is an application component that provides view which users can interact with the application [14].

In our android application there are many activities as shown in Figure 2. The main Activity is named DiabMonSys.java. This activity is responsible to get the user log in information and authenticate this information. After successfully logged in, the patient will be allowed to choose from four features: My Services, My Information, Call Expert and Setting. Each of these features contains sub-functions in deep. My Services can run: GluoseReadingActivity.java, IntakeFoodActivity.java, PhysicalActivitiesActivity.java and GlucoseInjectionActivity.java.

The same is applied for My Information feature. It can run: MyDosesActivity.java, MyAppointment.java and GlucoseRanges.java. The Call Expert feature is an Activity in its own. We prefer to present it in the main screen because the patient may need it in urgent cases, so it has to be directly reachable.

Finally for the Setting feature, it contains two activities: ChangePasswordActivity.java and ChangeLanguageActivity.java. In the following sub-section we describe each activity in more details.

The *Main Activity* in our project launches log in screen with two data fields, user name and password. When the patient write his/her name in the fields, the Application will connect to the central database, authenticate the input information, and then if the patient authenticated, the patient id with his/her preferred language will be retrieved from the database. The patient id will be used in the next activities, and the preferred language will be used to set the interfaces language.

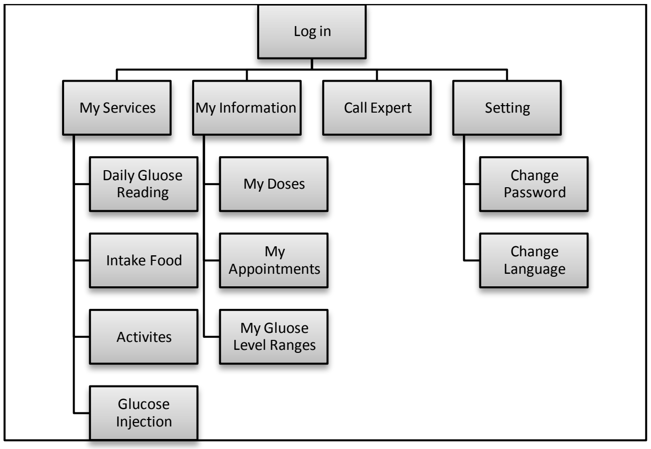

Fig. 2. Patient-Side Android Application's Activities

In *My Services Activity* the patient can select from four sub-activities. First is 'Daily Glucose Reading Activity' which allows the patient to enter his/her daily readings. These readings can be entered either manually or via Bluetooth. After entering the glucose reading, the patient specifies whether this reading is pre-meal or post-meal. This is done because the application will analyze the glucose reading with the time situation and then advice the patient what to do. The analysis of glucose readings is based on standards of medical care in diabetes [15]-[19].

Another service here is 'Intake Food and Physical Activities'. These two activities are based on the patient entry. The patient can select from a menu what he/she was eaten and the amount. The calculation of the calories is based on Food and Nutrition Information Center [20]. After calculation is done, the patient will be advised about what to do e.g.: eat some fruit, drink something, have a walk and so on.

The final service in 'My Services Activity' is 'Glucose Injection'. As a treatment of hypoglycemia the patient have to take the glucose injection. If the patient takes this injection, the endocrinologist may decide to change the next few insulin doses for some time. So, our application allows the patient to enter this information and the endocrinologist will be alerted about that in order to modify the insulin doses if needed.

In *My Information Activity*, we allow the patient to preview the insulin doses, the appointments, and the average of his glucose readings. 'My Doses Activity' will retrieve the insulin doses from the MySQL database and present them to the patient. When the endocrinologist modifies these doses, the new values for these doses will be updated in the patient side as well. Also, the patient will receive the starting time to take this dose and the duration. 'My Appointment Activity' presents the patient with the next appointment. If the status of this appointment is 'urgent', he/she will be alerted about this appointment. The final activity is 'My Glucose Reading Rang'. This activity will show the patient average reading of the glucose for the last 7/14/21 days. This is to give the patient an overall vision about the glucose level.

In addition, sometimes the patient needs a quick advice from his/her endocrinologist. In our application, we allow the patient to send SMS message to the endocrinologist. In the MySQL, each patient is associated with an endocrinologist who follows his/her diabetes. Once the patient starts *Call Expert Activity*, the mobile number of this endocrinologist will be retrieved from the MySQL. And then, the text written by the patient will be sent by the android application to that number. After that, the endocrinologist advises the patient as needed.

Setting is the last activity in the patient side. The patient will be able either reset his/her account password or change the preferred language. If the patient tries to change the password, he/she will be prompted to enter the previous one. If they matched, he/she will be allowed to enter a new one and this new password will be stored in the MySQL database. Also, the patient can select the prefered language. These changes will be stored in the central database for future logins.

V. Doctor-Side Implementation

In this section we will discuss the implementation environment on the doctor-side Application. Also, we will introduce the system privileges that are supported by the doctor-side application and the functions available for each privilege. Finally we will discuss how we use Java Database Connector (JDBC) in our system to communicate with the central database.

A. Implementation Environment

This side of the application was implemented using java programming. Since this side is straight forward retrieving form the MySQL database and writing to it, the java programming was a good solution for that. The doctor-side application needs an extra library the JDK library which is default with any java application. The extra library is called mysql-conetor-java-x.x.x-bin.jar, where x.x.x is version number. This library is needed to facilitate communication with MySQL database. By using this java library, we can prepare SQL statements and execute it directly within the code. This eliminates the need of PHP scripts. But instead, we divided the functions that perform the tasks as web services. Each of which is specialized to do something in the database.

B. Application privileges

In the MySQL database, the doctor's information contains privilege field. This field may contain one of the two values: 'ENDO' for the endocrinologist and 'GP' for the general physician. If the doctor has 'ENDO' privilege which is the highest scope of functionality. The endocrinologist can have the following functions:

- Preview patient record: shows record number, patient name, patient ID, Date of birth, and phone number.
- Glucose Injection: present the injection dose and whether the patient took it or not. The Endocrinologist has the ability to edit the glucose injection dose.
- Physical Examination: shows the last examination date, the hA1C result and physical examination result. The

Endocrinologist has an ability to enter new test result for a specific patient.

- Appointments: shows the last visit, and the next visit. Sometimes the endocrinologist needs to make an urgent appointment according to some results, hA1C result for example, so the endocrinologist will have authority to make an urgent appointment by specifying the date and the priority for this appointment.

- Insulin Doses: presents the doses for the insulin injection, the start date for these doses and for how many months. The endocrinologist has the ability to edit these doses and accept the changes.

And as the main idea of the project was to add a general physician role to the system to balance the load with the endocrinologist, the general physician will have a preview privilege with an authority to insert new test examination. Each test examination result is associated with the doctor ID. So, the endocrinologist will know who did this examination for the patient.

C. *Java Database Connector (JDBC)*

The JDBC API is a java API that facilitates everyday access relational database [21]. By using JDBC the application can connect to MySQL database, send queries and update statements to the database, and retrieve results from the executed queries. In our application, we deal with the database as a separate class which we call "database". The constructor of this class receives the database host as a string variable. Then, a connection with the database will be established in order to be ready for the coming services. This can be done by calling the drive manager of JDBC as the following:

```
con = DriverManager.getConnection(Host, "root", "");
```

Where 'con' is variable connection, 'Host' is the transmitted parameter to the constructor. After that, whatever the services are there will be a function in this class to perform the task. Each service receives a query as a string and some needed parameters to execute the query or the update.

VI. Central Data Base

In our project, we build central databases between the patient-side application and the doctor-side application. These central databases are installed using Wamp Server to synchronies the information between the clients. We have two databases; 'accounts' database and 'dms' database. In our project, there are two databases: 'accounts' database and 'dms' database. 'Accounts' database contains the users log in information for the both application sides, e.g. patient-side application and doctor-side application. These data is used to authenticate users log in information. Once the application is authenticate the user, it will connect with the 'dms' database. The database contains all the system relational tables such as: patient, doctor, appointment and so on.

The databases are installed on a Wamp Server, which is a web development environment that allows creating MySQL databases and applications with PHP [22]. We use this server to build a MySQL relational database. In our project, there are two databases: 'accounts' database and 'dms' database. 'Accounts' database contains the users log in information for the both application sides, e.g. patient-side application and doctor-side application. These data is used to authenticate users log in information. Once the application is authenticate the user, it will connect with the 'dms' database. It contains all the system relational tables such as: patient, doctor, appointment and so on. An early version of our design was published in [23].

VII. System Evaluation

This section will discuss the evaluation of the integrated system. Our project is considered to be e-health system. And in our evaluation, we will apply the criteria of e-health evaluation [24].

A. *Areas of Evaluation*

There are some important areas that have to be evaluated to ensure that the system is successful. First is to ensure that the system is useable so the users can achieve the target goal easily. The usability is important in e-health system because if the system is not useable, the patient will never get the benefit of the system. Cost implications are important in evaluation e-health applications [24].

B. *Usability Evaluation*

Since the target user for our mobile application is diabetes patients, our design should be easy to use and flexible. We put in our consideration that the patient may have vision problems, may be an elderly, or may have an urgent problem. So, in our user interfaces design, we try to follow the mobile application usability check list [25]. Table 1 shows these issues that we considered:

TABLE 1. CONSIDERED ISSUES

No.	What is the Standard?	How to ensue it in our project?
1	Clear and consistent way to go back on every screen	(Back) Button is applied in the activity to go one step back word. (Home) Button is applied in the activity to go the select services home screen.
2	Labels and buttons text are clear and concise	We avoid using much word to explain labels and buttons. We just use the simplest word and well known to the public.
3	Retains overall consistency and behavior with the mobile platform	As android phones are considered to be touchable. We take this consideration in our design and ensure that the touch are working well in our application.
4	Minimalist design - excess features removed	We do not offer more tasks than the minimums the application specification

		needs. This is to help the patient in urgent case that he/she is straight forward.
5	Content is concise and clear	We ensure that advises are understandable and easy to applied.
6	Provides feedback to the user of system status	Our system tells the patient is his/her SMS was send successfully or not. Our system feeds the patient back about his/her glucose insertion in the database.
7	Number of buttons / links is reasonable	There are no buttons that have no significant reason to be.
8	UI elements provide visual feedback when Pressed	The labels prompt the users about what to insert. If the patient put invalid input, he/she will also prompt about this.
9	Colors used provide good contrast	In our design, we put in our consideration the patient cases. We depend on only 4 colors with a blank background. We repeat these colors in same sequence to help the patient self-remembering the task from the color.
10	Colors used provide good readability	We avoid using wooded, striped, nor dotted icons or buttons in our design.
11	Font size and spacing ensures good readability	As we mentioned before, the patient may have vision problems, so we adopt a medium font size that is easy to read.
12	If changes can be made, ensure there is a Save button	In My services activities, the patient can enter new values. In each activity there is a submit button that apply the changes and connect to the database to store the results.
13	Present users with a confirmation option when deleting.	The mobile application side seems to be feeding side, so there are no tasks that require delete operation.
14	Speak the users' language (not technical)	In our design, we use a simple language that is understandable to the public. Also, we present the application in two supported language.
15	Error messages are free of technical language	We avoid using technical words to illustrate the errors. Instead we just inform the patient about the error exists

VIII. System Strength

Since our integrated system is design as client-server model, it has many strength points that make it better than some existing software. These strength points are:

- Language independent: Our system interfaces is design based on language dictionaries. Currently, we support two languages. In future, it can contain many languages just by building the XML language dictionary.
- Shared Resources: The database in our application is installed in Wamp Server. The resources in this database are shared between the patient side application as well as doctor side application.
- Database isolation: Since the resources in the database are very critical, we limit the insertion to the database according to the authority. System administrator is the one who is able to insert/edit/delete users and equipments information, but not medical ones. The Endocrinologist is the one who is responsible to enter/update the critical medical information, such as: insulin doses, urgent appointments… etc. The GP enters examination results only. This ensures the right person is dealing with the right information.
- Cost implication: As Android offers many mobiles with variety in cost. The patient will be able to select a smart phone that is within the budget. Currently, the mobile-side application was tested on HTC Desire which runs on Android 2.2. And regarding the glucose meter, we use myglucohealth glucose meter/ wireless kit, it costs about $89. This is a mediate cost between the public.

IX. Summary And Conclusion

In this paper, we discuss our implementation of a diabetes monitoring system for managing and monitoring diabetes patients. The specification of our implemented project is based on Android platform. The architecture of the system is depends on three units: the patient unit, the endocrinologist unit, and the general physician unit. These three units are working together forming an integrated diabetes monitoring system.

The Presentation layer contains the actors of the system: the patient, the endocrinologist, and the general physician. The Presentation Layer is followed by the Service Layer: it contains the main two services provided by the system which are: the report extractor service and the smart analyzer service. The report extractor services are responsible for collecting the information and present them to the endocrinologist and the GP along with patients' record and medical history. The smart analyzer service is responsible to analyze the entered glucose readings and HA1c test result in order to alert the endocrinologist about critical readings. Finally, there is a resource layer which handles the database repository.

Our implemented system provides the patient with many facilities to better monitoring diabetes. Also, the endocrinologist is another aim in our system that we try to reduce the amount of regular medical checkups and examinations done for every diabetes patient. We achieve this goal by adding a general physician who can do this medical checkups and examinations and feed the system with the results. The endocrinologist can access the system and request a report for a certain patient. The endocrinologist can modify the insulin doses and the treatment plan if needed.

Our Implemented system is divided into three environments: Patient-side, doctor-side and central database environments. The patient environment is implemented using Android SDK. In patient-side application, the patient is able to do many services. First, the patient is allowed to feed the system with information through My Services Activity. Patient can enters daily glucose reading, enter intake food, enter physical activities, and enter glucose injection information. Also, patients are allowed to preview their own information through My Information Activity and they can preview the insulin doses, the appointments, and the glucose level ranges. In addition, the patient can make an urgent call to the endocrinologist throw sending SMS message. We add two personal activities which are: change my password, and change my preferred language.

The doctor-side implementation is based on java programming. We use JDBC to facilitate communication with the database. In side Implantation, the interfaces in depending on doctor privilege. The doctor may have 'ENDO' authority which allows them to preview and edit patient record. On the other hand, they may have a 'GP' to preview patient record and enter physical examination results.

In our Implemented project, we use Wamp Server to create MySQL database. Our database is central between the patient-side application and the doctor-side application. We built an administer tool to manage the insert, update or delete users record in the database.

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Detection and Correction of Sinkhole Attack with Novel Method in WSN Using NS2 Tool

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***Abstract*— Wireless Sensor Networks (WSNs) are used in many applications in military, ecological, and health-related areas. These applications often include the monitoring of sensitive information such as enemy movement on the battlefield or the location of personnel in a building. Security is therefore important in WSNs. However, WSNs suffer from many constraints, including low computation capability, small memory, limited energy resources, susceptibility to physical capture, and the use of insecure wireless communication channels. These constraints make security in WSNs a challenge. In this article we discuss security issues in WSNs. In this paper we are discussing a vulnerable sinkhole attack, its implementation and correction.**

Keywords*— Wireless Sensor Networks (WSN); Intrusion Detection (ID); Base Station (BS); Sinkhole (SH);Ad-hoc on demand Distance Vector (AoDV).

I. Introduction

The pervasive interconnection of wireless sensor devices has given birth to a broad class of exciting new applications in several areas of our lives.

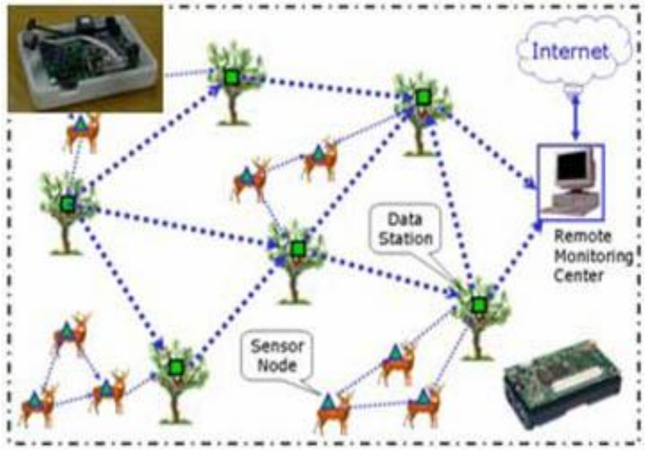

Fig. 1. A Wireless Sensor Network

However, as every network, sensor networks are exposed to security threats which, if not properly addressed, can exclude them from being deployed in the envisaged scenarios. Their wireless and distributed nature and the serious constraints in node battery power prevent previously known security approaches to be deployed and has created a large number of vulnerabilities that attackers can exploit in order to gain access in the network and the information transferred within. Securing sensor networks against these threats is a challenging research area, necessary for commercially attractive deployments. Encryption and authentication mechanisms provide reasonable defence for mote-class outsider attacks. However, cryptography is inefficient in protecting against laptop class and insider attacks. It remains an open problem for additional research and development since the presence of insiders significantly lessens the effectiveness of link layer security mechanisms. This is because an insider is allowed to participate in the network and have complete access to any messages routed through the network and is free to modify, suppress, or eavesdrop on the contents. What makes it even easier for attackers is the fact that most protocols for sensor networks are not designed having security threats in mind. As a consequence, deployments of sensor networks rarely include security protection and little or no effort is usually required from the side of the attacker to perform the attack. So, it is very important to study realistic attacker models and evaluate the practicality and efficiency of certain attacks.[1][2]

This paper investigates one of the most severe routing attacks in sensor networks, namely the sinkhole attack, from the attacker's point of view. Our goal is to describe the most effective ways to launch this attack and demonstrate them in practice. We reveal the weaknesses of the routing protocol that is used by the research community, hoping that this will lead to a better awareness of the threats and the study of more efficient security protocol. Then we propose some countermeasures against these threats in the direction of intrusion detection. Some first intrusion detection systems have started to appear for sensor networks, but rarely do they include specific detection rules. Rules against specific attacks, like the one we present here, if properly generalized could lead to better and more realistic IDS design. [5]

II. Routing Protocol

Ad-hoc On-Demand Distance Vector (AODV) Routing Protocol is used for finding a path to the destination in an ad-hoc network. To find the path to the destination all mobile nodes work in cooperation using the routing control messages. Thanks to these control messages, AODV Routing Protocol offers quick adaptation to dynamic network conditions, low processing and memory overhead, low network bandwidth utilization with small size control messages. The most distinguishing feature of AODV compared to the other routing protocols is that it uses a destination sequence number for each route entry. The destination sequence number is generated by the destination when a connection is requested from it. Using the destination sequence number ensures loop freedom. AODV makes sure the route to the destination does not contain a loop and is the shortest path.

Route Requests (RREQs), Route Replay (RREPs), Route Errors (RERRs) are control messages used for establishing a path to the destination, sent using UDP/IP protocols. Header information of these control messages are explained in. When the source node wants to make a connection with the destination node, it broadcasts an RREQ message. This RREQ message is propagated from the source, received by neighbors (intermediate nodes) of the source node. The intermediate nodes broadcast the RREQ message to their neighbors. This process goes on until the packet is received by destination node or an intermediate node that has a fresh enough route entry for the destination.

III. Problem Formulation

A sinkhole attack prevents the base station from obtaining complete and correct sensing data, and thus forms a serious threat to higher-layer applications. It is particularly severe for wireless sensor networks given the vulnerability of wireless links, and that the sensors are often deployed in open areas and of weak computation and battery power. Although some secure or geographic based routing protocols resist to the sinkhole attacks in certain level, many current routing protocols in sensor networks are susceptible to the sinkhole attack.

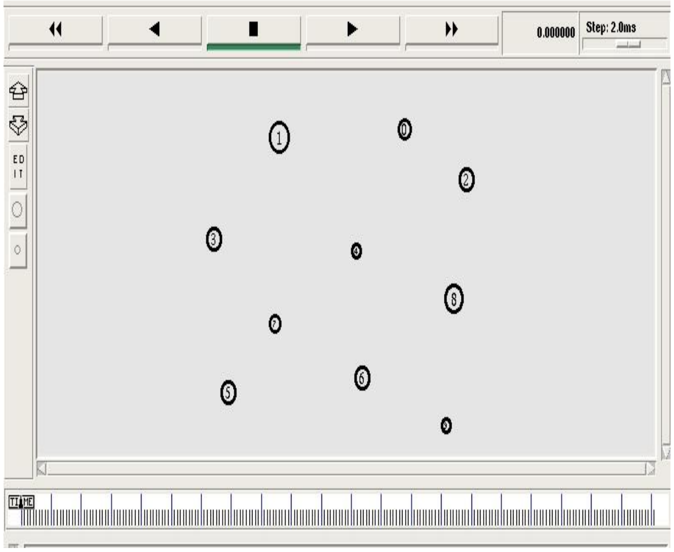

Fig. 2. A WSN Comprised Of Various Nodes

We consider a sensor network that consists of a base station (BS) and a collection of geographically distributed sensor nodes, each denoted by a unique identifier *IDv*. The sensor nodes continuously collect and send the sensed application data to the base station by forwarding packets hop-by-hop.

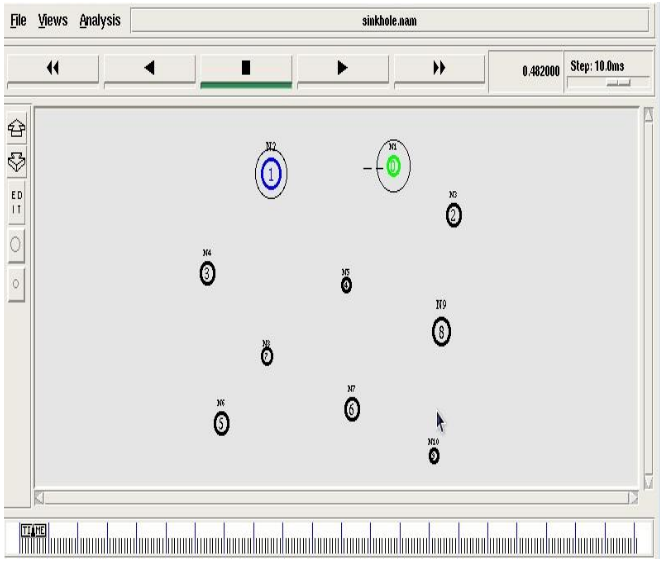

Fig. 3. Data sharing in WSN

As mentioned earlier, this commonly used many-to-one communication pattern is vulnerable to sinkhole attacks. In a sinkhole attack, an intruder usually attracts network traffic by advertising itself as having the shortest path to the base station. For example, an intruder using a wireless-enabled laptop will have much higher computation and communication power than a normal sensor node, and it could have a high-quality single-hop link to the base station (BS). It can then advertise imitated routing messages about the high quality route, thus spoofing the surrounding nodes to create a sinkhole (SH).

A sinkhole can also be performed using a wormhole, which creates a metaphorical sinkhole with the intruder being at the center. An example, where an intruder creates a sinkhole by tunneling messages received in one part of the network and replays them in a different part using a wormhole. We assume the sensor nodes are either *good* or *malicious*. The center of a sinkhole attack is a malicious node compromised by the intruder. Note that, even if there is only one compromised node providing a high quality route to the base station, it can affect many surrounding sensors. Furthermore, this intruder may also cooperate with some other malicious nodes in the network to interfere detection algorithms. In an extreme case, all the malicious nodes are colluding with the intruder. They may collaboratively cheat the base station by claiming a good node as the intruder (the victim, SH'), and thus hide the real one. In our work we implemented sinkhole attack in AODV routing protocol, that works on hop by hop method, means the request goes hop by hop till we reach the destination. The figures 2,3,4,5 shows nodes in wireless sensor networks comprised in which if some node want to send data to other, it will be destined by hop by hop method.

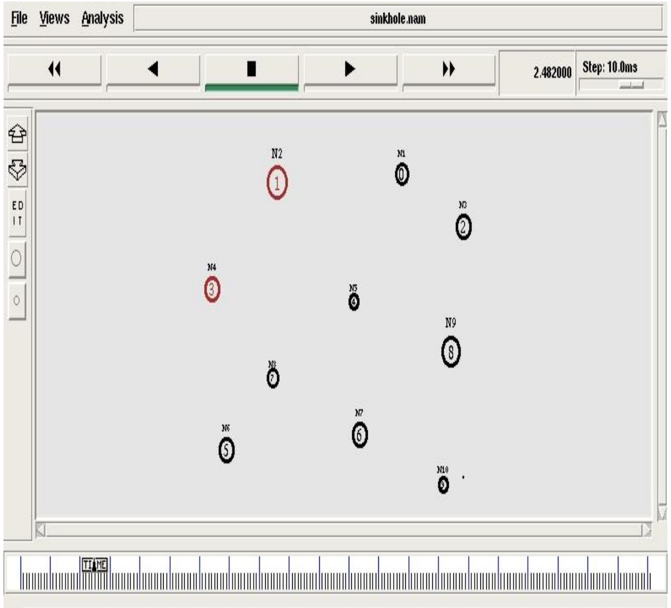

Fig. 4. A Sinkhole attack in WSN

IV. Problem Solution

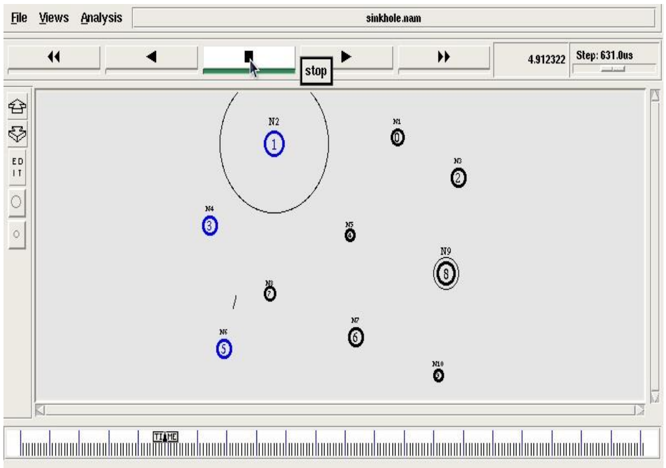

Fig. 5. Correction of Sinkhole attack

The solution proposed for SINKHOLE attacks in WSN is done in three steps. Wireless Sensor Network is an open network as it has wireless nature. The security feature becomes less when we are working in a Wireless Sensor Networks. To avoid this problem, the sender node first requests the sequence number with the rreq message, if the node replies its sequence number with rrep message. Transmitting node will match sequence number in its routing table. If matches then data will be shared otherwise it will be assign the sequence number to the node. If the node accepts the sequence number then the node will enter in the network otherwise it will be eradicated from the network. The focus of our work is to effectively identify the real intruder in the sinkhole attack in presence of colliding nodes. We assume that the base station is physically protected or has tamper-robust hardware.

Hence, it acts as a central trusted authority in our algorithm design. The base station also has a rough understanding on the location of nodes, which could be available after the node deployment stage or can be obtained by various localization mechanisms.

V. Results And Discussion

All we discussed above is Implementation of Sinkhole attack and its prevention. Now, our network is protected from sinkhole attacks. The discussion is about what happens to our network performance. As we seen in the figures, we have chosen two parameters for discussion about what happens to the network. In the first figure, the first parameter chosen is about the packet which tells how many packets lost and received during sinkhole attack and packets lost and received after correction of sinkhole attack.

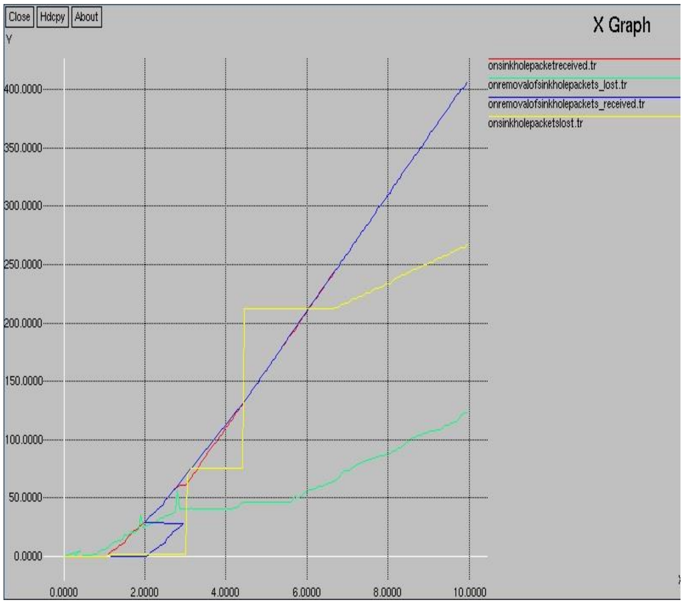

Fig. 6. Results of packet loss and packet received during and after sinkhole attack.

Here we have arranged different color combinations for various parameters. During sinkhole attack, packet lost represented by yellow line and packet received by red line whereas after the correction of sinkhole attack, packet lost are very less and denoted by green line and packets received by Blue line which are much more than the latter.

Next parameter chosen is the Latency which tells how much time a packet needs to travel from source to destination. During Sinkhole attack, main aim of the network is to reduce the network performance by delaying the routing packets. Figure shows the results of routing time or the Latency during Sinkhole attack and after correction of Sinkhole attack.

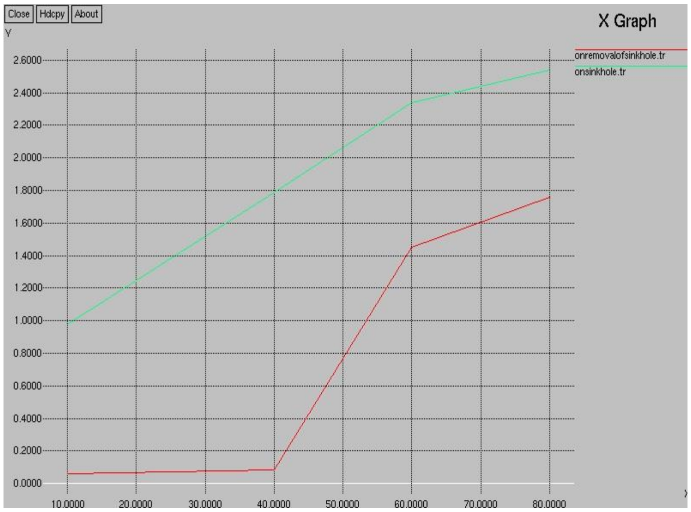

Fig. 7. Comparison of routing time while and after sinkhole attack.

Discussion ends by saying that performance of the network will be affected if there is any Sinkhole attack in the network.

VI. Future Work

Wireless sensor network is very vast topic for new research. It discovers various steps during data sharing. As we decided Sinkhole attack for research work, several other attacks will be chosen for future work. And if someone want to choose this selected topic, then the performance of the network will be measured by choosing different parameters like routing overhead, delay, or the same attack will be implemented by choosing other protocol.

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Intelligent Collaborative Quality Assurance System for Wind Turbine Supply Chain Management

Intelligent Collaborative Quality Assurance System for Wind Turbine Supply Chain Management

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***Abstract*—To determine the root causes or sources of variance of bad quality in supply chains is usually more difficult because multiple parties are involved in the current global manufacturing environment. Each component within a supply chain tends to focus on its own responsibilities and ignores possibilities for interconnectivity and therefore the potential for systematic quality assurance and quality tracing. Rather than concentrating on assigning responsibility for "recall" incidents, it would be better to expend that energy on constructing a collaborative system to assure product quality by employing a systematic view for the entire supply chain. This paper presents a systematic framework for intelligent collaborative quality assurance throughout an entire supply chain based on an expert system for implementing two levels of quality assurance: system level and component level. This proposed system provides intelligent functions for quality prediction, pattern recognition and data mining. A case study for wind turbines is given to demonstrate this approach. The results show that such a system can assure product quality improved in a continuous process.**

Keywords*—Wind turbine expert system; Supply chain management; Collaborative quality assurance; Prediction; Pattern recognition;

I. INTRODUCTION

Quality is a critical requirement for customers, especially in the case of expensive and complex products. In recent years, an increasing number of product recalls are occurring. Such product recall incidents have resulted in serious customer dissatisfaction and significant company losses in both image and business. Rather than argue who ought to apologize to the "recall" incidents, it would be better to expend that energy on constructing a collaborative system to assure product quality by employing a systematic view for the entire supply chain. A product supply chain can encompass multiple, diverse parties in the current global manufacturing environment. Each functional part in supply chain tends to focus on its own responsibilities, resulting in a lack of strong interconnected infrastructure to support systematic quality assurance, such as clear management structure and a quality tracing enabled data collection framework. It is therefore often difficult to identify or trace the exact reason for bad quality. How to ensure product quality collaboratively becomes a vital task for the companies along the supply chain.

Supply chain management (SCM) was defined as the management of a network of interconnected businesses involved in the ultimate provision of product and service packages required by the end customers. It spans all movement and storage of raw materials, WIP inventory and finished goods from point-of-origin to point-of-consumption. A good SCM is essential for companies to meet global competition. Nowadays, many manufacturers and service providers collaborate with their suppliers and upgrade their purchasing and supply management functions from a clerical role, to an integral part of SCM. In terms of possessing a systematic quality assurance function and a collaborative data collection framework for quality tracing, gaps still exist.

Quality assurance was defined as "a strategic management function concerned with the establishment of policies, standards and systems for the maintenance of quality"[1]. Later, as a result of benchmarking studies, Baines and Ryan determined that quality assurance could be identified as [2]:

1) *A tool to demonstrate regulatory compliance;*
2) *A business efficiency tool to ensure product quality and minimize hygienic risks;*
3) *A communication tool to customers and consumers, wherever they are in the world.*

Quality assurance becomes increasingly important in integrated SCM [3-4]. As for the methodologies, the majority of prior works tend to conduct failure testing or statistical control to improve quality assurance system [5-9]. Over the past thirty years, considerable advances have been made in computational intelligence. Various intelligent technologies and/or algorithms like artificial neural networks genetic algorithms, fuzzy/logic systems, learning algorithms, and metaheuristics have been developed for realizing intelligent control or expert systems [10]. Compared to traditional statistical control based quality assurance, computational intelligence technologies have advantages for making intelligent decisions such as quality prediction and pattern recognition for the situations with high complexity. If the quality can be predicted before production, it will greatly help avoid generating bad products. Designer can forecast the quality and thus optimize designed settings and tighter tolerance before releasing the design, while downstream parties, such as manufacturing, can optimize real settings in the similar way prior to production. And moreover, if the quality can be classified into several levels such as “good quality”, “average quality” and “bad quality,” products classified lower than “good quality” can be analyzed and traced back to the settings of the impact factors in order to determine the root cause of quality deficiencies. Through such analysis, the rules of best settings can be obtained, and the necessary changes in product or process design can be determined. Hence, providing intelligent functions such as quality prediction, pattern classification and data mining can improve quality by improving overall design; in addition, such functions can help optimize quality assurance for other downstream parties as well. Currently, there exists little research [11] on developing such intelligent systems for quality improvement in industry process. Extensive space could be explored to improve the performance of collaborative quality assurance.

With the consideration of the significance in closing above mentioned gaps, this paper will base on computational intelligence technologies to establish a collaborative quality assurance expert system for machinery products to ensure and improve their quality continuously.

This paper is structured as follows. In Section 2, the methodology of collaborative quality assurance in SCM is proposed. Section 3 takes wind turbine as a case to demonstrate the methodology. Finally, conclusions and future work are provided in Section 4.

II. Methodology For Collaborative Quality Assurance In SCM

Methodology to develop the collaborative quality assurance expert system in SCM is provided in this section. Quality and quality assurance will be defined first. Three conceptual frameworks, including a management model, a technical model and a database management model, will be established to help guide the coordination of quality assurance along the whole supply chain. Intelligent functions such as quality prediction, pattern recognition and knowledge mining will be designed in the technical model to support two levels of collaborative quality assurance in SCM: system level and component level.

A. Problem formulation

1) *Quality*

It is important to realize that quality is determined by the intended users, clients or customers, not by society in general. 'Expensive' does not always mean 'high quality'. Even goods with low prices can be considered quality items if they meet a market’s requirements.

Quality ultimately is measured in terms of customer satisfaction. Customers may have various measurements, such as number of product recalls, number of maintenance fix requests per year, defects found after product delivery per function point, cost of defects (e.g. annual maintenance costs), costs of quality activities (e.g. costs of inspections, diagnostics, test execution, defect tracking, preventive measures and QA education), mean time between failure (MTBF), mean time to repair (MTTR), and so on, to check the product quality characteristics like functionality, reliability, safety, efficiency, and maintainability.

For this paper, no matter what a customer’s requirements are, a product that is closest to meeting these requirements is considered to be of good quality.

2) *Quality Assurance*

Quality Assurance, or QA for short, was described as a set of activities intended to ensure that products (goods and/or services) satisfy customer requirements in a systematic, reliable fashion. QA can’t absolutely guarantee the production of quality products, unfortunately, but makes this more likely. Two objectives are therefore set for achieving the optimal QA (see Figure 1).

a) Objective 1: To optimize the design of product

Customer requirements will be translated by designers into parameters for what constitutes a high quality product. This paper assumes that designers will provide the optimal value setting and tolerance of all possible quality impact factors in advance, including raw material specification, product dimensions, manufacturing environment, machine statuses, delivery requirements and so on. The evaluation criterion of an optimal design is that the design can best meet customer-defined requirements. The objective 1 is identified as:

To Minimize Difference 1 = Design Setting - Customer Requirement

b) Objective 2: To maximize the compliance with design

Given an optimal design, quality assurance will attempt to make the real value setting of each quality impact factor along supply chain (e.g. raw material, manufacturing, delivery) in line with those of the design, so as to meet the functionality or the specifications of design. This objective can also be represented as minimizing the difference between real settings and design settings, that is:

To Minimize Difference 2 = Real Setting – Design Setting

The difference 2 is essentially the deviation of real settings from design settings. A maximum acceptable deviation from a nominal design setting is called tolerance.

The scales of the differences of different factors are not the same. A Compliance Index (CI) is defined to represent the degree of accuracy of the real setting in comparison to the design setting in a standardized scale from 0 to 1. A value of 0 means that the real setting matches design requirements perfectly, while a value of 1 means that real settings do not adequately match design requirements. These values can be obtained by

$$\begin{aligned} &\boldsymbol{CI} = 1 - \boldsymbol{e}^{-\left|\frac{\boldsymbol{R}-\boldsymbol{D}}{\boldsymbol{D}}\right|} \\ &\boldsymbol{s.t.} \qquad \boldsymbol{R} >= 0, \boldsymbol{D} > 0 \end{aligned} \tag{1}$$

where R and D represent the real setting and design setting for a same impact factor, respectively. If the setting of certain input factors for the best design is zero, then the following equation could be used to calculate the compliance index:

$$\boldsymbol{CI} = 1 - \boldsymbol{e}^{-|\boldsymbol{R}-\boldsymbol{D}|}$$
$$\boldsymbol{s.t.} \quad \boldsymbol{R} >= 0, \boldsymbol{D} >= 0 \qquad (2)$$

Objective 2 is therefore to "Minimize CI".

Accordingly, QA includes two activities in this study: to design the best regulation of the quality related factors which rely on raw materials, assembly, components and overall products, as well as the services related to production, inspection and delivery processes; and to seek the maximum compliance between each real factor setting and their corresponding design factor settings.

3) *Closed loop quality assurance improvement to guarantee good*

An expert system based closed loop quality assurance improvement process is proposed in Figure 1 to fulfill the above two objectives continuously. There are multiple factors (e.g. raw material factors, manufacturing environment factors, machine factors, assembly factors, delivery factors, etc) throughout supply chain that may influence product quality in various ways and in dynamic situations. The individual and combined influence of multiple factors on quality is unclear. The rules of knowledge base will be obtained from the intensive study of the impact of multiple factors on product quality by the expert system. The product quality will be predicted and patterns will be recognized. The features indicative of bad quality will be extracted and feedback to designers to determine, and improve upon, parameter settings and tolerances for bad quality. The deviation of real settings from nominal design settings on multiple factors will also be studied in order to provide knowledge for compliance improvement. Once the root causes for bad quality are determined, they will be delivered to appropriate personnel for quality improvement. The above improvement of design and compliance will be made in a continuous process.

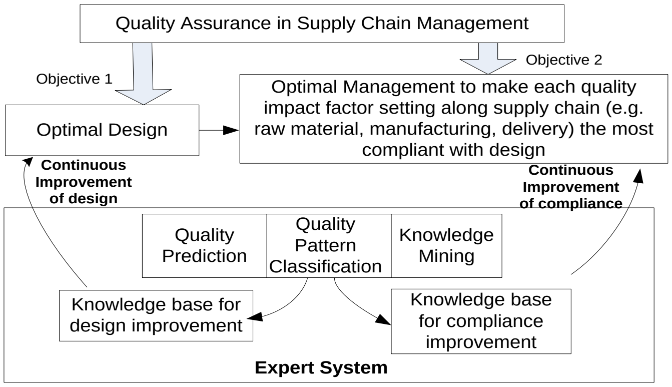

Quality Assurance in Supply Chain Management
Objective 1
Objective 2
Optimal Design
Optimal Management to make each quality impact factor setting along supply chain (e.g. raw material, manufacturing, delivery) the most compliant with design
Continuous Improvement of design
Continuous Improvement of compliance
Quality Prediction
Quality Pattern Classification
Knowledge Mining
Knowledge base for design improvement
Knowledge base for compliance improvement
Expert System

Fig. 1. Closed Loop Improvement Method To Guarantee A Good Quality Assurance In SCM.

The management-level method for guaranteeing the quality impact factor setting's compliance with design is demonstrated in Section 2.2, while the expert system for studying multi-factor impacts on quality, providing intelligent functions such as prediction, pattern recognition, and generating the knowledge bases for above two objectives is presented in Section 2.3. The distributed database management system proposed in Section 2.4 can help a user trace back the situation in which a quality issue has been discovered.

B. *Management Structure for collaborative quality assurance*

Assuming that a certain design is optimal, an order oriented collaborative quality assurance team management mode is proposed in order to assure the supply chain factor settings' compliance with the design.

For the products of the same order, a quality assurance (QA) team will be organized among all the parties along the supply chain. The system supplier needs to take direct responsibility for delivering the product (a complete assembled system is defined as a product) to end users and it also needs to guarantee the quality of the components outsourced. The system supplier has a good connection to the end user and component suppliers. Considering these connections, the system supplier is the best party to lead the quality assurance team. Each quality related department, such as system level design, assembly process and delivery, component level design, raw material supply, manufacturing, and delivery will work together for QA.

After receiving the customer expectations of what they expect from a product, system level QA will design the optimal regulations (e.g. parameter value setting and tolerance setting for materials, manufacturing and delivery along supply chain) for the best quality product. The quality parameters for components will be delivered to each component QA as a customer requirement. Component QA will continue to update the optimal settings for a component if the customer requirements received need to be amended, or if new requirements are identified. The designed settings will then be passed to each party along the component supply chain.

Each downstream party will check the compliance of real settings with design settings after it completes its part. If the completed part passes the quality compliance check, then it will be delivered to its upstream party. If all parties, including those responsible for raw materials, manufacturing and delivery, have finished their check, a total quality assurance (TQA) will be carried out before the completed component is sent for system level assembly. System level QA will start after all component level QAs are completed. The same quality compliance check will be conducted for the system assembly process and its delivery path. The customer will do a TQA for the final assembled product. Those products which fail the TQA will be sent back for rework.

C. *Two levels of quality assurance expert system in SCM*

Ensuring a high level of quality for products throughout a supply chain is a much-needed perspective into the SCM due to the importance of quality in terms of improving system reliability and customer satisfaction. Various factors along a supply chain can influence the quality of a product. Determining the impact of multiple factors on product quality is of significant importance in providing useful information to improve quality assurance. Few quality assurance approaches can satisfy this need due to the complexity of the real situation. This section will propose a quality assurance expert system to close this gap. As the product (or system) and each of its components have their own supply chains, the framework for the expert system is developed based on two levels: system-level quality assurance and component-level quality assurance.

1) *System level quality assurance in SCM*

The procedure for conducting system level quality assurance is illustrated in Figure 2. As indicated in the procedure, the supply chain of the product (or system) is identified first. The criteria for what constitutes system-level quality, such as reliability, based on the customer requirements, are then defined. Component level quality assurance is one important step for guaranteeing system level quality assurance. Theoretically speaking, quality assurance for each component will ensure the optimal result, in terms of quality, for the overall product. However in reality, it is not necessary to research each component, and it would be costly to do so. Thus, it becomes essential to balance the costs versus the benefit first. For the situation in which it is not cost effective to do quality assurance for each component, the critical component analysis and selection needs to be conducted. Subsequently, it is vital to define component-level quality for the chosen critical component(s) in order to conduct component-level quality assurance. The factors of the component that are most indicative of quality will be selected for studying their impact on the defined component-level quality. With this information, the component-level quality assurance expert system can be constructed. The comparison of component quality performance before and after applying the proposed system will be used for evaluation and to determine if improvements to the system can be made. The customer's requirements are another criterion for making a quality determination. The order of using these two criteria can be adjusted according to the target of the quality improvement. Once the quality of all the studied components is improved to meet the defined requirements, the overall quality of the product will be evaluated to see whether it can meet the system requirements. If not, the prior steps should be revisited in order to continue improving the component-level quality. Therefore, through the procedure of system-level and component-level quality assurance, the quality of product can be better ensured.

2) *Component level quality assurance in SCM*

A component-level quality assurance expert system has been designed (Figure 3) for improving component quality based on the study of the impact of multiple factors on quality. For each component, the selection of factors from different parties along component supply chain, and the quality of the components produced, will be determined. The database system for data collection is presented in following section. Some samples will be selected from the database and input as training data for the expert system.

One major function of the expert system is to provide a scientific way for quality prediction and quality classification. For this purpose, quality forecasting and quality classification models will be built based on the training data. Inputting any test sample of impact factors, the forecasting model will predict the corresponding quality. For the predicted quality, the quality pattern recognition model will identify the pattern that it belongs to. The designer can use this system to test if the design settings will result in a good or bad quality product before releasing the design to downstream parties. Downstream parties, such as manufacturing, can apply the proposed system to predict the quality of products to be produced based on simulated real settings. They are then able to optimize their real settings before production. With this intelligent measurement system, tremendous loss from incorrect design settings or incorrect real settings will be saved.

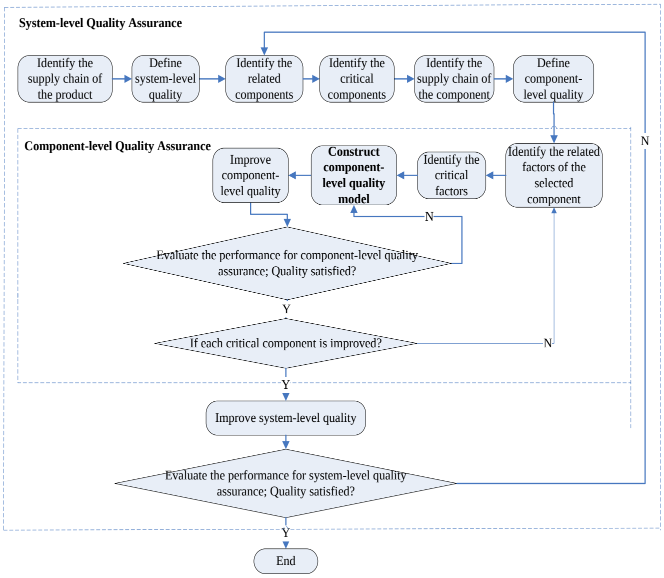

System-level Quality Assurance
Identify the supply chain of the product
Define system-level quality
Identify the related components
Identify the critical components
Identify the supply chain of the component
Define component-level quality
Component-level Quality Assurance
Improve component-level quality
Construct component-level quality model
Identify the critical factors
Identify the related factors of the selected component
N
Evaluate the performance for component-level quality assurance; Quality satisfied?
Y
If each critical component is improved?
N
Y
Improve system-level quality
Evaluate the performance for system-level quality assurance; Quality satisfied?
N
Y
End

Fig. 2. System level quality assurance in SCM.

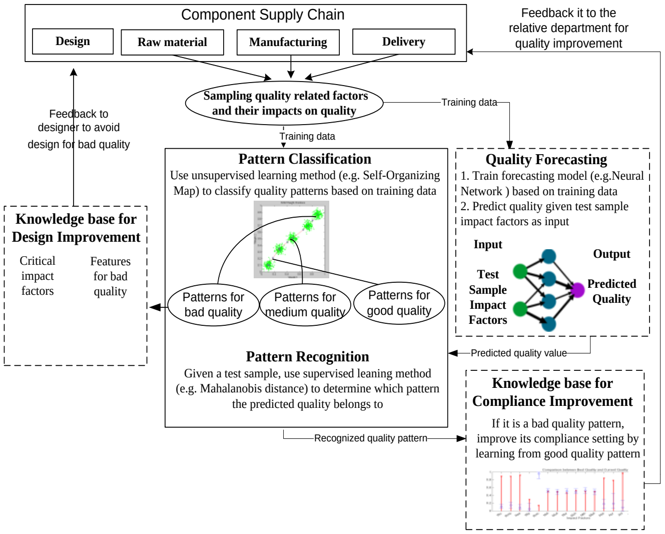

Component Supply Chain
Design
Raw material
Manufacturing
Delivery
Feedback it to the relative department for quality improvement
Sampling quality related factors and their impacts on quality
Training data
Training data
Feedback to designer to avoid design for bad quality
Pattern Classification
Use unsupervised learning method (e.g. Self-Organizing Map) to classify quality patterns based on training data
Quality Forecasting
1. Train forecasting model (e.g.Neural Network) based on training data
2. Predict quality given test sample impact factors as input
Input
Test Sample Impact Factors
Output
Predicted Quality
Knowledge base for Design Improvement
Critical impact factors
Features for bad quality
Patterns for bad quality
Patterns for medium quality
Patterns for good quality
Pattern Recognition
Given a test sample, use supervised leaning method (e.g. Mahalanobis distance) to determine which pattern the predicted quality belongs to
Predicted quality value
Knowledge base for Compliance Improvement
If it is a bad quality pattern, improve its compliance setting by learning from good quality pattern
Recognized quality pattern

Fig. 3. Component level quality assurance in SCM

The expert system has another function: to generate knowledge bases for design improvement and compliance improvement for achieving the best quality assurance. For instance, a correlation study of the impact factors and their affect on quality will reveal the critical impact factors that have bigger influence on bad quality. Further data mining conducted on bad quality patterns, such as a histogram of each critical impact factor, is helpful to find the features (i.e. range of settings) that result in bad quality. The knowledge obtained will be shared with the designer for better design settings and tighter tolerances and hence avoid designs that result in bad quality. For other parties in a supply chain, the analysis of the difference between their input factors and those indicative of good quality will show them how to adjust their settings to improve their compliance with the design settings.

3) *Distributed database management system for quality assurance*

Data collection for quality assurance is a challenge because it requires the cooperation of the different parties within the whole supply chain. A good organization with clearly assumed responsibility is important for successful data collection.

This paper thus presented a distributed quality assurance database management system (see Figure 4), in which one quality assurance database (QADB) is associated with each supply chain party, all quality assurance databases are connected via internet, and are under the control of a central database management system (CDBMS). It is suggested that the CDBMS be managed by the system supplier, while the end user has authorization to access and manage the QA information of the products they ordered. Consistent data recording and assessment and documentation integrity is necessary. Each produced part, including components and final product, is attached with an e-tag, such as a Radio Frequency Identification (RFID), which stores its basic information and path for accessing its QADB.

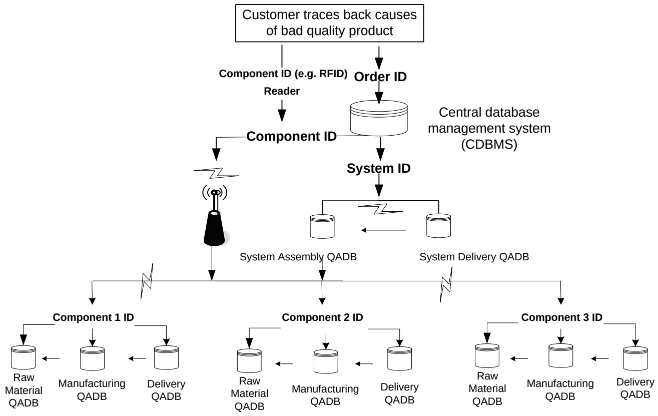


Fig. 4. Distributed quality assurance database management system.

When a quality problem occurs during usage, the end user may trace back its causes. If the source of the problem cannot be located, they may input the order number into the CDBMS to find the system ID and then trace the system delivery status and production status. If there is no problem with the system level process, then the user can continue to trace the issue back to the delivery status, production status and even to the raw material status for each component, with the assistance of each QADB. This process is conducted until it is determined at which stage the quality issue originated.

If the user knows the problem component, he can trace back the component status in the corresponding QADB directly with the assistance of the component ID and other relative information read from its e-tag.

Although manufacturers and suppliers have noticed the importance of quality assurance for wind turbines, they usually confine their quality assurance efforts to their specific realm, which does not make use of potential opportunities for collaboration. For example, designers only focus on how to improve product design, while manufacturers only focus on how to ensure quality during assembly and production and distributers on storage, delivery and logistics. Ignoring the interrelationship between them may easily cause bad products due to poor quality coordination. Thus, it becomes essential to study the relationship between all parts in supply chain and build a collaborative model for quality assurance.

Considering the marvelous long term growth of wind turbine, and its utmost needs for collaborative quality assurance, it will be taken as an example to demonstrate the proposed systematic framework for quality assurance in supply chain based on the study of the relationship between the critical impact factors and product quality. Through the successful application of this proposed methodology, this collaborative quality assurance model can be certainly applicable to some other machinery products.

D. *Identify the supply chain for a wind turbine*

A wind turbine has a unique and internationally distributed supply chain the parameters of which is strongly influenced by the recent increase in wind turbine production. The components of wind turbines have their corresponding supply chains as well. A typical supply chain for a wind turbine is demonstrated in Figure 5. A general supply chain may have warehouses, distribution centers or retailers between the manufacturer and customer. However, in this study, the supply chain can be simplified as a wind turbine is the kind of customized products which is usually directly delivered from a wind turbine manufacturer to their customers.

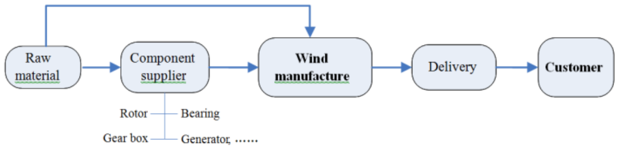


Fig. 5. A typical supply chain for wind turbine.

Based on the framework in Section 2.3, first, system level quality for awind turbine can be defined as high reliability of wind turbine to ensure smooth operation. Through understanding the structure of a wind turbine, its components can be analyzed so as to define component level quality. A collaborative quality assurance model for component level will be discussed in the following sections, which can be applied as quality assurance model for the system level too by defining the system quality index and its corresponding impact factors.

E. *Select critical components of wind turbine*

The general structure of wind turbine is shown in Figure 6 [12]. The main parts of a wind turbine (as shown below) are the rotor, blades, brake, controller, gear box, generator, high-speed shaft, low-speed shaft, nacelle, pitch, wind direction, wind vane, yaw drive and yaw motor. Most turbines have either two or three blades. Wind blowing over the blades causes the blades to "lift" and rotate. Generally, the blades and the hub together are called the rotor. When the blades rotate, the gears rotate; the gears connect the low-speed shaft to the high-speed shaft and increase the rotational speeds from approximately 30 to 60 rotations per minute (rpm) to approximately 1000 to 1800 rpm, which is the rotational speed required by most generators to produce electricity. Generally, the gear box is the most costly part of a wind turbine.

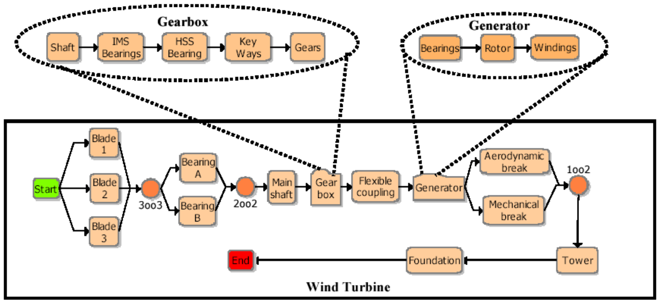


Fig. 6. General structure of wind turbine.

Although a wind turbine is comprised of many components, it is more cost effective to focus on the critical components for quality assurance. In order to identify the critical components of a wind turbine, the typical way is to determine which component has the greatest influence on wind turbine breakdowns. In recent years, numerous failure surveys have been conducted on wind turbines. A downtime distribution was presented in [13], based on a population of German wind turbines. Braam and Tavner both provided recent studies on failure probabilities [14-16]. McMillan and Ault then selected four component categories from these multiple sources and illustrated their annual probability of failure on the same chart [17]. They further used this data to study reliability benchmarks [18]. This paper summarizes their researches in Figure 7 to illustrate the effect of both the failure probability and downtime distribution of four components of wind turbines, namely the electronics & controls, rotor blades, gearbox and generator. The X value is the downtime distribution data from Winstats Newsletter[13], meanwhile, while the Y value is the failure probability from the surveys for the same component [14-16]. It should be noted that each component has three samples marked in different colors. The plot area is divided into four quarters, namely quadrants 1 to 4, based on the high or low values of the axis. All gearbox & bearing samples, as well as all generator samples and some blades samples, fall in quadrant 4, which shows that all these components have a high downtime distribution with comparatively a low failure probability. Therefore, gearbox, generator and rotor blades are taken as more critical components.

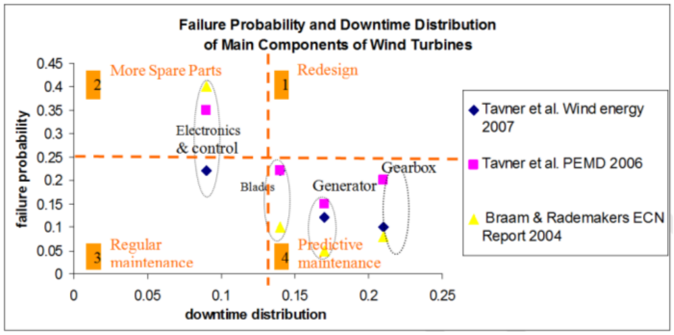


Fig. 7. Wind Turbine Critical Components Selection Based On Integrated Failure Effect Study.

F. *Define component level quality*

Component level quality assurance will then be established for the component selected with its corresponding quality criteria (i.e. rules in quality assurance model) and impact factors. As shown in Figure 6, bearings are key sub-components in both gearboxes and generators, which are two critical components of wind turbines. It is thus taken as an example in the following sections to demonstrate the approach of building component level quality assurance model. This approach can be applied to other components.

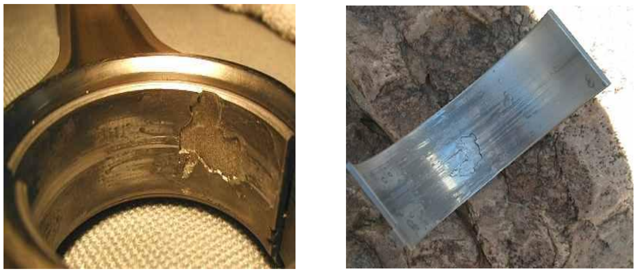


Fig. 8. Fault of bearing.

TABLE I. PRIMARY TYPES OF QUALITY RELATED BEARING DAMAGES.

Bearing damage	Caused by	Bearing damage	Caused by
wear	abrasive particles	flaking	Preloading
	inadequate lubrication		oval compression
	vibration		axial compression
smearing	rollers and raceways		Misalignment
	external surfaces		Indentations
	roller ends guide flanges		Smearing
crack	rough treatment		deep seated rust
	excessive drive-up		fretting corrosion
	smearing		Fluting
Cage damage	vibration	corrosion	deep seated rust
	excessive speed		fretting corrosion
	wear	indentation	Overloading
	blockage		foreign particles

The primary types of bearing damages are necessary to be well researched before building the component level quality assurance model. Bearings as prominent parts among the most important components in the majority of machines sometimes, do not always meet their life expectancy due to damages from multiple sources for diverse reasons, such as heavier loading, careless handling, ineffective sealing or unsuitable fits. Each of these factors produces its own particular type of damage and leaves its own special impact on a bearing. Thus, it is essential to examine the damaged bearing and study the cause of the damage so as to provide support for quality assurance.

Based on the most prevalent types of bearing damage (see Table 2), it can be seen that most damage is caused by quality issues along the supply chain. Hence, the quality index and the major impact factors influencing bearing quality will be identified and their relationship will be well studied by using this proposed model.

As mentioned before, there exist various types of quality index according to customer requirement. Reliability is adopted in this section to represent the quality of the bearing. Other quality indices can also be considered in the same way, according to a customer's requirements. In engineering, reliability is the ability of a system or component to perform its required functions under stated conditions for a specified period of time. The traditional notation for reliability is $\boldsymbol{R(t)}$, while here it is shown as one index of quality, and is denoted as $\boldsymbol{Q_{re}}$. Mathematically, reliability may be expressed as

$$\boldsymbol{Q_{re} = R(t) = P(T > t) = \int_t^\infty f(x)dx} \qquad (3)$$

where $\boldsymbol{f(x)}$ is the failure probability density function and t is the length of the period of time that is assumed to start from time zero .

G. Identify quality impact factors for critical component

By analyzing bearing damages and its causes, 19 main quality impact factors which can cover the majority of the causes of damage are selected for study. Five of them are factors related to raw material, six of them are about machining, four of them are machine status factors, three are manufacturing environment factors, and one is the delivery condition. Those 19 impact factors and 1 quality index (i.e. reliability of bearing) are listed in Table 3.

As stated in the methodology section, the designed settings are assumed to be optimal. The quality assurance target of other parties is to make the real settings meet the designed settings. The deviations of real settings from design settings instead of the real setting values are studied because they can reflect the quality compliance level. The results of which can further help design tighter tolerances. As discussed in Section 2.1, *CI* is introduced to transfer the different scales of the deviations to a standardized range, from 0 to 1. In terms of the chosen standard value range, 0 means the difference between real settings and designed settings is the smallest, while 1 means the difference between them is the biggest. *CI[R$_{lu}$]* indicates the compliance index of lubricant in "Raw material" category. Equations (1) and (2) provide the method to calculate *CI*. The *CIs* of all selected impact factors are taken as the inputs of the quality assurance model. *CI[Q$_{re}$]*, the compliance index of reliability, is the output factor. *CI[Q$_{re}$]* is calculated by $(1-R(t))$, in order to make it comply with the *CI* of the input factors. That is 0 means the perfect case with the best reliability, while 1 reflects the worst one.

H. Quality prediction and pattern recognition for critical component

For the purpose of quality prediction and pattern recognition, many intelligent approaches can be used. In this study, two neural network models, called Feedforward neural network and self-organizing map neural network (SOM) are used. A Feedforward neural network is developed to predict the component quality and a self-organizing map (SOM) is built to classify the quality pattern, through learning the relationship between quality and its impact factors collected along the supply chain.

1) *Quality prediction*

A Feedforward neural network is an artificial neural network in which connections between the units do not form a directed cycle.

TABLE II. SELECTED IMPACT FACTORS AND QUALITY INDEX.

Factors		**Notation**	**Range of CI**
Input			
Raw material	Lubricant	R_{lu}	[0,1]
	mounting pressure	R_{mp}	[0,1]
	seating out of alignment	R_{sa}	[0,1]
	foreign particles	R_{fp}	[0,1]
	material containing	R_{mc}	[0,1]
Manufacturing	inner diameter	M_{id}	[0,1)
	outer diameter	M_{od}	[0,1)
	surface roughness	M_{sr}	[0,1)
	chamfer	M_{ch}	[0,1)
	thickness	M_{th}	[0,1)
	ball diameter	M_{bd}	[0,1)
Machine	Balance	A_{ba}	[0,1]
	Precision	A_{pr}	[0,1]
	Health index	A_{hi}	[0,1]
	Vibration	A_{vi}	[0,1]
Environment	Temperature	E_{te}	[0,1]
	Humidity	E_{hu}	[0,1]
	Dust tolerance	E_{dt}	[0,1]
Delivery	Delivery condition	D_{dc}	[0,1]
Output			
Quality index	Reliability	Q_{Re}	(0,1]

Note: CI range values have been standardized for all factors.
CI Value range in "Manufacturing" represents the difference between real manufacturing setting and design requirements. 0 means no difference. The closer to 1, the bigger difference it is. So 0=perfect case; 1=worst case

It is most commonly used with the back propagation algorithm that often has one or more hidden layers of sigmoid neurons followed by an output layer of linear neurons. In this network, the information moves in only one direction, forward, from the input nodes, through the hidden nodes and to the output nodes. There are no cycles or loops in this type if network. Multiple layers of neurons with nonlinear transfer functions allow the network to learn nonlinear and linear relationships between input and output vectors. A well learned network is often applied for function approximation or regression analysis tasks, including forecasting. Cost function is an important concept in learning, as it is a measure of how far away we are from an optimal solution to the problem that we want to solve. Learning algorithms search through the solution space in order to find a function that has the smallest possible cost. A commonly used cost is Mean Square Error (MSE) which tries to minimize the average squared error between the network's output and the target value over all the example pairs.

In this case study, for each selected impact factors and quality index, 1000 samples are collected and then their compliance indices are standardized into a range [0,1]. For each factor, 1000 standardized CI samples are stored in one factor vector, and 1000 quality index samples are in one quality index vector.

In the Feedforward neural network model, the input is the vector of 19 factor vectors, and the output is the quality index vector. Two layers are set and the Levenberg-Marquardt rule is chosen to train this neural network model. The epoch is set to be 1000. The Mean Square Error (MSE) is used to examine the prediction performance. The MSE <=0.01 is set as threshold to stop training. After training, Feedforward neural network model could be used to predict *CI* of quality index (i.e. reliability of bearing) given any test sample.

In Figure 9, the training results of the Feedforward neural network model, including the training state and the corresponding MSE (0.0068) are presented respectively. The results show that this Feedforward neural network model fits the samples to the degree that it is requested, which means this trained Feedforward neural network model can be used to predict the quality index based on the selected impact factors.

The following are two examples in which the proposed model is used to predict the quality index for two test samples:

Test sample vector of impact factors is:
[0.32576;0.30902;0.30753;0.30937;0.28538;0.43926;0.44336;0.52081;0.45899;0.53185;0.48846;0.33633;0.3077;0.46696;0.35483;0.090269;0.044895;0.90836;0.77512].
Quality index is predicted to be: [0.2925]

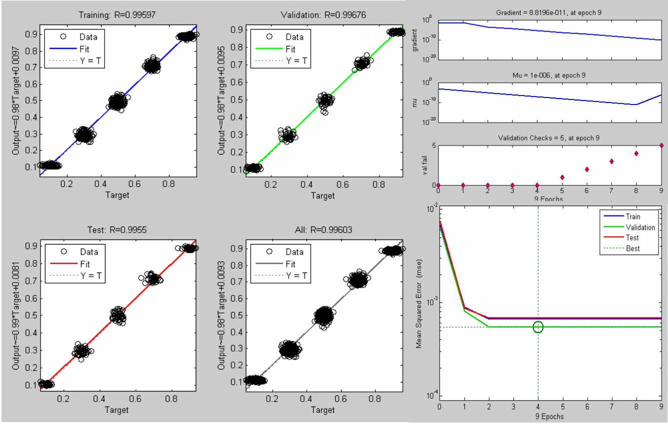


Fig. 9. Training results of Feedforward neural network.

Test sample vector of impact factors is:
[0.8927;0.8942;0.9217;0.2920;0.1420;0.5032;0.4932;0.4675;0.5239;0.5061;0.5018;0.8447; 0.7880; 0.9724; 0.1794; 0.9296; 0.9256; 0.3489; 0.3816]
Quality index is predicted to be: [0.9476]

2) *Quality pattern recognition*

In addition to being able to predict a certain quality index value, it would be advantageous to be able to determine the patterns of the whole values as well. For this purpose, SOM has been adopted to classify a certain quality index into various levels. If a certain pattern needs to be deeper studied, a specific analysis can be conducted for that.

SOM is another type of artificial neural network that is trained using unsupervised learning to produce a low-dimensional, discretized representation of the input space of the training samples. It produces a map to represent the input space of the training samples. It is different from other artificial neural networks in the sense that SOM uses a neighborhood function to preserve the topological properties of the input space. SOM has one layer with the neurons organized in a grid, which makes it useful for visualizing low-dimensional views of high-dimensional data, —this function is akin to multidimensional scaling.

SOM operates in two modes like most neural networks: training and mapping. Training builds the map using input samples. Mapping automatically classifies a new input vector. Training is a competitive process, also called vector quantization. Firstly, it will randomize the map's nodes' weight vectors, and then grab an input vector, traverse each node in the map, including the use of Euclidean distance formula to find similarity between the input vector and the map's nodes' weight vector. It also includes the track of the best matching unit (BMU), the node that produces the smallest distance. Afterward, the nodes in the neighborhood of BMU will be updated by pulling them closer to the input vector. The whole procedure will be repeated till current iteration reaches the limit on time iteration.

In this study, 1000 samples of quality index are used as training data to build a SOM neural network for quality pattern classification. Within SOM one layer is set, and the Batch unsupervised weight/bias training algorithm is chosen.

In Figure 10, the results displayed by the developed of SOM are presented, in which 5 classes are obtained, after training. This means that the quality index can be classified into 5 levels: *“very good quality”*, *“good quality”*, *“average quality”*, *“bad quality”* and *“very bad quality”*, respectively.

This SOM model can then be used for recognizing the quality pattern given a certain quality index value. For instance, the predicted quality index, 0.2925, in the abovementioned sample test 1, is classified by the SOM into class 2, which is considered to be of *“good quality”*; the quality index in sample test 2, 0.9476, is classified by the SOM into class 5, which is considered to be of *“very bad quality”*.

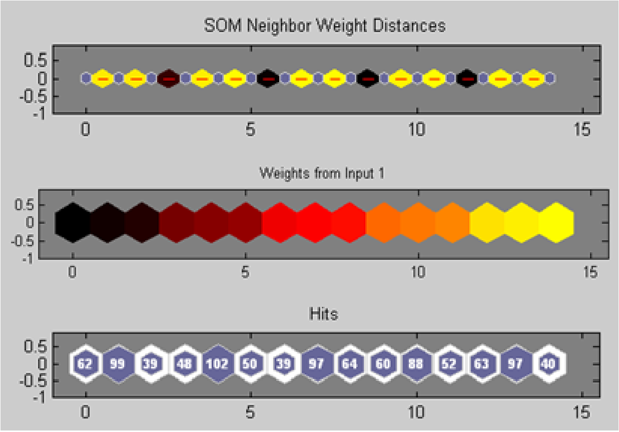


Fig. 10. Training results of self-organizing map.

The above two artificial neural network models constructs an intelligent measurement system which is capable of predicting the product quality and indentifying corresponding quality class for any given test sample. This method can also strongly help designers and other downstream parties conduct simulation based experiments to study the impact of designed settings or real settings on quality before real application. By comparing the values of the quality index generated on various simulated settings, the optimal setting could be found and applied before design regulation releases or before production starts.

I. *Knowledge for design and compliance improvement*

More data mining works, like correlation, distribution and comparison studies, can be conducted based on the above data, which help generate knowledge bases for optimizing quality assurance for both designers and other downstream parties.

1) *Correlation study*

For determining the quality pattern, a correlation study of the impact factors and quality change will reveal the critical impact factors that have bigger impact on quality. In probability theory and statistics, correlation (often measured as a correlation coefficient) indicates the strength and direction of a linear relationship between two random variables. A number of different coefficients are used for different situations. The best known is the Pearson product-moment correlation coefficient, which is obtained by dividing the covariance of the two variables by the product of their standard deviations, as shown below.

$$Corr(X,Y) = \rho_{X,Y} = \frac{\mathrm{cov}(X,Y)}{\sigma_X \sigma_Y} = \frac{E((X-\mu_X)(Y-\mu_Y))}{\sigma_X \sigma_Y} \qquad (4)$$

where $Corr(X,Y)$ or $\rho_{X,Y}$ is correlation between two random variables X and Y, $\mathrm{cov}(X,Y)$ means covariance between X and Y, σ_X, σ_Y are standard deviations, u_X , u_Y are expected values, and E is the expected value operator.

The correlation is 1 in the case of an increasing linear relationship, −1 in the case of a decreasing linear relationship, and some value in between these two values in all other cases, indicating the degree of linear dependence between the variables. The closer the coefficient is to either −1 or 1, the stronger the correlation between the variables (see Table 4).

TABLE III. INTERPRETATION OF THE SIZE OF A CORRELATION.

Correlation	Negative	Positive
Small	−0.3 to −0.1	0.1 to 0.3
Medium	−0.5 to −0.3	0.3 to 0.5
Large	−1.0 to −0.5	0.5 to 1.0

All 1000 samples were selected for this correlation study. The correlations of each impact factor and quality index are plotted in a Radar chart (see top left chart of Figure 11). The results reveal that seven factors have stronger correlation with quality for the samples studied. Three are raw material factors, namely, seating out of alignment (*Rsa*), mounting pressure (*Rmp*), and Lubricant (*Rlu*); two are machine status factors, namely, Health index (*Ahi*), Precision (*Apr*), and Balance (*Aba*); and two are manufacturing environment factors: Humidity (*Ehu*), and Temperature (*Ete*).

2) *Distribution study*

As the quality index can be traced back to the original collected impact factors data, for all bad quality indices, a further distribution analysis of the parameter settings of each critical factor can be conducted to illustrate that what range it is most in, which is very important information to posses for impact factor design.

The distribution of all settings of the impact factor Rsa in very bad quality class (i.e. Class 5) is shown on top right chart in Figure 11. The range of settings is one type of feature of the root causes of bad quality, and should be avoided in design.

3) *Comparison study*

For such parties as material, manufacturing, and delivery, they can simulate their real setting and predict the quality index before production using the proposed expert system. If the predicted quality is bad or very bad, then the system can do an analysis to check the difference between the impact factors settings of the bad quality predicted and those settings in a very good quality pattern.

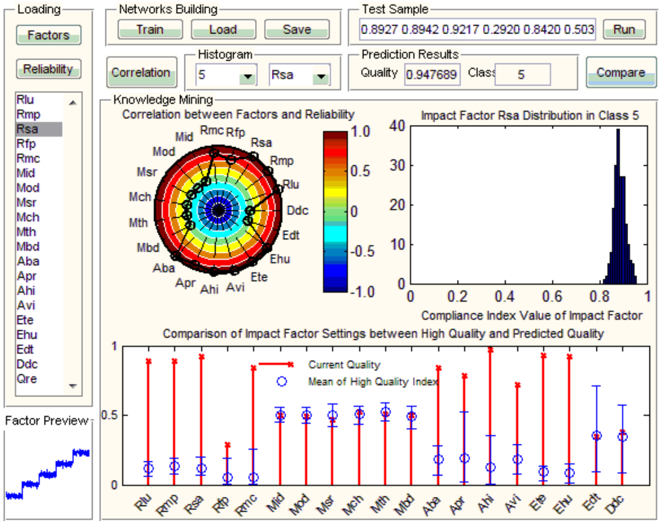
The bottom chart on Figure 11 presents an example of comparison, where the mean and range of each impact factor setting in very good quality pattern are compared with the real setting of each factor in test sample 2, which generated a very bad quality. The differences will feedback to instruct people how to adjust their settings to improve the compliance with design.

J. *System level quality assurance*

The procedures introduced in Section 3.3 to 3.6 are applied to all critical components. After all component level quality improvements have been completed, the system level quality will be improved as well. Like the impact factors in the component level quality assurance model, the impact factors for the system level quality assurance model are the factors influencing the quality of the wind turbines received by customers. The system level quality index is defined by customer requirements. A system level quality assurance model can be constructed in the same way as that at the component level. By using the Feedforward neural network and SOM methods, the quality index of a wind turbine system can then be predicted and the pattern of quality index can also be identified. Useful knowledge can be obtained from data mining. By continuously measuring the quality index, classifying its pattern and redefining the impact factors' settings, quality can be improved at both the system level and the component level until the quality index reaches the pre-determined threshold.

III. Conclusion and Future Work

The importance of performing quality assurance throughout an entire supply chain has been gradually gaining recognition by the decision makers in industry. In this study, the frameworks of collaborative quality assurance in a supply chain, including management model, technical model, and database model, were proposed so as to ensure high quality of products. In the wind turbine case study presented, bearings have been identified as an important component of wind turbines, and taken as an example to demonstrate the proposed component level quality assurance approach.


Test Sample: 0.8927 0.8942 0.9217 0.2920 0.8420 0.503

Histogram: 5 Rsa

Prediction Results: Quality 0.947689 Class 5

Fig. 11. Knowledge mining results in quality assurance expert system

The component quality assurance model acted as an intelligent measurement system, to predict quality and recognize the quality pattern given a set of quality impact factors. With these promising functions, designers can test whether the design settings will result in a good or bad quality product before releasing the design to downstream parties. Downstream parties, such as those responsible for manufacturing, can simulate different real settings to determine which may generate the best quality before production. More knowledge is mined based on the results through statistical analysis, such as correlation, distribution, and comparison, and feedback to designers and downstream parties for optimizing settings and tighter tolerance. With this intelligent quality assurance model, potential losses from bad design settings or incorrect real settings will be saved, and product quality will be ensured.

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Introducing SMART Table Technology in Saudi Arabia Education System

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***Abstract*—Education remains one of the most important economic development indicators in Saudi Arabia. This is evident in the continuous priority of the development and enhancement of education. The application of technology is crucial to the growth and improvement of the educational system in Saudi Arabia. Introducing SMART Table technology in the Saudi Arabian education system is argued in this paper as being able to assist teachers and students in the process of accommodating both technological changes and new knowledge. SMART Tables also can enhance the level of flexibility in the educational system, thus improving the quality of education within a modern Saudi Arabia. It is crucial to integrate technology effectively and efficiently within the educational system to improve the quality of student outcomes. This study will consider the potential benefits and recommendations associated with the adoption of SMART Tables in Saudi Arabian education system.**

***Keywords*—ICT; Smart Table; education; barrier; implementation**

I. Introduction – Smart Table Technolgy

SMART Table technology referred to throughout this paper is the registered trademark of SMART Table collaborative learning centres (see, for example, http://smarttech.com/table). SMART Table represents a relatively new technology in the form of a multi-touch interactive learning centre that is designed for effective and efficient use for primary pupils.

The application of technology in the education system offers the opportunity for primary pupils to interact, discuss, and share information in the process of grasping vital knowledge from their teachers. SMART Table technology enables the pupils to collaborate, discuss, and enhance their knowledge through digital aspects of education. The students have the opportunity to explore digital lessons, participate in the educational games, and form teams as an element of working together in the search for relevant solutions. The technology is multi-user in its design to enable numerous pupils to participate in the interaction and discussion at the same time. The table provides unlimited opportunities for students in relation to enjoy learning and expressing elements of teamwork. The designing of the table makes it vital and relevant to the primary pupils and their teachers (Ghavifekr & Ghani 2011, p. 86).

The table is designed with a durable surface that is suitable for the requirements of the primary pupils in the pursuit of education. The application of networking system in the form of wireless connections enables students to share during the learning process. Teachers also have the opportunity to design the learning objectives and activities within the table to enhance the process of transmitting information to the pupils. This is receiving positive acceptance from the teachers and students in Saudi Arabia, where it is being implemented, because of the ability to encourage connections between the learners and the teachers.

SMART Tables are also durable in their design in enabling education programs for a diverse range of students. A strength is the ease in which it can be used and has the capacity to support up to six users at a time. In addition, the table demonstrates numerous further benefits in relation to its implementation in the educational system of Saudi Arabia. This reflects development towards the achievement of quality education that would promote growth and development of the nation (Kian-sam 2011, p. 1279).

II. Benefits of the Smart Table Technology

SMART Tables being implemented in the educational system of Saudi Arabia provide the opportunity for the primary pupils to learn together and this is creative in nature since the pupils have the chance to express their knowledge with their peers. The pupils can make learning gains through the process of learning in the presence of other pupils.

Enjoyment for learning is enhanced through the implementation of the table as it enables the pupils to view the process of knowledge generation and acquisition as a game to be played. The learning process is creative, and has the ability to differentiate and personalize instructions with the aim of supporting a variety of learning styles in fun and engaging forms. The learning process is similar to playing environments whereby pupils interact with their teachers effectively and efficiently. This is vital towards the grasping of the crucial information from the between students and their teachers (Al-Fahad 2010, p. 67).

The teachers and students develop important collaborations thus creating a virtual environment to foster learning process. It is beneficial for students to grasp the fundamental aspects of knowledge at initial stages to promote their development as they progress within the educational system. Application of SMART Table provides the opportunity to ensure that each student has an equal chance of succeeding in the process of grasping essential knowledge. The table also enhances teamwork in the pursuit of education thus the opportunity to improve the creative environment.

A. SMART Table and English Language Learning

SMART Table also aims at minimizing the barriers that limit the ability of pupils to learn English language needed for their development through the learning process. The application of the table system in Saudi Arabia provides students with the opportunity to enjoy virtual aspect of knowledge, and this includes approaches which promote the ability to learn English language through using SMART Tables.

The interactive products play an important role in the development of virtual information to generate development and awareness of the students. It is also crucial for students to grasp the English language with minimal time possible to enhance further development. Further research is needed to determine if SMART Table can enable faster acquisition of English language proficiency. English language also develops through application of numerous products and interactive sessions using SMART Tables. The pupils develop the ability to communicate in English. The ability to learn collaboratively reduces anxiety in the pupils thus creates an environment to learn English language and relevant subject-area content. During the sessions, all students can engage in discussion and providing the opportunity to explain and share English words. There are substantial opportunities for students to see, listen, and interact with the available learning products or materials. This makes the learning process to be meaningful to the pupils hence the motivational aspect in relation to learning and participating in the classroom activities.

B. SMART Table and Enhancing Education

SMART Table enables the educational system in Saudi Arabia to create vibrant and meaningful lessons. This is possible through the application of the physical world into the classroom environment. This relationship makes the learning process interactive and user friendly, hence pupils understand the concepts with ease. The application of technology enables students to ask questions, discover, and collaborate with teachers thus the opportunity to explore and learn effectively and efficiently. Within the context of Saudi Arabia, SMART Table provides the opportunity for pupils to instill lifelong interest in science, technology, engineering, and mathematics. This can enable the educational system to improve academic achievement in relation to the pupils in need of knowledge. Teachers also play a critical role in encouraging pupils to participate in the learning process. This is possible through the provision of opportunities to hear, see, and touch the lesson products or materials.

C. SMART Table and Student Support

SMART Table is also useful in promoting accessibility through providing students with relevant support through visual, auditory, physical and mobility. These elements enable the student to satisfy their social and communication needs. This makes it easy for students to interact both academically and socially within the class environment. Creation of support in the pursuit of education is vital in the provision of equal opportunity to students to enhance their understanding on the concepts. The students have the chance to express themselves, interact with relevant learning activities, and perceive appropriate concepts. The table is essential towards tailoring of instruction that relates to each student with the aim of creating ample environment to achieve academic and social goals.

D. SMART Table and Flexibility

SMART Table enhances flexibility in relation to the teaching style and content of the educational system in Saudi Arabia. SMART Table comes with a toolkit that enables teachers to create numerous activities within the learning centre. The toolkit is also essential in the customization of activities that are new and ready-made in nature. In the process of learning, it is critical to redesign activities with the aim of keeping students challenged or engaged. The students have the opportunity to interact with the teachers and fellow students equally and freely thus accurate and effective learning process.

SMART Table complements the application of SMART Board interactive whiteboard and other interoperable technologies. This leads to the accommodation of numerous teaching styles and is advantageous to student learning. The educational system in Saudi Arabia has the opportunity to develop interactive lessons between the whole-class or within the small learning groups. The modern students are often tech-savvy, and hence appreciate the application of SMART Table as an interactive learning centre. The horizontal and 360 degree surface provides the opportunity for students to enjoy the learning process and collaborate with each other.

The educational system in Saudi Arabia enables students to build cognitive, social, and acute motor skill. This is possible through implementation of SMART Table activities within the educational system. The system caters for students who are usually shy to participate effectively and demonstrate leadership abilities through the completion of group tasks. The table has different features that are engaging in the process of pursuing knowledge. The table system is accessible to all students including the pupils with exceptional needs.

E. SMART Table and IT Applications

SMART Table has the opportunity to integrate notebook and laptop software. This promotes the transfer of files and data from the main computer to the learning centre. The learning activities reflect on the table to provide students with prior information on the topic of concern. This is crucial towards the achievement of social and academic goals. The students also have the opportunity to capture the images through document camera. The captured images are applicable in the process of learning within the interactive centre (Karfash 2010, p. 67).

The Saudi government utilizes significant financial resources to enhance the education portfolio. For example, besides offering free education, the Saudi government provides its students with free learning tools, health services, and living expenses if necessary. As a result of its focus on education over the many years, the number of children at School increased from 547,000 students in 1970 to more than five million students in 2007, and the majority of these students attend nearly 32,000 public schools as shown in Table 1 (Vanderlinde, Braak & Tondeur, 2010).

TABLE I. SCHOOLS AND STUDENTS 1970-2007

Year	Schools	Girls	Boys	students
	Number	“000”	“000”	“000”
1970	3,282	135	412	547
1975	5,634	311	673	984
1980	11,070	511	951	1,462
1985	15,079	876	1,273	2,149
1990	16,609	1,310	1,624	2,934
1995	21,284	1,912	2,022	3,934
2000	22,770	2,369	2,404	4,774
2004	29,807	2,403	2,379	4,783
2007	31,798	2,496	2,522	5,019

As noted, this increase in students and the resources essential for their education places substantial strains on an education system which is still comparatively new and which needs considerable improvement in its standards to adhere to the needs of economic growth, a civil society, and international prospects. The aim of this paper is to make the case for the implementation of Smart Table technologies into Saudi Arabia Education System in order to meet those needs, and complement the use of other technologies in the learning and teaching environment.

F. *Barriers to Implementing ICT and SMART Table Technologies*

SMART Table has a potential to enhance the methods of teaching and learning. However, there are some barriers that hinder the integration or rather the implementation of the SMART Table technology into the education system. Choy, Berkner, Yopper & Department of Education (ED) (2010) assert that, even though teachers accept the significance of ICT to enhance the education system, some challenges arise in the process of integrating these technologies. This section highlights several barriers on the implementation of both ICT and SMART Table technologies into the educational system.

While the integration of ICT and SMART Table into education may have the potential to generate positive changes in teaching and learning environments, this process is difficult. Barriers to ICT and SMART Table integration vary from case to case, depending on the existing environments of the country, society, education, school, teachers and conceivably the students. This section, therefore, seeks informed commentaries about issues which may relate to developing countries, and to Arab societies.

As mentioned above, there are many and various issues in integrating ICT and SMART Table in any given curriculum, including both external and internal barriers to reform (Kian-Sam & Songan, 2011).

According to Bose (2010), the barriers comprise a lack of access to computers and software, inadequate time to plan instruction, lack of technical and administrative support and inadequate resources. Vanderlinde, Braak & Tondeur (2010) adds to these barriers the establishment and on-going costs of providing sufficient ICT for teachers. The external environment barriers include systems outside individual schools, for instance, educational districts, communities, and the larger society. There is a lot of criticism about Education having isolated itself from the local and the larger society. Societal involvement during technology planning with new pedagogy is an indispensable part of structuring a sustainable system (Kaveie, 2011). These barriers are discussed below as intrinsic and extrinsic barriers that impede implementation, and environmental issues.

A. *Intrinsic Barriers*

Intrinsic barriers refer to individual teacher dimensions, such as confidence, motivation and attitudes towards using technology. For example, Scott (2009) in a research study observing and interviewing teachers who attained different levels of ICT integration found that even though external barriers restrained all teachers' attempts in the school, individual teachers reacted in different ways to these external constraints, based largely in part on an individual teacher’s evaluation and design of efficient classroom practice. In another study, Scott (2009) stated that the affiliation between a lack of teacher self-assurance and teachers’ computer unease, and the lack of teacher competency were internal barriers or *intrinsic factors*, while the lack of access to ICT and resources were external barriers or *extrinsic factors* (see Figure 3).

As technology in education changes, pre-service teachers entering into the classroom may be the first in a school to initiate new techniques or take alternative paths to engaging students in learning experiences. SMART Table is an example of a new technology being introduced in modern education systems.

It is possible as well for some teachers to refuse to incorporate new technologies which might disrupt their historical approaches to curriculum design and implementation, based upon arguments that they achieved positive outcomes prior to the introduction of the new technologies. Caution is needed not to interpret this resistance to change may be “as anti-progressive or technophobia” Alenezi, Karim, & Veloo (2010). On the other hand, even when teachers are convinced that the new technology is worthwhile adopting, there may be numerous intrinsic factors that prevent teachers from using the SMART Table technology in their teaching. Kian-Sam & Songan (2011) indicate that the intensity of teachers’ training and skills are important factors that influence the implementation of ICT and SMART Table technologies. Also, Choy, Berkner, Lee Topper, & Department of Education (ED) (2009) note that opposing change relates to SMART Table strategy anxiety through several factors: psychological, sociological, and outfitted. There is perhaps a causal correlation between the external and internal barriers (Ghavifekr, Hussin, & Ghani, 2011).

To implement SMART Table effectively into the curriculum, teachers require proficiency in ICT skills as well as instructive knowledge of efficient ICT teaching practices. Intrinsic variables in ICT integration include positive teaching skills with computers; teacher's confidence with computers; viewpoints supporting the use of computers as an educational tool; training; inspiration; support; and teaching efficiency Ghavifekr, Hussin, & Ghani, (2011) and Kian-Sam & Songan, (2011) found that quality of training and inadequate time as barriers that put off teachers from integrating SMART Table and ICT into the classroom.

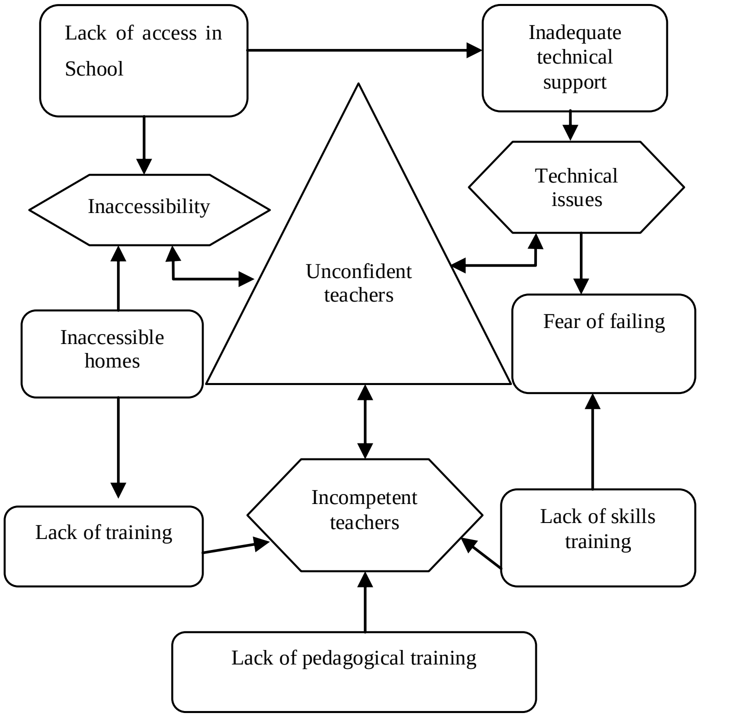

Fig. 3. Integration Of SMART Table And ICT: Intrinsic And Extrinsic Factors

Source: *Choy, Berkner, Lee Topper, & Department of Education (ED) (2009).*

To implement ICT and SMART Table effectively into the education system, teachers require proficiency in ICT skills as well as pedagogical acquaintance of efficient ICT teaching practices. Intrinsic variables in computer assimilation comprise positive teaching skill with computers; teacher's acquaintance with computers; beliefs supporting the use of computers as an educational tool; training; motivation; support; and teaching effectiveness. Choy, Berkner, Lee Topper, & Department of Education (ED) (2010) asserted that ineffective training and inadequate time are barriers that prevent teachers from integrating SMART Table and ICT into the education system. Scott (2009, p. 7) cited "numerous teachers with insufficient competence in ICT feel nervous about using in front of students who are perhaps acquitted to using it. Sub-standard ICT experience comprise factors that may include inadequate skills or insufficient pedagogical training. Moreover, the lack of ample time for teachers to finish their work comprises inadequate time for preparation of the subject, for the discovery and practice of using ICT equipment, and for training; these are also considered significant barriers to the implementation of SMART Table. Ghavifekr, Hussin, & Ghani (2011) cited that science teachers' motivation is an imperative aspect in introducing ICT, alluding to the inadequacy of time to obtain self-confidence with ICT, a science curriculum congested with content, and absence of subject-specific direction for using ICT to support learning.

1) *Extrinsic Barriers*

Researchers cite that the external barriers that put off the teacher from implementing SMART Table and ICT in the classroom are principally functional: inaccessibility to ICT and internet, inadequate time to build up courses, and unproductive training **(**Choy, Berkner, Lee Topper, & Department of Education (ED), 2010). Additional issues cited by authors Kaffash Kargiban, Kargiban & Ramezani (2010), and Hyland (2010) relate to inadequate organization and technical support, high costs of equipment, and that students lack skills**.** In addition, the barriers faced in Saudi Arabia, are similar as the ones faced by others in other countries that are the shortage of finance. As you know, technology is relatively expensive, and feasibility means balance between costs of inputs and outputs. The Ministry spares no effort to supply suitable finance, but there are a large number of schools for boys and girls.

Hyland (2010) cites practical issues of resources and access due to the "the lack of high-quality ICT resources in a school will not only prevent teachers from making good use of ICT in their teaching, but will as well have a negative effect on pupils' success" (p. 11). These barriers are summarized in Figure 4.

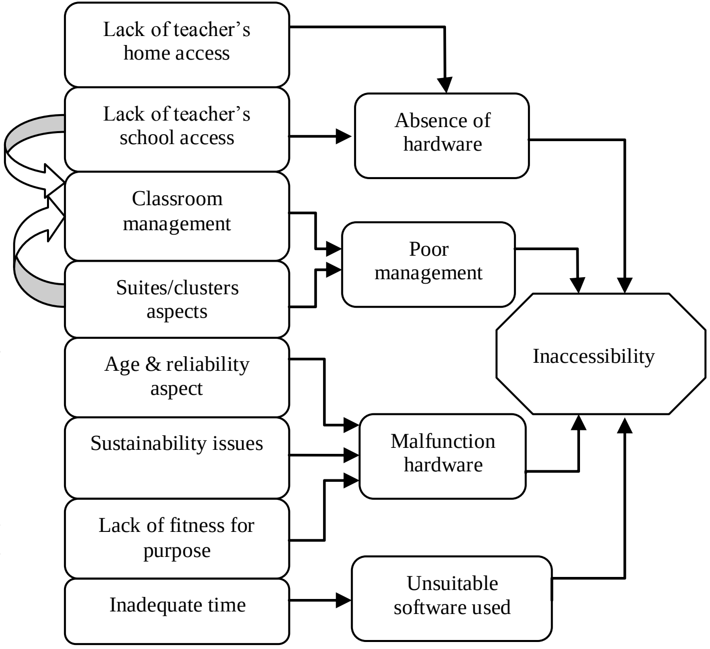

Fig. 4. Issues Regarding Access to SMART Table and ICT Resources

Source: *Ghavifekr, Hussin, & Ghani (2011).*

III. Potential Smart Table Outcomes

Application of SMART Table technology within the educational system of Saudi Arabia can result in potentially useful outcomes for the students and teachers. These outcomes are discussed in the following sections.

A. *Increased engagement*

A positive outcome is an increase in the level of engagement in the learning process. For example, Tondeur (2010) shared a view and illustrated the interrelationships between ICT, Policy and Management, in which teaching, learning and ICT are in the centre. In order to achieve implementation of the SMART Table strategy in teaching and learning, there should be connectedness and balance between management, and ICT and policy and their different aspects as shown in the following conceptualization.

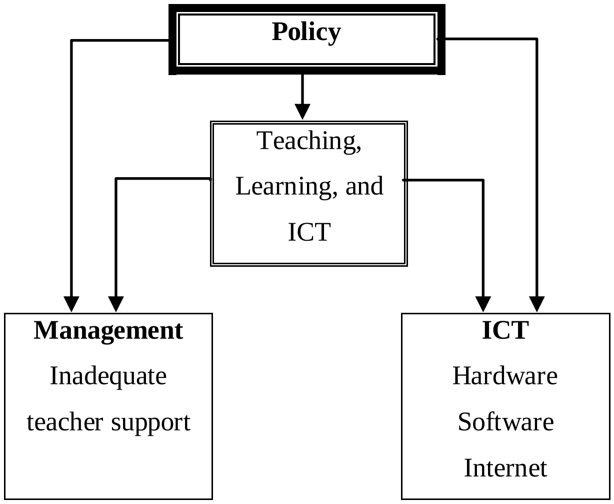

Fig. 5. Interrelationships Between Policy, Management And ICT With Teaching, Learning And ICT

The students, through using SMART Tables, can participate effectively and efficiently in the learning process to enhance their social and academic development. All students can contribute with minimal fear since they develop quality collaboration with the teachers and fellow students. Even the shy students have the chance to participate and enhance their academic and social achievements. Application of SMART Table within the educational system in Saudi Arabia can enable the use of technology in relation to the curriculum.

B. *Technological Application*

Since the modern world is increasingly technology oriented, it is vital for students to be technologically confident to meet the requirements of the 21st Century. Technology also enables students to implement the physical world into relevant concepts that are understandable in the elementary aspects. The application of SMART Tables is also beneficial in the expression of learning activities in large formats. This provides the opportunity for students to see and participate during the learning process. This offers the chance for all students including the physically challenged pupils to participate in the interactive learning process. Application of SMART Table can enhance the creation of visual images in the critical thinking of the students. This can assist the understanding process and thus the ability to grasp vital knowledge. The implementation of SMART Tables in the educational system of Saudi Arabia increases the pursuit of knowledge. This is possible since teachers have the opportunity to provide absentee students with relevant information on a previous topic (Khan 2011, p. 889). The notes are also available on the web to offer the chance to students and parents to access the lesson activities. This is elementary towards the development of teachers and students. Teachers reduce the elements of stress that might relate to the preparation of lesson plans and activities. The process enhances the productivity of the teachers in helping students achieve social and academic goals.

IV. Discussion

This paper has provided an examination of the potential benefits as the barriers for the integration of SMART Table technology in the Saudi education system, and associated implications for teachers' professional development. This discussion relates to the nature of online learning, and expected outcomes and issues pertaining to the introduction of ICT more widely in the classroom. In introducing ICT as a curriculum resource, interlinking enabling and mitigating factors need to be considered. Research elsewhere describes the potential for improved student outcomes (Ghavifekr & Ghani 2011, p. 86).

A. *Implementation of SMART Table*

In order to implement SMART Table and ICT in science education, it is imperative to first identify the specific purpose of that education and match the suitable use of such resources to the accomplishment of those purposes (Kian-sam 2011, p. 1279). Al-Fahad (2010) summarizes the use of ICT in education through three methods: first, learning about the computer with ICT literacy as the objective; second, learning by the computer, in which this type of technology ascertains learning across the curriculum; and the third approach is learning through the computer, incorporating ICT into the curriculum. Using these methods requires extensive professional development for teachers and corresponds to the main purposes of this research study. Developing this theme in a US study, (Kian-Sam & Songan (2011) accentuates the need for the study of the manner by which ICT integration occurs within schools, factors that increase its acceptance by instructors, and the lasting impacts that such technologies have on instructors and students. Noting its social and economic implications, Bose (2010) nominates four types of approach to using ICT:

a) As delivery: ICT can enhance the manner in which instructional methods are delivered without linking elementary change;

b) As the goal: ICT is the focus of learning new skills; for student understanding: ICT can support students' deep understanding of subjects, as teams of students engage in solving complex, real-world problems;

c) As knowledge creation: knowledge creation and technological innovativeness can lead to revolution of education system and sustainability of economic and social growth (Bose 2010).

These approaches are grounded in ICT-based methodologies in use today. Online learning, used often by educators and students for out-of-hours communications or distance learning is generally classified into two types: synchronous and asynchronous learning (Bose, 2010). In synchronous online learning, students and their instructors meet over the internet at given times to communicate; whereas with asynchronous online learning students and teachers do not interact live but access the 'virtual' classes from any location at their convenience (Bose). Educators, such as Vanderlinde, Braak & Tondeur (2010), cite that both types of online learning are powerful tools for teaching and learning. However, there are issues with online instruction; it can have limited capability to engage students unless learners are self-motivated and well organized in their learning habits (Ghavifekr, Hussin, & Ghani, 2011).

In Ghavifekr's study, online learners also reported that ICT learning lacked the immediacy of group interchange and lacked empathy between learners and instructors. This factor influences learner satisfaction and learning absorption. Scott (2009) argues that delivering vivid learning experiences to online learners requires a sense of belonging, of immediacy, and a strong learning environment. There is a distinct difference between ICT-based learning opportunities in the developed countries and those of Saudi Arabia (Hyland, 2010). Internet services are limited in Arabic countries due to the government monopolies over the telecommunications sector, resulting in higher prices (Kian-Sam & Songan, 2011). The authors contend that a very small percent of internet users originate from Arab World, although the Arabic population is very small in comparison to the entire world population. Further, English is generally used for e-learning and most Arab users are not fluent in English, and do not have sufficient familiarity with the language to decipher discipline-based terms and acronyms, or to communicate using English. These factors can distance them from e-learning sources and educational courses. Lastly, social and cultural problems are reflected in varying levels of censorship by Arab governments, as the internet contains opinions that violate Islamic traditions and cultural values (Kian-Sam & Songan, 2011).

V. Conclusion And Recommendations

This paper has argued that SMART Table technology has the potential to be a useful technology for enhancing the educational system in Saudi Arabia. The educational system provides students with equal opportunity to improve their understanding and grasping of relevant concepts. It is crucial for students to enjoy full benefits of the application of technology within the educational system in order to achieve both social and academic goals.

In summary, SMART Table technology enables the creation of learning environments that encourages creativity, teamwork, participation, and interaction between students and teachers. The technology is also essential in relating the physical world to the classroom set-up. This is important for the overall development of the students in areas such as cognition and academic growth. SMART Table set-up also offers the opportunity for students to enhance their scope of pursuit of knowledge thus the perfect scenario to develop effectively and efficiently.

Since technology is essential in so many areas of life in the 21st Century and therefore it is important for new technologies to be integrated into learning environments, the implementation of SMART Tables within the Saudi Arabian educational system is worthy of serious consideration. As discussed in this paper, this can enhance the students' participation in the learning activities, and it is recommended that SMART Tables should be applied in the illustration of complex concepts and collaborative learning within a range of learning areas. This would assist the process of students' acquisition and generation of knowledge. It is also important to promote the adoption of the SMART Table in the educational system to assist teachers in their task of planning for the lessons for all students through catering for the diversity of student learning needs and learning styles (Boss 2010, p. 8).

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SS-SVM (3SVM): A New Classification Method for Hepatitis Disease Diagnosis

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Abstract—**In this paper, a new classification approach combining support vector machine with scatter search approach for hepatitis disease diagnosis is presented, called 3SVM. The scatter search approach is used to find near optimal values of SVM parameters and its kernel parameters. The hepatitis dataset is obtained from UCI. Experimental results and comparisons prove that the 3SVM gives better outcomes and has a competitive performance relative to other published methods found in literature, where the average accuracy rate obtained is 98.75%.**

Keywords—Support Vector Machine; Scatter Search; Classification; Parameter tuning

I. INTRODUCTION

The classification problem may be encountered in different domains, such as "disease diagnosis". Disease diagnosis usually depends on many symptoms and results of medical exams that demonstrate the presence or absence of the disease. Thus, disease diagnosis can be described as a classification problem.

Recently, many researchers try to propose new classification methods to improve or enhance the outcomes of existing methods. Several machine learning algorithms and data mining tools are employed; most studies are interested in proposing new methods that may be help in diseases diagnosis. The term hepatitis means an inflammation of the liver without determining a specific reason [28], [6]. There are more than two viruses that cause hepatitis, the serious of them are Hepatitis B virus (HBV) and Hepatitis C virus (HCV), where about 600000 and more than 350000 people died every year from HBC and HCV, respectively according to WHO (World Health Organization) statistic, Also, Countries with high rate from (HCV) are Egypt (**22%**), Pakistan (**4.8%**) and China (**3.2%)** [1]. This study concentrates on hepatitis disease due to its wide spread diseases around the world, as well as proposing a new method that may help the diagnosis of this serious disease.

The suggested method 3SVM combined support vector machine with scatter search (SS) approach. The SVM algorithm is used due to the following advantages: SVMs one of the most powerful classifiers and is applied to many different domains like pattern recognition [5], and bioinformatics [27], in the case separable datasets SVMs can find the optimal separation hyperplane, SVMs have ability to deal with very high dimensional data " means handle the curse of dimensionality well" [33], from computation perspective SVMs provide a fast training. Furthermore, SS methodology is employed due to its promising performance when applied with machine learning algorithms.

Hepatitis datasets used are obtained from UCI repository. The main difference with other methods published in literature is the usage of SS approach to find near optimal values of SVM parameters and its kernel parameters. All features of the datasets are used without applying any reduction techniques, using SVMs classifier, in addition, two types of experiments are conducted using 10-fold cross validation method and holdout method for datasets partitioning with three different rates (50-50%,70-30%,80-20%), for training and testing, respectively. The obtained results are very promising where the accuracy is 98.75% in case of 10-fold method, while 92.5%, 95.83% and 100% for the three partition methods, respectively.

The paper is organized as follows. Next section gives an overview about the methods that are found in literature. Section 3 gives a brief description about datasets. Section 4 describes the 3SVM steps in details. Section 5 reports numerical experiments and results. Finally, the conclusions and future work make up Section 6

II. RELATED WORK

This section summarizes some works that found in literature. Plot and Günes in [28] present a new method called FS-AIRS with fuzzy resource allocation for hepatitis diagnosis. The method relies on a hybrid method that uses Feature Selection (FS) and Artificial Immune Recognition System (AIRS) with fuzzy resource allocation mechanism. The obtained results are very promising when compared with more than 20 approaches proposed in literature, where the average accuracy rate is 92.59%. Authors in [14] suggest a new method for classifying medical data, where a hybrid model is proposed by combining a case-based data clustering method and a fuzzy decision tree. The model is tested by using breast cancer wisconsin (diagnosis) and liver disorders datasets from UCI, where the produced accuracy rate is 98.4%and 81.6%, respectively. Researchers conclude that the proposed method could help doctors to extract effective conclusions in medical diagnosis. In [16], a new classification approach called FCS-ANTMINER is presented, where ant colony optimization is used to extract a set of fuzzy rules for diagnosis of diabetes disease; the accuracy rate is 84.24\%. Researchers in [7] present a new hybrid method called LFDA-SVM for hepatitis disease diagnosis; Local Fisher Discriminant Analysis (LFDA) and SVM are combined. The method employed LFDA for performing feature reduction to improve the performance of standard SVM algorithm. Datasets from UCI is used in testing, and the obtained accuracy rate is (96.77%) which is the best results when compared with other published approaches in literature. Also, a new intelligent method for hepatitis disease diagnosis called PCA-LSSVM, is suggested by [6]. The proposed method based on Principle Component Analysis (PCA) and Least Square SVM (LSSVM).The PCA is employed for feature extraction and reduction while LSSVM for classification, using Hepatitis datasets from UCI repository. The accuracy rate that produced is(95%). Furthermore, authors in [32] present a hybrid method based on SVM combined with Simulated Annealing (SA) for hepatitis disease diagnosis, also the method uses the same datasets which is used by previous studies in [7],[6]. The obtained accuracy is (96.25%), which the best accuracy rate when compared with other methods. In recent study presented by [4], the authors summarized the most works in the area of hepatitis disease diagnosis, and proposed a new method by employing Probabilistic Neural Network structure called PNN (10xFC), the results that obtained is 91.25%.

Classification results of the most previous methods may need to be enhanced or improve, especially when applied to critical applications, such as disease diagnosis. The diagnosis of some disease like hepatitis is very difficult task for a doctor, where doctor usually determines decision by comparing the current test results of patient with other one who has the same condition. All these reasons motivated for suggesting new methods to improve the outcomes of existing approaches, as well as to help a doctors and specialists to diagnose hepatitis diseases.

III. DESCRIPTION ABOUT DATASET

This study conducts experiments on hepatitis dataset, which is obtained from UCI machine learning repository. The dataset contains 155 instances distributed between two classes die with 32 instances and live with 123 instances. There are 19 features or attributes, 13 attributes are binary while 6 attributes with 6-8 discrete values. The goal of the dataset is to forecast the presence or absence of hepatitis virus. Table I lists information about the features.

TABLE I. INFORMATION ABOUT THE FEATURES OF THE HEPATITIS DATASET

Number	Name of features	The values of features
1	Age	10,20,30,40,50,60,70,80
2	Sex	Male, Female
3	Steroid	Yes, No
4	Antivirals	Yes, No
5	Fatigue	Yes, No
6	Malaise	Yes, No
7	Anorexia	Yes, No
8	Liver big	Yes, No
9	Liver firm	Yes, No
10	Spleen palpable	Yes, No
11	Spiders	Yes, No
12	Ascites	Yes, No
13	Varices	Yes, No
14	Bilirubin	0.39,0.80,1.20,2.00,3.00,4.00
15	Alk phosphate	33,80,120,160,200,250
16	SGOT	13,100,200,300,400,500
17	ALBUMIN	2.1,3.0,3.8,4.5,5.0,6.0
18	PROTIME	10,20,30,40,50,60,70,80,90
19	HISTOLOGY	Yes, No

IV. THE PROPOSED METHODOLOGY

a) In this section, SVM and its parameters are defined. In addition, the steps of 3SVM are explained in details, as illustrated in figure

b) Support Vector Machine and Solution Definition

Support Vector Machines (SVMs) one of the promising machine learning algorithms, which depends on statistical learning theory developed by Vapnik [10, 35, 11, 19, 2]. The main problems that are encountered in SVMs are how to find near optimal values for its parameters and select a SVMs kernel as well as tuning its parameter. The parameters that should be optimized are the complexity parameter **C**, epsilon **ε** and tolerance **t** and the kernel function parameters, such as **γ** for Gaussian kernel. The parameter **C** determines the trade-off between the fitting error minimization and model complexity [37, 29, 9, 24], where a bad choice of C leads to an imbalance between model complexity minimization and empirical risk minimization. The last two parameters **ε**, where its value indicates the error expectation in the classification process of the sample data, and it impacts the number of support vectors generated by the classifier [24], while **t**, is the tolerance parameter. In 3SVM the solution for finding the near optimal values of SVMs parameters and its kernel is represented as vector with dimensions equal to the number of trial solutions as in equation 1.

$$X= [P_1, P_2 ,P_3, P_4] \qquad (1)$$

Where P_1**σ**is kernel parameter in range [0.0001, 33], while others are SVM parameters P_2 **C** is Complexity and its range [0.1, 35000], P_3 **ε** is epsilon [0.00001, 0.0001] and P_4 **t** tolerance [0, 0.5]. These chosen values are based on the common settings in the literature [12, 36, 8]. As known, the classification process is divided into two phases: model building and model testing. In first phase, a learning algorithm runs over datasets to develop a model that could be employed in estimating an output. The aim of the model is to describe the relationship between the class and the predictor [15, 20, 13, 30]. The quality of the produced model is assessed in the model testing phase. Usually, accuracy measure is used for assessing the performance of the most classification methods, where it is calculated as in equation 2.

$$Accuracy= \frac{TP+TN}{\mathrm{TP}+TN+FP+FN} \qquad (2)$$

where, TP (True Positive) is the positive cases that are classified correctly as positive, TN (True Negative) is the negative cases that are classified correctly as Negative, while, FP (False Positive) are cases with negative class classified as positive, and FN (False Negative) is the cases with positive class classified as negative [19, 21, 31]. Thus, the accuracy rate is used in this method to measure the quality of generated solutions, which is called the fittness function (fit). Furthermore, there are other performance measures employed, such as sensitivity. Sensitivity is the proportion of the cases with positive class that are classified as positive (true positive rate, expressed as a percentage); specificity is the proportion of cases with negative rate class, classified as negative (true negative rate, expressed as a percentage). Sensitivity and specificity reflect how well the classifier discriminates between case with positive and with negative class [19, 21]. They are calculated as in 3 and 4 equations as below:

$$\textit{Sensitivity} = \frac{TP}{(\mathrm{TP}+FN)} \qquad (3)$$

$$\textit{Specificity} = \frac{TN}{(TN+FP)} \qquad (4)$$

c) Preprocessing Phase

To use SVM classifier all features of the datasets must be set in real number format. Therefore, the nominal features are converted into numerical data. After that, data normalization using equation 5 is performed. In order to prevent feature values in greater numeric ranges from dominating and to avoid numerical difficulties during the calculation. In addition, two methods are used in splitting dataset for training and testing phase. In first method is k-fold Cross Validation (CV), which is a popular strategy to estimate the performance of the classification methods, as well as to avoid trap in over-fitting problem, where the training sample is independent from the testing sample [3, 19, 2]. In k-fold CV the k value is usually set to 10. Therefore, the datasets are split into 10 parts. Nine data parts are applied in the training process, while the remaining one is utilized in the testing process. The program is run 10 times to enable each slice of data to take a turn as testing data. The accuracy rate for training process and testing process is calculated by summing the individual accuracy rates and error rates for each time of run, and then divided by 10. The second method is holdout. The datasets are split into two parts: one for training and the second for testing with various rates 50% - 50%, 70% - 30%, 80% - 20%, respectively. The major aim from using two methods for dataset split is evaluate the applicability of the method from more than one perspective.

$$X_{Normalization} = \frac{X - X(min)}{X(max) - \mathrm{X}(min)} \qquad (5)$$

d) Applying Scatter Search Methodology

Scatter Search (SS) is one of meta-heuristics approaches classified as population-based algorithm, which is first suggested by F. Glover in the 1970's [18], due to his results in 1960's [17]. SS has more flexible framework than the other Evolutionary algorithms and uses a memory-type diversification procedure for more efficient globally search [22]. In addition, Glover in 1998 [26, 22] published the SS template, which presents an algorithmic description of the SS method. In addition, the SS is a promising meta-heuristic technique and has been applied to many different applications successfully. Some of these applications may be found in [22]. Furthermore, there are some studies that applied SS to machine learning algorithms as in [34], Authors suggest a hybrid procedure combining neural networks, and scatter searches to optimize the continuous parameter design of back-propagation neural network. Another method is suggested by [25] which constructed three scatter search-based algorithms to solve the feature-selection problem. In the area of parameter setting, a few works are done using SS. Lin *et al*. in [23] suggest an approach to determine the parameters and feature selection for C4.5 algorithm by employing SS meta-heuristics strategy. In [8], researchers propose a method to enhance the classification accuracy by using SS approach to determine the parameters of three machine learning algorithms and performing feature selection for these algorithms. The SS depends on five steps which are:

Diversification Generation Method, An improvement Method, Reference Set Method, Subset Generation Method and Solution Combination.

1)- Diversification Generation Method:

After the preprocessing phase, the first method of scatter search is invoked in which a set of random solutions (value for parameters) are generated, based on the upper and, lower bound of every parameters defined in first section, and according to equation 6, the number of generated solutions is 30.

$$Sol_x = LWB[i] + (UPB[i] - LWB[i]) \times Rnd \qquad (6)$$

where the *LWB[i]*: is the Lower Bound of the parameter number *i*, *UPB*: is the Upper Bound of the parameter number *i* and *Rnd*: is a random value in (0,1). After that, the model is training and testing using all solutions that are generated. After that, the initial Reference Set *(RefSet)* is develop by selecting the *b* solutions that produce the best accuracy rate *b=5*. After that, the subset generation, solution combination and *Refset* update steps, as described below, are repeated until one of the termination conditions is satisfied. This paper defines three termination conditions and if any condition of them is satisfied the process will be stopped. The conditions are: **- First Condition**: When the accuracy rate gets up to 100% for at least one solution.

-Second Condition: When *I_max >= 75* , where *I_max* is the maximum iteration.

-Third Condition: When *OldRefset= NewRefSet* this means that no update is achieved.

2)- Subset Generation Method:

This method depends on or operates on the *RefSet* to generate all pairs of solutions, where the maximum number of subsets is $(b^2-b)/2$. Means that 10 subsets are generated each subset is pair of solutions.

3)- Solution Combination Method:

In this method, a number of new solutions are generated from each subset of parents P_1 and P_2 as follows:

$$X_1 = P_1 + (P_2 - P_1) \times r_1 \qquad (7)$$

$$X_2 = P_1 + (P_2 + P_1) \times r_2 \qquad (8)$$

$$X_3 = P_1 + P_2 \times r_3 \qquad (9)$$

Where r_1, $r_2$and r_3 are random numbers in (0,1). From this method, there are **30** new solutions are generated these solution will be used for training and testing the model. After that, solutions are put in pool together with solutions in the *Refset* in order from the best one to worst.

4)- Solution Combination Method:

In this method, the *Refset* is updated to has the best $b_1= 4$ solutions from the pool and the $b_2=1$ diverse solutions, where $b_1+ b_2 = b$. Diverse solution is selected, which depends on calculating the Euclidean distance for each solution in the *Refset* and solutions in the pool. The b_2 solution with the maximum distance is selected as diverse one.

V. Numerical Experiments

The 3SVM approach is implemented on PC with Core2Due 2.93 Ghz CPU, 2GB of RAM, and windows XP Professional OS. Visual Studio 2008-Visual C# and Accord.net framework are used in development.

A. Results and Discussion

The *3SVM* approach performs two types of experiments: first one: uses k-fold cross validation method for splitting the dataset, and the second holdout method is used. Tables II and III list results of experiments, which are produce by using two different range for parameter C as in tables. Table II contains first row accuracy rate for testing (**ACC.TS**), and the remainder rows contained standard deviation for accuracy of testing (**STDEV.TS**), accuracy rate for training (**ACC. TR**), rate for training (**ERR.TR**), standard deviation for error rate of training phase (**STDEV.Err.TR**), sensitivity and specificity. While Table III contains in the first row the number of generation when the best is obtained (**No.Gen.Best Sol.Obt.**) and the rest of the rows contain the number of hitting the best solution (**No.Hit.Best Sol.**) and fitness function evaluation times (**Fitness Fun.Eval**). These factors reflect some performance aspects of the 3SVM method. All obtained results are very promising for various methods of experiments. The obtained accuracies are **98.75%**, **93.75%**, **91.66%** and **87.5%** for first range and **98.75%**, **100%**, **95.83%** and **92.5%** for the second range. The best results appear when using second range [0.1, 35000] for different methods of splitting dataset. In addition, figure 2 displays the accuracy rate for training data and testing data of various methods for splitting dataset. The differences between the accuracy rate for training and testing are reasonable for all splitting methods. This proves that the 3SVM method does not suffer from over-fitting and under-fitting problems, according to the fact that there is no large difference between the training and testing accuracy [23, 8]. Furthermore, the classification outcomes of 3SVM approach are compared with results of other published approaches. Table IV lists comparisons of **30** methods proposed in literature as listed in [6], [7], [23] and [4]. From comparisons, the 3SVM gives the better results than other methods proposed in literature, where the 3SVM enhances the performance of classification and the accuracy rate increases with **2.5%**, **1.98%** and **7.5%** from the recently published methods [32], [7] and [4]. In addition, there are some major differences with other approaches in literature like some methods perform feature reduction, as well as using different training algorithms like neural network, using different implementation environments and different tools for SVM implementation. Finally, one may conclude that obtained results by 3SVM method is encouraged and gives the best performance when compared with methods that are published recently, [4], [6], [7] and [32], as summarized in Table IV. In addition, the experimental results prove the efficiency of scatter search method for tuning SVM parameters. Therefore, the 3SVM method may be successfully employed to help doctors or specialists in diagnosis of hepatitis disease, providing them with some hints or indication that may help in making decision for disease diagnosis.

TABLE II. RESULTS

Measure	Rang of C parameter	The Method Used			
		10-fold	80-20%	70-30%	50-50%
ACC.TS	0.1-25000	98.75	93.75	91.66	87.5
STDEV.TS		0.0395	-	-	-
ACC.TR		99.16	100	100	100
ERR.TR		0.00833	0	0	0
STDEV.TR		0.0134	-	-	-
Sensitivity		100	100	95	96.87
Specificity		30	0	75	50
ACC. TS	0.1-35000	98.75	100	95.83	92.5
STDEV.TS		0.0395	-	-	-
ACC.TR		99.86	100	100	95
ERR.TR		0	0	0	0.05
STDEV.TR		0.00439	-	-	-
Sensitivity		98.57	100	95.45	100
Specificity		80	100	100	0

TABLE III. RESULTS

Measure	Rang of C Parameter	The Method Used			
		10-fold	80-20%	70-30%	50-50%
No.Gen.Best Sol.Obt	0.1-25000	89	75	75	75
No.Hit.Best Sol.		286	0	0	0
Fitness Fun.Eval.		3410	2650	2650	2650
No.Gen.Best Sol.Obt	0.1-35000	82	2	75	75
No.Hit.Best Sol.		118	1	0	0
Fitness Fun.Eval.		3170	100	2650	2650

TABLE IV. RESULTS OF 3SVM
COMPARED WITH APPROACHED [6],[7],[32],[4],[7]

Author	Method	Accuracy
Adamczak	MLP+BP(Tooldiag)	77.4
Adamczak	RBF(Tooldiag)	79.0
Adamczak	FSM with rotations	89.7
Adamczak	FSM without rotations	88.5
Bascil and Temurtas	MLNN(MLP) + LM	91.87
Bascil and Oztekin [4]	PNN(10×FC)	91.25
Chen,Liu, *et al* [7]	LDFA-SVM	96.77
Calisir and Dogantekin [6]	PCA-LLSSVM	95
Dogantekin, Avci	LDA-ANFIS	94.16
Grudzinski	Weighted9NN	92.9
Grudzinski	18NN,stand.Manhattan	90.2
Grudzinski	15NN,stand.Euclidean	89.0
Jankowski	IncNet	86.0
Ozyildirim, Yildirim *et al*	MLP	74.37
Ozyildirim, Yildirim *et al*	RBF	83.75
Ozyildirim, Yildirim *et al*	GRNN	80.0
Polat and Gunes	FS-AIRS with fuss res	92.59
Polat and Gunes	PCA-AIRS	94.12
Stern and Dobnikar	LDA	86.4
Stern and Dobnikar	NaiveBayes and semi-NB	86.3
Stern and Dobnikar	QDA	85.8
Stern and Dobnikar	1-NN	85.3
Stern and Dobnikar	ASR	85
Stern and Dobnikar	FDA	84.5
Stern and Dobnikar	LVQ	83.2
Stern and Dobnikar	CARC (DT)	82.7
Stern and Dobnikar	ASI	82.0
Stern and Dobnikar	LFC	81.9
Stern and Dobnikar	MLP with BP	82.1

Sartakhti, Zangooei *et al* [32]	SVM+SA	96.25
Our Method	**3SVM**	**98.75**

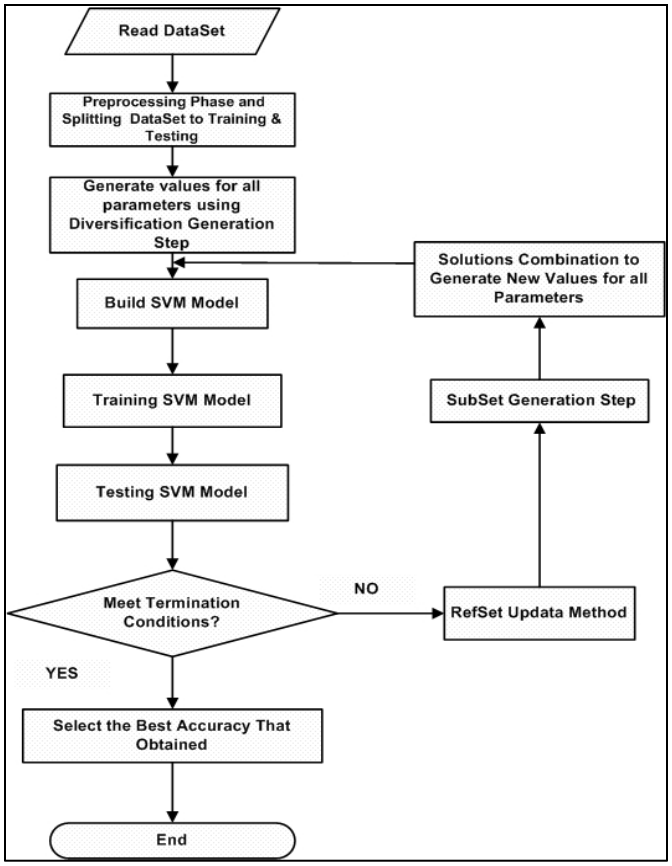
Read DataSet
Preprocessing Phase and Splitting DataSet to Training & Testing
Generate values for all parameters using Diversification Generation Step
Build SVM Model
Training SVM Model
Testing SVM Model
Meet Termination Conditions?
NO
YES
RefSet Updata Method
SubSet Generation Step
Solutions Combination to Generate New Values for all Parameters
Select the Best Accuracy That Obtained
End

Fig. 1. Methodology Steps Flowchart

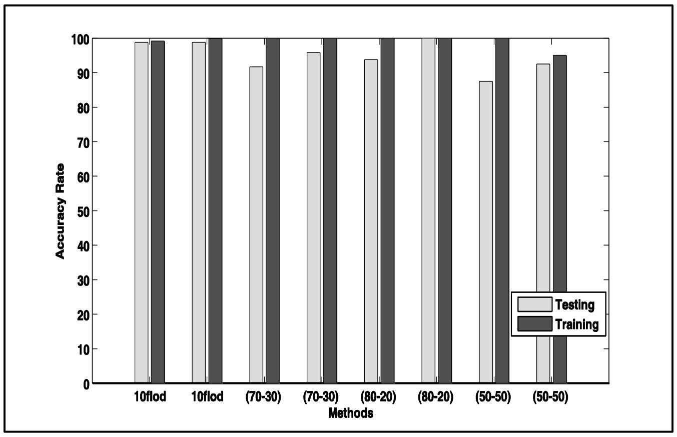

Fig. 2. The accuracy for Training and Testing Process

VI. Conclusions and future work

This paper proposed a new method 3SVM, for hepatitis virus diagnosis, which combined SVM with scatter search. Experiments proved that 3SVM has very promising performance in classifying the living liver from the dead one, with accuracy rate **98.75%**. Also, experiments demonstrated that the SS was a practical approach for tuning parameters of SVM and its kernel parameters. A comparison of the obtained results with other published approaches found in literature demonstrated that the 3SVM given better results than others. However, the 3SVM method may be successfully used to help diagnosis of hepatitis disease. In future, the performance of the proposed method may be enhanced by performing feature reduction. In addition, more features will be added to existing datasets to enhance 3SVM to be able to forecast the treatment procedures according to the level of disease. Moreover, 3SVM will be applied to multiclass problems.

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Comparison of the Information Technology Development in Slovakia and Hungary

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Abstract— **Nowadays the role of information is increasingly important, so every company has to provide the efficient procurement, processing, storage and visualization of this special resource in hope to stay competitive. More and more enterprises introduce Enterprise Resource Planning System to be able to perform the listed functions. The article illustrates the usage of these systems in Hungary and Slovakia, as well as tests the following presumption: the level of Information Technology (IT) development is lower in Hungary than our northern neighbor.**

***Keywords*— *Information society; Information Technology; Slovakia, Hungary*[1]**

I. Introduction

The role of information has become more and more substantial in the economy recently, and information is regarded as an important resource since it is more difficult for companies to improve their market positions in the long term without having the appropriate amount of available information [5]. Globalization in the business world has brought about the possibility of getting a greater amount of information in much less time, which means that companies are forced to spend more time and energy on handling the increased information load [10] [17].

As information systems are designed to provide effective help in this process, they are becoming increasingly popular among companies due to the robust technological development [11]. This paper deals with the usage of business information systems among Hungarian enterprises and analyzes the following three key questions: how the usage of business information systems influences a company's economic performance, what expenditure is required for an individual company to develop its information technology infrastructure and finally, to what extent information technology is considered important as a functional area within the organization of a company [2].

The aim of the research presented in this paper was to explore the current situation of Hungarian enterprises in terms of using business information systems, gaining a more thorough insight into the background of the decisions made on introducing such information systems, together with the possible problems related to their introduction and further usage [10].

The IT development of the two countries compared (Hungary (HUN) and Slovakia (SK)) may be corresponding with their economic status, so first we have analyzed some essential economic indicators.

TABLE I. Economic indicators in Hungary and Slovakia [27] [28]

	2008		2009		2010		2011	
	HUN	**SK**	**HUN**	**SK**	**HUN**	**SK**	**HUN**	**SK**
GDP (PPP) EU=100 (%)	64	73	65	73	65	73	66	73
Unem-ployment rate (%)	7.8	9.6	10.0	12.1	11.2	14.4	10.9	13.5
Avarage monthly gross wage (EUR)	705.5	723.0	708.5	744.5	718.4	769.0	755.6	786.0

The GDP /purchasing power parity/ indicate the quality of living standards; this data is constantly higher in Slovakia, while in Hungary we can see a slow development. The unemployment rate is lower in our country, so this indicator favors us. However the average monthly gross wage is greater in Slovakia.

In recent years the number of companies has multiplied across the EU, only the economic crisis has sat back this dynamism. Micro enterprises make up the most typical size both in Europe and in Hungary, this amount to 91.8% of all the companies. Since most jobs are created by SME-s, we cannot ignore researching them. In Hungary the number of SME-s per 1000 habitants is higher than the average in the EU. The reason of this is the existence of forced businesses, formed by the regulatory environment.

Hungary was the 49th in 2012 by the classification of the Doing Business Index, while Slovakia was the 46th. This indicator scans different parameters in the economies then shows their ease of doing business. In 2013 Slovakia keeps its position, but Hungary becomes only the 54th, because of the difficulty in access to credit, the deterioration in solving bankruptcies, and the hardness of starting business.

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Whereas these economic indicators show that Slovakia is in a more favorable economic position. Our purpose is to analyze that question of „which country is more developed by IT perspective".

II. Definition and classification of Information Systems

There are several definitions offered on business information systems in the literature. According to Burt and Taylor's approach, "business information systems can be regarded as an information source in any combination thereof, or any access to and any recovery of their use or manipulation. Any business information system is designed to link the user to an appropriate source of information that the user actually needs, with the expectation that the user will be able to access the information satisfying their needs" [3]. Davis and Olson define business information systems as "an integrated user-machine system for providing information to support the operations, management, analysis, and decision-making functions in an organization. The system utilizes computer hardware and software, manual procedures, models for analysis, planning, control, and decision-making by using a database" [6].

"Information systems are a part of any organization that provides, generates, stores, separates, divides and uses information. They are made up of human, technical, financial and economic components and resources. In fact, they can be regarded as inherently human systems (organizations, manual systems) that may include a computer system, and automatizes certain well-defined parts and selected items of the system. Its aim is to support both the management functions and the daily operation of an organization." [7]

In a broader sense, a business information system is the collection of individuals, activities and equipment employed to collect, process and store information related to the company's environment, its internal activities, together with all transactions between the company and its environment. Beyond giving direct support to operations, its basic task is to provide decision-makers with the necessary information during the whole decision-making process. The system's main components are the following [9]:

- Individuals carrying out corporate activities: the actual users of technical apparatus. Decision-makers also belong to this group, as leaders who receive information on the factors affecting business operations, and use business information systems to make decisions in relation to planning, implementation and monitoring business activities.
- Information (also known as processed data on external and internal facts) which – due to its systematized form – can be used directly in the decision-making process.
- Technical apparatus, nowadays usually a computer system that supports and connects the subsystems applied to achieve corporate objectives.

The computer system standardizes a significant part of the information and communication system, thus making it easier to produce and use information.

According to one definition proposed [4] "information systems are systems that use information technology to collect information, transmit, store, retrieve, process, display and transform information in a business organization by using information technology."

Raffai's understanding of information systems is as follows: "it uses data and information as a basic resource for different processing activities in order to provide useful information for performing useful organizational tasks. It's main purpose is the production of information, that is dedicated to creating messages that are new to the user, uncertainties persist, and their duties, to assist in fulfilling the decisions" [19].

The classification of business information systems is a difficult task because, due to the continuous development, it is hard to find a classification system that can present unanimously defined information system types. It occurs quite often that different abbreviations are used to refer to the same system or certain system types appear to be merged together. As a consequence, the classification of business information systems can be done in several ways, the lists of several groups of business information systems presented below just to show a few alternatives for classification [1].

Dobay [8] made a distinction between the following types:

- Office Automation Systems (OAS): used for efficient handling of personal and organizational data (text, image, number, voice), making calculations and document management.
- Communication systems: supporting the information flow between groups of people in a wide variety of forms.
- Transaction-processing systems (TPS): used for receiving the initiated signals of transactions, generating and giving feedback on the transaction event.
- Management Information Systems (MIS): used for transforming TPS-related data into information for controlling, management and analysis purposes.
- Executive Information Systems (EIS): intended to give well-structured, aggregated information for decision-making purposes.
- Decision support systems (DSS): applied to support decision-making processes with information, modelling tools and analytical methods.
- Facility Management Systems (facility management, production management): used for directly supporting the value production process.
- Group work systems: intended to give group access to data files, to facilitate structured workflows and the implementation of work schedules.

Another possible approach to defining categories is based on Raffai's work [19]:

- Implementation support systems: this group includes transaction processing systems (TPS), process control systems (PCS), online transaction processing systems (OLTP), office automation systems (OAS), group work support systems (GS), workflow management (WF), and customer relation management systems (CRM).

- Executive work support systems: this category can include strategic information systems (SIS), executive information systems (EIS), online analytical processing systems (OLAP), decision support systems (DSS), group decision support systems (GDSS), and management information systems (MIS).
- Other support systems: business support systems, (BIS), expert systems (ES), integrated information processing systems (IIS), and inter-organizational information systems (IOS) can be found in this category.

Based on Gábor’s [12] findings, information systems can also be examined by applying the following classification criteria.

- According to organizational structure:
    - functional systems such as reporting applications,
    - comprehensive business systems such as corporate management systems used by the entire organization,
    - inter-organizational systems such as reservation systems.
- According to the field of application:

Depending on the scope of activities, systems used for accounting, finance, production, marketing or human resource management belong to this category. These systems are generally related to the various functions a company performs.

- According to the type of support:
    - TPS (Transaction Processing System) – it focuses on a particular purpose, its basic function is to serve as a supporting tool for data processing related to business activities.
    - MIS (Management Information System) – it basically supports functional executive activities (O’Brien 1999).
    - KMS (Knowledge Management System) – it facilitates the execution of tasks related to knowledge as a valuable corporate resource.
    - OAS (Office Automation System) – it supports office document management, group work and communication.
    - DSS (Decision Support System) – it supports decisions made by managers and analyses done by experts.
    - EIS (Enterprise Information System) – it is designed to support the whole organization and its management.
    - GSS (Group Support Systems) – it facilitates the cooperation between ad hoc and permanent work groups both within an organization and between different organizations.
    - ISS (Intelligent Support System) – it is mainly designed to support the work of employees performing mental work.
    - Applications supporting production activities: CAD/CAM (Computer Aided Design/Computer Aided Manufacturing) – they are designed to support planning and production processes by using information technology devices (Shaw 1991).

The information system connected to an organization, or a part of it, provides methods to fix, process and make the information available, thereby helping the company reach its goals.

The categorization of the information systems is a difficult task as there is no unified classification. Because of the continuous development we have to classify these systems according to different point of views. We will show some clustering methods below.

According to the supported function we can distinguish:

- Office Automation Systems (OAS),
- Communication Systems,
- Transaction Processing Systems (TPS),
- Management Information Systems (MIR, MIS),
- Executive Information Systems (EIS),
- Decision Support Systems (DSS),
- Implementation Information Systems,
- Collaboration Systems.

According to the roominess of the user groups we can separate:

- Unique, special needs systems.
- Public, complex systems with general purpose.

According to the role of the user, the below types can be delimited:

- Implementation information system: creating those data, information, and documents which are necessary for doing routine tasks.
- Management information system: handling information, which is necessary for the successful and efficient decision-making activities.

III. THE METHOD OF THE RESEARCH

The statements of the paper are based on a database of a primer survey research. The survey was carried out between May and December 2012.

The questions of the questionnaire are scanning more areas by the companies, but we will focus on one major topic later. The introductory questions aim at the background information of the enterprises who filled in the questionnaire, then the IT infrastructure, internet usage habits, the practice of information management are also the subject of the inquiry. This article deals with the use of information systems and examines these questions of the questionnaire.

A. *The presumption of the research*

The purpose of our present survey is to justify our next assumption: the level of information development at Slovakian enterprises – considering every size classes – is higher than at Hungarian partners.

B. *The combination of the sample*

The target group of the survey included hundreds of micro-, small-, medium- and big enterprises. We received 94 pieces of questionnaires from Hungary and 86 pieces from Slovakia. The 21% of the Hungarian responder companies are micro-, 29% are small-, 29% are medium- and 21% are big enterprises. In spite of this more than half of the 86 Slovakian responders (51%) are micro-, 26% are small-, 15% are medium-, and only 8% are big companies. By the evaluation of the questionnaire this asymmetry in the size of the companies has not given rise to confusion, because we have compared the enterprises by countries and by size classes.

IV. COMPARISON OF THE IT DEVELOPMENT

The listed ERP systems in the questionnaire have been distinguished according to Dobay’s [8] typing. The enterprises could select between three options: the system is used; not used, introduction is planned; not used, and introduction is not planned either. Because of the low rate of the second option and the easier transparency we have compared graphically only the used systems. The 1st figure illustrates the result.

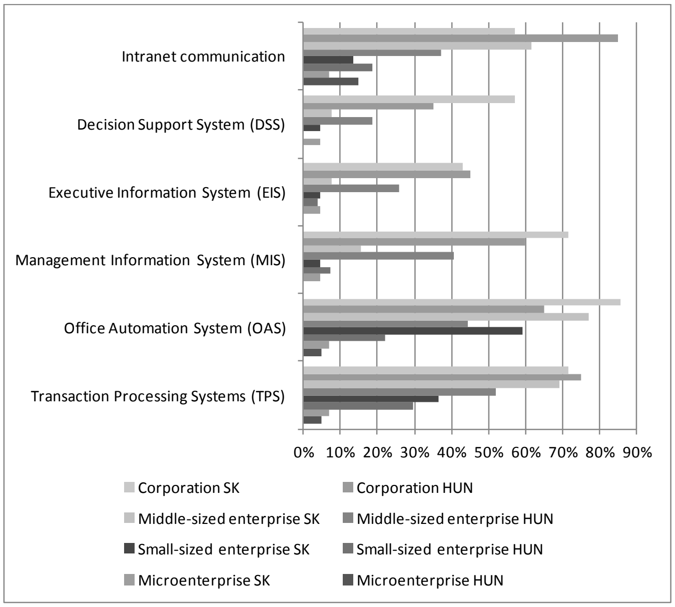

Fig. 1. Types of the applied information technology systems

The variegation of the first figure shows, that the companies use one of the listed IT systems almost in every category. However, the small and the bigger enterprises use different types by different frequency. An average micro enterprise has no need for an Executive Information System, Decision Support System or Management Information System, these do not appear on the Hungarian bar chart. The situation is different in Slovakia, the small companies also chose EIS, DSS or MIS. In the case of both countries we can say that the decision support and management systems get a higher emphasis by the increase of the company size, but this tendency is also true in every type of the systems. The Slovakian enterprises use the listed systems more often in three size classes.

The Transaction Processing Systems have been used more often by the Slovakian companies, the Hungarian data is higher only in the biggest size class. The Slovaks prefer the Office Automation Systems, while the Hungarian SME-s use the Management Information Systems more frequently than the Slovaks. The Executive Information Systems have been used more often by the Hungarian medium and large enterprises.

In case of the Decision Support Systems Hungary leads only on the medium size category. Besides the Intranet communication is more widespread among the domestic companies than in Slovakia. In total the most popular information technology systems are the Transaction Processing Systems, the Office Automation Systems and the Intranet communication, these are used by companies almost in every size class and in both countries.

Those enterprises, which use a sort of information technology systems typically, have bought ready-made systems, as you can see on the 2nd figure. This asymmetry toward the ready-made systems is the most conspicuous in Slovakia, but in Hungary only the micro size enterprises use own developed information systems mostly. The usage of the own developed systems has also appeared at the Slovakian micro companies, while the Hungarian medium and large companies use ready-made and own developed systems equally. The benefit of the latter is the customization, although the development costs are higher than in the case of the purchased systems.

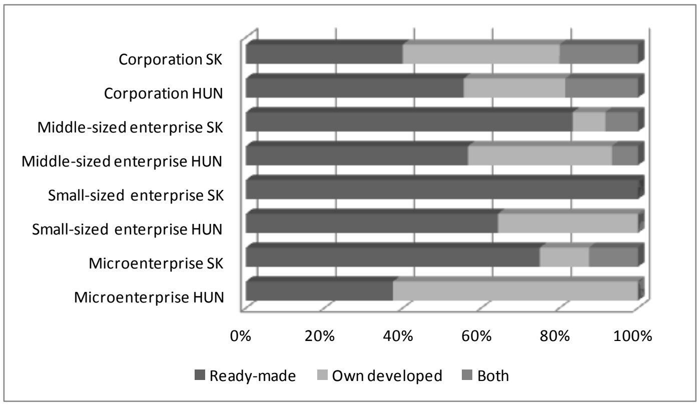

Fig. 2. Ready-made and own developed information systems

During the analysis of the information technology systems we should examine that in which area of the company operations the responders apply (at least once a week) the given software; the 3^{rd} figure shows the result. We can see the correlation between the company size and the applied systems. The larger a company is, the more functional areas have access to the information systems. The Hungarian micro and small size enterprises use these applications in fewer areas, than the Slovaks. In contrast Hungary utilizes the software in more corporate functions in the category of medium and large companies. The most popular areas of applied information technology systems are accounting, finance and sales without reference to the company size. Logistics, marketing and senior management decision support functions also come into view by the growth of the company size.

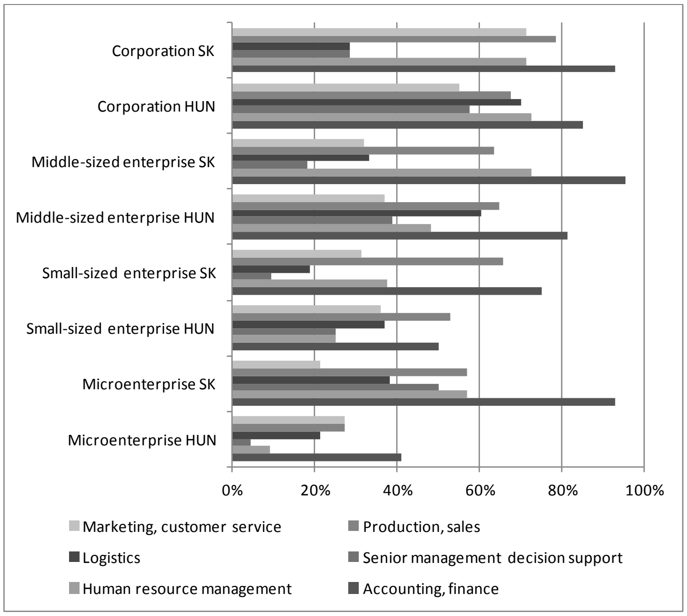

Fig. 3. Application of the information technology systems under the company operations' different areas

V. CONCLUSION

The purpose of writing this article was to find out if Slovakian enterprises are more developed informatically than Hungarians or not. We have applied the results of an empirical survey. The subjects of the questionnaire were nearly 100 per countries.

We have waited for a verification of our assumption from the evaluation, the questions verified it partly, but some of them denied it. In case of both countries we can say that the usage of the information technology systems becomes more frequent and varied by the increase of the company size. The Slovakian companies apply ready-made systems primarily, while in Hungary the rate of the own developed and ready-made systems is almost equal. This perception refers to a higher level of IT development. The larger a company is, the more functional areas have access to the information systems. Even though micro- and small companies utilize the IT softwares in more functional areas in Slovakia, in the category of medium- and large companies the Hungarian responders use these applications in a wider range of activities [20].

To sum up, according to the survey we can say that there is no significant difference between the IT development of Hungary and Slovakia. At the same time it seems that there is a directly proportional relationship between the company size and the willingness to use the information technology systems.

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Automated Localization of Optic Disc in Retinal Images

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***Abstract*—An efficient detection of optic disc (OD) in colour retinal images is a significant task in an automated retinal image analysis system. Most of the algorithms developed for OD detection are especially applicable to normal and healthy retinal images. It is a challenging task to detect OD in all types of retinal images, that is, normal, healthy images as well as abnormal, that is, images affected due to disease. This paper presents an automated system to locate an OD and its centre in all types of retinal images. The ensemble of steps based on different criteria produces more accurate results. The proposed algorithm gives excellent results and avoids false OD detection. The technique is developed and tested on standard databases provided for researchers on internet, Diaretdb0 (130 images), Diaretdb1 (89 images), Drive (40 images) and local database (194 images). The local database images are collected from ophthalmic clinics. It is able to locate OD and its centre in 98.45% of all tested cases. The results achieved by different algorithms can be compared when algorithms are applied on same standard databases. This comparison is also discussed in this paper which shows that the proposed algorithm is more efficient.**

Keywords—disease; healthy; optic disc; retinal image

I. INTRODUCTION

Study of colour fundus images is considered to be the best diagnostic modality available till date as it is reliable, non-invasive and easy to use. It allows recording the diagnostic data and enabling the ophthalmology consultation afterwards. For a particularly long time, automatic diagnosis of retinal diseases from digital fundus images has been an active research topic in the medical image processing community.

Fig. 1 shows the retinal fundus image with main anatomical structures. The retina is an interior surface of eye which acts as the film of eye. It converts light rays into electrical signals and sends them to the brain through the optic nerve. Optic nerve is the cable connecting the eye to the brain. OD is the bright region within the retinal image. It is the spot on the retina where the optic nerve and blood vessels enter the eye. Macula is responsible for our central vision and colour vision. The fovea is an indentation in the centre of the macula. This small part of our retina is responsible for our highest visual acuity. The vascular network is a network of vessels that supply oxygen, nutrients and blood to the retina.

An important prerequisite for automation is the accurate localization of the main anatomical features in the image. An accurate and efficient detection of these structures is a significant task in an automated retinal image analysis system.

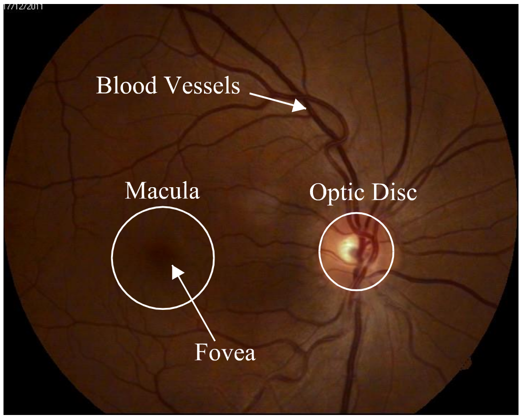


Fig. 1. Retinal Fundus Image With Main Anatomical Structures

Once these locations are known, a frame of reference can be established in the image. The OD localization is important for many reasons. Some of them are mentioned here.

The automatic and efficient detection of the position of the OD in colour retinal images is an important and fundamental step in the automated retinal image analysis system [1], [2].To successfully find abnormal structures in a retinal image, it is often necessary to mask out the normal anatomy from the analysis. An example of this is the OD, an anatomical structure with a bright appearance, which should be ignored when detecting bright lesions. The attributes of OD are similar to attributes of hard exudates in terms of colour and brightness. Therefore it is located and removed during hard exudates detection process, thereby avoiding false positives.

OD detection is the main step while developing automated screening systems for diabetic retinopathy and glaucoma. OD boundary and localization of macula are the two features of retina necessary for the detection of exudates and also knowing the severity of the diabetic maculopathy [3]. In case of diabetic maculopathy lesions identification, masking the false positive OD region leads to improvement in the performance of lesion detection.

The OD has an inner portion called the optic cup. The optic cup is always smaller than the disc and the relative size of one to the other is called the cup disc ratio. The cup disc ratio (CDR) ranges from 0.1 to 0.5 [4], [5]. Specifically, this is an important indicator for glaucoma [6].

The distribution of the abnormalities associated with some retinal diseases (e.g. diabetic retinopathy) over the retina is not uniform; certain types of abnormalities more often occur in specific areas of the retina [7]. The position of a lesion relative to the major anatomy could thus be useful as a feature for later analysis. It is used as prerequisite for the segmentation of other normal and pathological features by many researchers. The position of OD can be used as a reference length for measuring distances in retinal images, especially for the location of macula. In case of blood vessel tracking algorithms, the location of OD becomes the starting point for vessel tracking.

The OD, fovea, blood vessel bifurcations and crosses can be used as control points for registering retinal images [8]. The registration of retinal images is an important step for super-resolution and image change detection. Unique feature points within image are used as control points for registration. OD is an unique anatomic structure within retinal image. These methods play major role in automatic clinical evaluation system. When feature based registration algorithms are used, the accuracy of the features themselves must be considered in addition to the accuracy of the registration algorithms [9]. OD acts as landmark feature in registration of multimodal or temporal images.

Location of the retinal OD has been attempted by several researchers recently. According to S. Sekhar *et al.*, the OD is usually the brightest component on the fundus, and therefore a cluster of high intensity pixels will identify the OD location [10].

Sinthanayothin *et al*. [11] presented a method to detect the location of the OD by detecting the area in the image which has the highest variation in brightness. As the OD often appears as a bright disc covered in darker vessels, the variance in pixel brightness is the highest there. They also presented method for the detection of the macular centre. They used a template matching approach in which the template was a Gaussian blob. The search area was constricted by the fact that the macular centre was assumed to be in the darkest part of the image approximately 2.5 times the OD diameter from the OD [12]. In macula localization the approximate distance between OD and macula is used as a priori knowledge for locating the macula [13].

A method based on pyramidal decomposition and Handoff-distance based template matching was proposed by Lalonde *et al*. [14]. The green plane of the original image was sub-sampled and the brightest pixels in this sub-sampled image were selected as candidate regions. An edge detector was used on the candidate regions in the original image. Next, multiple circular templates were fit to each of the regions using the Hausdorff-distance as a distance measure. The centre of the fitted circular template was taken as the OD centre.

Sopharak *et al*. [15] presented the idea of detecting the OD by entropy filtering. After pre-processing, OD detection is performed by probability filtering. Binarization is done with Otsu’s algorithm [16] and the largest connected region with an approximately circular shape is marked as a candidate for the OD.

Hoover *et al*. [17] described a method based on a fuzzy voting mechanism to find the OD location. In this method the vasculature was segmented and the vessel centrelines were obtained through thinning. After removal of the vessel branches, each vessel segment was extended at both ends by a fuzzy element. The location in the image where most elements overlap was considered to be the OD.

Ravishankar *et al.* [18] tried to track the OD by combining the convergence of the only thicker blood vessels initiating from it and high disk density properties in a cost function. A cost function is defined to obtain the optimal location of the OD that is a point which maximizes the cost function.

Niemeijer *et al.* [19] defines a set of features based on vessel map and image intensity, like number of vessels, average width of vessels, standard deviation, orientation, maximum width, density, average image intensity etc. The binary vessel map obtained [20] is thinned until only the centerlines of the vessels remain and all the centerline pixels that have two or more neighbors are removed. Next, the orientation of the vessels is measured by applying principal component analysis on each centerline pixel on both sides. Using the circular template of radius 40 pixels having manually selected OD center within the radius, all features are extracted for each sample location of the template including distance d to the true centre. To locate OD, a sample grid is overlaid on top of the complete field of view and features vector are extracted and location of OD is found containing pixels having lowest value of d.

Improved results on the same dataset were reported by Foracchia *et al.* [21]. They described a method based on the global orientation of the vasculature. A simple geometrical model of the average vessel orientation on the retina with respect to the OD location was fitted to the image.

Li *et al.* [22] presented a model based approach in which an active shape model was used to extract the main course of the vasculature based on the location of the OD. Next, the information from the active shape model was used to find the macular centre.

Huajun Ying *et al.* [23] utilized fractal analysis to differentiate OD area from other large and bright regions in retinal images due to the fact that the OD area is the converging point of all major vessels.

Hiuiqi, Chutatape [22], C. Sinthanayothin *et al.* [11] used PCA (Principal Component Analysis) method for OD detection. The accuracy of PCA algorithm is based on number of training images used for matching intensity pattern. Major drawback of PCA algorithm is that the time complexity of this algorithm is very high.

In most of the papers researchers considered the OD as the brightest region within retinal image. However, this criterion may not be applicable for retinal images those include other bright regions because of diseases such as exudates due to diabetic retinopathy. Some considered the OD as the area with highest variation in intensity of adjacent pixels. Both the criteria considered by many researchers are applicable for normal, healthy retinal images. M.D. Abramoff and M. Niemeijer clearly mentioned in the paper [2] that the approach in this paper has the potential to detect the location of the OD in retinal images with few or no abnormalities.

This paper presents a novel algorithm for OD localization. The proposed algorithm ensembles the steps based on different principles and produces more accurate results. First we estimated threshold using green channel histogram and average number of pixels occupied by OD. Applying this threshold, all bright regions within image called clusters are detected. Then we applied two different criteria on these clusters, a: area criterion and b: density criterion. The details about this are discussed in further sections. Once the candidate cluster for OD is identified, the brightest oculus criterion is applied to locate the centre of OD.

The contribution of this work is that we propose an automatic system to locate an OD not only in normal, healthy images but also in images affected because of diseases such as diabetic retinopathy and images of poorer quality. There are more chances of false OD detection in images affected due to diseases and images of poor quality than desirable. The problem with retinal images is that the quality of the acquired images is usually not good. As the eye-specialist does not have complete control over the patient's eye which forms a part of the imaging optical system, retinal images often contain artifacts and/or are of poorer quality than desirable [24]. Despite controlled conditions, many retinal images suffer from non-uniform illumination given by several factors: the curved surfaces of the retina, pupil dilation (highly variable among patients) or presence of disease among others [25]. However, our system avoids detecting false OD applying different criteria based on different principles. We tested proposed system on 453 retinal images which include normal (healthy) as well as abnormal (affected) retinal images. We are able to locate OD in 98.45% of all tested cases. Once the OD is located accurately, its centre is also located accurately.

II. Material and Methods

Database used for OD localization is as shown in Table I.

TABLE I DATABASE USED FOR OD LOCALIZATION

Sr. No.	Test Database	Number of Images
1	Diaretdb0	130
2	Diaretdb1	89
3	Drive	40
4	Walimbe Eye Clinic, Pune (M.S.), India	34
5	Bhagali Clinic and Nursing Home, Pune (M.S.), India	160

Thus, a set of 453 retinal images is studied for automated localization of OD and its centre.

A. *Proposed Algorithm for Detection of Candidate Region for OD*

Step 1: Estimate Threshold.

Step 2: Apply Threshold and identify bright regions.

Step 3: Select candidate regions which satisfy area criterion.

Step 4: Select candidate region which satisfies density criterion.

Step 5: If no candidate region is selected, reduce threshold.

Step 6: If threshold is greater than zero, apply steps 2 through 5.

Step 7: Stop.

The major steps in the algorithm are discussed in detail here.

1) Threshold estimation

In normal, healthy retinal images, OD is mostly the brightest region. However, in retinal images affected due to diseases such as diabetic retinopathy, there may exist other bright regions in addition to OD. So first we detected all bright regions within retinal images. In paper by Li and Chutatape [22], they used the highest 1% gray levels in intensity image to obtain threshold value to detect candidate bright regions. However, there is possibility of not detecting OD as candidate region if highest 1% gray levels are occupied by other bright regions within image.

Siddalingaswamy P.C. *et al.* [1] used iterative threshold method to estimate threshold for OD detection. This criterion is also not applicable to all types of retinal images.

Green channel image shows better contrast than red channel or blue channel image. It is observed that OD appears most contrasted in the green channel compared to red and blue channels in RGB image. Therefore, only the green channel image is used for the effective thresholding of the retinal image. So, we estimated threshold considering green channel histogram. Optimal thresholding method divides the pixels of the image in two groups: group A and group B such that group A contains pixels at least equal to the number of pixels occupied by the OD.

OD size varies from person to person. It is a vertical oval, with average dimensions of 1.76mm horizontally by 1.92mm vertically [26]. Its width and height are 1/8 and 1/7.33 of retinal image diameter, respectively [27]. Thus, it is possible to determine the number of pixels occupied by the OD as :

$$P_{count} = Estimated\ OD\ pixel\ count = \frac{\pi\times(D/2)^2}{(7.33)\times(8)} \qquad (1)$$

where D is the diameter of the retinal image in pixels.

To obtain an optimal threshold, the histogram derived from the source image is scanned from highest intensity value to the lowest intensity value. The scanning stops at intensity level T when scanned pixels are greater than the estimated OD pixels and there is a 10% rise in pixel count between two consecutive intensity levels. Thus, the optimal threshold is calculated as follows :

Step1 : Initialize i = 255 and sum = 0

Step2: sum = sum + H[i]

Step3: i = i − 1

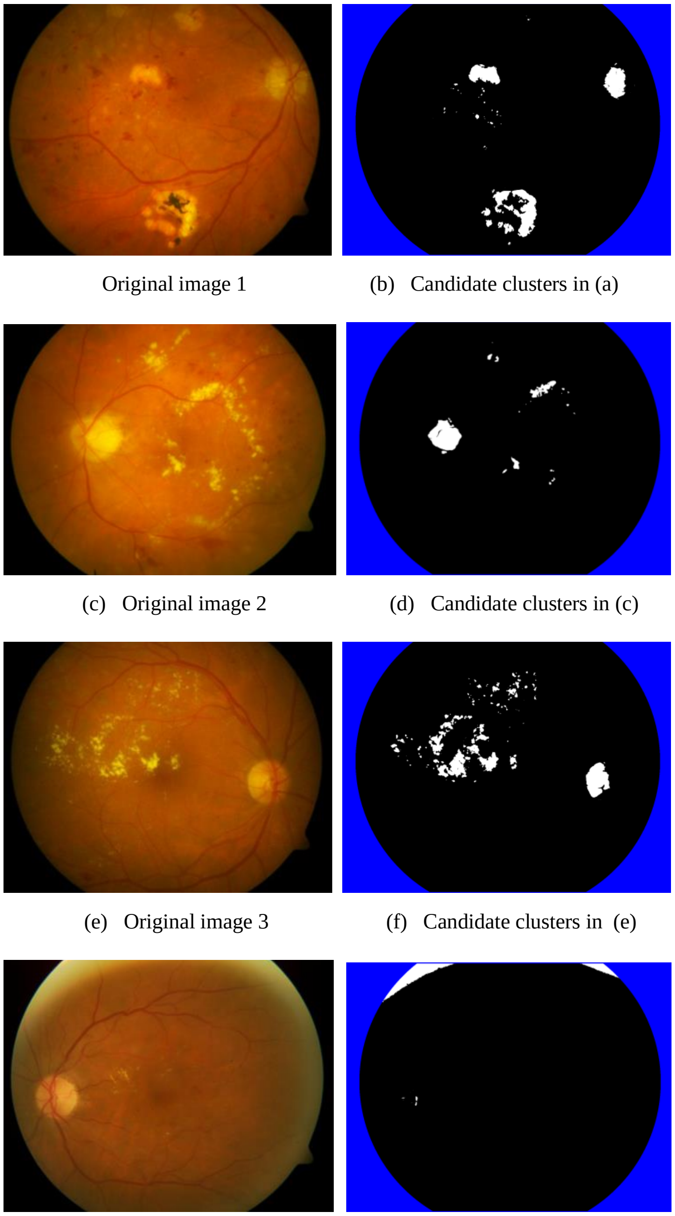
Step4: if $sum \le P_{count}$ or

$$\frac{(H[i\text{-}1] - H[i])}{(H[i])} < 0.1 \quad \text{repeat steps 2 through 4}$$

Step5: Threshold, T = i

where H[i] indicates the histogram of the source image and i indicates the intensity level.

Fig. 2 illustrates some examples of candidate clusters determined by this algorithm.



Original image 1 (b) Candidate clusters in (a)

(c) Original image 2 (d) Candidate clusters in (c)

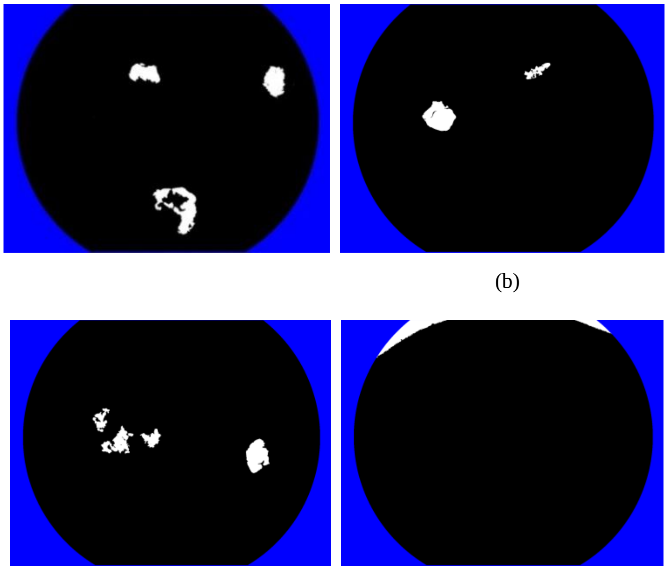
(e) Original image 3 (f) Candidate clusters in (e)

(g) Original image 4 (h) Candidate clusters in (g)

Fig. 2. Examples of candidate clusters

2) *Area criterion*

The optimal threshold when applied to the image results in one or more isolated connected regions (clusters). Each of the cluster in the thresholded image is labeled and total number of pixels in each cluster are calculated. The clusters having more than 125% or less than 10% of the OD area are discarded. This criterion minimizes the possibility to miss the OD from the selected candidate clusters. Fig. 3 illustrates some examples of candidate clusters resulted after application of area criterion.



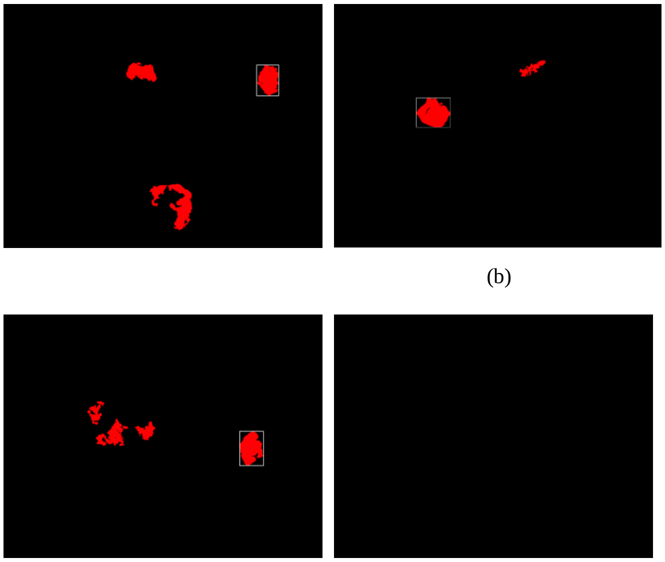
(b)

(c) (d)

Fig. 3. Examples of resulted candidate clusters after area criterion

3) *Density criterion*

The density criterion is applied to clusters which have already satisfied the area criterion. According to the density criterion, if the ratio of number of pixels occupied by cluster to the number of pixels occupied by rectangle surrounding the cluster is less than 40%, the cluster is discarded. From the remaining clusters the cluster having highest density is considered to be the primary region of interest. Fig. 4 illustrates some examples of candidate clusters resulted after application of density criterion.



(b)

(c) (d)

Fig. 4. Examples of resulted candidate clusters after density criterion

As shown in the Fig. 4(d), if no candidate cluster is selected for OD, the pixel count is re-calculated as given below to reduce the threshold and entire process is repeated with this threshold.

$$P_{count} = 2 * P_{count} \qquad (2)$$

Fig. 5 shows the result of candidate cluster resulted after application of reduced threshold algorithm.

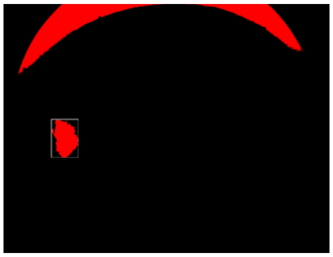


Fig. 5. Result of reduced threshold algorithm

B. *Localization of Centre of an OD*

The cluster which occupies OD is located in algorithm discussed above. The centroid of this cluster is determined using calculus method. A search area is defined around this centroid such that this centroid is center of the search window. This search window is a square window with side equal to twice of OD diameter (ODD).

A circular window called an oculus of radius ODD/2 is moved across the search area. This is illustrated in Fig. 6. The maximum intensity oculus is identified using procedure given here.

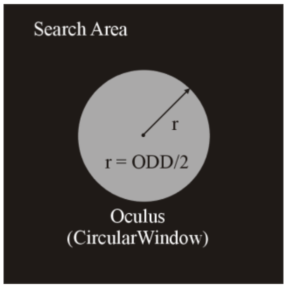


Fig. 6. Circular window for OD detection

Each pixel within the square window of side equal to ODD is tested for its distance (*d*) from the centre of the window. As shown in Fig. 7, if the distance, d is less than or equal to the radius *r* (radius of the oculus), it is considered as inside pixel. The total intensity of the oculus is calculated by adding squares of intensities of all inside pixels. It can be expressed mathematically as,

$$I_{sum} = \begin{cases} \sum_{j=1}^{ODD} \sum_{k=1}^{ODD} I^2(j,k), & for\ d \leq r \\ 0, & otherwise \end{cases} \qquad (3)$$

where $d = \sqrt{(x_{cen} - j)^2 + (y_{cen} - k)^2}$ and

(x_{cen}, y_{cen}) is the centre of an oculus

The centre of maximum intensity oculus is marked as a centre of OD.

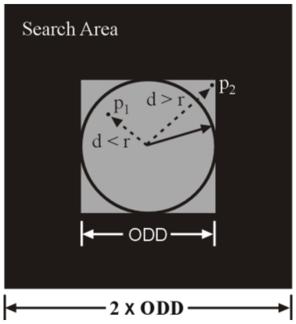
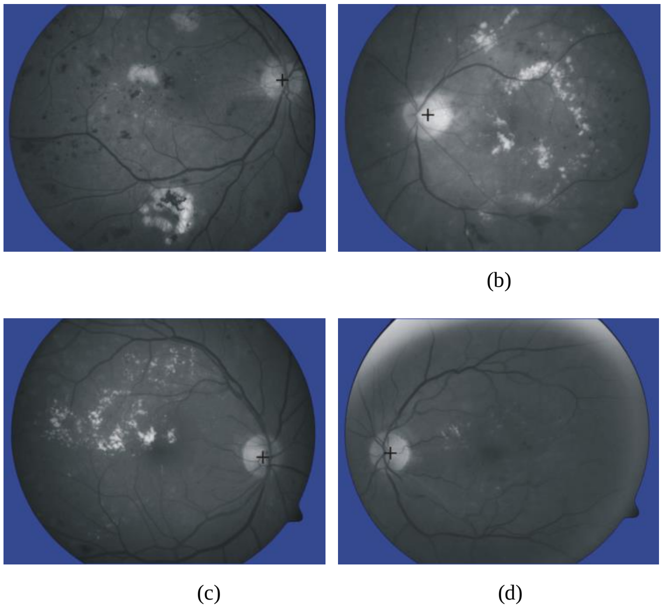


Fig. 7. Pixel inside circle test

There may be more than one window of same maximum total intensity. In this case, the central window amongst the same intensity windows is the resultant window and the centre of the resultant window is considered as a centre of an OD. Fig. 8 illustrates some examples of centre of OD.


(b)

(c) (d)

Fig. 8. Examples of centre of OD

III. Results

TABLE II RESULTS OF PROPOSED OD LOCALIZATION METHOD

Test database	Images	OD Detected	% Accuracy
Diaretdb0	130	126	96.92
Diaretdb0	89	86	96.62
Drive	40	40	100
Walimbe Eye Clinic, Pune	34	34	100
Bhagali Clinic and Nursing Home	160	160	100
Total	453	446	98.45

The outcome of OD localization is deemed true detection if obtained centre is within the OD area. Table II shows the accuracy of true OD detected retinal images.

TABLE III COMPARISON OF RESULTS OBTAINED USING DIFFERENT METHODS

Test database	$\mathbf{OD_{pd}}$	$\mathbf{OD_{ed}}$	$\mathbf{OD_{fv}}$	$\mathbf{OD_{ef}}$	$\mathbf{OD_{ht}}$	**Combined system**	**Proposed method**
Diretdb0	89.52%	77.56%	77.56%	95.29%	80.12%	96.79%	98.46%
Diaretdb1	88.99%	75.46%	75.46%	93.70%	76.41%	94.02%	96.62%
Drive	80.55%	97.22%	97.22%	98.61%	86.10%	100%	100%
Walimbe Eye Clinic, Pune	-	-	-	-	-	-	100%
Bhagali Clinic and Nursing Home	-	-	-	-	-	-	100%
Total Average	87.95%	79.88%	76.12%	95.26%	79.78%	96.34%	98.45%

A. Comparison of results obtained using different methods

Rashid Jalal Qureshi *et al.* [28] discussed different OD detection algorithms and OD percentage detection rate in each case using standard databases. Table III summarizes the percentage accuracy achieved applying each algorithm discussed in this paper and proposed algorithm.

$\mathbf{OD_{pd}}$: Based on pyramidal decomposition [14]

$\mathbf{OD_{ed}}$: Based on edge detection [14]

$\mathbf{OD_{fv}}$: Based on feature vector and uniform sample grid [19], [20]

$\mathbf{OD_{ef}}$: Based on entropy filter [15]

$\mathbf{OD_{ht}}$: Based on Hough transformation [18]

We can easily conclude observing Table III that proposed method gives better accuracy in localizing OD compared to other methods. Rashid Jalal Qureshi *et al.* [28] mentioned that performance of the methods listed in columns 2 through 6 of Table III is generally good, but each method has situations, where it fails. These methods fail on a difficult data set i.e., the diseased retinas with variable appearance of ODs in terms of intensity, colour, contour definition etc. The criteria used in the proposed algorithm are determined by considering abnormality of retinal images and hence provides better accuracy in localizing OD as shown in the last column of Table III.

IV. DISCUSSION AND CONCLUSION

An automated method has been presented which is able to locate an OD in retinal images. The results show that the system is able to locate the OD accurately in 98.45% of all tested cases. The percentage of successful detection of OD is increased using method presented in this paper.

The method of OD localization is tested on retinal images and qualitatively valuated by comparing the automatically segmented OD with manual ones detected by an experienced ophthalmologist. Original detection of OD leads towards the development of a fully automated retinal image analysis system to aid clinicians in detecting and diagnosing retinal diseases. Compared to the approaches by other researchers, our algorithm for OD detection has the advantage that it is applicable to all types of retinal images, healthy as well as abnormal, affected due to disease and/or acquisition process.

The work in this paper is carried out for control point detection which is an important step for registration of retinal images. As the OD and its centre are located accurately, macula and its centre can be detected accurately. OD, macula and vascular network are unique anatomical structures of retinal image. So centre of OD, centre of macula and bifurcation points of vascular network can be used as control points for registration of retinal images. The bifurcation points within retinal images which are to be registered can be co-related by checking their distances from centre of OD and centre of macula. The accurate registration of retinal images can be further used for retinal image change detection and super-resolution.

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Neural Network Solution For Service Level Agreement

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Abstract— **Service Oriented Computing is playing an important role in sharing the industry and the way business is conducted and services are delivered and managed. This paradigm is expected to have major impact on service economy; the service sector includes health services, financial services, government services, etc. This involves significant interaction between clients and service providers[1]. This paper is pointed in addressing the problem of enabling Service Level Agreement (SLA) oriented resources allocation in data centers to satisfy competing applications demand for computing services. A QoS report designed to compare performance variables to QoS parameters and indicate when a threshold has been crossed. This paper was suggested a methodology which helps in SLA evaluation and comparison. The methodology was found on the adoption of policies both for service behavior and SLA description and on the definition of a metric function for evaluation and comparison of policies. In addition, this paper contributes a new philosophy to evaluate the agreements between user and service provider by monitoring the measurable and immeasurable qualities to extract the decision by using artificial neural networks (ANN).**

Keywords— Service Oriented Architecture; Service Level Agreements; QoS; and Neural Network.

I. Introduction

Service-level agreements are, by their nature, "output" based the result of the service as received by the User is the subject of the "agreement." The (expert) service provider can demonstrate their value by organizing themselves with ingenuity, capability, and knowledge to deliver the service required, perhaps in an innovative way. Organizations can also specify the way the service is to be delivered, through a specification (a service-level specification) and using subordinate "objectives" other than those related to the level of service.

This type of agreement is known as an "input" SLA. This latter type of requirement is becoming obsolete as organizations become more demanding and shift the delivery methodology risk on to the service provider [2].

The development of SOA, organization is able to compose complex applications from distributed services supported by third party providers. Service providers and User negotiation based service level agreement (SLA) to determine different activities (security, cost, penalty,…..etc) on the achieved performance level. The service providers need to manage their resources to maximize the profits [3].

To maximize the SLA revenues in shared data environments, it can be formulated as the dual problem of minimizing the response time and maximizing throughput. That proposal considers the problem of hosting multiple web sites.

In service oriented architecture the problem is guaranteeing the "quality" of services to final users, in terms of functional and non-functional requisites like performance (measurable qualities) or security (immeasurable qualities). In general, a service provider is able to guarantee a predefined service level and a certain security level (supposing it can be measured).

II. The Evaluation methodology

Having formalized and expressed SLAs by a policy form, in this paper we need an evaluation methodology to compare them and decide to request a service from the server or changing the server to provide the request service [1].

The proposed methodology is based on a Reference Evaluation Model (REM) to evaluate and compare different security policies and behavior policies, quantifying their security level by either value 0 (represent not existing sub provision for each immeasurable provisions) or value 1 (represent existing provisions) . The model will define how to express in a rigorous way the security policy (formalization), how to evaluate a formalized policy, and what is its service level. In particular the REM is made of three different components:

A. The policy formalization

The formalization policy is a way to express all the qualities parameters for SLA in a rigorous technique to define either the qualities exist or not, or for measurable qualities with defined values.

B. The evaluation technique

We propose REM includes the definition of a technique to compare and evaluate the policies; we have called this component the REM Evaluation technique. Different evaluation techniques represent and characterize the measurable and immeasurable level associated to a policy in different ways, for example with a numerical value, a fuzzy number [4][5] or a verbal judgment representing its security level.

C. The reference levels

The last component of the REM is the set of SLAs levels that could be used as a reference scale for the numerical evaluation of SLA. When references are not available, the REM could be used for direct comparison among two or more policies.

III. SLA Structure

The service providers and the users often negotiate by the qualities to base the Service Level Agreements (SLAs) by behavior aspects based on the achieved performance levels. The service provider needs to manage its resource to maximize its profits. The optimization approaches are commonly used to provide the service load balancing and to obtain the optimal classifications for quality of service levels. By the above are also used as guidelines and for realizing high level trends. One main issue of these systems is the high variability of the workload according to values of measurable and immeasurable qualities [6].

By such model, the service can dynamically be allocated among the service providers depending on the service availability. Fig. 1 shows the architecture of SLA model implementing an autonomic infrastructure. Service providers are allocated and de-allocated on demand on servers. The server level agreement model can monitor the qualities and by predictor phase, it can allocate the server to provide the service.

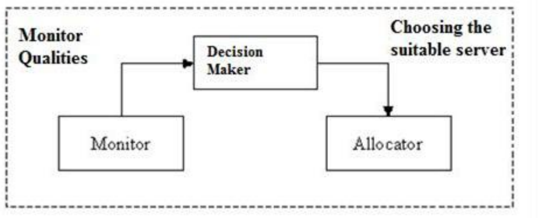


Fig. 1. SLA Architecture Of Data Center

The main components of the SLA model [7] include a monitor, a decision maker and a server allocator. The system monitors the qualities and performance matrices of each form, identifies requested classes and estimates requested service time. The decision maker can evaluate the system performance from the trace values. The allocator chooses the best system configuration [8].

IV. Service Level Agreement Categories

SLA was defined as a contract between the users and service providers, and then the contract has many rules. Their rules can be established by different ways either manually or automatically. It can be either static, which means the system will be fixed without any modifications or upgrading all the service providing or the contract rules be dynamic and changing all the time, the SLA can be classified according to the inputs values collection way and the SLA, the inputs can define as qualities can classify as below:

D. Measurable Qualities

There are many measurable qualities; it can measure for each user, the definitions of the measurable qualities are shown *below:*

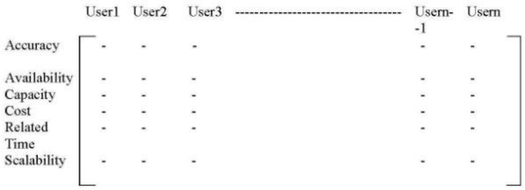
- Accuracy is concerned with the error rate of the service. It is possible to specify the average number of errors over a given time period.
- Availability is concerned with the mean time to failure for services, and the SLAs typically describe the consequences associated with these failures. Availability is typically measured by the probability that the system will be operational when needed. It is possible to specify the system’s response when a failure occurs − the time it takes to recognize a malfunction.
- Capacity is the number of concurrent requests that can be handled by the service in a given time period. It is possible to specify the maximum number of concurrent requests that can be handled by a service in a set block of time.
- Cost is concerned with the cost of each service request. It is possible to specify the cost per request the cost based on the size of the data − cost differences related to peak usage times.
- Latency is concerned with the maximum amount of time between the arrival of a request and the completion of that request.
- Provisioning-related time (e.g., the time it takes for a new client’s account to become operational).
- Reliable messaging is concerned with the guarantee of message delivery. It is possible to specify how message delivery is guaranteed (e.g., exactly once, at most once) whether the service supports delivering messages in the proper order.
- Scalability is concerned with the ability of the service to increase the number of successful operations completed over a given time period. It is possible to specify the maximum number of such operations.

E. Immeasurable Qualities

- There are three main immeasurable qualities that can be defined by main provision and sub provision for each quality, in the following we define the immeasurable qualities:
- Interoperability is concerned with the ability of a collection of communicating entities to share specific information and operate on it according to an agreed upon operational semantics. It is possible to specify the standards supported by the service and to verify them at runtime. Significant challenges still need to be overcome to achieve semantic interoperability at runtime.
- Modifiability is concerned with how often a service is likely to change. It is possible to specify how often the service’s Interface changes or Implementation changes.
- Security is concerned with the system’s ability to resist unauthorized usage, while providing legitimate users with access to the service. Security is also characterized as a system providing non-repudiation, confidentiality, integrity, assurance, and auditing. It is possible to specify the methods for
    - ➢ authenticating services or users
    - ➢ encrypting the data

F. Policy Formalization

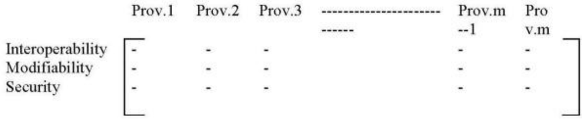
It will depend on measurable and immeasurable qualities which are mentioned is previous section. It will form two unsymmetrical matrices; first one describes the immeasurable qualities for n users, as well as the output matrix describe the decided output. The second matrix represent the measurable matrix, each row represent the provision and the state of each column represent if the sub provision exist or not, the output matrix represent the trace value of measurable matrix. Trace is the value of each matrix by maximum value of matrices.



$$\begin{array}{l|cccccc|} & \text{User1} & \text{User2} & \text{User3} & \text{--------------------------------} & \text{Usern-1} & \text{Usern} \\ \text{Accuracy} & - & - & - & & - & - \\ \text{Availability} & - & - & - & & - & - \\ \text{Capacity} & - & - & - & & - & - \\ \text{Cost} & - & - & - & & - & - \\ \text{Related} & - & - & - & & - & - \\ \text{Time} & & & & & & \\ \text{Scalability} & - & - & - & & - & - \end{array}$$

Measurable Matrix

Output user = [Trace, Request, Delay Request, Wait, Change Provider, New User]



$$\begin{array}{l|cccccc|} & \text{Prov.1} & \text{Prov.2} & \text{Prov.3} & \text{---------------------- ------} & \text{Prov.m --1} & \text{Pro v.m} \\ \text{Interoperability} & - & - & - & & - & - \\ \text{Modifiability} & - & - & - & & - & - \\ \text{Security} & - & - & - & & - & - \end{array}$$

Immeasurable Matrix

Output= [Trace, Activated output]

V. Mathematical Evaluation Technique

To adopt WS-policy framework and to express policies for security-SLA the framework is structured as a hierarchical tree to express all sub provisions. We have started the formalization by considering the set of items proposed by [9].

Given the qualities matrices for measurable matrices as shown in section III, the evaluation process takes into account just the provisions of the policy which represent the sub provisions status for immeasurable qualities and the values of measurable qualities for each user.

With the formalization, each provision is represented by a real data type; the policy space "P" is defined as the vector product of all n provisions Ki

i.e. P = K1 x K2 x…... x Kn.

The policy space "P" has been transformed into an homogeneous one, denoted "PS" thanks to a family of threshold functions (F-functions) which allow us to associate a Local Security Level (LSL for short) to each provision. "PS" is represented by a n x 4 matrix whose n rows represent the single provisions Ki and 4 is the chosen number of LSLs admissible for each provision. For example, if the LSL associated to a provision is 3, the vector corresponding to its row in the matrix is: (1, 1, 1, 0).

The distance criteria for the definition of the metric space is the Euclidean distance among matrices, defined as:

$d(A, B) = \sqrt{\sigma(A - B, A - B)}$

Where: σ (A - B, A - B) =T r ((A - B) (A - B) T)

The T r ((A - B) (A - B) T) represents the trace value to know the invariant between any base and other qualities matrix. Below we show a sample of immeasurable matrix, the main provision was defined and sub-provisions were represented by existing status:

Provision Name	1	1	0	1
Digital Certificate Management	0	1	0	1
Policy applicability	-	-	-	-
Time between certificate request and issuance	-	-	-	-
Notification of certificate issuance and revocation	-	-	-	-
Local Registration Authorities (LRAs)	-	-	-	-
Repositories	-	-	-	-

SLA-P, SLA-X, and SLA-Y are supposed as different immeasurable matrices with the same provisions and different values of sub-provisions. SLA-X and SLA-Y; are supposed globally stronger than SLA-P since they have a lot of sub-provisions for each provision. Each policy in the example has just 10 provisions; this is just a simplification which does not affect the validity of the method.

$$\mathrm{SLAP} = \begin{pmatrix} 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{pmatrix}$$

$$\mathrm{SLAX} = \begin{pmatrix} 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 0 \\ 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{pmatrix} \mathrm{SLAY} = \begin{pmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 \\ 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 \end{pmatrix}$$

Example 1: SLA-X is a policy that appears stronger than SLA-P, just looking at the levels of the single provisions; we first calculate the trace:

Tr((SLAX-SLAP)(SLAX-SLAP)T) = 6

Where: $d(X, P) = \sqrt{\sigma(X - P, X - P)}$ d(X, P) is the distance among matrices

Where: σ (X - P, X - P) =T r ((X - P) (X - P) T)

The distance between SLA-X and SLA-P is: d-2.45.That mirrors the fact that SLA-X is just a little stronger than SLA-P.

Example 2: SLA-Y is a policy that appears stronger than SLA-X and much stronger than policy SLA-P, while SLA-P is the same as that of the example 1; the trace is:

Tr((Y-P)(Y-P)T) = 19

The distance between SLA-Y and SLA-P is: d-4.36 .This result mirrors the evident difference between the two cases. These examples show how it is very simple to evaluate the distance between policies, once they have been represented as a matrix. The distance will be adopted to define the metric function.

VI. Proposed ANNSLA Model

In this section we will propose an artificial service level agreement model to be the base for qualities testing and comparing. The main idea of this model is to be able to decide if the services can supply by service provider or not depending on the value of the activated outputs. Because of this model was proposed depending on artificial neural network then the ANN needs to train by input and output data sets to be able to extract the outputs for other input data sets. Fig. 2 shows the general concepts of Neural Network Service Level Agreement in SOA.

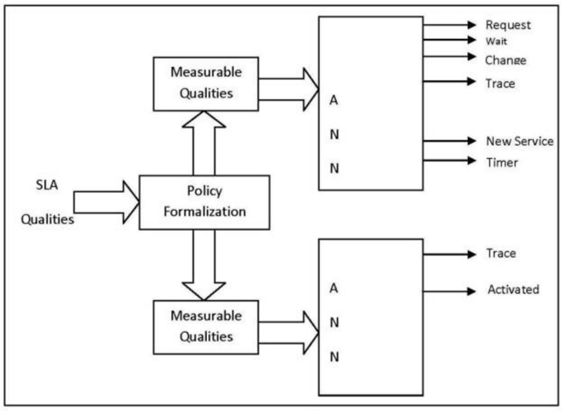


Fig. 2. ANN Service Level Agreement

The training input and output data sets will be represented according to the mathematical models. The input sets of ANN represent the measurable and immeasurable matrices which are used in mathematical model while the output sets represents the extracted outputs for the traces and the activated outputs from the mathematical calculations model. To build the artificial service level agreement model, there are two phases should execute to extract the correct decision. In the following we will discuss the phases of ANNSLA model:

- ANN Training phase: in this phase, the extracted data sets (formalized inputs and calculated outputs) from the SLA mathematical model will apply to ANN to train it. Section V.B will explain the simulation method of training phase for ANN. The training phase should apply for both part of ANNSLA model, measurable and immeasurable qualities and trained according for input/output matrices. It's very important to notice when any changing happen for the contact between the user and the service provider (i.e. the contract rules) will lead to change the SLA measurable and immeasurable qualities, the trace value will change directly as well as the outputs matrix may change. All those lead to reconfigure the ANN architecture and retrain it according to the new values of inputs/ outputs matrix values. From all the above we can consider the ANNSLA model is dynamic not static model and can be suitable for future extending, there are no limitations of users number or qualities number. The accuracy of output values ANNSLA depending on data sets and the training procedures. Fig. 3 shows the general ANNSLA model in the training phase. The ANN will train in 1st set of qualities and outputs. There are two training model one of them for measurable qualities ANN model and second one for immeasurable qualities ANN model, it can train separately because of the first one represent a logical model and the second one represent the behavior model between the user and service provider. The architecture of the ANN is very easy to build, for this reason we propose only one activated output for immeasurable formalization while there are more than one output for measurable formalization to mention that the ANN architecture may not be fixed and modifiable depending on the requirements and the rules in the contract between the user and the service providers [10].
- Operation Phase: when the ANN trained correctly according to inputs/outputs data sets, it will be ready to use it as decision maker for different input sets to extract the trace value and activated output or outputs for either immeasurable qualities or measurable qualities. To evaluate the output values, it can compare the extracted outputs with calculated outputs from mathematical model, the evaluation will explain in details in 8. Fig. 4 shows the general trained ANNSLA model. By this model can extract the outputs for different inputs by applying it to trained ANN. As we mentioned in the training phase, the trained ANN be as a decision maker to extract the outputs. When applying the immeasurable or measurable matrices to trained ANN it can extract the trace and activated output or outputs. The operation phase can be fixed for long period except if there is any rules in the SLA contact will be changed, it will lead to go again to training phase to modify the ANN architecture according to new measurable and immeasurable qualities.

From the entire above if there is any modifications in input qualities or/and the active outputs will lead to reconfigure the ANN model and retrain it according to new values of the input qualities and outputs. The evaluation method will not change when the architecture of the ANN model changed because all the time we will calculate the difference between the calculated values and extracted outputs.

The process of ANNSLA will show in 6.1.The validation of the activated outputs and the reasons of defining activated outputs for both formalizations (measurable and immeasurable) will discuss in section VI. There are many limitations in ANNSLA operation phase, one of important operation phase limitation that can't test this model online because of the servers' operation restrictions and no experiments lab to evaluate this model practically.

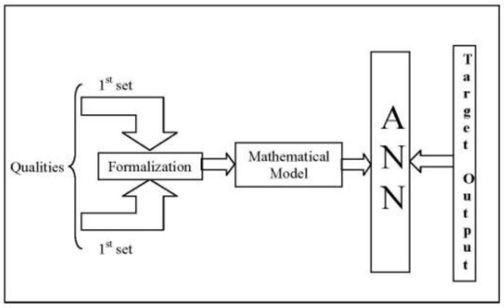


Fig. 3. ANNSLA training phase

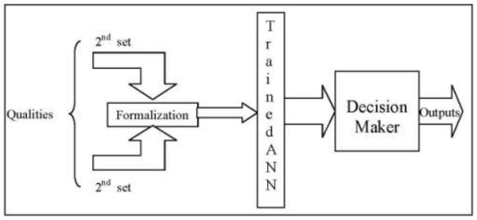


Fig. 4. ANNSLA operating phase

G. ANNSLA Process

- The ANNSLA process for two parts of the model, the first part represents measurable part with their extracted and target outputs and the second part represents immeasurable part with their extracted and target outputs, each phase has many steps will discuss in the following:
- The training phase process consist the following steps:
- Define the ANN architecture, number of hidden layers, number of input nodes in input layer, and number of output nodes in output layer. The process initiated sets of measurable and immeasurable qualities as inputs for ANNSLA model. Formalize the inputs into measurable and immeasurable input matrices to apply it to ANN. The target outputs will define for the both measurable and immeasurable ANN. The training process will initiate to train the ANNs. The training process will continue till the extracted outputs reached to target outputs. When the error percent reached to acceptable value, the training process will stop and the ANN will consider trained.
- The operation phase process consist the following steps:
- The process initiated a set of measurable and immeasurable qualities as input for trained ANNSLA model. Formalize the input into measurable and immeasurable input matrices to apply it to ANN
- Apply formalize measurable and immeasurable matrices to trained ANN. The trained ANN will run and stop when the ANN produces the outputs. The extracted outputs represent the outputs for both measurable and immeasurable parts.

From all the above, it consider that the ANNSLA model can modify the ANN architecture by changing the number of inputs and/or the number of outputs, this will lead to repeat the ANNSLA process in both training and operation phases.

H. ANNSLA Simulation

The ANNSLA will build using ANN architecture, it's very important to select the architecture by defining the number of layers (hidden layers), the number of input nodes in input layer, the output nodes in output layer, the values of inputs, the values of target outputs, and the error value. These architectures can be done by using MATHLAB package version 7.7.0. The simulation procedure will introduce the ANN architecture, the experimental data sets, training process and the running process of ANNSLA by MATHLAB model in next sections.

I. ANNSLA MATLAB Architecture

As we mentioned in the above sections the ANNSLA model architecture has two part one for measurable qualities and the second one for immeasurable qualities, this means there are two ANN.

The measurable ANN part consists the following: Input layer with consist 6 input neurons for each user. The inputs represent the measurable qualities which are the accuracy, availability, capacity, cost, related time, and scalability. The values of these inputs represent numeric value all the time ≤ 1 [11].One or two hidden layers to test the effect of increasing the hidden layers upon the performance of the architecture. The output layer consists either one neuron if we want to calculate trace of measurable matrix or five neurons represent the outputs (Request, Wait, Change, New Service, and Timer) for measurable part in ANNSLA model.

The immeasurable ANN part consists the following: Input layer with consist 40 input neurons for each user. The inputs represent the immeasurable qualities represent interoperability, modifiability, and security. All the values of these inputs will be represented either 1 (exist) or 0 (not exist).One or two hidden layers to test the effect of increasing the hidden layers upon the performance of the architecture. The output layer consist either one neuron if we want to calculate trace of immeasurable matrix or one neuron represents the activated output for immeasurable part in ANNSLA model[12].

The above ANN architecture can modify according to the measurable and immeasurable requirements in ANNSLA model.

VII. Data Collection and Experimental Results

In our test scenario, we used a sample of different matrices for measurable and immeasurable qualities; there are two experimental results as following: The trace and the distance for each matrix will calculate by mathematical model. The values of the mathematical traces will apply to train the ANNSLA. The ANN will train for input matrices and for target outputs. The trained ANN can run to extract the outputs when applying any new immeasurable or measurable matrices. Below we will mention the training input data sets and the target output which represent the trace vales and the activated output/outputs by applying it to trained ANN for both measurable and immeasurable parts for ANNSLA model. In next section, we will run the trained measurable and immeasurable ANN to extract the actual outputs for any data sets.

J. Immeasurable Experimental Results:

To train the immeasurable ANN to extract the trace value and activated output for each immeasurable matrix, the training data sets with target outputs (trace and activated output) will apply and train ANN by MATHLAB. TABLE I mentions the data sets of the immeasurable matrices with calculated trace (by mathematical SLA model which is mentioned in section IV) and the activated output (proposed simulation values).

These matrices are used to train the immeasurable ANN, it used as inputs while the calculated traces and the activated outputs are used as target outputs of immeasurable ANN. The trace ANN is used to extract the trace value for any measurable or immeasurable matrices. The trace value represents the invariant with respect to a change of basis. It means choosing a base matrix then by calculating distance between the choosing one with any other selected matrix. It easy to calculate the trace mathematically, and by applying the qualities to trained trace ANN (shows in Fig. 5) can extract the trace value, in the next section will show the comparison between the two values.

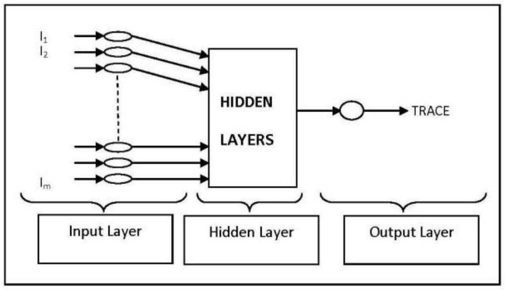


Fig. 5. Trace ANN Architecture

The trace value will extract by individual ANN represented in Fig. 5, the trace ANN should train by applying the immeasurable matrices as inputs and the target output is represented by calculated trace values. To train the ANN immeasurable ANN, the immeasurable qualities will apply with their target activated output; the number of training matrices is about 17. TABLE I shows the training set for immeasurable ANN. Fig. 6 shows the general ANN architecture for immeasurable ANN part, the number of input neurons is 40 neurons for each immeasurable matrix in input layer, and only one neuron in output layer represents the target output.

The values of the target output are representing the activated output values. To train the immeasurable ANN, we will apply 17 immeasurable matrices (M1, M2,……….Mn) with their proposed activated outputs. It represents 10 provisions with 4 sub-provisions for each provision; the provision represents some of security level tree structure, Interoperability, and Modifiability with their sub-provision. After training the immeasurable ANN, it will be ready to run and extract the activated output for any immeasurable matrix. Feed forward network architecture with back propagation momentum training algorithm was used. The back propagation algorithm was considered since it is the most successful algorithm for the design of multilayer feed forward networks

TABLE I. TRAINED IMMEASURABLE DATA SETS FOR THE TARGET TRACE VALUE

Matrix No.	Calculated Trace	Proposed Activated Output
M1	3.581	0.5
M2	3.771	0.7
M3	4.123	0.6
M4	3.5541	0.9
M5	4.321	0.6
M6	3.5487	0.8
M7	4.242	0.65
M8	5.1832	0.75
M9	3.6111	0.8
M10	4.0231	0.5
M11	4.1101	0.7
M12	4.3465	0.85
M13	4.5732	0.7
M14	4.1021	0.55
M15	4.0231	0.65
M16	3.945	0.7
M17	4.1001	0.5

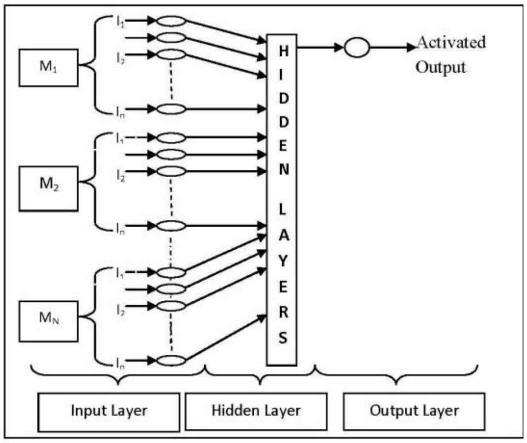


Fig. 6. Immeasurable ANN Architecture

K. Measurable Experimental Results:

The measurable qualities can be represented by the measurable matrices as input and the target outputs (representing the values Accuracy, Availability, Capacity, Cost, Related Time, and Scalability) for each user, it already defined previously.

To train the measurable ANN part in ANNSLA, we will apply the measurable matrices as input data sets for the ANN and the activated outputs (Request, Delay Request, Wait, Change Provider, and New Customer) and trace as a target outputs for ANN. The values of simulation inputs are represented analogy; it's all the time ≤1. The activated outputs are represented logically either 0 or 1. TABLE II shows the proposed activated outputs for each measurable matrix with calculated trace by mathematical model. These input data sets with proposed activated outputs and calculated trace will apply to train the measurable ANN part in ANNSLA.

TABLE II. TRAINED MEASURABLE DATA SETS FOR PROPOSED ACTIVATED OUTPUTS AND TARGET TRACE VALUE

Matrix No.	Activated Output	Calculated Trace
MM1	1,1,0,1,0	0
MM2	1,1,0,0,0	7.2621
MM3	1,0,1,1,0	8.3946
MM4	1,1,0,1,0	7.4403
MM5	1,1,0,1,0	6.6554
MM6	1,1,1,1,0	6.8806
MM7	1,0,1,1,0	6.5035
MM8	1,1,0,1,1	5.6391
MM9	1,1,1,1,0	7.1493
MM10	1,0,1,1,0	9.0777
MM11	1,1,0,1,1	5.6391
TMM1	1,0,1,1,0	6.5035
TMM2	1,1,0,1,1	5.6391
TMM3	1,1,1,1,0	7.1493

Fig 7. shows the general measurable ANN part for ANNSLA model, it represents the input, hidden, and output layers. To train the measurable ANN can be done by applying 12 inputs/outputs measurable qualities/ target outputs.

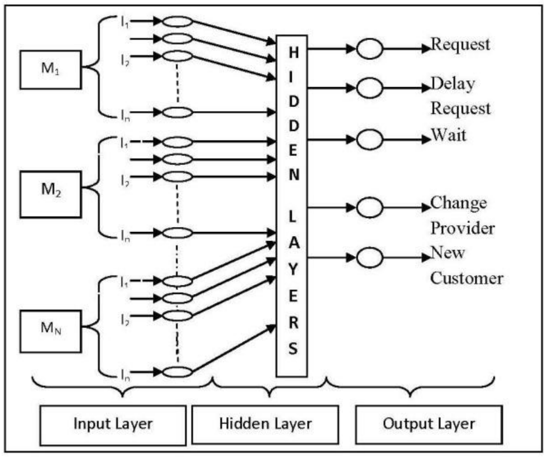


Fig. 7. Measurable ANN Architecture

VIII. SIMULATION RESULT DISCUSSION

After the trace, measurable and immeasurable ANNs in ANNSLA are trained, and then it can be operated as a decision maker. The scenario to run the trace and the immeasurable ANN, we apply 20 immeasurable matrices with by trace ANN, it can extract the trace value for each measurable matrix by ANN is shown in Fig. 5. The immeasurable ANN extracts the activated output for each matrix (ANN is shown in Fig. 6). In TABLE III the set of immeasurable tested matrices are shown, it shows the calculated trace and proposed activated output for each tested immeasurable matrices to compare the calculated trace with extracted output from trace ANN and the proposed activated output with extracted activated output from immeasurable ANN.

The scenario to run the trace and the measurable ANN, we apply 3 measurable matrices with its activated outputs. By trace ANN and measurable ANN can extract the trace and the activated outputs for each matrix. TABLE IV shows the set of measurable tested matrices, the calculated trace, proposed activated output for each tested measurable matrices, and extracted activated outputs.

IX. RESULTS EVALUATION

From TABLEs III and IV, we can conclude that the error value between the calculated activated output and ANN activated output is about +/- 0.04 and the error between the calculated trace and extracted ANN trace is between 0.1141 and -0.0088 for both measurable and immeasurable ANN running, this means that ANNSLA can specify the SLA requirements specially the value of trace for measurable and immeasurable matrices. From the extracted trace value, by ANNSLA can decide the suitable SLA between the user and service providers. The activated outputs/output for measurable/immeasurable ANN can justify the SLA work flow.

From all the above, it can consider the ANN SLA can work properly as policy selector and as a decision maker between users and service providers. The figures below mention charts represent different comparison between the values which are extracted from ANNSLA and other calculated or supposed values. Fig. 8 shows the chart for calculated and ANN trace for different immeasurable qualities matrices, it shows the extracted values are very close to calculated values, the error as mentioned in above not more +/- 0.12. Fig. 9 shows the chart for activated and ANN output for immeasurable ANN part, the error between two values is between +/-0.04.

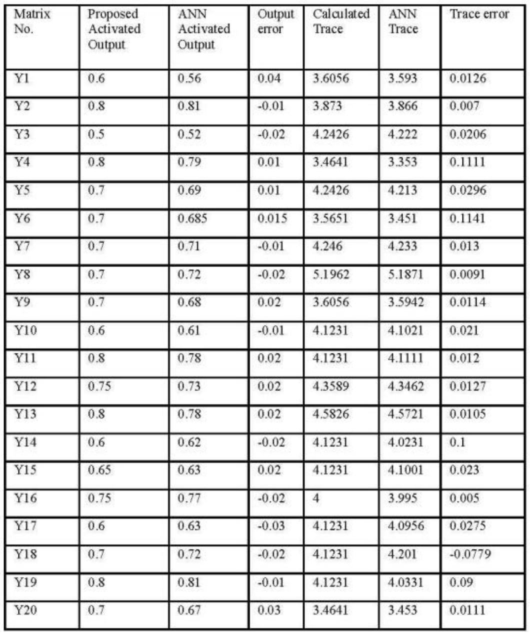
For measurable ANN part in ANNSLA model, Fig. 10 shows the chart for calculated trace and ANN trace for different measurable qualities matrices set.

From above, the ANNSLA model can use as a decision maker to extract the best policy and the suitable activated output/outputs value; it means, the ANNSLA can define the roles of the contract between the users and service providers.

The model can modify easily by reconstruct the ANN architecture to be suitable for the approximate number of the users and providers. It can very secure if each user has his key to be part of the immeasurable input qualities then the model can train to accept or refuse the user in other hand the model can accept or refuse the key for the provider.

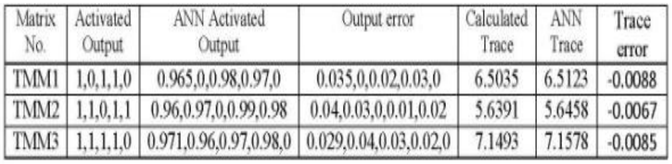
The error value of the extracted outputs of the model was very small according to the testing sets; it's very simple to modify the model. The ANN can be extended simply and the training rules are very efficient and know for different users.

TABLE III. TESTING IMMEASURABLE MATRICES SETS



Matrix No.	Proposed Activated Output	ANN Activated Output	Output error	Calculated Trace	ANN Trace	Trace error
Y1	0.6	0.56	0.04	3.6056	3.593	0.0126
Y2	0.8	0.81	-0.01	3.873	3.866	0.007
Y3	0.5	0.52	-0.02	4.2426	4.222	0.0206
Y4	0.8	0.79	0.01	3.4641	3.353	0.1111
Y5	0.7	0.69	0.01	4.2426	4.213	0.0296
Y6	0.7	0.685	0.015	3.5651	3.451	0.1141
Y7	0.7	0.71	-0.01	4.246	4.233	0.013
Y8	0.7	0.72	-0.02	5.1962	5.1871	0.0091
Y9	0.7	0.68	0.02	3.6056	3.5942	0.0114
Y10	0.6	0.61	-0.01	4.1231	4.1021	0.021
Y11	0.8	0.78	0.02	4.1231	4.1111	0.012
Y12	0.75	0.73	0.02	4.3589	4.3462	0.0127
Y13	0.8	0.78	0.02	4.5826	4.5721	0.0105
Y14	0.6	0.62	-0.02	4.1231	4.0231	0.1
Y15	0.65	0.63	0.02	4.1231	4.1001	0.023
Y16	0.75	0.77	-0.02	4	3.995	0.005
Y17	0.6	0.63	-0.03	4.1231	4.0956	0.0275
Y18	0.7	0.72	-0.02	4.1231	4.201	-0.0779
Y19	0.8	0.81	-0.01	4.1231	4.0331	0.09
Y20	0.7	0.67	0.03	3.4641	3.453	0.0111

TABLE IV. TESTING MEASURABLE MATRICES SETS



Matrix No.	Activated Output	ANN Activated Output	Output error	Calculated Trace	ANN Trace	Trace error
TMM1	1,0,1,1,0	0.965,0,0.98,0.97,0	0.035,0,0.02,0.03,0	6.5035	6.5123	-0.0088
TMM2	1,1,0,1,1	0.96,0.97,0,0.99,0.98	0.04,0.03,0,0.01,0.02	5.6391	5.6458	-0.0067
TMM3	1,1,1,1,0	0.971,0.96,0.97,0.98,0	0.029,0.04,0.03,0.02,0	7.1493	7.1578	-0.0085

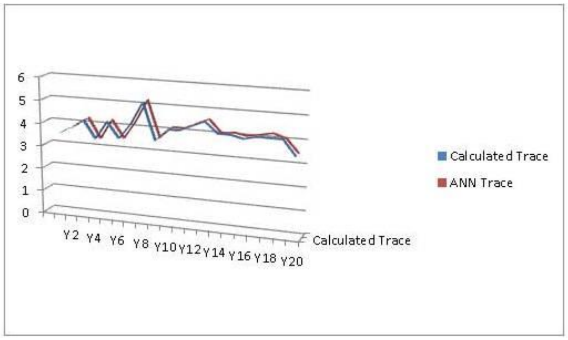


Fig. 8. Calculated and ANN Trace Chart for immeasurable matrices

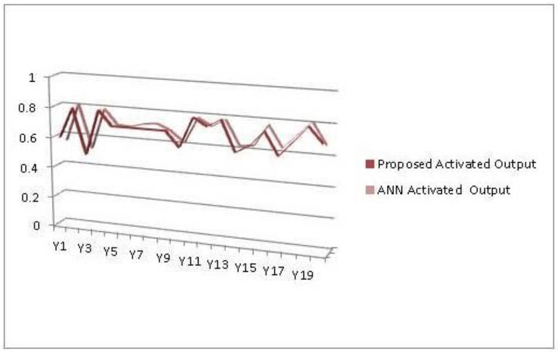


Fig. 9. Activated and ANN Output Chart for immeasurable matrices

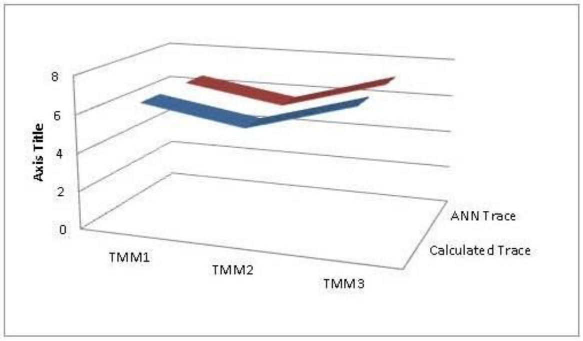


Fig. 10. Calculated and Trace Chart for measurable matrices

The ANN takes the decision according to how the user train it and what the data types give to it, then the main important should manage carefully from the beginning before constructing the model is as the following:

- Number of users.
- Number of providers.
- Define certain policy formalization for the qualities.

The main immeasurable and immeasurable qualities (it's very important to define the security level for each user and providers).The architecture of trace, measurable, and immeasurable ANN. The presented approach aims to use the neural network as the intelligent part of service level agreement model. The global architecture will permit the provider to provide a new type methodology of providing a service by checking the system completely with all other users and service providers. This will help to reduce the cost while preserving the required QoS. The ANNSLA can provide monitoring of traffic for service request by service waiting or service reallocation to other service provider. Then the deployed architecture will be evaluated with respect to the mathematical model

X. CONCLUSION

In this research we have introduced a theoretical methodology to evaluate Service Level Agreement in SOA. The methodology is based on two fundamental features; the first one is the SLA formalization through the use of standard policy while the second one is the formalization of "qualifiable service levels" against which we could measure the SLA.

In particular, we have adopted a Reference Evaluation Model, developed for different methodology, to evaluate and compare different policies and quantifying their levels. The application of the methodology in different samples of measurable and immeasurable qualities and we adopted it in the integration of mathematical model and artificial model to guarantee the same perceived service level to the end-user. SLAs have been applied in service organizations in general, including IT organizations, to formalize the level of service between a service provider and service user. While SLAs are well understood in these domains, they are less understood for services in the SOA context.

SOA enables the integration of automated services from multiple organizations. External providers may offer services that were not initially implemented to meet the quality attribute requirements of the service consumer organization. Defining an SLA and establishing SLA management mechanisms are important factors when clarifying the quality requirements for achieving the business and mission goals of SOA systems.

Standardized SLAs are going to be an important element for organizations moving to automation, SLA systems characterized by the dynamic discovery, composition, and invocation of services based on QoS and other contextual information.

There are efforts to standardize the SLAs for web services; it’s an effort to make SLAs machine adaptable. However, there is no established standard for SLA specification

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IRS for Computer Character Sequences Filtration: a new software tool and algorithm to support the IRS at tokenization process

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***Abstract*—Tokenization is the task of chopping it up into pieces, called tokens, perhaps at the same time throwing away certain characters, such as punctuation. A token is an instance of token a sequence of characters in some particular document that are grouped together as a useful semantic unit for processing. New software tool and algorithm to support the IRS at tokenization process are presented. Our proposed tool will filter out the three computer character Sequences: IP-Addresses, Web URLs, Date, and Email Addresses. Our tool will use the pattern matching algorithms and filtration methods. After this process, the IRS can start a new tokenization process on the new retrieved text which will be free of these sequences.**

Keywords—Information Retrieval; Tokenization; pattern matching; and Sequences Filtration.

I. Introduction

People use search engines for instance to locate and buy goods, to choose a vacation destination, to select a medical treatment or to find background information on candidates of an election. It's necessary to build a searching system being able to support users expressing their searching by natural language queries is very important and opens the researching direction with many potential [7].

As a human nature, people prefer to search for their information using their natural language especially with the existence of huge amount of information these days. Thus, a good Information Retrieval System is on demand.

Information retrieval (IR) [1, 2] is finding material (usually documents) of an unstructured nature (usually text) that satisfies an information need from within large collections (usually stored on computers). An information retrieval system (IRS) [2] is a software program that stores and manages information on documents. This system assists users in finding the information they need. Designing an efficient IRS which tries to touch the optimal results in retrieving the relevant documents of information, that design will face a lot of parameters which are to be taken into account such as precision and recall [1]. There is always a trade of between precision and recall.

At the core of IRS immerges the tokenization process which is considered a primary part in IRSs. Tokenization [1] is the task of chopping character sequence up into pieces, called tokens. Sounds good; but it's not as simple as its definition, many times the tokenizer should not split on some locations of the document.

Computer technology [1] has introduced new types of character sequences that a tokenizer should probably tokenize as a single token, including email addresses (qalhaija@kfu.edu.sa), web URLs (http://www.kfu.edu.sa), numeric IP addresses (192.168.0.1), and Date (16/07/1982).

Several methods and approaches where proposed to provide these services, but researches showed that many measures should be addressed to ensure complete the retrieving process.

The problem addressed in this proposal will focus on designing an IRS for Computer Character Sequences Filtration. Computer technology has introduced new types of character sequences that a tokenizer should probably tokenize as a single token. As we see from figure 1, our proposed work will focus on filtering email addresses, web URLs, date, and numeric IP addresses.

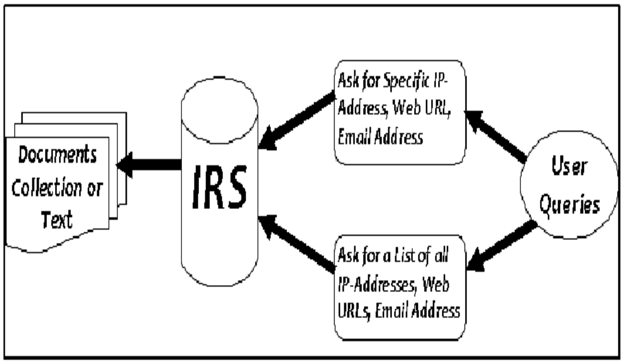

Documents Collection or Text
IRS
Ask for Specific IP-Address, Web URL, Email Address
Ask for a List of all IP-Addresses, Web URLs, Email Address
User Queries

Fig. 1. Problem Statement Figure.

In this paper, we propose a new software tool and algorithm to support the IRS at tokenization process. Our proposed tool will filter out the three computer character Sequences: IP-Addresses, web URLs, and email addresses. Our tool uses the pattern matching algorithms [4, 5] and filtration methods [2, 3].

After this process, the IRS can start a new tokenization process on the new retrieved text which will be free of these sequences.

II. RELATED WORKS

In the last years many classical solutions tried to address the tokenization process issues such as Computer Character Sequences Filtration. The most commonly used solution is the filtering and matching schemes [1].

Christopher D. Manning, Prabhakar Raghavan, Hinrich Schutze in [1] established the infrastructure for how to build IRSs by explaining all concepts and objects for several IRSs. They explained in details the tokenization process which sets at the core of the IR-Systems. They also discussed many of the challenges in the tokenization process such as the Computer Character Sequences (IP-Addresses, email addresses, date and web URLs), the use of the apostrophe for possession and contractions, hyphenation, foreign phrases, compound nouns and others.

Christos Faloutsos, Douglas Oard in [2] surveyed the major techniques for IRS. They provided an overview of some traditional IRSs (full text scanning, inversion, signature files and clustering) and discussed attempts to include semantic information (natural language processing, latent semantic indexing and neural networks.

Nicholas J. Belkin and W. Bruce Croft in [3] designed information filtering systems for unstructured or semi structured data, as opposed to database applications, which use very structured data. These systems also dealt primarily with textual information, but they may also entail images, voice, video or other data types that are parts of multimedia information systems.

Information filtering systems also involve a large amount of data and streams of incoming data, whether broadcast from a remote source or sent directly by other sources. Filtering is based on descriptions of individual or group information preferences, or profiles that typically represent long-term interests. Filtering also implies removal of data from an incoming stream rather than finding data in the stream; users see only the data that is extracted [1, 3].

Mary Elaine Califf, Raymond J. Mooney, in [4] presented an algorithm RAPIER, which uses pairs of sample documents and filled templates to induce pattern-match rules that directly extract fillers for the slots in the template. RAPIER is a bottom-up learning algorithm that incorporates techniques from several inductive logic programming systems. They have implemented the algorithm in a system that allows patterns to have constraints on the words, part-of-speech tags, and semantic classes present in the filler and the surrounding text. They presented encouraging experimental results on two domains.

Richard M. Karp, Michael O. Rabin, in [5] proposed randomized algorithms to solve the following string-matching problem and some of its generalizations. Given a string X of length n (the pattern) and a string Y (the text), find the first occurrence of X as a consecutive block within Y. The algorithms represent strings of length n by much shorter strings called fingerprints, and achieve their efficiency by manipulating fingerprints instead of longer strings. The algorithms require a constant number of storage locations, and essentially run in real time. They are conceptually simple and easy to implement. The method readily generalizes to higher-dimensional pattern-matching problems.

Sumalatha Ramachandran Sujaya Paulraj Sharon Joseph Vetriselvi and Ramaraj in [8] showed that there is no guarantee for information correctness and lots of conflicting information is retrieved by the search engines and the quality of provided information also varies from low quality to high quality. The filtering of trustworthiness is based on 5 factors - Provenance, Authority, Age, Popularity, and Related Links.

All the previous methods have strong filtration pattern-matching for the IR-Systems. Our proposed work is to design a new software tool and algorithm to support the IRS at tokenization process for computer character sequences filtration.

III. MOTIVATIONS AND METHODOLOGY

The proposed research is motivated by many factors. First of all, the information retrieval which is a very important issue in real life applications as in banks, companies, hospitals, and at the personal level too. Second, previous studies showed that the tokenization process of IRS must leave some of the computer character sequences such as IP-Addresses, emails, web URLs, and date without any splitting operation; it should be treated as a single token. Our research will focus on the design and implementation of new software tool and algorithm to support the IRS at tokenization process. Another main reason to conduct this research is that IRSs are deemed world-wide hot research topic especially after the increasing demand on information and its applications.

The proposed methodology throughout this research consists of the following steps:

1) *The approach for proceeding in the proposed solution started by studying several Information Retrieval System (IRSs) [1, 2] concepts.*

2) *Understanding the important parameters in each IRS that can be helpful for solving the proposed problem.*

3) *Studying several information filtering systems [2, 3] which are designed for unstructured data.*

4) *Studying the matching algorithms [4, 5] trying to make some contribution to such algorithm. This will support the IR systems and will be helpful in solving our proposed problem.*

The proposed solutions were implemented and verified using Java programming language.

IV. SIMULATION ENVIRONMENT

Our proposed work is to design a new software tool to support IRSs at the tokenization process to filter out some computer character sequences. Our proposed solution is programmed and implemented in Java programming language.

Java [6]; A simple, object-oriented, network-savvy, interpreted, robust, secure, architecture neutral, portable, high-performance, multithreaded, dynamic programming language. The Java programming language and environment is designed to solve a number of problems in modern programming practice. Java started as a part of a larger project to develop advanced software for consumer electronics. These devices are small, reliable, portable, distributed, and real-time embedded systems. When we started the project we intended to use C++, but encountered a number of problems. Initially they were just compiler technology problems, but as time passed more problems emerged that were best avoided by changing the language.

V. TESTS AND RESULTS

The proposed work has shown marvelous results in terms of performance and low text processing using many advanced and intelligent techniques. Some of these techniques are regular expressions which is an advanced efficient technique for pattern matching. Regular expressions have been used to detect the special character sequences. What makes this work unique is the ability to extend and modify the application so that it can detect more character sequence patterns.

Another technique is the use of XML hierarchal structure in the configuration of the application. This has shown great results in terms of performance and use. The application can be extended to handle more and more special character sequences and can be integrated with many IRSs to boost their operations.

As mentioned previously, our principle is simulated in Java programming language. We have adopted two interfacing techniques to satisfy deferent requirements. The first is Command Line Interface (CLI) which is harder to use and interact but better in terms of performance. The other is the Graphical User Interface (GUI), the easier to use while worse when the performance has utmost priority. Anyway, we focus here on the GUI to show our work and results simply and clearly. Figure 2 shows the basic interface which will be the user's guide through the tokenization process.

Here is a brief description about each component, augmented with snapshots to make everything concrete:

- The "open" - shown in figure 3- button is used to load the ".txt" document that is intended to be tokenized. Upon clicking this button, open file dialog is popped up to the user to choose the desired document.

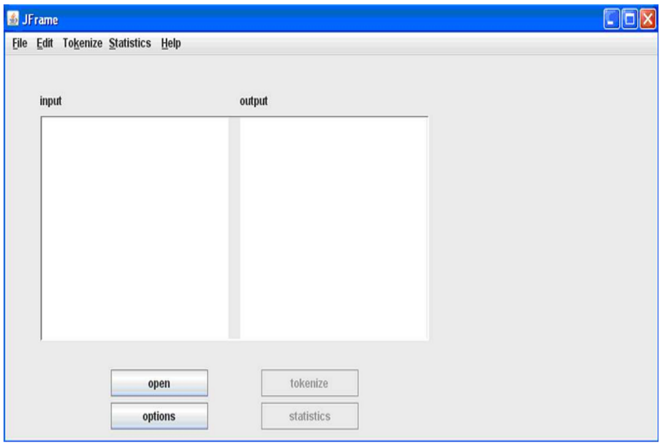


Fig. 2. The basic interface.

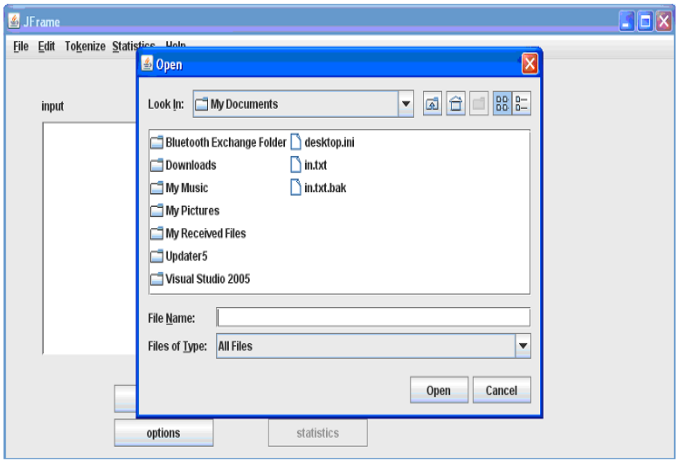
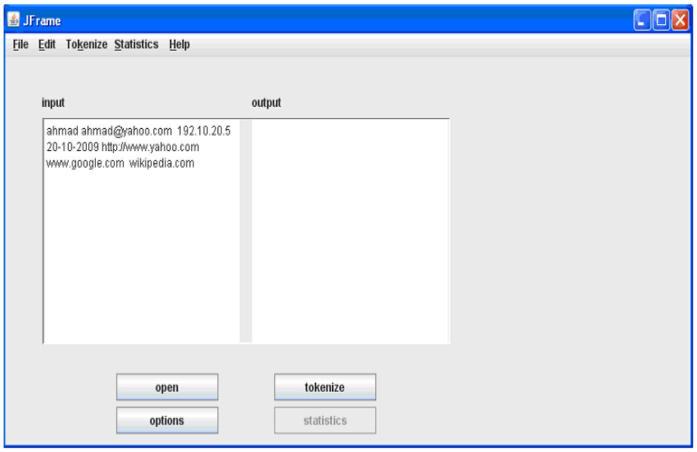


Fig. 3. The "open" button.

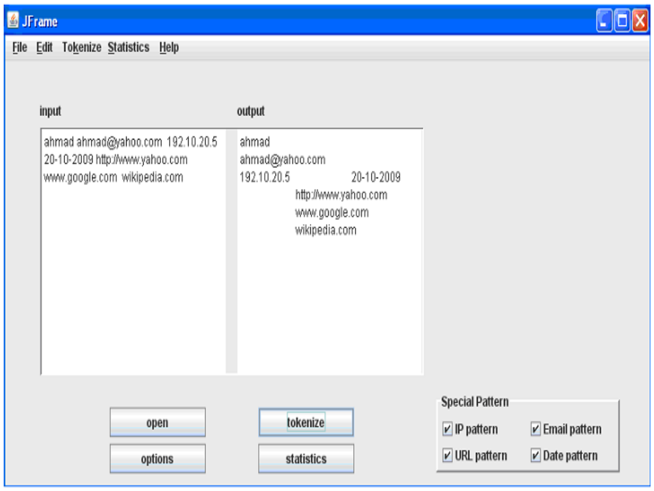
- Once the desired document is opened, see figure 4, the user is supposed now to choose the desired special character sequences to be recognized as one token. This can be accomplished by clicking the "options" button, or go to menu -> Tokenize -> options. As seen in figure 5 below, four checkboxes appears so that the user can choose the desired options.



ahmad ahmad@yahoo.com 192.10.20.5
20-10-2009 http://www.yahoo.com
www.google.com wikipedia.com

Fig. 4. Opened Document in the input pane.

- As we can see, there are four special character sequences: IP address, Email address, URL address, and Date. These special character sequences can be treated as one token, which could be removed (i.e. reduce the size of the index) or indexed as semantic unified terms which in turn increases the precession and the versatility of the IRS.
- Now, the user can initiate the tokenization process by clicking the tokenize button. The result of the tokenization will be saved in an output file (its path is configured) and will be shown to the user on the output text pane. Figure 5 below depicts this.



```
ahmad ahmad@yahoo.com 192.10.20.5
20-10-2009 http://www.yahoo.com
www.google.com wikipedia.com
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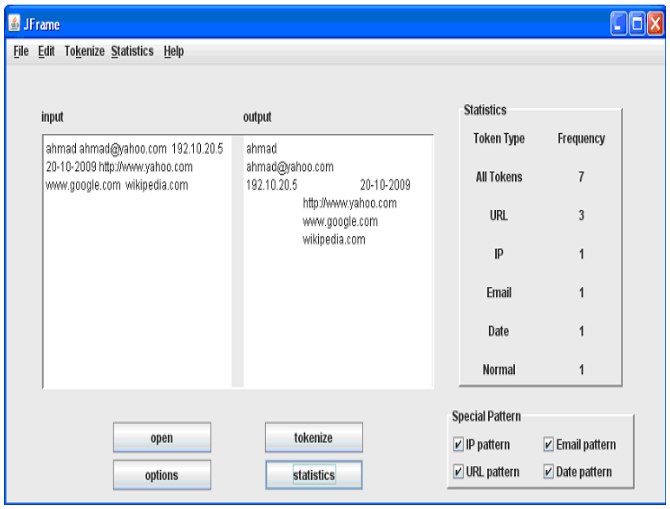
```
ahmad
ahmad@yahoo.com
192.10.20.5                20-10-2009
               http://www.yahoo.com
               www.google.com
               wikipedia.com
```

☑ IP pattern ☑ Email pattern ☑ URL pattern ☑ Date pattern

Fig. 5. Clicking the tokenize button

- Finally, the application provides one more feature that can be used in weight and score based IRSs. Upon clicking the statistics button, a piece of useful statistical results appears at the extreme right corner of the frame as shown below in figure 6.



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ahmad ahmad@yahoo.com 192.10.20.5
20-10-2009 http://www.yahoo.com
www.google.com wikipedia.com
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```
ahmad
ahmad@yahoo.com
192.10.20.5                20-10-2009
               http://www.yahoo.com
               www.google.com
               wikipedia.com
```

Statistics

Token Type	Frequency
All Tokens	7
URL	3
IP	1
Email	1
Date	1
Normal	1

☑ IP pattern ☑ Email pattern ☑ URL pattern ☑ Date pattern

Fig. 6. Clicking on the statistics button.

VI. Conclusions and Remarks

A new software tool and algorithm to support the IRS at tokenization process is implemented and proposed in this paper. Information retrieval Systems (IRS) which is meant of searching for information within documents and for metadata about documents. There are many applications of IR in the real life, for example Search engines like Google which sits at the throne of IRSs. At the heart of the IRS; is the tokenization process in which the text in the documents is split into small pieces called tokens. Sometimes there are some character sequences that must be taken as a single token without any splitting process, such as IP-Addresses, Email Address, date, and Web URLs.

This work can be extended by including other tokenization issues such as the use of the apostrophe for possession and contractions, hyphenation, foreign phrases, compound nouns and others. It can also be enhanced by implying some other issues such as stop words, normalization, stemming and lemmatization in information retrieval that can work in one coherent IR system.

Moreover, the ability to use heuristic algorithms such as Genetic algorithms that can make the IRS more efficient and can improve the system precision and recall. Finally, to involve retrieval tools that can be useful for bio-metrics and medical applications such as content-based image analysis [9].

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A Simple Exercise-to-Play Proposal that would Reduce Games Addiction and Keep Players Healthy

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***Abstract*—Games players usually get addicted to video games in general and more specifically to those that are usually played over the internet. These players prefer to stay at home and play games rather than playing sports or outdoor games. This paper presents a proposal that aims to implement a simple way to let video games players exercise in order to play. The proposal targets games where players virtually live inside a certain area such as a forest, city or a war zone. Their aim is to explore the area, capture, kill and avoid being killed by something or someone. A costumed built treadmill acting as a movement capture device is proposed to capture players' commands for movements. These movements include Running, walking, Stopping, and Turning. In that way, the players enjoy exercising as well as playing the game. However, sooner or later, the players get exhausted driving them to exit the game. That way, we believe that such a proposal would keep players healthy, and reduce the chance of addiction.**

Keywords—Virtual Reality; Gaming; Video Game.

I. INTRODUCTION

Computer and video games have come a long way since Space Invaders and Pac Man. Video games are becoming increasingly complex, detailed, and compelling to a growing international audience of players. Today's games are much more interesting, and the technology has advanced to the point where a gamer can become immersed in a multimedia-enabled 'virtual reality' or 'alternate world'. With better graphics, more realistic characters, and greater strategic challenges, it's not surprising that some teens would rather play the latest video game than hang out with friends, play sports, or even watch television. Some games, especially online role playing games, can become a substitute for 'real life', and players can become immersed in the experience of living in an imaginary world. Some gamers report that they play games to escape things like family or personal problems – in a similar way to people who use drugs or alcohol to escape their problems.

Although gaming addiction is not yet officially recognized as a diagnosable disorder by the American Medical Association, there is increasing evidence that people of all ages, especially teens and pre-teens, are facing very real, sometimes severe consequences associated with compulsive use of video and computer games.

Thus, people can become addicted to games. Young gamers have shown similar symptoms to people who have drug or alcohol dependence – an inability to stop playing.

Of course, all gamers are not addicts – many teens can play video games a few hours a week, successfully balancing school activities, grades, friends, and family obligations. But for some, gaming has become an uncontrollable compulsion. Studies [1] estimate that 10 percent to 15 percent of gamers exhibit signs that meet the World Health Organization's criteria for addiction. Just like gambling and other compulsive behaviors, teens can become so enthralled in the fantasy world of gaming that they neglect their family, friends, work, and school. Many children spend hours a day on computers, so much so that computers have become a primary source of entertainment for them, as well as a convenient baby-sitter for parents.

In reference [2] by Ricky Lam, many controversial cases in which addicted players commits suicide, murder, or robbery, caused death to negligence, or skipped school were listed. For instance, case number 2, a seventeen-year-old Daniel Petric murdered his mother and injured his father after they refused to let him play an online game named Halo 3. Also, just a week ago, among the ridiculous calls that people made to Emergency 999 in 2012 which the UK police revealed was a midnight call of a father to a 14 year old son who was ignoring his parents' pleas to switch a video game off and get some sleep [3].

In the following section, we will present few of the symptoms and injuries that addicted gamers usually start developing. Next in section 3, solutions proposed by literature and concerned centers will be presented. Section 4, will cover existing tools offered to players to capture real life movements and interpret them into games commands. Then, the costumed build treadmill will be proposed before we conclude.

II. SYMPTOMS AND POSSIBLE INJURIES

Addicted gamers usually try to be with the computer as much as possible, and in many cases, such gamers lose their confidence; they cannot involve with the social world in real time and they cannot communicate and compete with other people. When such thing happened, it means that they need video game addiction treatment as soon as possible.

In other words, computer game addiction can be diagnosed with a few easily spotted signs. They include but not restricted to:

- School grades dropping
- Avoiding other commitments in order to be with the computer (wagging school, stopping participation in sport)

- Not seeing friends
- Not talking to parents/family
- Being on the computer in most or all of your spare time.
- Anxiousness to be with the computer.
- Sleep and memory problems when playing an exciting game for 2 or 3 hours before bed
- Family negligence

Furthermore, when playing video games, as with many activities, you may experience occasional discomfort in your hands, arms, shoulders, neck, or other parts of your body. Symptoms such as these can be associated with painful and sometimes permanently disabling injuries or disorders of the nerves, muscles, tendons, blood vessels, and other parts of the body. These musculoskeletal disorders (MSDs) include carpal tunnel syndrome, tendonitis, tenosynovitis, vibration syndromes, and other conditions. While researchers are not yet able to answer many questions about MSDs, there is general agreement that many factors may be linked to their occurrence, including: medical and physical conditions, stress and how one copes with it, overall health, and how a person positions and uses their body during work and other activities, including playing a video game.

RSI (Repetitive Strain Injury) for instance can be developed from playing games or sitting at the computer too long, or repeating certain movements, eg. clicking a mouse button. For gamers or heavy computer users, it's common to get RSI in the wrist. This results from the tendons in the arm and wrist being overworked, causing the tendons and the tissue covering the tendons to become inflamed and sore. Other overuse problems such as neck pains, tingling in the fingers, black rings in the skin under the eyes and muscular stiffness in the shoulders may also be developed from excessing playing.

To summarize, video games can cause injury and addiction. The following section presents solutions which specialists believe that may deal with the injury and addiction problems.

III. Possible Solution

Many of the discussed injuries may be avoided by taking breaks while playing. This helps the player’s body to avoid MSDs. Also players must make sure that their positions when playing do not encourage discomfort. Whereas, to avoid addiction problems, we believe that there are three ways to approach this: through parents, through offering alternatives, and through exercising to play.

A. *Parents’ supervision*

Increase parental supervision and parental control may help in avoiding games addictions. Some Consoles like the PS3, Xbox360, Wii, and the PSP have parental control. Parental supervision and control can also be in the form of setting boundaries as to how long the child can be playing games/chatting on the computer. Furthermore, it is suggested that rewarding children with computer time for doing something, like completing an assignment, would make them feel like no one is trying to 'stop' them from using the computer as such, and thus helps.

B. *Finding alternatives:*

There are many alternatives to computer games and computers in general for entertainment. They include:

- Playing a sport with friends
- Going out often
- Eating at a restaurant
- Getting involved with a local recreational group
- Drawing

C. *Exercising while playing*

So far, exercising while playing has been presented to the gamers as a way to increase the joy when playing, such as in MSE Weibull Virtual Theater. Giving gamers a feeling of the real world through virtual reality is an exciting challenge. Another reason for exercising while playing is to practice and improve certain physical skills of the player, such as in Tacx. Both examples will be addressed later. Regardless whether the reason for exercising is to enjoy the game more, or to improve certain physical skills, or to get the chance to play if one is prevented from playing by parents or self-control, players sooner or later will get exhausted, and consequently quit playing for the day. These three different reasons could be classified under playing while exercising, exercising while playing, and exercising to play.

As long as players do exercise, addition will not be of a concern. In what follows, we will give a history to the introduction of body interaction in games, and then we will present some recent tools or controllers that are used to interpret and perceive body motions. In section ??, we will propose our vision to a tool that could be used to reduce games addiction by exercising to play, before we state our conclusion.

IV. History to Body Interactions in Games

In 1996, Mandala Gesture Xtreme (GX) System [4] became the first commercial arcade application using computer vision. Instead of a projector, the system used a large CRT display, which changed the player’s experience where the player could move with more confidence. In 2001, Intel®PlayTM Me2Cam Virtual Game System [5] was the first home product released. At the time, when an average PC screen was a 15” CRT display, it was difficult to play, due to the small screen size. It was hard to see the action on the screen. The recent commercial success of Sony PlayStation Eyetoy [6] and Nintendo Wii [7], which are not a “proper” full body interactive game, introduced the idea of a computer body interaction, full body interaction, and physically interactive games, i.e. games where the main interaction device is a user’s body. The user’s action was finally moved to take place in front of a large screen (i.e. TV display), where there was more space available for the physical gameplay.

Early design projects in full body interaction games such as those in [8] [9] presented principals for game design. Labanotation has been used in the interaction design context to evaluate Eyetoy Sony PlayStation games [10] and it provided a valuable foundation for the design of movement based interaction. Work of QuiQui Giant Bounce [11] and Kick Ass

Kung-fu [12] focused around transforming the user movement into the gameplay.

Fairly new types of games called massively multiplayer online role-playing game, (MMORPG), have recently been developed and became very popular in a short time. A very large number of players interact with one another within a virtual game world. Players assume the role of a character (often in a fantasy world) and take control over many of that character's actions. MMORPGs are distinguished by the number of its players, and by the game's persistent world which continues to exist and evolve while the player is offline and away from the game. Worldwide revenues for MMORPGs exceeded half a billion dollars in 2005,[14] and Western revenues exceeded US$1 billion in 2006, [15]. In 2008, Western consumer spending on subscription MMOGs grew to $1.4 billion [16]. World of Warcraft, a popular MMORPG, has more than 10 million subscribers as of February 2012.[17] Star Wars: The Old Republic, released in 2011, became the world's 'Fastest-Growing MMO Ever' after gaining 1 million subscribers within the first three days of its launch[18,19].

In these games, the movement commands, which are walking and running, as well as in other similar games such as Runescape, Tibia, Call of duty, assassin's creed, Starcraft, Prius Online, Gears of War, Second Life, Legend of Mir, Halo, and Everquest, are controlled via one of the following methods:

- A Mouse click on destination position in an overview map, such as in Runescape and World of Warcraft
- A Keystroke or a joystick to indicate forward, backward, left and right directions to move, such as in Call of Duty, Hello, and Assasin’s creed.

Although, a small background application can be developed to convert one approach to another, the paper’s proposal works with only the second approach in which keystrokes or joysticks commands dictates the moving direction of the virtual player within the game.

V. Off shelf and Special Controllers for Motion Capture

In this section, we will introduce the most popular off shelf motion controllers that could be used for playing at home. PlayStation Move is a motion-sensing game controller platform for the PlayStation 3 (PS3) video game console by Sony Computer Entertainment (SCE). Based around a handheld motion controller wand, PlayStation Move uses the PlayStation Eye camera to track the wand's position, and inertial sensors in the wand to detect its motion. It was first revealed on 2 June 2009, [20]. Kinect is another controller but designed for Xbox 360. Kinect is a motion sensing input device by Microsoft for the Xbox 360 video game console and Windows PCs. Based around a webcam-style add-on peripheral for the Xbox 360 console, it enables users to control and interact with the Xbox 360 without the need to touch a game controller, through a natural user interface using gestures and spoken commands, [21]. It was aimed at broadening the Xbox 360's audience beyond its typical gamer base. It gives the experience of a controller-free gaming that involves a full body play.

Wii MotionPlus was developed by Nintendo in collaboration with game development tool company AiLive, [22]. The device incorporates a dual-axis [23] tuning fork gyroscope, [24] and a single-axis gyroscope which can determine rotational motion. The information captured by the angular rate sensor can then be used to distinguish true linear motion from the accelerometer readings. This allows for the capture of more complex movements.

In a different setup, MSE Weibull [26] offers system solutions within the sectors of production, test and training in civilian and military markets. The Virtual Theatre and the Omnidirectional treadmill link between the Live and Virtual domains. The Virtual Theatre from MSE is based on an omnidirectional floor, Figure 1.

It was shown to the public at ITEC 2011 for the first time. It facilitates omnidirectional unrestricted walking in the infinite virtual environment, within a finite real world footprint. The increased immersion is claimed to lead to a giant leap towards convergence of the real and the virtual world has been taken.

The WIZDISH™ locomotion platform, [27], is another controller similar to a treadmill but with no moving parts. It offers the navigation for Virtual Reality and Immersive Worlds. The users experienced when using wizdish [27] is claimed to be similar to a regular treadmill. The player stands on a slick concave disk, as shown in Figure 2, which minimizes friction under foot so the player can shuffle along in place, pretending to walk around.

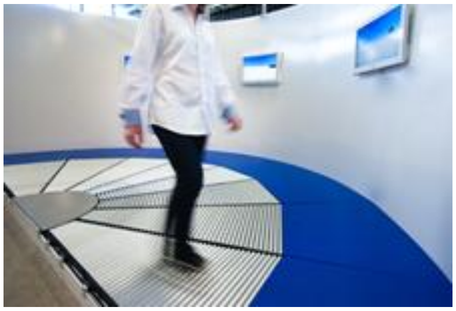


Fig. 1. Mse Weibull Omnidirectional Treadmill

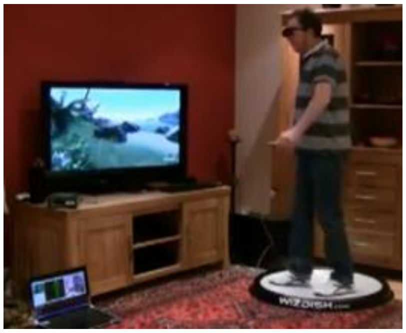


Fig. 2. WIZDISH

Although, all these controller or approaches may come close to satisfy our objective, which is to reduce games addiction, but not exactly. Players would stop playing their session once they get bored and not once they get tired. Thus, this may prevent them from using these controllers again. Our proposal aims to get players to sweat while playing. If one puts more efforts in each move, then the outcome would be different and shorter durations per session would make players get tired and have better chance to get back and use the same setup when play again.

Figure 3 shows another setup where players put greater efforts in the moves.

Tacx has created a video game to link cycling around the world and to offer a way to exercise at any time regardless to the weather situation. Tacx' has become a household name for cyclists all over the world. They offered their customers Virtual Reality trainers through software programs and cycling films a unique experience in virtual worlds. They connect the bicycle to a rotation speed sensor as well as sensors for the left and right turnings. The cyclist then rides and starts playing or exercising. However, the main objective behind this is to exercise rather than play.

Finally, the closest to our proposal is Gamerunner [28]. It was an attempt to exhaust the player using a treadmill as a controller which was made available in February 2011. It was yet another way to blend exercise and gaming. As seen in the Figure 4, it was mounted by a joystick to control moving directions and other gamming tools. The Gamerunner is a person-powered treadmill that features 17 buttons and a handlebar that can be turned for looking or moving.

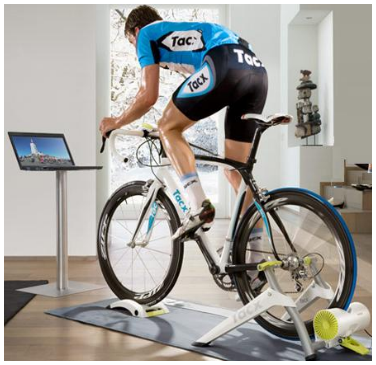


Fig. 3. Tacx Virtual Reality Cycling

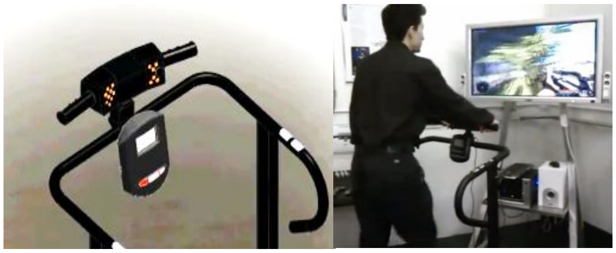


Fig. 4. Gamerunner

VI. Proposal

This paper proposes a controller that adopts the idea of exhausting the player while playing a video game to avoid long playing sessions; hence, neither reaching a state where the player may start feeling bored, nor playing for long which may lead to addiction.

We believe the presented earlier GameRunner is a good choice; however, keeping the players' hands on the mounted handler all the time, is something that is not preferred by players. This would unfortunately reduce the feeling of excitement when playing the game; thus giving players more reasons for not getting back to the same setup when playing again.

Considering the Call of Duty game, for instance, this paper proposes modifications to the GameRunner in order to give the player more of a feeling to the convergence of the real and the virtual worlds. Keeping in mind that the player may sweat while playing, the addiction becomes of a no concern when playing video games.

The primary modification proposed is to make the fixed handler portable, or at least to split it into two pieces: one that is portable and another that is fixed. The portable handler could be in the form of a wireless joystick or fake machine gun (in case of a FPS, First Person Shooter, game) that includes few buttons which are responsible for the most frequent commands, such as Fire, Crouch, Stand, prone, and Jump as well as Looking left or right. That way, the player will have his/her hands off the treadmill and on the device that may resemble the virtual device being carried in the game.

The proposal classifies the commands offered by the game into three: Frequent, Motion based, and Optional. It distributes these commands over three devices. The frequent commands, such as those mentioned earlier, will be placed on the portable handler (or machine gun). The treadmill will include the motion based commands, such as Running, walking, and moving left or right. While the optional (or least used) commands such as Equipment and Inventory will be placed on the fixed handler, or added to the portable handler, if fixed handler is chosen not to exist. Moreover, the treadmill speed triggers, such as to increase or reduce as well as to come to a gradual full stop will be added to the frequent commands.

To implement the four Motion-based commands on the treadmill, namely: Running, Walking, and Moving left or right, first the rotation sensor similar to that used by Tacx will be used to indicate Running and walking.

This will basically translate the motor speed to the appropriate command based on a preset threshold. Second, for moving right and left, two concave slim switches are installed beneath the front sides of the rotating belt of the treadmill: one under the right-front, and another under the left-front corners, as shown in the Figure 5. Once a player steps on the center of any of these two switches, it will indicate moving left or right.

Each right or left switch press will represent a number of keystrokes used to control left or right movements depending on its sequence number, up to a specific maximum value. If the maximum is four, for instance, then the first step on a switch will represent one keystroke; the second will represent two keystrokes, and so on till either the switch is not stepped on it for some time that is long enough to break the sequence or a maximum of four keystrokes is reached. Breaking the sequence will result in the sequence reset.

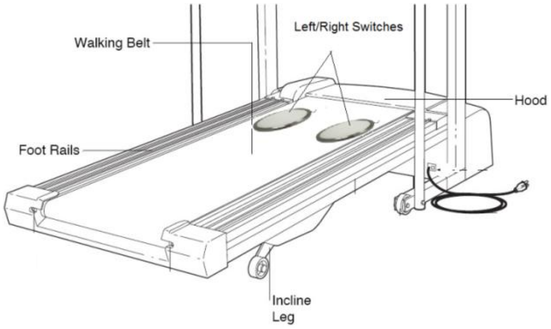
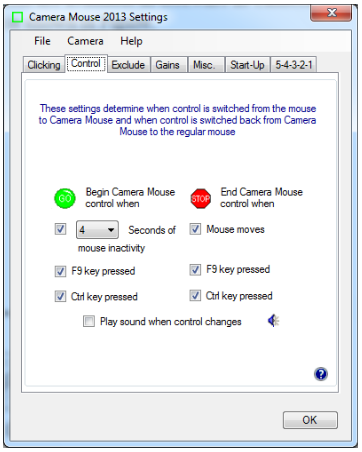


Fig. 5. Similar to Gamerunner but with portable Handler

The portable handler, in turn, is similar to a wireless keyboard providing the needed keystrokes to represent both frequent and optional commands (which also could include the right and left moving buttons, as alternatives to stepping on the switches). For the mouse pointer, which is used to look left or right, there are many ways to connect the portable handler with a wireless Motion sensing air mouse, such as Measy RC11 [29] or Flymouse Mouse [30]. We could also provide a webcam and object motion tracker software to detect motion produced by the head of the player or the tip of the portable handler. One example of such software that is available as a freeware is Camera Mouse 2013 [31]. A snapshot of the software settings is shown in Figure 6. That way, if the player turns his/her head left, the mouse will follow which consequently will be perceived as a look-left command in the Call of Duty game.



These settings determine when control is switched from the mouse to Camera Mouse and when control is switched back from Camera Mouse to the regular mouse

Begin Camera Mouse control when

☑ 4 Seconds of mouse inactivity

☑ F9 key pressed

☑ Ctrl key pressed

End Camera Mouse control when

☑ Mouse moves

☑ F9 key pressed

☑ Ctrl key pressed

☐ Play sound when control changes

Fig. 6. Camera Mouse 2013 setting screen shot

VII. Conclusion

The paper has discussed the issue of games addiction that many players may be suffering from. Such a phenomenon has recently been bubbling up to the surface and becoming the concern of not only parents but also the society. The paper presented the symptoms that may appear on people who may be addicted to games or are becoming ones, as well as the possible injuries. The paper then drives the readers towards discussing possible solutions to avoid such a problem. It then focuses on one of these possible solutions by presenting the available tools and devices that could be used within the solution category. After discussing the drawback of them, it proposes one that is believed to have overcome most of these drawbacks, except one. The proposal of this paper suffers from the same problem that most of the other pieces of gaming exercise equipment have suffered: its size. With the advent of more family friendly consoles, like the 360, that problem would grow. However, self or parental control would then be necessary to offer such a proposal as a way to allow players to play without imposing any time control, yet with the confidence that such a setup will lead to no addiction.

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Segmentation of Ultrasound Breast Images using Vector Neighborhood with Vector Sequencing on KMCG and augmented KMCG algorithms

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***Abstract*— B mode ultrasound (US) imaging is popular and important modality to examine the range of clinical problems and also used as complimentary to the mammogram imaging to detect and diagnose the nature breast tumor. To understand the nature (benign or malignant) of the tumor most of the radiologists focus on shape and boundary. Therefore boundary is as important characteristic of the tumor along with the shape. Tracing the contour manually is a time consuming and tedious task. Automated and efficient segmentation method also helps radiologists to understand and observe the volume of a tumor (growth or shrinkage). Inherent artifact present in US images, such as speckle, attenuation and shadows are major hurdles in achieving proper segmentation. Along with these artifacts, inhomogeneous texture present in the region of interest is also a major concern. Most of the algorithms studies in the literature include noise removal technique as a preprocessing step. Here in this paper, we are eliminating this step and directly handling the images with high degree of noise. VQ based clustering technique is proposed for US image segmentation with KMCG and augmented KMCG codebook generation algorithms. Using this algorithm images are divided in to clusters, further these clusters are merged sequentially. A novel technique of sequential cluster merging with vector sequencing has been used. We have also proposed a technique to find out the region of interest from the selected cluster with seed vector acquisition.**

Results obtained by our method are compared with our earlier method and Marker Controlled Watershed transform. With the opinion of the expert radiologist, we found that our method gives better results.

Keywords— ***codebook; seed vector; training set; vector quantization***

I. Introduction

B-Mode ultrasound (US) imaging is widely used diagnostic tool to examine the range of clinical problems because of its real-time image availability, non invasive nature and low cost of a scan. It has very low health risk to the patient during examination and image acquisition process relative to the other imaging modality [1, 2]. In the tissue characterization of the breast, US imaging is a complimentary method to the mammogram to distinguish between benign and malignant solid masses [3, 4]. Usually a malignant tumor has different characteristics, such as irregular shape, ill defined margins and heterogeneous echo texture as compare to benign tumor. Round or oval shape with well defined boundary of a tumor is the most valuable information in the detection as benign and can be used to reduce the number of biopsies performed [5].

Segmentation of US images provides clinically valuable information for radiologists in terms of shape irregularity, boundary definition and quantitative measurement of lesion size. The accurate measurement of a lesion is basically used to monitor the tumor growth and also helps in treatment and planning for surgery [6]. Due to the limitation of acquisition process (dependence on expert radiologist) and technology, detection and measuring the size of tumor manually is difficult and time consuming process. However, with the improvement in the scanning devices (transducers), the inherent artifacts, such as speckle (which decrease signal-to-noise ratio), attenuation, shadows and signal dropout degrades the quality of the US images acquired. Many traditional segmentation algorithms are not suitable for such poor quality images, unless preprocessing steps to remove these artifacts has been used [7]. The artifact such as attenuation, which is causes by the gradual loss in the intensity of the ultrasound waves, generates inhomogeneous intensities within the same tissue type regions (i.e. tumor) and significant overlap between different class tissues (i.e. at the boundary). Blurred boundary and presence of tissue intensity variation in the region of interest are major constraints to achieve accuracy in the automated intensity based segmentation [8]. Some methods are discussed in the literature which handles this issue with the help of multiple images of the same region (sequence of images), but the processing of multiple images together is computationally inefficient [9, 10]. Other methods discussed in the literature for segmentation and classification such as, texture feature, thresholding [11,12], region growing and region merging [13,14], neural network, wavelet and watershed transform [15, 16], clustering [17, 18] etc, are strongly influenced by these inherent artifacts and involves steps to remove them to enhance the quality of images. The most usual artifact in US images is speckle and its degree is depends on human expertise, acquisition process and devices. This phenomenon highly affects the accuracy of segmentation and requires attention, so removal of noise has been extensively studied by the researchers and provides solutions [19-22]. Here, in this paper, we are demarking the boundary of the tumor in high degree noisy and attenuated US images without involving any preprocessing (i.e. image enhancement) step. We are proposing Vector Quantization (VQ) based clustering with new computationally efficient codebook generation algorithm [23], i.e. Kekre's Median Codebook Generation (KMCG) and augmented KMCG. Improved method of cluster merging with vector neighborhood is proposed on novel method of sequential merging of clusters [24] and compared with each other.

The other sections of this paper are organized as follows, in section II, vector quantization is discussed with encoding technique and its usability in segmentation. In section III, original VQ based KMCG codebook generation algorithm and augmented KMCG are discussed along with training set formation for horizontal and vertical division of the images. A novel technique of vector neighborhood with vector sequencing is described in section IV along with new technique for closing the holes in the clusters. In section V results are discussed followed by conclusion in section VI.

II. Vector Quantization

Vector Quantization (VQ) was initially developed and implemented for image compression, with the help of many codebook generation and quantization algorithms [25, 26, 27, 28], but now a days it has been extensively use in other applications, such as image segmentation [29], speech recognition [30], pattern recognition and face detection [31, 32], tumor demarcation in MRI and Mammogram images [33, 34], content based image retrieval [35, 36] etc. In this paper, this method has been used as clustering aid in demarcation of area of interest (cysts and tumor) in breast ultrasound images.

A two dimensional image I(X, Y) is converted into K dimensional vector space of size M, V = {V_1, V_2, V_3,………., V_M} (training set). VQ is used as a mapping function to convert this K dimensional vector space to finite set CB = {C_1, C_2, C_3, C_4,…….., C_N}. CB is a codebook of size N and each code vector from C_1 to C_N represents the specific set of vectors of the entire training set of dimensions K and size M. The codebook size is much smaller than size of the training set and it can represent entire training set. Here, in this paper, the work has been done in spatial domain and size of the codebook is limited to only eight codevectors, which are further used to forms eight clusters. As discussed in the section III A and B, KMCG and augmented KMCG are used as VQ based clustering algorithms and each cluster represents different regions of the image.

III. Cluster Formation Using Codebook Generation Algorithms

A. Kekre's Median Codebook Generation algorithm (KMCG)

This algorithm was proposed for data compression [37, 38, 39], but this VQ based algorithm, proved its potential and usefulness in various applications, such as segmentation of mammographic images[35], content based image retrieval, face recognition etc. Here, in this paper, this iterative algorithm has been explored for demarcation of tumor from the breast US images.

Initially, Image I, is divided into M non-overlapping blocks of size 2x2 and these blocks are further converted into vectors of dimension 1 x K, (K=4) as shown in the Fig. 1(a). Let, V be the training set, i.e. V = {V_1, V_2, V_3,……….., V_M}, where V_1 to V_M are individual vectors of the training set. This entire training set (matrix) of dimension M x 4 is considered as first cluster and become the input to the KMCG algorithm. To divide this cluster further, during the first iteration of this algorithm, entire training set has been sorted with respect to first value of all vectors (i.e. first column) and obtained the median of this sorted column. This median is consider as first codevector, and then divide training set into two clusters with respect to this codevector ,as shown in Fig. 1(b). (i.e upper part including median is first cluster C1 and lower part is second cluster C2). In second iteration, clusters C1 and C2 are sorted separately with respect to second column (i.e. second value of all the vectors) of the training set and obtain the medians of C1 and C2. Further, cluster C1 and C2 are divided into four clusters by using these new medians, as shown in Fig. 1(c). Same procedure has been repeated till we obtained the desired number of clusters. In Fig. 1, cluster formations are shown up to second iteration with k = 4. After acquiring desired number of clusters, they are merged together sequentially as discussed in section IV.

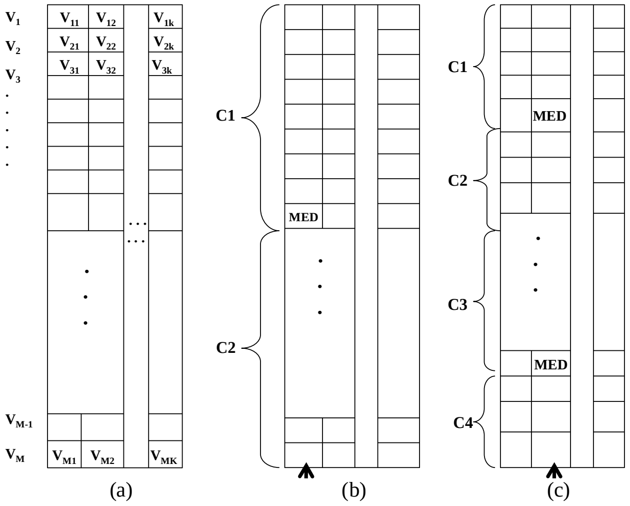


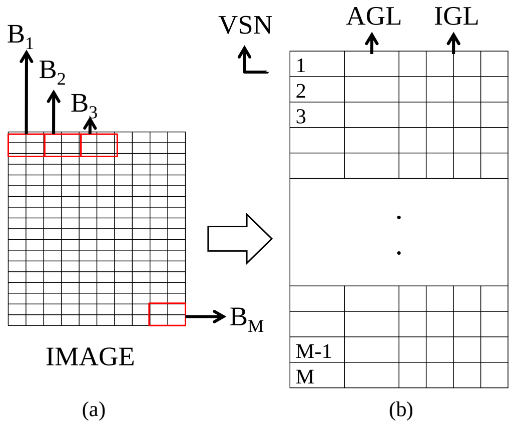
Fig. 1. Clustering Using KMCG Algoritm (A) Entire Training Set Of Size M X K (K=4) Obtained From Image. (B) Clusters C1 And C2 Obtained After First Iteration W.R.T. First Column Shown By Arrow. (C) Four Cluster Ontainned From C1 And C2 W.R.T. Second Column.

B. Augmented KMCG

KMCG algorithm has been augmented, to decrease the time require in the clustering process. In this method, vector size is increased to 6 columns, in which last four columns are used to store original gray levels obtained from 2 x 2 blocks of the image. Further, averages of each of these blocks are done separately and stored at the second column in the respective vectors. At the first column, sequence number of the respective vectors has been stored. Eventually, the size of the entire training set used for this method becomes M x 6. Therefore, unlike the original KMCG, sorting process is done only once on the second column and accordingly vectors of the entire training set are shuffled by keeping vector intact (i.e. vectors are arranged in the increasing order of their average values stored at second column). To make clusters, during the process median value is obtained from the second column and entire training set is divided into two clusters. Further, these two clusters are handled separately and obtained median value from each of them from the same column. These median values further divides two clusters into four. This process is repeated until desired number of cluster has been formed. Since sorting process is applied only once on the second column (i.e. column of average gray values of the block), time require for clustering is drastically reduced as compared to original KMCG algorithm.

C. *Training set formation with vector sequencing*

Original KMCG and augmented KMCG algorithms are used to form clusters from the training set. Here, in this paper, two separate training sets are formed for each codebook generation algorithms, Fig. 2 shows training set used for augmented KMCG algorithm. First training set is created by dividing image I (X,Y) into 2x2 non overlapping blocks horizontally and sequence number of these blocks are added at the first location of respective vectors as the vector number as shown in Fig. 2, therefore, first column of the training set contains vector sequence number. Similarly, same image is divided into non overlapping blocks vertically and forms the second training set by adding sequence number of blocks at the first column of the vector. Same procedure has been followed to create two training sets for original KMCG algorithm, except calculation of average gray levels. Therefore, size of these training sets becomes M x 5 and clusters are created according to the method discussed in section III. A.



(a) (b)

Fig. 2. (a) Original image, divided horizontaly into M nonoverlaping blocks shown by red boxes. i.e. B_1, B_2, …., B_M and stored at Last four column of the respective vector. (b) Training set generated from Image shown in (a), where, first column indicates sequence number of the block used as Vector Sequence Number (VSN), Second column Indicates Average Gray Lavels (AGL) calculated from Image Gray Levels (IGL) shown in last four column.

IV. Cluster Merging and Seed Vector Acquisition

A. *Sequential cluster merging*

As discussed in section III. C, pair of separate training sets is used for each codebook generation algorithms to make clusters. Initially, first training set (i.e. formed by horizontal division of image) from the pair is divided in to eight clusters using code book generation algorithms, similarly second training set (i.e. formed by vertical division of image) divided in to another set of eight clusters by same algorithm. So pair of similar clusters is obtained for each algorithm. “Fig. 4”, shows cluster images obtained using KMCG algorithm. “Fig. 5”, shows cluster images obtained using augmented KMCG. These two sets of clusters are handled separately in segmentation process. Further these clusters are merged sequentially one-by-one and forms new sets of merged clusters. As shown in the “Fig. 6”, first cluster is added with second, resultant clusters is then added with third and resultant third cluster added with fourth and so on. Similarly clusters obtained by augmented KMCG are merged and shown in “Fig. 7”.

B. *Seed vector and exploration of clusters with horizontal and vertical sequencing*

Images are divided horizontally and vertically into blocks and sequence of these blocks are used as vector sequence number (VSN) and added to the first column of the training set. After making eight clusters for these training sets, first cluster has been sorted by its vector sequence number (i.e. first column) and accordingly vectors are shuffled. Further median is acquired from the first column of the training set and vector which contains this median value is considered as seed vector as shown in “Fig. 3”. In most of the ultrasound images, gray level distribution is inhomogeneous but the pixels with lower gray value are concentrated at region of interest. Therefore after clustering, usually these gray levels are components of the first cluster in the form of vectors. Due to these characteristics of image, mostly seed vector obtained from the first cluster falls in the region of interest Therefore sequence number of the seed vector is used to gather neighboring vectors in the cluster. All the vectors in the cluster are searched with respect to sequence values of seed vector. Searching is done in both, right hand side and left hand side of the seed vector. Since cluster is in sorted order with respect to sequence number, it searches vectors only for consecutive sequence number, if any interlude occurs in between, it stops searching and marked all searched vectors as found and this vector line is considered as seed vector line as shown in “Fig. 3”. Obtained new seed vector by adding sequence number of the first seed vector with number of vectors present horizontally in the row (i.e. X/2). To explore other vectors in the region of interest, first this new vector is checked whether it is present or not in the cluster by using equation 1. If this new vector is present in the cluster then second line has been explored, this process is repeated and lines are explored and lower region is grown from the region of interest. Same procedure is repeated to explore the upper part of the original seed vector line, only difference is, instead of addition, subtraction is used to obtained new seed vector (sequence number of the original seed vector is subtracted from number of vectors present horizontally in the row). Furthermore all marked vectors from these clusters are preserved and other vectors are removed. As shown in the “Fig. 3” vectors which are representing noise are removed from the cluster, since they are not the neighbors of the seed vectors and this new cluster is converted to the original size image as shown in the “Fig. 8 (a)”. Similar procedure is followed to explore the cluster with vertical sequencing, except addition and subtraction of value (i.e. Y/2) is done with the vector sequence number every time to get the new seed vector. With addition of this value, right hand side region is explored and with subtraction left hand side of the region is explored. This exploration has been stop similarly when newly generated vector does not present in the cluster. Cluster image for vertical indexing is shown in “Fig. 10 (a)”. Same procedure is applied for second merged cluster and third merged cluster after closing the opening as per discussed in the section IV C and cluster images are formed.

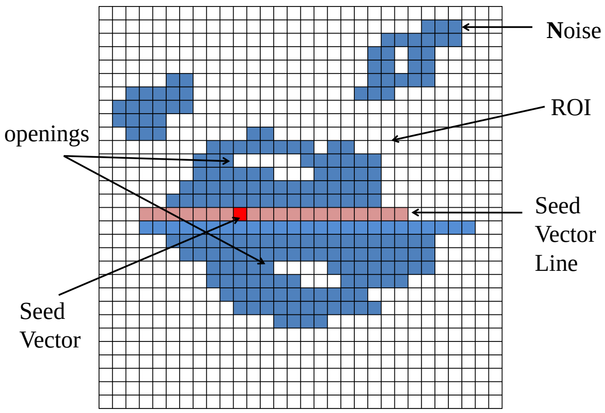
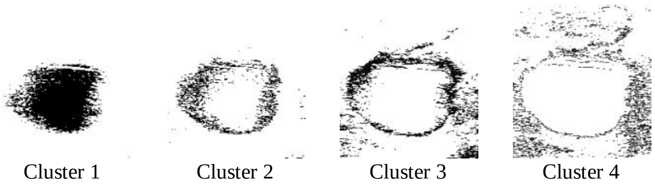


Fig. 3. Image Of First Cluster, Used To Obtain Seed Vector And Generate Seed Vector Line. This Seed Vector Further Used To Acquire Region Of Interest (ROI) By Vector Neighborhood With Vector Sequence Number.

C. Closing the opening of clusters

As discussed in the section IV-A, clusters are merged together one-by-one and sets of eight merged clusters are obtained for both horizontal and vertical sequencing. From this set desired merged cluster has been selected for closing the opening (Break in the sequence number of vector as shown in the “Fig. 3”. These vectors are not present in the cluster but they are part of region of interest). Here in this paper we proposed new technique to close the opening directly on cluster rather on cluster images. Here we select the certain threshold value, which indicates the number of vectors. Then selected cluster has been sorted with respect to its sequence number. This sorted cluster has been traversed sequentially from the first vector, if any consecutive interlude occur with respect to sequence number and it is less than or equal to threshold value then that many number of vector are added to the cluster with zero gray level. Sequence number of first newly added vector is stared from sequence number of the vector where the interlude has started plus one. After closing the opening of these clusters, they are converted into images of original size as shown in “Fig. 8(c)” and “Fig. 10(c)”. for horizontal and vertical sequencing respectively.



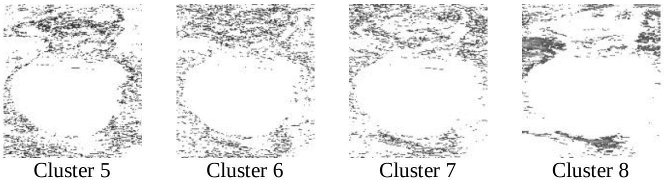


Fig. 4. Eight Cluster Images Obtained Using Original KMCG Algorithm For Dimension K= 4. Cluster Images Obtained For Both Horizontal And Vertical Division Of Image Are Same.

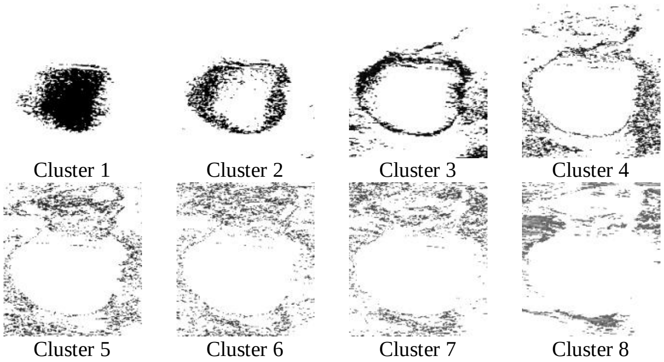


Fig. 5. Eight Cluster Images Obtained Using Augmented KMCG Algorithm For Dimension K= 4. Cluster Images Obtained For Both Horizontal And Vertical Division Of Image Are Same.

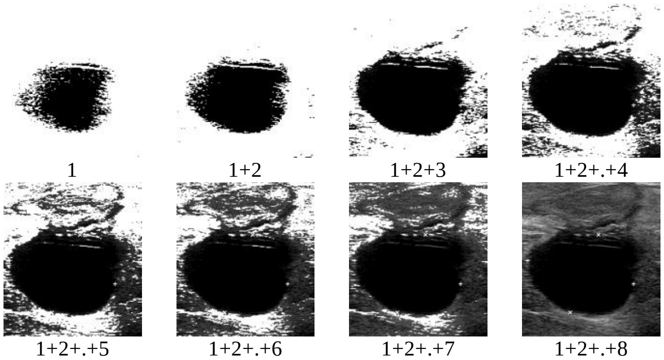


Fig. 6. Eight Sequentialy Merged Clusters Images Obtained From Clusters Shown In “Fig. 4” Using KMCG For Both Horizontal And Vertical Division

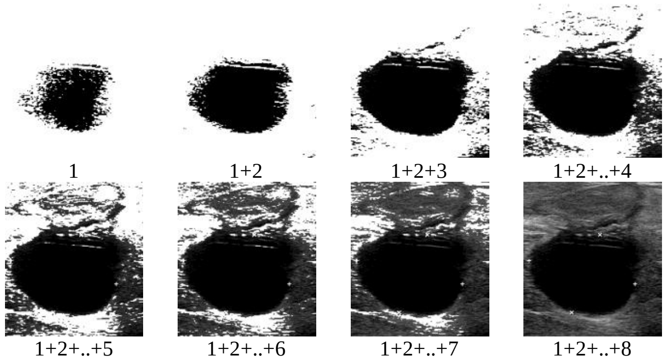


Fig. 7. Eight Sequentialy Merged Clusters Images Obtained From Clusters Shown In “Fig. 5” Using Augmented KMCG For Both Horizontal And Vertical Division

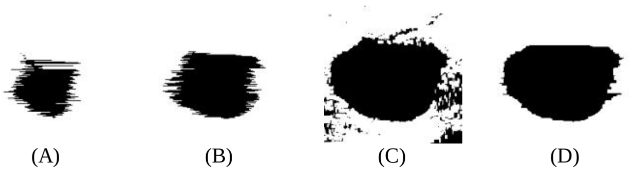


Fig. 8. Images Obtained From The Merged Clusters For **Horizonatl Direction** Shown In "Fig. 6" (A) Image Obtained From The First Cluster Generated By Using Seed Vector. (B) Image Obtained From Second Merged Cluster Generated By Using Same Seed Vector Acquired From First Cluster. (C) Image Obtained From Third Merged Cluster After Closing The Holes. (D) Image Obtained From Third Cluster Shown In "Fig. 8(C) By Using Same Seed Vector

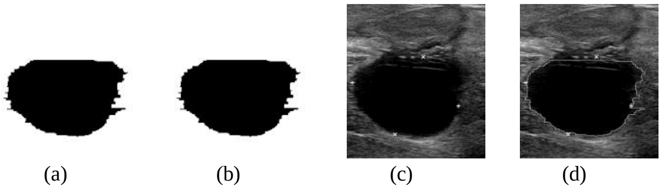


Fig. 9. Resultant Images Obtained By KMCG Algorithm With **Horizontal Division** (A) Image Obtained By Merging Cluster Images Shown In "Fig. 8 (A),(B) And (D)" (B) Segmented Resultant Image (C) Original Breast US Image With Tumor At The Center, Marked By Radiologist (D) Superimposed Image.

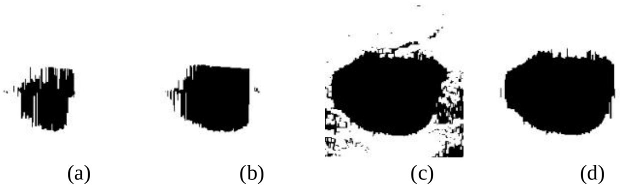


Fig. 10. Images Obtained From The Merged Clusters For **Vertical Direction** Shown In "Fig. 6" (A) Image Obtained From The First Cluster Generated By Using Seed Vector. (B) Image Obtained From Second Merged Cluster Generated By Using Same Seed Vector Aquired From First Cluster. (C) Image Obtained From Third Merged Cluster After Closing The Holes. (D) Image Obtained From Third Cluster Shown In "Fig. 10(C)" By Using Same Seed Vector.

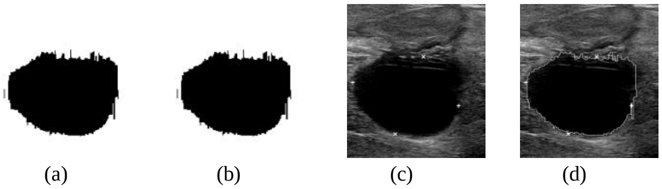


Fig. 11. Resultant Images Obtained By KMCG Algorithm With **Vertical Division** Of Orignal Image. (A) Image Obtained By Merging Cluster Images Shown In "Fig. 10 (A),(B) And (D)". (B) Segmented Resultant Image (C) Original Breast US Image With Tumor At The Center, Marked By Radiologist (D) Superimposed Image.

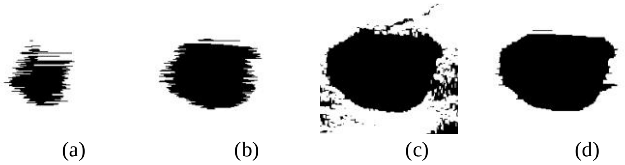


Fig. 12. Images Obtained From The Merged Clusters For **Horizonatl Direction** Shown In "Fig. 7". (A) Image Obtained From The First Cluster Generated By Using Selected Seed Vector. (B) Image Obtained From Second Merged Cluster Generated By Using Same Seed Vector Selected From First Cluster. (C) Image obtained from third merged cluster after closing the holes. (d) Image obtained from third cluster shown in "Fig. 12.(c) by selecting same seed vector

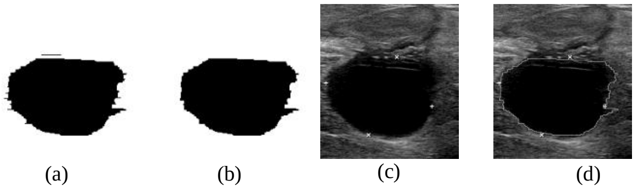


Fig. 13. Resultant Images Obtained By Augmented KMCG Algorithm With **Horizontal Division** Of Orignal Image. (A) Image Obtained By Merging Cluster Images Shown In "Fig. 12 (A),(B) And (D)". (B) Segmented Resultant Image (C) Original Breast US Image With Tumor At The Center, Marked By Radiologist (D) Superimposed Image

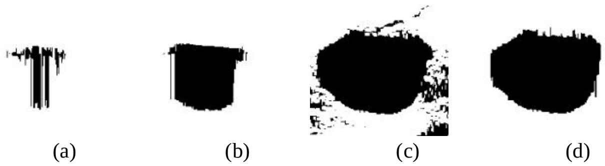


Fig. 14. Images Obtained From The Merged Clusters For **Vertical Direction** Shown In "Fig. 7." (A) Image Obtained From The First Cluster Generated By Selecting Seed Vector. (B) Image Obtained From Second Merged Cluster Generated By Using Same Seed Vector Selected From First Cluster. (C) Image Obtained From Third Merged Cluster After Closing The Holes. (D) Image Obtained From Third Cluster Shown In "Fig. 14.(C)" By Selecting Same Seed Vector.

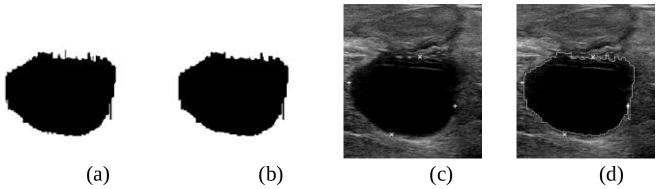


Fig. 15. Resultant Images Obtained By Augmented KMCG Algorithm With **Vertical Division** Of Orignal Image. (A) Image Obtained By Merging Cluster Images Shown In "Fig. 14 (A),(B) And (D)". (B) Segmented Resultant Image (C) Original Breast US Image With Tumor At The Center, Marked By Radiologist (D) Superimposed Image

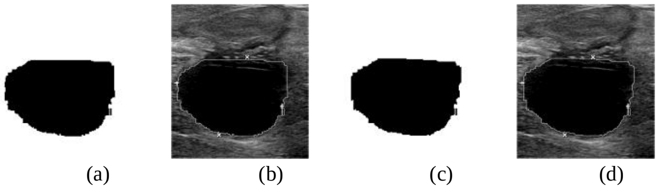


Fig. 16. Segementation Results Obtained By KMCG Algorithm & Augmented KMCG Algorithm. (A) Image Obtained By Taking INTERSECTION Of Cluster Images Shown In "Fig. 9.(B)" With Cluster Image Shown In "Fig. 11.(B)" (Using KMCG) (B) Segmentation Results Superimposed On Original Image. (C) Image Obtained By Taking INTERSECTION Of Cluster Image Shown In "Fig. 13.(B)" With Cluster Image Shown In "Fig. 15.(B)" (Using Augmented KMCG). (D) Superimposed Image.

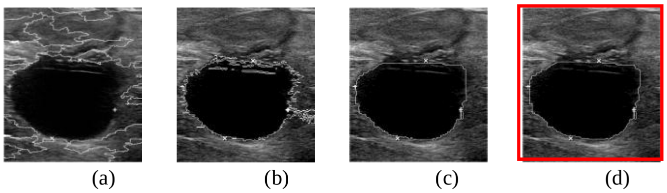


Fig. 17. Results Comparison (A) Results Of Marker Controlled Watershed Algorithm (B) Results By VQ Based Clustering [24] (C) Result By Our Method Shown In "Fig. 16.(B)". (D) Results By Our Method Shown In "Fig. 16.(D)".

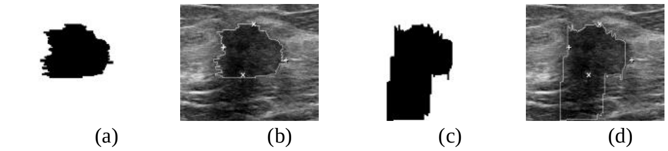

(a) (b) (c) (d)

Fig. 18. Resultant Images Obtained By KMCG Algorithm With **Horizontal** And V**ertical Division** Of Orignal Image. (A) Segmented Image Obtained By Horizontal Division. (B) Superimposed Image (C) Segmented Image Obtained By Vertical Division. (D) Superimposed Image

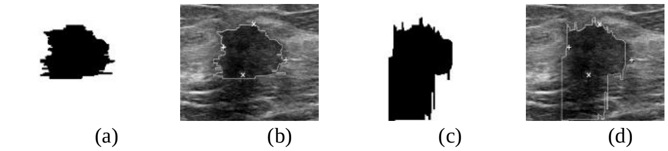

(a) (b) (c) (d)

Fig. 19. Resultant Images Obtained By Augmented KMCG Algorithm With **Horizontal** And **Vertical Division** Of Orignal Image. (A) Segmented Image Obtained By Horizontal Division. (B) Superimposed Image (C) Segmented Image Obtained By Vertical Direction. (D) Superimposed Image

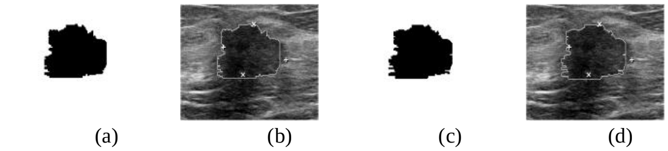

(a) (b) (c) (d)

Fig. 20. Resultant Images Obtained By Taking INTERSECTION Of Two Images. (A) Image Obtained By INTERSECTION Of Images Shown In "Fig. 18.(A) And 18 (C)". (B) Superimposed Image. (C) Image Obtained By INTERSECTION Of Images Shown In "Fig. 19.(A) And 19 (C)". (D) Superimposed Image

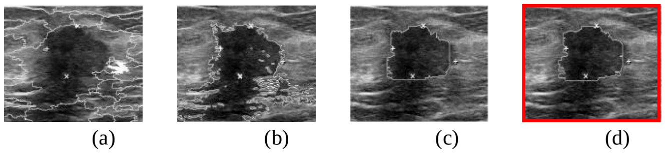

(a) (b) (c) (d)

Fig. 21. Results Comparison (A) Results Of Marker Controlled Watershed Transform (B) Results By VQ Based Clustering [24] (C) Result By Our Method Shown In "Fig. 20.(B)". (D) Results By Our Method Shown In "Fig. 20.(D)".

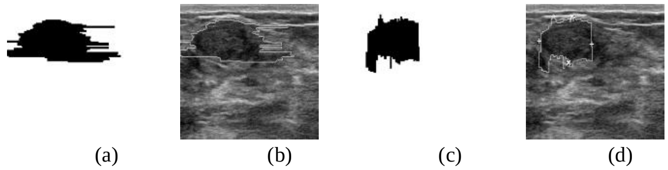

(a) (b) (c) (d)

Fig. 22. Resultant Images Obtained By KMCG Algorithm With **Horizontal** And V**ertical Division** Of Orignal Image. (A) Segmented Image Obtained By Horizontal Division. (B) Superimposed Image (C) Segmented Image Obtained By Vertical Division. (D) Superimposed Image

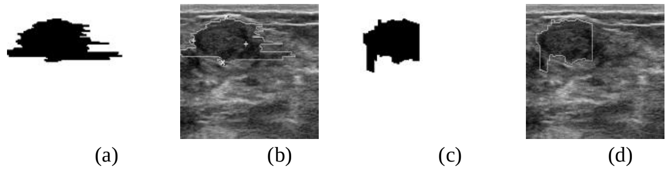

(a) (b) (c) (d)

Fig. 23. Resultant Images obtained by augmented KMCG algorithm with **Horizontal** and V**ertical division** of orignal image. (a) Segmented image obtained by Horizontal division. (b) Superimposed image (c) Segmented image obtained by Vertical division. (d) Superimposed image

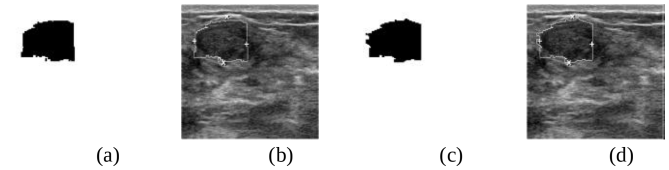

(a) (b) (c) (d)

Fig. 24. Resultant Images Obtained By Taking INTERSECTION Of Two Images. (A) Image Obtained By INTERSECTION Of Images Shown In "Fig. 22.(A) And 22 (C)". (B) Superimposed Image. (C) Image Obtained By INTERSECTION Of Images Shown In "Fig. 23.(A) And 23.(C)". (D) Superimposed Image

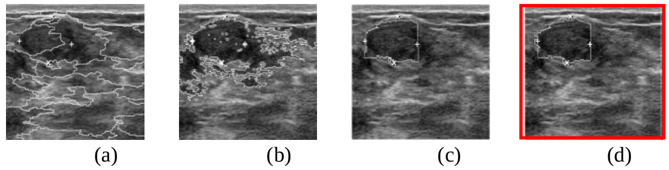

(a) (b) (c) (d)

Fig. 25. Results comparison (a) Results of Marker Controlled Watershed transform (b) Results by VQ based clustering [24] (c) Result by our method, shown in "Fig. 24. (b)". (d) Results by our method, shown in "Fig. 24. (d)".

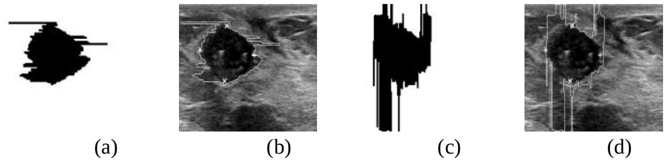

(a) (b) (c) (d)

Fig. 26. Resultant Images Obtained By KMCG Algorithm With **Horizontal** And V**ertical Division** Of Orignal Image. (A) Segmented Image Obtained By Horizontal Division. (B) Superimposed Image (C) Segmented Image Obtained By Vertical Division. (D) Superimposed Image

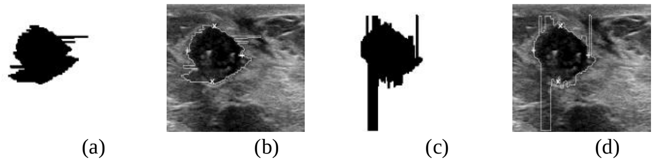

(a) (b) (c) (d)

Fig. 27. Resultant Images Obtained By Augmented KMCG Algorithm With **Horizontal** And V**ertical Division** Of Orignal Image. (A) Segmented Image Obtained By Horizontal Division. (B) Superimposed Image (C) Segmented Image Obtained By Vertical Division. (D) Superimposed Image

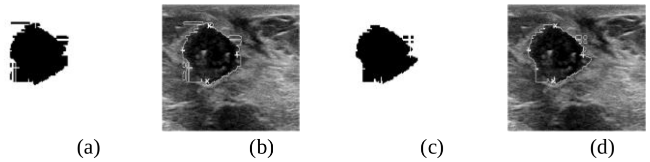

(a) (b) (c) (d)

Fig. 28. Resultant Images Obtained By Taking INTERSECTION Of Two Images. (A) Image Obtained By INTERSECTION Of Images Shown In "Fig. 26.(A) And 26 (C)". (B) Superimposed Image. (C) Image Obtained By INTERSECTION Of Images Shown In "Fig. 27.(A) And 27.(C)". (D) Superimposed Image

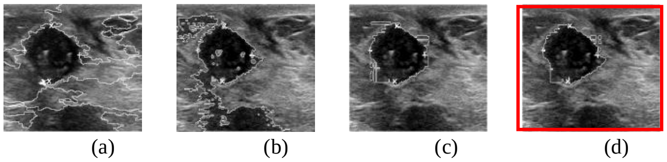


Fig. 29. Results Comparison (A) Results Of Marker Controlled Watershed Transform (B) Results By VQ Based Clustering [24] (C) Result By Our Method, Shown In "Fig. 28.(B)". (D) Results By Our Method, Shown In "Fig. 28.(D)".

V. Results

Here, in this paper, KMCG and augmented KMCG codebook generation algorithms are implemented for clustering process and further improved cluster merging technique is used to get final segmentation results. These methods are tested on real US images, using MATLAB 7.0 and Intel Core2 Duo 2.20GHz processor with 1 GB RAM. Results of four different images are shown.

Using these algorithms, sets of clusters and merged clusters are obtained, for different images. But complete result (results of each and every stage) is displayed only for one image shown in "Fig. 9(c)" and for other original images final segmented results are shown directly. All the results are validated by expert radiologists with visual inspection. Final results are compared with other techniques such as Marker Controlled Watershed transform and our other method [24]. Our results are compared with other method's results as shown in the "Fig. 17", "Fig. 21", "Fig. 25" and "Fig. 29" and best results are shown by red box drawn around the image. Marker controlled watershed transforms gives over segmentation and other method discussed in [24], boundary is not clear around the tumor.

VI. Conclusion

VQ based, KMCG and augmented KMCG algorithms are used for clustering and further it has been used to segment the ultrasound breast images. Here we used training set of size Mx5 and Mx6 for KMCG and augmented KMCG respectively. Since augmented KMCG algorithm requires sorting only once, it is computationally efficient than KMCG and on the basis of visual inspection by expert radiologist, it also having better segmentation results. Here in this paper we used vector indexing in the cluster formation process, which further helps to get the seed vector to grow the region of interest. Some images contains inhomogeneous texture within the tumor region, due to this openings may exist. This openings affects the accuracy of the segmentation, therefore we developed a new technique for closing. This technique is implemented directly on the clusters rather than cluster images.

Ultrasound images probably have smooth texture at the region of interest but course texture at the boundary of the normal tissue region and defected tissue region. Therefore tracing the boundary around the area of region is not remains a trivial task. Here in this paper we use US images with strong attenuation and high degree of noise without using any preprocessing task, because during preprocessing step, important information from the image could be lost. Our method focused on the computational efficiency as well as accuracy of the segmentation. Results are compared with the recently developed marker control watershed transform and our newly developed method [24]. With the help of visual inspection and opinion of the expert radiologists, it is found that our results are improved and accurate

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An Improved Scheme on Morphological Image Segmentation Using the Gradients

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***Abstract*— An improved scheme for contour detection with better performance measure has been proposed. It is based on the response of human visual system during visualization of any type of an image. The scheme consisted of two parts namely to find the edge of the image by using the modified mask of Laplacian of Gaussian edge operator and subsequent modulation of the edge by using watershed algorithm. The method has been applied to a digital image and better performance measure of contour detection has been achieved.**

***Keywords*— Contour detection; gradients; watershed algorithm.**

I. INTRODUCTION

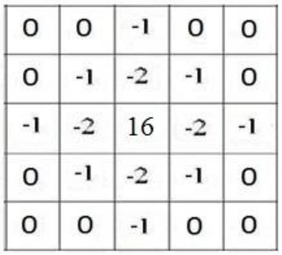
Contour detection [1-3] in real life images is a major problem to enable them for subsequent processing by machines. Contours are salient coarse edge which belongs to object and image boundaries in the image. Saliency of an edge is a subjective matter [4] and the perception about the contour of an image varies from one human being to another one. Contours are sparser than the edges of an image as detected by various edge detector operators [2] and following various lower and upper threshold values for edge detection. Thus, it can be apprehended that contour map is an efficient representation of an image as it possesses only salient information and thus provide more valuable information for high level computer vision and recognition tasks. Hence design of improved contour detection scheme is gaining gradual importance.

To perform image segmentation and edge detection tasks, there are many detection techniques [13-22]. Among them in mathematical morphology watershed algorithm using gradients is a popular one. The initial stage of this segmentation [4-7] method is to produce a gradient image from the actual image. It has been observed that the use of standard 5x5 mask of Laplacian of Gaussian edge detector for image segmentation does not also solve the main problem associated with the watershed transform: over-segmentation. In this paper a modified scheme of Laplacian of Gaussian operator with 9x9 mask for generating gradient images is proposed and produces greater accuracy and lesser over segmentation [5-6] in edge detection with subsequent modulation of the edge by using watershed algorithm. The entropy which is a statistical measure of randomness that can be used to characterize the texture of the input image is studied along with peak signal to noise ratio (PSNR), mean square ratio (MSE) and execution times are also studied in this paper.

The structure of this work is the following: Section 2 introduces conventional Laplacian of Gaussian edge detection operator for gradient images. Section 3 presents a brief description on gradients. Section 4 and 5 is devoted to the segmentation process for edge detection using watershed algorithm. Section 6 presents the proposed scheme of modified Laplacian of Gaussian moderator with9x9 mask. The results are discussed in section 7 and we finish this paper with some concluding remarks with section 8.

II. CONVENTIONAL LAPLACIAN OF GAUSSIAN OPERATOR

This detector finds edges by looking for zero crossings after filtering *f(x, y)* with a Laplacian of Gaussian filter. In this method, the Gaussian filtering is combined with Laplacian to break down the image where the intensity varies to detect the edges effectively. It finds the correct place of edges and testing wider area around the pixel. It have been observed and studied that the standard mask of Laplacian of Gaussian edge detector of 5x5mask can be modified and the scheme can be improved for generating masks of arbitrary size for gradient images for more accurate detections of object edges in a digital image. A 5x5 mask LOG filter has been shown in below.



0	0	-1	0	0
0	-1	-2	-1	0
-1	-2	16	-2	-1
0	-1	-2	-1	0
0	0	-1	0	0

III. MORPHOLOGICALGRADIENT CALCULATION

In contrast to classical area based segmentation, the watershed transform [2] was executed on the gradient image. A morphological gradient is the difference between the dilation and the erosion of a given image in mathematical morphology and digital image processing. It is an image where each pixel value (typically non- negative) indicates the contrast intensity in the close neighborhood of that pixel.

The morphological gradient m of a function f is defined by:

$$m(p) = [(p \oplus s) - (p \ominus s)] \tag{1}$$

Where, $(p \oplus s)(i) = Sup(p(j))$ is the dilation of f at the point x and $(p \oplus s)(i) = Inf(p(j))$ is the erosion of f and S would be the detection of obstacles but the main problem is structuring element applied on image.

IV. Watershed Algorithm

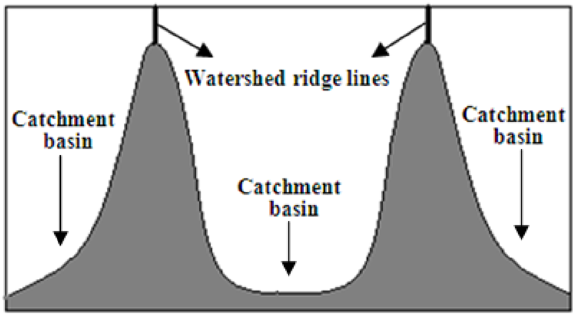


Fig. 1. Watershed segmentation-local minima yield catchment basins; local maxima define the watershed lines.

Watershed algorithm is a tool for morphological image segmentation. A gray scale image can be interpreted as the topographic image of landscape. This is accomplished (the image intensity) as an altitude. Using the features of these images, the technique of digital image processing called Watershed Transform. It consists in placing a water source in each regional minimum (catchment basins), to flood the relief from sources, and build barriers when different sources are meeting. The resulting set of barriers constitutes a watershed by flooding, i.e., the set of pixels along which the gray levels changes sharply gives rise to a watershed edge.

V. Mathematical Background Of Watershed Algorithm

Assume, M_i where $i= 1$ to n be the set of coordinates points in the regional minima (catchment basins), of the image $P(x,y)$ and $C(M_i)$ be the coordinates points of catchment basins associated with the regional minima M_i

$$Tn = \{(s,t) \mid P(s,t) < n\} \qquad (2)$$

Where,

$T[n]$ = set of points in $P(x,y)$ which are lying below the plane $p(x,y) = n$

min, max = minimum or maximum gray level value.

n = stage of flooding varies from min + 1 to max + 1

Let $C_n(M_1)$ be the set of points in the catchment basin associated with M_1 that are flooded at stage n.

$$Cn(M1) = \cap \{C(M1), T[n]\} \qquad (3)$$

Where,

$$Cn(M_i) = \begin{cases} 1, & if\ (x,y) \in C(M_i) and (x,y) \in T[n] \\ 0, & otherwise \end{cases} \qquad (4)$$

C[n] is the union of flooded catchment basin portions at the stage n.

Where,

$$C[n] = Cn(m1) \cup Cn(m2) \ldots\ldots Cn(mR) \qquad (5)$$

$$C[max + 1] = C(m1) \cup C(m2) \ldots\ldots C(mR) \qquad (6)$$

If the algorithm keeps on increasing flooding level then $C_n(M_i)$ and $T[n]$ will either remain constant or increase. Algorithm initializes $C[min + 1] = T[min + 1]$, and then precedes recursively by assuming that at step n $C[n - 1]$ has been constructed.

Let, G is a set of connected components in $T[n]$ and for each connected component $g \in G[n]$, there possibilities will arise.

1. $g \cap C[n - 1]$ is empty.

2. $g \cap C[n - 1]$ contains one connected component of $C[n - 1]$.

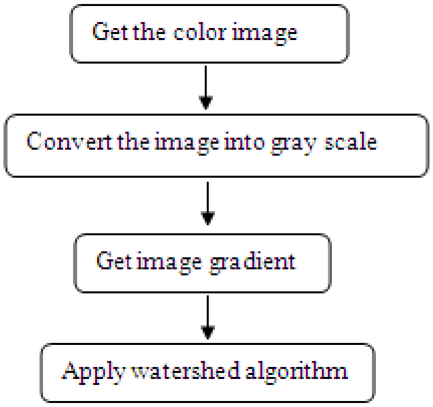
3. $g \cap C[n - 1]$ contains more than one connected component of $C[n - 1]$.

VI. Proposed Scheme

In proposed scheme a modified 9x9 mask of Laplacian of Gaussian operator has been presented. After large number of trials using masks of larger dimensions, the size of the optimal mask was obtained and found to have 9x9 in dimensions. The modified mask is shown here.

0	**0**	**0**	**1**	**1**	**1**	**0**	**0**	**0**
0	**1**	**3**	**4**	**4**	**4**	**3**	**1**	**0**
0	**2**	**3**	**2**	**2**	**2**	**3**	**2**	**0**
1	**4**	**2**	**-8**	**-14**	**-8**	**2**	**4**	**1**
1	**4**	**2**	**-14**	**-30**	**-14**	**2**	**4**	**1**
1	**4**	**2**	**-8**	**-14**	**-8**	**2**	**4**	**1**
0	**2**	**3**	**2**	**2**	**2**	**3**	**2**	**0**
0	**1**	**3**	**4**	**4**	**4**	**3**	**1**	**0**
0	**0**	**0**	**1**	**1**	**1**	**0**	**0**	**0**

The flowchart of the proposed scheme is given in below. In initial stage a color image is converted into gray scale or black and white image. The gradient image is accrued from the grayscale image with the help of proposed modified mask of Laplacian of Gaussian edge detection operator. Finally the watershed algorithm is applied to detect the edges of the different objects within the image.



VII. Comparison Of Various Edge Detection Operators With The Proposed Scheme

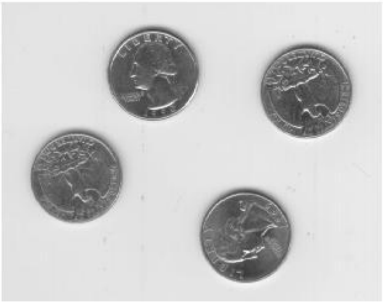


Fig. 2. Grayscale image.

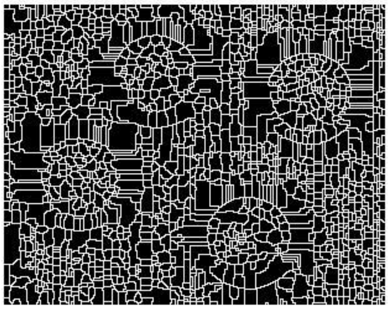


Fig. 3. Average.

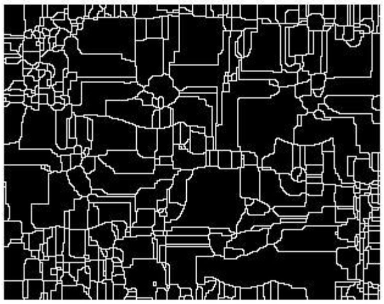


Fig. 4. Disk.

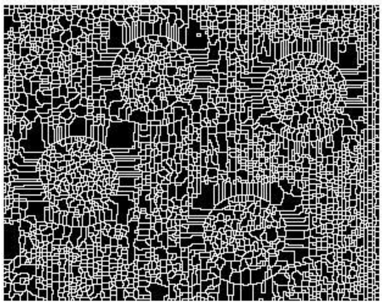


Fig. 5. Gaussian.

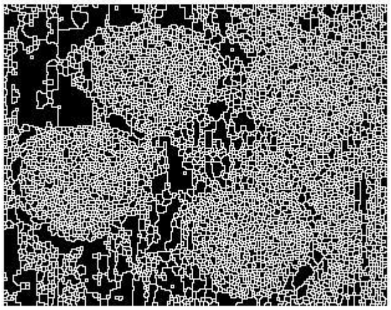


Fig. 6. Laplacian.

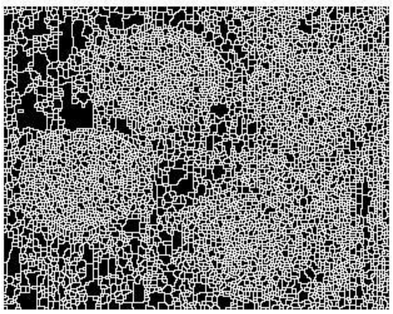


Fig. 7. Log.

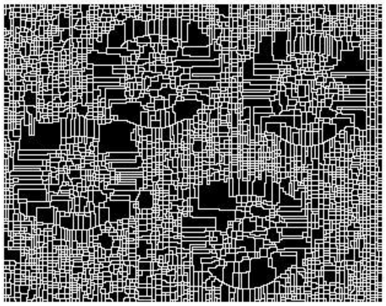


Fig. 8. Motion.

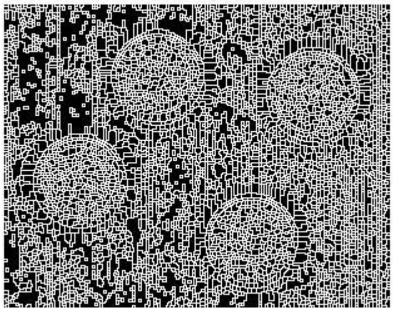


Fig. 9. Prewitt.

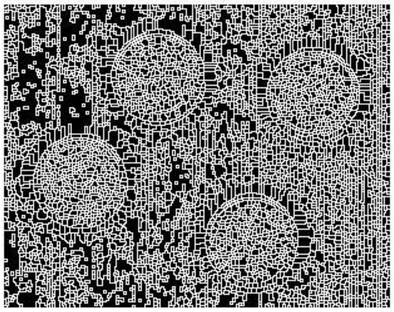


Fig. 10. Sobel.

The proposed approach is applied on a natural image and shown in from figure 2 to figure 12 respectively. Figure 2 shows the original image. Figure 3 to figure 11 illustrates the segmented images with watershed algorithm using different gradient operators like Average, Disk, Gaussian, Laplacian, Laplacian of Gaussian , Motion, Prewitt, Sobel and Unsharp. The segmented image using watershed algorithm with proposed scheme which is a modified 9x9 mask of Laplacian of Gaussian operator is shown in figure 12. We obtained output images that consist of all edge information and regions about the objects of input image.

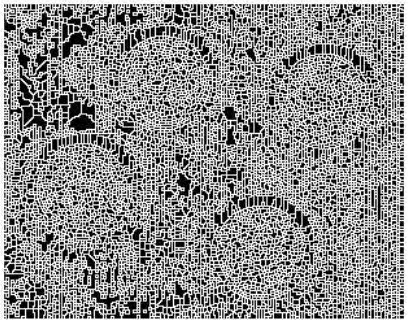


Fig. 11. Unsharp.

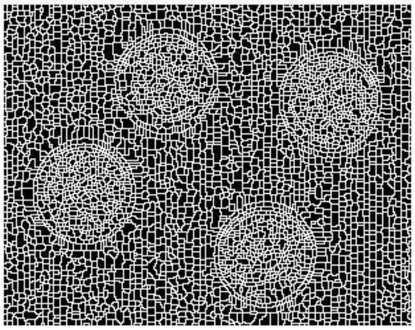


Fig. 12. Proposed scheme with modified 9x9 mask .

It have been observed by comparing the resultant images that the segmented images with watershed algorithm using conventional edge detection operators (figure 3 to figure 11) produces over segmentation and also the edges in the images are not very sharp. However the segmented image obtained by using the proposed scheme produces much better, accurate and sharp edges of different objects with less over segmentation. Statistical measurements of different segmented images are shown in table 1.

The entropies of the final segmented images using watershed algorithm through different edge detectors with watershed algorithm using gradients and the proposed scheme with modified log filter having 9x9 mask have been calculated and the values have been shown in the table 1.

VIII. Conclusion

The present work introduced the concept of edge detection with gradients and has used it to produce an effective watershed segmentation technique for natural images. The resultant image with the proposed scheme produces much higher accuracy to detect object edges compared with the other segmented images that is obtained by applying watershed algorithm using different edge detection operators for generating gradients images. Additionally, an improved scheme on morphological image segmentation with gradients has been implemented for better and accurate edge detection counteracts the problem of over-segmentation.

TABLE I. STATISTICAL MEASUREMENT

SEGMENTED IMAGE	ENTROPY	PSNR	MSE
Watershed with average	2.5884	6.4471	14736
Watershed with disk	2.2669	5.7638	17246
Watershed with Gaussian	2.5808	6.8883	1 3312
Watershed with Laplacian	2.5519	7.0469	12835
Watershed with Laplacian of Gaussian	2.5527	7.2787	12168
Watershed with Motion	2.5506	7.1162	12632
Watershed with Prewitt	2.5752	7.2311	12302
Watershed with Sobel	2.5662	7.2124	12355
Watershed with Unsharp	2.5166	7.9300	10473
Watershed with proposed modified mask	2.5910	6.8776	13345

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Coordinated Resource Management Models in Hierarchical Systems

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Abstract—**In response to the trend of efficient global economy, constructing a global logistic model has garnered much attention from the industry .Location selection is an important issue for those international companies that are interested in building a global logistics management system. Infrastructure in Developing Countries are based on the use of both classical and modern control technology, for which the most important components are professional levels of structure knowledge, dynamics and management processes, threats and interference and external and internal attacks. The problem of control flows of energy and materials resources in local and regional structures in normal and marginal, emergency operation provoked information attacks or threats on failure flows are further relevant especially when considering the low level of professional ,psychological and cognitive training of operational personnel manager. Logistics Strategies include the business goals requirements, allowable decisions tactics, and vision for designing and operating a logistics system .In this paper described the selection module coordinating flow management strategies based on the use of resources and logistics systems concepts.**

Key-words- Strategy models; logistic system; resources management; optimisation; routing; transport

I. Introduction

Large distributed real-time embedded systems [1] are often designed with static resource management strategies and tailored for specific goals or missions. These rigid resource allocation strategies are incapable of adapting to changing system goals, resource levels and operating environments. This inability to adapt can cause systems to fail to meet the end-to-end quality of service requirements when conditions change. Strategic management [2] often entails identifying the organization’s mission, vision, goals, policies, plans, projects and programs. It also involves defining and allocating resources to manage the organization. Strategic management is also described as an on-going process of assessing, and managing the business [3],watching competitors; reassessing each business regularly and determining the best way to make it succeed**.**

More effective approach[4], based on the concept of intelligent control, which includes the following components:

- Receiving and processing data from the objects of measurement system;
- Recognition situation in the state space object discrimination and classification;
- Construction of decision tree splitting at the alternative target of the state space systems under the strategy achieving ;
- Logic circuit, the team executive management mechanisms under tactics ;
- Tracking the path system and forecast of possible situations;
- Optimization and adaptation strategies goal-oriented behaviour.

The Company systems are characterised by central planning and control methods, which shows a wide range of weaknesses and cannot fulfil these demands**.** Conventional planning and control methods are based on simplified premises (predictable throughput times, fix processing times etc.), which lead to an inadequate and unrealistic description of the production system. In case of disturbances or fluctuating demand, centralised planning and control methods are insufficient to deal with the complexity of centralised systems. And this rises disproportionately to their size and heavily constrains the fault tolerance and the flexibility of the overall system. These weaknesses of conventional logistic planning and control systems require a fundamental reorganisation. Recently in scientific research the concept of autonomously controlled logistics systems as an innovative approach of a decentralised planning and control system is investigated**, which** meets the increasing requirements of a flexible and efficient order processing. To establish the logistic concept of autonomous control, adequate modelling methods are needed systematic models optimization strategy, coordination strategy which allows an exact description of autonomously controlled logistics processes.

II. Effective Strategic Models

Consider the diagram of the performance criteria process formation [5] based on the conception of logistics (Fig .1), as a strategic management function based on logistic criteria, which they are founded on:

- Growth effect through changing the goals.
- growth effect through optimization strategies;
- changing logistics management structure of production and transport structure (PTS);
- rational restructuring components of the logistics system;

- optimization of logistic functions, processes, method of action according to plans and tactics of behavior, terminal time execution of orders;
- Changing management principles, systematic changes in the structure of production, logistics optimization procedures, information provision of decision making based DSS.
- formulate strategies achieving the goal (local and strategic);
- decomposition strategies tactics and action plans to control the flow of resources (material, energy, information);
- implementation of strategies and tactics through system control commands;
- Control of facilities management before and after the control action.
- Prognosis situations scenarios based of events.
- Forming logistics strategic goals.

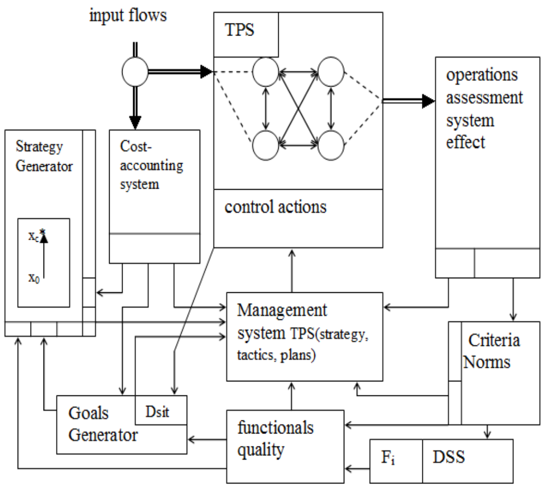

Fig 1. Scheme of formation of management under quality criteria and selection strategies

III. Systematic Optimization Strategy Models

Extension and complexity of hierarchical structures have created a number of logistical, resource, information, knowledge training, psychological and cognitive problems that lead to disorientation commands and false solutions, respectively, leading to the collapse of the system, crises, accidents, disasters, technological and managerial nature.

The effectiveness of the system strategies based on:

- optimizing the hierarchical structure according to purpose;
- optimization of strategic reserves by local plans and objectives;
- Adaptation and optimization algorithms for processing data streams in the system feedback and hierarchical levels of data exchange;
- systematic evaluation functions, resources cost optimization , personnel, information resources;
- formation of coordination strategies on the upper level and the optimal strategies that connect all levels of the hierarchy;
- synthesis management strategies according to criteria of quality and minimize costs;

All these approaches to optimal resource management systems are based on the system analysis of quantitative and qualitative indicators functioning of all hierarchy levels, integrating management programs, improving the structure and management strategy**.**

Systematic approach to formulate strategies characterized conditions:

- main strategy is related with functional all levels of the hierarchy;
- Strategy connects all levels of the hierarchy and all business sectors;

Accordingly is formed procedure decomposition of global strategy at local target selection by the management team [5]:

- integration strategy functions processes at all levels of the hierarchy;
- strategy of consolidating resources;
- strategies to minimize inventory and maximize the production and services;
- strategy to reduce the production cycle;
- strategy of differentiating service flow of orders;
- strategy cooperation in the logistics chain;
- logistics strategy, research, information and knowledge oriented innovation;
- Logistics outsourcing strategy.

For specifics transport resource transportation should consider such as [6]:

- backup strategy and calculation of transportation;
- Strategic logistics planning and supply chain ;
- development of information and telecommunication systems, navigation routes of control in normal and emergency situations;
- Strategy to Synchronized Resource Planning or Flow Planning (MRPIII).

IV. Information Resource Management Strategic

Development of crisis at present, functioning of industrial and socio-administrative structures indicates poor performance management strategies in both the global and the local scales.

Information can add value to your products and services. Improved information flows can improve the quality of decision making and internal operations. Yet, many managers do not fully understand the real impact of information - the cost of a lost opportunity, of a poor product and of a strategic mistake - all risks that can be reduced using the appropriate information.

Accordingly, it is necessary to identify components of influence in decision-making information and cognitive nature:

- Insufficient training of personnel manager, which leads to misunderstanding content change scenarios of events and incorrect actions.
- inability to clearly logically build tactics and action plans under stress, crisis and conflicting situations;
- global and local goals conflict and strategies for their implementation;
- mobilization of intellectual and information resources through coordination management strategies at all levels of the hierarchy;
- Ability to identify critical signs of crisis.

Formulation and subsequent implementation of coordination and sourcing agreement require appropriate conditions [1, 7], which include:

- Availability of local and global strategy at all levels of the hierarchy and executions;
- changes in the structure of production and transportation systems by logistics strategies;
- vertical integration of logistics;
- systematic structuring of resource flows and assessment of their dynamics and control;
- compliance information systems processing data flow dynamics and dynamic situations in the system with the aim of forming correct states of the situations in the state space, target, terminal;
- compliance management strategies tools and hardware and software management system processes in MTC;
- Availability of suitably qualified personnel and mental goal-orientation;
- presence of a strong base professional and fundamental knowledge;
- A computer system supporting decision-making **;**
- Integration of computer software logistics processes and automated process control based <MRP, DRP, EDI> and <CAD, CAM, CIM, ACU>;
- System integration processes for data collection at all levels of the hierarchy and displayed in 3D-space multimedia center operational management resource streams.

General functions of logistics information while preparing control solutions [15]:

- organizing a network of communication between customers, suppliers and MTC;
- planning operations by tactics and strategy;
- Coordination of logistics;
- monitoring of resource flows;
- control of orders;
- monitoring of external systems and evaluation of dynamic situations;

Under this approach**,** provides effective solutions suitable to the market situations and resources capable of withstanding crises and information attacks and ground creating information networks for the exchange of data flows in the hierarchy of the system and its environment.

V. Integration of Information and Navigation Cartographic Systems

To integrate in this, information systems must comply with the principles of [10]:

- coordination of hardware and software modules;
- synthesis ICS based deployment phases;
- coordination places docking telecommunication and computer networks;
- providing structural flexibility of the information system in AMS;
- principle of access to information dialogue rules-based priorities;
- harmonization of methods and means of data packets transmission;
- Information coordination of local and strategic data networks;
- Openness functioning ICT networks and satellite navigation systems.

In integrated systems [7] are updated requirements for the operational management of material resource flows, which requires support of parallelism in time material and information flows, the collection, processing and transmission flow and packets in real time based technologies (EDI) and identification (AI) .

An important effect of the functioning of the integrated systems is the ability to manage localized resources stocks selected according to coordinating strategies.

Openness information system for clusters of customers, suppliers, and operational agents helps to create an integrated logistics information system, which is the basis for management the logistics chain flow of resources and information flows for economic calculations. Information Logistics provides the functions of strategic management and coordination [1-8] resource and information flows in the hierarchy of the system connects the logistic chain into a single structure. Accordingly, it is the basis for logistics information structures (LIS).

SIF – System perturbing factors influence ($F_1…F_n$) with stochastic dynamics , (SR_V) – sources resources, TOM – technological object management , IMS – Information measuring system , ACS – Automated control system , SP– Storage products and resources ,UR – User resources ,FOsit(τ_i)– formation of situation state on time τ_i .

Phase of separation of the logistics activities systems, according to the strategic goals, can isolate building blocks [1-8]:

- IACS **-** Integrated system of automated management;
- block collection and storage of information;
- block data processing and analysis of the content;
- Informative block preparation decisions.

Accordingly, functional blocks of logistics infrastructure can be represented in the form (Fig .3).

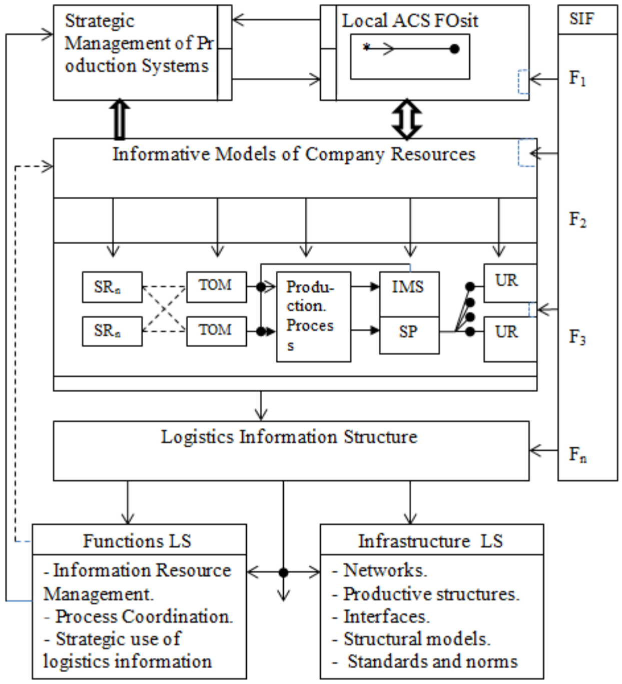

Fig 2. Scheme of structuring logistics information management schemes active resources.

VI. Coordination Strategies

Coordination strategy is based on the verification of the situation according to the purpose of the system [8]:

- the situation in the state space;
- the situation in the target area;
- the situation in the terminal area;
- Evaluation and ranking of object trajectory in the state space;
- Assessment coordinates the route and determine the distance to the target;

pattern matching situations in state space, target, terminal and their projection on the route map to determine the degree of approximation to the area of the target state based coordination strategy;

Evaluation criteria for effective routes held by strategic framework of region-based coefficient CV center of mass (center of influence) [5]:

$$\underset{T_i}{opt}\, C_V = [\sum_{i=1}^{n} D_i \cdot M_i + \sum_{i=1}^{m} d_i \cdot S_i] / [\sum_{i=1}^{n} M_i + \sum_{i=1}^{m} S_i] \gtrless C_n$$

where D_i – distance to the i-th client,d_i – distance to the source resource, M – weight coefficient passengers number, S_i – weight of traffic, C_n – normative coefficient, T_i – terminal time.

The optimization of transport cost is based on selected graph model with n-sources and m-sinks with models $< \vec{x}_i |_{i=1}^{n} \xrightarrow{g_{ij}} \vec{x}_j |_{j=1}^{m} >$ then [9]:

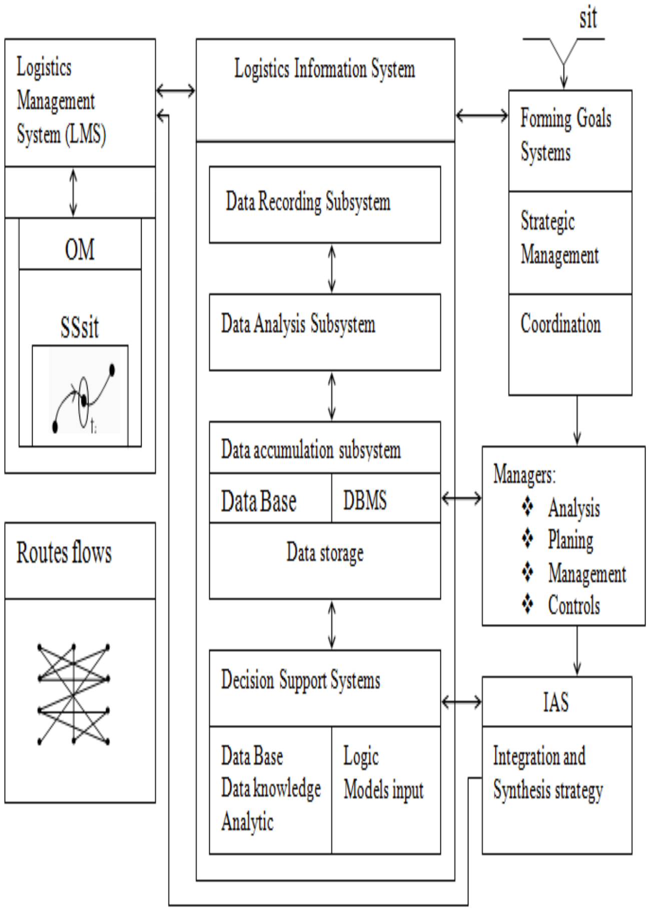

Fig 3. Formation Strategy Coordination

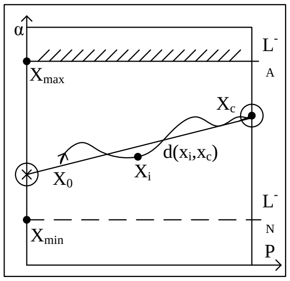

Fig 4.

$$\sum_{x_i \in \Gamma^{-1}(x_j)} \xi_{ij} \le W_j, \forall x_i \in \vec{x} \qquad (1)$$

Where g_{ij} – bandwidth arcs, W_j – bandwidth vertices, ξij – flow from xi⟶x_j.

The itinerary which will win at selected flow management strategy is evaluated by the formula [9], based on tree routes [13] :

$$g(S_{MR}) = \prod_{(x_i,x_j)\in F} g_{ij} \cdot \prod_{(x_i,x_j)\in B} 1/g_{ij} \qquad (2)$$

Where F – the set of direct arcs, B - set of reverse arcs.

Optimization of transport cost in the integrity cards routing is based on the procedure of cycle traffic $T_{(zi)}$.

$$V_{zi} = \sum_{i=1}^{n}\sum_{j=1}^{m} C_{ij} \cdot x_{ij} \xrightarrow[T_{(zi)}]{} V_z \left| \begin{array}{l} \sum\limits_{i=1}^{n} x_{ij} = a_i ; a_i \in A \\ \sum\limits_{i=1}^{n} x_{ij} = b_i ; b_i \in B \\ (i, j) \in [1..N, M] \end{array} \right. \quad (3)$$

the performance conditions for volume and cost of each other operations C_{ij} based on the balance of resource flows[12] :

$$\sum_{i=1}^{n} a_i = \sum_{j=1}^{n} b_j \quad (4)$$

To build route systems in cycles {T$_{\text{(zk) k=1,e}}$}, route traffic based matrix and plan transportation problem arising from strategy traffic flows of resources. Used for that number of methods[16]:

Diagonal, lowest cost, potentials, integer methods [6] and conditionally optimal by criteria time, screen models, dynamic linear programming**.**

Accordingly problem solving scheduling traffic requires one side coordination sequence operations (logistics) and coordination time (synchronization) based scheduling with complete certainty requirements and objectives defined parameters: execution time of the transport operation, passing, expectations and delay.

Under the influence of factors, perturbation regime change and obtain the stochastic nature of the parameters that are probabilistic. For the duration of the transport, resource transactions have introduced mitigation strategies in the form:

$$Strat[R(t,\tau)_{\Pi Di}] = \sum_{i=1}^{n} t_h + \sum_{i,j \in T_m} \tau_{ij} \to \min T_m(R(t,\tau))$$

(5)

Where $R(t,\tau)_{\Pi Di}$ – during the operation with a sequence of actions ΠD_i on the terminal cycle T_m according to the plan of operations.

Optimization plan can be performed based on branch and bound method [14] according to strategy of acceptable choice plan:

$$\exists Strat(U \mid C_{TiDi}) : f(C_i, x) \to \min F_{\Pi Di}, x \in D \quad (6)$$

$$D_i \subset G_{O\Pi D_i}, i \in 1, k, (\bigcup_{i=1}^{k} D_i = D), (D_s \cap D_p = 0, s \neq p)$$

(7)

where D – partition into branches sets of plans targeted functional selection strategies, defined as [11]:

$$I(str[R(t,\tau)_{\Pi Di}] = \int_{0}^{T_m} H_i(F_{1i}(t)...F_{ni}(t))dt = optT_m \quad (8)$$

Where F$_i$( ) – Local criteria is forming operational decisions.

Then, the coordination task of integer programming, while the chosen management strategy is formed as:

$$H_0(F_1...F_N) \to \max_{T_m}; \quad (9)$$

$$H_m(F_1...F_N) \geq b_m, m \in [1, N]; \quad (10)$$

$$F_i \in Q_i(F), i \in [1, N] \quad (11)$$

$Q_i(F)$ – area of optimization functional quality.

VII. Conclusion

We have proposed models which evaluate the effectiveness of management strategies resource streams in decision making and internal operations in hierarchical distributed systems. Shown that the optimization procedures are formed on the basis of coordination strategies and structuring routes for resource flows are performed by logistic approach to management tasks. in the paper, there have been determined components, formulas and models logistical coordination strategy in optimization of the transport system company. In our future work, we will try to integrate these models into the system but trying to change the weight of each component of these models according to the strategies chosen by the manager. And we will try to integrate the intelligent agent which is necessary to manage all these models. This problem-solution approach of management resource flows is oriented to the developing countries (Asia, Africa, especially Tunisia).

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Modeling and Simulation Multi Motors Web Winding System

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Abstract— Web winding systems allow the operations of unwinding and rewinding of various products including plastic films, sheets of paper, sheets, and fabrics. These operations are necessary for the development and the treatment of these products. Web winding systems generally consist of the same machine elements in spite of the diversity of the transported products. Due to the wide rang variation of the radius and inertia of the rollers the system dynamic change considerably during the winding/ unwinding process. Decentralized PI controller for web tension control and linear speed control are presented in this paper. The PI control method can be applied easily and is widely known, it has an important place in control applications. Simulation results show the effectiveness of the proposed linear speed and tension controller for web winding multi motors systems.

Keywords- Multi motors web winding system; PI controller; tension control; linear speed control

I. INTRODUCTION

Many types of materials are manufactured or processed in the form of a sheet or a web (textile, paper, metal, etc.) which then couples the processing rolls and the associated motor drives. The drives are required to work in synchronism to ensure quality processing and rewinding of the product. Tension is a very important web manufacturing and process setting. If severe tension variations occur, rupture of the materiel during processing or degradation of product quality can occur, resulting into significant economic losses due to material loss and reduced production rate. Therefore, in order to minimize the potential for loss, the need arises to adequately control the tension within a predefined range in a moving web processing section.

Henceforth, due to their importance in industry, tension control problems have drawn the attention of many researchers. One problem is the establishment of a proper mathematical model. In [1], a mathematical model of a web span is developed, but this model does not predict the tension transfer.

This problem was addressed in [2] and [3], with the assumption that the strain in the web is very small. However, the form of the nonlinear and coupling terms in the model are not always convenient for controller design so that other model structures, with comparable precision, are desirable. Several control strategies have been suggested to maintain quality and reduce sensitivity to external disturbances, including centralized multivariable control schemes for steel mill applications [4][5] and an H∞ control strategy to decouple web velocity and tension [3][6]. Also, for tension regulation in a web transport system, [7] proposed a control method based on a unique active disturbance rejection control (ADRC) strategy, which actively compensates for dynamic changes in the system and unpredictable external disturbances. In [8] and [9], Port-Controlled Hamiltonian with Dissipation (PCHD) modeling is considered to develop stabilization strategies with a physical interpretation and motivation of the control action, interpreted as the realization of virtual dampers added to the system, which resulted into a type of dual action controller with velocity feedback and velocity error feedback terms. Some limited improvements were obtained in disturbance rejection properties and robustness with respect to some parameter variations. The conventional PI control dominates industry, it is simple and easy to implement [15]. Tuning of PI controllers is intuitive and is well accepted by practitioners. PIs can at most achieve a compromise in performance in terms of system response speed and stability, and this approach becomes insufficient at the increasingly high web velocities demanded by the industry and with thin or fragile materials. Nonlinearities that appear at high velocities, disturbance rejection properties and robustness to some parameter variations must be accounted for by the controller. A decentralized nonlinear PI controller is proposed to respond to this demand. The model of the winding system and in particular the model of the mechanical coupling are developed and presented in Section 2. Section 3 shows the controllers design for winding system. Section 4 shows the Simulation results using Matlab Simulink. Finally, the conclusion is drawn in Section 5.

II. SYSTEM MODEL

In this system, the motor M1 carries out unreeling and M3 is used to carry out winding, the motor M2 drives two rollers via gears “to grip” the band (Fig.1). The stage of pinching off can make it possible to isolate two zones and to create a buffer zone [8, 9]. The objective of these systems is to maintain the linear speed constant and to control the tension in the band.

The used motors are five phase induction motors type which each one is supplied by an inverter voltage controlled with Pulse Modulation Width (PWM) techniques. A model based on circuit equivalent equations is generally sufficient in order to make control synthesis. The electrical dynamic model of five-phase Y-connected induction motor can be expressed in the d-q synchronously rotating frame as [13]:

$$\begin{cases} \dfrac{di_{ds}}{dt} = \dfrac{1}{\sigma.L_s}.\left(-\left(R_s + \left(\dfrac{L_m}{L_r}\right)^2.R_r\right).i_{ds} + \sigma.L_s.\omega_e.i_{qs} + \dfrac{L_m.R_r}{L_r^2}.\phi_{dr} + \dfrac{L_m}{L_r}.\phi_{qr}.\omega_r + V_{ds}\right) \\ \dfrac{di_{qs}}{dt} = \dfrac{1}{\sigma.L_s}.\left(-\sigma.L_s.\omega_e.i_{ds} - \left(R_s + \left(\dfrac{L_m}{L_r}\right)^2.R_r\right).i_{qs} - \dfrac{L_m}{L_r}.\phi_{dr}.\omega_r + \dfrac{L_m.R_r}{L_r^2}.\phi_{qr} + V_{qs}\right) \\ \dfrac{d\phi_{dr}}{dt} = \dfrac{L_m.R_r}{L_r}.i_{ds} - \dfrac{R_r}{L_r}.\phi_{dr} + (\omega_e - \omega_r).\phi_{dr} \\ \dfrac{d\phi_{qr}}{dt} = \dfrac{L_m.R_r}{L_r}.i_{qs} - (\omega_e - \omega_r).\phi_{dr} - \dfrac{R_r}{L_r}.\phi_{qr} \\ \dfrac{d\omega_r}{dt} = \dfrac{P^2.L_m}{L_r.J}.(i_{qs}.\phi_{dr} - i_{ds}.\phi_{qr}) - \dfrac{f_c}{J}.\omega_r - \dfrac{P}{J}.T_l \end{cases} \tag{1}$$

Where σ is the coefficient of dispersion and is given by:

$$\sigma = 1 - \frac{L_m^2}{L_s L_r} \tag{2}$$

The tension model in web transport systems is based on Hooke's law, Coulomb's law, [8, 9] mass conservation law and the laws of motion for each rotating roll.

A. Hooke's law

The tension T of an elastic web is function of the web strain ε

$$T = ES\varepsilon = ES\frac{L - L_0}{L_0} \tag{3}$$

Where E is the Young modulus, S is the web section, L is the web length under stress and L0 is the nominal web length (when no stress is applied).

B. Coulomb's law

The study of a web tension on a roll can be considered as a problem of friction between solids, see [8] and [9]. On The roll, the web tension is constant on a sticking zone of arc length a and varies on a sliding zone of arc length g (cf. Fig.1, where Vk(t) is the linear velocity of the roll k). The web tension between the first contact point of a roll and the first contact point of the following roll is given by:

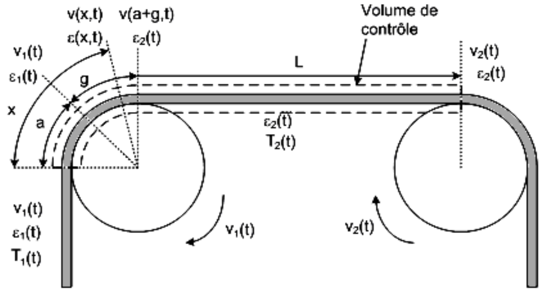


Fig. 1. Web Tension On The Roll

$$\begin{aligned} &\varepsilon(x,t) = \varepsilon_1(t) && \text{if } x \le a \\ &\varepsilon(x,t) = \varepsilon_1(t)e^{\mu(x-a)} && \text{if } a \le x \le a+g \\ &\varepsilon(x,t) = \varepsilon_2(t) && \text{if } a+g \le x \le L_t \end{aligned}$$

Where μ is the friction coefficient, And Lt = a + g + L. The tension change occurs on the sliding zone. The web velocity is equal to the roll velocity on the sticking zone.

C. Mass conservation law

Consider an element of web of length $L = L_0(1+\varepsilon)$

With a weight density ρ, under an unidirectional stress. The cross section is supposed to be constant. According to the mass conservation law, the mass of the web remains constant between the state without stress and the state with stress

$$\rho SL = \rho_0 SL_0 \Rightarrow \frac{\rho}{\rho_0} = \frac{1}{1+\varepsilon} \tag{4}$$

D. Tension model between two consecutive rolls.

The equation of continuity, cf. [8], applied to the web gives:

$$\frac{\partial\rho}{\partial t} + \frac{\partial(\rho V)}{\partial x} = 0 \tag{5}$$

By integrating on the variable x from 0 to Lt (cf. Fig. 1), taking into account (4), and using the fact that a + g << L, we obtain

$$\frac{d}{dt}\left(\frac{L}{1+\varepsilon_2}\right) = \frac{V_1}{1+\varepsilon_1} - \frac{V_2}{1+\varepsilon_2}.$$

Therefore:

$$-L\frac{d\varepsilon_2}{dt} = V_1\frac{(1+\varepsilon_2)^2}{1+\varepsilon_1} - V_2(1+\varepsilon_2). \tag{6}$$

This equation can be simplified by using the approximation $\varepsilon_1 << 1 \quad and \quad \varepsilon_2 << 1$

$$\frac{(1+\varepsilon_2)^2}{1+\varepsilon_1} \approx (1-\varepsilon_1)(1+2\varepsilon_2) \tag{7}$$

And using Hook's law, we get:

$$L_{k-1}\frac{dT_k}{dt} \cong ES(V_k - V_{k-1}) + T_{k-1}V_{k-1} - T_k(2V_{k-1} - V_k). \tag{8}$$

k = 2, 3, 4, 5.

where Lk−1 is the web length between roll k−1 and roll k, Tk is the tension on the web between roll k−1 and roll k, Vk is the linear velocity of the web on roll k, Ωk is the rotational speed of roll k, Rk is the radius of roll k, E is the Young modulus and S is the web section.

E. Roll velocity calculation

The law of motion can be obtained with a torque balance:

$$\frac{d(J_k\Omega_k)}{dt} = R_k(T_{k+1} - T_k) + Cem_k + C_f \qquad (9)$$

Where $\Omega_k = V_k / R_k$, is the rotational speed of roll k Cem_k is the motor torque (if the roll is driven) and Cf is the friction torque.

F. Complete model of the five motors system

Fig.2 shows a typical five motors system with winder, unwinder, and three tractors.

The complete model of this system is given by the following equations:

$$\left\{\begin{array}{l}
L_2\dfrac{dT_3}{dt} = ES(V_3 - V_2) + T_2V_2 - T_3V_3. \\[2ex]
L_3\dfrac{dT_4}{dt} = ES(V_4 - V_3) + T_3V_3 - T_4V_4\,. \\[2ex]
L_4\dfrac{dT_5}{dt} = ES(V_5 - V_4) + T_4V_4 - T_5V_5\,. \\[2ex]
\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad (10) \\[2ex]
\dfrac{d(J_1(t)\Omega_1)}{dt} = R_1(t)T_2 + C_{em1} - f_1(t)\Omega_1. \\[2ex]
\dfrac{d(J_2\Omega_2)}{dt} = R_2(T_3 - T_2) + C_{em2} - f_2(t)\Omega_2. \\[2ex]
\dfrac{d(J_3\Omega_3)}{dt} = R_3(T_4 - T_3) + C_{em3} - f_3(t)\Omega_3. \\[2ex]
\dfrac{d(J_4\Omega_4)}{dt} = R_4(T_5 - T_4) + C_{em4} - f_4(t)\Omega_4.
\end{array}\right.$$

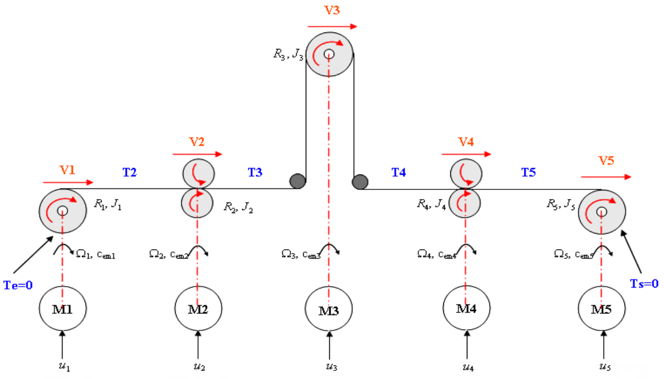


Fig. 2. Simple Web Winding System

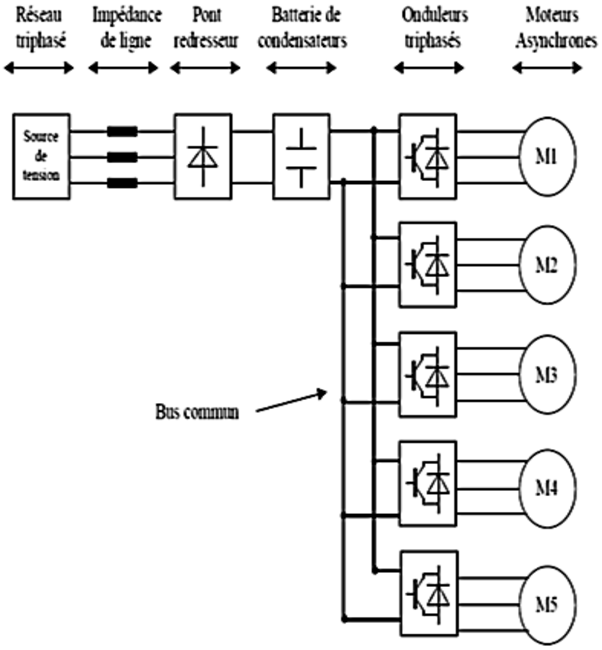


Fig. 3. Electrical part of the five drive system

III. CONTROLLER DESIGN

A. Linear speed Controller Design

The speed controller permits to determine the reference torque, the mechanical equation defined as

$$\frac{\omega_r}{C_{em}} = \frac{P}{f_c + J \cdot s} \qquad (10)$$

The diagram of speed controller as shown below

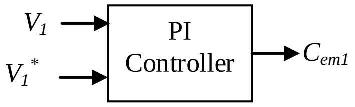


Fig. 4. Linear Speed Controller

The parameters of the PI controller is

$$K_{i\omega} = \frac{2 \cdot J \cdot \rho_{\omega}^{2}}{P} \tag{11}$$

$$K_{p\omega} = \frac{2 \cdot \rho_{\omega} \cdot J - f_c}{P} \tag{12}$$

B. Tension Controller Design

The proposed tension controller in the system permits to get a linear speed of reference in relation with the strength tension. Thus, we can use (8) as follows:

$$\frac{dT_i}{dt} = \frac{1}{L}\left[-V_{i-1}(ES + T_{i-1}) + V_i(ES - T_i)\right] \tag{13}$$

While achieving the linearization

$$V_a = -V_1(ES + T_1) \tag{14}$$

The eq (10) become

$$\frac{dT_i}{dt} = \frac{1}{L}\left[V_a + V_i(ES - T_i)\right] \tag{15}$$

While introducing the anticipatory term $V_a = U + V_b$ where $V_b = -V_i(ES - T_i)$ then we gets

$$\frac{dT_i}{dt} = \frac{1}{L}U \tag{16}$$

This equation allows us to define the structure of controller shows in the Fig 3. Note that this structure contains a controller, an anticipation term as well as a linearization.

This equation allows us to define the structure of controller shows in the Fig 5. Note that this structure contains a controller, an anticipation term as well as a linearization.

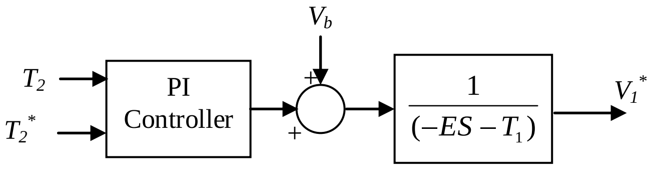


Fig. 1. Tension Controller

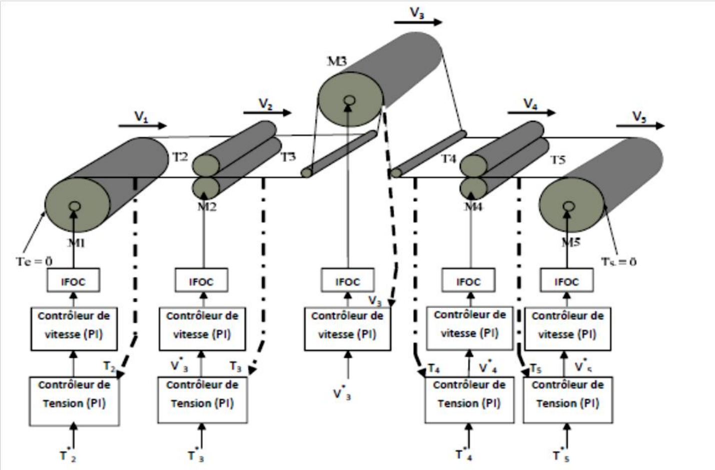
Where the parameters of the PI controller are

$$K_P = 2\rho L \tag{17}$$

$$K_I = 2\rho^2 L \tag{18}$$

In the sequel, the decentralized structure shown on (Fig.4) will be considered. The control structure is composed of 5 elementary controllers associated respectively to each motor.

The cascade control configuration uses the tension as primary measurement and velocity as secondary measurement. The manipulated variable is the torque applied to the motors.


V₁
V₂
V₃
V₄
V₅
M1
M2
M3
M4
M5
T2
T3
T4
T5
Tc = 0
Tc = 0
IFOC
IFOC
IFOC
IFOC
IFOC
Contrôleur de vitesse (PI)
Contrôleur de vitesse (PI)
Contrôleur de vitesse (PI)
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Contrôleur de Tension (PI)
Contrôleur de Tension (PI)
T₂
V*₃
T₃
V₃
V*₃
T₄
V*₄
T₅
V*₅
T*₂
T*₃
T*₄
T*₅

Figure.4. Control structure of a winding system (PI)

IV. Simulation Results

The winding system we modeled is simulated using MATLAB SIMULINK software and the simulation is carried out on 10s. To evaluate system performance we carried out numerical simulations under the following conditions:

Start with the linear velocity of the web of 5m / s.

The motor M1 has the role of Unwinder a roll radius R1 (R1 = 2.25 m).

The motors M2, M3, M4 are the role is to pinch the tape.

The motor M5 has the role of winding a roll of radius R5. The aims of the STOP block is to stop at the same time the different motors of the system when a radius adjust to a desired value (for example R5 = 0.8 m), by injecting a reference speed zero.

As shown in Fig (5, a b c d e), an improvement of linear speed, moment of inertia, belt tension, torque, and radius of the coil, and has follows the reference speed for PI controller after 1 sec, in all motors.

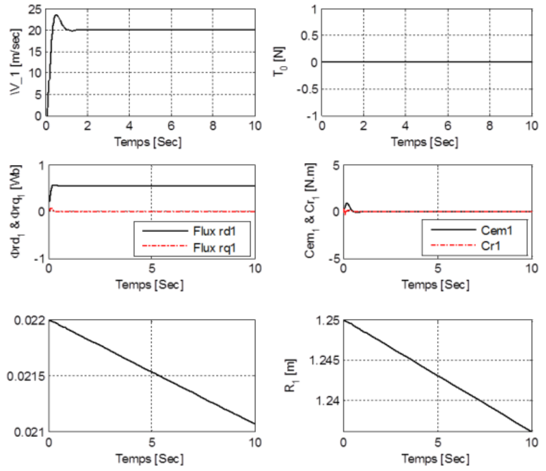

Fig. 5. a): Simulation results of the first motor

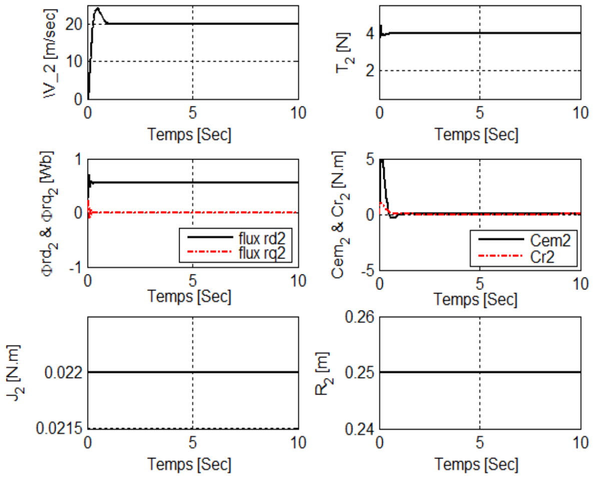

Fig. 5. b): Simulation Results Of The Second Motor

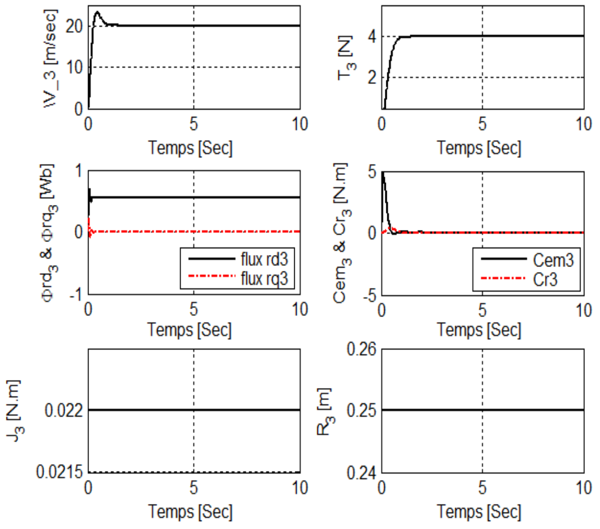

Fig. 5. c): Simulation Results Of The Third motor

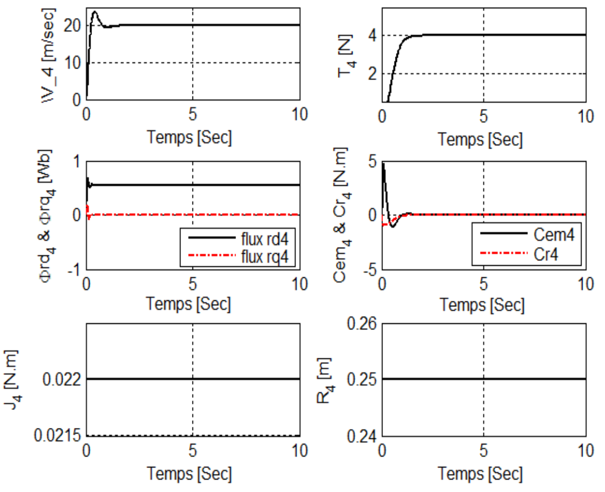

Fig. 5. d): Simulation Results Of The Fourth Motor

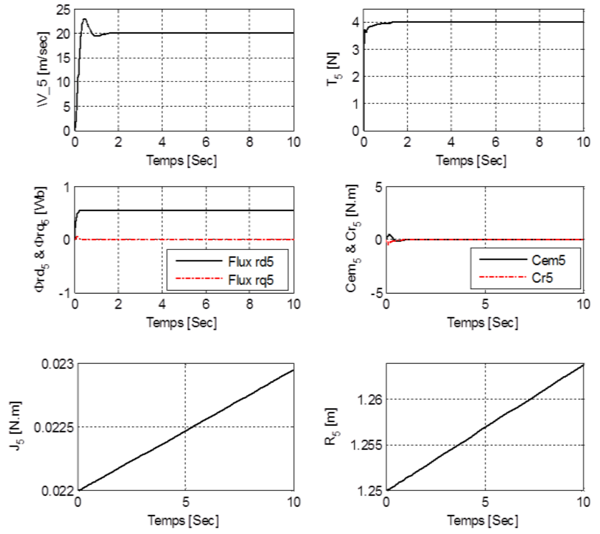

Fig. 5. e): Simulation Results Of The Fifth Motor

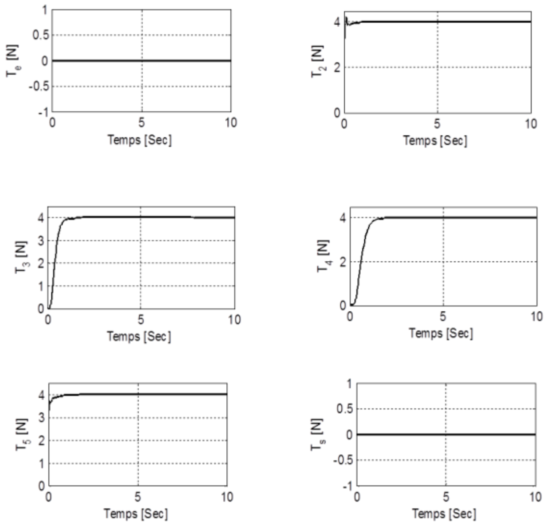

Fig. 6. The Tension Of The Strip

From the figures (6), we can say that: the tension follows the reference tension with application of PI controller.

It appears clearly that the classical control with PI controller in linear speed control and tension control offers better performances in both of the overshoot control and the tracking error. However is easy to apply.

V. Conclusion

The objective of this paper consists in developing a model of a winding system constituted of five motors that is coupled mechanically by a strap whose tension is adjustable and to develop the methods of analysis and synthesis of the commands robust and their application to synchronize the five sequences and to maintain a constant mechanical tension between the rollers of the system.

Computer simulations show the robustness and the performance of the winding system with the PI controllers, however PI control dominates industry and it is simple and easy to implement.

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TABLE I. SYSTEM PARAMETERS

E	1.6e8	L_1= L_2= L_3[m]	5
S [m^2]	2.75e-3	f_n [Hz]	50
R_1 [m]	1.25	T_{1ref}= T_{2ref} [N]	4
R_2=R_3 [m]	0.25	V_{2ref} [m/s]	20
J_{01}=J_{02}= J_{03}[Kg.m^2]	0.022	*p*	2

The Visual Web User Interface Design in Augmented Reality Technology

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***Abstract*—Upon the popularity of 3C devices, the visual creatures are all around us, such the online game, touch pad, video and animation. Therefore, the text-based web page will no longer satisfy users. With the popularity of webcam, digital camera, stereoscopic glasses, or head-mounted display, the user interface becomes more visual and multi-dimensional. For the consideration of 3D and visual display in the research of web user interface design, Augmented Reality technology providing the convenient tools and impressive effects becomes the hot topic. Augmented Reality effect enables users to represent parts of the digital objects on top of the physical surroundings. The easy operation with webcam greatly improving the visual representation of web pages becomes the interest of our research. Therefore, we apply Augmented Reality technology for developing a city tour web site to collect the opinions of users. Therefore, the website stickiness is an important measurement. The major tasks of the work include the exploration of Augmented Reality technology and the evaluation of the outputs of Augmented Reality. The feedback opinions of users are valuable references for improving AR application in the work. As a result, the AR increasing the visual and interactive effects of web page encourages users to stay longer and more than 80% of users are willing to return for visiting the website soon. Moreover, several valuable conclusions about Augmented Reality technology in web user interface design are also provided for further practical references.**

Keywords- Visual Represeantion; User Interface Design; Augmented Reality; Google SketchUp

I. INTRODUCTION AND RESEARCH BACKGOUND

With the popularity of webcam, digital camera, stereoscopic glasses, or head-mounted display, the user interface becomes more visual and diverse. It's an interesting time to be working on the visual web user interface now. The web pages evolved from a text-based system to the current rich and interactive medium that supports images, 2D graphics, audio and video. There is no question of the coolness of Augmented Reality Technology. We have seen many world-class brands like Lego, Star Wars, and Avengers commercialize the technology. Many Enterprises start to pursue developing the web sites based on Augmented Reality technology.

It was in the late 60’s that researchers started to describe how and where people interacted with technology. The term ‘augmented reality,’ however, was not coined until the early 90’s, when airplane manufacturer Boeing started using augmented reality goggles to assist engineers in the airplane assembling process. Recently, Augmented Reality enables you to represent parts of the digital world on top of the physical world. Augmented Reality is a hot topic that is growingly attracting attention of the developers of web user interface. This is sometimes reinforced by the fact that available tools for 3D UIs are toolkits, interface builders, rendering engines, etc. Moreover, rendering skill is mostly used in the work for increasing the visual representation. As a result, the user interaction and visual design in 3D are becoming more and more popular.

The research work increases the visual web page design in Augmented Reality. The purpose is to explore the feasibility of Augmented Reality in web page design. The web page design skill with text-based, image-based, flash-based design is no longer popular. With the extremely increasing new users of online games, the visual effect becomes an important element of web page design since the users are used to the visual representation on the screen. The research work builds a city tour web site in Augmented Reality tasks. We also do the evaluation for collecting the opinions of users for modifying the research direction. Therefore, the research result contains the skillful comments of Augmented Reality tools as well as the practical suggestion for further visual web page design.

II. RELATED WORK

The webcam and mobile phone and diverse devices have led to a complete redesign on the traditional User Interface (UI). There is a new emphasis on intuitive ease of use. Moreover, the development of 3D User Interfaces (UIs) mostly remains an art more than a principled-based approach.

Several methods have been introduced to decompose this life cycle into steps and sub-steps, but these methods rarely provide the design knowledge that should be typically used for achieving each step [1][9][17].

A. Visual User Interface Design

User interface design or user interface engineering is the design of computers, appliances, machines, mobile communication devices, software applications, and websites with the focus on the user's experience and interaction. Web user interface focuses on the web page design to link users and web content.

Visual user interfaces have been regarded as one of the most promising routes. They exploit powerful human vision and spatial cognition. Carefully designed visual user interfaces can shift the user's mental load from slow reading to faster perceptual processes such as visual pattern recognition. Visual interfaces should support information exploration and bring users' attention [5][8].

Text-based web page is not suitable for the current modern users. Therefore, visual presentation is an important topic. More visual and interactive web operations are more crucial for web pages. With the stimulation of 3D tools, Augmented Reality tools are used for improving the presentation of web content. Unlike images or video, the user can operate and control the display of web objects. Therefore, more relative research topics become popular.

B. Augmetned Reality

The goal of Augmented Reality is to add information and meaning to a real object or place. The field of Augmented Reality (AR) has existed for just over one decade, but the growth and progress in the past few years has been remarkable. In 1997, the first author published a survey [1][2] and defined the field, described many problems, and summarized the developments up to that point. Since then, the field has grown rapidly.

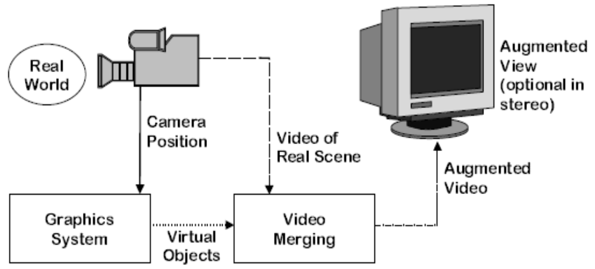


Fig. 1. The Explanation Of Augmented Reality Effect

Unlike virtual reality, augmented reality does not create a simulation of reality. Instead, it takes a real object or space as the foundation and incorporates technologies that add contextual data to deepen a person's understanding of the subject, as shown in Figure 1[26]. Many popular applications of AR successfully developed in various fields are explained as follows.

- Advertising and marketing: Marketers started to use AR to promote products via interactive AR applications. From Toyota to Nivea to Disney, a diverse array of brands has applied AR bandwagon for creating hype interaction with consumer.
- Task support: Complex tasks such as assembly, maintenance, and surgery can be simplified by inserting additional and useful information with AR technology. Some complicated repair works depend on AR information as well. Moreover, some restaurants provide the AR-enabled menu for users to 'see' the food first before they enjoy the food.
- Product design: AR can simulate planned products, including architecture, machine, car and more objects for better design discussion in advance.
- Navigation: AR can create virtual objects in museums and exhibitions, theme park attractions and books. The overlay between real and virtual worlds always makes novel navigation for users.

C. Redering Technique

Rendering is the final process of creating the actual 2D image or animation from the prepared scene. This can be compared to taking a photo or filming the scene after the setup is finished in real life. Several different, and often specialized, rendering methods have been developed. Rendering (computer graphics), generating an image from a model by means of computer programs. Many types of rendering are given as follows:

- 3D rendering, generating image or motion picture from virtual 3D models.
- High dynamic range rendering allows preservation of details that may be lost due to limiting contrast ratios.
- Non-photorealistic rendering, focuses on enabling a wide variety of expressive styles for digital art.
- Scanline rendering, algorithm for visible surface determination.
- Volume rendering, used to display a 2D projection of a 3D discretely sampled data set

Rendering engine has different types. Two major types are explained as follows.

- Game engine, system designed for the creation and development of video games.
- Web browser engine, software that takes information and displays the formatted content on the screen

D. Evaluation Method

The evaluation for user interface causes many discussions. From the perspectives of usability, the experts "inspect" your interfaces during formative evaluation and widely used in practice. Three major evaluation strategies which are considered to be used in the research are explained as follows:

- Heuristic Evaluation - Heuristic evaluations were introduced by Nielsen and Molich in 1990 in the influential paper "Heuristic Evaluation of User Interfaces" and later assembled as part of a book [23][27]. Usability inspection method for computer software that helps to identify usability problems in the user interface (UI) design. It specifically involves evaluators examining the interface and judging its compliance with recognized usability principles (the "heuristics"). An additional practical problem is that multiple usability experts should be used. It can often be more expensive and difficult to find many usability professionals.
- Cognitive Walkthroughs - A cognitive walkthrough is also a usability inspection method like heuristic evaluation but the emphasis is on tasks. The idea is basically to identify users' goals, how they attempt them in the interface, then meticulously identify problems

users would have as they learn to use an interface. The method was also introduced at the same conference as Heuristic Evaluation (Lewis et al 1990). The cognitive walkthrough was an extension of earlier work by Polson and Lewis [15].

- Pluralistic Walkthroughs - A pluralistic walkthrough is a usability inspection method whereby representative users (normally played by the evaluators), developers and usability experts, step through a scenario, discussing the usability issues associated with each scenario step. Also known as storyboarding, the method involves the development of a series of tasks, presented to a panel of users in the form of hard-copy panels; the panelists are then asked to write down the actions they would take to complete the task [4].

III. RESEARCH FLOW AND IMPLEMENTATION

A. Development Flow

The research development flow containing four phases is explained as follows.

- The Concept phase - In the beginning, the concept of visual representation is the first idea. Then, the subject of web has to be decided. Not all the pages are suitable for visual effects. Therefore, the topic of city tour becomes the interesting work.
- The Implementation and Content Development phase – Many web design tools and Augmented Reality tool are applied in the phase. Building models, rendering pictures, web page design and Augmented Reality effects are the major efforts in the phase. Google SketcUp and 3D Max are the tools for building models. It is pretty time consuming, but the output is really inspiring and exciting. The well-constructed models are helpful for generating good Augmented Reality effects.
- The User Interaction Phase – With the identification card of Augmented Reality, the user can control the representation of Augmented Reality on the screen. The output of real world and virtual objects combing together is really interesting for users.
- The Evaluation Phase - Heuristic evaluation is the most popular of the usability inspection methods. Heuristics Evaluations is done prior to and in addition to user-testing, not instead of user-testing. The feedback of evaluation is important for design improvement.

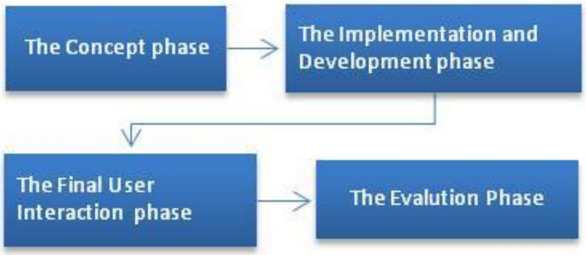

The Concept phase
The Implementation and Development phase
The Final User Interaction phase
The Evalution Phase

Fig. 2. The research development flow

B. The Augmented Reality Implement and Research Ouput

The index page of the web system is shown in Figure 3. It is the first image of the web to users. According to the opinions of users, the 3D-like, colorful and visual image brings lots of attention and they are attracted to stay on the site. The rendering technique is well applied for the effect. Rendering is the process of generating an image from a model, by means of computer programs. Many rendering software with SketchUp for rendering purposes are provided for different purposes, such light, motion or realism. There are Kerkythea, TrueSpace, Blender, Vue, and Podium are among the most popular rendering applications for SketchUp [28]. The rendering images used for the index page is one of successful designs in the work.

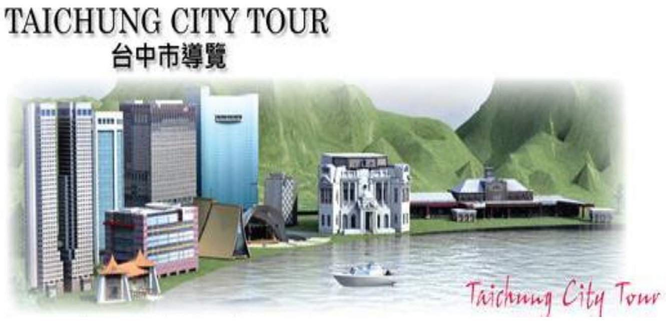


Fig. 3. The index page of the city tour web

Building models and make Augmented Reality effect are two major tasks. Googld Sketch Up and FLARTookit are used in the phases. Google SketchUp is a free, fun, easy-to-use 3D modeling application. Originally created for architects and designers, SketchUp is also a great tool for teaching geometry. FLARToolKit recognize the marker from input image, and calculate its orientation and position in 3D world. FLAToolKit has support for all major flash 3D graphics engine.

In order to explain the different effects of traditional 2D-like picture and 3D-like Augmented Reality technology, an example of the Mid-Lake Pavilion of Taichung Park is given below.

The picture of the Mid-Lake Pavilion shown in Figure 4 displays the 'real' outlook of the building. In the other hand, the model of the Pavilion built with Google SketcUp given is given in Figure 5. According to the users' opinions, they spend more time to look the 3D-like model rather than picture. The model catches users' eyes immediately after they browse the web. The visual effect works again. We collect many opinions from users for improving the built models and page design.

Furthermore, the user will like to pay more attention to operate the Augmented Reality function. Since the webcam is easy to setup with the PC, the user can easily play with the Augmented Reality card to view the Pavilion model, as shown in Figure 6. The user can control the direction of the identification card to view the model from different angles and directions. With the Augmented Reality operation, the attached introduction information will possibly get the attention of users, as shown in Figure 7. As long as the user read the introduction, the major function of city tour website is herein fulfilled.

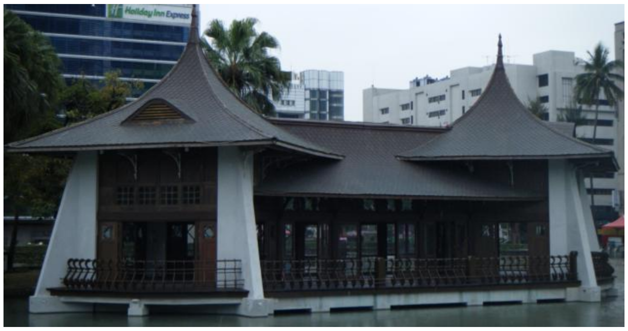


Fig. 4. The picture of the Mid-Lake Pavilion of Taichung Park

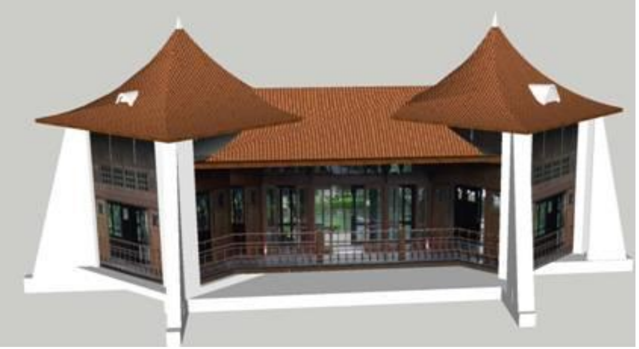


Fig. 5. The built model of the Mid-Lake Pavilion of Taichung Park

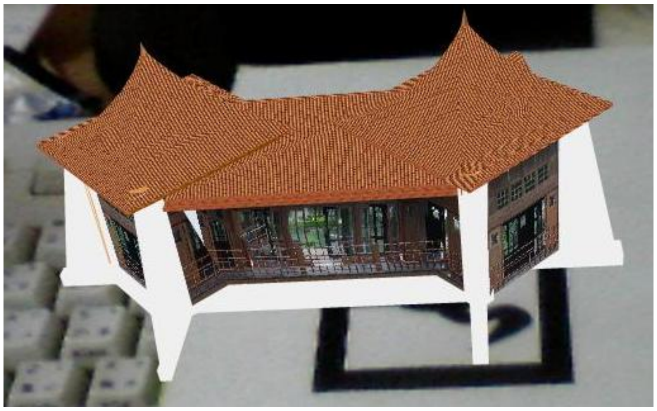
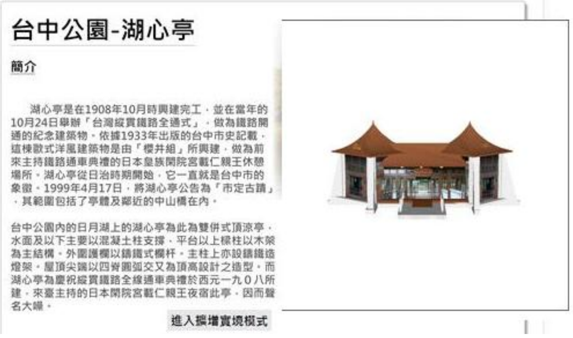


Fig. 6. The AR operation of the Mid-Lake Pavilion of Taichung Park



台中公園-湖心亭

簡介

湖心亭是在1908年10月時興建完工，並在當年的10月24日舉辦「台灣縱貫鐵路全通式」，做為鐵路開通的紀念建築物。依據1933年出版的台中市史記載，這棟歐式洋風建築物是由「櫻井組」所興建，做為前來主持鐵路通車典禮的日本皇族閑院宮載仁親王休憩場所。湖心亭從日治時期開始，它一直就是台中市的象徵。1999年4月17日，將湖心亭公告為「市定古蹟」，其範圍包括了亭體及鄰近的中山橋在內。

台中公園內的日月湖上的湖心亭為此為雙併式頂涼亭，水面及以下主要以混凝土柱支撐，平台以上樑柱以木架為主結構。外圍護欄以鑄鐵式欄杆。主柱上亦設鑄鐵造燈架。屋頂尖端以四脊圓弧交叉為頂高設計之造型。而湖心亭為慶祝縱貫鐵路全線通車典禮於西元一九０八所建，來臺主持的日本閑院宮載仁親王夜宿此亭，因而聲名大噪。

Fig. 7. The complete introduction web page of the Mid-Lake Pavilion of Taichung Park

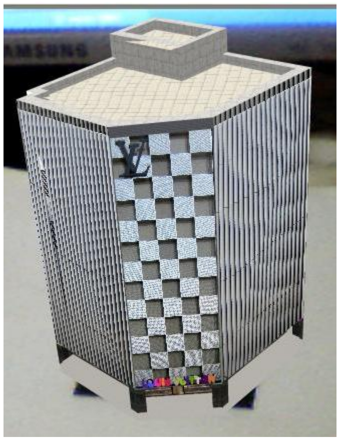


Fig. 8. The AR operation of one famous building in Taichung

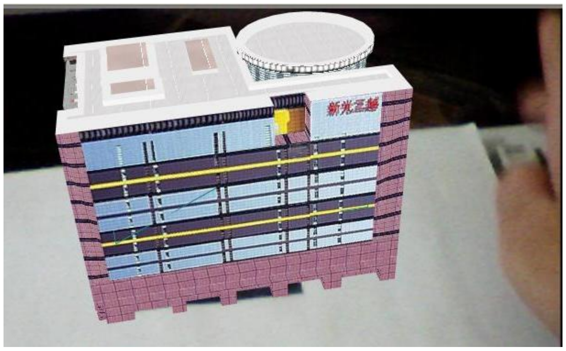


Fig. 9. The AR operation of the famous department building in Taichung

More famous buildings and parks are introduced with Augmented Reality effect on the web site, as shown in Figure 8 and Figure9. According to users' opinions, the interesting operation givens they lots of fun. As playing with the Augmented Reality effect, they read lots of introduction pages and know more interesting information about the city.

Another visual example is given as follows. The introduction of famous Taiwan food is also introduced in the website. The example is given in Figure 10 and Figure11. The rending design increases the visual effect of the web page. Most of the users who really like the visual design stay much longer on the webpage for reading the introduction of local famous food.

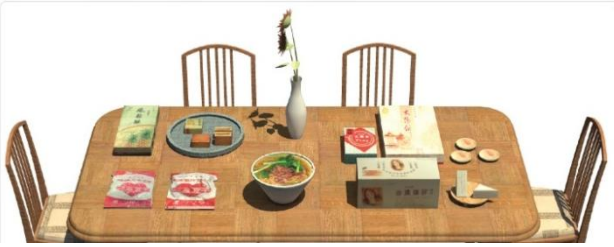


Fig. 10. The visual representtion of famous Taiwn food

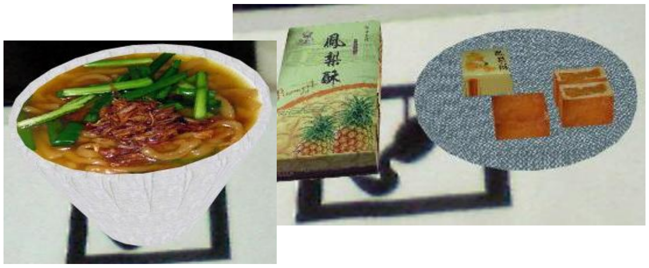


Fig. 11. The AR operation of Taiwan snack

RESEARCH DISCUSSION

To please users is not an easy job, but it is an important for keeping the web stickiness. However, a good web page designer has to rapidly cause the attention of users since web surfers have so much information available to them that they often get bored. In order to keep the user's attention, new technology is always a good try. Augmented Reality is such popular since the webcam and network become more convenient for PC users. The result is a rich combination of physical and virtual realities to increase the visual representation of web pages. The advantage is helpful for attracting the user's attention and interest. Therefore, the user stays longer on the page and possibly reads the supplied information on the website.

The first conclusion is that Augmented Reality technology increasing the visual web page design helps to attract the users' attention and increases the chance for users to read the information on the web pages. The visual representation in Augmented Reality is rapidly in progress currently and will become the main trend of mobile devices in the near future.

The second conclusion is that the 3D models have to be built closely to the real object. Do not cheat users with beautiful but fake models. Moreover, the third conclusion is that the easy operation of Augmented Reality technology is an important issue. Turn on the webcam automatically and shown the Augmented Reality effect quickly can help users continuously to enjoy the Augmented Reality application. Some users will give up since the system asks them to install the webcam or software.

During the research, we found the importance of attention management. Clear and concise graphics are the basic requirement of the web page design. Rendering design is such popular. However, some opinions imply that the 3D-like or visual model is sometimes embellished too much. It is easily cause the disapproval of users.

With Augmented Reality tasks the view of the real world behind the graphical annotations, and the interaction between the graphics and the real world, make Augmented Reality perception qualitatively different from anything previously studied. We will focus on the study of Augmented Reality technology for improving the representation skill. The user opinions are such important to increasing the opportunities of operations and business. Moreover, the application of Augmented Reality with smart phones is also interesting. To increase the user interactive operations for different experiences is always the research direction in the future.

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E-Government Grid Services Topology Based On Province And Population In Indonesia

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Abstract— **The e-Government Grid Service Model in Indonesia is an adjustments based on the framework of existing e-Government and also the form of government in the country. Grid-based services for interoperability could be a solution for resource sharing and interoperability of e-Government systems. In previous study, we designed and simulated the topology of Indonesian e-Government Grid services based on function group from e-Government application solution map to connect the ministry/agency/department /institution. In this paper we analyse the result of e-Government services topology simulation based on the province and population in the country.**

Keywords— e-Government; Grid Services; e-Government Grid

I. INTRODUCTION

Information and Communication Technologies (ICTs) has been pointed out as fundamental paths towards improving democracy and increasing people's participation in the decision-making process. It forces government to make new management patterns that related to issues of transparency, accountability, efficiency, effectiveness, service and other public policies in order to respon the community aspiration.

Public management reform is influenced by management progress of ICT, called e-Government (e-Gov) which is the use of information technology to perform activities of government services to the public. It is a permanent commitment made by the government to improve the relationship between the private citizen and the public sector through enhanced, cost-effective, and efficient delivery of services, information and knowledge [1].

Chen, et al [1] proposed that one needs to consider some factors such as History and Culture, Technical Staff, Infrastructures, Citizens and Government officers for studying e-Government of a country. For Indonesian case, these factors are provided in Table I.

In Indonesia, e-Government is needed to support the government change towards a democratic governance practices and to support the application of authority balances between central and local government. Indonesian E-Government is also needed to facilitate communication between central and local governments, to gain openness and transformation towards information society era.

TABLE I. FACTORS FOR STUDYING E-GOVERNMENT IN INDONESIA

Indonesia	
History and Culture	• Indonesia is a Republic with a presidential system, and a unitary state with power concentrated in the national government. • Since 1945, Indonesia has been struggling with democracy and after reformation in 1998, Indonesia has been experiencing a democratic movement generated in a new political conditions. • Although there are some problems of poverty, health and infrastucture, Worldbank reported as of July 2012, Indonesia's economy baseline outlook for growth is expected to be 6 percent in 2012 and increase to 6.4 percent in 2013 [2]
Technical Staff	• Indonesia has a large number of in-house staff but since there is no policy standard of e-Government implementation, the current staff unable to define specific requirements. • Some provinces in Indonesia have an ability to implement e-Government because of good financial and staff, but others still face some problems to implement it.
Infrastructure	• Since Indonesia has more than 17,000 islands and 33 provinces, in some areas with high population like Java island, there are superior current infrastructure and high internet access for employees and citizens, but in remote areas there are inferior current infrasturcture and low internet access for employees and citizens.
Citizens	• In a big city like Jakarta, Surabaya and others, there are high Internet access and citizens are trust in online services; many citizens know how to operate computers, but in a small town, there are low Internet access and citizens are reluctant to trust online services; few citizens know how to operate computers • Since Indonesia has a new experience of democracy after 1998 reformation, citizens more actively participate in governmental policy-making process
Government Officers	• Indonesia Government reported that in 2012 the number of Internet users in Indonesia significantly increased to 55 million, 25% of population in this country has access to computer and internet as well.

Changes are expected to build clean and transparent government which is capable to respond the changes effectively, to build a new dimension into organization, management system and process, and soon to apply the transformation process towards e-Government.

Since Indonesia have not yet implemented Grid technology to conduct e-Government services, we propose the e-Government Grid services topology based on the province and population. A topology of our scenario is a schematic description of the arrangement of a network.

Our proposal will give a new perspective to develop e-Government in Indonesia to achieve a good governance and a clean government. As developing country, the practice of e-Government Grid Services in Indonesia is facing some challenges in particular encountered by government organizational. The application of e-Government Grid Services in the public officials needs to be supported by the policy and employees who understand technology well.

A. E-Government Implementation Strategy

The United States, as the largest developed country, has one of the most advanced e-Government Infrastructures in the world that focuses on increasing effectiveness and efficiency of government work and at the same time, reducing costs [1].

In 2012, US Government launches new Digital Government strategy, entitled "*Digital Government*: *Building a 21st Century Platform to Better Serve the American People*". The Digital Government Strategy sets out to accomplish three things [3]:

1) Enable the American people and an increasingly mobile workforce to access high-quality digital government information and services anywhere, anytime, on any device. For interoperability and openness, modernize our content publication model, and deliver better, device-agnostic digital services at a lower cost.

2) Ensure that as the government adjusts to this new digital world, we seize the opportunity to procure and manage devices, applications, and data in smart, secure and affordable ways. Build a sound governance structure for digital services, and do mobile "right" from the beginning.

3) Unlock the power of government data to spur innovation across our Nation and improve the quality of services for the American people. Enable the public, entrepreneurs, and our own government programs to better leverage the rich wealth of federal data to pour into applications and services by ensuring that data is open and machine-readable by default.

B. E-Government Development Stages

According to the United Nations E-Government Survey in 2012, Indonesia increased its world e-Government ranking from 109 in 2010 into 97 in 2012. It showed that Indonesia have made a tremendous effort to provide e-Government services to its people, despite the challenges faced by the country.

The United Nations Department of Economic and Social Affairs [4] conducted an assessment of e-Government in large countries by evaluating the *information services* developed by the Government such as websites to provide information on public policy, governance, laws, regulations, relevant documentation and types of government services provided. It is expected that the websites have links to ministries, departments and other branches of government.

The next stage is to asses whether the *enhanced information service* is available which is expected that the government websites deliver enhanced one-way or simple two-way e-communication between government and citizen. Citizens can download forms for government services and applications. The sites also have audio and video capabilities and are multi-lingual, among others.

The next stage is to asses whether the *transactional services* engaged in two-way communication between government with their citizens, including requesting and receiving inputs on government policies, programmes, regulations, etc. In this stage, some form of electronic authentication of the citizen's identity is required to successfully complete the exchange. Government websites process financial and non-financial transactions.

And the last stage of e-Government in large countries is connected service where the government websites have changed the way governments communicate with their citizens from a government-centric to a citizen-centric approach.

C. E-Government in Indonesia

The Indonesian Central Government (called the Government) is the President and its supporting units which holds the power of the government as defined in the Constitution of the Republic of Indonesia Year 1945 [5]. To conduct governance, the Government uses the principle of Desentralisation, Deconsentration and Task Assistance [6]. Government in conducting the government affairs has a relationship with the local governments. This relationship includes the authority relationships, finances, public services, resource utilization, and other resources.

The initiative of e-Government in the country was introduced through President's Instruction No. 6/2001 dated 24 April 2001 on Telematika (Telecommunication, Media, and Information) which states that government officials should use the technology of Telematika to support good governance and to accelerate democracy process. Furthermore, e-Government should be publicized for different objectives to the governmental offices. Public administration is one of areas in which Internet can be used to provide access for citizens who constitute basic service and to simplify the relations between citizens and government [7].

The initiative is then enhanced by Presidential Instruction No.3 Year 2003 on National Policy and Strategy of e-Government Development. It is an effort to build an electronic-based governance in order to improve the quality of public services effectively and efficiently. E-Government development means that management systems and work processes are reorganized within governmental agencies to optimize the utilization of information technology [8].

Some factors to consider for developing e-Government in Indonesia were proposed in[8], they are:

1) Consistently approach to the citizens, businesses, employees and local government in conducting a business transaction with the central government.

2) Development a shared strategic vision at all levels to build e-Government, including the technical architectures.

3) The design of standards-based approach to implement e-Government

4) Cooperation and collaboration among all parties to make e-Government policy.

There have been various types and specifications of technology that was implemented by each government agency. Determination to apply a particular technology on e-Government implementation will impact on the investment that has been expent by each agency. This can lead to enormous waste and state financial harm for the whole country. Access, infrastructure and basic applications is the key components to support the implementation of public services portal by information management and processing organization.

As the developing country, Indonesia has some strategic plans to develop e-Government as follows [9]:

1) To develop a good service system with reasonable cost. The focus are to extend and improve the quality of information and communication network, to build the information portals and integrated public services, to build the electronic document management system, standardization and information security system;

2) To develop management system of central and local government. The focus are to improve the quality of services needed by the community, to manage the changes, to enforce the leadership and to improve the product of the regulation.

3) To optimize the use of information technology. The focus are on building the interoperability, standardization and procedure of electronic document management system, information security, basic application (e-billing, e-reporting) and to develop inter government network.

4) To improve the participation of private sector and information technology industry. The focus are to use the expertise of the private sector, to encourage participation of private sector and small industries.

5) To develop manpower capacity in the central and local government. The objectives are to develop ICT culture in government institutions, to optimize the use of ICT training facilities, to extend the use of ICT for distant learning, and to put ICT as input for school curriculum and to improve the quality of teaching.

Data and information integration is important among government agencies in Indonesia. It needs to formulate methods and technology of collaboration. The requirements of a broader and comprehensive data interaction among government agencies, especially in the use of data and information together should be encouraged.

Interoperability concepts and strategies are crutial agenda of the national e-Government development to achieve integrated, safe and efficient utilization of data and information. Interoperability is defined as system ability to share and integrate information and work processes using a set of standards. One of solutions to the interoperability problem is using Grid technology. Open grid services aim for the integration of services across distributed and heterogeneous virtual organizations with disparate resources and relationships [10].

E-Government interoperability can be addressed using a cross-organizational workflow [11][12][13][14] and semantic web or semantic driven [15][16][17].

Yang, et al [18] proposed a service-grid-based framework for Shanghai e-Government interoperability, named eGov Grid, which targets at facilitating among "horizontal" organizations and interoperability among "vertical" e-Government subsystems. Hereinafter, "horizontal" means cross-organizational application, and "vertical" means information system within one organization. According to Yang, et al [18], service grid [19] is a kind of combination of grid computing [20] and SOA technology, open up a new way for cross-organizational resources integrating and collaboration in e-Government. Service grid technologies can be used to build the platform resource sharing in e-Government system, and also bring new feature of better reusability, flexibility and scalability.

II. Design and Simulation of e-Government Grid Services in Indonesia

Grid has proven resolve the problem of resources sharing on information that placed separately and dynamic including the sharing of data structures, databases, computational resources, storage resources, and other information using open-standard protocols. The use of open-source to meet the requirement of the e-Government that have already designed a set of middleware to support the E-government applications is necessary and it can reduce the cost of the government and fully utilize the IT resources existing in the government [21].

There have been various types and specifications of technology that was implemented by each government agency. Determination to apply a particular technology on e-Government implementation will impact on the investment that has been expended by each agency. This can lead to enormous waste and state financial harm for the whole country. Access, infrastructure and basic application is the key components to support the implementation of public services portal by information management and processing organization. We have proposed a function group based of Indonesian e-Government services topology as the result of the simulation using three different types of scenarios to see whether the effects of the formation or hierarchy of links and router configurations–which connect the ministry / agency / department / institution that have functions to serve the public/citizens (G2C), business groups (G2B), inter-agencies (G2G) and services to employees (G2E). Indonesia requires major infrastructure development hence a great amount of investment. The separation of basic application and function application make the interoperability processes easier because specific services are made in cluster. The division of the application also influences the development of e-Government Grid Services independently and gradually [22].

In this paper, we simulate scenarios based on province and population in Indonesia. Our topology and scenarios follow that of Suhartanto, et al [23] with some modification for e-Government purpose. In our topology, we considered the government of Indonesia data consisting of 33 provinces, 370 regencies and 95 municipals [24] and also the number of population of each province based on results of 2010 population cencus by Indonesian Statistics Office [25]. Although the Minister of Internal Affairs of Indonesia said the moratorium or suspend the expansion area will be in place until the end of 2012 but in fact, at October 22, the parliament of Indonesia and the Government agreed for the addition of new province in Indonesia, that is North Kalimantan which is the division of the province of East Kalimantan. It will take 3-5 years for the preparation of new province infrastructures, so we used the number of province that has been in operation and have an administrative service to the citizens.

These are given details in the Table II.

To evaluate and analyze the performance of a Grid system topology, the experiment must be repeatable and controlled. It will be hard to conduct heterogeneous and dynamic Grid system. In addition developing environment for testing Grid systems is very limited, expensive and time consuming and it also should handle administration different policy on each resource. Thus, it needs a simulation to study the behavior of Grid system and implement some complex scenarios to see the behavior of the system. Simulations can be performed on a single computer so that the cost, time of development and other barriers can be overcome. As our previous works, In the simulation, we also used GridSim of Buyya and Murshed [26].

We design the simulation that consists of three scenarios based on various configurations of the router and link connections. We use three different types of scenarios to see whether the effects of the formation or hierarchy of links and router configurations–which connect the province grouped by island and region. Simulations are performed using three scenarios based on the link connectivity and router configurations hierarchically to determine the effect of the configuration of the links and routers that are connected. The three scenarios will show the shortest processing time in the grid services. We use FIFO (First In First Out) scheduling algorithm and SCFQ (Self-cCocked Fair Queuing) scheduling algorithm.

A. *First Scenario*

The first scenario divides the country into three region according to its time division, namely west Indonesia consisting of Sumatera and Java islands, central Indonesia consisting of Kalimantan, Sulawesi, Bali and Lombok Islands, and east Indonesia consisting of Maluku and Papua islands. The scenario involves three types of routers that are configured hierarchically which consist of leaf routers, edge routers and core routers. The leaf router is a router that is connected directly to hosts on the network.

TABLE II. PROVINCE AND POPULATION IN INDONESIA

o	Province	Regency	Municipal	Population
1	Nanggroe Aceh Darussalam	18	5	4,494,410
2	Sumatera Utara	21	7	12,982,204
3	Sumatera Barat	12	7	4,846,909
4	Riau	9	2	5,538,367
5	Jambi	9	1	3,092,265
6	Sumatera Selatan	11	4	7,450,394
7	Bengkulu	8	1	1,715,518
8	Lampung	9	2	7,608,405
9	Kep. Bangka Belitung	6	1	1,223,296
10	Kepulauan Riau	4	2	1,679,163
11	DKI Jakarta	1	5	9,607,787
12	Jawa Barat	17	9	43,053,732
13	Jawa Tengah	29	6	32,382,657
14	Daista Yogyakarta	4	1	3,457,491
15	Jawa Timur	29	9	37,476,757
16	Banten	4	3	10,632,166
17	Bali	8	1	3,890,757
18	Nusa Tenggara Barat	7	2	4,500,212
19	Nusa Tenggara Timur	19	1	4,683,827
20	Kalimantan Barat	12	2	4,395,983
21	Kalimantan Tengah	13	1	2,212,089
22	Kalimantan Selatan	11	2	3,626,616
23	Kalimantan Timur	10	4	3,553,143
24	Sulawesi Utara	9	4	2,270,596
25	Sulawesi Tengah	9	1	2,635,009
26	Sulawesi Selatan	20	3	8,034,7

				76
27	Sulawesi Tenggara	10	2	2,232,586
28	Gorontalo	5	1	1,040,164
29	Sulawesi Barat	5	-	1,158,651
30	Maluku	7	2	1,533,087
31	Maluku Utara	6	2	1,038,087
32	Papua	20	1	2,833,381
33	Papua Barat	8	1	760,442

A host can be either a user's computer or resources on the Grid system and the function of the leaf router is to handle packets movements into or out of the host. The leaf routers are connected by an edge router that is situated in a central core router. A central core router is a router in the core network and serves the whole sub-network into a single large network. A baud rate for a link that connects a whole host with leaf router is set at 10 Mbps (megabits per second), while the baud rate for a link that connects the leaf router with edge router is set at 100 Mbps and the baud rate for the a link that connects all the edge router with central router is set at 1 Gbps (gigabit per second) because edge router have a function to forward packets in between networks. Core routers due to their role as internet backbone routers, support multiple telecommunication interfaces with high data throughput. A baud rate for link among core router is set at 500 Mbps.

Fig. 1 shows the network topology for the first scenario.

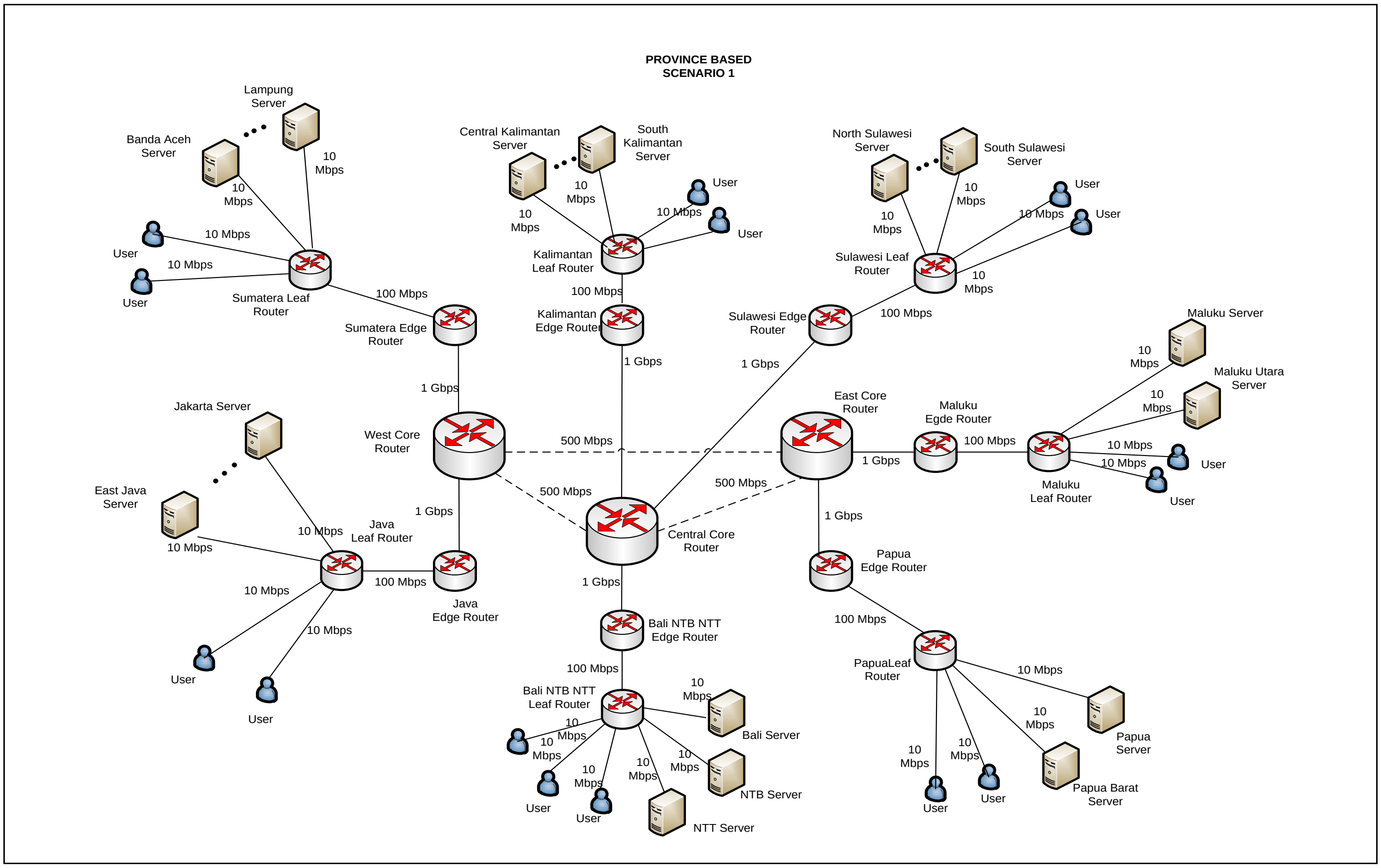

Fig. 1. First Scenario

B. Second Scenario

The second scenario is almost similar to the first scenario. The difference is that this scenario involve two types of routers, they are leaf routers and edge routers which configured hierarchically. The leaf routers are connecting the hosts to edge router and all the edge routers are connected by high-speed network between routers. A baud rate for a link that connects all hosts with leaf router is set at 10 Mbps. A leaf router is responsible to gather group information. While the baud rate for link that connects leaf router with edge router is set at 100 Mbps and the baud rate for link that connects edge router is set at 1 Gbps so that the edge router can forward packets in between networks faster.

Fig. 2 shows the network topology for the second scenario.

C. Third Scenario

The third scenario represents the whole province of the government structure. In this scenario, each province group by island/archipelago that coordinated by leaf router. The leaf router will receive the first packets from each province and gathering information from group. All the leaf routers are connected by services with high-speed network among routers. Baud rate for link among leaf router is set at 100 Mbps.

Fig. 3 shows the network topology for the third scenario.

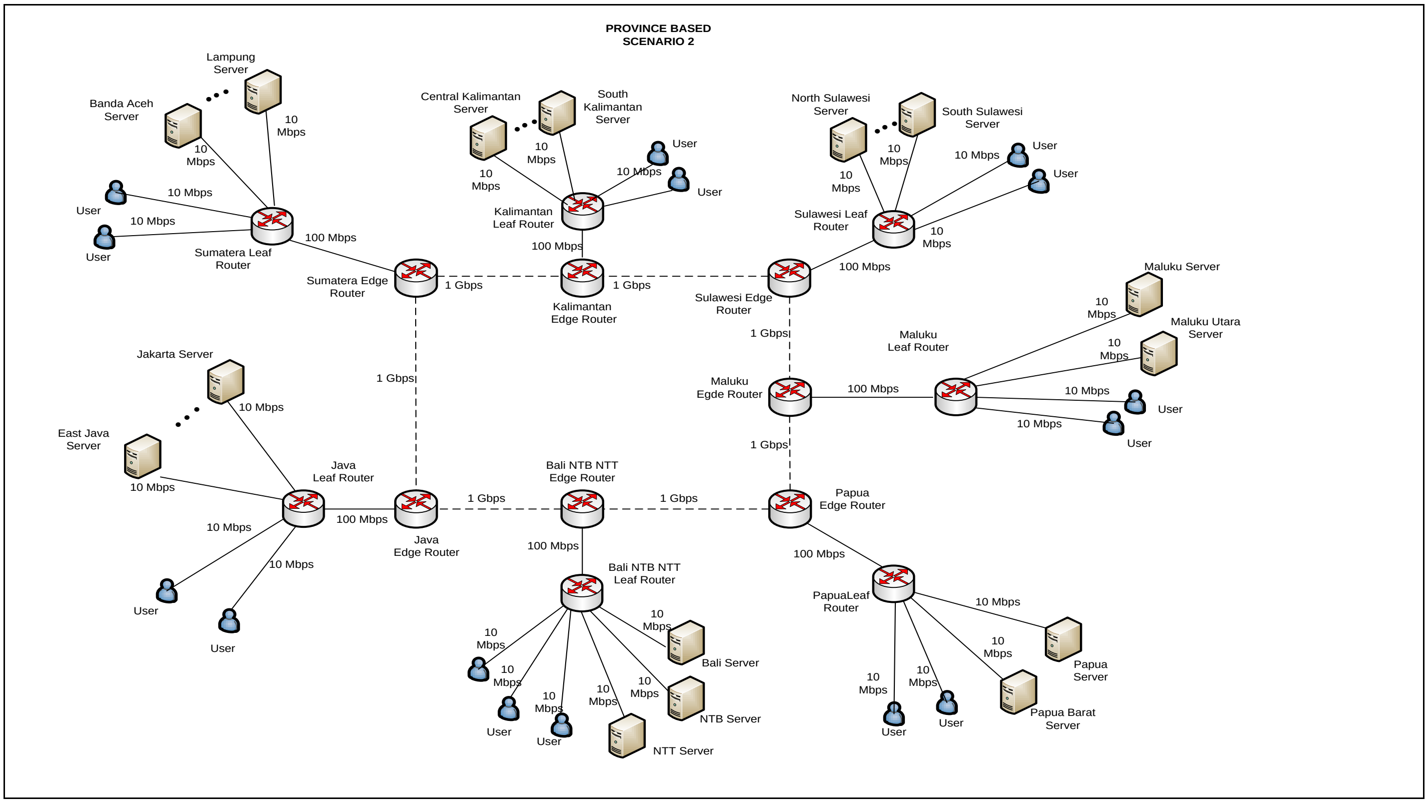

Fig. 2. Second Scenario

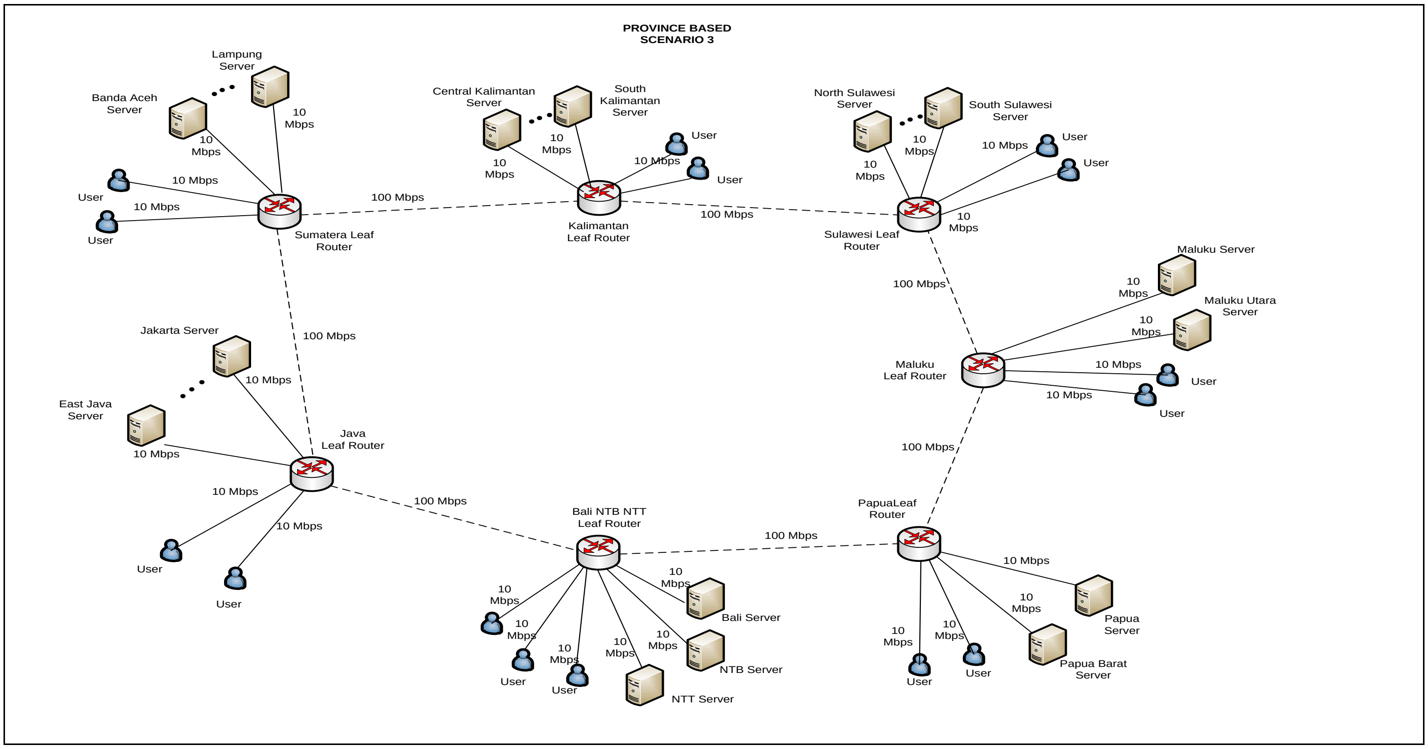

Fig. 3. Third Scenario

D. Result

We define three samples which based on three types of how the numbers of users are in each province where the total number of users in the country is set the same. In the first simulation, we assume that there is one user in each regency and municipal in each province and we label the sample as DS0. In the second simulation sample, DS1, we define the number of users in each province is proportional with the number of population in the province, however the total number of users in the country are the total number of users in DS0. Thus in each province the number of users is given as:

$$u = p/t \times nd0 \qquad (1)$$

where:

u = number of user in each province

p = number of population in each province

t = total population in the country

nd0 = number of users of DS0

And for the third simulation, DS3, we use same number of users at each province as:

$$u = nd0 / np \qquad (2)$$

where:

u = number of user

nd0 = number of users of DS0

np = number of province

We round the number of users in each province in DS0, DS1 and DS2 to the nearest integer. Fig. 4 describes these samples:

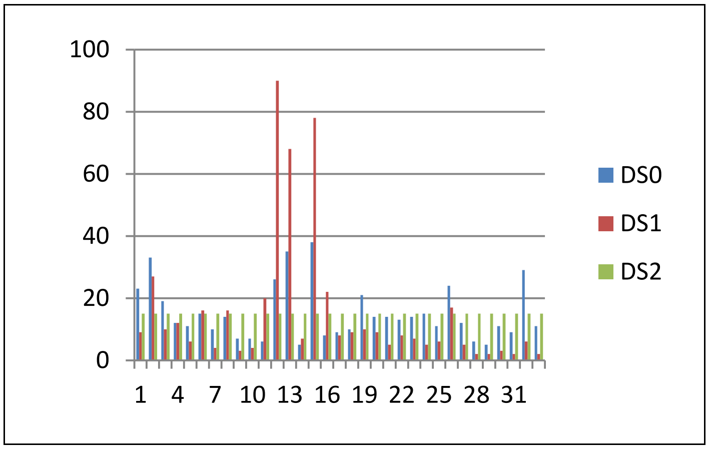

Fig. 4. Number of users in each province based on various sample type

In each simulation using the above three scenarios S1, S2, and S3, and two algorithms FIFO and SCFQ, we introduce three Gridlets which define jobs in GridSim sent by each user successively to a resource and the resource will give a sign which Gridlet is ready to be processed. The computing time in each province is defined to be the average of these three Gridlets response time, and the average computing time in the country is defined as the average computing time from all computing time in the provinces. The results are given in the Table III.

Where S1FIFO indicates the first scenario using FIFO algorithm, S1SCFQ indicates the first scenario using SCFQ, the same meaning applies to S2FIFO, S2SCFQ, S3FIFO, and S3SCFQ. Fig. 5 shows in general that sample DS1 is the most efficient one compared with DS0 and DS2.

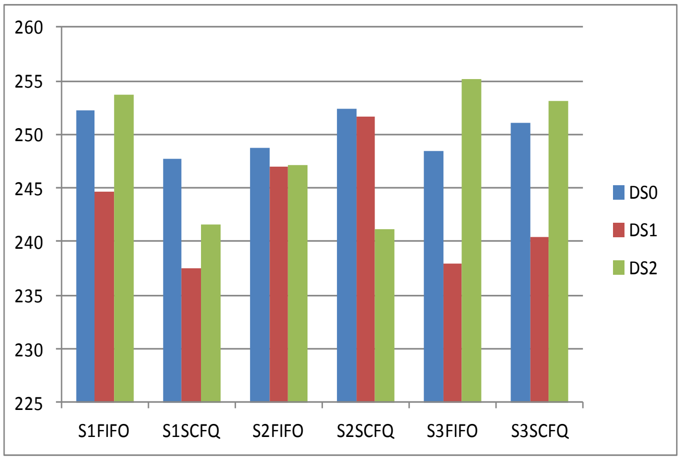

Fig. 5. Result comparison of DS0, DS1, DS2

The results above show that Scenario 1 using SCFQ algorithm in DS1 gives the best processing time and Scenario 3 using FIFO algorithm in DS2 gives the worst processing time.

Scenario 1 using SCFQ scheduling algorithm in DS1 tends to make packet lifetime in routers with crowded traffic becomes shorter. As we see that more than 70% of population in Indonesia is in Java Island which is use West Core Router. Packet lifetime shows the difference between the enqueuing and dequeuing time of packets. This is because there are packet priority settings where the packets with higher priority will be served first, so the overall packet lifetime will be reduced. SCFQ algorithm can provide differentiated services for data traffics by changing the weight associated with traffic classes. The higher the weight of a traffic class, the better treatment of the class. Treatment here means the wider bandwidth allocation (bandwidth) so that the execution time would be smaller.

Scenario 3 using FIFO algorithm in DS2 gives the worst processing time because packet lifetime is higher. In FIFO mechanism, all packets are enqueued at the end of a queue, and the first packet located in the beginning of the queue will be dequeued first. The packets are unordered and no differentiated service will be provided.

The data above can be analyzed that in the development of e-Government Grid services in Indonesia using FIFO (First In First Out) scheduling algorithm, then the most suitable is the topology that allows data packets having a low number of hops. In this simulation, network with the lowest number of hops seen in the third scenario of DS1 using the population comparison as the number of user in each province.

TABLE III. RESULT OF THE SIMULATION

Scenario / Simulation	S1FIFO	S1SCFQ	S2FIFO	S2SCFQ	S3FIFO	S3SCFQ
DS0	252.23357	247.72993	248.76200	252.34099	248.45325	251.00456
DS1	244.60348	**237.48944**	246.93003	251.68368	237.95047	240.34692
DS2	253.70659	241.51920	247.14717	241.07650	**255.08733**	253.06667

If using SCFQ (Self-Clocked Fair Queuing) scheduling algorithm, then the most suitable is the topology that makes the data packets with the same priority has small possibility to meet each other in a single router or link. In this simulation, topology that meet this condition is a topology on the first scenario of DS1 using the population comparison as the number of user in each province.

And we can see that DS1 give the best performance. So we can say that the most suitable for Grid topology in Indonesia is using the number of population comparison as the number of user in each province.

III. CONCLUSION

The research aim at modelling an e-Government Grid in Indonesia by performing a simulation using GridSim toolkit that is based on the Java programming language. Simulations carried out by testing three different types of topologies in terms of link and router configuration with FIFO and SCFQ algorithms and three types of number of users based on the province, population and same number of users in each province. The result is the average time processing that is used to obtain the most effective topology for each scheduling algorithm.

From the simulation results can be concluded that the SCFQ scheduling algorithm tends to create packets lifetime in the router with heavy traffic becomes shorter. Packet lifetime is the time of packet in the queue or the time difference between time the packet is enter into the queue and time the packet is out of the queue. It is due to packet priority setting where high-priority packet will be prioritized so that the overall packet lifetime will be reduced.

The proposed Grid arhitecture in this paper will be used as inputs for providing e-Government services and its implementation on a Cloud platform for the best performance. Comparing Grid services to Cloud services, we can see that Grid is about performance and Cloud is about scalability. In our next work, we will model the country e-Government Grid services based on Cloud Computing to test the scalability of the Grid system driven by economical scale considering some factors in existing practices done by the government.

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Authors’ Profile

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Performance Comparison of DCT and Walsh Transforms for Watermarking using DWT-SVD

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***Abstract*—This paper presents a DWT-DCT-SVD based hybrid watermarking method for color images. Robustness is achieved by applying DCT to specific wavelet sub-bands and then factorizing each quadrant of frequency sub-band using singular value decomposition. Watermark is embedded in host image by modifying singular values of host image. Performance of this technique is then compared by replacing DCT by Walsh in above combination. Walsh results in computationally faster method and acceptable performance. Imperceptibility of method is tested by embedding watermark in HL2, HH2 and HH1 frequency sub-bands. Embedding watermark in HH1 proves to be more robust and imperceptible than using HL2 and HH2 sub-bands.**

Keywords—Discrete Wavelet Transform (DWT); Discrete Cosine Transform (DCT); Singular Value Decomposition (SVD); watermarking.

I. Introduction

Advancement in technology has resulted in use of digital data which includes text, images, audio, video and multimedia data. Technology has also made it easy to duplicate/manipulate the contents of these data by various means. Piracy is a very good example of this. Thus authentication of data becomes obvious requirement before it is made available as digital data. Authentication includes information of owner of data within data itself to avoid taking undue credit as well as to prevent tampering of data. Digital watermarking is one of the most popular techniques used for digital data authentication.

Watermark is secret information which is embedded into a digital signal. Digital signal into which watermark is embedded is called as host signal or cover signal. Host signal can be text, image, audio or video data. Depending on the type of host signal, watermarking is classified as text watermarking, image watermarking, audio watermarking and video watermarking[1]**.** Image watermarking can be further classified into transform domain watermarking and spatial domain watermarking based on how the watermark is embedded into an image. Transform domain watermarking is one in which image is first transformed using appropriate transformation technique and then watermark is embedded into transformed coefficients of image. Spatial domain watermarking refers to directly modifying pixel values of an image to embed watermark into it. Transform domain watermarking is complex as compared to spatial domain watermarking but it is more robust also. Watermarking technique is said to be robust with respect to transformations, if watermark embedded into digital image can be easily extracted even if any attempts are made to change the data contents thereby degrading the host image. Discrete Wavelet Transform[2],[8],[13] and Discrete Cosine Transform[3],[8],[13] are most popular transforms used for Transform domain watermarking. Singular Value Decomposition[4],[8] is yet another popular approach for the same. In this paper an attempt has been made to exploit strengths of all these techniques to provide robust and imperceptible watermarking technique. Other characteristics of a good watermarking technique are perceptibility and security. Perceptibility refers to the ability to notice existence of watermark into image. Low perceptibility is desirable. Security of watermarking algorithm refers to inability to extract data contents by unauthorised party even after knowing embedding and extraction algorithm.

II. Related Work

In literature, various approaches have been tried out for digital watermarking using wavelet transform and singular value decomposition. Xi-Ping and Qing-Sheng Zhu [5] have proposed a wavelet based method using sub-blocks of image. Instead of applying wavelet transform on whole image, it was applied to local sub-blocks. These sub-blocks were randomly extracted from original image. Watermark was embedded into part of frequency coefficients of these sub-bands by computing their statistical characteristics. A Mansouri, A Mahmoudi Aznaveh, F Torkamani Azar [6] have proposed a method using Complex Wavelet Transform (CWT) and singular value decomposition (SVD). The watermark was embedded by combining singular values of watermark in LL band of transformed image. The method proposed by them is non-blind watermarking because singular values of original image are required in extraction phase. Rashmi Agarwal and K. Venugopalan [7] have proposed a SVD based method for watermarking of color images. Each plane of color image is separately treated for embedding and extracting process. Different scaling factors were used to test the robustness of their method. Satyanarayana Murty. P. and P. Rajesh Kumar[8] have proposed a hybrid DWT-DCT-SVD based approach. HL frequency band was selected by them for embedding purpose. Method proposed in this paper is motivated by their work. Satendra Kumar, Ashwini Kumar Saini, Papendra Kumar[9] have also proposed a watermarking scheme based on discrete wavelet transform and singular value decomposition. They have used three level wavelet transform and then by modifying singular values of cover image, watermark is embedded into it. Medium frequency bands i.e. HL3 and LH3 were preferred for embedding. PSNR and Normalized Cross Correlation (NCC) values were used to measure the effectiveness of the method. Krishnamoorthi and Sheba Kezia[10] proposed a watermarking technique based on orthogonal polynomial based transformation for copyright protection of digital images. A visual model was used to determine strength of watermarking. This visual model was used to generate Just Noticeable Difference (JND) by analyzing low level image characteristics like texture, edges and luminance of cover image in polynomial based transformation domain. Ko-Ming-Chan and Long-Wen Chang[11] have proposed a watermarking system which embeds two different watermarks –robust and fragile into spatial and frequency domain separately. Robust watermark is embedded in wavelet coefficients of LL band whereas fragile watermark is embedded in least significant bits of watermarked image. Advanced encryption standard- Rijndeal block cipher was used to make watermarking technique public. Veysel Atlantas, A Latif Dogan, Serkan Ozturk [12] proposed a DWT-SVD based watermarking scheme using Particle Swarm Optimizer (PSO). Singular values of each sub-band of cover image are modified by different scaling factors. Modifications were further optimized using PSO to obtain highest possible robustness.

III. Discrete Wavelet Transform, Discrete Cosine Transform And Singular Value Decomposition

A. Discrete Wavelet Transform(DWT)[13]

Wavelets are special mathematical functions that represent scaled and shifted copies of finite length waveform. DWT is based on wavelets and analyzes the signal into its frequency components at multiple resolutions. Applying wavelet transform on two dimensional images divides image into four sub-bands LL, LH, HL and HH which consist of low frequency, middle frequency and high frequency components of an image. Maximum energy of an image is concentrated in LL sub-band whereas high frequency components in HH sub-band correspond to edges and textures [8]. Hence imperceptible watermarking can be achieved by using these high frequency components for embedding.

B. Discrete Cosinet Transform(DCT)

Discrete Cosine Transform converts the signal into its elementary frequency components. After applying DCT, most of the energy of a signal is concentrated into top left corner of an image. Due to this property, DCT is widely used in image compression. This property also helps in watermarking for selecting appropriate frequency coefficients to embed the watermark.

C. Singular Value Decomposition (SVD)

Singular Value Decomposition is a matrix factorization technique having many applications in image processing. Since digital image is a two dimensional matrix, SVD can be applied to it. If I is a digital image of dimension M*N, then applying SVD on I decomposes it into three matrices U, S and V with following relationship.

$$I=USV^T$$

Here U is a M*M unitary matrix, V is a N*N unitary matrix and S is M*N matrix whose first r diagonal values are Eigen values of positive definite matrix $I^T * I$. Coefficients of matrix U, S or V can be appropriately selected and altered for watermark embedding.

IV. Proposed Method

In this paper a hybrid approach for watermark embedding and extraction has been proposed. Two combinations have been used to compare their performances. First combination is of DWT, DCT and SVD, whereas second combination is of DWT, Walsh and SVD. Thus main aim here is to compare performance of DCT and Walsh when combined with DWT and SVD. Further different frequency sub-bands (HL2, HH2 and HH1) of host image are tried for embedding purpose in order to observe the effect of frequency band selection on robustness and perceptibility. Experiments are carried out on 10 different color host images of size 256*256*8 by embedding five different color images / logos of size 128*128*8 into each host image. Let H be the host image and W be the watermark. WI refers to watermarked image. Embedding and Extraction algorithms given below are for HL2 Frequency sub-band. Same steps are conducted for HH2 and HH1 sub-band. For using HH1 frequency sub-band to embed watermark single level discrete wavelet transform is taken instead of two level DWT.

A. Embedding Algorithm

Embedding algorithm further can be subdivided into four sub-processes: a) Transformation of host image, b) Transformation of watermark, c) Embedding process and d) Generating stego image. Each of these are explained below.

a) Transformation of host image

*1) Apply two level Discrete wavelet transform on host image H separately on each plane. This gives us the wavelet transformed image H' of size 64*64*8. We also get an image which can be distinguished into four different frequency bands namely LL2, HL2, LH2 and HH2.*

2) On HL2 sub-band of individual plane of wavelet transformed image i.e. H', apply DCT/WALSH transform. This results into DCT/WALSH transformed image say H".

*3) Arrange H" in zigzag manner and then form four quadrants out of it say Q1, Q2, Q3and Q4 of size 32*32*8 each.*

b) Transformation of watermark

*4) Repeat step 1 and step 2 on watermark image W to get W" of size 32*32*8.*

5) Apply Singular Value Decomposition on each quadrant obtained in step 3. This decomposes each quadrant into 3 matrices U, S and V. S is the singular value matrix used for embedding purpose.

6) Apply Singular Value Decomposition on W'' obtained in step 4. This decomposes W'' into 3 matrices U', S' and V'.

c) Embedding watermark

7) Scale the S matrix of each quadrant of H'' by value say K using Equation (1) to get S''. Different values of scaling factor k have been tried out to observe its effect on robustness and perceptibility.

$$S'' = S + KS' \qquad (1)$$

d) Generating stego image

*8) Using S'', reconstruct quadrants of H''. i.e. Qi'= U*S''*V.*

9) Rearrange these new quadrants by inversing the zigzag procedure to get modified H''.

10) Take inverse DCT/WALSH of modified H'' to get H'.

11) Take two- level inverse Discrete Wavelet Transform of H' obtained in Step 10 to get watermarked image WI.

B. Extraction Algorithm

Similar to embedding algorithm, extraction algorithm is divided into three sub-processes: a) Transformation of watermarked image, b) Extraction of watermark, c) Reconstruction of watermark. Each of these are explained below.

a) Transformation of host image

*1) Apply two-level Discrete wavelet transform on watermarked image WI separately on each plane. This gives us the wavelet transformed image WI' of size 64*64*8. This image can be distinguished into four different frequency bands namely LL2, HL2, LH2 and HH2.*

2) On HL2 sub-band of individual plane of wavelet transformed image i.e. WI', apply DCT/WALSH transform. This results into DCT/WALSH transformed image say WI''.

*3) Arrange WI'' in zigzag manner and then form four quadrants out of it say Q1, Q2, Q3and Q4 of size 32*32*8 each.*

4) Apply Singular Value Decomposition on each quadrant obtained in step 3. This decomposes each quadrant into 3 matrices U, S and V.

b) Extraction of watermark

5) Extract singular values from watermarked image using modified and original singular values of R G B planes of host image using Equation (2).

$$S' = (S'' - S)/K \qquad (2)$$

c) Reconstruction of watermark

6) These extracted singular values are then used to construct DCT/Walsh transform coefficients of watermark say W'' from each quadrant.

7) Take inverse DCT/Walsh transform of W'' to get W'.

8) Take inverse wavelet transform of W' to get extracted watermark EW.

Table I below shows host images of size 256*256*8 used for experimentation. Images from left to right and top to bottom are Lena, Mandrill, Peppers, Balls, Puppy, Tiger, Flower, Ganesh, Titanic and Waterlili.

TABLE I. HOST IMAGES USED FOR EXPERIMENTATION

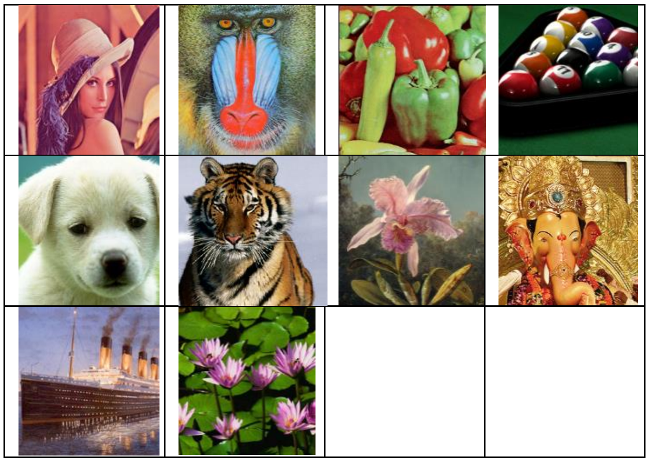


Table II below shows five different logos/images of size 128*128*8 used as watermark. Images from left to right and top to bottom are NMIMS, Austral, Bear, Logo and CCD.

TABLE II. WATERMARK IMAGES USED FOR EXPERIMENTATION

V. RESULTS

C. Results for embedding process using DCT and Walsh with DWT-SVD

Table III on next page shows host image Lena after embedding watermark into its HL2, HH2 and HH1 frequency components using DCT. These results are for K=0.05(except HH1), 0.1, 0.2, 0.4 and 0.6. It can be seen that, as scaling factor is increased (0≤K≤1), quality of host image is degraded. This is due to considerable changes taking place into singular values of frequency components of host image with increased value of K. Table IV shows host image Lena after embedding watermark into its HL2, HH2 and HH1 frequency components using Walsh. Observations for Walsh are also similar to that of DCT.

Comparisons of results obtained for DWT-DCT-SVD and DWT-Walsh-SVD combinations are shown in following graphs. Fig. 1 shows comparison of Mean Absolute Error (MAE) between host image and watermarked image for different values of scaling factor K, when watermark is embedded in HL2 sub-band using DCT and Walsh with DWT-SVD.

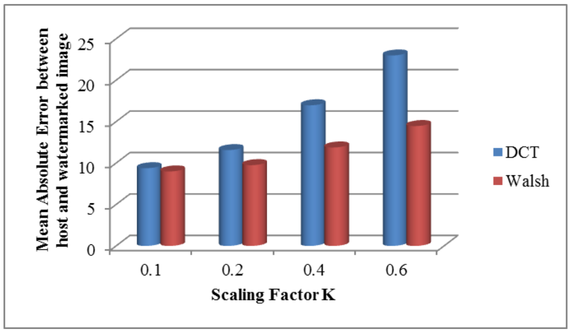


Fig. 1. Comparison of Mean Absolute Error (MAE) between host image and watermarked image for different values of scaling factor K when watermark is embedded in HL2 sub-band using DCT and Walsh with DWT-SVD.

From Fig.1 it can be observed that Walsh transform shows more imperceptibility than DCT for all scaling facto values. Fig. 2 and Fig. 3 show Mean Absolute Error between host and watermarked image for different scaling factor K when watermark is embedded in HH2 and HH1 sub-bands respectively with DWT-SVD.

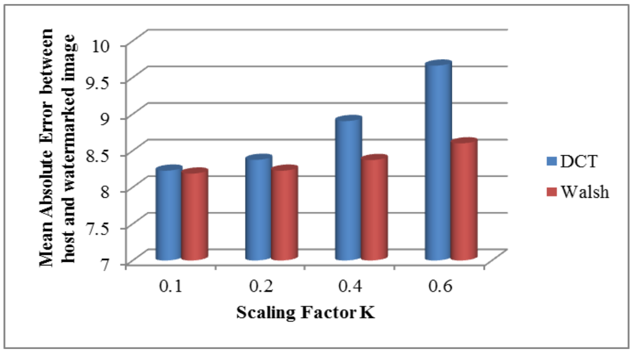


Fig. 2. Comparison of Mean Absolute Error (MAE) between host image and watermarked image for different values of scaling factor K when watermark is embedded in HH2 sub-band using DCT and Walsh with DWT-SVD.

Fig. 2 clearly shows that Walsh transform with DWT-SVD for HH2 sub-band is more imperceptible than DCT with DWT-SVD.

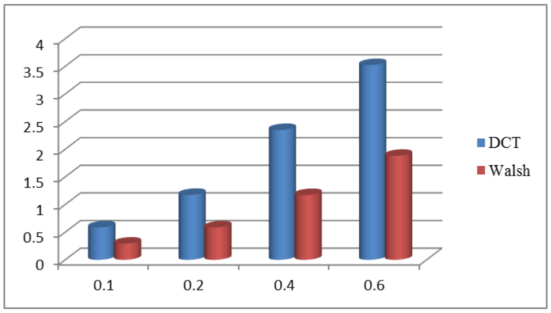


Fig. 3. Comparison of Mean Absolute Error (MAE) between host image and watermarked image for different values of scaling factor K when watermark is embedded in HH1 sub-band using DCT and Walsh with DWT-SVD.

Difference in imperceptibility for DCT and Walsh is more significant for HH1 sub-band as shown in Fig. 3.

To summarize, from Fig. 1, Fig. 2, and Fig. 3, it can be observed that distortion caused in host image due to embedding watermark is much less for Walsh as compared to DCT in all three frequency sub- bands, i.e. Walsh shows higher imperceptibility than DCT. It also indicates that, embedding watermark into high frequency components leads to higher imperceptibility which is a requirement for good watermarking technique. Though higher frequency components are more susceptible to various image processing attacks especially image compression, it is affordable in watermarking. The reason is that, main purpose of watermarking is to provide authentication of data contents which makes the image compression issue secondary. MAE can be directly related to perceptibility because it is the absolute difference between two images and hence noticeable by Human Visual System (HVS). Table VI shows result images for watermark extraction when no attacks are performed on watermarked image (K=0.6) for HL2, HH2, HH1 sub-band using DCT.

TABLE III. WATERMARKED IMAGES FOR LENNA HOST IMAGE IN HL2, HH2 AND HH1 FREQUENCY SUB-BANDS FOR DIFFERENTVALUES OF SCALING FACTOR K USING DWT-DCT-SVD

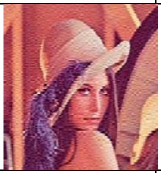
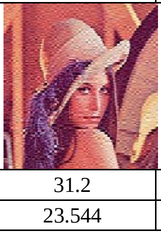
Scal	**Watermarked Images (DWT-DCT-SVD)**		
ing Factor (K)	***HL2***	***HH2***	***HH1***
K=0.05			-
RMSE	9.8622	9.5669	-
MAE	5.6053	5.0714	-
K=0.1			
RMSE	10.754	9.6301	0.97263
MAE	6.7203	5.1099	0.56891
K=0.2			
RMSE	13.755	9.8784	1.9453
MAE	9.6149	5.2676	1.1378
K=0.4			
RMSE	21.985	10.814	3.8905
MAE	16.365	5.8456	2.2756
K=0.6			
RMSE	31.2	12.214	5.8358
MAE	23.544	6.6577	3.4134

TABLE IV. WATERMARKED IMAGES FOR LENNA HOST IMAGE IN HL2, HH2 AND HH1 FREQUENCY SUB-BANDS FOR DIFFERENTVALUES OF SCALING FACTOR K USING DWT-WALSH-SVD

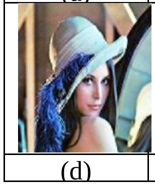
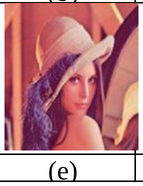
Scal	**Watermarked Images (DWT-WALSH-SVD)**		
ing Factor (K)	***HL2***	***HH2***	***HH1***
K=0.05			-
RMSE	**9.6239**	**9.551**	-
MAE	**5.2354**	**5.062**	-

K=0.1			
RMSE	**9.8549**	**9.5669**	**0.48631**
MAE	**5.6192**	**5.0718**	**0.27981**
K=0.2			
RMSE	**10.729**	**9.6302**	**0.97263**
MAE	**6.7407**	**5.1111**	**0.55963**
K=0.4			
RMSE	**13.678**	**9.8785**	**1.9453**
MAE	**9.6179**	**5.269**	**1.1193**
K=0.6			
RMSE	**17.522**	**10.279**	**2.9179**
MAE	**12.864**	**5.5206**	**1.6789**

D. Attacks on watermarked images:

Generally attacks on digital image can be categorized into two groups. Attacks which affect the pixel values of image and which affect geometry of image [7]. In the work presented in this paper, five different types of attacks have been performed. These attacks are contrast stretching, image cropping, Gaussian noise, histogram equalization and image resizing. Table V below shows Lena image watermarked with 'NMIMS' image (K=0.6) after performing various attacks on it. Images in Fig. 4 from left to right and top to bottom correspond to contrast stretching, cropping, adding Gaussian noise (0.1 variance), histogram equalization, and resizing. Robustness plays an important role here because, watermark should survive the attacks performed on host image for successful authentication. Due to space constraints, results of watermark extraction without any attack are shown in Table VI only for K=0.6 for HL2, HH2 and HH1 sub-band with DWT-DCT-SVD. Table VII shows results of watermark extraction without any attack for K=0.6 for HL2, HH2 and HH1 sub-band with DWT-Walsh-SVD.

TABLE V. VARIOUS ATTACKS ON LENA IMAGE AFTER EMBEDDING 'NMIMS' IMAGE INTO IT (A) CONTRAST STRETCHING (B) CROPPING (C) GAUSSIAN NOISE (D) HISTOGRAM EQUALIZATION (E) RESIZING

(a)	(b)	(c)
		
(d)	(e)	

E. Results of watermark extraction from HL2, HH2 and HH1 sub-bands against various attacks using DCT with DWT-SVD:

Fig. 4(a), (b), (c) and (d) below show performance comparison of different sub-bands against various attacks for K=0.1, 0.2, 0.4, 0.6 using DCT.

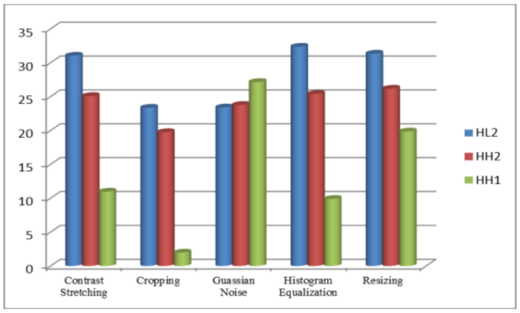


Fig. 4. .(a) Mean Absolute Error between original and extracted NMIMS watermark from HL2, HH2 and HH1 for K=0.1 and DCT

From Fig.4 (a), it can be noticed that for different attacks performed on watermarked image with K=0.1, HH1 sub-band gives smaller value of MAE than HL2 and HH2 sub-bands (except for Gaussian noise attak.). This in turn indicates more robustness when watermark is embedded in HH1 sub-band.

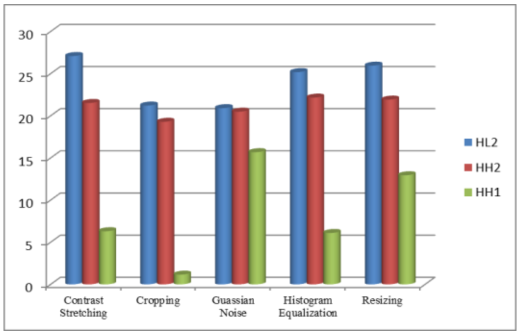


Fig. 4. (b) Mean Absolute Error between original and extracted NMIMS watermark from HL2, HH2 and HH1 for K=0.2 and DCT.

However, from Fig. 4(b) it is observed that with K=0.2, for all attacks, HH1 gives smallest value of MAE. Also these MAE values are smaller as compared to MAE values for K=0.1in previous case.

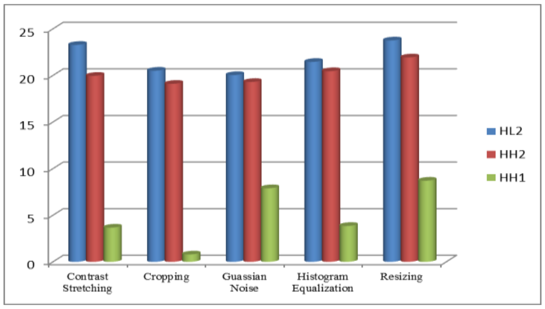


Fig. 4. (c) Mean Absolute Error between original and extracted NMIMS watermark from HL2, HH2 and HH1 for K=0.4 and DCT.

From Fig. 4.(c), we can say that HH1 is much better in robustness than HL2 and HH2 for K=0.4. MAE values are further reduced with increase in value of K.

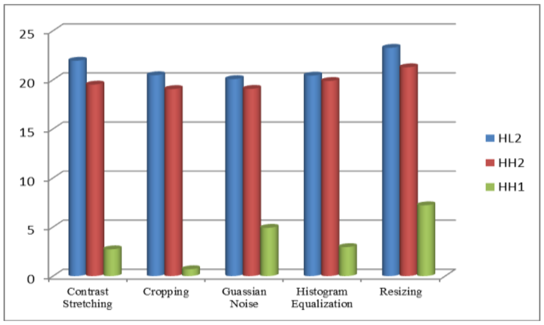


Fig. 4. (d) Mean Absolute Error between original and extracted NMIMS watermark from HL2, HH2 and HH1 for K=0.6 and DCT

This improvement in robustness for HH1 sub-bands continues for higher value of K(K=0.6) as shown in Fig.4 (d),

Thus it can be concluded that as we increase the value of scaling factor, watermark recovered from attack are closest to original watermark for HH1 sub-band. Similar results are observed for Walsh with DWT-SVD.

Further, for each sub-band, robustness of DCT and Walsh is compared by considering average MAE between original and extracted watermark for different attacks and for different values of K. For this, average MAE is computed over 10 host images for each attack in HL2, HH2 and HH1 sub-band separately. It is observed that robustness shown by Walsh transform is acceptable with less computational cost for each sub-band except for Gaussian noise in HH1 sub-band. This Comparison of robustness (MAE) for DCT and Walsh with K=0.6 is shown in Fig. 5(a)-(c). Watermarks extracted from each quadrant of HH1 sub-band for various attacks and K=0.6 using DWT-DCT-SVD and DWT-Walsh-SVD are shown in Table VIII and Table IX respectively.

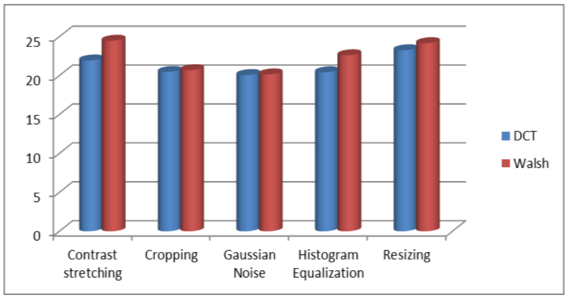


Fig. 5. a) Comparison of average MAE for DCT and Walsh for HL2 sub-band (K=0.6, 'NMIMS' Watermark)

From Fig. 5(a), it is observed that MAE between original and extracted watermark from HL2 sub-band is slightly more for Walsh as compared to DCT and hence it is acceptable.

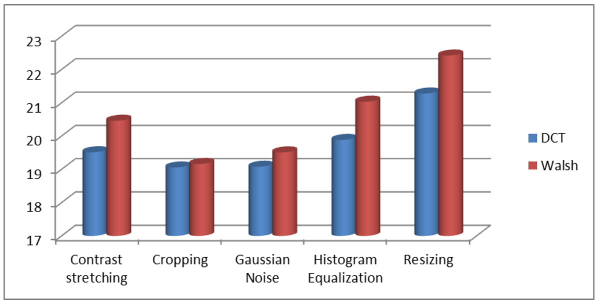


Fig. 5. (b) Comparison of average MAE for DCT and Walsh for HH2 sub-band (K=0.6, 'NMIMS' Watermark)

From Fig. 5(b), it is observed that MAE between original and extracted watermark from HH2 sub-band is slightly increased for Walsh. It is still acceptable because MAE for embedding process using Walsh is better than DCT.

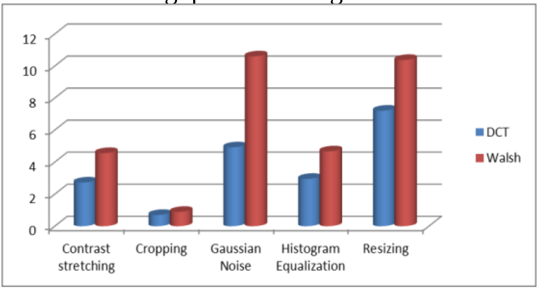


Fig. 5. (c) Comparison of average MAE for DCT and Walsh for HH1 sub-band (K=0.6, 'NMIMS' Watermark)

From Fig.5(c), it can be said that the performance of Walsh is acceptable for extraction from HH1 sub-band since MAE values are much smaller as compared to MAE values for HL2 and HH2 sub-band for watermark extraction process

TABLE VI. WATERMARKE EXTRACTED FROM FOUR QUADRANTS OF HL2, HH2 AND HH1 SUB-BAND OF LENA HOST IMAGE FOR K =0.6USING DWT-DCT-SVD WHEN NO ATTACK IS PERFORMED ON IT.

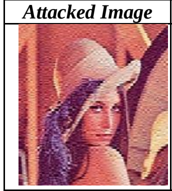
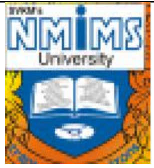
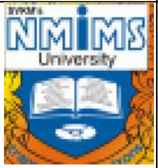
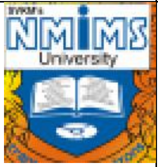
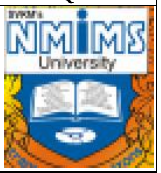
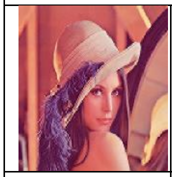
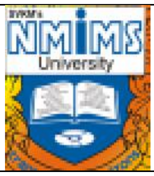
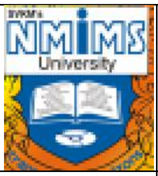
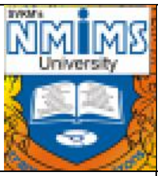
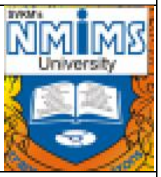
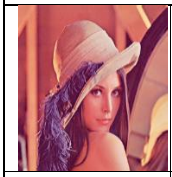
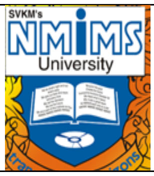
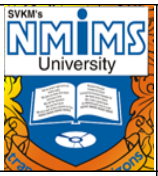
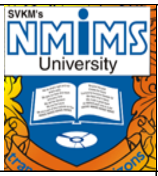
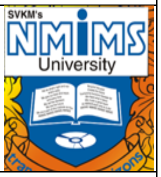
	Extracted Watermark			
Attacked Image	***Q1***	***Q2***	***Q3***	***Q4***
				
RMSE=31.2	33.391	33.382	33.384	33.395
AME=23.544	19.403	19.37	19.379	19.375
(A) K=0.6, HL2 sub-band				
				
RMSE=12.214	33.198	33.198	33.198	33.199
AME=6.657	18.793	18.792	18.792	18.804
(B) K=0.6, HH2 Sub-band				
				
RMSE=5.835	0.0355	0.1074	0.1322	0.2004
MAE=3.413	0.0012614	0.011536	0.017476	0.04
(C) K=0.6, HH1 sub-band				

TABLE VII. WATERMARKE EXTRACTED FROM FOUR QUADRANTS OF HL2, HH2,HH1 SUB-BAND OF LENA HOST IMAGE FOR K=0.6 USING DWT-WALSH-SVD WHEN NO ATTACK IS PERFORMED ON IT.

	Extracted Watermark			
Attacked Image	***Q1***	***Q2***	***Q3***	*Q4*

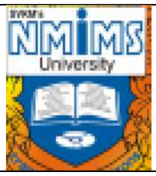
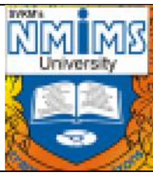
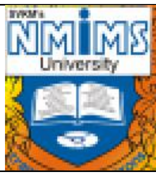
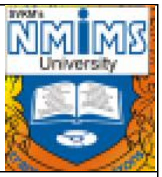
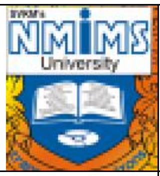
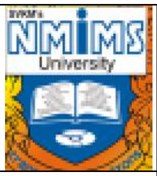
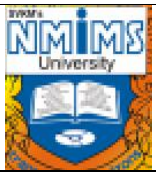
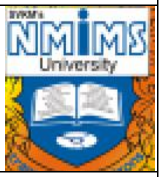
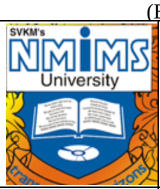
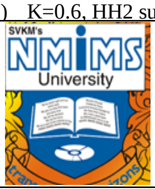
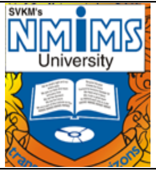
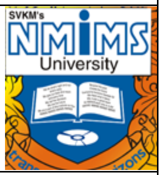
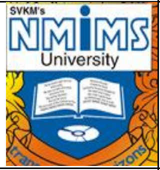
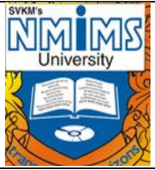
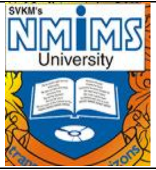
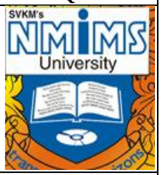
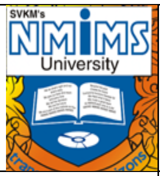
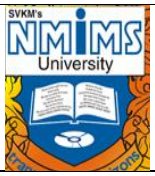
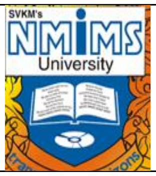
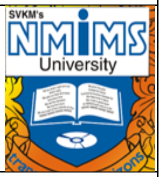
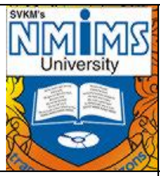
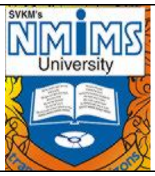
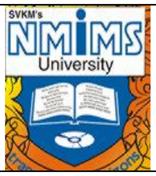
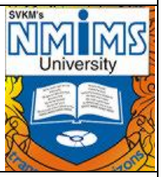
				
RMSE=17.522	33.227	33.232	33.228	33.236
AME=12.864	18.977	19	18.981	18.993
(A) K=0.6, HL2 sub band				
				
RMSE=10.279	33.196	33.197	33.197	33.196
AME=5.520	18.782	18.78	18.783	18.782
(B) K=0.6, HH2 sub-band				
				
RMSE=2.917	0.0285	0.0433	0.0251	0.0406
AME=1.678	0.0008138	0.0018717	0.000631	0.00165
(C) K=0.6,HH1 sub-band				

TABLE VIII. WATERMARKE EXTRACTED FROM FOUR QUADRANTS OF HH1 SUB-BAND OF LENA HOST IMAGE FOR K=0.6 USING DWT-DCT-SVD FOR (A) CONTRAST STRETCHING, (B) CROPPING, (C) GAUSSIAN NOISE, (D) HISTOGRAM EQUALIZATION (E) IMAGE RESIZING ATTACKS.

	Extracted Watermark			
Attacked Image	***Q1***	***Q2***	***Q3***	***Q4***
				
RMSE=29.29	5.5803	5.5303	5.983	6.8927
AME=25.048	2.8771	2.8503	3.0178	3.3298
(A) Contrast stretching				
				
RMSE=55.921	0.62653	0.801	0.73025	0.46367
AME=18.936	0.22917	0.32019	0.3264	0.16331
(B) Cropping				
				
RMSE=	10.8816	10.085	9.7701198	8.9896803
AME=	6.05751546	5.61658	5.4804688	5.09706624
(C) Gaussian noise				

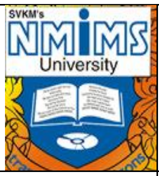
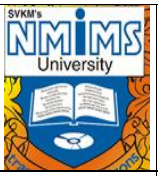
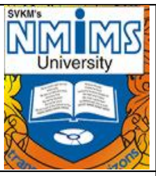
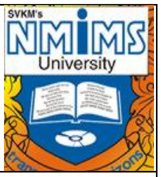
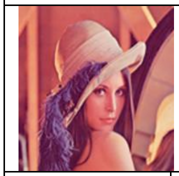
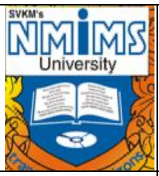
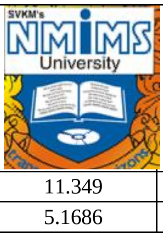
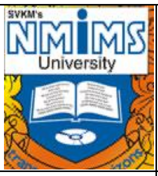
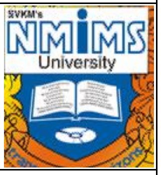
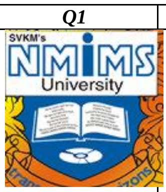
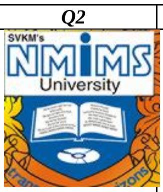
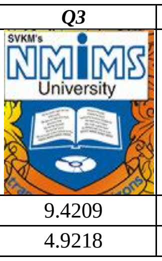
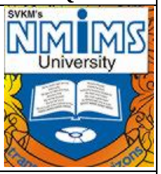
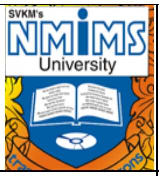
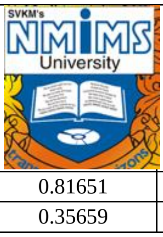
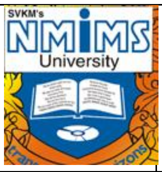
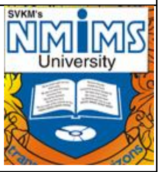
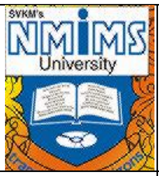
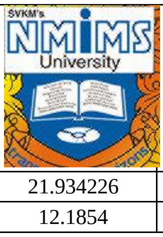
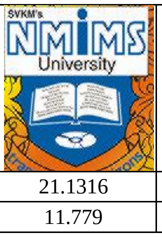
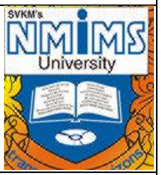
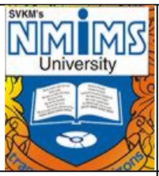
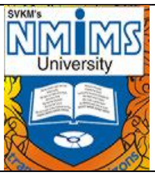
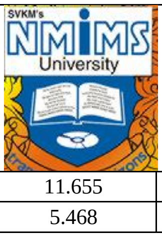
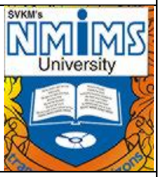
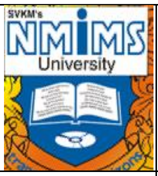
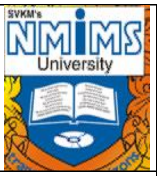
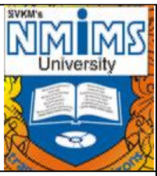
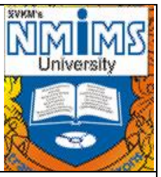
				
RMSE=48.849	7.5344	7.5138	7.8871	8.7403
MAE=41.249	3.4099	3.3394	3.5149	3.8415
(D) Histogram Equalization				
				
RMSE=10.883	10.561	11.349	12.644	15.791
MAE=6.171	4.7369	5.1686	5.8723	7.3549
(E) Resizing				

TABLE IX. Watermarke extracted from four quadrants of hH1 sub-band of Lena host image for K=0.6 Using DWT-Walsh-SVD for (A) contrast stretching, (B) cropping, (C) Gaussian noise, (D) histogram equalization (E) Image resizing attacks.

	Extracted Watermark			
Attacked Image	***Q1***	***Q2***	***Q3***	***Q4***
				
RMSE=29.29	8.4939	8.7267	9.4209	10.946
AME=25.046	4.3429	4.5289	4.9218	5.3963
(A) Contrast stretching				
				
RMSE=55.105	0.65387	0.81651	0.75272	0.55661
AME=18.937	0.24969	0.35659	0.32318	0.24801
(B) Cropping				
				
RMSE=34.397	23.3019	21.934226	21.1316	20.0063
AME=28.388	13.0506	12.1854	11.779	11.2329
(C) Gaussian noise				
				
RMSE=49.067	9.9075	10.48	11.655	12.931
MAE=41.454	4.6353	4.8488	5.468	5.9934
(D) Histogram Equalization				

				
RMSE=9.032	12.486	14.277	16.595	21.053
MAE=4.992	5.7634	6.8108	8.0143	9.9391

(E) Resizing

VI. Conclusion and Further Work

Following conclusions can be drawn based on the work presented in this paper. As value of scaling factor increases, MAE between host image and watermark becomes significant thereby reducing imperceptibility. However, loss of perceptibility is less when watermark is embedded in high frequency components of host image. Since high frequency components of an image correspond to edges and borders of an image, embedding watermark causes distortion in images. But this distortion is affordable as compared to distortion in image caused by embedding watermark in HL or LH frequency components. Frequently, in image processing attacks, high frequency components are eliminated which results into loss of watermark information. However, such elimination is possible or can be of major concern in data compression. In watermarking, main emphasis is on protecting copyright information or content identification and not on data compression. Thus, it is acceptable to embed the watermark image in high frequency components rather than in low or medium frequency components. Walsh transform when used with DWT-SVD results in computationally faster watermarking scheme. Robustness and imperceptibility provided by Walsh is acceptable when compared with DWT-DCT-SVD.

Further work includes use of different orthogonal transforms like slant, Hartley, Kekre's transform and wavelet transforms obtained from them for watermarking.

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Framework of Designing an Adaptive and Multi-Regime Prognostics and Health Management for Wind Turbine Reliability and Efficiency Improvement

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***Abstract*—Wind turbine systems are increasing in technical complexity, and tasked with operating and degrading in highly dynamic and unpredictable conditions. Sustaining the reliability of such systems is a complex and difficult task. In spite of extensive efforts, current prognostics and health management (PHM) methodologies face many challenges, due to the complexity of the degradation process and the dynamic operating conditions of a wind turbine. This research proposed a novel adaptive and multi-regime prognostics and health management (PHM) approach with the aim to tackle the challenges of traditional methods. With this approach, a scientific and systematic solution is provided for health assessment, diagnosis and prognosis of critical components of wind turbines under varying environmental, operational and aging processes. The system is also capable of adaptively selecting the tools suitable for a component under a certain health status and a specific operating condition. The adopted relevant health assessment, diagnosis and prognosis tools and techniques for wind turbines are warranted by the intensive research of PHM models by the IMS center for common rotary machinery components. Some sub-procedures, such as information reconstruction, regime clustering approach and the prognostics of rotating elements, were validated by the best score performance in PHM Data Challenge 2008 (student group) and 2009 (professional group). The success of the proposed wind turbine PHM system would greatly benefit current wind turbine industry.**

***Keywords*—PHM; Adaptive tool selection; Multi-regime prognostics; Information reconstruction; Holo-coefficient**

I. Introduction

Wind energy is an unlimited, renewable and clean energy source and makes it possible to establish a large number of Megawatts in a relatively short time. Wind energy has become a progressively more competitive source of energy. The American wind energy association reported that wind percentage in all the new capacity added increased from 2% in 2004 to 42% in 2008 (Figure 1). It is remarkable that the United States and China have now become the leaders in the wind power market industry in terms of newly installed capacity, surpassing Germany, the previous leader in wind power (Figure 2). The US market's new wind energy converter installations, reaching up to 8.5 GW at the end of 2008, have increased the total wind power generating capacity by half when compared to the previous year. Such a notable feat is due in part to the US Department of Energy's 2008 report [1] purporting that the power that can be harvested from the country's wind resources has the potential to supply 20% of its domestic demand for electricity.

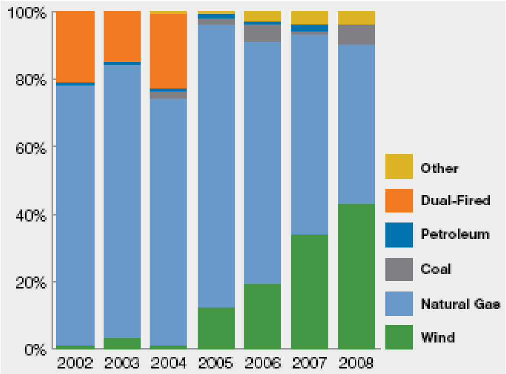


Fig. 1. Percentage Of New Capacity Additions (Source: AWEA-Annual Wind Industry Report 2009)[2]

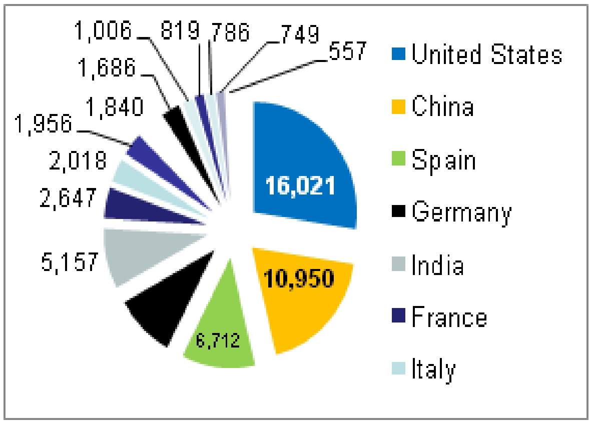


Fig. 2. Total increased wind turbine capacity from 2005 to 2008

The increased reliance on wind energy as an energy source for the world makes the increased uptime and reliability of wind turbine systems become more critical issues. The degradation of wind turbine critical components' health in the dynamic operating conditions could badly impact the wind energy generation efficiency. In recent years, increasing interests have been put on researching the condition monitoring and health management technologies based on the fact that the preventing the failure of critical equipments in advance could result in a significant amount of time and cost savings, and the overall improved reliability and safety of operations.

Ciang et al. provided a review of fault detection approaches for wind turbines, such as, acoustic emission events method, thermal imaging method, ultrasonic methods, various modal-based approaches, fiber optics method, laser Doppler vibrometer method, electrical-resistance based damage detection method, strain memory alloy method, x-radioscopy method and eddy current method [3]. The techniques surveyed focus more on physical models for structural health monitoring. In recent decade, with the spread of artificial intelligent and machine learning technologies, data driven methods, which base on the analysis of signals (e.g. vibration from accelerometers) to assess the asset's health degradation status, diagnose current failure modes, and predict future health, have gained wide attention for their success in rotary machines [4][5][6].

In spite of extensive efforts by current prognostics and health management (PHM) methodologies, based on both data-driven and physical models, a successful deployment of these existing techniques to wind turbine applications still faces many challenges, such as, the complexity of the wind turbine health degradation and the dynamic operating conditions of a wind turbine. Wind turbine systems are increasing in technical complexity, and are tasked with operating in highly dynamic and unpredictable operating conditions.

Each component may degrade to various health statuses even under a same operating condition. Multi-regime approach is necessary to be researched to extend traditional health management techniques to consider the dynamic behavior of these components by segmenting the component health aging and operating conditions to various operating regimes. Moreover, considering the health management models may not have the same performance on different regimes, the selection of the proper model for a certain component under a specific application condition is significant. In practice, health representative data collected is a complicated and energy wide-range distributing signal. Only some parts of the signal related to the particular regime are of interest. In order to remove or reduce noise, a novel and effective information reconstruction method is desired to filter and reassemble the signal components without losing the information of interest.

An investigation of current industrial health management systems was conducted for the largest wind turbine manufacturers, namely GE Energy, Vestas and Siemens [7][8][9]. It is found that GE Energy's system provides more advanced functionalities in diagnosis and fault detection for drive train components than the others. Nevertheless, some functions, such as, system degradation assessment and failure prediction based predictive condition monitoring, adaptive and multi-regime prognostics for dynamic conditions, are non-existent.

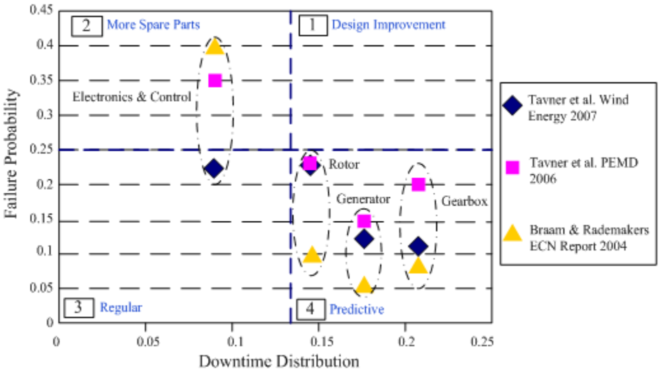


Fig. 3. Survey of critical components of wind turbines[10][11][12]

Numerous surveys conducted on faults experienced by wind turbine components have revealed that gearbox, generator and rotor blades have longer downtime once they fail. (Figure 3). Maintenance costs are estimated to make up approximately 15% of production costs in many industries. In the survey of the failure modes and hot spots of the critical component gearbox conducted by Musial [13], almost 100% of the 500 to 900 kW gearbox designs have had at least one retrofit/design change to the high speed bearing arrangement. More than half change happened on planet bearings and intermediate shaft locating bearings. A more accurate health estimation of critical components of wind turbines would be significant for their reliability improvement and breakdown cost reduction.

In order to minimize breakdown performance and associated maintenance and logistics costs, and improve efficiency of power generation and safety considerations, an adaptive and multi-regime prognostics and health management (AMPHM) approach is proposed in this paper. The proposed wind turbine AMPHM is a data driven method for health assessment, diagnosis and prognosis through the analysis of vibration signals from accelerometers. Its key technology was validated upon the research that resulted in the first place award in the international PHM Challenge in 2009. The proposed AMPHM system aims to provide an effective and systematic solution to improve the uptime and reliability of wind turbines working under the varying environmental, operational and aging processes, which will make a breakthrough for traditional PHMs.

This paper is structured as follows: the architecture of the adaptive and multi-regime wind turbine PHM system, which consists of data acquisition, health management, and health visualization, is firstly presented in section 2. The data acquisition is introduced in section 2 too. Health management details, including adaptive tool selection and multi-regime PHM, are explained in sections 3 and 4 respectively. Section 5 takes gearbox as an example to demonstrate the health visualization. A conclusion is made at the end section

II. Architecture Of Adaptive And Multi-Regime Wind Turbine PHM System

The architecture of adaptive and multi-regime wind turbine prognostics and health management system working in remote and online mode is proposed in Figure 4. Inside Nacelle, the up-tower data acquisition sub-system continuously collects signals, including both the operating conditions and the system behaviors, from installed sensors, as well as the wind turbine control system. Data files are transmitted through wind farm network from the nacelle to the remote health management database and server, where, the data files are downloaded and processed for health assessment, diagnosis and prognosis. The processing result will be visualized in a user-friendly human-machine interface (HMI) on client computer so that users can immediately understand and determine the health condition the critical components, and decision aid actions (e.g. predictive maintenance) can be taken on wind turbines timely, and accordingly.

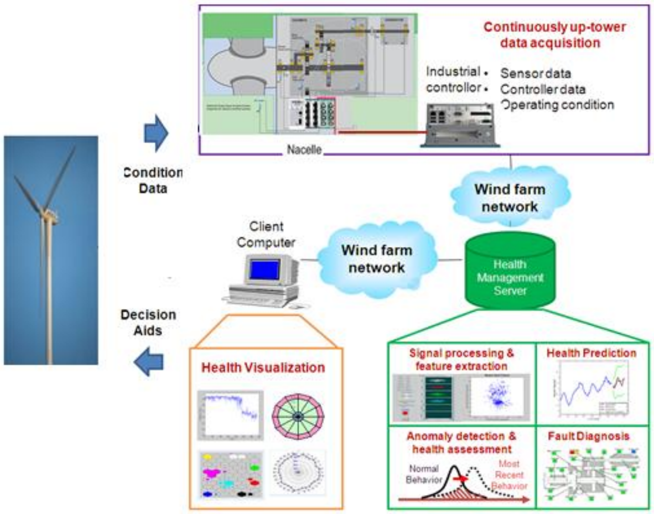


Fig. 4. Architecture of adaptive and multi-regime wind turbine PHM System

The proposed instrumentation plan for the up-tower condition monitoring sensor data acquisition (DAQ) for the critical components of wind turbine, gearbox and generator, is demonstrated in Figure 5. One low frequency PCB IEPE accelerometer, typically with sensitivity 500mV/g and frequency span 0.2-3000Hz, is placed on the main shaft (blade passing, main bearing) to collect vibration signals. Five PCB IEPE accelerometers with sensitivity 100 mv/g and frequency span of 0.5-15000Hz are positions on the gearbox and generator which have higher rotational speeds and gear mesh frequencies. One PCB laser tachometer is used to monitor the main bearing speed and synchronize the vibration. Three Compact DAQ NI USB 9234 (4 channels) are adapted for accelerometers and the tachometer signal collection. An industrial controller (NI 3110) is sitting in the Nacelle connected to NI USB 9234 to collect data continuously.

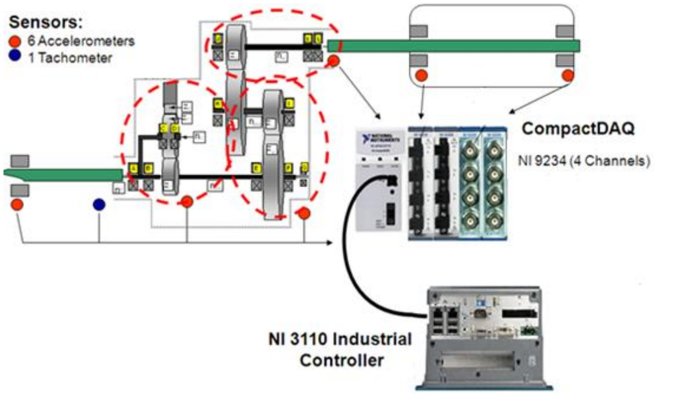


Fig. 5. Data acquisition solution (*source: NI*)

III. Technical Approach

Figure 6 illustrates the flow of the proposed wind turbine PHM which is conducted on health management server. As rotational components of a wind turbine work under dynamic conditions, an adaptive tool selection agent is designed to select the proper tool for a certain component under a specific situation. With the multiple operating regimes segmented, the health representative features are extracted and fed into the corresponding health assessment models. After health assessment, multi-dimensional features will be converted into a 1-Dimention health index between 0 and 1, with 1 indicating a perfect health condition and 0 indicating an unacceptable heath condition. The history of the health index can then be further processed for fault diagnosis and health prediction.

An illustrative example is presented in the following sections to demonstrate the procedure of the adaptive tool selection, multi-regime PHM approach, and the health visualization at users' end as well.

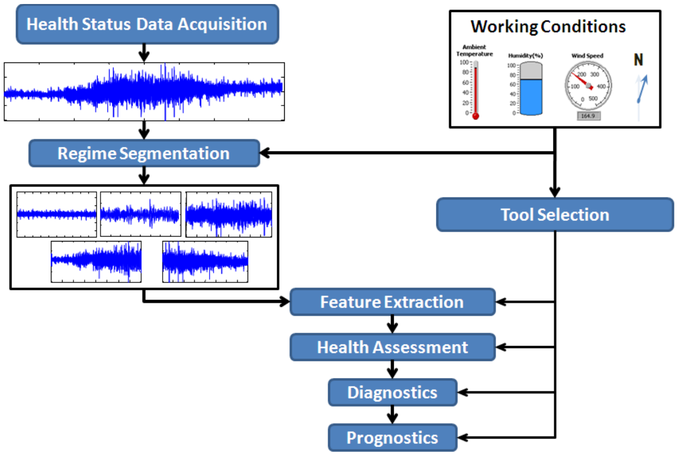
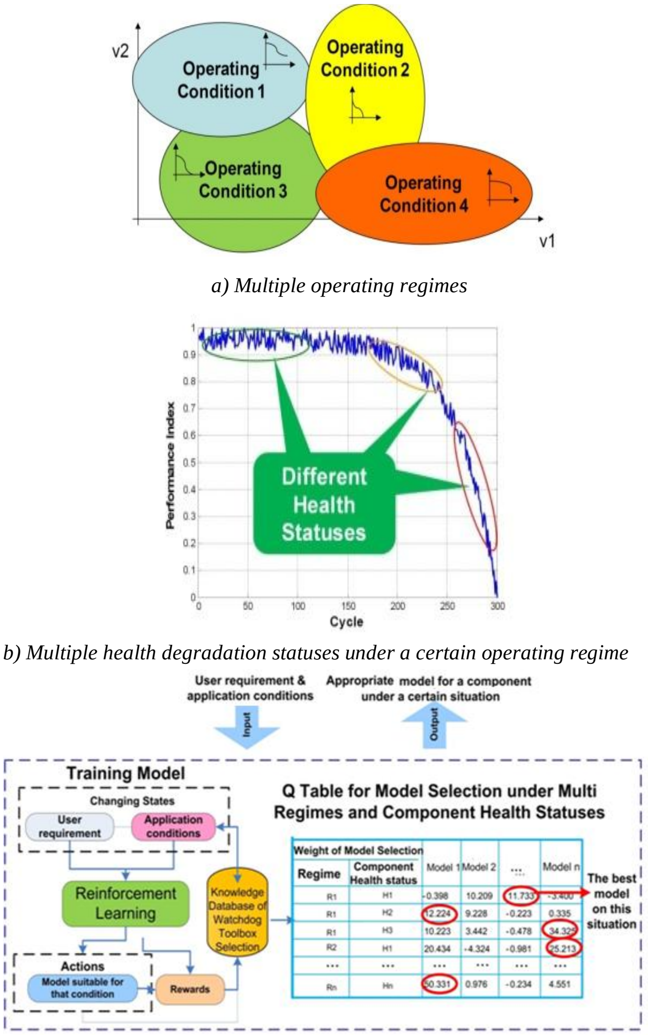


Fig. 6. Flow of adaptive and multi-regime wind turbine PHM

A. Adaptive Model Selection

Due to constantly changing operating conditions, such as wind speed and wind direction, as well as slow evolving environmental conditions such as temperature, the electrical and mechanical system of a wind turbine actually operates under highly dynamic conditions (Figure 7a). These operating conditions will be classified into different regimes in the following study. On each operating regime, wind turbine will experience different health statuses during degradation (Figure 7b). The combinations of various regimes and corresponding health statuses constitute the multiple application conditions. Considering a wind turbine has multiple components, and the performance of different PHM models may be sensitive to application conditions, the selection of the proper model for a certain component under a specific application condition is significant. An adaptive tool selection agent (Figure 7c) is designed for this purpose. This agent self adapts to the input of the customer requirements (e.g. implementation cost, human involvement, system knowledge, computation efficiency and signal sampling frequency, etc.) and application conditions, and automatically identifies a particular model that is suitable for that specific condition.


v2
v1
Operating Condition 1
Operating Condition 2
Operating Condition 3
Operating Condition 4

a) Multiple operating regimes

Performance Index
Cycle
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
Different Health Statuses

b) Multiple health degradation statuses under a certain operating regime

User requirement & application conditions
Input
Appropriate model for a component under a certain situation
Output
Training Model
Changing States
User requirement
Application conditions
Reinforcement Learning
Knowledge Database of Watchdog Toolbox Selection
Actions
Model suitable for that condition
Rewards
Q Table for Model Selection under Multi Regimes and Component Health Statuses
The best model on this situation

Weight of Model Selection					
Regime	Component Health status	Model 1	Model 2	...	Model n
R1	H1	-0.398	10.209	11.733	-3.400
R1	H2	12.224	9.228	-0.223	0.335
R1	H3	10.223	3.442	-0.478	34.325
R2	H1	20.434	-4.324	-0.981	25.213
...	...	...	...	...	...
Rn	Hn	50.331	0.976	-0.234	4.551

c) Adaptive Tool Selection

Fig. 7. Operating regime and analyze tool

The expert knowledge of various situations that a particular model is suitable to use will be structured to initialize a model selection rules knowledge base.

Taking the customer requirements and applications conditions as inputs, and the models used in those situations as outputs, a reinforcement learning model will be trained to learn the model selection knowledge under different situations [14].

Formally, the basic reinforcement learning model according to Wikipedia consists of:

1) a set of environment states S (i.e. a set of user requirements and application conditions);

2) a set of actions A (i.e. a set of models suitable for that state); and

3) a set of scalar "rewards" in $\mathbb{R}$.

The environment is typically formulated as a finite-state Markov Decision Process (MDP). At each time t, the reinforcement learning agent perceives its state $s_t \in S$and the set of possible actions $A(s_t)$. It chooses an action $a \in A(s_t)$ and receives from the environment the new state s_{t+1} and a reward r_{t+1}.

Based on these interactions, the reinforcement learning agent must develop a policy $\pi : S \to A$which maximizes the quantity $R = r_0 + r_1 + \cdots + r_n$ for MDPs which have a terminal state, or the quantity.

The adaptive tool selection agent selects the most appropriate model for each application condition by choosing the largest Q-value for all the application condition /model pairs in the row of that application condition. The Q-value is determined by the sum of the (maybe discounted) reinforcements received when performing an action following a given policy.

Model selection rules will then be updated and structured into a knowledge base again. The reinforcement learning agent will iterate when receiving a new state.

B. Multi-regime Prognostics and Health Management

The changing operating conditions have significant influence on the baseline of a data-driven wind turbine PHM model. The relationship between the operating conditions and the model baseline is very hard to be established analytically or experimentally. To conquer the problem, it is proposed to use the operating regime approach [15] to employ multiple simple PHM models developed for static operating conditions to deal with dynamic operating conditions, which will be referred to as multi-regime PHM here.

The procedure of multi-regime prognostics is illustrated in Figure 8. First, the collected data, including those indicating system operating conditions and those indicating system behaviors, will be used to identify what regime the system is operating in. If the new measurement cannot fit to any of the existing patterns, a new operating regime will be learned. Once the operating regime is identified, the data will be fed into the corresponding PHM model that has either been established, or will have to be created for a newly-learned operating regime. The PHM models include sub-procedures, such as feature extraction, health assessment and fault diagnostics, which have been studied and applied intensively by the IMS center for common rotary machinery components. Finally, the health indices obtained from different operating regimes will be fused together to form a continuous time series of the system health, which will be used for health prediction.

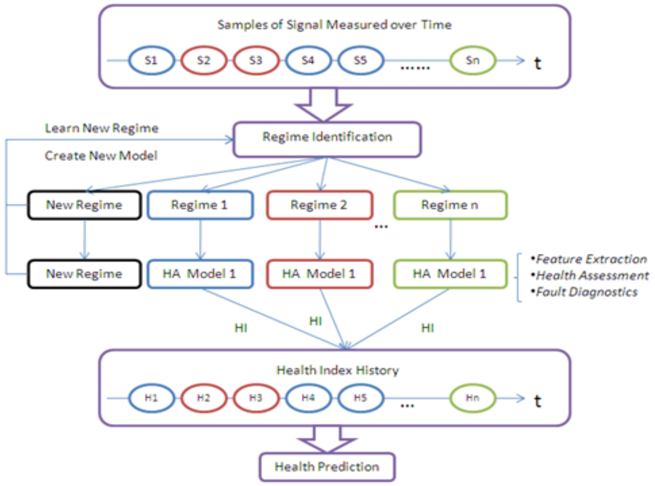


Fig. 8. Multi-regime Wind Turbines Health Assessment and Prediction

1) *Signal Processing*

Due to frequent environmental changes and unpredictable wind turbulence, as well as the frequent stopping and starting of a wind turbine, recorded raw sensor data are not appropriate as direct input to various signal processing tools, even though they are continuous vibration or acoustic time series. In order to enhance data quality and improve signal processing efficiency, data preprocessing, such as de-noising and data segmentation, is a necessary preliminary step for signal processing. In order to remove or reduce noise and effects from other unrelated sources, de-noising can be performed by using noise smoothing filters or band pass filters, based on knowledge of the frequency distribution of wind turbine signals. Data segmentation can be performed by using working condition data to sift and retain the active vibration or acoustic time series.

To detect changes in the vibration signatures caused by abnormal behaviors, recorded data can be analyzed in the time domain. A number of simple signal metrics based on the time domain waveform, such as peak level, root mean square (RMS) value and kurtosis, have widespread applications in condition monitoring and fault detection for wind turbines. However, in order to gain more comprehensive knowledge and extract more reliable and effective health indicators for wind turbines, signals need to be observed in the frequency domain and time-frequency domain. Fast Fourier Transform (FFT) and cepstral analysis are applied for frequency domain analysis to decompose a signal into its component frequencies and amplitudes, and to isolate individual components of a complex signal for easier pattern identification. Spectral analysis of the electric power and of accelerations measured in the wind turbine system is performed effectively for stationary signal analysis where energy variation over time is dispensable. For non-stationary, non-linear time series which can be observed from time to time in wind turbine systems under varying environmental and operating conditions, more advanced signal processing tools in time-frequency domain such as short-time Fourier Transform (STFT), Wigner-Ville distribution (WVD), Wavelet Transform (WT), and Hilbert-Huang transform (HHT) are applied. A time-frequency representation is a view of a signal represented over both time and frequency. In a wind turbine system, non-stationary, non-liner time series often appear during the transient period between different working conditions, and they usually carry abundant dynamic information of the system. The aforementioned advanced signal processing tools, especially WT and HHT methods, are able to capture the transient characteristics of non-stationery vibration data and are suitable for impact detection caused by a stroke of lightning, a collision with a large bird, or wave-induced tower oscillations of off-shore plants.

2) *Feature Selection*

After signal processing, various features can be extracted such as mean, peak, RMS in time domain, characteristic frequency, amplitude and phase in frequency domain and energy-time-frequency distribution in time-frequency domain. There may be, however, a lack of quality features, or there may be redundant features which increase feature dimension and affect the efficiency of the prognostics and health management activity. Feature selection has become the focus for applications in which tens or hundreds of variables are available. Appropriate feature selection can improve the data mining performance, help data visualization and reduce dimensionality and noise. For wind turbines, feature selection is further complicated by the fact that a wind turbine system is usually operating in varying environmental conditions, under diverse operating conditions and experiencing different aging processes. To establish an accurate and effective feature set to facilitate operation regime segmentation and health assessment of critical rotary components, it is necessary to identify operating condition parameters and select damage-sensitive features.

For feature selection, four methods are proposed; principal component analysis (PCA), fisher criterion, SVM-based feature selection and GA-based feature selection. PCA transforms a number of possibly correlated variables into a smaller number of uncorrelated variables, called principal components, and usually involves the calculation of the eigen-value decomposition of a data covariance matrix, or the singular value decomposition of a data matrix after mean centering the data for each attribute. Fisher criterion seeks the features that are efficient for discrimination to minimize the within-class distance and maximize the between-class distance. The objective of the SVM-based feature selection method is to find a subset of size r among d variables (r<d), which maximizes the performance of the classifier and predictor. This method is a backward sequential selection approach. It starts with all the features and removes one feature at a time until only r features are left, and until the performance of the classifier and predictor are maximized. In a GA-based approach, a given feature subset is represented as a binary string of length d, with a zero or one in position i

denoting the absence or presence of feature i in the set. A population of chromosomes is maintained. Each chromosome is evaluated to determine its “fitness”. Based on a “fitness” threshold setting, an optimized binary string can be obtained to describe the feature selection result.

3) Information Reconstruction

The mechanical drive-train of a wind turbine is a very complex system that can generate vibrations from its various elements, such as gears, shafts, and bearings. Transmission path effect, signal coupling, and noise contamination can further induce difficulties in the development of a PHM system for wind turbines. In practice, vibration data collected by accelerometer is a complicated and energy wide-range distributing signal. But only some parts of the signal related to the particular machine condition are of interest. In order to remove or reduce noise and effects from other unrelated sources and further enhance signal components of interest, a novel information reconstruction method for filtering and reassembling the signal components to reconstruct signal without losing the information of interest is introduced. This method can also work for signal clustering and wind turbine diagnosis in varying operating conditions.

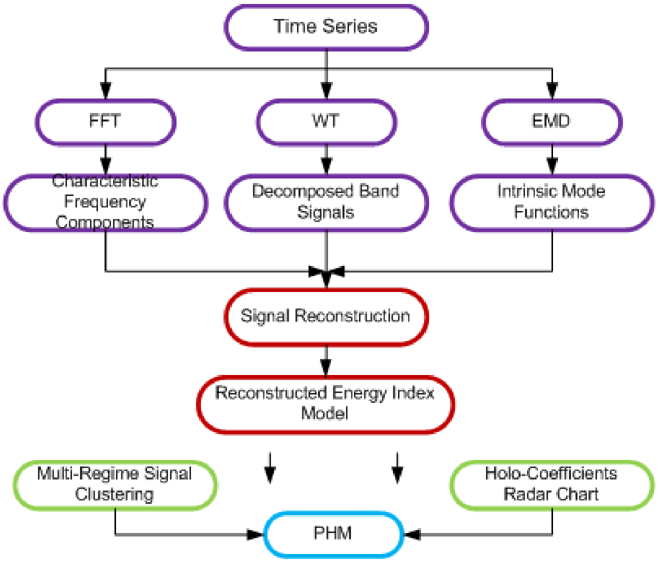

Time Series
FFT
WT
EMD
Characteristic Frequency Components
Decomposed Band Signals
Intrinsic Mode Functions
Signal Reconstruction
Reconstructed Energy Index Model
Multi-Regime Signal Clustering
Holo-Coefficients Radar Chart
PHM

Fig. 9. Information Reconstruction

Firstly, the signal is transformed from time domain to frequency domain or time-frequency domain with FFT, WT, or HHT. Then, reconstruction filters are employed to sift the frequency components in FFT spectrum, to sift the decomposed band signals from WT analysis, or to sift the intrinsic mode functions (IMFs) from empirical mode decomposition (EMD) process of HHT. Next, sifted signal components are reassembled together to reconstruct a new signal.

4) Regime Clustering

Energy coefficients are then calculated for the reconstructed energy index model, in which energy coefficients are selected to have certain classification power. The basic idea is to identify and further classify the data with similar attributes to the same specified group. Moreover, energy coefficients are also supposed to be comprehensible for the user or have physical meaning. This is necessary whenever the classified pattern is to be used for supporting a decision to be made. Knowledge comprehensibility can be achieved by using high-level knowledge representations from experts or historic data resources.

Then, correlation analysis (CA) and distance measurement (DM) techniques are utilized to cluster signals under diverse shaft speeds and loads. CA on two energy coefficient vectors is defined as

$$CA = (C_{Ei} \cdot C_{Ej}) / (|C_{Ei}| * |C_{Ej}|)$$

where • means dot product, |•| means the largest singular value of a vector. The result of CA ranges between zero and one, with higher CA signifying a higher correlation.

DM on two signals is

$$DM = \| C_{Ei} - C_{Ej} \|$$

where ||•|| is the Euclidean distance, with lower DM signifying a higher similarity.

5) Diagnosis

Finally, energy coefficients are used as health indicators in holo-coefficients radar chart for the purpose of health assessment and prognostics of rotating elements in the wind turbine mechanical drivetrain. A holo-coefficients radar chart consists of all the energy coefficients. The multivariate coefficients are displayed in radar chart starting from the same point and in different equi-angular spokes, with each spoke representing one of the variables. The data length of a spoke is proportional to the magnitude of the variable. In the chart, the contribution rate of each coefficient can be revealed very clearly along with its variation with operating conditions. Figure 10 shows an example of using holo-coefficients radar chart to identify two patterns. In Pattern A, input shaft unbalance (radials 1 and 19) and bearing outer defect at input shaft output side (radial 21) are diagnosed. Figure 10 (b) shows the holo-coefficients radar chart of another pattern (Pattern B). It is determined that this pattern contains gear error defect at idler shaft 2 location (radials 8 and 26).

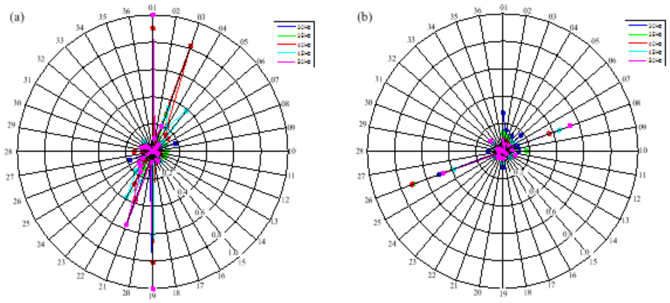


Fig. 10. Holo-coefficients Radar Chart of (a) Pattern A, (b) Pattern B

6) Prognosis

The similarity-based prognostics (SBP) approach is adopted from The Watchdog Agent® toolbox developed by the IMS Center for predicting future values of health indicator under dynamic operating conditions [16].

This similarity based prognostic technique was validated in the 2008 Prognostics and Health Management Society data challenge in which it produced the best prediction estimates and achieved number one overall in the competition [17]. By using multiple SBP models under different regimes, the given sensor data are fused into a single time series of health indices, which is then used in multi-regime SBP model.

IV. Health Visualization

An illustrative example is taken to demonstrate the visualization of the detection of mechanical faults and prediction of future health for a generic gearbox using accelerometer data and information about bearing geometry. On the first step (Figure 11), the operating conditions are classified to different regimes, and the vibration signals collected from gearbox is segmented to corresponding regimes.

The second step in Figure 12 applies the adaptive tool selection approach and selects the time domain, frequency domain and wavelet analysis tools to process the raw data in different regimes and extract corresponding features. The third step, Figure 13, selects the principle features, reconstructs signals and generates energy coefficients, which are used as health indicators in holo-coefficients radar chart for the purpose of health assessment and diagnosis. A fault of chipped tooth problem in the first gear, for instance, is diagnosed. Also higher risk in high speed regime is alarmed. And the last step as in Figure 14, similarity based Match Matrix method is chosen to learn the health pattern based on the historical runs of similar gearboxes, and predict the future health.

The above mentioned information reconstruction and regime clustering approach, and the prognostics of rotating elements, were validated by the best score performance in the PHM Data Challenge Competitions 2008 (student group) and 2009 (professional group)[18].

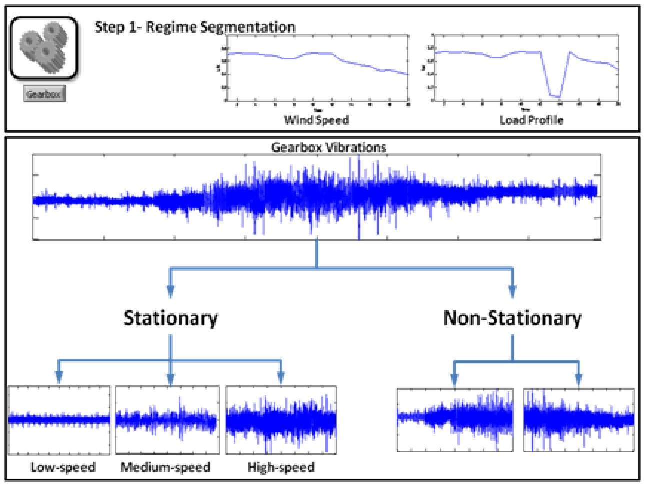


Fig. 11. Step 1 of wind turbine PHM: regime segmentation

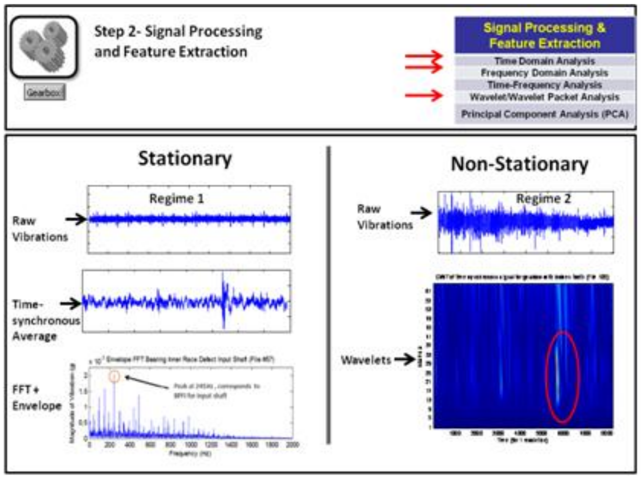
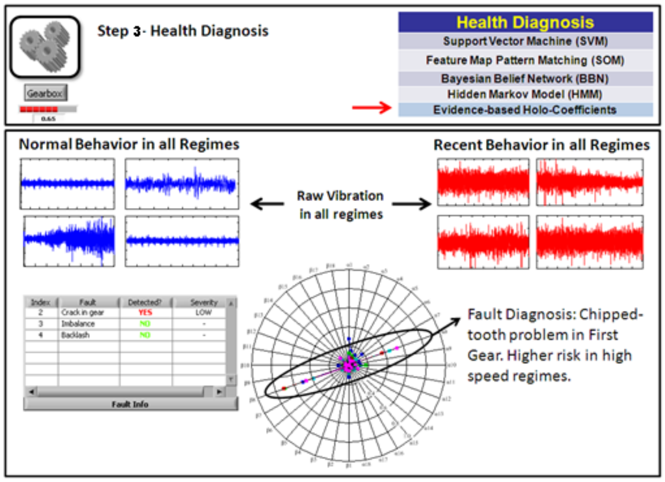


Fig. 12. Step 2 of wind turbine PHM: signal processing and feature extraction


Gearbox
Step 3- Health Diagnosis
Health Diagnosis
Support Vector Machine (SVM)
Feature Map Pattern Matching (SOM)
Bayesian Belief Network (BBN)
Hidden Markov Model (HMM)
Evidence-based Holo-Coefficients
Normal Behavior in all Regimes
Recent Behavior in all Regimes
Raw Vibration
in all regimes
Fault Info
Fault Diagnosis: Chipped-
tooth problem in First
Gear. Higher risk in high
speed regimes.

Index	Fault	Detected?	Severity
2	Crack in gear	YES	LOW
3	Imbalance	NO	-
4	Backlash	NO	-

Fig. 13. Step 3 of wind turbine PHM: health diagnosis

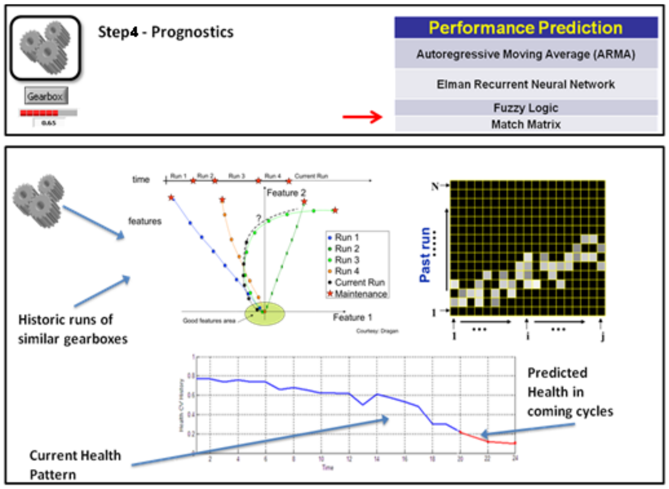


Fig. 14. Step 4 of wind turbine PHM: prognostics

V. CONCLUSION

The adaptive and multi-regime PHM system developed in this paper provides a more accurate health estimation, diagnosis and prognosis of critical components of wind turbines. The proposed research advances the understating of how to adaptively apply PHM to the various situations composed by dynamic operating conditions of wind turbines and the health condition of rotary components. This approach could be used in an intelligent and predictive maintenance program to minimize the time needed for inspection of components via on-line inspection, conducting remote site supervision and remote diagnosis, preventing catastrophic failures and secondary defects, preventing unnecessary replacement of components, allowing utility companies to be confident of power availability, improving designs and supporting further development of wind turbine. The reduction of maintenance risks and costs and improvement of reliability and efficiency will eventually make this green energy sector more competitive.

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Automatic Detection of Electrocardiogram ST Segment: Application in Ischemic Disease Diagnosis

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Abstract— **The analysis of electrocardiograph (ECG) signal provides important clinical information for heart disease diagnosis. The ECG signal consists of the P, QRS complex, and T-wave. These waves correspond to the fields induced by specific electric phenomenon on the cardiac surface. Among them, the detection of ischemia can be achieved by analysis the ST segment. Ischemia is one of the most serious and prevalent heart diseases. In this paper, the European database was used for evaluation of automatic detection of the ST segment. The method comprises several steps; ECG signal loading from database, signal preprocessing, detection of QRS complex and R-peak, ST segment, and other relation parameter measurement. The developed application displays the results of the analysis.**

Keywords-Electrocardiogram (ECG); Ischemia; European ST-T database; QRS complex ; ST segment.

I. Introduction

Electrocardiographic (ECG) signals information is derived from analysis of the information indirectly reflected on the surface ECG. The ECG signal is able to make of basic information for heart disease, indisposed of the autonomic nervous system and stress. The world Health Organization estimates that 17.5 million people died of cardiovascular disease. It is representing 30% of all global deaths. Out of these, 7.6 million were due to coronary artery disease (CAD)[1]. During the last few years, a lot of research has provided the solution of analysis and diagnosis in ECG by adopting new technologies and algorithms. Among them, ischemic heart disease constitutes one of the most common fatal diseases in the world. Myocardial ischemia is caused by a lack of sufficient blood flow to the contractile cells and many lead to myocardial information with its severe sequel of heart failure, arrhythmias and death [2]. The ischemic disease is usually identified in the standard ECG by changes in values of measured amplitudes, times and durations on the ST-T complex. The ST-T complex of the ECG reflects the time period from the end of active ventricular depolarization to the end of depolarization in the heart cycle [3-4]. Therefore, ST-segment changes are common ECG signal markers of important Myocardial ischemia [5]. The several methods for ischemia parameter detection (T wave and ST complex) have been proposed. In generally, all of them are based on the spectral estimation [6] and signal point from the ST segment better characterizes ischemic patterns [3, 7]. The various methods have been applied to the ECG for ischemia analysis and detection: used the First Fourier Transform (FFT) to analyze the frequency component [8], fuzzy-logic, neural network, genetic algorithm, support vector machines (SVM), wavelet transform and many more [9]. However, most of the algorithms have sensitivity above the 80%. In this study we consider two applications of the ST segment detection and display program: Detection of ischemia episodes and monitoring PC programming. The modifications in the shape parameters have been used for ST segment measurement.

II. Method And Material

A. European ST-T Database

The European ST-T database [10-11] is intended to be used for evaluation of algorithm for analysis of ST and T wave changes. It consists of three following files: 1) Header file has the patient’s information, lead, medication, clinical findings and recording equipment information. 2) Data file has an ECG data recording format that is of double-channel 2-hour length, resolution of 12bits and 250Hz sampling frequency, and data format of MIT-212 format. 3) Finally, annotation file contains data information (data beat, ST and T change start-peak-end, noise, rhythm). It includes numerous ischemic episodes of all types and thus it is very useful in evaluating ischemic detection algorithms.

B. Description of the detection system

This system is intelligent computer applications that provide decision support through acquisition and processing of human experts knowledge. In order to operate the plotting signal and detection algorithms through European ST-T database signal, we used a 2.5GHz Pentium processor, 2Gbyte of RAM and the Microsoft^{TM} Visual C++6.0 programming tools. Figure 1 show the block diagram of the automatic detection of ST change and segment system. This system comprises three separate parts: an ECG data loading and open from the database, signal parameter detection of ECG signal, and ST measurement of the ischemia disease.

C. Signal Preprocessing

The infinitesimal ECG signal have included for various noise. Accordingly, noise has to be reduced before the signal processing. The source of noise is encountered at every stage of data acquisition until the data is digitized. Power noise, muscular contract noise, electrode movement with signal wandering, and analog-to-digital converter noise all perturb the ECG signals [12].

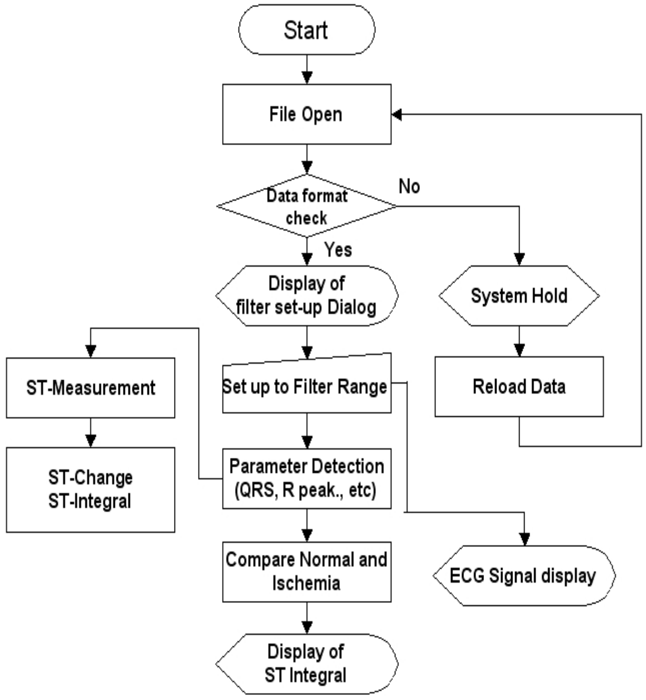

Fig. 1. Automation Detection Of ST-Segment Block Diagram

Therefore, the signal future of detection and analysis need for noise removal method. Such as, signal filtering, rhythm and beat wandering canceling. In this paper, we used FIR (Finite Impulse Response) filter method in order to remove noise, which is cancelled for low and high frequency in signal. This filtering frequency default range was set at 5 to 15Hz. We also used dialog option for perform to control for user's convenience and noise characteristic that it is able to filtering for variety noise band. The reduced noise signal for filter is as follows.

$$y(nT)=\sum_{k=0}^{M} a_k x(nT-kT) \qquad (1)$$

D. QRS complex and R-peak detection

Many algorithms and method have been applied in QRS-wave detection research. In fact, many systems have already been designed and implement to perform signal-processing tasks such as 12-lead off-line ECG analysis, Holter system analysis, and real-time patient monitoring. All these applications require an accurate detection of the QRS complex of the ECG [13]. Therefore, the precision detection of QRS complex and R-peak in the analysis of the ECG are very important and first step of signal analyze. The RR-Interval is the distance between two subsequent QRS complex and represent the Heart Rate (HR) variability. In our system, we used a robust real-time QRS detection algorithm popularly known as Pan-Tompkins algorithm [14] and added searchback compare method [7].

Pan-Tompkins algorithm has detection sensitivity for 99.3% that it has competence for real-time ECG signal parameter detection. The algorithm includes a series of six steps: ECG signal preprocessing, derivative, squaring, integration, adaptive threshold and searchback. Figure 2 shows the block diagram for the QRS and R peak detection method.

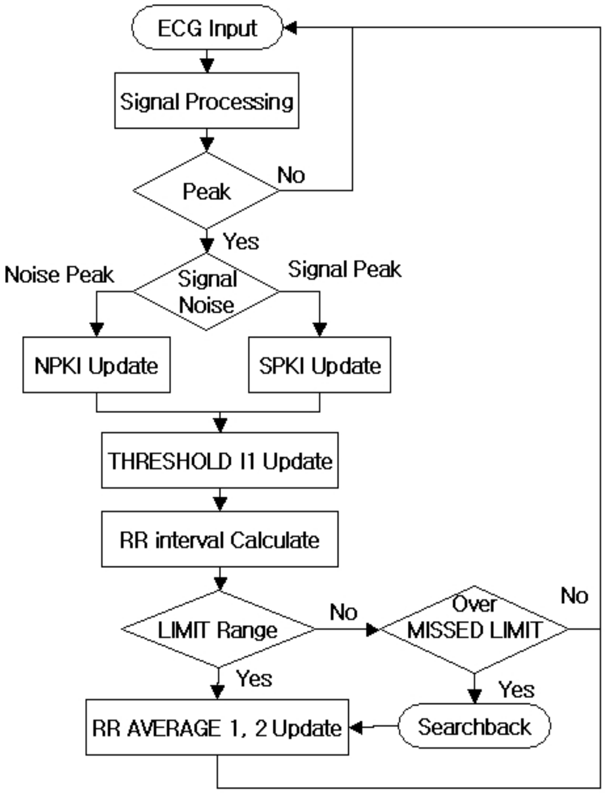

Fig. 2. QRS complex and R peak detection of block diagram

After filtering, the derivative stage provides the slop information of the QRS complex and transfer function flows:

$$y(n)=\frac{1}{8}[2x(n)+x(n-1)-x(n-3)-2x(n-4)] \qquad (2)$$

The integration operation intensifies the slope of the frequency response curve. The output of a derivative-based operation will exhibit multiple peaks within the duration of a single QRS complex. The equation 3 is this operation.

$$d(n)=\frac{1}{N}[x(n-(N-1))+x(n-(N-2))+...+x(n)] \qquad (3)$$

QRS complex can be identified using general ECG parameter detection method. R-peak is easier to distinguish from noisy component since it has large amplitude [12]. So, already detected R-peak should pass verification. For deciding ultimate R-peak position by comparing to the maximum data value of a datum line in the front and rear each 10 msec range we have verified this.

The equation 4 shows this operation and figure 3 shows the detection of the R-peaks.

$$r(n)=\frac{1}{T}[\,x(n)-x(n\pm1)] \qquad (4)$$

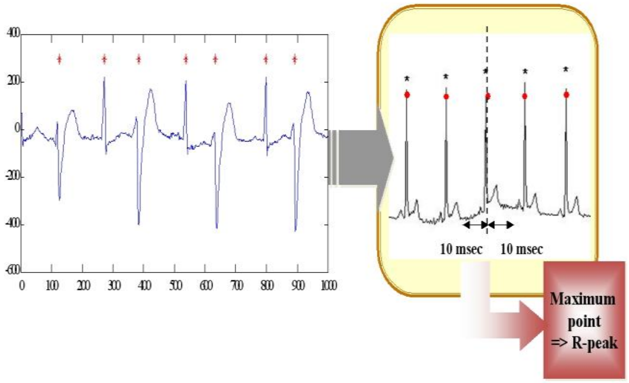

Fig. 3. Decide of the R peak detection

E. Automatic detection of ST segment and measurement

In ECG, the ST segment connects the QRS complex and the T wave and has duration of 0.08 to 0.12 sec (80 to 120 msec). Abnormal ST segments are occurring by exceptional ventricular depolarization of myocardial ischemia and acute myocardial infarction. Consequently, a rising of ST's is appeared myocardial ischemia, acute endocarditis and such like things. The descent of ST's are appeared subendocardial ischemia, subendocardial infarction and such like things. That is a rising or descent of ST segment can be identified clinically that coronary artery disease. In this study, the main focus was extracting ST-segment information. Also, the preservation of the J-point was ensured. The ST-segment position is between the end of the S-wave and beginning of the T-wave [15], also the J-point where the QRS ends and the ST segment begins [16]. The calculation of the ST-segment is follows:

$$ST_{segment}=(S_{point}-R_{point})+140_{m\sec} \qquad (5)$$

The three parts of ST measurement were taken from each average beats are 60 msec, 80 msec and ST-integral after the J-point. They are named ST60 and ST80. Figure 4 is explanation for ST measurement. A normal ECG does not showing the any ST 60 and 80 changes. Also, the calculation of the ST- integral is follows:

$$Si(n)=[\,Si(n)+r(n)+j(n)+s(n)\,]-a(n) \qquad (6)$$

where $Si(n)$, is the measured ST-integral from the ECG signals; $r(n)$, the R-peak position value; $j(n)$, the J-point position value; $s(n)$, the ST-integral start position value; $a(n)$, the subtraction of from R-peak position to ST segment baseline end (between T-wave and P-wave) position value.

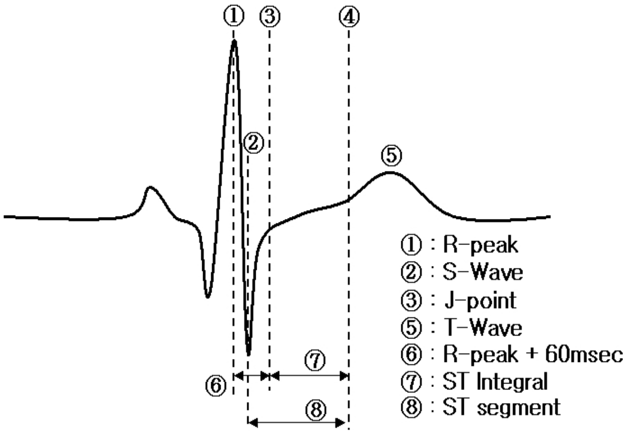

Fig. 4. ST segment and measurement

III. Experiments and Results

The ECG is a cornerstone in the diagnosis of acute and chronic ischemic heart disease. The findings depend on several ischemia disease detection factors: the nature of the process versus irreversible, the duration (acute versus chronic), extent, and localization of other underlying abnormalities [17]. Hence, amplitude of ECG signal is a few mV/V and Table 1 is explanation for waveform and characteristic normal ECG signal.

TABLE I. Characteristics Of Normal ECG Waveform

	Amplitude (mV)		Parameter Duration (Sec)
P Wave	0.25	RR Interval	0.12 – 0.20
R Wave	1.60	QRS Interval	0.09
Q Wave	25% R wave	QT Interval	0.31 – 0.44
T Wave	0.1 – 0.5	ST Interval	0.05 – 0.15

We tested the performance of the detection algorithm and application program used e0103 data on the European ST-T segment database. This application program has been implemented using visual C++6.0 tools. This data was obtained from the 62 years old patient with angina and one blood vessel disease. The analysis of the application program consists of two activities. The activities are main view part and ST measurement analysis part. Figure 5 shows the application program. The main view is the original ECG signal read and operation seven-function user interface icon in Figure 5 (a); each interface icon is filter, differential, a square, windows, baseline, signal parameters position and ST measurement. The signal analysis shows (Figure 5 (b)). The set for the baseline decision of each beat which is apply to the P and T-wave (Figure 5 (b) in ①); the ST parameter measurement, It is each ST-integral and ST 60/80 change (Figure 5 (b) in ②); the ST 60/80 change graph (Figure 5 (b) in ③); the ST-integral graph (Figure 5 (b) in ④); the ST 60/HR and ST 80/HR graph (Figure 5 (b) in ⑤).

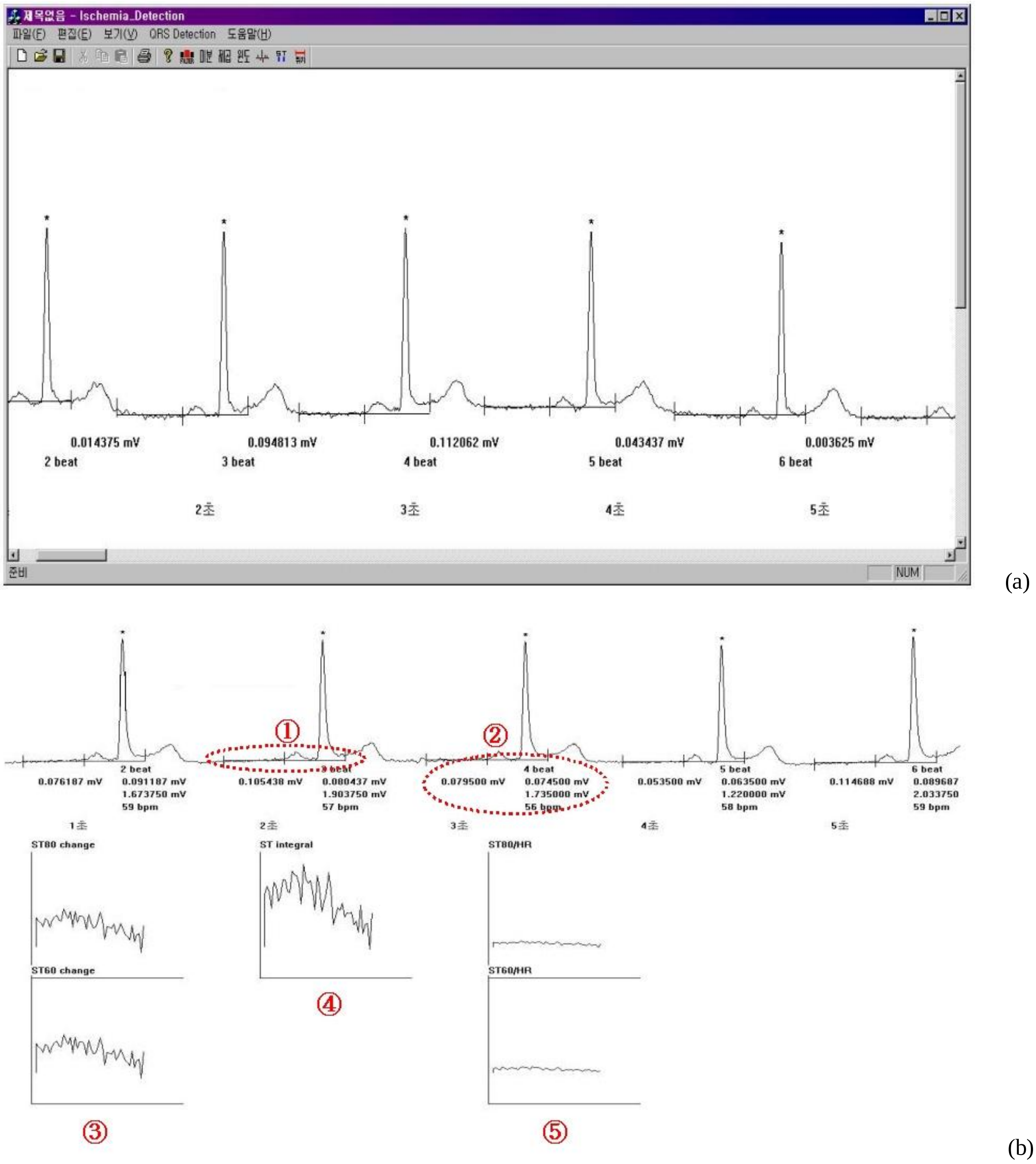

Fig. 5. Results of the ST measurement and analysis: (a) application main view; (b) signal analysis and measurement view

IV. CONCLUSIONS

This paper presents a completely automatic algorithm and application program for component detection in ECG signal. The performance and the limitations of this method are discussed. The method and the various limits and the detection parameters used were test on just one patient's data. The performance of the method must also be assessed for the value and position of all marker positions in ECG signal. In this work, this assessment is limited to the J-point, ST60/80 and ST-segment. This signal application program experimentation is an enough successful but we have a few improvement parts and not real-time signal analysis, such as considering of the noise reduction, apply to the strong diagnostic algorithm, and totally measurement of the other physiological signals (e,g., Electromyography (EMG), Magnetoencephalography (MEG), Electroencephalography (EEG)).

Also, we would study real-time ECG signal analysis, using the algorithm for comparing the normal and abnormal ECG signals, elevation of environment design of the use interface system, testing on a long term data set, and system safety for clinical trials in a variety of conditions. Finally, the developed PC application can be useful for optimization of the already available diagnosis algorithms and would assist of the early heart disease detection for medical doctors.

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ZeroX Algorithms with Free crosstalk in Optical Multistage Interconnection Network

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Abstract— **Multistage interconnection networks (MINs) have been proposed as interconnecting structures in various types of communication applications ranging from parallel systems, switching architectures, to multicore systems and advances. Optical technologies have drawn the interest for optical implementation in MINs to achieve high bandwidth capacity at the rate of terabits per second. Crosstalk is the major problem with optical interconnections; it not only degrades the performance of network but also disturbs the path of communication signals. To avoid crosstalk in Optical MINs many algorithms have been proposed by many researchers and some of the researchers suppose some solution to improve Zero Algorithm. This paper will be illustrated that is no any crosstalk appears in Zero based algorithms (ZeroX, ZeroY and ZeroXY) in using refine and unique case functions.**

Through simulation modeling, the Zero based algorithm approach yields the best performance in terms of minimal routing time in and number of passes comparison to the previous algorithms tested for comparison in this paper.

Keywords— component; Optical multistage interconnection networks (MINs); ZeroX Algorithm; crosstalk in Omega network.

I. INTRODUCTION

Multistage interconnection networks (MINs) have been proposed as interconnecting structures in various types of communication applications ranging from parallel systems [1]

, switching architectures [2], to multicore systems [3]. Advances in optical technologies have drawn the interest for optical implementation in MINs to achieve high bandwidth capacity at the rate of terabits per second. Optical MINs (OMINs) are an attractive solution that offers a combination of high bandwidth, low error probability, and large transmission capacity [4].

However, OMINs introduce optical crosstalk, which results from coupling two signals within a switching element (SE). Optical crosstalk degrades the performance of OMINs in terms of reduced signal-to-noise ratio and limits the size of the network [5]. Limited by the properties of optical signals, it is not possible to route more than one message simultaneously, without optical crosstalk, over a switching element in an OMIN. Reducing the effect of optical crosstalk has been a challenging issue considering trade-offs between aspects i.e. performance, hardware and software complexity.

There are three main approaches for solving optical crosstalk in OMINs namely the space [6], time [7] and wavelength [8][9] dilation approach. In this paper, the interest is on the time dilation approach to solve the optical crosstalk problem in the omega networks, a class of self-routable networks, which is topologically equivalent to the baseline, butterfly, cube networks et[10]. The time dilation approach solves the crosstalk problem by ensuring that only one signal is allowed to pass through each switching element at a given time in the network [11][12]. Typical MINs consist of N inputs, N outputs and n stages with n=log N. Each stage is numbered from 0 to (n-1), from left to right and has N/2 Switching Elements (SE). Each SE has two inputs and two outputs connected in a certain pattern.

The critical challenges with optical multistage interconnections are optical loss, path dependent loss and optical crosstalk [13] [14]. Optical crosstalk is caused by coupling two signals within a switching element.

In this paper, the focus is illustrated that is no any crosstalk in *ZeroX*, *ZeroY* and *ZeroXY* if the refine and unique case apply in the given networks. And illustrate that is *Fast ZeroX* depends for that is some crosstalk still occurs in ZeroX without author used refine and unique case in *ZeroX* [15][16].

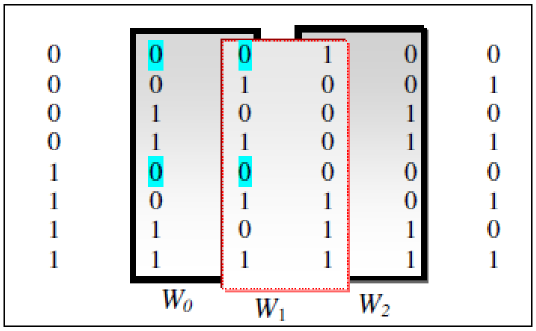
II. RELATED WORKS

There are various approaches available to reduce the problem of crosstalk like space domain, time domain and wavelength domain approach. In the present paper, our consideration is time domain approach [7]. Crosstalk is considered as a conflict in this approach. It is a good approach because it can make a balance between the electronic processor and Optical MINs [16][17]. It is not possible to send all the source addresses at the same time to their corresponding destination because it will create the switch and link conflict problem. Therefore, to route the data packets, Permutation and Semi-permutation is applied on the message groups. So that a conflict free route can be obtained for each group [4]. The source and destination address is combined to build combination matrix. On the basis of combination matrix message partitioning is performed so that some specific message should get their destination in the first pass and network remains crosstalk free. There are various techniques for message partitioning like Window Method [4][18], Improved Window Method[19] and Heuristic Routing Algorithms [19]. In this paper, the focus is to provide best message partitioning scheme so that a switch and link conflict free network can be obtained. Before describing our algorithms just have a look on the Window Method and Improved Window Method and Heuristic Routing Algorithm.

A. Window Method

This method [4] [20] basically separates the messages, which have the same bit pattern so that crosstalk can be removed. If we consider the network size N x N, it shows that there are N source and N destination address. To get a combination matrix, it is required to combine the corresponding source and destination address. This matrix shows that the optical window size is M-1, where M=log2N and N is the size of the network. The first and last columns of the combination matrix are not considered in this method and all the processing is performed on the remaining columns. If the two messages having the same bit pattern then they will be routed in the different passes.

In our example, the window size will be two and the number of window will be three W0, W1 and W2 as shown in Figure 1.



0	0	0	1	0	0
0	0	1	0	0	1
0	1	0	0	1	0
0	1	1	0	1	1
1	0	0	0	0	0
1	0	1	1	0	1
1	1	0	1	1	0
1	1	1	1	1	1

Fig. 1. Three Optical Windows in an 8×8 OON

Then, we take the second and third columns as a matrix, where example messages 000 and 100 in this window have the same bit pattern of 00 inside the window and have a conflict. The bit patterns can be any of the four combinations of 00, 01, 10, and 11.

B. Conflict Matrix

A conflict matrix is the new proposed method proposed in this research, it is a square matrix with $N \times N$ entry, where N is the size of the network, it consist of the output of the window method , the propose definition of Conflict Matrix is the matrix *Mij* with size $N \times N$ where N is the size of network,

$$M_{ij} = \begin{cases} 1 & \text{if conflict} \\ 0 & \text{otherwise} \end{cases} \qquad (1)$$

Where *Mij* is the entries of the Conflict Matrix.

Conflict matrix can be formed by assigning the value 1 when there is a conflict between the source and destination; otherwise the value 0 is assigned [4][20].

III. ZERO BASED ALGORITHMS

To avoid the crosstalk problem in omega network a new algorithm called Zero Based Algorithm is proposed and named it ZeroX algorithm, ZeroY algorithm and ZeroXY algorithm. The following sections explain these algorithms.

A. ZeroX algorithm

This algorithm depends on taking the zero values from the row *N+1*(axis X) in conflict matrix and putting it in a new group. Then, the entries of this group are considered as having zero value in the matrix. After that, anew summation for the other entries of the matrix it will be done and collecting the zero values on row N+1 as a new group. These steps are to be repeated until the whole matrix becomes Zero. That means, all the entries of matrix are found to be in separate groups. Figure 2 illustrates the general flowchart of ZeroX algorithm [4] [20].

```
Initialization
A: Matrix N*N,
 N: no. of the nodes, S: current node
$A_R$: Reduced matrix contains the currently rows $r_i$ and columns, $i \in G[k]$
$r_i$ ,$c_j$ are  the $i^{th}$ row and $j^{th}$ column   where    $0 \le i \le N-1,\ 0 \le j \le N-1$
G: List of groups; k: group index
Input   : conflict matrix A with size N*N
Output: (K and G[k]), k is the color number and G[k] is nodes at the color k
Begin
K: = 0; S: = 0 $A_R$ :=A;
While S < N do
  Begin
   For i = 1 to N do
   For j = 1 to N do
      Sum [i] = Sum [i] +  $A_R$ [i,j];
// Sum [i] is the sum for all columns in matrix $A_R$
     For j: = 0 to N-1 do
 // this loop to clustered the entries element in Current group called G[k]
          Begin
            If Sum[j] = 0 Then
             Begin
                 Color[j]:= k; G[k]:= G[k] +j;  S: = S+1;
              End if
              End for
        If S = 1 then
  // s =1 this mean the current group G[k] have only one entry equal zero
          Call Unique_Case ($A_R$, j, G[k], S)   //  function for Unique case
          Call Refine ($A_R$, G [k], S)          // function for enhance the group
             $A_R$: = $A_R$ with rows $r_j$ and columns $c_j$ where $j \notin G[k]$
             K: = k+1
   End While
 Return (k, G[k])
```

Fig. 2. Pseudo Code of ZeroX Algorithm

To avoiding the crosstalk the algorithm must implement the refine Function and Unique Case Function. The refine function illustrated in Figure 3 is used to enhance the current groups by adding one or more entries in Matrix M the intersection with current group G equal to zero.

The unique function illustrated in figure 4 is only used to check whether the current group G consists of only one entry equals zero in order for the successor entry equals to zero to be added in the same row of the G and return for the main algorithm[4][20].

Authors' are use ZeroX algorithm without apply refine function and Unique case Function and decided that are some crosstalk still occur in ZeroX algorithm in papers [12][15] [16] [18].

```
Function Refine ($A_R$ ,G[k],S)        // rows of $A_R$ which only in G[k]
Begin //The Function Refine is used to add new elements to the current group.
 For i = 1 to N do
 For j = 1 to N do
 Sum [i] = Sum [i]+ $A_R$ [i,j];
 // Sum [i] is the summation for all columns in matrix $A_R$
    For j: = 0 to N-1 do
         Begin
          If Sum[j] =0 and (j $\notin$ G[k] ) Then
            Begin
              Color[j]:= k;
              G[k]:= G[k] +m;
               S: = S+1;
            End if
         End For
    Return (G[k], S)
  End Refine
```

Fig. 3. Refine Function in *ZeroX* Algorithm

```
Function Unique_Case ($A_R$ , j, G[k], S)        // function for Unique
case
  Begin
    For m: = j+1 to N-1 do
     Begin
        If $A_R$ [j, m] = 0 then
       Begin
          G[k]:= G[k] +m;
           S: = S+1;
          Exit For
        End if
     End For
  Return (G[k], S);
  End Unique_Case
```

Fig. 4. Unique Case in *ZeroX* Algorithm

B. *ZeroY Algorithm*

ZeroY algorithm is another new algorithm proposed to avoid the crosstalk problem in Omega Network. It has the same steps of ZeroX algorithm, but with a difference in the first step where it considers the summation of rows instead of columns. The rest of the algorithm operates in the same way ZeroX algorithm does. In addition, the columns will be changed to rows an vice versa [4][20].

C. *ZeroXY Algorithm*

The ZeroXY algorithm is another new algorithm proposed to avoid the crosstalk problem in Omega network. The minimum number of passes between *ZeroX* and *ZeroY* algorithms is the output of the *ZeroXY* algorithm [20].

IV. UNIQUE CASE FUNCTION TO AVOIDING CROSSTALK IN ZEROX

The unique case is only used to check whether the current group consists of only one entry equal zero in *ZeroY* algorithm then the previous entry equal to zero is added in the same column of the current group and the next step of the algorithm is continued. That also happened in *ZeroX* for the same reason, but in *ZeroX* the successor entry equal to zero is added in the same row of current group and the next steps of the algorithm is continued. This section provides an illustrate example that show how the unique case happens and explain that no any crosstalk occur *in ZeroX* or *ZeroY* algorithms.

Assuming that the source and the destination are randomly generated and the size of the network is 8×8, the shuffle exchange in Omega network for the unique case would be as shown in Table I.

TABLE I. SHUFFLE EXCHANGE IN OMEGA NETWORK FOR UNIQUE CASE

Node No.	Source	Destination
0	000	011
1	001	001
2	010	010
3	011	000
4	100	100
5	101	101
6	110	110
7	111	111

The first column in Table 1 shows the node number of the network while, the second and third columns present the sources and the destinations. Using the Window method, the generated conflict matrix would be as it is shown in Table II.

TABLE II. THE CONFLICT MATRIX IN UNIQUE CASE

Message	000	001	010	011	100	101	110	111
000	0	0	1	0	1	0	0	0
001	0	0	0	1	0	1	0	0
010	0	0	0	0	0	0	1	0
011	0	0	0	0	0	0	0	1
100	0	0	0	0	0	1	1	0
101	0	0	0	0	0	0	0	1
110	0	0	0	0	0	0	0	1
111	0	0	0	0	0	0	0	0

From Table II, upon completing the first step of the ZeroY algorithm, the results would be as it is presented in Table III.

TABLE III. THE SUMMATION STEP IN ZEROY ALGORITHM

Message	000	001	010	011	100	101	110	111	Sum
000	0	0	1	0	1	0	0	0	2
001	0	0	0	1	0	1	0	0	2
010	0	0	0	0	0	0	1	0	1
011	0	0	0	0	0	0	0	1	1
100	0	0	0	0	0	1	1	0	2
101	0	0	0	0	0	0	0	1	1
110	0	0	0	0	0	0	0	1	1
111	0	0	0	0	0	0	0	0	0

Table III shows that only one summation appears to be zero, which is the row (message) 111. If this unique case happened, the solution would be adding the previous entry equal to zero in the same column of the current group and then continuing the next step of the algorithm. As observed from this example, the only one entry which satisfies this condition is entry 100. By adding this entry to the current group, the group will be including 2 entries 100, and 111, and then continue with the normal steps to get the rest of the nodes in the first group. Figure 5 illustrates the two passes (colors), acquired from the example after finishing the implementation of the whole ZeroY algorithm steps. The first color includes the nodes 000, 101, 011, and 110, and the second color includes the nodes 010, 001, 100 and 111.

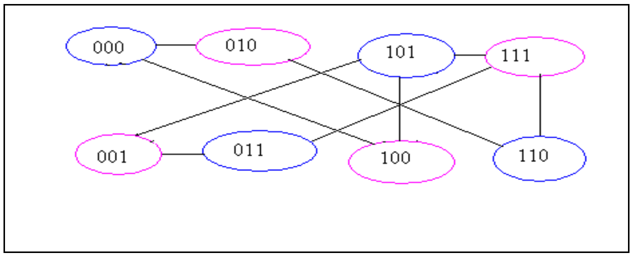


Fig. 5. Two Colors in Unique Case

The Figure 5 illustrate that is no any crosstalk in this network like the authors says in papers [12] [15] [16][18].

V. Comparative Analysis and Discussion

The comparison in this section is between the ZeroX algorithm with include refine and Unique Case functions and the routing algorithms, which includes the four heuristic algorithms namely; the Sequential up (Seq), the Sequential down (SeqDn), the Degree Ascending (Ascend), the Degree Descend (Descend), and the SA algorithm. The comparison depends on two parameters which are the average number of passes parameter and the execution time parameter using different values of the network size.

The average number of passes is shown in figures 6, and execution time shown in figures 7 respectively.

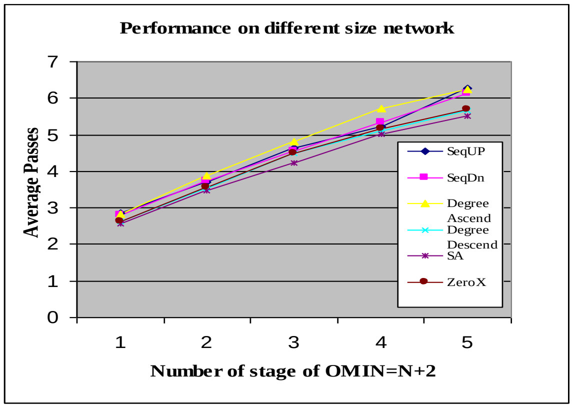


Fig. 6. Average number of Passes

From the results elaborated in figure 6 it is observed that the Degree-Ascending algorithm performs the worst in terms of the average number of passes. However, the Descend algorithm and ZeroX algorithm have the better performance. Seq algorithm and SeqDn algorithm perform better than Ascend algorithm and poorer than Descend. The Figure 6 illustrate that the SA Algorithm has been the best. The results obtained by ZeroX algorithms match closely those obtained by the Degree-Descending Algorithm. Therefore, the simulated annealing is still considered to be more appropriate for finding the average number of passes for a given network.

In the execution time terms, the results of the different heuristic algorithms, SA algorithm and ZeroX algorithm are shown figure 7.

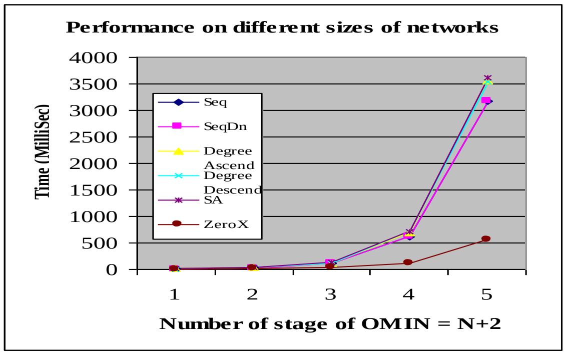


Fig. 7. Execution Time for ZeroX and Routing Algorithms

It is illustrated in figures 7 that the algorithms SA, Degree Ascend and Degree Descend perform the worst in terms of the execution time. Sequential and Sequential algorithm Down SeqDn algorithm perform better than SA, Ascend and Descend algorithms, but poorer than ZeroX algorithm. In addition, all the five routing algorithm in Figure 7 take the longest time to compute a solution compared the ZeroX algorithm in terms of the execution time. Therefore, the ZeroX algorithm can be considered more appropriate for finding the execution time for a given network. And finally the ZeroX algorithm includes refine and unique case function is free crosstalk for any given network.

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A Mixed Finite Element Method for Elasticity Problem

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***Abstract*—This paper describes a numerical solution for plane elasticity problem. It includes algorithms for discretization by mixed finite element methods. The discrete scheme allows the utilization of Brezzi - Douglas - Marini element (BDM$_1$) for the stress tensor and piecewise constant elements for the displacement. The numerical results are compared with some previously published works or with others coming from commercial code like ABAQUS.**

***keywords*—Elasticity problem; Mixed Finite element method; BDM$_1$ approximation; ABAQUS**

I. INTRODUCTION

Mixed finite element methods for linear elasticity are based on approximations of a stress- displacement system derived from the Hellinger-Reissner variational principle [7], in which both displacements and stresses were approximated simultaneously.

The mathematical analysis and applications of mixed finite element methods have been widely developed since the seventies. A general analysis for this kind of methods was first developed by Brezzi [8]. We also have to mention the papers by Babuska [14] and by Crouzeix and Raviart [15] which, although for particular problems, introduced some of the fundamental ideas for the analysis of mixed methods.

We also refer the reader to [16][17], where general results were obtained, and to the books [6][18][19].

Many mixed finite element methods have been developed for plane elasticity, and generally speaking, they can be grouped into two categories: methods that enforce the symmetry of the stress weakly, and methods that enforce the symmetry exactly (strongly). In the former category, the stress tensor is not necessarily symmetric, but rather orthogonal to anti-symmetric tensors up to certain moments. Weakly imposed stress symmetry methods also introduce a new variable into the formulation that approximates the anti-symmetric part of the gradient of u; see for example [2][3].On other hand, exactly symmetric stress methods have been much more difficult to construct. The first class of

inf_sup stable methods was the so called composite elements [4][5].

Section II presents the model problem used in this paper. The discretization by mixed finite elements described is in section III. Numerical experiments carried out within the framework of this publication and their comparisons with other results are shown in section IV.

II. GOVERNING EQUATIONS

The equilibrium equations and boundary conditions are

$$\nabla.\sigma + f = 0 \; in \; \Omega \qquad (1)$$

$$\sigma.n = \bar{t} \; on \; \Gamma_t \qquad (2)$$

$$\sigma.n = 0 \; on \; \Gamma_{c+} \qquad (3)$$

$$\sigma.n = 0 \; on \; \Gamma_{c-} \qquad (4)$$

Where n is the unit outward normal. In the above, σ is the Cauchy stress, and f is the body force per unit volume.

The constitutive relation is given by Hooke’s law:

$$\sigma = C{:}\varepsilon \qquad (5)$$

Where C is the Hooke tensor, C is assumed here to have constant coefficients. Its inverse (compliance tensor) will be denoted by E. Hence

$$\sigma = C{:}\varepsilon \Leftrightarrow \varepsilon = E{:}\sigma. \qquad (6)$$

We consider small strains and displacements. The kinematics equations therefore consist of the strain-displacement relation

$$\varepsilon = \varepsilon(u) = \nabla_S u \qquad (7)$$

Where $\nabla_s u = \frac{1}{2}(\nabla u + \nabla u^T)$ is the symmetric part of the gradient operator, and the boundary condition

$$u = \bar{u} \; on \; \Gamma_u \qquad (8)$$

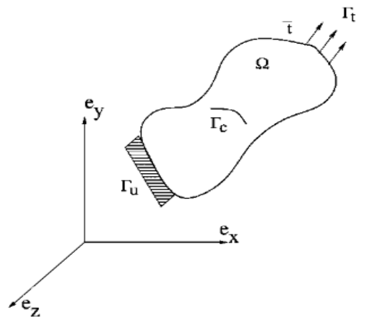

Fig. 1. Body With Internal Boundary Subjected To Loads.

We set

$$H(div,\Omega) = \{\sigma | \sigma \in \left(L^2(\Omega)\right)^4;$$

$$\sigma_{ij} = \sigma_{ji} \quad \forall i,j\,; div\sigma \in (L^2(\Omega))^2\}. \tag{9}$$

$$H_g\ (div,\Omega) = \{\tau \in H(div,\Omega);\ \tau.n = g \ on\ \Gamma_t\} \tag{10}$$

$$L^2_{dis}(\Omega) = \{u \in (L^{\,2}(\Omega))^{\,2};\ u\ discontinuous\ on\ \Gamma_c\,\} \tag{11}$$

Then the standard weak formulation of the equilibrium equations is the following:

Find $\sigma \in H_{\bar{t}}(\mathrm{div},\Omega)$ and $u \in L^2_{\mathrm{dis}}(\Omega)$ such that:

$$\int_\Omega (E : \sigma) : \tau\, dx + \int_\Omega u.\,div\ \tau\, dx = \int_{\Gamma_u} \bar{u}\ \tau.n\ d\Gamma, \tag{12}$$

$$\forall \tau \in H_0(div,\Omega)$$

$$\int_\Omega v.\,div\sigma\, dx + \int_\Omega f.v\, dx = 0\ \forall v \in L^2_{dis}(\Omega). \tag{13}$$

One can see that (12)-(13) practically coincide with the variational formulation of the Hellinger-Reissner principle. The use of this principle in the framework of finite elements can be traced Back to the pioneering work of Herrmann [9] and Hellan [10]. The interest in using the stress field σ as an independent variable is questionable in as simple a case as the present one, but it is clear in more general and more complicated problems involving nonlinearities, plasticity, and so on.

Let the bilinear forms a and b, and the linear forms l and s such that:

$$a(\sigma,\tau) = \int_\Omega (E : \sigma) : \tau\, dx \tag{14}$$

$$b(\sigma,u) = \int_\Omega u.\,div\ \sigma\, dx \tag{15}$$

$$l(v) = -\int_\Omega f.v\, dx \tag{16}$$

$$s(\tau) = \int_{\Gamma_u} \bar{u}\ \tau.n\ d\Gamma, \qquad for\ all\ \tau \in H\ (div,\Omega). \tag{17}$$

The underlying weak formulation (12)-(13) may be restated as:

Find $\sigma \in H_{\bar{t}}$ and $u \in L^2_{dis}(\Omega)$ such that:

$$a(\sigma,\tau) + b(\tau,u) = s(\tau), for\ all\ \tau \in H_0(div,\Omega) \tag{18}$$

$$b(\sigma,v) = l(v), for\ all\ v \in L^2_{dis}(\Omega). \tag{19}$$

THEOREM 1. Let E and Ψ be real Hilbert spaces, $a(\xi_1,\xi_1)$ a bilinear form on E × E, and $b(\xi,\psi)$a bilinear form an E × Ψ. Set

$$K = \{\xi |\ \xi \in E, b(\xi,\psi) = 0\ \forall\psi \in \Psi\}, \tag{20}$$

And assume that:

$$\exists\ \alpha > 0, \quad such\ that\ a(\xi,\xi) \geq \alpha \parallel \xi \parallel^2_E\ ,\forall \xi \in K \tag{21}$$

$$\exists \beta > 0, \quad such\ that \underset{\xi \epsilon E - \{0\}}{SUP} \frac{b(\xi,\psi)}{\|\xi\|_E} \geq \beta \|\xi\|_\Psi\,, \quad \forall \psi \in \Psi \tag{22}$$

Then for every $l_1 \in E'$ and $l_2 \in \Psi'$ there exist a unique solution $(\bar{\xi},\bar{\psi})$ of the problem

$$a(\bar{\xi},\xi) + b(\xi,\bar{\psi}) = \langle l_1,\xi\,\rangle, for\ all\ \xi \in E \tag{23}$$

$$b(\bar{\xi},\psi) = \langle l_2,\psi\,\rangle, for\ all\ \psi \in \Psi. \tag{24}$$

REMARK 1. If problem (21)-(22) has a unique solution for every $l_1 \in E'$ and $l_2 \in E'$, then (20) holds and the bilinear form $a(\xi_1, \xi_2)$ restricted to K, is nonsingular (in the sense that it induces an isomorphism from K onto K'). Clearly if one assumes that a (ξ_1, ξ_2) is symmetric and positive semi definite, then (21) and (22) are necessary and sufficient for the existence and uniqueness of the solution of (23)-(24).

REMARK 2. It is clear that if a (ξ_1, ξ_2) is symmetric; the solution $(\bar{\xi},\bar{\psi})$ of (23)-(24) minimizes the functional

$$J\,(\xi) = \frac{1}{2} a(\xi,\xi) - \langle l_1,\xi\,\rangle \tag{25}$$

On the subspace of E,

$$K(l_2) = \{\xi\ |\ \xi \in E, b(\xi,\psi) = \langle l_2,\psi\,\rangle\ \forall\psi \in \Psi\} \tag{26}$$

And the formulation (23)-(24) corresponds to the introduction in (25)-(26) of the Lagrange multiplier $\bar{\xi}$.

III. Mixed Finite Element Approximation

Let $T_h;\ h > 0$, be a family of rectangulations of Ω.

The edges of elements will be denoted e_i(*i=1, 2, 3 or i=1, 2, 3, 4*) in the two-dimensional case. Let us deal first with the abstract framework (23)-(24). Assume that we are given two sequences $\{E_h\}_{h>0}$ and $\{\Psi_h\}_{h>0}$ of subspaces E and Ψ, respectively.

We set

$$K_h = \{\xi_h | \xi_h \in E_h, b(\xi_h, \psi_h) = 0 \ \forall \psi_h \in \Psi_h\}. \qquad (27)$$

We have the following approximation theorem

THEOREM 2. Assume that

$$\exists \alpha_h > 0, \quad such\ that\ a(\xi, \xi) \geq \alpha_h \|\xi\|_E^2, \forall \xi \in K_h \qquad (28)$$

$$\exists \beta_h > 0, \quad such\ that \underset{\xi \epsilon E_h - \{0\}}{SUP} \frac{b(\xi, \psi)}{\|\xi\|_E} \geq \beta_h \|\psi\|_\Psi \qquad (29)$$

$$\forall \psi \in \Psi_h$$

Then for every $l_1 \in E'$ and $l_2 \in \Psi'$, and for every $h > 0$, the discrete problem

$$a(\bar{\xi}_h, \xi) + b(\xi, \bar{\psi}_h) = \langle l_1, \xi \rangle, for\ all\ \xi \in E_h, \qquad (30)$$

$$b(\bar{\xi}_h, \psi) = \langle l_2, \psi \rangle, for\ all\ \psi \in \Psi_h \qquad (31)$$

Has a unique solution. Moreover, there exists a constant $\gamma_h(\alpha_h, \beta_h) > 0$ such that

$$\|\bar{\xi} - \bar{\xi}_h\|_E + \|\bar{\psi} - \bar{\psi}_h\|_\psi \leq \gamma_h(\underset{\xi_h \in E_h}{inf} \|\bar{\xi} - \xi_h\|_E + \underset{\psi_h \in \Psi_h}{inf} \|\bar{\psi} - \psi_h\|_\psi). \qquad (32)$$

The dependence of γ_h on α_h and β_h can be easy traced [8]. Clearly if (21) and (22) hold with constants $\bar{\alpha}$ and $\bar{\beta}$ independent of h, then (32) holds with a constant $\bar{\gamma}$ independent of h.

We define in general, for m integer ≥ 0,

$$H^m(\Omega) = \{v | D^\alpha v \in L^2(\Omega), \forall |\alpha| \leq m\} \qquad (33)$$

Where

$$D^\alpha v = \frac{\partial^{|\alpha|} v}{\partial x_1^{\alpha_1} \ldots \partial x_n^{\alpha_n}}, |\alpha| = \alpha_1 + \ldots + \alpha_n \qquad (34)$$

These derivatives being taken in the sense of distributions. On this space, we shall use the semi-norm

$$|v|_{m,\Omega}^2 = \sum_{|\alpha|=m} |D^\alpha v|_{L^2(\Omega)}^2 \qquad (35)$$

and the norm

$$\|v\|_m^2 = \sum_{K \leq m} |v|_{k,\Omega}^2. \qquad (36)$$

We are now ready for the error estimates.

THEOREM 3. If (σ, u) is the solution of (12)-(13) and (σ_h, u_h) is the solution of (30)-(31), there exist a constant C > 0 such that:

$$\|\sigma - \sigma_h\|_0 + \| u - u_h \|_0 \leq Ch^2(\| \sigma \|_2 + \| u \|_3). \qquad (37)$$

Discretization of the mixed formulations, for linear elliptic operators, many examples of successful discretization of (12)-(13) are known. The first ones were introduced by Raviart and Thomas in [11] and then re-elaborated and extended to more general cases by Nedelec [12]. Other families of possible discretization were introduced years later by Brezzi, Douglas, and Marini [1][13].

To give a more precise definition of our mixed finite element approximation we shall need a few definitions. Let us define on an element K.

P_k: the space of polynomials of degree ≤ k.

We shall also need polynomial spaces on the edges of the elements

$$R_k(\partial K) = \{\phi | \phi \in L^2(\partial K), \phi|_{e_i} \in P_k(e_i), \forall e_i \in \partial K\}. \qquad (38)$$

In the two-dimensional, for the triangular elements we have

$$BDM_k(K) = (P_k(K))^2, (k \geq 1) \qquad (39)$$

$$BDFM_k(K) = \{q \in \left(P_k(K)\right)^2 \mid q.n|_{\partial K} \in R_{k-1}(\partial K)\}, (k \geq 1) \qquad (40)$$

$$RT_k(K) = (P_k(K))^2 \oplus x(P_k(K)), (k \geq 1). \qquad (41)$$

Restricting $q \in BDM_k(K)$ to have a normal trace in $R_{k-1}(\partial K)$ yields a space larger than $RT_k(K)$, but having essentially the same properties, that we denote $BDFM_k(K)$.

The dimension of BDM_k is thus

$$\dim BDM_k = \begin{cases} (k+1)(k+2) & for\ n = 2 \\ \frac{1}{2}(k+1)(k+2)(k+3) & for\ n = 3. \end{cases} \qquad (42)$$

For the triangular case we thus have the following inclusions between the spaces just defined

$$RT_0 \subset BDFM_1 \subset BDM_1 \subset RT_1 \subset BDFM_2 \subset BDM_2 \subset RT_2 \qquad (43)$$

We consider the space obtained basically from the space of Brezzi-Douglas-Marini.

$$BDM_1(K) = (P_1(K))^2. \qquad (44)$$

We have

$$div(BDM_1(K)) = P_0(K). \qquad (45)$$

$$\dim BDM_1 = 6 \qquad (46)$$

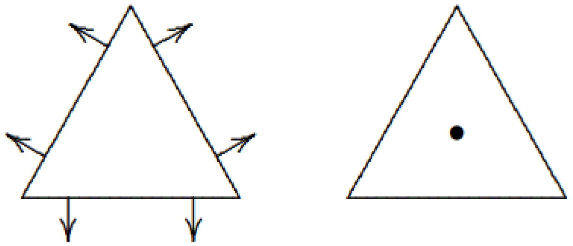

Fig. 2. . Brezzi - Douglas - Marini element, the element diagrams for the stress and displacement elements.

The discrete scheme allows the utilization of BDM_1 for the stress tensor and piecewise constant elements for the displacement.

We define, for choice of BDM_1 (K), a space

$$W_h = \{\tau_h \in H(div,\Omega), \tau_h|_K \in BDM_1(K) \quad \forall K \in T_h\} \qquad (47)$$

$$V_h = \{v_h \in L^2_{dis}(\Omega), v_h|_K \in P_0(K)\ \forall K \in T_h\}. \qquad (48)$$

We chose finite dimensional subspace $H_0^h(div,\Omega) \subset H_0(\text{div}, \Omega)$.

A mixed finite element approximation of (12)-(13) is defined by

Find $\sigma_h \in W_h$ and $u_h \in V_h$ such that

$$\int_\Omega (E : \sigma_h) : \tau_h dx + \int_\Omega u_h.div\tau_h dx = \int_{\Gamma_u} \bar{u}\,\tau_h.n\,d\Gamma \quad \forall \tau_h \in H_0^h(div,\Omega) \qquad (49)$$

$$\int_\Omega v_h.div\sigma_h dx + \int_\Omega f.v_h dx = 0\ \forall v_h \in V_h. \qquad (50)$$

We obtain a system of linear equations

$$\begin{pmatrix} A & B^T \\ B & 0 \end{pmatrix}\begin{pmatrix} T \\ U \end{pmatrix} = \begin{pmatrix} S \\ L \end{pmatrix}. \qquad (51)$$

Where $S = [s_m], L = [l_m]$.

The matrix associated for the system (51) is symmetric indefinite. We use the iterative methods Minimum Residual Method (MINRES) for solving the symmetric system.

IV. NUMERICAL SIMULATIONS

Example 1. Circular Void in a Finite Plate

Here a void of radius 0.3 is placed in the center of a plate of size 3 × 3 which is subjected to a unit stress in the y-direction.

The stress plot for σ_{yy} s is in excellent agreement with the expected 3σ stress concentration at the edges of the hole.

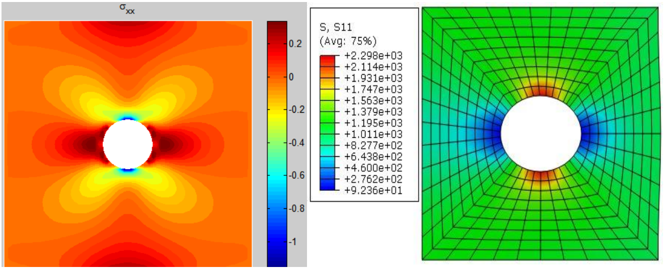

Fig. 3. Stress Solution Σ_{xx} By Mixed Finite Element Method (Left) And Stress Solution (Right) Computed By ABAQUS.

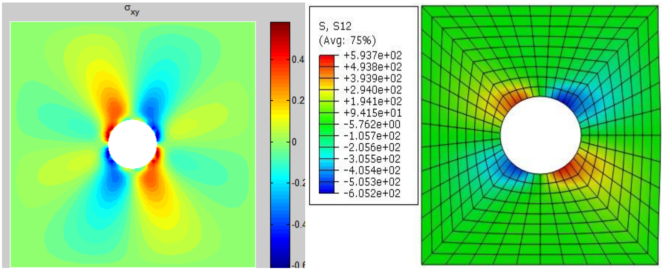

Fig. 4. Stress Σxy By Mixed Finite Element Method (Left) And Stress Solution (Right) Computed By ABAQUS.

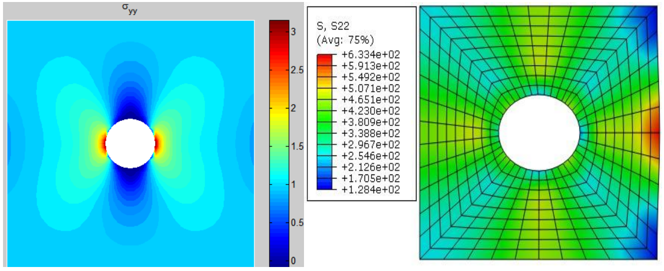

Fig. 5. Stress Σ_{yy} By Mixed Finite Element Method (Left) And Stress Solution (Right) Computed By ABAQUS.

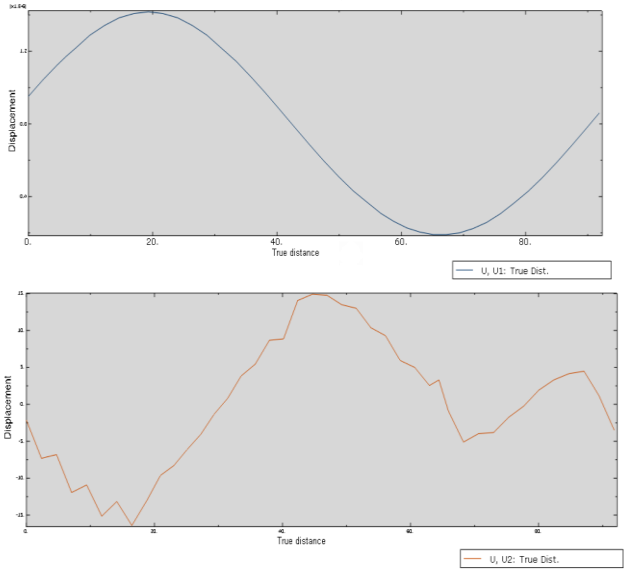

Fig. 6. Curve Of The Displacement Ux And Uy Along Hole In A Finite Plate

Example 2. Circular Inclusion in a Finite Plate

Here an inclusion with E = 70gpa and $\upsilon = 0.3$ and radius 0.5 is placed in the center of a plate of size 6 x 10 with E = 50gpa and $\upsilon = 0.3$ which is subjected to a unit tension in the y-direction.

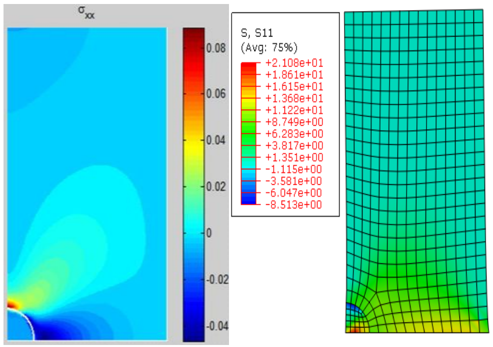

Fig. 7. Stress Σ_{xx} By Mixed Finite Element Method (Left) And Stress Solution (Right) Computed By ABAQUS.

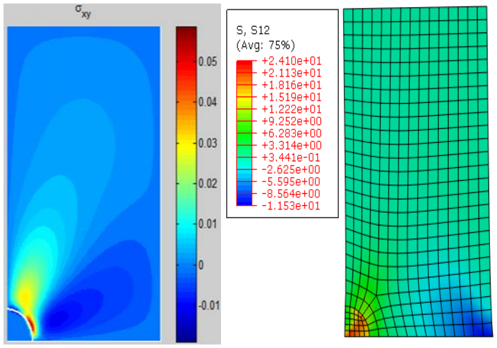

Fig. 8. Stress Σ_{xy} By Mixed Finite Element Method (Left) And Stress Solution (Right) Computed By ABAQUS.

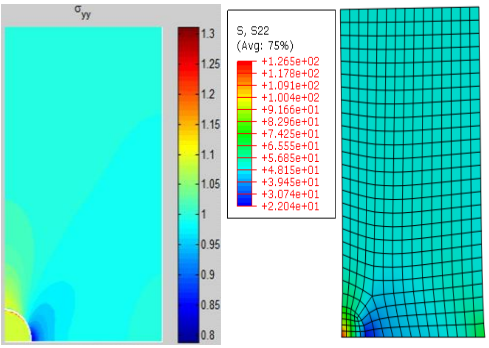

Fig. 9. Stress Σyy By Mixed Finite Element Method (Left) And Stress Solution (Right) Computed By ABAQUS.

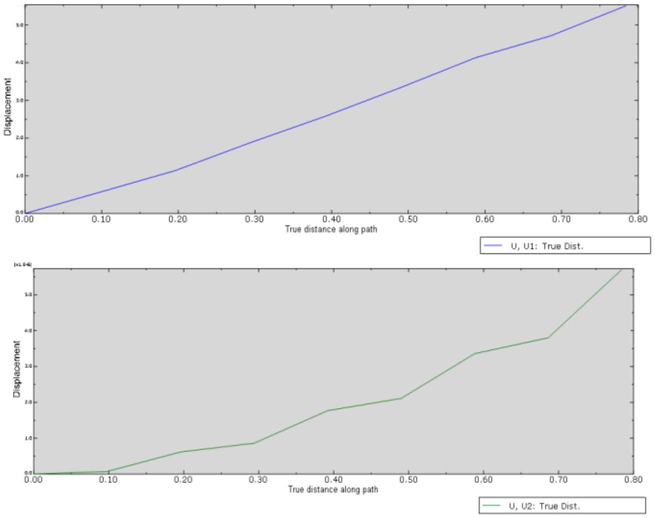

Fig. 10. Curve Of Displacement Ux And Curve Of Displacement Uy Along Inclusion In A Finite Plate.

V. Conclusion

We were interested in this work in the numeric solution for equilibrium equations. It includes algorithms for discretization by mixed finite element methods. The discrete scheme allows the utilization of BDM_1 for the stress tensor and piecewise constant elements for the displacement. Our results agree with ABAQUS.

Numerical results are presented to see the performance of the method, and seem to be interesting by comparing them with other recent results.

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Omega Model for Human Detection and Counting for application in Smart Surveillance System

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Abstract— **Driven by the significant advancements in technology and social issues such as security management, there is a strong need for Smart Surveillance System in our society today. One of the key features of a Smart Surveillance System is efficient human detection and counting such that the system can decide and label events on its own. In this paper we propose a new, novel and robust model: "*The Omega Model*", for detecting and counting human beings present in the scene. The proposed model employs a set of four distinct descriptors for identifying the unique features of the head, neck and shoulder regions of a person. This unique head-neck-shoulder signature given by the Omega Model exploits the challenges such as inter person variations in size and shape of people's head, neck and shoulder regions to achieve robust detection of human beings even under partial occlusion, dynamically changing background and varying illumination conditions. After experimentation we observe and analyze the influences of each of the four descriptors on the system performance and computation speed and conclude that a weight based decision making system produces the best results. Evaluation results on a number of images indicate the validation of our method in actual situation.**

Keywords - Omega Model; Human Detection; Surveillance; Back ground Subtraction; Gaussian Mixture Model (GMM); Mixture of Gaussians (MOG).

I. Introduction

The state-of-art of surveillance has made a quantum jump in recent years. However with the increase amount of video data to be processed it is becoming more and more unmanageable for human beings to monitor continuously. So if we could develop a surveillance system which could detect and classify objects, take decisions and label events autonomously, then a complete revolution can be brought in the current surveillance system. Vision based Human detection and counting is currently one of the most challenging tasks in the field of computer vision. The general surveillance cameras are like machines that can only see, but cannot decide or identify things or events on its own. So, keeping in mind the present day scenarios, it is important that we make our surveillance system intelligent and smart. Therefore, we propose to design a new framework to robustly and efficiently detect and count human beings, for application in surveillance. The proposed system would consist of: Background subtraction, boundary extraction, Head-neck-shoulder detection and, finally human/non-human classification and based on that, counting the number of human present in a scene. For these, we first intend to subtract the background and extract the foreground of any real time video. There are a lot of techniques available for background subtraction. And Gaussian Mixture Model (GMM) is found to be more efficient in the literature. So we intend to use GMM for this purpose. Moreover some of the commonly faced problems in background subtraction are sudden changes in illumination, dynamic background, camouflage, etc. Hence we intend to design a robust adaptive GMM algorithm which can effectively deal with all these problems and produce a foreground mask. Secondly we intend to detect human presence in the scene by detecting the head and shoulder portion by using the *Omega Model*. We propose this model because the head-shoulder portion is the most unvarying part of human body. Based on the number of human beings detected we shall count the total number of human present in the scene. And hence the entire system could be used for application in an effective surveillance system.

The rest of the paper is organized as follows: In section II we discuss some of the related work in this field; in section III we give an overview of the method adopted for our work. In section IV our human detection and counting system is discussed giving a detailed description of our proposed Omega model explaining each of the descriptors and the algorithm. In section V we have explained results followed by conclusion and our future work in section VI.

II. Related Work

There is an extensive literature on shape classification. Various approaches for shape based classification are discussed in [1-10].However different moving objects like bird, vehicle, etc may be present in the scene, so it is very important that we correctly distinguish humans from other moving objects. There are mainly two methods for classifying a moving object: shaped based detection and motion based detection [11]. In former one, human can be detected with the help of their shape information. This kind of a work was done in [12-14] where they used an SVM classifier to detect human beings based on finding people's head by searching for circular patterns through a 2D correlation using a bank of annular patterns. Also it is a general fact that non articulated human motion exhibits certain periodicity. This property was used by many researchers to detect human beings based on their motion. In [14] based on the color object's moving and background subtraction method, a color classifier based on the HS thresholds was proposed to detect moving object. In [15] edge-based features combined along with color and texture information was used for efficient human detection. In [16] human had been detected by detecting skin like pixels and locating each face like region. Also some researchers have employed model based human detection [17,18].In [17] such kind of work was done wherein they proposed a method for human detection by modeling human as flexible assemblies of parts represented by co-occurrence of local features. In [18] part detectors were learned by boosting a number of weak classifiers based on edgelet features. Recently in 2013 authors [19] have presented a method for human detection in range images captured from a vertically oriented camera by analysis of 3D range data.

III. Overview of the Method

This section gives an overview of the method adopted in our Human detection and Counting system. One of the major challenges in the field of object recognition is the ability to detect human beings irrespective of the variations in pose, body shape, clothing, illumination, moving cameras and changing background. So in this work we have developed the Omega model that could detect human beings under all this challenging scenarios. The methodology or the general flow diagram of our work is shown below:

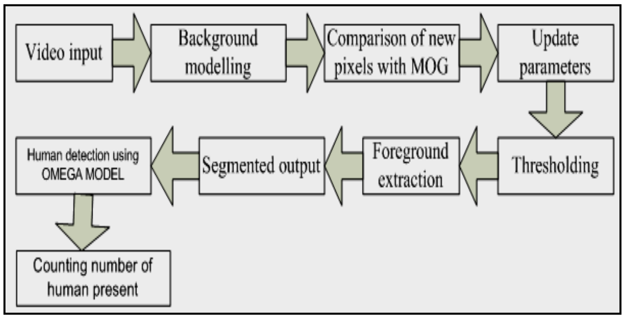

Video input
Background modelling
Comparison of new pixels with MOG
Update parameters
Thresholding
Foreground extraction
Segmented output
Human detection using OMEGA MODEL
Counting number of human present

Fig. 1. General Flow Diagram Of Our Human Detection And Counting System.

The various steps involved are:

- Acquiring real time video input from any video acquisation device
- Background modelling using adaptive GMM
- Background subtraction and shadow detection
- Human detection and counting using the Omega Model.

IV. Human Detection and Counting System

In this work, we first perform adaptive background modeling to extract the foreground region from a real time Surveillance video. Then we acquire a set of these foreground images from a surveillance video. As we know that the human head shoulder portion is the most unvarying part of human body, so we have used this dominant feature as the key information and developed the Omega Model for human detection.

A. Foreground Extraction

A good surveillance system requires an accurate segmentation of moving objects from a video sequence. Foreground extraction is generally done by using background subtraction, optical flow and frame differencing. However, Background subtraction is one of the most efficient and widely used methods for segmenting dynamic scene in a video. The most common paradigm for background subtraction is to use an explicit model of the background. Background is generally modeled based on some regular statistical characteristics. Intruding objects are then detected by comparing the statistical parameters of the modeled background with that of the current frame. However this method does not work well in surveillance scenarios where the background is generally subjected to challenges like dynamic lightning conditions, long term scene changes, bimodal background, repetitive flickering motions etc. So, for application in surveillance it is important that the parameters of the background are also adaptive. Hence we have employed the adaptive GMM method proposed in [20] for modeling the background.

a) Gaussian mixture Model:

A Gaussian Mixture Model (GMM) is a parametric probability density function represented as a weighted sum of Gaussian component densities. GMMs are commonly used as a parametric model of the probability distribution of continuous measurements or features in a biometric system, such as vocal-tract related spectral features in a speaker recognition system. GMM parameters are estimated from training data using the iterative Expectation Maximization (EM) algorithm or Maximum A *Posteriori* (MAP) estimation from a well-trained prior model.

A Gaussian mixture model is a weighted sum of M component Gaussian densities as given by the equation,

$$p(X|\lambda) = \sum_{i=1}^{M} w_i g(X|\mu_i, \Sigma_i)$$

where x is a D-dimensional continuous-valued data vector (i.e. measurement or features), w_i, i=1, . . . ,M, are the mixture weights, and $g(x|\mu_i,\Sigma_i)$, i = 1, . . . ,M, are the component Gaussian densities. Each component density is a D-variate Gaussian function of the form,

$$g(X|\mu_i,\Sigma_i) = \frac{1}{(2\pi)^{\frac{D}{2}}|\Sigma_i|^{1/2}} \exp\{-\frac{1}{2}(X-\mu_i)'\Sigma_i^{-1}(X-\mu_i)\}$$

with mean vector μ_i and covariance matrix Σ_i. The mixture weights satisfy the constraint that $\sum_{i=1}^{M} w_i=1$.

b) Parameter updates

The new pixel value $\mathbf{Z_t}$ is checked against each Gaussian. A Gaussian is labeled as matched if

$$\|Z-\mu_h\| < d\sigma_h$$

Then its parameters may be updated as follows:

$$w_{i,t} = (1-\ \alpha) * w_{i,t-1} +\ \alpha * M_{i,t}$$
$$\mu_t = (1-\rho) * \mu_{t-1} + \rho * Z_t$$
$$\sigma_t^2 = (1-\rho) * \sigma_{t-1}^2 + \rho * (Z_t-\mu_t)^T * (Z_t-\mu_t)$$
$$\rho = \alpha * N(\mu_t)$$

Where α is the learning rate for the weights.

If a Gaussian is labeled as unmatched only its weight is decreased as

$$w_{i,t} = (1 - \alpha) * w_{i,t-1}$$

If none of the Gaussians match, the one with the lowest weight is replaced with $\mathbf{Z_t}$ as mean and a high initial standard deviation.

The rank of a Gaussian is defined as w/σ. This value gets higher if the distribution has low standard deviation and it has matched many times. When the Gaussians are sorted in a list by decreasing value of rank, the first is more likely to be background. The first B Gaussians that satisfy (1) are thought to represent the background.

$$B = \arg min_b \left(\sum_{k=1}^{b} w_i > T\right) \qquad (1)$$

The Gaussian mixture model (GMM) is adaptive; it can incorporate slow illumination changes and the removal and addition of objects into the background. Further it can handle repetitive background changes like swaying branches, a flickering computer monitor etc. The higher the value of T in (1), the higher is the probability of a multi-modal background.

In our work we have modeled the background as a mixture of three Gaussians.

B. Omega Model for Human Detection

Significant research has been devoted to detecting people in images and videos. Human detection is a challenging classification problem which has many potential applications in the field of machine vision. The main problems in detecting human beings are due to the variations in pose, body shape, clothing, illumination, moving cameras and changing background.

Therefore the main challenge is to find a set of unique features that characterizes human being in a scene, while remaining resistant to the above mentioned problems.

Thus in this work a new algorithm is presented to detect human beings in still images using a set of four descriptors. After the foreground extraction, the human beings have been detected by studying some of their invariant features like the head-neck- shoulder signature.

a) Outline of approach for Human Detection system:

The block diagram of the proposed Human detection system is as shown below in Fig2.

This approach uses a shape based representation of the extracted foreground contour for human detection. The advantages of this approach are:

- It can detect human beings even in partial occlusion (when legs are partially occluded).
- It is tolerant to varying human pose.
- It can detect human beings even if the person is not facing the camera directly.
- The final decision is weight based and depends on multiple evidences obtained from descriptors.

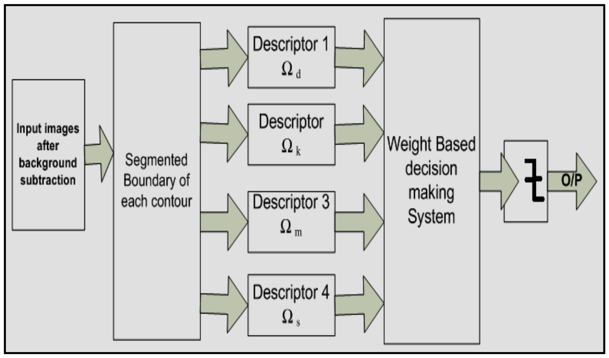

Input images after background subtraction
Segmented Boundary of each contour
Descriptor 1 Ω d
Descriptor Ω k
Descriptor 3 Ω m
Descriptor 4 Ω s
Weight Based decision making System
O/P

Fig. 2. Flow chart for Omega model for human detection

In this approach, the boundary of the contour of the extracted foreground object has been examined experimentally to obtain some of the invariant features of human beings from the shape of the contour. Four descriptors have been designed to specifically analyze these invariant features and thereafter take a weight based decision to detect the presence of human beings in the scene.

b) Descriptors for Human Detection:

The choice of the distinguishing features for classification is a critical design step and depends on the characteristics of the problem domain. Having extracted the contour of the foreground objects, a set of invariant features have been chosen to detect the presence of human being in the scene. In this work we have developed four descriptors to classify the human beings from other non- human objects by using distinct features that are simple to extract as well as invariant to irrelevant transformations.

From the set of boundary points obtained, by processing the contour of the segmented objects, the main aim here is to develop descriptors that describe the '*Omega*' shape (i.e. the shape of upper portion of human body) in the best possible manner.

The four Descriptors we use are as follows:

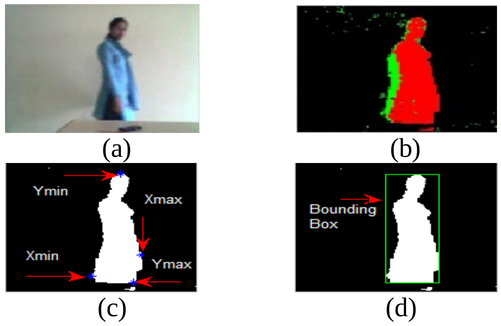
Descriptor 1 (Ω_d) :(Head-neck- shoulder dimensions of Ω)

- This shape based descriptor is firstly defined by its dimension given as shown in figure (3(b)):

  $\{\mathbf{Y_{max} - Y_{min}, X_{min} - X_{max}}\}$

- A bounding box is designed to include the object of interest and whose axes are aligned with the image axes as shown in figure (d)
- Based on the set of boundary points obtained, co-ordinates of the centroid are calculated.
- From this obtained centroid, data for width of shoulder and neck is obtained.
- The data obtained is then experimentally analyzed with a number of training images to obtain a threshold for

describing the optimum ratio of these width and compare with the testing images.



(a) (b)

(c) (d)

Fig. 3. (a) original image, (b) image after background subtraction(c) dimensions of the image (d) Bounding box for the contour.

Based on this threshold (obtained experimentally) a decision is made if a human being is present in the scene or not.

Descriptor 2 (Ω_m): *(Radial Feature of Ω)*

- This descriptor particularly defines the radial feature of the human head.
- Based on experimental analysis the upper (head) portion of the contour is extracted and a point (S') lying somewhere between the neck and tip of head is obtained.
- The radial distance between each of the points in the boundary and point S' is calculated.
- The pattern of occurrence of these distances is observed for human contours.
- Based on the pattern a decision is taken if the extracted contour is that of human head or not.

Descriptor 3 (Ω_k): *(Curvature of Ω)*

- This descriptor classifies human based on the information of curvature of human head-neck-shoulder portion.
- At each point in the boundary of the contour, curvature is estimated which is an indicator of the amount of bending of the curve that occurs at that position.
- Based on the set of curvature values obtained for each of the boundaries of the contour, the patterns have been studied.
- Analysis of these pattern shows that a specific number of local minimas occur if the contour under observation is that of human being.
- Based on this experimental analysis, a threshold is obtained and decision is taken whether a human being is present in the scene or not.

Descriptor 4 (Ω_s): *(Convexity of Ω)*

- Here shape description is based upon the convex hulls of the set of boundary points obtained from the extracted contour.
- The convex hull of the set of boundary points of the contour is the enclosing convex polygon with the smallest possible area.
- So here we analyze the convexity of the head-shoulder portion of human body. We define convexity (R_s) as:

$$\boldsymbol{R_s} = \frac{\textbf{\textit{area of rectangle bounding the upper segmented contour}}}{\textbf{\textit{area of Convex hull}}}$$

- The ratio obtained above have been analyzed for a number of test image and based on experimentation a threshold have been obtained to detect the presence of human being in the scene.

Weights are assigned to each of the descriptor based on the experimental analysis. Finally based on the decisions obtained from the four descriptors, a weight based decision is taken and if outcome is above a certain threshold than a human being is said to be present in the scene.

The complete algorithm for detecting human beings employing these four descriptors is given in the next sub-section.

c) Algorithm for Human Detection: The algorithm, that have been designed for human detection is as described below.

Each of the extracted contour present in an image is processed to find human beings based on the descriptors. Each of the descriptors has been assigned a weight depending on their performance analysis. Finally a weight based decision is taken and compared with a standard threshold (**Ω_{th}**) obtained from experimental analysis and accordingly the human beings present in the scene is detected and counted.

V. Experimental Results and Discusions

The results obtained for human detection and counting are very satisfactory. Here after background subtraction, the contours present in the segmented foreground image is processed using the developed algorithm for *Omega model*. The resolution of the camera used in the work is 120X160, running in a 32 bit operating system, 2.00 GHz processor, and 2 GB RAM. The achieved speed of execution for foreground extraction is 21 fps. The developed algorithm was then tested on 100 frames, each consisting one or more number of human beings (including frames where the human is partially occluded i.e legs are occluded) and 50 frames that did not contain human beings. We have achieved a success rate of 95%. The time required to detect human in a frame is 18ms.Certain error arouse due to complete occlusion of the head shoulder portion. However our method is tolerant to changing background and also effectively deals with different poses of head- shoulder shape taken from different camera angles. A Matlab based tool with Graphical User Interface (GUI) has been developed for the ease of use by anyone to detect the number of human being present at a scene.

Algorithm for Omega model for human detection:

Descriptor 1(Ω_d) (*Neck shoulder dimensions of Ω)*

1. Get the boundary points $\{x_i, y_i\}$ for each contour obtained from background subtraction.
2. Find $\mathbf{Y_{min}}$, $\mathbf{Y_{max}}$, $\mathbf{X_{min}}$, $\mathbf{X_{max}}$ values for each of the boundaries obtained in step1.(refer fig.3(c))
3. Obtain the height (**h**) and width (**w**) of the contour.
4. Find the co-ordinates of centroid $(\mathbf{C_x}, \mathbf{C_y})$ of the contour.
5. Find distance, **d**= 1/3 of **h** and **d'** =1/2 of **d**.
6. Obtain the following points:

(a) $X_{min1}, X_{max1} < C_x$

(b) $X_{min2}, X_{max2} > C_x$

7. Define two variables ш_1 (neck width) and ш_2 (shoulder width) such that:

(a) $\text{ш}_1 = X_{max1} - X_{min2}$

(b) $\text{ш}_2 = X_{max2} - X_{min1}$

8. Take a decision, $[\Omega_d = 1$ **if** $\text{ш}_1/\text{ш}_2 = T_d$,
$=0$ **otherwise].**

Descritor2 (Ω_m): *(Radial feature of Ω)*

9. Obtain a point '**S**' (from experimentation) lying between nose and neck in the y direction from C_y to Y_{min}.
10. Find the distance **S'** between S and Y_{min}.
11. Define a set of points $\{S_1', S_2' S_3' S_4' S_5' S_6' \ldots\ldots\ldots\ldots S_n'\}$ to all other points in the segmented boundary.
12. Take a decision such that:

$[\Omega_m = 1$ **if** $S' > \{S_1', S_2' S_3' S_4' S_5' S_6' \ldots\ldots\ldots\ldots\ldots S_n'\}$,
$=0$ **otherwise].**

Descriptor 3(Ω_k): *(Curvature of Ω)*

13. Calculate the absolute values of curvatures $\{C_i\}$ for the segmented boundary (1/3 of **h**) given as

$$C = \frac{x'y'' - x''y'}{\sqrt[3]{x'^2 - y'^2}}$$

14. Find the number of local minima for the segmented upper contour.
15. Take a decision:

$[\Omega_k = 1$, **if** $a_1 < C < a_2$
$= 0$ **otherwise]**, where a_1 and a_2 are the thresholds for number of local minima.

Descriptor 4(Ω_s) *(Convexity of Ω)*

16. Find the convex hull of the upper segmented boundary of the contour.
17. Find the area (A_c) of the convex hull.
18. Find the area (A_r) of the rectangle bounding the upper segmented contour.
19. Find the ratio: $R_s = A_r / A_c$.
20. Take a decision:

$[\Omega_s = 1$, **if** $r_1 < R_s < r_2$
$= 0$ **otherwise]**,

where r_1 and r_2 are the thresholds values for R_s.

21. Finally take a weight based decision.

Define a function **H (Ω)** such that:

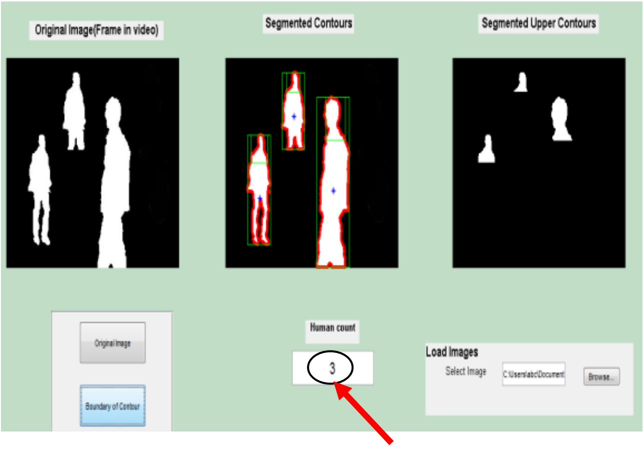
$$\mathbf{H(\Omega) = S_d\Omega_d + S_m\Omega_m + S_k\Omega_k + S_s\,\Omega_s},$$

where $\mathbf{S_d}$,$\mathbf{S_m}$, $\mathbf{S_k}$, $\mathbf{S_s}$ are the respective weights of descriptors.

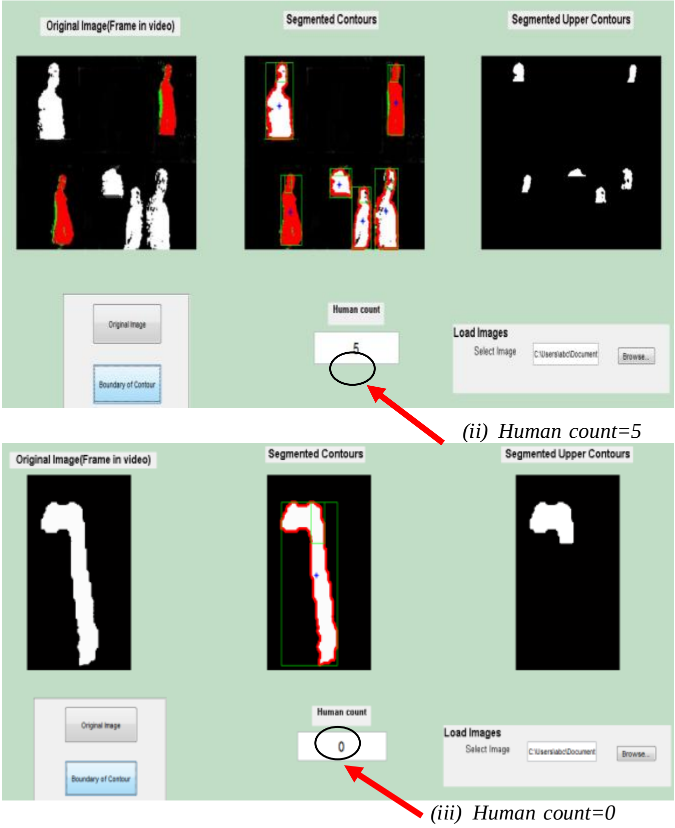
An extracted contour is said to be that of human if

$$\mathbf{H\ (\Omega) >= \Omega_{th.}}$$

When the tool is started, the user can browse and select any image containing contours of foreground object. The GUI shows the user a bounding box for each of the object present in the original image. Then the segmented contour for each of the object is also shown in the window and then using the algorithm it automatically generates the count of the number of human beings present in the image. A screen shot of the developed GUI is as shown below.



(i) Human count=3



(ii) Human count=5

(iii) Human count=0

Fig. 4. GUI shown for human count in images using the developed algorithm.

VI. Conclusion and Future work

A method for human detection and counting has been presented in this paper. The key feature of our work is, we have employed four descriptors to detect four invariant and significant feature of human head-shoulder region to achieve our goal. We studied the influence of various descriptor parameters and conclude that none of them can individually detect human, hence we employed a weight based decision system for a good performance. Experiments performed on several images validate the effectiveness of our approach.

In our future work we shall focus on implementing the Omega Model in video, and hence develop a Real-time Smart Surveillance Systems that can decide and label events and give threat alerts for security conscious venues.

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Integration of Automated Decision Support Systems with Data Mining Abstract: A Client Perspective

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ABSTRACT**—Customer's behavior and satisfaction are always play important role to increase organization's growth and market value. Customers are on top priority for the growing organization to build up their businesses. In this paper presents the architecture of Decision Support Systems (DSS) in connection to deal with the customer's enquiries and requests. Main purpose behind the proposed model is to enhance the customer's satisfaction and behavior using DSS. We proposed model by extension in traditional DSS concepts with integration of Data Mining (DM) abstract. The model presented in this paper shows the comprehensive architecture to work on the customer requests using DSS and knowledge management (KM) for improving the customer's behavior and satisfaction. Furthermore, DM abstract provides more methods and techniques; to understand the contacted customer's data, to classify the replied answers in number of classes, and to generate association between the same type of queries, and finally to maintain the KM for future correspondence.**

Keywords—Decision Support Systems; Knowledge Management; Data Mining; Customer's Satisfaction.

I. INTRODUCTION

Customers are regularly in contact with the organizations through telephone lines, online website portal, or through customer care centers directly. The organizations keen to learn their employees about how to deal with the customers in efficient manner. Customer's satisfaction and to improve in their behavior with the company is the main aim for every organization. As customers are supposed large stakeholders; those can increase and decrease the profit ratio of the company.

Abdullah et al. [9] described that customer's feedback and satisfaction level is the major performance indicators to improve customer's behavior which a customer leaves behind of his/her every visit to the company. In this paper we presented the model of automated decision support systems for dealing with the customer's queries for increase the customer's satisfaction ration. For this, we integrated the model with DM abstract to build a KM database in connection with automated DSS database. Ruey [3] discussed the connection of DM technique with customer's data that, the systemic applications of DM strengthens the KM process and allows marketing personnel to know their customers well to provide better services. Figure. 1 by [13] showed the working of traditional hot-line customer service center which representing the long process of customer dealing via telephone line and advisory system. Which shows that in current days we cannot relied upon dealing with the customers in traditional manner. There is a need to focus on current trends and technology to improve the performance and growth of the organization.

Before discussing the proposed model in this paper, the subsequent sections discussing the introduction of DSS and DM approaches using literature are reviewed to understand more about the subject matter. Therefore, in the next section the discussion about the DSS configuration and components is presented. Followed by discussion on DM tasks to provide some background of it too.

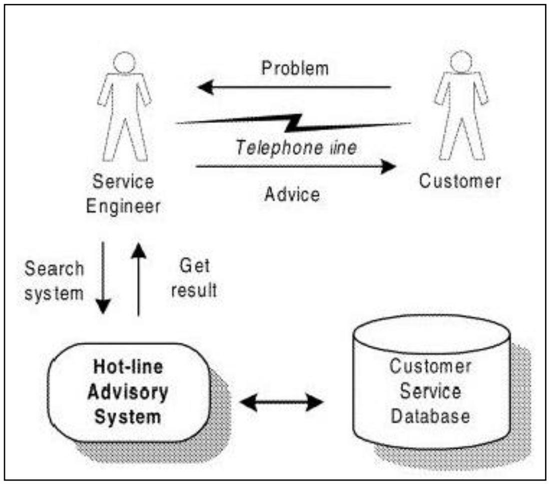

Fig. 1. Traditional Hot-Line Service Center [13]

A. *Decision Support System*

Currently, business environment is more complex than ever before. The reason behind is the rapid growth and involvement of the technology in the businesses. Modern technology is managing the cause of increasing business pressure on the business men. Furthermore, the businesses are need to be updated using current technology to defend their selves from competitor's attack timely. The computerized support and automated decision support systems are becoming the fundamental elements for almost every organization to stay in the market safe and healthy.

DSS provides the environment to apply many tools for all kind of business environmental factors such as; markets, technology, customer demand, and societal & environmental factors to generate several choices and in the end to be selected optimal solution [2]. A DSS can have several phases to analyze the problem and take the decision. As Turban described a DSS must consider four phases for complete decision making process such as; Intelligent, Design, Choice and Implementation [2].

Industries build DSS for making themselves proactive and anticipative. The configuration of DSS can be based on data or model. The major classification of DSS are based on (i) Data Oriented DSS, (ii) Model Oriented DSS [2]. While some other scholars also categorized DSS into several categories such as; individual and group DSS, spreadsheet DSS, solver oriented DSS, etc.

Figure-2 [2] showed the basic model of DSS including linkages with its components. In this figure showing the four parts of DSS are; data, models, knowledge and user interface. In this paper we are applying the same concept with some integration in the model, discussed later in methodology section.

In the succeeding section presented the most common DM approaches and tasks which will describe more about the DM background.

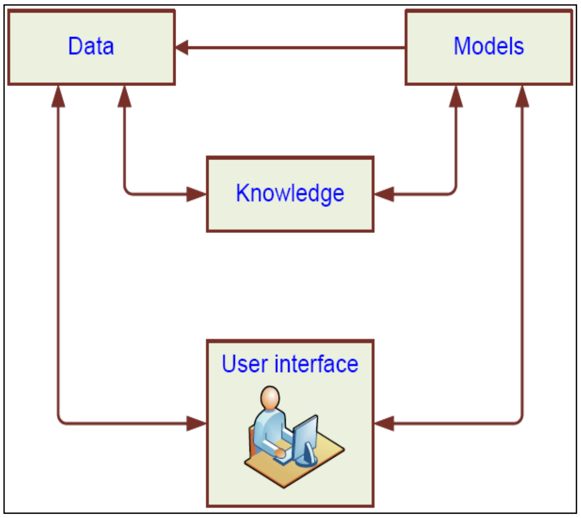

Fig. 2. Components of DSS [2]

B. Data Mining Approaches

Data Mining, which also known as Knowledge Discovery in Databases (KDD), refers to the significant extraction of hidden, previously unknown and potentially useful information from data in databases. While DM and knowledge discovery in databases (or KDD) are frequently treated as synonyms, DM is actually part of the knowledge discovery process [5, 8]. Furthermore, Abdullah et. Al described the DM concept in connection with decision support systems (DSS), in decision support management terminology, DM can be consider as a decision support process in which decision maker is searching to generate rule for the help in decision making process [9, 7, 16]. There are several other fields where data mining techniques has been applied by researchers such as, medical database and ERP database [1, 14].

Mainly, DM tasks has been divided into descriptive and predictive methods. Classification, clustering and rule association mining are most common techniques use for predictive and descriptive analysis [10]. Therefore, mainly scholars describe DM in three major tasks. As Zaine [5] stated in his book chapter about major techniques of DM as follows:

a) Classification: Classification analysis is the organization of data in given classes. Also known as supervised classification, the classification uses given class labels to order the objects in the data collection

Classification consider as an important task of DM. Using this approach data must be already defined a class label (target) attribute. Firstly we divide the classified data into two sets; training and testing data [11]. Where each datasets contains others atrributes also but one of the attributed must be defined as class lable attribute. Jiawei Han [11] described classification task in two steps process; first is model construction and the second is model usage. The main target of this task is to build the model by using training dataset and then assign unseen records into a class by using the trained model as accurately as possible. While training data set is use to build the model on the other hand testing data set is use to validate the model [10].

b) Clustering: Similar to classification, clustering is the organization of data in classes. However, unlike classification, in clustering, class labels are unknown and it is up to the clustering algorithm to discover acceptable classes. Clustering is also called unsupervised classification.

Clustering is one of the major task has been applying for DM, work on unsupervised data (no predefined classes) [12]. Clustering is a collection of data objects, clustered by taking similar object to one another within the same cluster, and dissimilar to the objects related in other clusters. Cluster differentiate by using similarities between data according to the characteristics found in the data and grouping similar data objects into clusters [11].

c) Association: Association analysis is the discovery of what are commonly called association rules. It studies the frequency of items occurring together in transactional databases, and based on a threshold called support, identifies the frequent item sets.

Data can be use to find association between several attributes, generate rules from data sets, this task is known as association rule mining [12]. Given a set of transactions, find rules that will predict the occurrence of an item based on the occurrences of other items in the transaction. The goal of association rule mining is to find all rules having support ≥ minsup (minimum support) threshold and confidence ≥ minconf (minimum confidence) threshold [10].

Moreover, association rule mining can be viewed as a two-step process, first, find all frequent itemsets: items satisfying minimum support. Second, generate strong association rules from the frequent itemsets: these rules must satisfy minimum support and minimum confidence [11].

II. METHODOLOGY

The main purpose of this paper is to discuss the enhancement of traditional customer's dealing process by using current technology. Figure.1 presented above describe the traditionally customer's dealing process. We presented the DSS model in this paper including DM abstract to generate new rules and patterns to maintain the KM. In order to reply on the customer requests, it will connect directly with KM which have managed all the previous given replies to the customers.

In addition, [15] presented the similar concept of combining the DSS and DM applications together to build joint application to solve evaluation and classification problem. Specially they presented hierarchical multi-attribute decision model which are generally use in decision analysis [17,18]. Basically, this concept attract our research presented in this paper where this research is not taking one techniques into consideration but we have designed a model which can work broadly with any kind of data mining in different phases of decision support system.

Therefore, this paper presents the extended model of the figure. 2 with the integration of DM abstract. The implementation of that model is from customer's point of view which also known as customer relationship management (CRM). The major purpose of the CRM is to build good relations with the customer in the form customer satisfaction and behavior. Moreover, CRM will provide the facility to understand the customer by evaluating customer behavior, profile, customer segmentation, loyalty and profitability [3].

A. Explanation of the Proposed Model – (Figure-3)

Proposed model in figure. 3 is the extended model of DSS components model (figure. 2) presented above. According to figure. 2 the broad view of four components in the DSS connected to fulfill the requirements of DSS. The components are; data, model, KM, and user interface. Our model in figure.3 is covering all the four major components of DSS with some integration of DM abstract and customer enquiry systems. Therefore, according to our proposed model we can divide them into four major parts again as per the requirements of DSS. The division is also described in table.1. The complete description of each part of the proposed model discussed in the subsections.

a) Part 1. Data: In the perspective of proposed model we are merging the DSS database with the DM abstraction. As DM tasks are more commonly use for data understanding and extraction new information from the data. In this scenario, firstly the queries will be asked from KM about suitable reply. If the decision is not available from KM, then it will proceed to DM abstract through DSS interface with selected data required for DM process. Afterwards, we can suppose that selected data is enough to produce some new patterns and rules. Simultaneously, the extracted information and rules will be saved in KM. Moreover, the DSS part 1. (DM) has some more methods to find and generate more alternatives for selecting best solution. As selecting the optimal solution is the major concern of DSS.

b) Part 2. Models: This part of DSS is to maintain the models generated while looking for new solutions. The proposed model has presented another aspect of the model generation which are known as DM models. Whenever DM tasks such as; Classification, clustering and association applied on the data, the tasks need to first build the model for data understanding and train the data. In addition of DSS own models, DM models will also be work and save in KM. These model can be available for the same type of request in future correspondence with the customer.

TABLE I. COMPARISON BETWEEN DSS MODEL AND PROPOSED MODEL

[COMPILED BY AUTHOR]

DSS Components	According to DSS Model (Figure. 2)	According to Proposed Model (Figure.3)
Part 1: Data	Data related with DSS Database	DM Abstract; will provide more tasks to do on the saved data
Part 2: Models	DSS Model with Choices	DM and DSS models; Association, Classification, and Clustering models
Part 3: Knowledge Management	Only maintain DSS models, and Choices	Maintained both DM and DSS models, patterns and rules
Part 4: User Interface	Any DSS Interface	Customer Inquiry Interface

c) Part 3. Knowledge Management: This part considerably has more importance for improving customer's behaviour and satisfaction with fast process of customer enquiries and complaints. KM is one of the types of database but the major purpose of building KM is to provide the facility to reply directly on customer queries (in current scenario) by using experienced data without contacting with DSS database.

While replying on customer queries, the DM models, rules & patterns, and DSS models will place in the KM for future correspondence with the customers. Those type of data placed in KM is also known as experienced data. As presented in the model firstly all customer's request are connected with the decision box. Whereas decision box search the decision using KM to find the proper answer from experienced data (knowledge base data). If the decision will not available through KM then let the query will drag towards the DSS interface. At last if DSS need more understanding and some other operations to apply on data then it will be forwarded to the DM abstract. DM cannot initiate the working on customer queries directly. According to the model, DM abstract will work only if DSS abstract will forward any query with suitable data to apply any of the DM task. The solution/models generated either by DSS abstract or DM abstract will be transmitted to KM. Finally, the KM is only channel from where the answer will be post back to the asked customer.

d) Part 4. User Interface: In the model the user interface delegated for receiving and sending the customer requests online. According to the scenario detailed in the model a customer is the general term we use in this paper. Whereas a customer may be a type of user, purchaser, seller, influencer, or enquirer etc. Therefore, the raised query may also have several type such as; suggestions, requisitions, questionnaires, sales enquiries, and reclamations depend on the customer type. The major task of this model is to improve customer's satisfaction and behavior. Therefore, we need to build a interface which can support both DSS and DM abstracts. Finally, both abstract must connect with same KM.

III. Conclusion and Future Work

In conclusion, we proposed the extended version of the DSS model with new perspective of DM and KM. Working on customer's query using DM and DSS abstract may work better than before. The concept of the model can also help to increase customer's satisfaction, behavior and ultimately the growth of the organization. As customer's plays significant role for making organization good will in the market. Therefore, the model may provide help for dealing with the customers in more efficient manner.

In future, the practical implementation of the proposed model with different attributed data may provide some fruitful results. Actually, each DM tasks deal with special attributed data. Model Implementation on real world data will guide more about the applicability of the model. Our future concerns is to apply this model using medical or student data for taking decision on student/patient online queries.

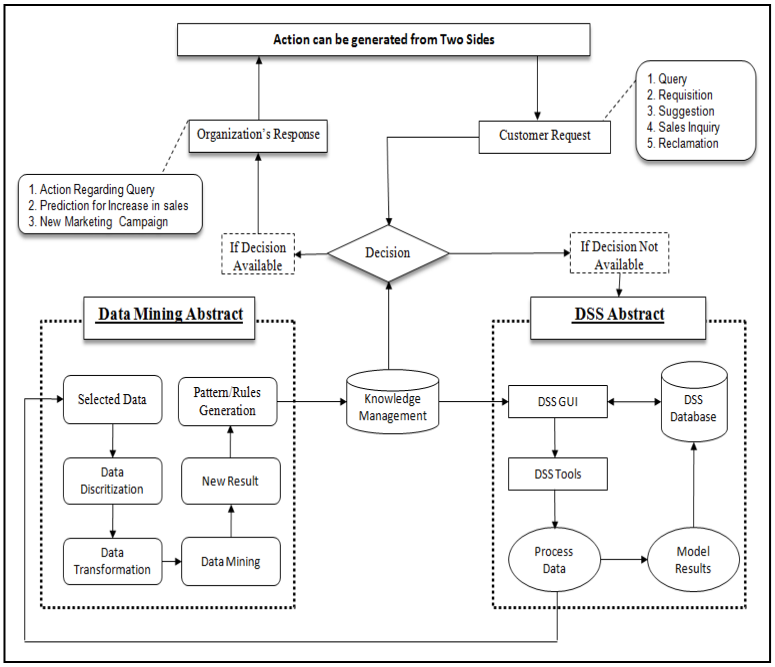

Fig. 3. Integrated Model of DSS with Data Mining Abstract [Proposed by Author]

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Automatic Image Registration Technique of Remote Sensing Images

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Abstract— **Image registration is a crucial step in most image processing tasks for which the final result is achieved from a combination of various resources. Automatic registration of remote-sensing images is a difficult task as it must deal with the intensity changes and variation of scale, rotation and illumination of the images. This paper proposes image registration technique of multi-view, multi- temporal and multi-spectral remote sensing images. Firstly, a preprocessing step is performed by applying median filtering to enhance the images. Secondly, the Steerable Pyramid Transform is adopted to produce multi-resolution levels of reference and sensed images; then, the Scale Invariant Feature Transform (SIFT) is utilized for extracting feature points that can deal with the large variations of scale, rotation and illumination between images .Thirdly, matching the features points by using the Euclidian distance ratio; then removing the false matching pairs using the RANdom SAmple Consensus (RANSAC) algorithm. Finally, the mapping function is obtained by the affine transformation. Quantitative comparisons of our technique with the related techniques show a significant improvement in the presence of large scale, rotation changes, and the intensity changes. The effectiveness of the proposed technique is demonstrated by the experimental results.**

Keywords*— Image registration; Steerable Pyramid Transform; SIFT; RANSAC*

I. Introduction

Image registration is a fundamental task in image processing used to match two or more images which are taken at different time, from different sensors or different viewpoints [1]. The present image registration methods can be generally divided into two broad categories: area-based and feature-based methods [2]. Area-based methods deal with the images without detecting salient features, and adopt optimization algorithms. These methods are substantial to the intensity distribution. The feature-based methods do not directly work with image intensity values, but, instead, use salient features extracted from two images, which has been shown to be more suitable for such situations that intensity changes and complicated geometric deformations are encountered. Therefore, these feature-based methods have been widely used in remote-sensing image registration. Feature-based image registration consists of five steps: preprocessing, feature selection, feature correspondence, transformation and resampling. Among them, feature selection, correspondence and transformation require numerous manipulation techniques, where in the most difficult one is the feature correspondence. If some correspondences are incorrect, they will produce an incorrect transformation function, which could yield totally wrong results, so a highly robust matching algorithm is needed. The process of image registration intersects with the following research areas: computer vision, pattern recognition, and remotely sensed data processing. In general, its applications can be divided into multi-view analysis, multi-temporal analysis and multimodal analysis according to the manner of the image acquisition.

In literature, there are several image registration techniques have been proposed, Xiangzeng and al. [3] Proposed multi-scale image registration technique based on steerable pyramid transform and Scale Invariant Feature Transform (SIFT) of remote sensing image. Nagham and al. [4] presented wavelet-based image registration technique that combined Scale Invariant Feature Transform (SIFT) with Mutual-Information (MI). Haidawati and al. [5] developed image registration approach based on a combination of Scale Invariant Feature Transform (SIFT), Belief Propagation (BP) for matching features and Random Sampling Consensus (RANSAC) adopted to filter out the mismatched points. Sang [6] introduced automatic coarse-to-fine image registration algorithm for satellite images, based on Haar Wavelet Transform (HWT) and the Speeded Up Robust Features (SURF) algorithm in the coarse registration, the normalized cross-correlation and RANdom SAmple Consensus (RANSAC) algorithm to achieve the fine registration. Mahmudul and al. [7] proposed a method to improve SIFT-based matching for multispectral image registration. Fatiha and al. [8] presented an efficient image registration algorithm that used the genetic algorithms and the cross-correlation similarity measure for matching within a multi-resolution framework based on the Non-Subsampled Contourlet Transform (NSCT).Yi and al. [9] presented an enhanced SIFT method for multi-spectral remote sensing image registration. Le and al. [10] developed a fully automatic and fast non-rigid image registration technique that coarsely aligned the input image to the reference image by automatically detecting their matching points by using the scale invariant feature transform (SIFT) method and an affine transformation model. Gang and Yun [11] introduced image registration technique, which is based on wavelet-based feature extraction technique, a normalized cross-correlation matching and relaxation-based image matching techniques. Leila and al. [12] presented efficient image registration algorithm of multi-temporal images with similar spectral responses based on modulus maxima of wavelet transform for point features extraction and a correlation based matching measure used in the matching process. Shirin and Kasaei [13] developed image registration method based on Contourlet Transform for extracting edge features from panchromatic satellite images and matching features by normalized cross-correlation.

In this paper we present automatic image registration technique of remote sensing image based on the Steerable Pyramid Transform and SIFT descriptors. This paper is organized as follows. Section 2 presents the proposed image registration technique. Experimental results and conclusions are given in Sections 3 and 4, respectively.

II. Proposed Image Registration Technique

In this section, we describe the proposed image registration technique which consists of six steps: preprocessing, decomposition by steerable pyramid transform, extract feature points using the Scale Invariant Feature Transform (SIFT), Find all matching pairs between two images ,remove false matching pairs, perform affine transformation and resampling to perform image registration. The work flow of the proposed technique is shown in Fig.1.

A. *Preprocessing*

Given two input images (the reference image and the sensed image), applying median filtering to the reference image and the sensed image in order to enhance the two input images.

B. *Steerable Pyramid Transform*

The steerable pyramid transform is a linear multi-scale, multi-orientation image decomposition that provides a useful front-end for image processing and computer vision applications [14]. It has been developed in order to overcome the limitations of orthogonal separable wavelet decompositions that were popular for image processing. The “steerable filter” refers to a class of filters, in which a filter of arbitrary orientation can be synthesized as a linear combination of a set of “basis filters”. For any function $f(x,y), f^{\theta}(x,y)$ is $f(x,y)$ rotated through an angle θ about the origin. We call $f(x,y)$ is steerable if it satisfies the following equation:

$$f^{\theta}(x,y) = \sum_{j=1}^{M} k_j\,(\theta)\, f^{\theta j}(x,y). \tag{1}$$

Where $k_j(\theta)$ are the interpolation functions $j = (1, \dots, M)$ .The basic functions of the steerable pyramid are directional derivative operators that come in different sizes and orientations, and the number of orientations may be adjusted by changing the derivative order. The structure of the steerable pyramid in the frequency domain is shown in Fig.2.The image is initially divided into high and low-pass sub-bands using filters $H_0(\omega)$ *and* $L_0(\omega)$. The low-pass branch is then further divided into oriented band-pass portions using filters $\{B_0(\omega), \dots, B_k(\omega)\}$ which ensure that the representation is rotation invariant and lower-pass portion using filter

$L_1(\omega)$.this lower-pass sub-band is sub-sampled by a factor of 2 in the X and Y directions. In order to ensure translation-invariance, the outputs of the high-pass filter and of the band-pass filters are not sub-sampled. In addition, that portion of the signal, which is iteratively decomposed by the band-pass and the low-pass filters, does not contain the larger high frequency components and has been preprocessed by a low-pass filter, thus removing most aliased component, thus, to eliminate aliasing terms, $L_1(\omega)$ is constrained as:

$$L_1(\omega) = 0 \;\; For \;\; |\omega| > \frac{\pi}{2} \tag{2}$$

The recursive construction of a pyramid is achieved by inserting a copy of the shaded portion of the System diagram in Fig.2 at the location of the solid circle. The steerable pyramid performs a polar-separable decomposition in the frequency domain, thus allowing independent representation of scale and orientation. In order to cascade the system recursively, there should be

$$|L_1(\omega/2)|^2 = |L_1(\omega/2)|^2 \left[|L_1(\omega)|^2 + \sum_{k=0}^{n} |B_k(\omega)|^2 \right] \tag{3}$$

In the proposed technique we apply the steerable pyramid transform to the two input images to level three with one orientation band-pass component. Fig.3 shows three level of steerable pyramid decomposition with one orientation band-pass filter for the reference image and the sensed image, respectively.

C. *SIFT Feature Point Extraction Algorithm*

SIFT algorithm was proposed in [15] as a method to extract and describe feature points, which is robust to scale, rotation and change in illumination. There are four steps to implement the SIFT algorithm:

1) Scale-space Extrema Detection: The first stage searches over scale space using a Difference of Gaussian (DoG) function to identify potential interest points that are invariant to scale and orientation. The scale space of an image is defined as a function $L(x,y,\sigma)$ *, which is produced from the convolution of a variable-scale Gaussian* $G(x,y,\sigma)$ *with an input image* $I(x,y)$*:*

$$L(x,y,\sigma) = G(x,y,\sigma) * I(x,y), \tag{4}$$

$$G(x,y,\sigma) = \frac{1}{2\pi\sigma^2} e^{-(x^2+y^2)/2\sigma^2} \tag{5}$$

To efficiently detect stable key-point locations in scale space using scale-space extrema in the difference-of-Gaussian function convolved with the image,$D(x,y,\sigma)$ which can be computed from the difference of two nearby scales separated by a constant multiplicative factor k:

$$\begin{aligned} D(x,y,\sigma) &= \big(G(x,y,k\sigma) - G(x,y,\sigma)\big) * I(x,y) \\ &= L(x,y,k\sigma) - L(x,y,\sigma). \end{aligned} \tag{6}$$

2) Feature Point Localization: The location and the scale of each candidate point are determined and the feature points are selected based on measures of stability this information allows points to be rejected that have low contrast (and are therefore sensitive to noise) or are poorly localized along an edge.

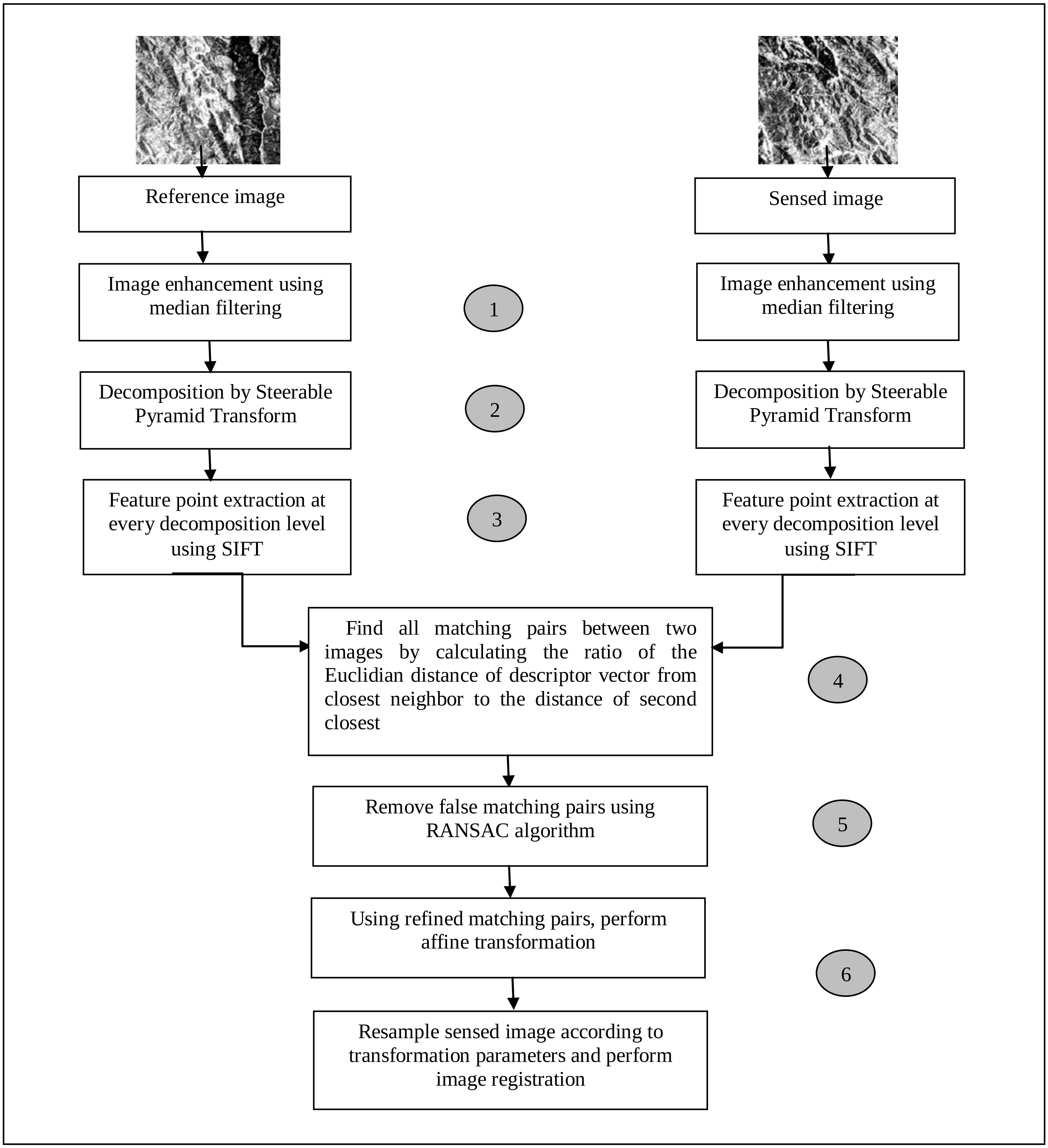

Reference image
Sensed image
Image enhancement using median filtering
1
Image enhancement using median filtering
Decomposition by Steerable Pyramid Transform
2
Decomposition by Steerable Pyramid Transform
Feature point extraction at every decomposition level using SIFT
3
Feature point extraction at every decomposition level using SIFT
Find all matching pairs between two images by calculating the ratio of the Euclidian distance of descriptor vector from closest neighbor to the distance of second closest
4
Remove false matching pairs using RANSAC algorithm
5
Using refined matching pairs, perform affine transformation
6
Resample sensed image according to transformation parameters and perform image registration

Fig. 1. Work Flow of the Proposed Technique

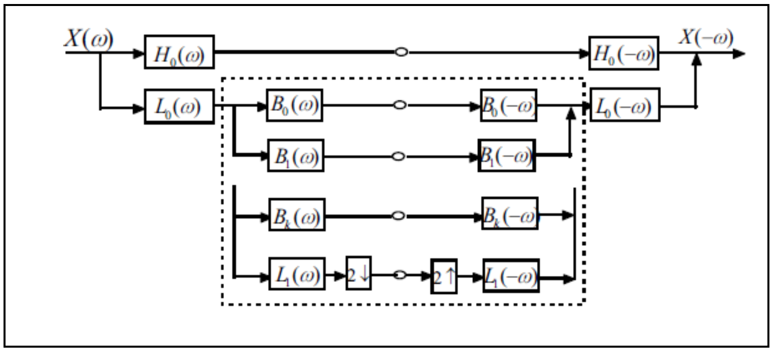


Fig. 2. System diagram for first derivative Steerable Pyramid

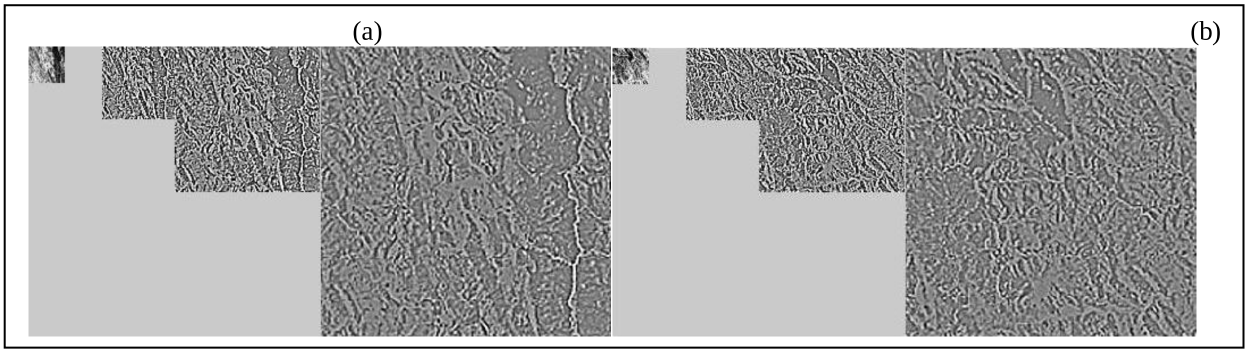


Fig. 3. Steerable Pyramid decomposition (l=3) for (a) reference image and (b) sensed image

3) Orientation Assignment: One or more orientations are assigned to each feature point location based on local image gradient directions. For each image sample at this scale $L(x, y)$, the gradient magnitude $m(x, y)$, and orientation $\theta(x, y)$ are precomputed using pixel differences:

$$m(x,y) = \sqrt{(L(x+1,y) - L(x-1,y))^2 + (L(x,y+1) - L(x,y-1))^2} \quad (7)$$

$$\theta(x,y) = \tan^{-1}((L(x,y+1) - L(x,y-1))/(L(x+1,y) - L(x-1,y))) \quad (8)$$

4) Feature Point Descriptor: A feature descriptor is created by first computing the gradient magnitude and orientation at each image sample point in a region around the feature point location, as shown on the left of Fig.4.These are weighted by a Gaussian window, indicated by the overlaid circle. These samples are then accumulated into orientation histograms summarizing the contents over 4x4 sub-regions, with 8 orientation bins. So each feature point has a 128-element feature as shown on the right, with the length of each arrow corresponding to the sum of the gradient magnitudes near that direction within the region. The SIFT feature point extraction for the reference image and the sensed image is shown in Fig.5 and Fig.6.

D. The proposed Feature Points Matching Using Structural Information

SIFT algorithm at first detects feature points in scale-space, feature points with low contrast and located at edges are discarded. Then a 128-element feature descriptor is generated for each feature point using statistics of the gradient directions which are scale and rotation invariant. These descriptors are used to find the corresponding feature points by calculating the ratio of the Euclidian distance of descriptor vector from closest neighbor to the distance of second closest. To illustrate the issue, we show an example in Fig.7. SIFT matching is applied to images *A* and *B*. The bold line shows a pair (a, c) of matched featured points in the two images. The dotted line shows the best match e of another feature point b in image *A*, while the correct match should be point d. In the proposed technique e is not selected as a matched feature point for b because the spatial distance between points c and e is too large. Feature points a and c are matched while the counterpart for neighboring feature point b cannot be decided because the SIFT descriptors for points d and e are almost equally different from the SIFT descriptor of point b. This problem is made worse by the fact that a lot of similar descriptors can be found in typical remote sensing images. The idea to solve this problem is as follows. Still considering the example in Fig.7, assume points a and c are already matched with high confidence that the match is correct. We can predict that the feature points around a (shown in the circular window) can be found around c. So, for point b we only search the neighborhood of point c for a matching descriptor, which results in a correct match at point d. For better matching accuracy we suggest modifications to SIFT matching by imposing a threshold on the Euclidian distance ratio as follows: A descriptor $D1(i, j)$ of feature point a in image A (reference image) is matched to a descriptor $D2(i, j)$ of feature point c in image *B* (sensed image) only if the Euclidian distance $d(D1, D2)$ multiplied by threshold (set to 1.5) is not greater than the distance of $D1$ to all other descriptors. SIFT matching result between the feature points of the reference image and the sensed image is shown in Fig.8.

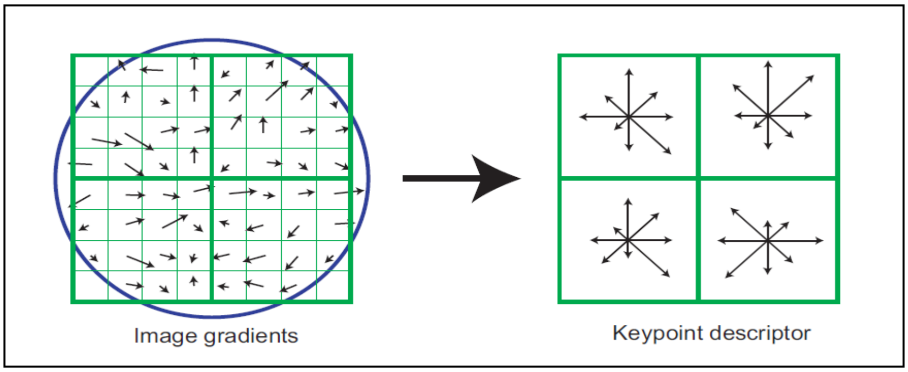


Fig. 4. Feature descriptor creation

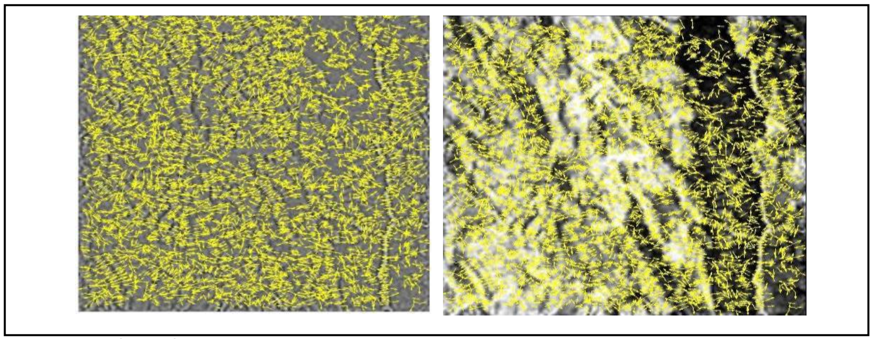


Fig. 5. Feature points returned by SIFT for reference image

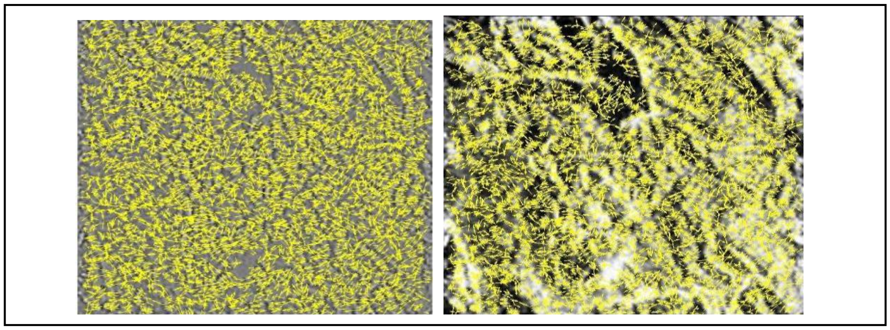


Fig. 6. Feature points returned by SIFT for sensed image

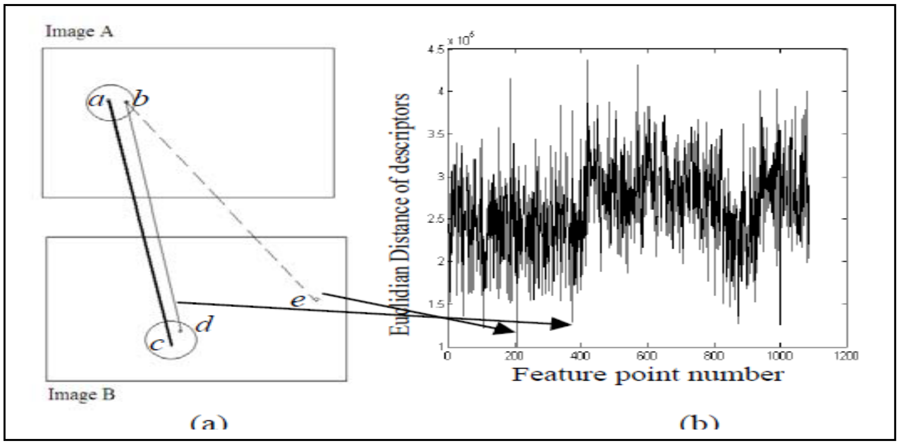


Fig. 7. a) Feature point matching results a to c points as correct match but no match found for b. (b) Euclidian distance of the descriptors of all the feature point on image B for the feature point b on image A.

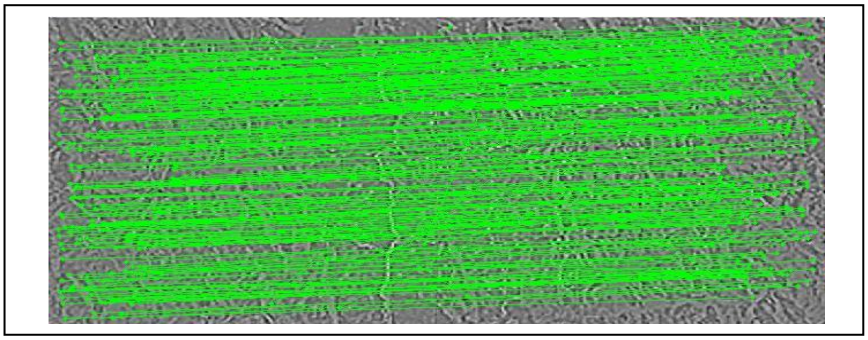


Fig. 8. Matching result between the reference image and sensed image in steerable domain.

E. RANSAC (Random Sample Consensus) Algorithm

In general there are all kinds of photometric and geometric transformations that can occur between two views of a scene. This means normalized cross-correlation will sometimes generate spurious correspondences. To robustly fit a model to the correspondences, we need to overcome the effect of these outliers. The RANdom SAmple Consensus (RANSAC) algorithm proposed by Martin and Robert [16] is a general parameter estimation approach designed to cope with a large proportion of outliers in the input data. There are two types of samples: contaminated, those that contain at least one outlier, and uncontaminated (all-inlier or outlier-free) samples. Only the latter ones are of interest, as the model parameters computed from data points including outliers are arbitrary. The number of iterations N is chosen high enough to ensure that the probability p (usually set to 0.99) that at least one of the sets of random samples does not include an outlier. Let u represent the probability that any selected data point is an inlier and $v = 1 - u$ the probability of observing an outlier, N iterations of the minimum number of points denoted m are required, where

$$1 - p = (1 - u^m)^N \tag{9}$$

, and thus with some manipulation,

$$N = \frac{\log(1 - p)}{\log(1 - (1 - v)^m)} \tag{10}$$

A RANSAC algorithm provides a general technique for model fitting in the presence of outliers and consists of the following steps:

1) Choose a model.

2) Determine the minimal number of points needed to specify the model.

3) Define a threshold on the inlier count.

4) Fit the model to a randomly selected minimal subset

5) Apply the transformation to the complete set of points and count inliers.

6) If the number of inliers exceeds the threshold, flag the fit as good and stop.

7) Otherwise repeat steps 4 to 6.

In our technique we apply RANSAC algorithm to the putative correspondences to remove false matching point pairs, which are consistent with this estimate because many of the putative correspondences obtained in the previous step are incorrect.

F. Perform Affine Transformation and Resampling

Given the refined matching point pairs, build the mapping function and get the affine transformation parameters to resample the sensed image and perform image registration.

III. EXPERMENTAL RESULTS AND EVALUATION

A. Data Sets

The proposed technique is tested for ten different sets of remote sensing images. We present three different sets of images. The first set of images is Landsat TM images from different bands (12-band 0 and 8) (Fig. 9(a) and (b)) with large rotation variation, which are used to show the implementation and accuracy of our algorithm. Images of the second set are Agricultural images from Landsat TM (band 5) of Amazon region acquired at different times (Fig.10 (a) and Fig. 10(b)) .The third data set are QuickBird panchromatic and near-infrared band images (Fig.11 (a) and (b)) with large scale difference derived from Digital Globe, Inc; acquired on Jul. 4, 2005 over Boulder, USA .The near-infrared band has been shown to be effective for estimating moisture content and plant biomass in the 760–900 nm wavelength range. In addition, the panchromatic and multispectral images have 0.6 m and 2.4 m spatial resolution at nadir, respectively. Here, the near infrared band image of low spatial resolution is registered to the high resolution panchromatic image. The feature points information of the three data sets are shown in Table 1.

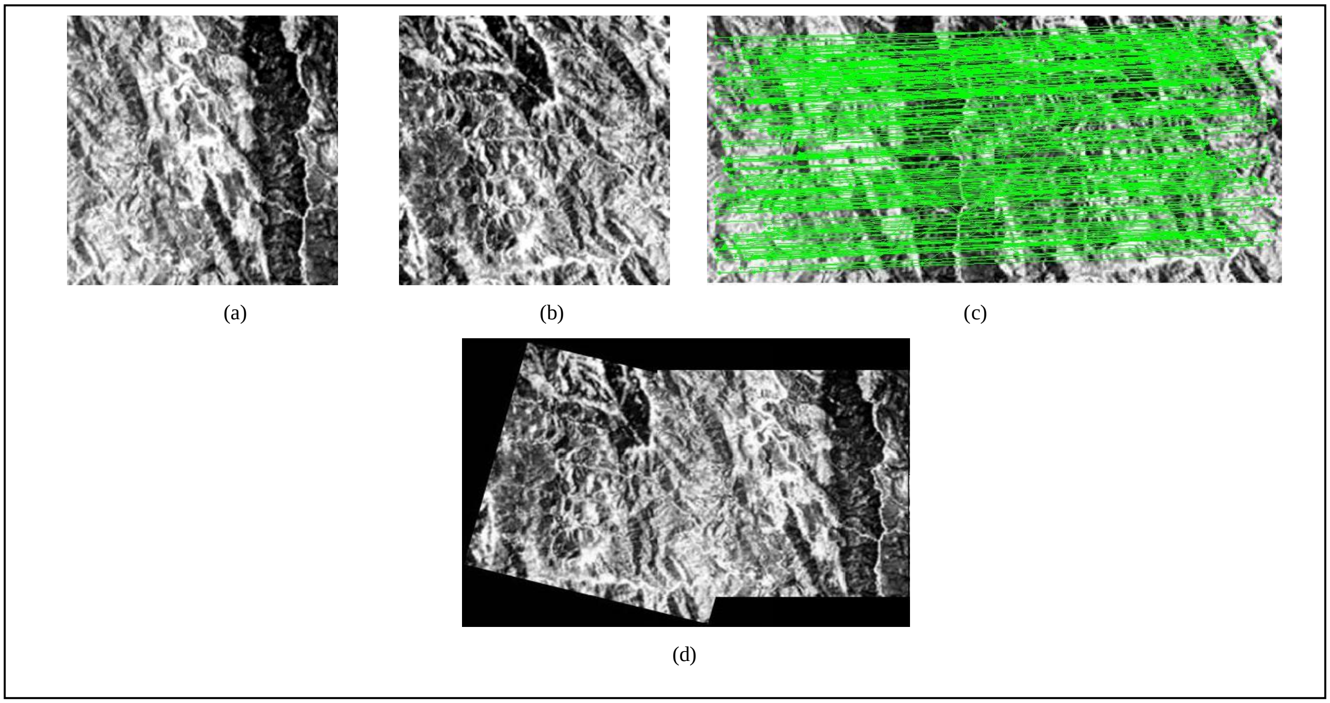


Fig. 9. Reference image, sensed image, matching results, and registration results (Landsat TM images). (a) The reference image (Landsat TM 12-Band 0, 512 by 512); (b) the sensed image (Landsat TM 12 -Band 8, 512 by 512); (c) the matching results of (a) and (b); (d) the registration results of (a) and (b).

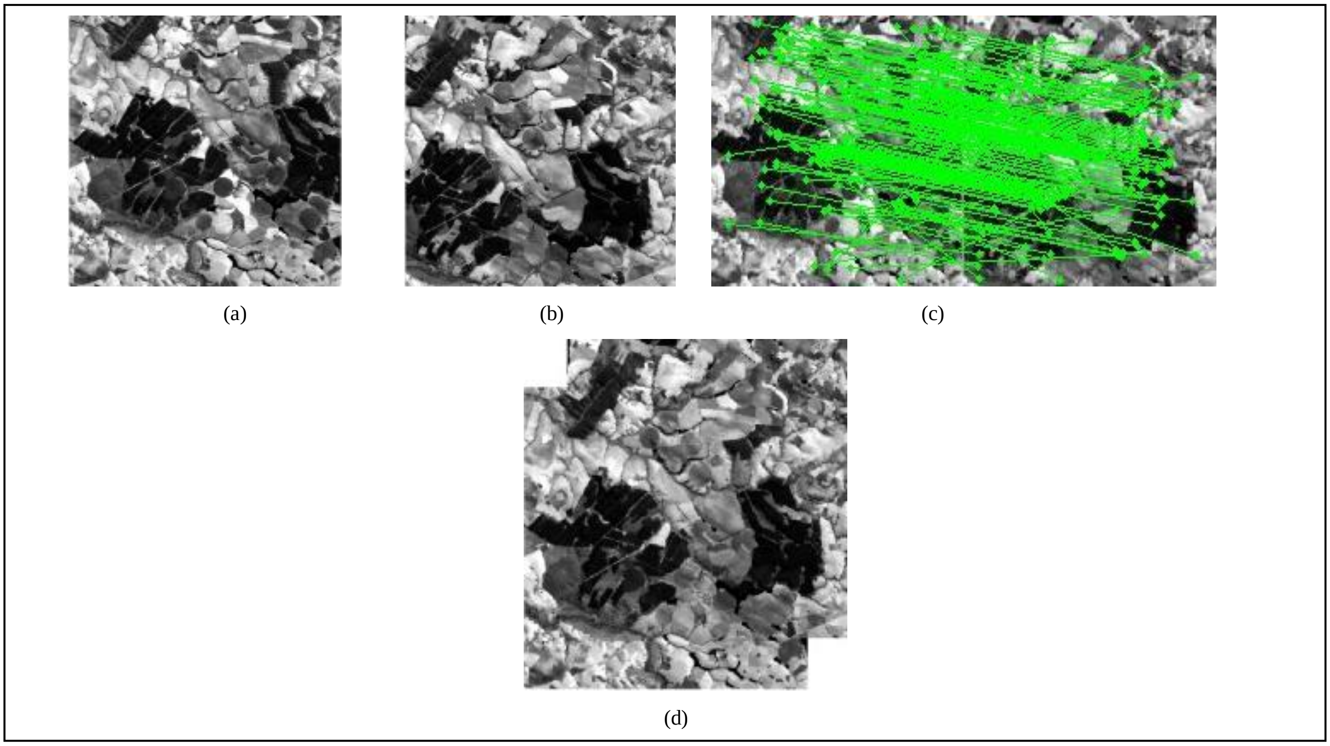
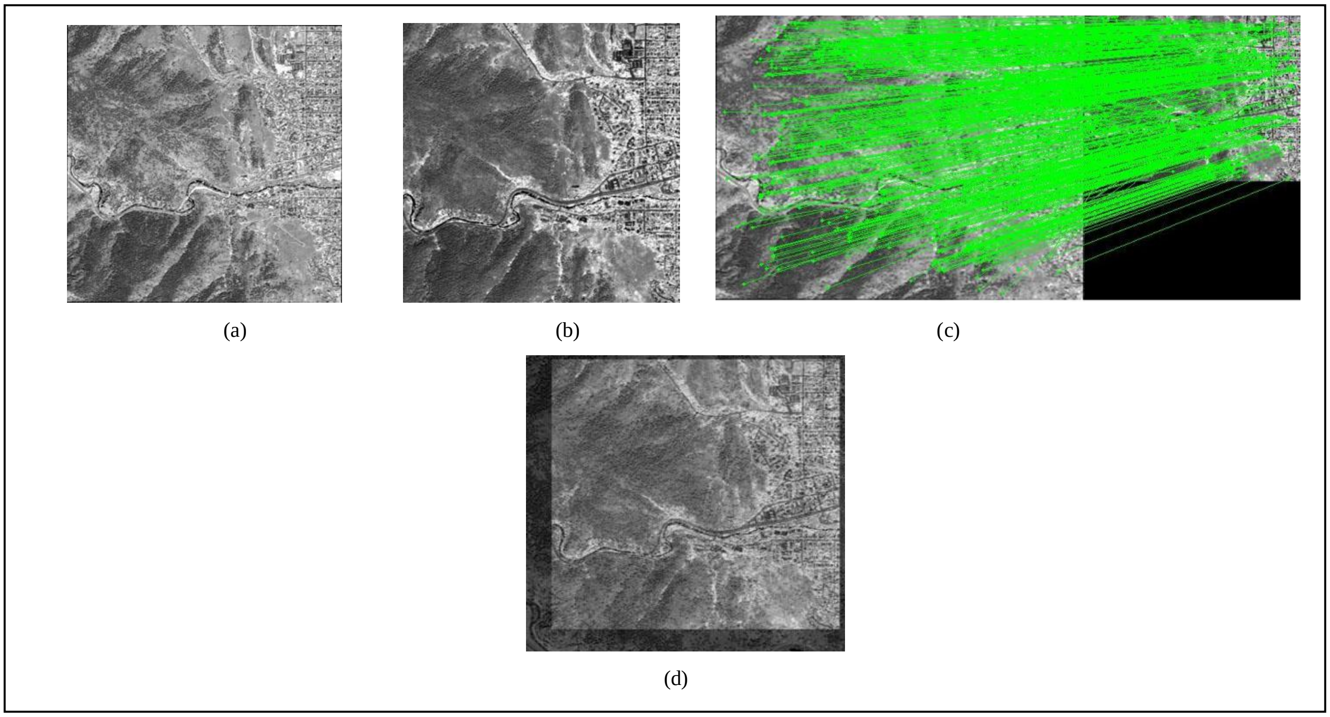


Fig. 10. Agricultural images from Landsat TM (band 5). (a) The reference image (Landsat TM 400 by 400 acquired on September 9, 1990); (b) the sensed image (Landsat TM 400 by 400 acquired on July 18, 1994.); (c) the matching results of (a) and (b); (d) the registration results of (a) and (b).



(a) (b) (c)

(d)

Fig. 11. Reference image ,sensed image, matching results, and registration results of QuickBird panchromatic and near-infrared images (Image courtesy of Digital Globe) (a) The reference image (QuickBird panchromatic, 2048 by 2048); (b) the sensed image (QuickBird near-infrared, 937 by 915); (c) the matching results of (a) and (b); (d) the registration results of (a) and (b).

TABLE I. FEATURE POINTS INFORMATION (FIG.9—11)

Data sets	Feature points information					
	Level no.	Image size(pixels)	Number of feature points		Number of initial matched pairs	Number of refined matched pairs using RANSAC
			Reference image	Sensed image		
Fig .9	1	512x512	6571	7502	244	161
	2	256x256	3285	3498	420	270
Fig .10	1	400x400	4313	4192	174	108
	2	200x200	1581	1519	169	102
Fig .11	1	2048x2048 937x915	19091	13261	578	505
	2	1024x1024 465x 457	16538	10137	1630	1553

B. Evaluation

In order to evaluate the proposed image registration technique; First we apply the proposed technique to the three sets of images. Second, we compare our technique with other two related techniques on the accuracy of matching and registration. To evaluate the matching result between the two input images, Assume that the transformation between the point (x_i, y_i) in the sensed image and its corresponding point (X_i, Y_i) in the reference image is affine transformation, we can use the root mean square error ($RMSE$) :

$$RMSE = \left(\frac{\sum_{i=1}^{m}[(ax_i + by_i + c - X_i)^2 + (dx_i + ey_i + f - Y_i)^2]}{m}\right)^{1/2} \quad (11)$$

Where m means the total number of matching points; (a, b, c, d, e, f) are affine transformation parameters. The transformation parameters between the two input images of the three data sets and their root mean square error ($RMSE$) are shown in Table 2.

The test three sets of images include large rotation, translation, scale, and intensity changes. We use Fig.9 (a) as the reference image and Fig.9 (b) as the sensed image. Fig.9

(c) and (d) shows the matching results and the registration results, respectively. In the second data set we use two Landsat TM (band5) images with translation differences; Fig.10 (a) and Fig.10 (b), are used as the reference image and the sensed image, respectively. Fig.10 (c) shows the matching results and Fig. 10 (d) shows the registration results .Fig.11 (a) and (b) are QuickBird panchromatic and near-infrared band images with large scale variations and intensity changes, which is used as the reference image and the sensed image, respectively. The matching results and registration results are shown in Fig.11 (c) and (d), respectively. To compare the registration accuracy, we consider the root mean square error of intensity ($RMSE1$),the correlation ($corr$) between the overlapping areas of registered image pairs and Peak Signal to Noise Ratio($PSNR$), which are defined as follows:

$$RMSE1 = \left(\frac{\sum_{m,n\in R}(I_{mn} - J_{mn})^2}{N}\right)^{\frac{1}{2}} \quad (12)$$

$$corr = \frac{\sum_{m,n\in R}(I_{mn} - \bar{I}_R)(J_{mn} - \bar{J}_R)}{\sqrt{\left(\sum_{m,n\in R}(I_{mn} - \bar{I}_R)^2\right)\left(\sum_{m,n\in R}(J_{mn} - \bar{J}_R)^2\right)}} \quad (13)$$

$$PSNR = 20\log\frac{255}{RMSE1} \quad (14)$$

Where I is the reference image, J is the registered image, R is the overlapping area between I and J, and N is the number of pixels in R . The accuracy of matching results and registration results for Fig.9, Fig.10, and Fig.11 are shown in Table3. Fig.12 shows the registration accuracy in four resolution levels for Fig.9.

Experiment have been carried out on the first set of images (Landsat TM images) in order to compare the registration accuracy of the proposed technique against other image registration techniques (Xiangzeng and al. [3]) and (Le and al. [10]); we consider $RMSE, RMSE1, corr$.$RMSE1$is smaller and the $corr$ is the larger which shows higher accuracy of registration. The comparisons of accuracy of matching results and registration results for Fig.9 are shown in Fig.13. From Fig.13, we can see both that $RMSE$ and $RMSE1$ of the proposed technique are the smallest and $corr$ of the proposed technique is the largest. From the above experimental results, we can see that the proposed technique performs better than the other two techniques when large scale variations, rotation, translation, and intensity changes exist between the two input image

TABLE II. THE TRANSFORMATION PARAMETERS AND THEIR RMSE (FIG.9—11)

Data sets	**Transformation Parameters and *RMSE***						
	a	***b***	***c***	***d***	***e***	***f***	***RMSE***
Fig .9	0.9626	-0.2551	-10.7779	0.2650	0.9757	264.9061	0.11
Fig .10	0.9872	-0.0006	69.6568	0.0005	1.0077	-60.8548	0.33
Fig .11	0.9914	-0.0001	-17.7040	0.0002	1.0276	-93.5854	0.17

TABLE III. THE ACCURACY OF MATCHING RESULTS AND REGISTRATION RESULTS (FIG.9—11)

Data sets	**Matching error, Registration error, Correlation and Peak Signal to Noise Ratio**			
	RMSE	***RMSE*1**	***corr***	***PSNR***
Fig.9	0.11	11.12	0.99	32.47
Fig.10	0.33	4.08	0.87	35.91
Fig.11	0.17	2.71	0.89	39.47

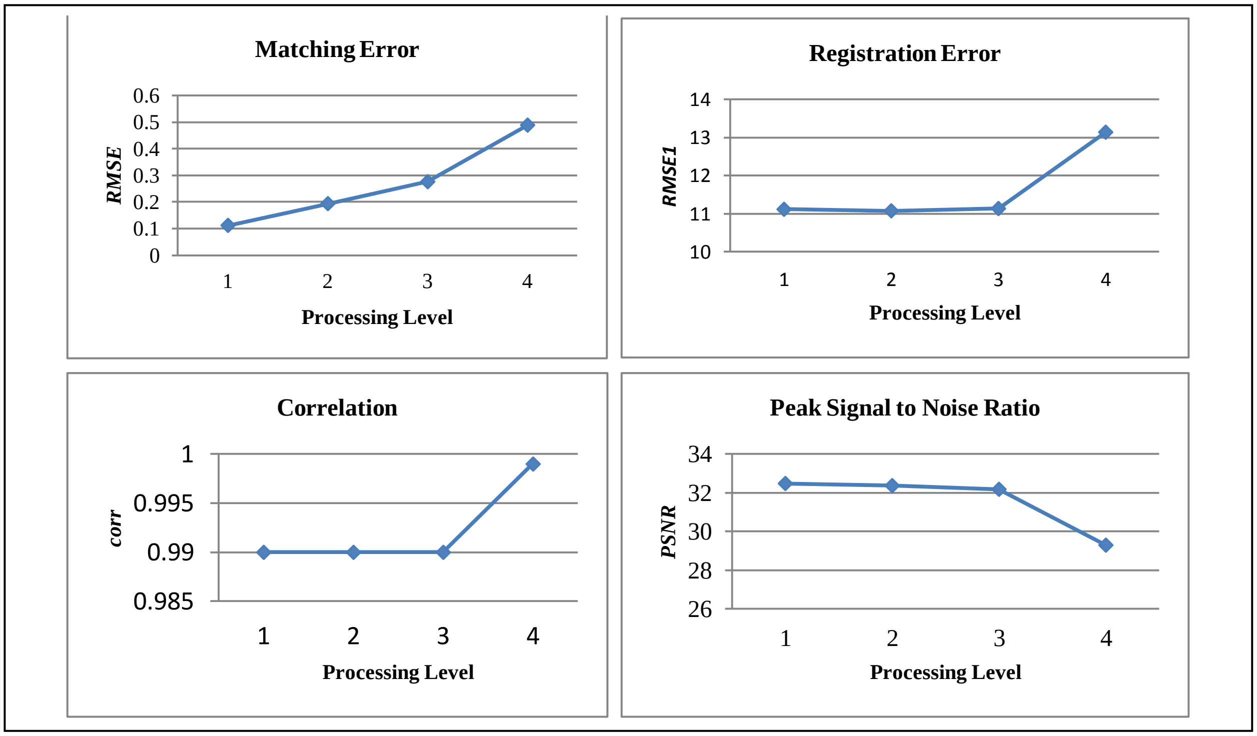


Fig. 12. Registration accuracy ($RMSE, RMSE1, corr$ and $PSNR$) in different resolution levels, (l=4) for Fig.9.

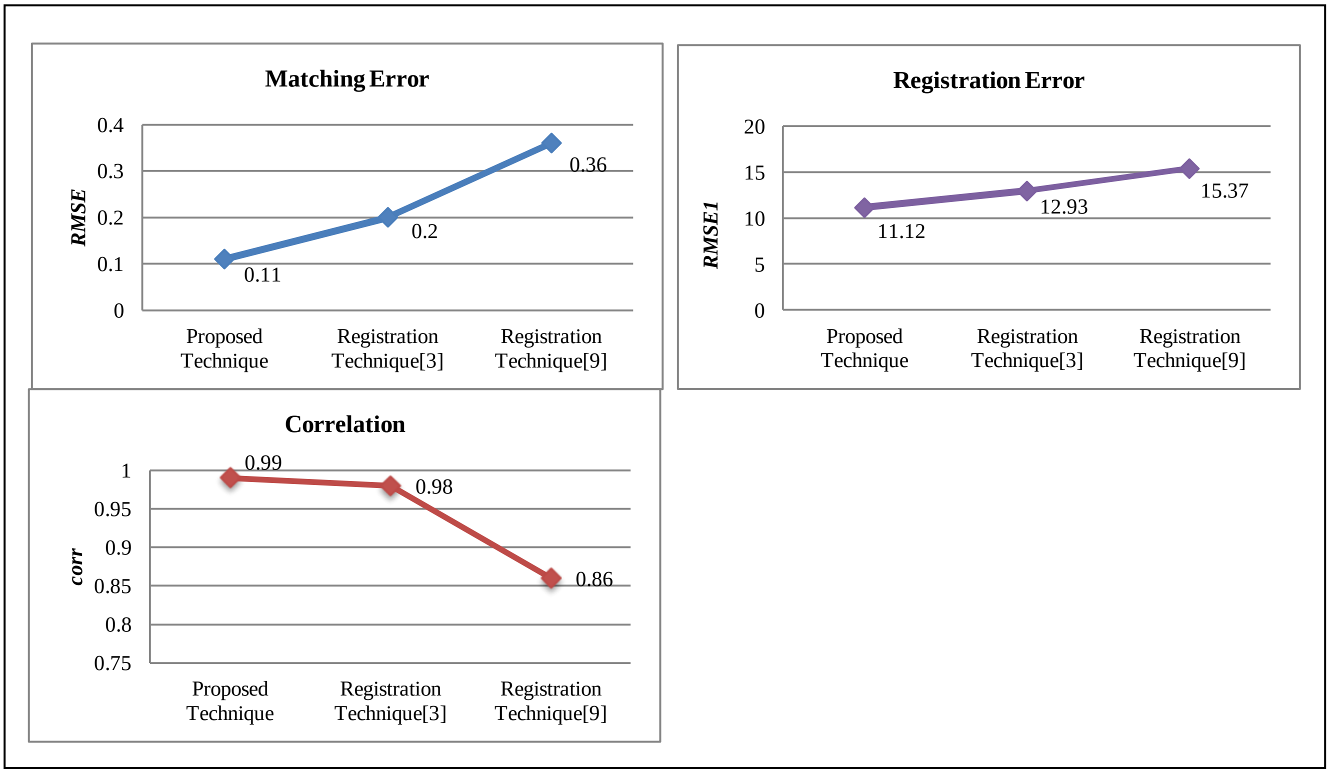


Fig. 13. Comparisons of the registration accuracy ($RMSE, RMSE1$ and $corr$) of the Proposed Technique against the two related Registration Techniques for Fig.9.

IV. CONCLUSIONS

In this paper we have presented an automatic registration technique of multi-view, multi-temporal, and multi-spectral remote sensing images based on the Steerable Pyramid Transform and SIFT features that can deal with the large variations of scale, rotation and illumination between images. The median filtering is applied in order to enhance the two input images. The advantage of the proposed technique lies in its ability to increase the number of matched points using the developed SIFT neighborhood matching method and to overcome the outliers introduced in the matching using RANSAC algorithm and hence correctly estimate the transformation matrix. The experimental results show that the proposed technique returns better performance for large scale variations, rotation and intensity changes as compared to the two other related image registration techniques.

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Indian Sign Language Recognition Using Eigen Value Weighted Euclidean Distance Based Classification Technique

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***Abstract*—Sign Language Recognition is one of the most growing fields of research today. Many new techniques have been developed recently in these fields. Here in this paper, we have proposed a system using Eigen value weighted Euclidean distance as a classification technique for recognition of various Sign Languages of India. The system comprises of four parts: Skin Filtering, Hand Cropping, Feature Extraction and Classification. 24 signs were considered in this paper, each having 10 samples, thus a total of 240 images was considered for which recognition rate obtained was 97%.**

Keywords*—Hand Gesture Recognition; Skin Filtering; Human Computer Interaction; Euclidean Distance (E.D.); Eigen value; Eigen vector.

I. INTRODUCTION

Sign Language is a well-structured code gesture, every gesture has meaning assigned to it. Sign Language is the only means of communication for deaf people. With the advancement of science and technology many techniques have been developed not only to minimize the problem of deaf people but also to implement it in different fields. Many research works related to Sign languages have been done as for example the American Sign Language, the British Sign Language, the Japanese Sign Language, and so on. But very few works has been done in Indian Sign Language recognition till date.

Finding an experienced and qualified interpreters every time is a very difficult task and also unaffordable. Moreover, people who are not deaf, never try to learn the sign language for interacting with the deaf people. This becomes a cause of isolation of the deaf people. But if the computer can be programmed in such a way that it can translate sign language to text format, the difference between the normal people and the deaf community can be minimized.

We have proposed a system which is able to recognize the various alphabets of Indian Sign Language for Human-Computer interaction giving more accurate results at least possible time. It will not only benefit the deaf and dumb people of India but also could be used in various applications in the technology field.

II. LITERATURE REVIEW

Different approaches have been used by different researchers for recognition of various hand gestures which were implemented in different fields. Some of the approaches were vision based approaches, data glove based approaches, soft computing approaches like Artificial Neural Network, Fuzzy logic, Genetic Algorithm and others like PCA, Canonical Analysis, etc. The whole approaches could be divided into three broad categories- Hand segmentation approaches, Feature extraction approaches and Gesture recognition approaches. Few of the works have been discussed in this paper.

Many researchers [1-11] used skin filtering technique for segmentation of hand. This technique separated the skin colored pixels from the non-skin colored pixels, thus extracting the hand from the background. Fang [12] used Adaptive Boost algorithm which could not only detect single hand but also the overlapped hands. In [13-15] external aid like data gloves, color gloves were used by the researchers for segmentation purpose.

Saengsri [13] in his paper Thai Sign Language Recognition used ‘5DT Data Glove 14 Ultra’ data glove which was attached with 14 sensors- 10 sensors on fingers and rest 4 sensors between the fingers which measures flexures and abductions respectively. But accuracy rate was 94%. Kim [14] used ‘KHU-1’ data glove which comprises of 3 accelerometer sensor, a Bluetooth and a controller which extracted features like joints of hand. He performed the experiment for only 3 gestures and the process was very slow. Weissmann [15] used Cyberglove which measured features like thumb rotation, angle made between the neighboring fingers and wrist pitch. Limitations were that the system could recognize only single hand gestures.

There have been wide approaches for feature extraction like PCA, Hit-Miss Transform, Principle Curvature Based Region detector (PCBR), 2-D Wavelet Packet Decomposition (WPD) etc. In [1][16-18] Principal Component Analysis (PCA) was used for extracting features for recognition of various hand gestures. Kong [16] segmented the 3-D images into lines and curves and then PCA was used to determine features like direction of motion, shape, position and size.

Lamar [17] in his paper for American and Japanese alphabet recognition used PCA for extracting features like position of the finger, shape of the finger and direction of the image described by the mean, Eigen values and Eigen vectors respectively. The limitations were accuracy rate obtained was 93% which was low and the system could recognize gestures of only single hand. Kapuscinski [2] proposed Hit-Miss transform for extracting features like orientation, hand size by computing the central moments. Accuracy rate obtained was 98% but it lacks proper Skin filtering with changes in illumination. Generic Fourier descriptor and Generic Cosine Descriptor is used [19] for feature extraction as it is rotation invariant, translation invariant and scale invariant. Rotation of the input hand image leads to shifting of hand in polar space. Rotation invariance is obtained by only considering the magnitude of the Fourier coefficient. While using centroid as the origin translational invariance is achieved and finally ratio of magnitude to area scale invariance is obtained. Only 15 different hand gestures were considered in this paper. Rekha [9] extracted the texture, shape, finger features of hand in the form of edges and lines by PCBR detector which otherwise is a very difficult task because of change in illumination, color and scale. Accuracy rate obtained was 91.3%.

After the features were extracted, proper classifier were used to recognize the gestures. There are various gesture recognition approaches used by different researchers like Support Vector Machines, Artificial Neural Network (ANN), Genetic Algorithm (GA), Fuzzy Logic, Euclidean distance, Hidden Markov Model (HMM), etc. [13][17] used ANN for recognizing gestures. Saengsri [13] used Elman Back Propagation Neural Network (ENN) algorithm which consisted of input layer with 14 nodes similar to the sensors in the data glove, output layer with 16 nodes equal to the number of symbols and hidden layer with 30 nodes which is just the total of input and output nodes. Gesture was recognized by identifying the maximum value class from ENN. Recognition rate obtained was 94.44%. Difficulty faced in this paper was it considered only single gestured signs. Lamar [17] used ANN which comprises of input layer with 20 neurons, hidden and output layer each with 42 neurons. Back propagation algorithm was used and after the training of the neural network one output neuron was achieved, thus giving the proper recognized gesture. Gopalan [1] used Support Vector Machine for classification purpose. The linearly non separable data becomes separable when SVM was used as the data was projected to higher dimensional space, thus reducing error. Kim [20] in his paper of Recognition of Korean Sign Language used Fuzzy logic. Fuzzy sets were considered where each set were the various speeds of the moving hand. They were mathematically given by ranges like small, medium, negative medium, large, positive large, etc. Accuracy rate obtained was 94% and difficulty faced by them was heavy computation.

We have thus proposed a system that could overcome the difficulties faced by various. Our proposed system was able to recognize two hand gestures with an improved accuracy rate of 97%. Moreover, experiment was carried out with bare hands and computational time was also less thus removing the difficulties faced by use of the hand gloves with sensors.

III. Theoretical Background

A. Eigen value and Eigen vector

Eigen values and Eigen vectors are a part of linear transformations. Eigen vectors are the directions along which the linear transformation acts by stretching, compressing or flipping and Eigen values gives the factor by which the compression or stretching occurs. In case of analysis of data, the Eigen vectors of the covariance are being found out. Eigenvectors are set of basis function which describes variability of data. And Eigen vectors are also a kind of coordinate system for which the covariance matrix becomes diagonal for which the new coordinate system is uncorrelated. The more the Eigen vectors the better the information obtained from the linear transformation. Eigen values measures the variance of data of new coordinate system. For compression of the data only few significant Eigen values are being selected which reduces the dimension of the data allowing the data to get compressed. Mathematically, it is explained in (1).

If x is a one column vector with n rows and A is a square matrix with n rows and columns, then the matrix product Ax will result in vector y. When these two vectors are parallel, $Ax = \lambda x$, (λ being any real number) then x is an eigenvector of A and the scaling factor λ is the respective eigenvalue.

$$\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} \rightarrow \begin{bmatrix} A_{11} & A_{12} & \cdots & A_{1n} \\ A_{21} & A_{22} & \ddots & A_{2n} \\ \vdots & \vdots & & \vdots \\ A_{n1} & A_{n2} & \cdots & A_{nn} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} \quad (1)$$

IV. Proposed System

The block diagram of the proposed system is given in Fig. 1 which comprises of mainly four phases: Skin filtering, Hand cropping, Feature Extraction and Classification.

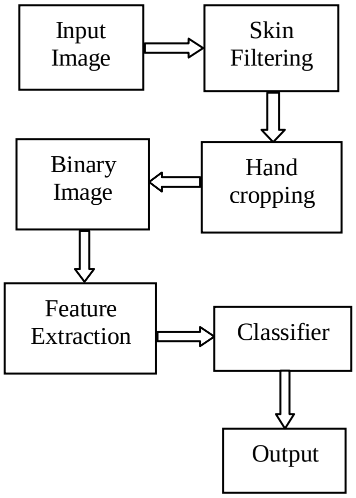


Fig. 1. Block Diagram Of The Proposed System

In our proposed system, we have considered 24 alphabets of Indian sign language, each with 10 samples thus a total of 240 images captured by camera. Some of the database images have been shown for each alphabet in Fig. 2.

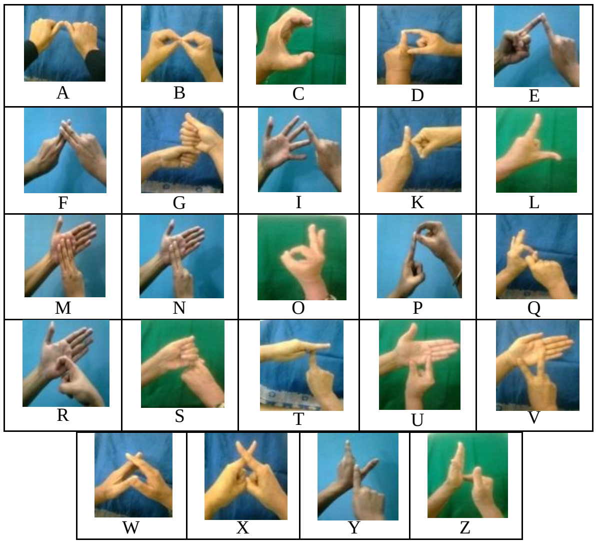


Fig. 2. Some of the database images considered for the proposed system

A. Skin Filtering

The first phase for our proposed system is the skin filtering of the input image which extracts out the skin colored pixels from the non-skin colored pixels. This method is very much useful for detection of hand, face etc. The steps carried out for performing skin filtering is given in Fig. 3.

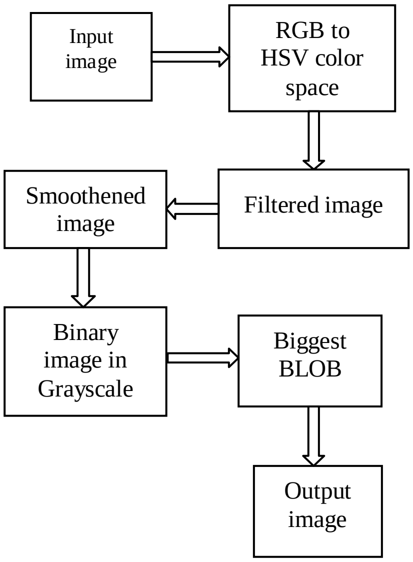


Fig. 3. Basic Block diagram of Skin Filtering

The input RGB image is first converted to the HSV image. The motive of performing this step is RGB image is very sensitive to change in illumination condition. The HSV color space separates three components: Hue which means the set of pure colors within a color space, Saturation describing the grade of purity of a color image and Value giving relative lightness or darkness of a color. The following Fig. 4 shows the different components of HSV color model.

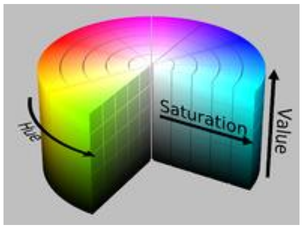


Fig. 4. HSV color model

In our proposed system, the RGB is converted to HSV color model by the following mathematical calculations:

$$H=\begin{cases}60\left(\frac{G-B}{\delta}\right) & if\ MAX=R\\ 60\left(\frac{B-R}{\delta}+2\right) & if\ MAX=G\\ 60\left(\frac{R-G}{\delta}+4\right) & if\ MAX=B\\ not\ defined & if\ MAX=0\end{cases} \tag{2}$$

$$s=\begin{cases}\frac{\delta}{MAX} & if\ MAX\neq 0\\ 0 & if\ MAX=0\end{cases} \tag{3}$$

where δ = (MAX − MIN), MAX = max(R, G, B) and MIN = min(R, G, B).

Then the HSV image is filtered and smoothened and finally we get an image which comprises of only skin colored pixels. Now, along with the hand other objects in the surroundings may also have skin-color like shadows, wood, dress etc. Thus to eliminate these, we take the biggest binary linked object (BLOB) which considers only the region comprising of biggest linked skin-colored pixels. Results obtained after performing skin filtering is given in Fig. 5.

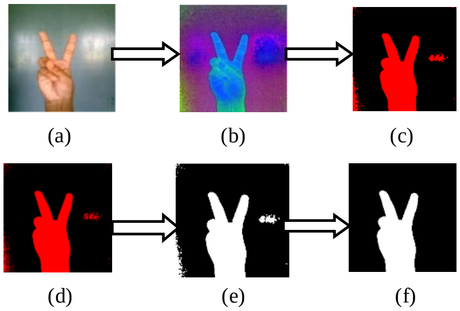


Fig. 5. a) RGB image, b) HSV image, c) Filtered image, d) Smoothened image, e) Binary image in grayscale, f) Biggest BLOB.

B. Hand Cropping

Next phase is the cropping of hand. For recognition of different gestures, only hand portion till wrist is required, thus the unnecessary part is clipped off using this hand cropping technique. Significance of using this hand cropping is we can detect the wrist and hence eliminate the undesired region. And once the wrist is found the fingers can easily be located as it will lie in the opposite region of wrist. The steps involved in this technique are as follows.

- The skin filtered image is scanned from all direction left, right, top, bottom to detect the wrist of the hand. Once the wrist is detected its position can be easily found out.
- Then the minimum and maximum positions of the white pixels in the image are found out in all other directions. Thus we obtain X_{min}, Y_{min}, X_{max}, Y_{max}, one of which is the wrist position.
- Then the image is cropped along these coordinates as used in [5].

Few images have been shown in Fig. 6 after performing hand cropping.

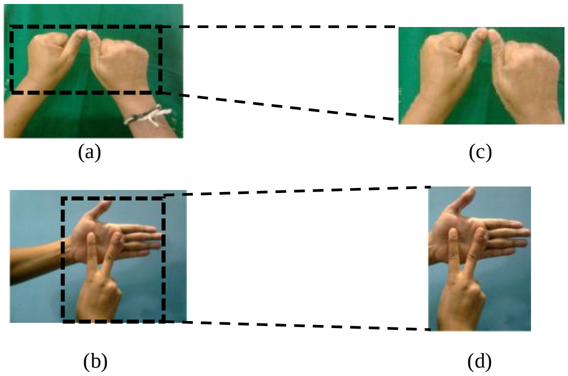


Fig. 6. Hand cropping: (a) and (b) showing the input image, (c) and (d) showing cropped image respectively.

C. Feature Extraction

After the desired portion of the image is being cropped, feature extraction phase is carried out. Here, Eigen values and Eigen vectors are found out from the cropped image. The mathematical steps for finding out Eigen values and Eigen vectors in our proposed system are:

- The input data is assumed to be X. Here, in our paper cropped image has been taken as the input image having a dimension 50 by 50.
- The mean of the above vector X is found out as
$$M = E\{X\} \tag{4}$$
- Then the covariance matrix C of the above input vector X was found out. Mathematically, it was given by
$$C = E\{(X - M)(X - M)'\} \tag{5}$$
- The Eigen vectors and the Eigen values are computed from the covariance matrix C.
- Finally the Eigen vectors are arranged in such a way that the corresponding Eigen values is in the decreasing order.

In our project, only five significant Eigen vectors out of 50 has been considered because the Eigen values were very small after this and so can be neglected. This provides advantages like data compression, data dimension reduction without much loss of information, reducing the original variables into a lower number of orthogonal or non-correlated synthesized variables.

D. Classifier

Classifier was needed in order to recognize various hand gestures. In our paper, we have designed a new classification technique that is Eigen value weighted Euclidean distance between Eigen vectors which involved two levels of classification.

- Classification based on Euclidean Distance: Euclidean distance was found out between the Eigen vectors of the test image and the corresponding Eigen vectors of the database image. As five Eigen vectors were considered, we get five Euclidean distances for each database image and then the minimum of each was found out. Mathematically,
$$E.D. = \sqrt{\sum_{n=1}^{m} (EV1(n) - EV2(n))^{2}} \tag{6}$$
where EV1 represents the Eigen vectors of the test image and EV2 represents the Eigen vectors of the database image.
- Classification based on Eigen value weighted Euclidean distance: The difference of Eigen values of the test image and the Eigen values of the database image was found out. Then, it was multiplied with the Euclidean Distance obtained in the first level of classification given as C2 in equation below. Then sum of results obtained for each image were added and minimum of them was considered to be the recognized symbol. Mathematically,
$$C2 = (E.D.) * |E1 - E2| \tag{7}$$
where E1 and E2 are the Eigen values of the test images and database images respectively.

V. Results and Discussions

Different images were tested and found that the new technique of classification was found to show 97% accuracy. Some images tested with other database images are given in the following table where 2 levels of classification were used to identify the gestures. Table I shows the Level 1 classification experimented for different test images and Table II shows the level 2 classification.

A comparison between the first level and second level of classification is being made in Table III and it is seen that the success rate has improved from 87% to 97% with the use of the Eigen value weighted Euclidean distance between Eigen vectors as a classification technique.

TABLE I. CLASSIFICATION BASED ON EUCLIDEAN DISTANCE

Test image	Image in database	Euclidean distance with 1st Eigen vector	Euclidean distance with 2nd Eigen vector	Euclidean distance with 3rd Eigen vector	Euclidean distance with 4th Eigen vector	Euclidean distance with 5th Eigen vector	Recognized symbol
	A	**0.1249**	1.5691	1.2558	**0.4792**	**0.8158**	**"A"**
	B	0.5533	0.5956	1.7043	1.4447	1.4507	
	C	0.7618	0.7394	1.0156	1.3916	1.3854	
	D	0.9854	1.2047	0.9849	1.5242	1.6026	
	E	0.5963	0.7418	1.6339	1.5727	1.6066	
	F	0.9521	1.0793	1.4544	1.5081	1.2504	
	G	1.1609	1.6549	1.7979	1.3987	1.7241	
	I	0.8485	0.8528	0.8169	1.2077	1.3014	
	K	0.9268	0.9928	0.5444	1.2782	1.0812	
	L	0.6364	1.9378	0.6811	0.8108	1.6678	
	M	0.3860	1.6395	1.4842	1.7437	1.3255	
	N	0.4770	1.1493	1.4225	1.7111	1.4469	
	O	0.6612	0.8577	1.4895	1.5931	1.3063	
	P	1.0740	1.0917	1.0965	1.3409	1.1151	
	Q	1.3458	1.4588	0.8631	1.7031	1.3686	
	R	1.1635	1.2585	1.1592	1.0778	1.6516	
	S	1.5031	1.1822	1.7871	0.8983	1.6370	
	T	0.9091	1.0428	0.8999	1.1844	1.2316	
	U	0.4152	1.0505	1.0741	1.1402	1.2867	
	V	0.4867	1.1147	1.3363	1.0399	1.4031	
	W	1.5046	1.2852	1.2904	1.6789	1.3340	
	X	1.4303	1.4346	1.6386	1.6693	1.3324	
	Y	1.5174	1.4646	1.1740	1.4543	1.5043	
	Z	1.4874	1.3243	0.9958	1.3852	1.4072	

TABLE II. CLASSIFICATION BASED ON EIGEN VALUE WEIGHTED EUCLIDEAN DISTANCE

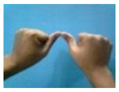
Test image	**Image in database**	**Eigen value weighted E.D. (1st Eigen values)**	**Eigen value weighted E.D. (2nd Eigen values)**	**Eigen value weighted E.D. (3rd Eigen values)**	**Eigen value weighted E.D. (4th Eigen values)**	**Eigen value weighted E.D. (5th Eigen values)**	**Sum**	**Recognized symbol**
	A	0.0536	2.6397	0.1272	0.2379	0.1277	**3.1861**	**"A"**
	B	2.0381	1.2870	0.4815	0.8599	0.2717	4.9382	
	C	0.9585	1.4476	0.0278	1.5120	0.0891	4.0350	
	D	2.4494	0.6792	0.0666	1.3786	0.0126	4.5864	
	E	0.7930	1.7588	1.3505	2.1545	0.0951	6.1519	
	F	1.5441	1.3513	1.2021	1.5735	0.0472	5.7182	
	G	0.6581	4.8827	3.2120	1.9195	0.3106	10.9829	
	I	3.5201	0.3021	0.2475	0.2014	1.0829	5.3540	
	K	7.0507	0.2316	0.3913	1.4674	0.0889	9.2299	
	L	2.6877	1.3673	0.1965	0.5769	0.5458	5.3742	
	M	0.4923	5.9935	0.3323	2.3351	0.0834	9.2366	
	N	0.6266	3.4768	0.2533	2.2766	0.0606	6.6939	
	O	1.2939	1.9144	1.2720	1.4887	0.3475	6.3165	
	P	0.8887	1.4092	1.8448	1.0864	0.3796	5.6087	
	Q	2.4164	0.1453	0.2031	0.5231	0.0593	3.3472	
	R	2.3273	2.4424	0.1145	0.8104	0.1669	5.8615	
	S	0.2087	0.9724	2.6583	0.3222	0.1852	4.3468	
	T	3.0581	0.3526	1.3615	1.7494	0.1140	6.6356	
	U	0.8202	2.0471	0.0857	0.3893	0.4308	3.7731	
	V	0.2843	2.6518	1.1536	0.2339	0.2783	4.6019	
	W	4.0941	0.8412	0.6467	2.4152	0.1949	8.1921	
	X	4.5624	0.4257	0.8330	2.8831	0.1120	8.8162	
	Y	1.8397	0.0949	0.5030	0.9159	0.6398	3.9933	
	Z	3.1385	2.5160	0.2507	1.4153	0.0757	7.3962	

TABLE III. SUCCESS RATES OF TWO LEVELS OF CLASSIFICATION

Symbol	Number of images experimented	Success rate of Euclidean distance classification	Success rate of Eigen value weighted Euclidean distance classification
A	10	100%	100%
B	10	90%	100%
C	10	100%	100%
D	10	70%	90%
E	10	90%	100%
F	10	90%	90%
G	10	100%	100%
I	10	90%	100%
K	10	90%	100%
L	10	90%	100%
M	10	70%	80%
N	10	70%	90%
O	10	100%	100%
P	10	80%	90%
Q	10	90%	100%
R	10	90%	100%
S	10	100%	100%
T	10	100%	100%
U	10	70%	90%
V	10	70%	90%
W	10	80%	100%
X	10	80%	100%
Y	10	80%	100%
Z	10	100%	100%

From the above experiments, we can say that we have designed a system that was able to recognize different alphabets of Indian Sign Language and we have removed difficulties faced by the previous works with improved recognition rate of 97%. The time taken to process an image was 0.0384 seconds. Table IV describes a brief comparative study between our works with the other related works.

VI. CONCLUSION AND FUTURE WORK

The proposed system was implemented with MATLAB version 7.6 (R2008a) and supporting hardware was Intel® Pentium® CPU B950 @ 2.10GHz processor machine, Windows 7 Home basic (64 bit), 4GB RAM and an external 2 MP camera. A system was designed for Indian Sign Language Recognition. It was able to handle different static alphabets of Indian Sign Languages by using Eigen value weighted Euclidean distance between Eigen vectors as a classification technique. We have tried to improve the recognition rate compared to the previous works and achieved a success rate of 97%. Moreover, we have considered both hands in our paper. As we have performed the experiments with only the static images so out of the 26 alphabets 'H' and 'J' were not considered as they were dynamic gestures. We hope to deal with dynamic gestures in future. Moreover only 240 images were considered in this paper so in future we hope to extend it further.

TABLE IV. COMPARITIVE STUDY BETWEEN OUR WORK AND OTHER APPROACHES

Name of the technique used	Success Rate	Difficulties faced
Hit-Miss Operation, HMM [2]	97.83%	Weak skin color detection
PCA, Gabor Filter and SVM [3]	95.2%	Single hand gesture recognition
Perceptual color space [6]	100%	Dealt with only 5 hand gestures
Contour based [8]	91%	• Use of hand gloves • Single hand gesture recognition
ANN based [13]	94%	Use of data gloves with 13 sensors
Kinematic Chain Theory based [14]	100%	• 3 simple hand gesture recognition • Use of Data gloves • Reduction in computation time

Our Work	Success rate	Advantages
Eigen value weighted Euclidean Distance based	97%	• Less computation time • Can recognize 2 hand gestures • Performed with bare hands, thus removing difficulties of using gloves • Can recognize 24 different gestures with high success.

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Recognition of Facial Expression Using Eigenvector Based Distributed Features and Euclidean Distance Based Decision Making Technique

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***Abstract*—In this paper, an Eigenvector based system has been presented to recognize facial expressions from digital facial images. In the approach, firstly the images were acquired and cropping of five significant portions from the image was performed to extract and store the Eigenvectors specific to the expressions. The Eigenvectors for the test images were also computed, and finally the input facial image was recognized when similarity was obtained by calculating the minimum Euclidean distance between the test image and the different expressions.**

***Keywords*—Facial expression recognition; facial expressions; Eigenvectors; Eigenvalues**

I. Introduction

A human face carries a lot of important information while interacting to one another. In social interaction, the most common communicative hint is given by one's facial expression. Mainly in psychology, the expressions of facial features have been largely considered. As per the study of Mehrabian [1], amongst the human communication, facial expressions comprises 55% of the message transmitted in comparison to the 7% of the communication information conveyed by linguistic language and 38% by paralanguage.

This shows that the facial expression forms the major mode of interaction between the man and machine. Since for communicating the non-verbal messages the face forms the basis, the ability to read the facial emotions becomes an important part of emotional intelligence [2].

In recent years, a lot of work has been done on the affective recognition of expressions which holds the major key in the human-machine interaction. The research on the facial emotions across different cultures points out that the recognition of expressions is universal and established as constant across cultures. The first suggestion of expression of emotions as universal was given by Charles Darwin in his contriving work build from his theory of evolution. Then the psychologist Ekman and Friesen showed in their cross culture studies that the six emotions "happiness, sadness, anger, surprise, disgust and fear" are interpreted in the same way and are universal across cultures, which are known as the six basic expressions [3] [12].

In this paper, a method has been presented to design an Eigenvector based facial expression recognition system. Eigenvector based features are extracted from the images. In the training phase, a set of 10 images for each basic expression is processed and Eigenvectors specific to the expressions are stored. In the testing phase, the Eigenvector of the testing image is computed and the Euclidean distance of the Eigenvector of the testing image and all the stored Eigenvector is computed. The testing image is classified as a particular facial expression if the Euclidean distance between the Eigenvectors of that expression and the Eigenvectors of the testing image is obtained minimum compared to the Eigenvectors of the other expressions. To make the system more efficient instead of the whole image being considered, segments of the image is processed. The detail of segmentation is discussed in section IV.

II. Literature Review

In 1977, Ekman and Friesen developed a famous and successful facial action coding system [4]. The Facial Action Coding System (FACS) identifies the facial muscles that cause changes in the facial expression thus enabling facial expression analysis. This system consists of 46 Action Units describing the facial behaviors. Gao, Leung, Hui, and Tananda [5] used the line based caricature of the facial expression for the line edge map (LEM) descriptor, measuring the line segment Hausdorff distance between the line caricature of the expression and the LEM of the test face. They achieved an optimal value of 86.6%, showing that the average recognition rate of females was 7.8% higher than that of males. In view of the color features, Lajevardi and Wu [6] presented a tensor based representation of the static color images. They achieved 68.8% accuracy at recognizing expression with different resolutions in CIEluv color space. A neural network is proposed in [7] that compresses the entire face region with 2-D discrete cosine transform. Ma and Khorasani [8] extended this image compression with the constructive one hidden layer neural network with the optimal block size to be 12 and the maximum number of hidden units to be 6, thus achieving the accuracy rate of nearly 93.75%.

Researchers have also used the MPEG-4 standard to provide the facial action parameters (FAPs) to represent the facial expressions. Aleksic and Katsaggelos [9] developed a facial expression recognition system utilizing these facial action parameters basically describing the eyebrow and the outer lip features, and classifying up to 93.66% of the test expressions by calculating the maximum likelihoods generated by the multistream hidden markov model (MS-HMM). Huang and He [10] presented a super resolution method to improve the face recognition of low resolution images. They applied canonical correlation analysis (CCA) to obtain the coherent features of the high resolution (HR) and low resolution (LR) images, and employed radial basis functions (RBFs) based non-linear mapping favoring the nearest neighbor (NN) classifier for recognition of single input low resolution image. The recognition rate of their method tested on the Facial Recognition Technology (FERET) face database was 84.4%, 93% for the University of Manchester Institute of Science and Technology (UMIST) database, and 95% for the Olivetti Research Laboratory (ORL) database.The approach of Eigenface method was given by Turk and Pentland [11]. Murthy and Jadon [12] enhanced this method to recognize the expression from the front view of the face, tested for the Cohn-Kanade (CK) Facial Expression database and Japanese female facial expression (JAFFE) database. Zhi, Flierl, Ruan, and Kleijn [13] applied the projected gradient method and developed the graph-preserving sparse non-negative matrix factorization (GSNMF) for extraction of feature verified on different databases. They achieved accuracy of 93.3% recognition for eyes occlusion, 94.0% for nose occlusion, 90.1% for mouth occlusion and 96.6% for images of spontaneous facial expression.

In recent years, automated recognition of facial expression has also gained popularity. Mase and Pentland [14] estimated the activity of the facial muscles using dense optical flow. In [15] this approach was extended combined with the face model, using recursive estimation and achieved an accuracy of 98%. Keith Anderson and Peter W. McOwan [16] used an enhanced ratio template algorithm to detect the frontal view of the face, and chose the multichannel gradient model (MCGM) for the motion of the face. They analyzed their recognition system using support vector machine classifier (SVM) and noted a recognition rate of 81.82%.In [17], the elastic graph matching (EGM) algorithm has been proposed and the analysis conducted for the feature extraction was a novel 2-class kernel discriminant analysis to improve the performance for the facial expression recognition. The recognition accuracy achieved for the Gabor-based elastic graph matching method was 90.5% whereas for the normalized morphological based elastic graph matching method was 91.8%. Facial expression recognition has been analyzed on visible light images, but [18] constructed a database for recognition of expression from both visible and infrared images. Gabor wavelets were also useful for recognition as it shows the enticing properties of specific spatial location and sparse object representation. Liu and Wechsler [19] presented a Gabor-Fisher based classification for face recognition using the Enhanced Fisher linear discriminant Model (EFM) along with the augmented Gabor feature, tested on 200 subjects. Zhang and Tjondronegoro [20] presented patch-based Gabor feature extraction from the automatically cropped images, in the form of patches. They matched the patches of the input image with the trained images by comparing the distance metrics and classification carried out by four different kernels SVM. The results were seen for two databases, obtaining correct recognition rate of 92.93% for JAFFE database and 94.8% for CK database. Two novel methods were proposed in [21], first detecting the dynamic facial expressions directly and second, the facial action units based detection. The classification was performed using SVMs. The recognition rate of 99.7% and 95.1% were achieved for both the methods respectively.

III. Theoretical Background

Eigenvectors and Eigenvalues are dependent on the concept of orthogonal linear transformation. An Eigenvector is basically a non-zero vector. The dominant Eigenvector of a matrix is the one corresponding to the largest Eigenvalue of that matrix. This dominant Eigenvector is important for many real world applications.

Steps used to find the features for expressions.

- Organizing the data set- Consider the data having a set of M variables that are arranged as a set of N data vectors. Thus the whole data is put into a single matrix X of dimensions M x N.

- Calculating the mean-

$$\mu_x = \frac{1}{N}\sum_{n=1}^{N} X[m,n] \quad (1)$$

where μ_x is the mean of the matrix *X*; m and n are indices and m=1, 2… M and n=1, 2… N

- Subtracting off the mean for each dimension-

$$X = X - \mu_x \quad (2)$$

The new matrix X comprises of the mean-subtracted data. The subtraction of mean is important, since it ensures that the first principal component indicates the direction of maximum variance.

- Calculating the covariance matrix-

Covariance has the same formula as that of the variance. Assume we have a 3-dimensional data set (*p*, *q*, *r*), then we can measure the covariance either between p and q, q and r or r and p dimensions. But measuring the covariance between p and p, q and q, r and r dimensions gives the value of variance of the respective *p, q, r* dimension. Variance is measured on a single dimension whereas covariance on multi-dimensions.

For 1-dimension,

$$Cov(x) = Var(x) = \frac{\sum_{i=1}^{N}(X-\mu_x)(X-\mu_x)}{N-1} \quad (3)$$

where *Var* is the variance matrix;

For 2-dimension say (x, y),

$$Cov(x,y) = \frac{\sum_{i=1}^{N}(X-\mu_x)(Y-\mu_y)}{N-1} \quad (4)$$

where *Cov(x, y)* is the covariance matrix; μ_y is the mean of another matrix Y.

- Calculating the Eigenvectors and Eigenvalues of the covariance matrix- For computing the matrix of Eigenvectors that diagonalizes the covariance matrix *C*

$$E \cdot Cov \cdot E^{-1} = D \qquad (5)$$

where *Cov* is the covariance matrix; *E* is the matrix of all the Eigenvectors of *Cov*, one Eigenvector per column; *D* is the diagonal matrix of all the Eigenvalues of *Cov* along its main diagonal, and which is zero for the rest of the elements.

The Eigenvector associated with the largest Eigenvalue displays the greatest variance in the image while the Eigenvector associated with the smallest Eigenvalue displays the least variance.

IV. Proposed System

The block diagram for the proposed system is represented in Fig. 1.

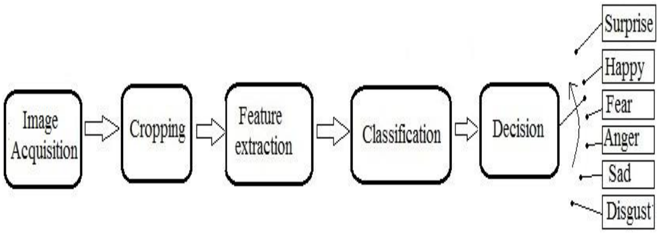


Fig. 1. Block Diagram For The Expression Recognition System

A. Image acquisition-

Images are acquired using a digital camera. First all the images are converted into gray-scale images before going for further processing.

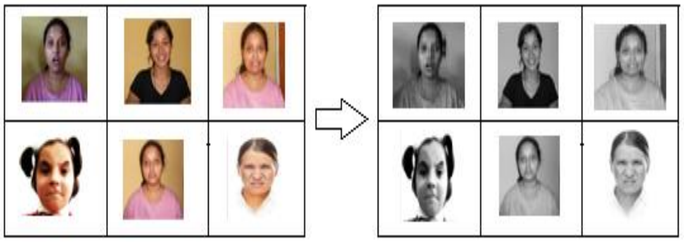


Fig. 2. Top row-Surprise, happy, fear. Bottom row-Anger, sad, disgust

B. Cropping-

Eyes, nose and lip take different shapes for different expressions and significant information is carried by them. So instead of processing the entire face, eyes, nose and lip are processed. Before going for further processing, five significant portions are cropped from the image as shown in Fig. 3 and it shall be called as feature image.

C. Feature extraction-

The cropped images are resized to give the value size 40 by 40 for the left and the right eye, 70 by 60 for the nose, 60 by 90 for the lip and 110 by 95 for the cropped nose and lip together. Eigenvectors are computed from these cropped images.

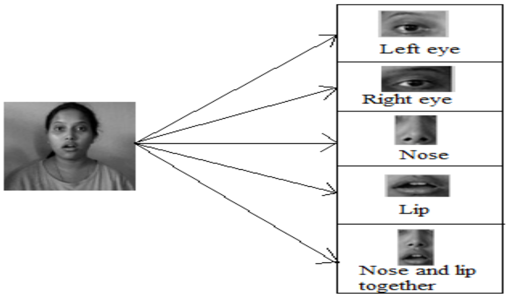


Fig. 3. Cropped images

In this work, the universal expressions are set into six classes as the training images. Eigenvectors and Eigenvalues of five different individual segments of the image is computed and stored. For a single class, after the selection of a particular feature, a matrix is obtained which is stored as, say L of dimension P x Q. Similarly for the rest of the features also, Eigenvectors and Eigenvalues are computed and stored as a matrix.

First the mean centered feature image vectors is obtained by subtracting the mean from the feature image. This image vectors are depicted as matrix only. Then the covariance matrix of each individual feature image is obtained by calculating the covariance of the matrix of each mean centered image vectors, and from each covariance matrix, the associated eigenvectors and Eigenvalues for the individually extracted features are computed.

Five significant Eigenvectors are considered for further processing which are sorted in the decreasing order of the associated Eigenvalues of the covariance matrix. With the available eigenvectors of expressions, separate subspaces for all the six universal expressions are created. With the available expression subspaces, the input image could be identified by incorporating a decision making system.

D. Classifier-

The classifier based on the Euclidean distance has been used which is obtained by calculating the distance between the image which are to be tested and the already available images used as the training images. Then the minimum distance is observed from the set of values.

In testing, the Euclidean distance (ED) has been computed between the new (testing) image Eigenvector and the Eigen subspaces for each expression, and minimum Euclidean distance based classification is done to recognize the expression of the input image. The formula for the Euclidean distance is given by

$$ED = \sqrt{\sum(x_2 - x_1)^2} \qquad (6)$$

V. Results And Discussions

The testing process for the expression ‘Sad’ with the left eye being considered is summarized in table I. The Eigenvectors are obtained from the input image, then EDs between each Eigenvectors and the reference Eigenvectors of each trained expressions are obtained. If two expressions are same, then ED will be minimum. From minimum ED, a decision can be made of certain expression (in this case it is sad). Since five principal vectors are being considered, there will be five selections. In this case, out of the five vectors, the expression sad has been shown by two Eigenvectors and the expression fear has been shown by another two Eigenvectors.

In table II, the testing process for the expression 'Sad', with the right eye being considered is summarized. The Eigenvectors are computed from the input image and the EDs are calculated for the Eigenvectors of the input image and the Eigenvectors of the trained images. For the similar two expressions, their Euclidean distance will be minimum. Considering that, the particular expression can be decided. Since five significant vectors are taken into account, five selections are made and from table II, it is seen that the expression sad and disgust are selected most.

In table III, the testing process for the expression 'Sad', in view of the nose is summarized. The Eigenvectors of the input image are attained. The EDs of each Eigenvectors in reference to the trained expression's Eigenvectors are obtained. The ED of the same two expressions will be minimum of all the EDs. The particular expression can be determined from the minimum ED. In this case, since five principal vectors have been considered, there will be five alternatives. From table III, it has been observed that expression sad and anger has been selected the most number of times.

In table IV, the testing process for the expression 'sad', the lip being considered is summarized. From the input image, the Eigenvectors are accomplished. The EDs are estimated for each Eigenvectors in relation to the Eigenvectors for the trained images. The minimum ED is obtained for the same two expressions and from this minimum ED, the specific expression can be accomplished. In this case, since five principal vectors have been considered, there will be five selections and from table IV, it is observed that expression sad is selected thrice of all the five EDs; hence the decided expression is 'Sad'.

In table V, the testing process for the expression 'Sad' is summarized. The Eigenvectors are procured from the input image. Then EDs of each Eigenvectors are procured from the reference Eigenvectors of each trained expressions. The two expressions which are same, the value of their ED will be minimum and the preference of specific expression can be made. As five principal vectors are being considered, there will be five selections. And final decision is attained out of all the five selections. Taken into consideration the nose and the lip together, two of the Eigenvectors has exhibited the expression sad and the other two has exhibited the expression surprise.

The testing for the six basic expressions has been performed. Finally, the summarization of the values of the lowest Euclidean distance measured for the different features for the particular expression is given in table VI. The expression that gets selected more number of times is considered as the decided expression. From this table, it has been observed that the expression 'sad' has been selected the maximum number of times. Thus, a decision can be taken that the expression in the testing image is 'Sad'.

TABLE I. EUCLIDEAN DISTANCE (ED) FOR THE MASKED LEFT EYE

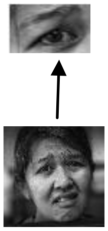
Testing image	Training image	ED1	ED2	ED3	ED4	ED5
	Surprise	1.2676	1.8119	1.7794	1.1874	1.5855
	Happy	1.4572	1.5182	1.5265	1.8055	1.6493
	Fear	0.8267	**1.2712**	1.8443	1.3175	**1.2972**
	Anger	0.9953	1.3782	1.7177	**1.1334**	1.4489
	Sad	**0.7931**	1.5523	**1.0986**	1.3872	1.4326
	Disgust	1.0762	1.6502	1.6997	1.5106	1.6576
	Result obtained from minimum ED	Sad	Fear	Sad	Anger	Fear

TABLE II. EUCLIDEAN DISTANCE (ED) FOR THE MASKED RIGHT EYE

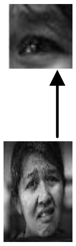
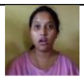
Testing image	Training image	ED1	ED2	ED3	ED4	ED5
	 Surprise	1.4307	1.8186	1.1411	1.6590	1.6835
	Happy	1.6744	1.2974	1.6189	1.6780	1.3144
	Fear	1.1157	1.0956	**0.8780**	1.3808	1.5251
	Anger	0.9820	1.7105	1.6698	1.4655	1.4475
	Sad	1.7410	1.3809	1.6995	**1.1275**	**1.2976**
	Disgust	**0.3020**	**0.8777**	1.3580	1.4427	1.5040
	Result obtained from minimum ED	Disgust	Disgust	Fear	Sad	Sad

TABLE III. EUCLIDEAN DISTANCE (ED) FOR THE MASKED NOSE

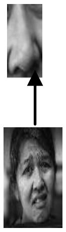
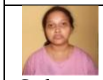
Test-ing image	**Training image**	**ED1**	**ED2**	**ED3**	**ED4**	**ED5**
	 Surprise	0.7883	1.7646	1.6823	1.1826	1.6365
	 Happy	1.8165	1.5430	1.3842	1.4952	1.5111
	 Fear	1.7987	1.6020	1.5370	1.4383	1.6254
	 Anger	1.0556	1.4425	**1.2735**	**1.0630**	1.6313
	 Sad	**0.7850**	1.2584	1.5923	1.4000	**1.2754**
	 Disgust	0.8231	**1.2545**	1.3076	1.4722	1.3457
	Result obtained from minimum ED	Sad	Disgust	Anger	Anger	Sad

TABLE IV. EUCLIDEAN DISTANCE (ED) FOR THE MASKED LIP

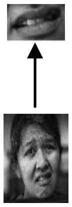
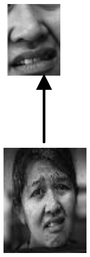
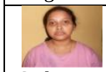
Test-ing image	**Training image**	**ED1**	**ED2**	**ED3**	**ED4**	**ED5**
	 Surprise	**0.8594**	1.7435	1.4553	1.3318	1.6708
	 Happy	1.6611	1.5389	1.4979	1.4459	1.4290
	 Fear	1.6277	1.5100	**1.0623**	1.3087	1.6064
	 Anger	1.2394	1.4300	1.5186	1.2620	1.3357
	 Sad	1.1744	**0.8795**	1.1459	**1.2443**	**1.2540**
	 Disgust	1.4730	1.5203	1.4403	1.3319	1.3884
	Result obtained from minimum ED	Surp-rise	Sad	Fear	Sad	Sad

TABLE V. EUCLIDEAN DISTANCE (ED) FOR THE MASKED NOSE AND LIP TOGETHER

Testing image	**Training image**	**ED1**	**ED2**	**ED3**	**ED4**	**ED5**
	 Surprise	**0.3955**	1.9696	1.3062	**1.0205**	1.7349
	 Happy	1.8522	1.4260	1.5798	1.4754	1.5429
	 Fear	0.8453	0.7654	1.4537	1.4948	1.4582
	 Anger	1.0770	1.5184	1.4441	1.2569	1.5348
	 Sad	0.7389	0.8601	**1.1359**	1.5248	**1.1669**
	 Disgust	0.5588	**0.6722**	1.8764	1.4028	1.5955
	Result obtained from minimum ED	Surprise	Disgust	Sad	Surprise	Sad

In table VII, the success rate has been calculated and found to be 95% with the use of Euclidean distance based classification for 60 samples with various expressions. The time taken to process a set of image was obtained to be 0.0295 seconds.

A comparative study of our proposed work with few of the previous works performed for the recognition of facial expression has been shown in table VIII.

VI. CONCLUSION AND FUTURE WORK

The former work on Eigen face features considered the Eigen space of the whole face. In this paper, the objective was to amend the facial expression recognition system using the Eigenvector method, creating different Eigen subspace for a distinct expression. The system has been proposed using MATLAB version 7.6.0.324 (R2008a) and Intel(R) Core(TM) i3-2330M CPU @ 2.20 GHz processor machine, Windows 7 Ultimate (32 bit), 2 GB RAM and a 14 MP camera

TABLE VI. TESTING RESULTS

Test image	Features	Number of votes for the selected features						Recognized expression
		Surprise	***Happy***	***Fear***	***Anger***	***Sad***	***Disgust***	
	Left eye	0	0	2	1	2	0	Sad
	Right eye	0	0	1	0	2	2	
	Nose	0	0	0	2	2	1	
	Lip	1	0	1	0	3	0	
	Nose and lip together	2	0	0	0	2	1	
	Total votes	3	0	4	3	11	4	

TABLE VII. SUCCESS RATE OF CLASSIFICATION

Expression	**Number of images experimented**	**Number of correct Recognition**	**Success rate**
Surprise	10	10	100%
Happy	10	10	100%
Fear	10	8	80%
Anger	10	10	100%
Sad	10	9	90%
Disgust	10	10	100%

TABLE VIII. COMPARATIVE STUDY WITH THE PREVIOUS WORKS

Expression	**Tensor perceptual color framework [6]**	**Eigenspaces [12]**	**HMM [9]**	**Facial movement features [20]**	**Our work**
Anger	62.08%	70%	70.6%	87.1%	100%
Disgust	57.54%	67%	97.3%	90.2%	100%
Fear	62.89%	77%	88.2%	92%	80%
Happy	75.13%	83%	98.4%	98.07%	100%
Sad	67.79%	73%	96.2%	91.47%	90%
Surprise	84.24%	80%	100%	100%	100%

The performance results show the efficacy of our suggested method, primarily used to recognize the six basic expressions. The recognition rate obtained for the proposed system is 95%.

As the humans can effortlessly recognize the facial expressions, the effectiveness of the machine doing the same performance without any delay is still a challenging job. Our future work is to develop a system to perform the same in real time videos.

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Expensive Optimisation: A Metaheuristics Perspective

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***Abstract*—Stochastic, iterative search methods such as Evolutionary Algorithms (EAs) are proven to be efficient optimizers. However, they require evaluation of the candidate solutions which may be prohibitively expensive in many real world optimization problems. Use of approximate models or surrogates is being explored as a way to reduce the number of such evaluations. In this paper we investigated three such methods. The first method (DAFHEA) partially replaces an expensive function evaluation by its approximate model. The approximation is realized with support vector machine (SVM) regression models. The second method (DAFHEA II) is an enhancement on DAFHEA to accommodate for uncertain environments. The third one uses surrogate ranking with preference learning or ordinal regression. The fitness of the candidates is estimated by modeling their rank. The techniques' performances on some of the benchmark numerical optimization problems have been reported. The comparative benefits and shortcomings of both techniques have been identified.**

Keywords—Evolutionary Algorithm; Preference Learning; Surrogate Modeling; Surrogate Ranking

I. INTRODUCTION

Evolutionary Algorithms (EAs) are biologically inspired iterative processes where a population of candidate solutions is evolved generation after generation. In a typical EA a number of new offspring candidate solutions are produced through mutation, recombination and selection. Individuals for producing offspring are chosen using a selection strategy after evaluating the fitness value of each individual in the selection pool. In many real world optimization problems this fitness evaluation can be very expensive.

The use of surrogates to reduce the expensive function evaluation is found to be orders of magnitude cheaper computationally [21, 9, and 18]. Incorporation of approximate models may be one of the most promising approaches to realistically use EA to solve complex real life problems, especially where: (i). Fitness computation is highly time-consuming, (ii). Explicit model for fitness computation is absent, (iii). Environment of the evolutionary algorithm is noisy etc. However, considering the obvious risk involved in such approach, an EA with efficient control strategy for the approximate model and robust performance is welcome.

There are different ways, in which a surrogate or approximation model can be incorporated in an EA [15]; some of which are as follows:

Problem level approximation. In this approach, the statement of the problem itself is replaced by a reduced one that is easier to solve. See [15] for some examples on this.

Functional approximation. As the name suggests, in this approach, an alternate and explicit expression is constructed for the objective function, for the purpose of reducing the cost of evaluation. A set of evaluated points are used to build the approximate fitness model. This model is used to predict the fitness of candidate solutions. Usually a fraction of individuals in the population are selected and evaluated within each generation or over a number of generations to generate training points and are added to the training set to update the surrogates to maintain a reliable surrogate during evolution. See [13, 14, and 15] for examples on this technique.

EA specific approximation. This approach is specific for evolutionary algorithms and utilizes the algorithm's structural and functional aspects.

For a detailed review on use of approximation in EA, see [15].In this paper we investigate three different methods which use surrogates to reduce the number of actual function evaluations in EA [4].

In the first one, namely, Dynamic Approximate Fitness based Hybrid Evolutionary Algorithm (DAFHEA), Bhattacharya et. al [2, 3] use both "functional approximation" and "EA specific approximation". It uses an approximation model to partially replace expensive fitness evaluations in evolutionary algorithm. DAFHEA uses an *explicit* control strategy (*a cluster-based on-line learning technique*) to improve reliability of using such approximate models to reduce expensive function evaluations. Also the approximate knowledge thus generated is exploited to avoid premature convergence (one of the major impediments of using evolutionary algorithm to solve complex real life optimization problems).

The second method, DAFHEA II [5] is an enhancement on DAFHEA to cover situations, where information from variable input dimensions and noisy data is involved. DAFHEA-II uses a multi-model regression approach. The multiple models are estimated by successive application of the SVM regression algorithm. Retraining of the model is done in a periodic fashion.

In the third method, Runersson [22] makes use of the EA feature that unlike classical optimization techniques, in rank based selection, selection of the best candidates requires only the rank or partial rank of the candidates. Here, the fitness of individuals is indirectly estimated by modeling their rank using surrogate. Preference learning or ordinal regression is used to implement a kernel-defined feature space.

The features and effectiveness of the above two surrogate-based methods have been investigated in this work. The above two methods have been selected for comparison as they are based on very different concepts and may reveal important characteristics which may be useful for specific problem cases.

Rest of the paper is organized as follows. Section II presents a brief review on use of surrogates in evolutionary computing. Section III outlines the features of the surrogate-based EA methods which we have investigated in this research. Section IV presents the experiment details and discussions on the findings. Finally, concluding remarks are summarized in Section V.

II. Surrogate-Based Evolutionary Algorithm

The use of an approximate model to speed up optimization dates all the way back to the sixties [8]. The most widely used models being Response Surface Methodology [17], Krieging models [23] and artificial neural network models [6]. As has been mentioned in Section 1, the concept of using approximate model varies in levels of approximation (*Problem approximation, Functional approximation, and Evolutionary approximation*), model incorporation mechanism and model management techniques [15].

In the multidisciplinary optimization (MDO) community, primarily response surface analysis and polynomial fitting techniques are used to build the approximate models [11, 27]. These models work well when single point traditional gradient-based optimization methods are used. However, they are not well suited for high dimensional multimodal problems as they generally carry out approximation using simple quadratic models.

In another approach, multilevel search strategies are developed using special relationship between the approximate and the actual model. An interesting class of such models focuses on having many islands using low accuracy/cheap evaluation models with small number of finite elements that progressively propagate individuals to fewer islands using more accurate/expensive evaluations [29]. This approach may suffer from lower complexity/cheap islands having false optima whose fitness values are higher than those in the higher complexity/expensive islands. Rasheed et al. in [19, 20], uses a method of maintaining a large sample of points divided into clusters. Least square quadratic approximations are periodically formed of the entire sample as well as the big clusters. Problem of unevaluable points was taken into account as a design aspect. However, it is only logical to accept that true evaluation should be used along with approximation for reliable results in most practical situations. Another approach using population clustering is that of fitness imitation [15]. Here, the population is clustered into several groups and true evaluation is done only for the cluster representative [16]. The fitness value of other members of the same cluster is estimated by a distance measure. The method may be too simplistic to be reliable, where the population landscape is a complex, multimodal one.

Jin et al. in [13, 14] analyzed the convergence property of approximate fitness based evolutionary algorithm. It has been observed that incorrect convergence can occur due to false optima introduced by the approximate model. Two *controlled evolution* strategies have been introduced. In this approach, new solutions (offspring) can be (pre)-evaluated by the model. The (pre)-evaluation can be used to indicate promising solutions. It is not clear however, how to decide on the optimal fraction of the new individuals for which true evaluation should be done [1]. In an alternative approach, the optimum is first searched on the model. The obtained optimum is then evaluated on the objective function and added to the training data of the model [19, 26, and 1]. Yet another approach as proposed in [14], a regularization technique is used to eliminate false minima.

III. The Investigated Methods

The main features of the three techniques investigated in this work, DAFHEA, DAFHEA II and the preference learning based EA are outlined below.

A. The DAFHEA Technique

The primary objectives of the proposed algorithm and their realization are as below.

1) The main objective of DAFHEA is to reduce the number of actual fitness function evaluations to speed up the search process. The proposed algorithm achieves this by partially replacing actual function evaluation (as is required in traditional genetic algorithm) by SVM based estimation. The DAFHEA framework includes a global model of genetic algorithm (GA), hybridized with support vector machine (SVM) [28] as the approximation tool.

2) The related major objective is to minimize the adverse effect of estimation. To this end explicit control strategies are used for evolution control, leading to considerable speedup without compromising heavily on solution accuracy.

The *controlled* use of estimation is the primary reason why the proposed algorithm should be successful in reducing actual fitness function evaluation without heavily compromising on solution accuracy. The basic algorithm is as below.

Step One: Create a random population of N_c individuals, where, $N_c = 5 * N_a$ and $N_a =$ actual initial population size.

Step Two: Evaluate N_c individual using actual expensive function evaluation. Build the SVM approximate model using normalized expensive function evaluation values as training set for off-line training. (Use of normalized values in the training set appears to improve performance of meta-model, reducing effects of unnaturally high or low values). SVM hyper-parameters are initially tuned based on this training set.

Step Three: Select N_a best individual out of N_c evaluated individuals to form the initial GA population.

Remarks: The idea behind using five times the actual EA population size (as explained in Step One) is to make the approximation model sufficiently representative at least initially. Since initial EA population is formed with N_a best individuals out of these N_c individuals, with high recombination and low mutation rates, the EA population in first few generations is unlikely to drift much from its initial locality. Thus it is expected that large number of samples used in building the approximation model will facilitate better performance at this stage. Also using the higher fitness individuals, chosen out of a larger set should give an initial boost to the evolutionary process.

Step Four: Select parents using suitable selection operator and apply genetic operators namely recombination and mutation to create a new generation.

Step Five: Use SVM approximation model to compute fitness of new generation individuals based on approximate evaluation. Form m distance-based (considering spatial distribution of individuals) clusters in the new population space. If for some n clusters, the standard deviation $\sigma \geq$ Predefined Threshold, rearrange solution space into $m+n$ clusters. Compute a merit function $f_m(x)$ as below:

$$f_m(x) = f_a(x) - \rho_1 \sigma_i - \rho_2 d_{ij} \ \rho_3 s_i \quad □□□$$

In the equation (1), $f_a(x)$ is the predicted fitness function value. σ_i is standard deviation (*in terms of objective value*) for the i^{th} cluster and d_{ij} is the normalized *minimum* Euclidean distance of j^{th} point of i^{th} cluster from the all truly evaluated points so far [22]. s_i is the sparseness of the i^{th} cluster. ρ_1, ρ_2 and ρ_3 are scaling factors for σ_i, d_{ij} and s_i respectively.

$$s_i = \frac{No\ of\ individuals\ in\ \ cluster\ i}{Dimension\ of\ individual} \quad □□□$$

Step Six: Dynamically update the approximate model as below:

1) *Identify the cluster containing the optimum based on approximation.*

2) *Perform expensive evaluation for the approximate optimum and its $k-$nearest neighbors.*

3) *Also perform expensive evaluation for the centroid of all other data clusters and their $k-$nearest neighbors.*

4) *Expand neighborhood for true evaluation until a point is found in each space dimension such that percentage error $\delta \leq$ Predefined threshold.*

$$\delta = \left| \frac{a_{it} - a_{ip}}{a_{it}} \right| \times 100 \quad □□□$$

In the equation (3), a_{it} =True value of the i^{th} neighbor and a_{ip} =Predicted value of the i^{th} neighbor and **max** $i = k$.

Add the newly evaluated points to approximate model training set to update model.

Step Seven: When termination/evolution control criteria are not met, repeat Step Four to Step Seven.

Remarks: It must be noted, the optimum is considered based on the original predicted value $f_a(x)$. For all other purposes fitness based on the merit function $f_m(x)$ is considered. Periodic parameter tuning of the SVM approximation model was incorporated, though no specific criterion was used.

Further details on the above method can be found in [2, 3].

B. The DAFHEA II Technique

As in the original DAFHEA framework, DAFHEA-II [5] includes a global model of genetic algorithm (GA), hybridised with support vector machine (SVM) as the approximation tool. Expensive fitness evaluation of individuals as required in traditional evolutionary algorithm is partially replaced by SVM approximation models (unlike the original DAFHEA, multi-model regression is used). *Evolution control* is implemented by periodic true evaluations, leading to considerable speedup without compromising heavily on solution accuracy. Also the approximate knowledge about the solution space generated is used to maintain population diversity to avoid premature convergence.

5) Functional Details

The operational detail of DAFHEA-II [15] framework is as described below:

Step One: Create a random population of N_c individuals, where, $N_c = 5 * N_a$ and $N_a =$ actual initial population size.

Step Two: Evaluate N_c individual using actual expensive function evaluation. Build the SVM approximate models using the candidate solutions as input and the actual fitness (expensive function evaluation values) as targets forming the training set for *off-line training*.

Step Three: Select N_a best individual out of N_c evaluated individuals to form the initial GA population.

Remarks: The idea behind using five times the actual EA population size (as explained in *Step One*) is to make the approximation model sufficiently representative at least initially. Since initial EA population is formed with N_a best individuals out of these N_c individuals, with high recombination and low mutation rates, the EA population in first few generations is unlikely to drift much from its initial locality. Thus it is expected that large number of samples used in building the approximation model will facilitate better performance at this stage. Also using the higher fitness individuals, chosen out of a larger set should give an initial boost to the evolutionary process.

Step Four: Rank the candidate solutions based on their fitness value.

Step Five: Preserve the elite by carrying over the best candidate solution to the next generation.

Step Six: Select parents using suitable selection operator and apply genetic operators namely recombination and mutation to create children (new candidate solutions) for the next generation.

Step Seven: The SVM regression models created in Step two are applied to estimate the fitness of the children (new candidate solutions) created in Step six. This involves assignment of most likely or appropriate models to each candidate solution.

Step Eight: The set of newly created candidate solutions is ranked based on their approximate fitness values.

Step Nine: The best performing newly created candidate solution and the elite selected in Step five are carried to the population of the next generation.

Step Ten: New candidate solutions or children are created as described in Step six.

Step Eleven: Repeat Step seven to Step ten until either of the following condition is reached:

1. The predetermined maximum number of generations has been reached; or
2. The periodic retraining of the SVM regression models is due.

Step Twelve: If the periodic retraining of the SVM regression models is due, this will involve actual evaluation of the candidate solutions in the current population. Based on this training data new regression models are formed. The algorithm then proceeds to execute Step four to Step eleven.

Remarks: The idea behind using periodic retraining of the SVM regression models is to ensure that the models continue to be representatives of the progressive search areas in the solution space.

C. The Preference Learning Based EA

The second method is directly based on preference learning or ordinal regression based technique proposed by Runersson in [22] with the variation that we have used a genetic algorithm implementation instead of CMA-ES. This method is based on the assumption that in a stochastic and direct search method such as EA, ordinal regression should be able to offer adequate surrogates as only full or even partial ranking of the individuals or search points is sufficient for the selection process. Accordingly, the surrogate approach is considered as a preference learning task, where a candidate point x_i is preferred over x_j if x_i has a higher fitness than x_j. The training set for the surrogate model is thus composed of pairs of points $(x_i, x_j)_k$ and a corresponding label $r_k \in [1, -1]$, taking the value +1 or -1 depending on whether x_i has a higher fitness than x_j or vice versa.

The technique used for preferential learning or ordinal regression is kernel based. See [Runersson] for details on the method of ordinal regression using kernel defined features.

Model selection in surrogate ranking involves appropriately choosing a suitable kernel and its parameters as well as the regulation parameter C which controls the balance between model complexities and training errors. Choice of a suitable kernel is problem specific.

As the search progresses, different regions of the search space are sampled and the original surrogate ranking model may be insufficiently accurate for new regions of the search space. It is therefore extremely important to update the surrogate during evolution. We have followed the surrogate update method suggested by Runersson in [22]. The strategy involves estimating the ranking of a population of points using the current surrogate and identifying the highest ranking point. The point is then evaluated using the true fitness function and its rank is calculated. Accuracy of the surrogate is evaluated by comparing the estimated rank with the true rank. The point evaluated with true fitness function is added to the training set.

IV. Experiments

A. Experiment Details for DAFHEA

It may be noted that the target problem domain for our proposed algorithm involves time consuming actual fitness function evaluation. This property or characteristic of the fitness function is *external to the EA process*. Hence, to verify DAFHEA's effectiveness, it is sufficient to verify if DAFHEA can effectively reduce the number of actual function evaluations without compromising on accuracy for any set of standard test functions. Considering this, the performance of the proposed algorithm has been tested on five classical benchmark test functions: namely, Spherical, Ellipsoidal, Schwefel, Rosenbrock, and Rastrigin. Description of the test functions are as given in **[**3**]**. These benchmark functions in the test suit are scalable and are commonly used to assess the performance of optimization algorithms [30]. For Spherical and Rastrigin the global minimum is $f(x)=0$ at $\{x_i\}^n = 0$. Rosenbrock has a global minimum of $f(x)=0$ at $\{x_i\}^n = 1$.

All simulations were carried out using the following assumptions: The population size of $10n$ was used for all the simulations, where n is the number of variables for the problem; for comparison purposes three sets of input dimensions are considered; namely, $n = 5$, 10 and 20. For all cases, tenfold validation was done with the number of generations being 1000; the SVM regression models [8] were trained with *five times* the real GA population size initially.

All the simulation processes were executed using a Pentium® 4, 2.4GHz CPU processor for both DAFHEA and the Preference Learning based EA.

B. Experiment Details for DAFHEA II

Both non-noisy and noisy versions of the chosen benchmark functions have been used to test DAFHEA II. The *noisy versions* of the functions have been obtained as follows.

$$f_{Noisy}(\vec{x}) = f(\vec{x}) + N(\mu, \sigma^2)$$ □□□

Here, $N(\mu, \sigma^2)$ = Standard Normal (or Gaussian) distribution with mean, μ = 0 and variance, σ^2 = 1. The probability density function $f(x; \mu, \sigma^2)$ is defined as follows.

$$f(x; \mu, \sigma^2) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$$ □□□

All simulations were carried out using the following experiment setup: The population size of $10n$ was used for all the simulations, where n is the number of variables for the problem; for comparison purposes three sets of input dimensions are considered; namely, $n = 5, 10$ and 20. For all three cases, tenfold validation was done with the number of iterations being 1000 for all non-noisy versions of the test problems; the SVM regression models were trained with *five times* the real EA (GA in this case) population size initially. However, in case of the noisy versions of the test functions much larger number of iterations has been used to obtain acceptable level of accuracy of results. All the simulation processes were executed using a Pentium® 4, 2.4GHz CPU processor.

C. Experiment Details for Performance Learning Based EA

Following Runersson's [22] method a 2-norm soft margin support vector machine (SVM) has been used and the technique has been implemented using a classical genetic algorithm. As mentioned earlier, choice of appropriate kernel is an important factor in the performance learning based EA. Runersson [22] has tried ordinal regression with different kernels and concluded that 4th order polynomial kernel produces the best results for the Rosenbrock's function. For the sake of fair comparison we have used the same kernel for this test function. For the Spherical function, the 2nd order polynomial kernel performed best. Gaussian distribution with variance 0.1^2 has been used for the Rastrigin's function.

Training points have been generated using a standard normal distribution centered about the origins (global minima) of the respective test functions. 1000 testing points were generated in the same manner. Using 60 randomly sampled training points the surrogate model has been estimated by ordinal regression. The regulation parameter C has been chosen as 1.0E6.

As the search zooms in on a local minimum, the search will benefit from use of different kernel [22]. As suggested by Runersson in [22] a Gaussian distribution with variance 0.1^2 was used in case of the Rosenbrock's and the Spherical functions in similar situations.

The surrogate has been validated and updated as explained in Section 3.2, every second generation.

D. Results and Discussions

Performances of the three investigated methods on non-noisy versions of Spherical, Ellipsoidal, Schwefel, Rosenbrock, and Rastrigin functions with $n =$ 5, 10 and 20 have been demonstrated in Table I. We have not reported any information on the number of actual function evaluations required for DAFHEA II in Table I as by design this technique employs additional function evaluations to achieve better performance in noisy environment. To give an idea about its efficacy in the noisy environment, Table II presents the comparative performances of the canonical Genetic Algorithm, DAFHEA and DAFHEA II in terms of number of actual function evaluations required when tested on the noisy versions of the test functions.

As can be observed from these results, Preference Learning based EA seems to have an advantage in terms of "number of actual function evaluations" over DAFHEA. However, its performance in terms of "mean fitness" is just not comparable to that of DAFHEA in all nine test cases. Both methods found the classical Spherical function easier to tackle as compared to the Rosenbrock's and the Rastrigin's functions. For both algorithms the mean function values for the spherical functions were better than their Rosenbrock counterparts. However, it may appear that based on the number of function evaluations, the spherical function was much harder for DAFHEA to solve than its Rosenbrock counterpart of the same dimension. It must be noted that increase in number of iterations and thus increase in the number of actual function evaluation showed no improvement in case of the Rosenbrock's function. In general, both models gained on performance with increase in training set size.

As can be anticipated, performances of both techniques deteriorated with increase in problem dimensions. However, this deterioration is much higher in case of the Preference Learning based EA, where the results are practically unusable except in case of Spherical function. Increase in the number of true function evaluations does not seem to improve the situation.

Other general observations are as below:

Both DAFHEA and Preference Learning based EA are applicable to situations where no explicit or computable fitness function is available. However, the concept of using preference learning based surrogate ranking may show more flexibility in such scenarios.

In the Preference Learning based EA, surrogate ranking has been realized using kernel based ordinal regression. That means the method is easily adaptable to any data types as long as a suitable kernel can be defined for the specific problem at hand. However, this is both an advantage and a disadvantage as this means, sufficient knowledge of the characteristics of the problem is required which may be difficult in real world scenarios.

The preference learning based EA benefits from selection of different kernel while the search zooms in on a local minimum. However, this switch may impose some additional computational as well as decisional overhead.

Surrogate ranking with RBF kernel tended to suffer from overfitting and get stuck in local minima. Second order polynomial performed better in case of higher order Rosenbrock's function.

The major drawback of the preference learning based surrogate ranking seems to be its inefficiency in handing higher dimensional problems, which is a common situation for most real world optimization problems.

TABLE I. PERFORMANCES OF THE DAFHEA TECHNIQUE (**M1**), THE DAFHEA II TECHNIQUE (**M2**) AND THE PREFERENCE LEARNING BASED EA (**M3**) AS IMPLEMENTED ON SPHERICAL, ELLIPSOIDAL, SCHWEFEL, ROSENBROCK, AND RASTRIGIN FUNCTIONS WITH $n = 5$, 10 AND 20. PERFORMANCE MEASURES HAVE BEEN EXPRESSED AS THE "MEAN FITNESS" AND THE "NUMBER OF ACTUAL FUNCTION EVALUATIONS".

Function	**Mean Fitness (M1)**	**Mean Fitness (M2)**	**Mean Fitness (M3)**	**No of Actual Function Evaluations (M1)**	**No of Actual Function Evaluations (M3)**
Rosenbrock(5)	1.789E-41	1.998E-38	1.1103E-0.7	7015	1200
Rosenbrock(10)	1.991E-39	1.918E-26	1.0005	6990	4000
Rosenbrock(20)	2.313E-36	1.901E-19	2.1108	21170	17000
Spherical(5)	1.138E-60	1.138E-56	1.0102E-7	21210	375
Spherical(10)	1.152E-58	1.588E-43	1.0081E-5.5	77520	1200
Spherical(20)	1.58E-55	1.388E-35	1.0125E-5.5	110420	2750
Ellipsoidal(5)	3.220E-57	3.412E-51	1.0000E-6.1	18500	400
Ellipsoidal(10)	3.271E-55	2.523E-39	1.0100E-5.5	65700	1500
Ellipsoidal(20)	2.209E-52	1.323E-32	1.0511E-4.5	95510	2900
Schwefel(5)	1.198E-54	1.911E-48	1.0001E-0.8	11500	2700
Schwefel(10)	1.199E-51	2.971E-38	0.9000	15000	5000
Schwefel(20)	1.023E-48	1.989E-31	2.0002	25100	18000
Rastrigin(5)	3.285E-5	3.322E-1	1.1901E-0.8	4550	1700
Rastrigin(10)	3.089E-3	3.388E-1	0.9899	7175	5000
Rastrigin(20)	1.324E-1	10.032	3.0011	28010	15000

V. CONCLUSIONS

Use of surrogates may be the most realistic answer to problems an iterative, stochastic search process like EA faces while dealing with situations, where, true fitness computation is highly expensive, or explicit model for fitness computation is absent, or environment of the evolutionary algorithm is noisy and so on. In this research, we have investigated three surrogate-based EA methods which aim at addressing some of these problems. While the first two methods, DAFHEA and DAFHEA II are based on "functional approximation" and "EA specific approximation" (see Section I), the second method uses surrogate ranking by ordinal regression or preference learning. Experiment results have shown, while Preference Learning based EA has some cost advantage in terms of number of true function evaluations, DAFHEA clearly should be the choice where accuracy (mean fitness value) is of paramount importance. DAFHEA II that uses multi-model regression for surrogate generation, shows some advantage over original DAFHEA and Canonical GA when applied to noisy functions, in terms of solution accuracy (results have not been shown in this article). However, this comes at the expense of some extra overhead in terms of number of actual function evaluations.

TABLE II. PERFORMANCES OF THE CANONOCAL GA (**M1**), THE DAFHEA TECHNIQUE (**M2**) AND THE DAFHEA II TECHNIQUE (**M2**) AS IMPLEMENTED ON **NOISY VERSIONS** OF SPHERICAL, ELLIPSOIDAL, SCHWEFEL, ROSENBROCK, AND RASTRIGIN FUNCTIONS WITH $n = 5$, 10 AND 20. THE PERFORMANCE MEASURE HAS BEEN EXPRESSED AS THE "NUMBER OF ACTUAL FUNCTION EVALUATIONS".

Function	**No of Actual Function Evaluations (M1)**	**No of Actual Function Evaluations (M2)**	**No of Actual Function Evaluations (M3)**
Rosenbrock(5)	35,000	9500	9000
Rosenbrock(10)	100,000	71250	71000
Rosenbrock(20)	500,000	290,500	290,000
Spherical(5)	100,000	59000	58000
Spherical(10)	100,000	76000	75000
Spherical(20)	500,000	300,500	300,000
Ellipsoidal(5)	100,000	59000	58000
Ellipsoidal(10)	100,000	85000	84500
Ellipsoidal(20)	250,000	81550	81500
Schwefel(5)	100,000	69000	68000
Schwefel(10)	100,000	65000	64500
Schwefel(20)	300,000	200,050	200,000
Rastrigin(5)	100,000	5500	5100
Rastrigin(10)	100,000	20500	20000
Rastrigin(20)	500,000	410,500	410,000

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GASolver-A Solution to Resource Constrained Project Scheduling by Genetic Algorithm

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Abstract-**The Resource Constrained Scheduling Problem (RCSP) represents an important research area. Not only exact solution but also many heuristic methods have been proposed to solve RCPSP (Resource Constrained Project Scheduling Problem). It is an NP hard problem. Heuristic methods are designed to solve large and highly Resource Constrained software projects. We have solved the problem of resource constrained scheduling problem and named as GASolver. It is implemented in C# using .net platform. We have used Dependency Injection to make the problem loosely coupled, so that other arena of scheduling like Time Cost Tradeoff (CT), Payment Scheduling (PS) etc can be merged with same solution in the future. We have implemented GASolver using Genetic Algorithm (GA).**

Keywords-Genetic Algorithm; Dependency Injection; GASolver.Core; Resource Constrained Scheduling.

I. Introduction

The Resource Constrained Project Scheduling Problem represents an important research problem. Not only exact solution but also many heuristic methods have been proposed to solve RCPSP. It being an NP hard problem, Alcaraz and Maroto [5] mentioned that the optimal solution can only be achieved by exact solution procedures in small software projects, usually with less than 60 activities, which are not highly resource constrained.

Therefore heuristic methods are designed to solve large and highly Resource Constrained software projects. Mohring [6] mentioned that RCPSP is one of the most intractable problems in operations research and many latest optimization techniques and local search were applied to solve it. We have solved the problem of resource constrained scheduling problem and named as GASolver. It is implemented in C# using .net platform. We have used Dependency Injection (DI) to make the problem loosely coupled, so that other arena of scheduling like Time Cost Tradeoff, Payment Scheduling etc can be merged with same solution in the future. We have implemented GASolver using Genetic Algorithm. The problem statement is explained in the following section. *Problem Statement for RCPSP (Resource Constrained Project Scheduling Problem)*

What is the best way to assign the resources to the activities at specific times such that all of the constraints are satisfied and the best objective measures are produced?

II. Genetic Algorithm

Genetic algorithms (GAs) are search algorithms that are conceptually based on the methods that living organisms adapt to their environment. These methods, known as natural selection or evolution, combine the concept of survival of the fittest among string structures with a structured yet randomized information exchange to form a search algorithm with some of the innovative flair of human search. In each generation, a new set of string structures is created from (bits and pieces of) the fittest strings from the previous generation and occasionally a randomly altered new part. This process of exploiting historical data allows the GA to speculate on new search points that will improve performance thus producing better solutions. Genetic algorithms were initially developed by JohnH.Holland, a professor of psychology and computer science at the University of Michigan. As an optimization tool, the Genetic Algorithm attempts to improve performance leading to an optimal solution.

In this process, there are two distinct steps, (1) the process of improvement and (2) reaching the optimum itself. Of these two steps, the most important is the process of improvement. In complex systems, due to the potential high costs involved, reaching the optimum solution may not be justified as long as continuous improvement is being made and an optimal (desirable) solution can be found.

Genetic algorithm (GA) [1][2][3] is a pioneering method of metaheuristic optimization which originated from the studies of cellular automata of Holland in the 1970s. It is also known as an evolutionary algorithm and a search technique that copies from biological evolution. In Genetic Algorithm, a population of candidate solutions called individuals evolves toward better solutions from generation to generation.

Advantages of genetic Algorithm

- GA can quickly scan a vast solution set. Bad proposals do not affect the endSolution negatively as they are simply discarded.
- The inductive nature of the GA means that it doesn’t have to know any rules of the problem - it works by its own internal rules. This is very useful for complex or loosely defined problems.
- They efficiently search the model space, so they are more likely (than local optimization techniques) to converge toward a global minima.
- There is no need of linearization of the problem.
- There is no need to compute partial derivatives.
- More probable models are sampled more frequently than less probable ones

III. Related Work

In 1978, Stinson et al.[9] formulated the multiple resource-constrained scheduling problem as an integer programming problem and advanced a branch-and-bound algorithm for solving it. The algorithm they developed was similar to branch-and-bound algorithm with differences in the node selection heuristics employed and the number of resources handled (Johnson's algorithm allows for a single resource). In their algorithm, branching corresponds to creating new partial feasible schedules from given partial feasible schedules.

An experimental investigation was completed in 1988 by Dumond and Mabert[4]. They studied RCPSP in an environment where new software projects arrive continuously or randomly to a system in which software projects share common resources and receive completion deadlines. Dumond and Mabert tested the performance of four due date procedures and five scheduling heuristics with full control on the due date assignment. A second test was conducted to examine the performance of the due date procedures when deadlines were set externally. Their experimental results failed to indicate a rule that uniformly outperformed the others.

In 2006 an improved Particle Swarm Optimization (PSO) algorithm[10] for resource-constrained software project scheduling problem was proposed. Improvements based on the basic PSO include: the particle swarm is initialized by heuristic rule to improve the quality of particles; inertia weight was self-adapted with iteration of the algorithm to decelerate the speed of particles; crossover mechanism of genetic algorithm were applied to particle swarm to enable the exchange of good characteristics between two particles.

Computational results for software project instances of PSPLIB demonstrate that this improved PSO was effective as compared with other mataheuristic approaches

In 2007 YanLiu presented a fuzzy genetic algorithm for software project scheduling problem with resource constraints and uncertain activity duration [11]. The objective of this research was to minimize the fuzzy software project make span. Firstly, fuzzy set was used to represent the uncertainty of activity duration and the corresponding comparison method of fuzzy number called integral value approach was introduced. Second, three genetic operators were used to search for an approximate shortest software project make span. Therefore, this study provided another metaheuristic method for solving resource-constraint software project scheduling problem with uncertain activity duration.

In 2009 itself Mohammad Amin Rigi, Shahriar Mohammadi K. N. Toosi [8] proposed a new evolutionary approach to resource constrained software project scheduling problem. Hybrid genetic algorithm (GA)-constraint satisfaction problem (CSP) has been applied to solve resource constrained software project scheduling (RCPS). GA's task was to find the best schedule. Their approach has used CSP in order to overcome the existing inconsistencies in activities precedence and resources conflicts. A full state CSP with min-conflict heuristic has been used for solving precedence conflicts and a simple iterative CSP is used to resolve the resource conflicts.

A more realistic resource-constrained software project-scheduling was solved in 2010[7]. A model that is applicable to real-world software projects, with discounted cash flows and generalized precedence relations is investigated under inflation factor such that a bonus–penalty structure at the deadline of the software project is imposed to force the software project not to be finished beyond the deadline. The goal was to find activity schedules and resource requirement levels that maximized the net present value of the software project cash flows. A Genetic Algorithm (GA) is designed using a new three-stage process that utilizes design of experiments and response surface methodology. The results of the performance analysis of the proposed methodology showed an effective solution approach to the problem.

IV. Solution to Resource Constrained Project Scheduling Problem

To implement RCPSP using GA we need to address the following objectives:-

A. *method of specifying the relationships between the tasks.*

B. *description of resources, skill, salary to perform the tasks.*

C. *The representation of the chromosome.*

D. *Implementation of selection, crossover and mutation function.*

E. *Calculation of an objective function to evaluate the best schedule and optimal cost.*

F. *Class Diagram and Implementation Details of RCPSP.*

A. *A method of specifying the relationships between the tasks*

A project is best represented as a Task Precedence Graph (TPG).A TPG is an acyclic directed graph consisting of a set of tasks and a set of precedence relationships. With the help of Task Precedence Graph we will be able to set the precedence for each task. The Task Precedence graph is shown below in the form of Table.

TABLE I. Task Precedence Graph For RCPSP

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
T1	0	0	1	1	0	0	0	0	0	0	0	0
T2	0	0	0	0	1	0	0	0	0	0	0	0
T3	0	0	0	1	0	0	0	0	0	0	0	0
T4	0	0	0	0	0	0	1	0	0	0	0	0
T5	0	0	0	0	0	0	0	0	0	0	0	0
T6	0	0	0	0	0	1	0	1	1	0	0	0

The task precedence graph describes that Task T1 and T2 are not dependent on any task although for task T3 to finish, Task T1 should be completely finished. Similarly for task T4 to complete, Task T1 and T3 should finish and so on. Thus Task

Precedence Graph enables us to set the precedence for various tasks and maintains the order of execution of tasks.

B. Description of resources, skills, salary to perform the tasks

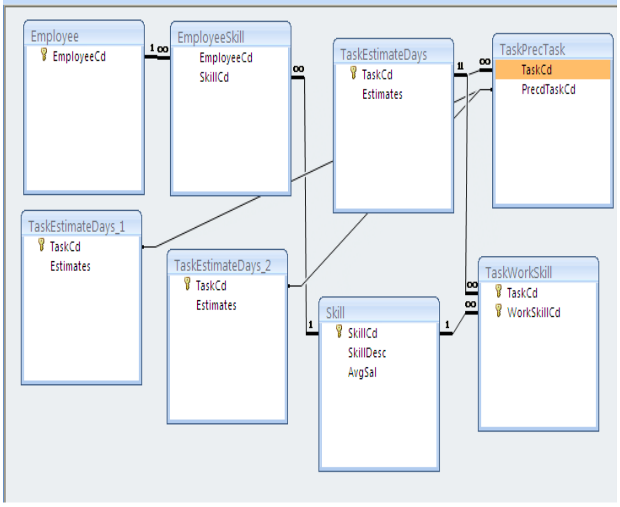


Fig. 1. Data Descriptions for RCPSP

Figure 1 above demonstrates the description of relationship for Resource Constrained database.

C. Representation of the chromosome for RCPSP

Before Implementation any application with genetic algorithm, the most important part of genetic algorithm is to decide the structure for a genome. The genome is an essential part of genetic algorithm as it will be generated randomly. The genome for our problem is a two-dimensional array consisting of employees and tasks. We will randomly generate the employees who can work on these tasks as the random numbers generated between 0 and 1. The chromosome structure is shown below.

TABLE II. CHROMOSOME STRUCTURE FOR RCPSP

	T1	T2	T3	T4
Emp1	0	1	0	1
Emp2	1	0	1	0
Emp3	1	0	0	1
Emp4	0	0	1	1

D. Design of operators for Genetic Algorithm

The three critical functions of genetic algorithm are *selection, crossover and mutation*. These are to be designed for a specific problem. We have designed these operators for RCPSP and they are explained below.

SELECTION:

We initially generate a 2 dimensional array of the above mentioned genome of employee who can work on various tasks. First we check the validity of genome by checking the following

1) *Have obeyed the task precedence relationship*
2) *Have fitness better than death fitness variable*
3) *Obeys employee skill matrix*

Here the death fitness variable signifies the fitness of the genome. If the fitness of the genome is -1 , (value of death fitness) then the genome is an invalid genome. We calculate the fitness of the genome. We select only those genome which are good reproducers i.e. which can reproduce. If the fitness is better, only then it will reproduce otherwise it is removed from the genome list and if it is able to reproduce it will be added to the list of genomes which will be further utilized for crossover and mutation. This way we will be able to select the genomes which have the capability to reproduce further.

Crossover

The crossover operator mimics the way in which bisexual reproduction passes along each parents good genes to the next generation. Normally, two parents Genomes create two new offspring Genomes by combining their “genes” using one point crossover. Let’s take an example of two genomes which are successfully randomly generated and passed the first operator of genetic algorithm.

Before crossover

Randomly we have chosen two genomes from the list of selected genomes which can reproduce well. They are represented as Genome1 and Genome2.

TABLE III. GENOME 1

	E1	E2	E3	E4	E5	E6	E7
T1	1	0	0	0	0	0	0
T2	0	0	0	0	0	0	1
T3	1	0	0	0	0	0	1
T4	1	1	1	0	1	0	0
T5	1	1	1	0	1	0	0
T6	1	1	1	0	1	0	0

The crossover can be performed row wise as well as column wise. Let’s take we have randomly generated the row wise crossover point as 2. So we will swap genome 1 and genome2 after T2, the two baby genomes will be as follows:

After Crossover

TABLE IV. GENOME 2

	E1	E2	E3	E4	E5	E6	E7
T1	1	0	0	0	0	0	0
T2	0	0	0	0	0	0	1
T3	1	0	0	0	0	0	1
T4	1	1	1	0	1	0	0
T5	1	1	1	0	1	0	0
T6	1	1	1	0	1	0	0

TABLE V. BABY GENOME1

	E1	E2	E3	E4	E5	E6	E7
T1	1	0	0	0	0	0	0
T2	0	0	0	0	0	0	1
T3	1	0	0	0	0	0	1
T4	1	1	1	0	1	0	0
T5	1	1	1	0	1	0	0
T6	0	0	1	1	1	1	1

We have thus four genomes after crossover. They are Genome1, Genome2 and two 2 baby genomes. They will be sorted according to the fitness values and best of the two are stored in the list of genomes. We have used row wise crossover, we will also perform column wise crossover. We will generate a random number and based on that random we will decide for row wise or column wise crossover operator.

TABLE VI. BABY GENOME 2

	E1	E2	E3	E4	E5	E6	E7
T1	1	0	0	0	0	0	0
T2	0	0	0	0	0	0	1
T3	1	0	0	0	0	0	1
T4	1	1	1	0	1	0	0
T5	1	1	1	0	1	0	0
T6	1	1	1	0	1	0	0

MUTATION

Following the crossover operator the offspring may be mutated by the mutation operator. Mutation is basically to get some variation in the result. Similar to random mutation in the biological world, this function is intended to preserve the diversity of the population, thereby expanding the search space into regions that may contain better solutions. Here for problem of Resource Constrained Project Scheduling, we have a two dimensional array of genome.

TABLE VII. GENOME BEFORE MUTATION

	E1	E2	E3	E4	E5	E6	E7
T1	1	0	0	0	0	0	0
T2	0	0	0	0	0	0	1
T3	1	0	0	0	0	0	1
T4	1	1	1	0	1	0	0
T5	1	1	1	0	1	0	0
T6	1	1	1	0	1	0	0

TABLE VIII. GENOME AFTER MUTATION

	E1	E2	E3	E4	E5	E6	E7
T1	1	0	0	0	0	0	0
T2	0	0	0	0	0	0	1
T3	1	0	0	0	0	0	1
T4	1	1	0	0	1	0	0
T5	1	1	1	1	1	0	0
T6	1	1	1	0	1	0	0

We randomly pick a genome. We randomly generate an index value, pick any array value randomly, e.g. (4, 3). Presently the array value of this cell is one. We flip this value to zero. And index (5,4) which is 0 is flipped to 1. This way we can have variation in the genome results. After mutation we again calculate their fitness and put it in the final list of genomes.

E. Calculation of an objective function to evaluate the best schedule

Our objective is to find a schedule which should finish in minimum duration and should have an optimal cost. Another important objective is that no task should be undone. Our project will not be complete if any of the tasks is left incomplete, so we have maintained a check that no task is left, it should be managed by at least one of the employee. We have made functions like calculate project duration () that is to calculate the duration of the entire project which is shown below with the help of an example. Let say we have chosen this genome to calculate the project duration and project cost which is mentioned below.

TABLE IX. GENOME 1

	E1	E2	E3	E4	E5	E6	E7
T1	1	0	0	0	0	0	0
T2	0	0	0	0	0	0	1
T3	1	0	0	0	0	0	1
T4	1	1	1	0	1	0	0
T5	1	1	1	0	1	0	0
T6	1	1	1	0	1	0	0

TABLE X. TASK VS ESTIMATED DAYS

T1	T2	T3	T4	T5	T6
20	10	15	25	7	10

As mentioned earlier the task and Estimated man days are also stored in the above Table. Based on the Task and Estimate days, we have calculated the Task Duration of Genome as shown in Table 11.

TABLE XI. TASK DURATION FOR RANDOM CHROMOSOME

	E1	E2	E3	E4	E5	E6	E7	Task Duration
T1	1	0	0	0	0	0	0	20
T2	0	0	0	0	0	0	1	10
T3	1	0	0	0	0	0	1	7.5
T4	1	1	1	0	1	0	0	6.25
T5	1	1	1	0	1	0	0	1.75
T6	1	1	1	0	1	0	0	2.5

TABLE XII. PROJECT DURATION

	20	10	7.5	6.25	1.75	2.5
	t1	t2	t3	t4	t5	t6
t1	0	0	1	1	0	0
t2	0	0	0	0	1	0
t3	0	0	0	1	0	0
t4	0	0	0	0	0	1
t5	0	0	0	0	0	0
t6	0	0	0	0	0	0
	20	10	27.5	33.75	11.75	36.25

On the basis of Table 11, the project duration is calculated and shown in Table 12.

Thus the project Duration comes out to be 36.25 Mandays Based on the salary of various skills, Project cost is calculated as the summation of these entire task cost.

F. Fitness Function

Genetic Algorithm mimics the survival of the fittest Principle of nature to make a search process. Therefore, GAs is naturally suitable for maximization problems, minimization problems are usually transformed into maximization problems by some suitable transformation. In general fitness function F(x) is first derived from objective function and used in successive genetic operations. For maximization problems, the fitness function can be considered to be the same as objective function F(x) =f(x). Where F(x) is the fitness function and f(x) is the objective function. For minimization problems:

F(x)= 1/(1+f(x))

In our case for RCPSP, Since we have to minimize the objective function ,the fitness function will be same as described in the above equation.

Therefore

Fitness= 1/1+functionvalue

Where function value = w1*projectduration+w2*projectcost.

Where w1 and w2 are the weights attached to project duration and project cost respectively. Depending on which is more crucial for our organization whether cost or duration we can decide the weights. If we have to give more weight to duration, the weight of duration will be increased and similarly for cost also and vice versa.

So we compare the fitness of this genome, with the previous generated genome and iterate this process and generate various generation and looks for best fitness that can be achieved. The best fit genome will be displayed by the console application.

V. CLASS DIAGRAM AND IMPLEMENTATION DETAILS

A. GASolver.Core

GASolver .Core is the main component of the solution. It is responsible for implementing all the three operators namely selection, crossover and mutation on various generations. It also provides a contract IGenome to be implemented in different genomes who wish to use GASolver for optimizing their problem. Following is the class diagram of GASolver.Core. It has a population (generation) class which essentially is collection of similar genomes.

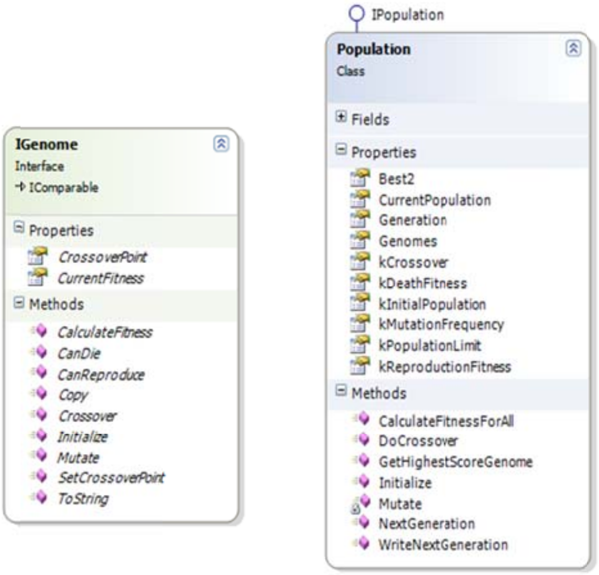
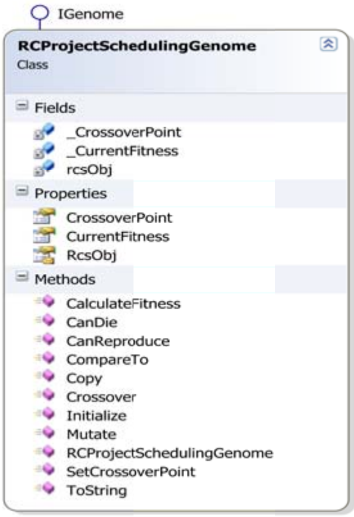


Fig. 2. Class diagram for GASolver

RCProjectSchedulingGenome implements a common contract IGenome, as shown in Figure 2 below, it does not worry about actual implementation of genome.

Hence with the use of interface IGenome, the solution is loosely coupled and there is no direct coupling between RCProjectSchedulingGenome and population class.



IGenome

RCProjectSchedulingGenome
Class

Fields
- _CrossoverPoint
- _CurrentFitness
- rcsObj

Properties
- CrossoverPoint
- CurrentFitness
- RcsObj

Methods
- CalculateFitness
- CanDie
- CanReproduce
- CompareTo
- Copy
- Crossover
- Initialize
- Mutate
- RCProjectSchedulingGenome
- SetCrossoverPoint
- ToString

Fig. 3. RCProjectSchedulingGenome Class

GASolver.Core population class is also responsible for creating collection of genomes objects, it must know about the actual implementation of IGenome e.g RCProjectSchedulingGenome. But we cannot instantiate the actual genome object since it will tightly couple the population class to that genome implementation and the population class could not be used for other Genomes. We have used dependency injection object oriented programming principle to overcome this problem.

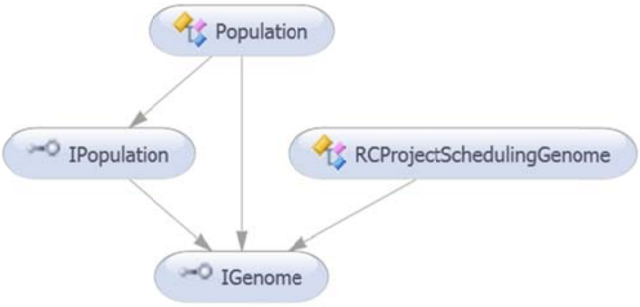


Fig. 4. GASolver's Dependencies Diagram

B. *GASolver.RCPSP*

GASolver.RCPSP is implementation of Resource constrained project scheduling problem. RCProjectSchedulingGenome class implements interface IGenome. This class is representation of genome and has methods for mutation, crossover and calculating fitness of genome. RCPSPDataConnection class is responsible making the connection to database and fetching different data from RCPSP database.

Above diagram is dependency graph of GASolver solution. GASolver.Core component instantiate RCProjectSchedulingGenome using unity dependency injection container.

VI. Test Results And Analysis

A. *Test Case 1*

Find a valid schedule that has lowest (PC), irrespective of the duration of the Project.

This is the first test case in which, we wish to optimize cost. We had two variables in the code, cost and duration. We changed the weight factor of cost to one and for duration it is made to zero i.e. the total focus is on project cost.

Project Cost is fully optimized while duration may vary high or low. The results are shown below in Table 13.

TABLE XIII. Optimized Project Cost

Generations	Project Duration	Project cost
1	65	2910910
3	65	2810910
61	31.67	2795520
66	51.67	2710040
73	47	2664760
94	29.35	2545550

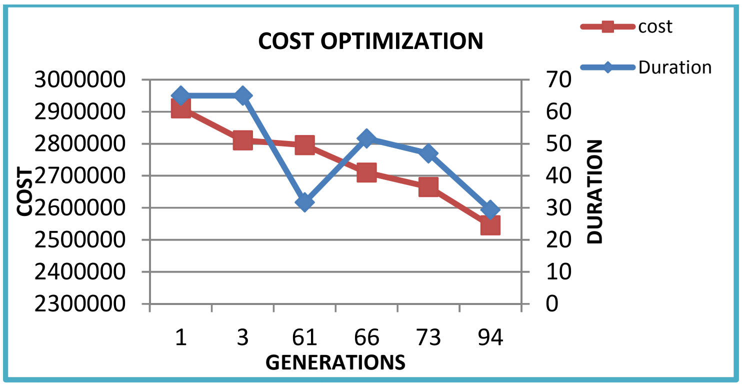


Fig. 5. RCPSP-Cost Optimization

The above Figure 5 shows the graph of cost optimization. We can analyze from the graph that Project Cost is constantly decreasing during higher generations while Project Duration is varying between higher and lower values as the weight factor for Project Cost is kept one.

B. *Test Case 2*

Find a valid schedule that has optimized duration, irrespective of the cost of the project.

This is the test case in which, we wish to optimize duration. We had two variables in the code, cost and duration. We changed the weight factor of duration to one and for cost it is made to zero i.e. the total focus is on Project Duration. Project Duration is fully optimized while Cost may vary high or low. The results are shown below in Table 14

TABLE XIV. RCPSP DURATION OPTIMIZATION

Generation	Duration	Cost
1	53.83	3153140
2	50.5	3109650
44	47.5	2758670
190	44.14	2589405
194	40.14	2565615
210	37.08	2702700
308	33	2667710

The Figure 6 below shows the graph of Duration Optimization. We can analyze from the graph that Project Duration is constantly decreasing during higher generations while Project Cost is varying between higher and lower values as the weight factor for Project duration is kept one and project cost is kept at zero.

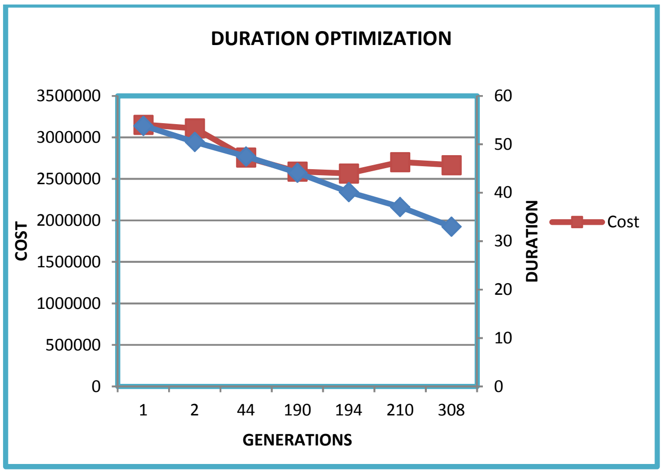


Fig. 6. RCPSP Duration Optimization

C. *Test Case 3*

Find the optimum valid schedule, satisfying a composite function including cost and duration.

This is the test case in which, we wish to optimize Cost and Duration both. We had two variables in the code, Cost and Duration.

We changed the weight factor of cost to 0.5 and for Duration it is made to 0.5 i.e. focus is on optimizing both Cost and Duration. The results are shown below in Table 15.

The Figure 7 shows the graph of Cost and Duration Optimization. We can analyze from the graph that Project Duration and well as Project Cost both are constantly decreasing during higher generations as the weight factor for Project duration is kept at 0.5 and Project Cost is also kept at 0.5.

TABLE XV. RCPSP- DURATION AND COST OPTIMIZATION

Generation	Project Duration	Project Cost
1	72	3038030
5	68	3013045
8	73.75	3012420
13	73	2946170
127	41.67	2614705
137	40	2507620
157	44.17	2347185

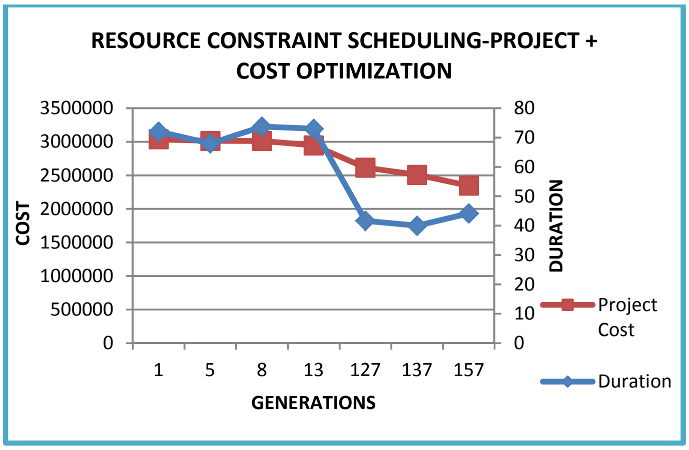


Fig. 7. RCPSP- Duration and Cost Optimization

VII. CONCLUSION AND FUTURE DIRECTIONS

Resource Constrained Project scheduling is an important problem as studied in literature survey. We have implemented this with Genetic Algorithm using C#.net. Most of the solutions that existed earlier for RCPSP were not extendable. We have implemented GASolver .core using which any specific problem domain genome can be constructed. The fitness function is only to be specified by the project manager for their own specific domain. The same GASolver .core can be extended to other important research areas like Time Cost trade off, Payment Scheduling problem etc. Once all these areas will be part of GASolver, it will be the complete solution to project scheduling problems.

List of abbreviation:

RCSP	- Resource Constrained Scheduling Problem
PS	- Payment Scheduling
DI	- Dependency Injection
CT	- Cost Trade off
GA	- Genetic Algorithm
PC	- Project Cost

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Method for Image Portion Retrieval and Display for Comparatively Large Scale of Imagery Data onto Relatively Small Size of Screen Which is Suitable to Block Coding of Image Data Compression

Satellite image (and/or High Definition TV image) retrieval and display for mobile phones

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***Abstract*— Method for image portion retrieval and display for the relatively large scale of imagery data onto comparatively small size of display is proposed. The method is suitable to the data compression methods based on block coding. Through experiments with satellite imagery data, it is found that the proposed method is useful for the display onto small sized screen such as mobile phone display and so on.**

Keywords-data compression; image retrieval; block coding

I. Introduction

There is a strong demand for displaying remote sensing satellite images onto mobile phone screen. Pixel size of the remote sensing satellite images, in general, is much greater than that of mobile phone screen. The pixel size of mobile phone is less than one million pixels while that of remote sensing satellite images is more than 10 million pixels, in general. On the other hands, the pixel size of High Definition of Television: HDTV[1] is 1125 by 1080 pixels. Therefore, it is impossible to display HDTV image onto mobile phone screen. Thus scrolling or roaming of the displayed HDTV image or remote sensing satellite image on the mobile phone screen is required. It is obvious that it takes time or a time consumable processes are required to search and display most preferable portion of images on the mobile phone display.

On the other hands, data compression is desirable to reduce the time required for transmission and receiving relatively large size of HDTV images and remote sensing satellite images. One of the image data compression methods is block coding. JPEG[2] data compression method is one of the well known and widely used block coding methods. JPEG is based on Discrete Cosine Transformation: DCT[3] for the block which is composed with 8 by 8 pixels. Namely, images are divided with 8 by 8 pixels of block and DCT is applied to the block by block. DCT allows conversion from image space or time component to frequency component. By eliminating high frequency components, data compression can be done. Image portion retrieval and display method proposed here is to search the most preferable portion of images by block by block. Therefore, the proposed search and display method is suitable to block coding of data compression method. The examples of image portion search and display with remote sensing satellite images of Advanced Very High Resolution of Radiometer: AVHRR which onboard NOAA satellites[4] is demonstrated.

There are a plenty of previous research works on the image retrieval methods. The first microcomputer-based image database retrieval system was developed [1]. Also, survey article documented progresses after 2007 [2]. The authors concentrate efficiency of image retrievals by using geophysical and spatial information of queries [3]-[5]. Also image portion retrieval method is proposed [6].

The following section describes proposed method for image portion retrieval and display method followed by some examples of image portion retrievals and display onto mobile phone screen. Then conclusion with some discussions is described.

II. Proposed Method

A. Process Flow of the Proposed Method

Process flow of the proposed image portion retrieval and display onto mobile phone screen is shown in Figure 1.

First, the relatively large scale of images such as HDTV, remote sensing satellite images are divided into blocks with 8 by 8 pixels of block. In this process, there two sets of divided blocks of images. The first block of the first divided sub-image starts from the first line/pixel coordinate of the original images while that of the second divided sub-image starts from fourth line/pixel coordinate of the original images as shown in Figure 2.

This image division is replaced and then sub-sub-images, and sub-sub-sub-images are created results in hierarchical

[1] http://e-words.jp/w/HDTV.html
[2] http://www.jpeg.org/
[3] http://ja.wikipedia.org/wiki/DCT
[4] http://noaasis.noaa.gov/NOAASIS/ml/avhrr.html

structure of the image database as shown in Figure 3. It looks like the well known coarse to fine retrieval method. Thus image portion can be retrieved fast as shown in Figure 4.

Figure 5 shows examples of portion image retrievals with sub-image and sub-sub-image. Namely, image portion retrievals can be done through the layer range from the bottom to the top which is shown in Figure 3.

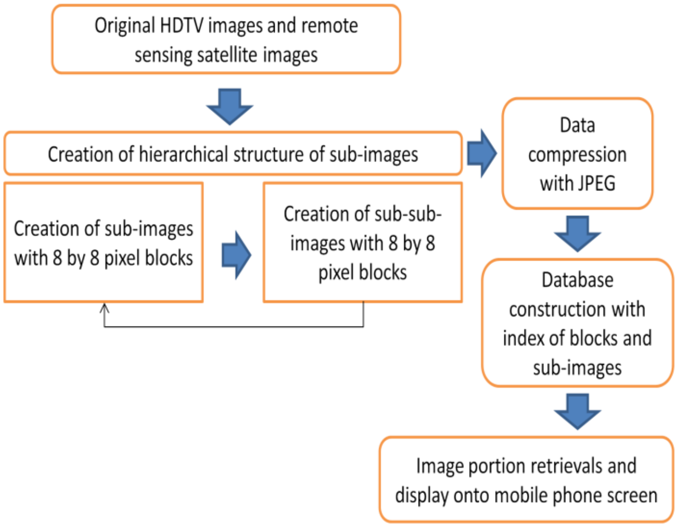

Original HDTV images and remote sensing satellite images
Creation of hierarchical structure of sub-images
Data compression with JPEG
Creation of sub-images with 8 by 8 pixel blocks
Creation of sub-sub-images with 8 by 8 pixel blocks
Database construction with index of blocks and sub-images
Image portion retrievals and display onto mobile phone screen

Fig. 1. Process flow of the proposed image portion retrieval and display onto mobile phone screen

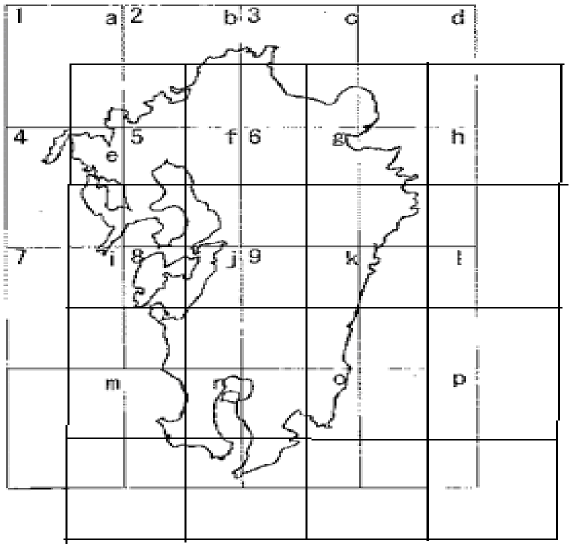


Fig. 2. Original image is divided into two sub-images which are composed with 8 by 8 pixel blocks (the first block of the first sub-image starts from the first line/pixel coordinate while the first block of the second sub-image starts from the fourth line/pixel coordinate)

The specific feature of the proposed image portion retrievals is to use the 50% overlapped area covers between two sub-image in the same layer. If the area of interest is situated in between two blocks, two adjacent blocks have to be retrieved for the conventional image portion retrievals method while only thing user has to do is to select one of two sub-image when they would like to search the areas for the proposed image portion retrieval method.

It makes retrievals based on the proposed method much faster than that for the conventional method.

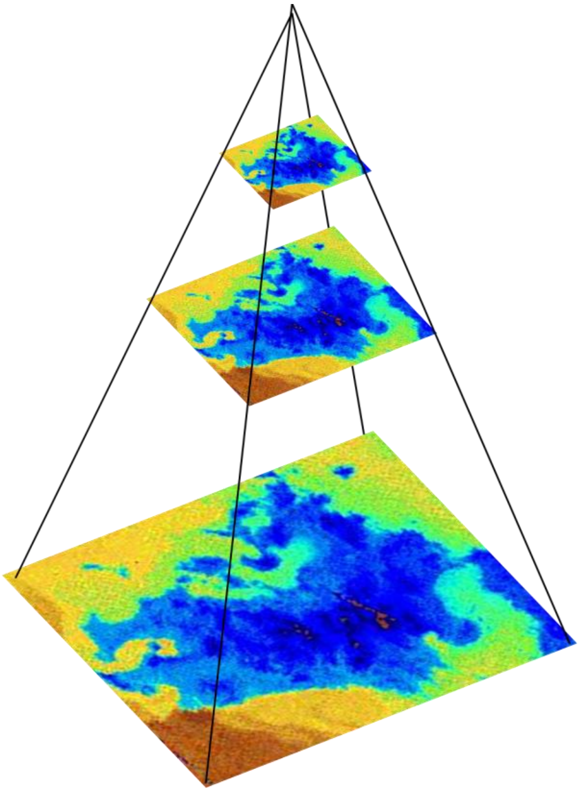


Fig. 3. Hierarchical representation of image database for acceleration of image portion retrievals

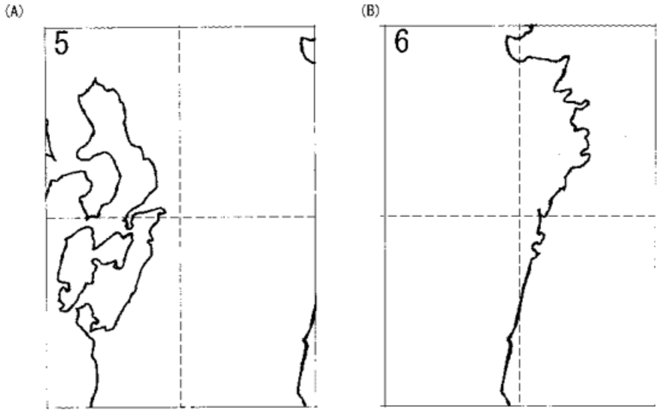


Fig. 4. Examples of sub-sub-images (portion of sub-images)

B. Data Compression and Database

Second, DCT based JPEG data compression is applied to two sub-images by block by block which composed with 8 by 8 pixels. Then the compressed image data is saved in the image database.

Also, all the blocks in the sub-images are indexed. The blocks in two sub-images are overlapped with 50 %. Thus it is possible to retrieve potion of image much faster than the conventional retrieval method with single sub-image.

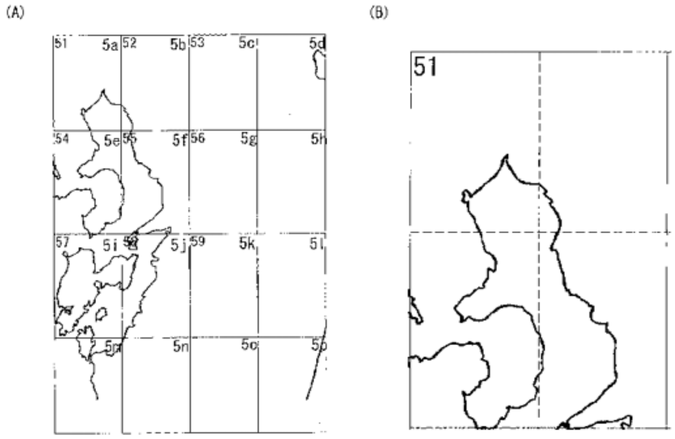


Fig. 5. Examples of portion image retrievals with sub-image and sub-sub-image.

III. Experiments

A. Data Used

Figure 6 shows the remote sensing satellite images of NOAA/AVHRR derived Sea Surface Temperature: SST which is acquired at 16:45 on November 30 2004 and at 17:11 on May 20 2002.

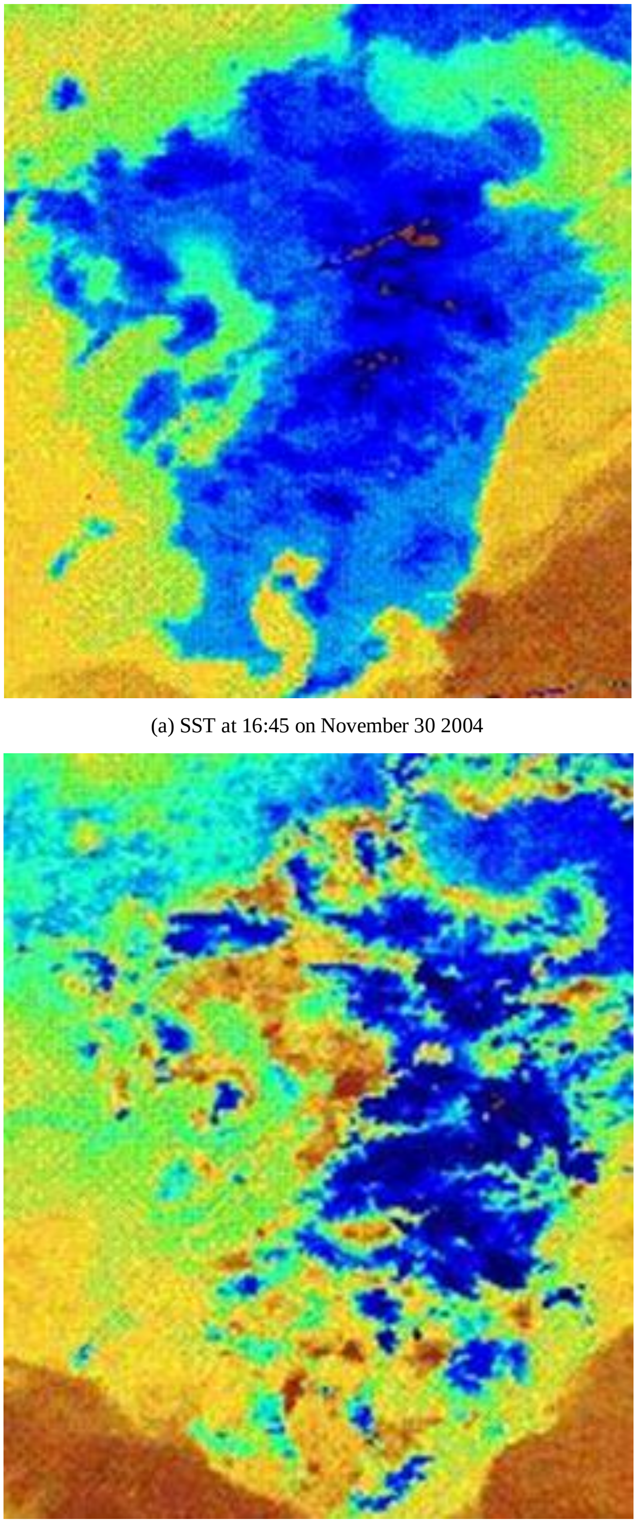
B. Portion Image Retrieval and Display onto Mobile Phone Screen

Figure 7 shows two sub-images, A and B sub-images with the meshes. Users can display low resolution (top layer of image of Figure 3) of whole image onto mobile phone screen at first. Then user goes to search the area of interest through going down to the bottom direction of layer.

After that, users select one of two sub-images depends on their preference. Users can select one of those two sub-image by referencing the area of interest.

Figure 8 (a) shows main menu image of the proposed image portion retrieval system which is displayed onto mobile phone screen while Figure 8 (b) shows retrieved image portion of retrieved result. Users may input retrieval parameters, data product, acquisition time and date.

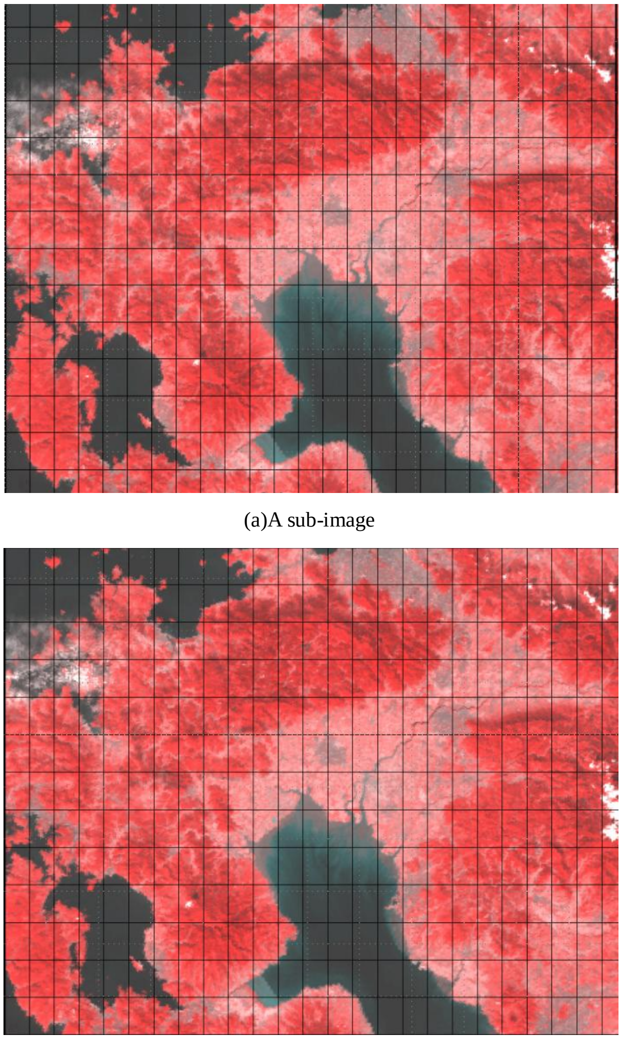
After that the proposed image portion retrieval system provides the top layered low resolution of whole image. Then users may go down the layer to the bottom layer of a small portion of image in accordance with users' guidance with referencing to the area of interest. When users find out the area of interest is situated in between two adjacent blocks, users have to switch the sub-image from A to B, or B to A.



(a) SST at 16:45 on November 30 2004

(b) SST at 17:11 JST on May 20 2002

Fig. 6. Remote sensing satellite images used for experiments



(a)A sub-image

(b)B sub-image

Fig. 7. shows two sub-images with the meshes.

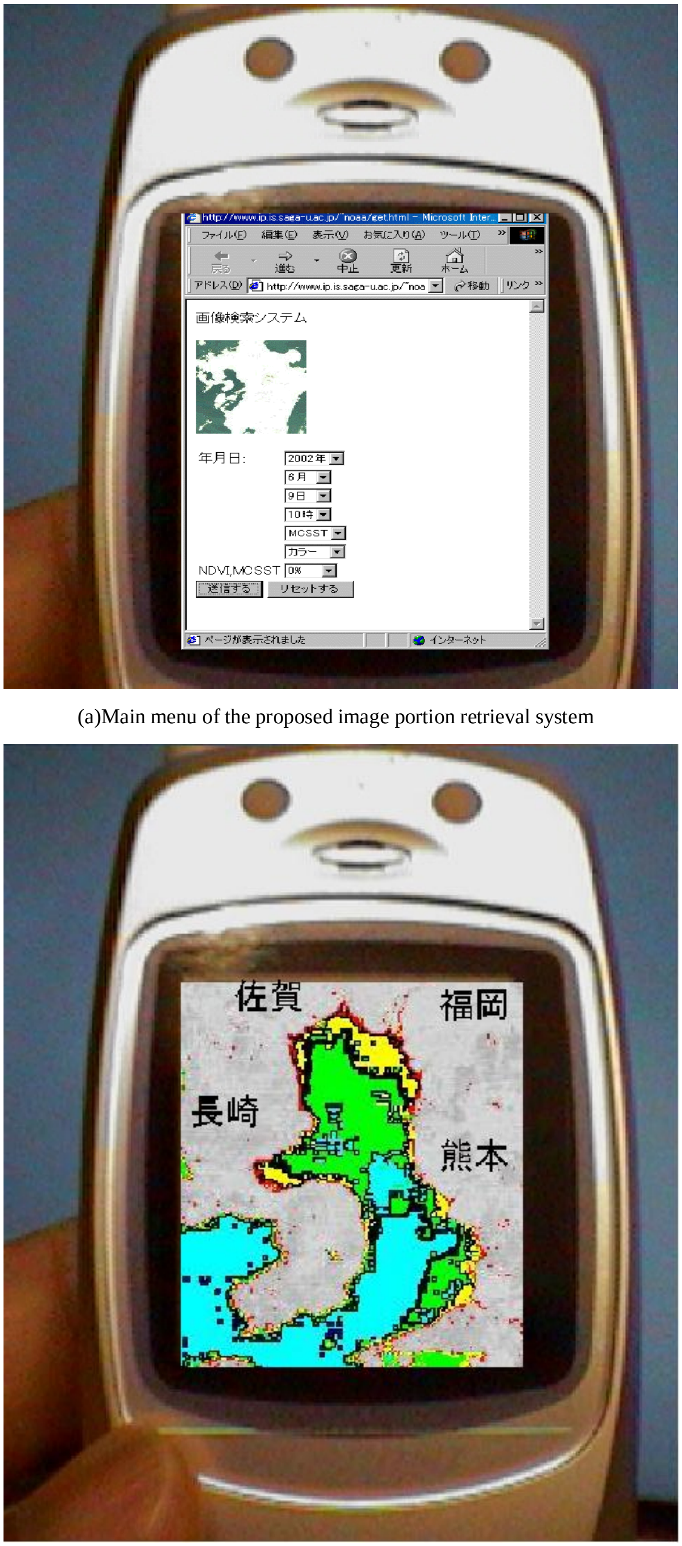
IV. Conclusion

Method for image portion retrieval and display for the relatively large scale of imagery data onto comparatively small size of display is proposed. The method is suitable to the data compression methods based on block coding. Through experiments with satellite imagery data, it is found that the proposed method is useful for the display onto small sized screen such as mobile phone display and so on

It is found that the proposed image portion retrieval and display method and system works well in terms of the time required for retrievals. This is caused by using 50% overlapping two sub-images.

Acknowledgment

The author would like to thank Mr. Kazuo Kojima for his effort to conduct image portion retrieval experiments.



http://www.ip.is.saga-u.ac.jp/~noaa/get.html - Microsoft Inter...

http://www.ip.is.saga-u.ac.jp/~noa

画像検索システム

年月日: 2002年
6月
9日
10時
MCSST
カラー

NDVI,MCSST 0%

(a)Main menu of the proposed image portion retrieval system

(b)Displayed SST image as retrieved result

Fig. 8. Displayed image onto mobile phone screen.

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AUTHORS PROFILE

Kohei Arai, He received BS, MS and PhD degrees in 1972, 1974 and 1982, respectively. He was with The Institute for Industrial Science, and Technology of the University of Tokyo from 1974 to 1978 also was with National Space Development Agency of Japan (current JAXA) from 1979 to 1990. During from 1985 to 1987, he was with Canada Centre for Remote Sensing as a Post Doctoral Fellow of National Science and Engineering Research Council of Canada. He was appointed professor at Department of Information Science, Saga University in 1990. He was appointed councilor for the Aeronautics and Space related to the Technology Committee of the Ministry of Science and Technology during from 1998 to 2000. He was also appointed councilor of Saga University from 2002 and 2003 followed by an executive councilor of the Remote Sensing Society of Japan for 2003 to 2005. He is an adjunct professor of University of Arizona, USA since 1998. He also was appointed vice chairman of the Commission "A" of ICSU/COSPAR in 2008. He wrote 30 books and published 332 journal papers.

E-governance justified

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***Abstract*—Information and Communication Technology today has become an indispensable part in our lives, gaining wide application in human activities. This is due to the fact that, its use is less expensive, more secure, and allows speedy information transmission and access. It serves as a good base for the development and success of today's relatively young technologies. It has relieved people of manual day-to-day activities in such areas as businesses organizations, transport industry, teaching and research, banking, broadcasting, entertainment amongst other. This paper takes an overview study of e-governance, one of the most demanding applications of information and communication technology for public services. The paper summarizes the concept of e-governance, its major essence and some ongoing e-governance activities in some parts of the world.**

Keywords—E-governance; Government; Human activities; Information Technology (IT); Service delivery; citizen.

I. Introduction

E-Governance is the application of Information and Communication Technology (ICT) for delivering government's services, exchange of information communication transactions, integration of various stand-alone systems and services between Government-to-citizens (G2C), Government-to-Business (G2B), Government-to-Government (G2G) as well as back office processes and interactions within the entire government frame work. Through e-Governance, government services are made available to the citizens in a convenient, efficient and transparent manner. Three main target groups that can be distinguished in governance concepts are governments, citizens and businesses/interest groups [5]. Three notable aspects to e-governance are (a) automation of government routine functions (b) Web-enabling government functions for access of the citizenry (c) Achievement of openness, accountability, effectiveness

and efficiency through improvement of government processes. E-governance promotes efficiency, reduces time delays, enforces accountability and brings transparency in the working of the governmental system. As a result, it

has become an integral part of democracy. All important government policies, acts, rules, regulations, notifications that are useful to the general public including land records, examination results, crime records, vehicle registration, birth and death registration, training and education, employment information, policies and legislation, telephone directory, etc. are made available on the Internet and can be accessed by the public free of cost. It is beneficial to the citizens as they can enjoy faster, effective and timely government services and also to the government as it can become more integrated into the community and can focus its resources where they are needed the most. E-governance that involves technology, policies, infrastructure, training and funds is becoming popular around the world including India and other European and Western countries. E-Governance is not just about government web sites and e-mails. Neither is it just about service delivery over the Internet or digital access to government information or electronic payments. E-governance aims at changing how citizens relate to governments as well as how citizens relate to each other. It brings forth new concepts of citizenship, both in terms of needs and responsibilities [1],[2],[3],[4].

II. Concept And Benefits Of E-Governance

The term e-governance emerged in the late 1990s and has become a viable concept as a result of the advancement and proven reliability of ICT. E-government is widely understood as the use of the information and communication technology (ICT) to achieve:

- improved information and service delivery;
- citizen participation in decision making process;
- more accountable government;
- effective and transparent governments.

E-governance means using ICTs as servants to the master of good governance, enabled route to

achieving good governance [9]. In its most ideal sense, e-governance is a practical concept meant to achieve all aspects of citizen-oriented governance; bringing the citizenry closer to the government and decision making process. Commitment to e-governance tends to transform how public servants work, relate to each other, do business, and engage citizens and others. E-government is a process that requires a sustained commitment of political will, resources and engagement among the government, private and public sectors [8].

The concept also seeks to improve the effectiveness and efficiency of service delivery between Government-to-citizens (G2C), Government-to-Business (G2B), Government-to-Government (G2G) as well as back office processes and interactions within the entire government frame work.

Governments all over the world are faced with the common challenge of improving their quality of services and gaining the confidence of their citizens. Citizen-centric service delivery has been identified as a key method to establish greater connections with the citizenry and build trust with them. This is to enable governments deliver better services to citizens more cost effectively. E-governance has been at the center of governments' success in many developed countries today. Such countries benefit from cheaper and more effective delivery of public services resulting in efficient public administration which is a backbone of retrieving the maximum responsibility owed by citizens to government. Governments' services, policies and strategies are availed at the door step of citizens while citizens' responsibility to the government is duly fulfilled, hence maximizing the enforcement of government's power in the state with high monitoring of affairs. Countries with well established system of e-governance correspondingly have a relatively better public service delivery [6],[7]. In the sections that follow, we take an overview study on the role of e-governance to development worldwide.

III. E-Governance As A Desirable Tool For Development.

A. E-governance as a means for effective citizen-government relationship and corruption reduction tool

[14], researching under the hypothesis "e-Governance initiatives are positively related to government–citizen relationships and corruption reduction" the authors used a structured questionnaire, to explore the perceived role of e-Governance in reducing corruption amongst 400 respondents each from Fiji and Ethiopia. By their findings, e-Governance is positively related to improved government–citizen relationships and corruption reduction. The authors suggest that

e-governance initiatives can make important contributions to improving public services improving overall relationships between governments and the citizenry. The authors however state that, even though e-Governance initiatives cannot cure all the structural factors that breed corruption in states and societies, its strategic implementation can help improve the critical variable in combating corruption—government-citizen relationships.

Roumeen, Islam (2003) showed that there is a strong relationship between good information flow and good governance. The authors explored: i) The role of existence and free flow of information in good governance and ii) how often economic data is made accessible in countries around the world. Both indicators showed a positive relationship between better information and better quality of governance.

Regions with higher information accessibility had better knowledge concerning the available political choices and made better decisions in their votes. The citizenry need information concerning governments' activity, on how decisions are being implemented.

B. E-governance as an effective managerial and administrative tool through board portals in organizations.

[10], The role of board portals; online software-service solutions in the successful running and governance of business bodies is significant as it allows board members to store and retrieve information as well as connect with each other in real time. The wide range of board portals have a common aim of providing boards of directors a platform for achieving good, efficient and transparent governance through document sharing, communication, and collaboration online through a web-based interface.

[11], the number of companies using board portals grew from 12 percent in 2005 to roughly 26 percent in 2007. More nonprofits are beginning to take notice of e-governance and to investigate the options available [12]. Even though e-governance is new in the nonprofit sector, organizations are testifying to the impact on their boards' ability to govern well [10]. The implementation of board portals in the Enterprise Center (TEC) [10] has produced a number of positive effects including:

- Saving of staff time and subsequent profitable reorganization of administrative staffing structure;
- Elimination of costs for express delivery of documents, paper, and publishing.
- Management estimate a 660 percent return on the annual investment.
- Increase in organization's transparency and ability to manage knowledge transfer

C. E-governance as an effective service delivery tool

Gradually, the positive influences of e-governance are being identified and enacted by governments all over the world with the aim of providing the best for their citizens. Advanced and developed countries like United States of America, Canada, United Kingdom and the Netherlands among others have taken the lead in e-governance and are doing really great in terms of public service delivery [13].

The developing countries on the other hand are putting up the necessary strategies to climb to achieve better status in e-governance in order to develop faster. [14], The governments of Ghana, India and South Africa for example have developed e-governance plans in which the provision of public services through local e-content is the main aim. Ghana and south Africa have prioritized the implementation of ICT infrastructure and processes for effective government-to-government governance while the government of India is simultaneously implementing government-to-government infrastructure and providing public services to citizens. [15],Promotion of e-government applications and government communication is one of the major aims of the e-Ghana project. The main concentration of this component of e-Ghana project is information sharing, communication and government database security. Other objectives like speedy delivery of government services, training of technical and information officers, development of interoperability standards are expected to be effected shared portal infrastructure to reduce costs. The Ministry of Communications has been charged with the responsibility of implementing the project.

The expected results of the e-Ghana project includes among others:

1) increase in ICT-based jobs by 200% over five years with equal opportunities for women,

2) an increase in export-led revenues generated by ICT/ITES industry by about US$90 million, *3) an increase by 25% in satisfaction of users with selected government services taken up for electronic delivery,*

4) an increase by 10% in number of ICT SMEs reporting increased revenues.

IV. Discussion

E-governance is a medium meant to provide better services to the citizenry. A way of involving the people in policy making and gaining their confidence. With e-governance, a different paradigm of leadership is introduced. The attitude of leaders and government officials is citizen oriented. The concept of e-governance is not limited to be implemented in managing the affairs of countries only. The same concept can be used for the administrative purposes of organization and institutions. The base of good leadership is information. The more the flow of information, the easier the involvement of the citizens in policy making. The citizenry being up to date with policies in the country lays more solid foundation for good governance. We identify ICT as the most reliable medium to closing the bridge between the citizenry and the government by enhancing quicker and more reliable information access.

V. Conclusion

This paper is a summary of e-governance, its essence and e-governance recent activities in some parts of the world. We have made a modest effort to present e-governance as a concept and explore the most fundamental of its aims and objectives. We see that the good effects of e-governance can be applied in any organized body where people have to be managed through, information sharing and communication using the internet as a medium. We have also realized that, e-governance is the provision of more effective, efficient and transparent public services economically.

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Method for Estimation of Aerosol Parameters Based on Ground Based Atmospheric Polarization Irradiance Measurements

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***Abstract*— Method for aerosol refractive index estimation with ground based polarization measurement data is proposed. The proposed method uses a dependency of refractive index on p and s polarized down welling solar diffuse irradiance. It is much easy to measure p and s polarized irradiance on the ground with a portable measuring instrument rather than solar direct, diffuse and aureole measurements. Through theoretical and simulation studies, it is found that the proposed method show a good estimation accuracy of refractive index using measured down welling p and s polarized irradiance data with a measuring instrument pointing to the direction which is perpendicular to the sun in the principal plane. Field experimental results also show a validity of the proposed method in comparison to the estimated results from the conventional method with solar direct, diffuse and aureole measurement data.**

Keywords- Degree of Polarization; aerosol refractive index; size distribution

I. Introduction

The largest uncertainty in estimation of the effects of atmospheric aerosols on climate stems comes from uncertainties in the determination of their microphysical properties, including the aerosol complex index of refraction, which in turn determines their optical properties. The methods that allow estimation of refractive indices have being proposed so far (Shaw, G.E. 1976, Hoppel W.A., et al., 1990, Holben B.N. et al., 1991). Most of the methods use ground based direct, diffuse and aureole measurement data such as AERONET (Holben B.N. et al., 1998) and SKYNET Aoki, K. et al., 2005). The methodology for estimation of a complete set of vertically resolved aerosol size distribution and refractive index data, yielding the vertical distribution of aerosol optical properties required for the determination of aerosol-induced radiative flux changes is proposed (Reddemann, J. et al., 2000). The method based on the optical constants determined from the radiative transfer models of the Jovian atmosphere is also proposed (Clapp M.L. et al., 1996). Laboratory based refractive indices estimation methods with spectral extinction measurements are proposed (Eiden R., 1971, Thomas G.E., et al., 2005). Refractive index and size distribution as well as single scattering albedo, Angstrome exponent, volume spectrum are, in general, estimated with ground based solar direct, diffuse and aureole data together with measured optical depth. Instrument that allows measurement is, in general, comparatively heavy and relatively large in comparison to the sun-photometer and polarized irradiance measuring instruments. They are not portable so that it is difficult to measure solar direct, aureole and diffuse irradiance at anywhere.

Measuring instrument for Degree of Polarization: DP, in turn, is portable and relatively light as well as comparatively small in comparison to the instrument. From optical depth measurement data in several atmospheric transparent wavelength channels, aerosol optical depth, and refractive index and size distribution are estimated. For instance, Junge parameter is estimated from Angstrome exponent derived from the optical depth measurement. DP, meanwhile, depends on molecule scattering (phase function of Rayleigh scattering) which is determined from atmospheric pressure and so on, aerosol scattering (phase function of Mie scattering) which is determined from refractive index and so on. Furthermore, it depends on surface reflectance so that surface reflectance, optical depth of molecule, aerosol and the other atmospheric components have to be known, then it might be possible to estimate DP results in estimation of refractive index and size distribution.

II. Proposed Method

A. Default Parameters

The proposed method utilizes a scattering angle dependency of DP on aerosol parameters, refractive index (Real: Re and Imaginary: Im) and size distribution. Junge parameter: Jp is chosen for size distribution model of which there are a variety of models, Junge, logarithmic normal, power of low, etc. (only one parameter is enough to represent size distribution). Obviously, scattering angle dependency of DP is highly related to the aerosol parameters so that it is possible to estimate the aerosol parameters with the measured DP of different scattering (observation) angle characteristics. In the principal plane composed with sun and the test site location, p and s polarized solar diffuse irradiance is measured with several different observation angles. Observation angle dependency of DP which is calculated with the measured p and s polarized irradiance is then compared to a previously calculated scattering angle dependency of DP with the possible parameters of Re, Im, and Jp which is shown in Table 1.

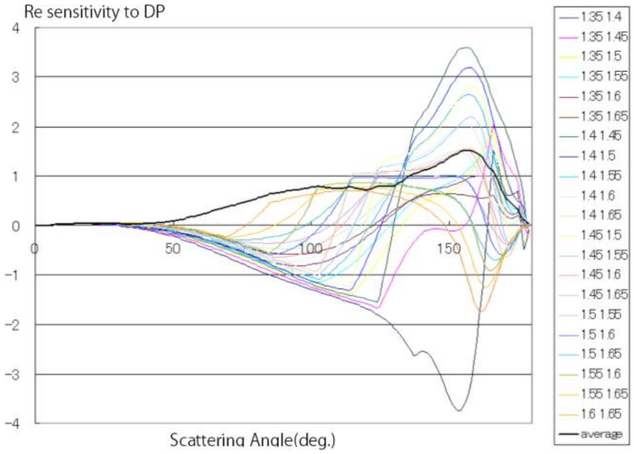
TABLE I. POSSIBLE PARAMETERS FOR DP CALCULATIONS (TYPICAL PARAMETER SET IS RE=1.5, IM=0.015, JP=3.0)

Re	1.35	1.40	1.45	1.50	1.55	1.60	1.65
Im	0.0001	0.005	0.010	0.015	0.020	0.025	0.030
Jp	2.4	2.6	2.8	3.0	3.2	3.4	3.6

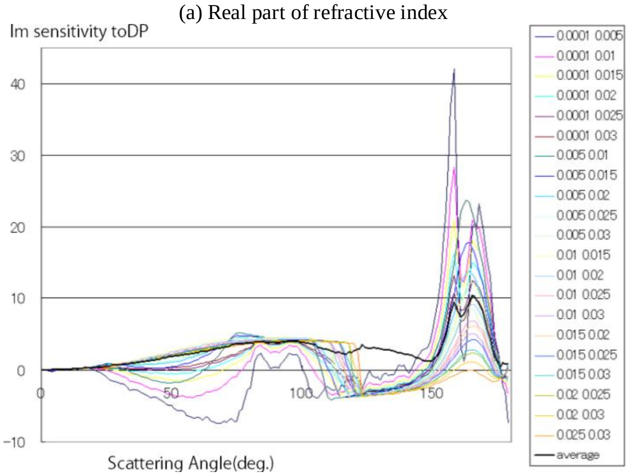
In this case, step size of Re is 0.05 while that of Im is 0.005 and that of Jp is 0.2. After finding an initial parameter set of a combination of Re’, Im’, and Jp’, More accurate solution estimation is tried to find out a best-fit scattering angle dependency by using golden section method. Thus best-fit scattering dependency of DP in a least square mean is determined results in find out a most appropriate set of parameters, Re, Im, and Jp.

B. Sensitivity Analysis

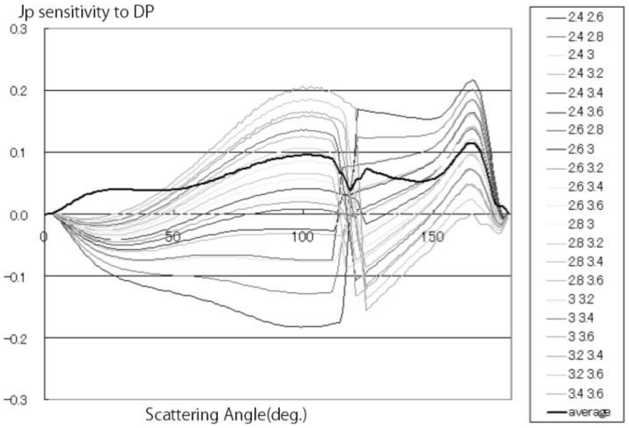
In order to determine most appropriate observation angles, a sensitivity analysis is conducted. Let (∂DP/∂x) be sensitivity of x to DP where x denotes Re, Im and Jp. Sensitivity for all the possible combinations of aforementioned parameters are estimated with the calculated DP derived from MODTRAN Mie code. Estimated sensitivities for Re, Im, and DP are shown in Figure 1.



(a) Real part of refractive index



(b) Imaginary part of refractive index



(c) Junge parameter

Fig. 1. Sensitivity Of Refractive Index: Re And Im And Junge Parameter: Jp To Degree Of Polarization: DP

There two peaks in the sensitivity characteristics for Re, Im, and DP at around 90 and 170 degrees of scattering angles. The peak at 90 degree is relatively stable in comparison to that at 170 degree so that 90 degree of observation (scattering) angle (perpendicular to the sun) is more recommendable.

C. Single Scattering Albedo

In this calculation, single scattering albedo is also calculated. Figure 2 shows the single scattering albedo with the possible parameters. Obviously, single scattering albedo decreases in accordance with increasing of imaginary part. Also single scattering albedo increases in accordance with increasing of real part of refractive index.

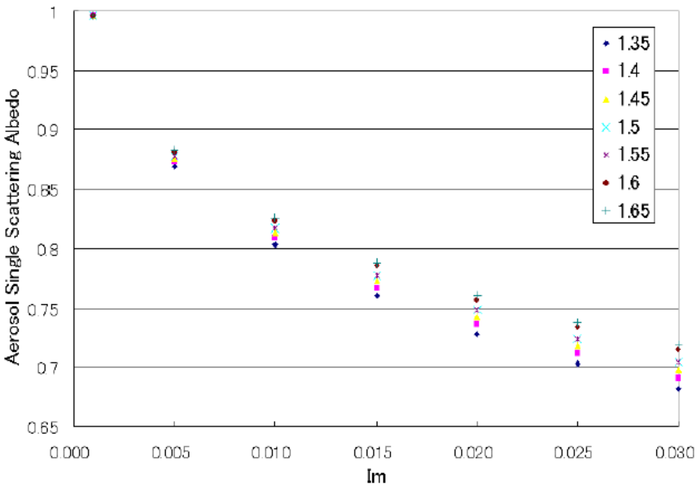
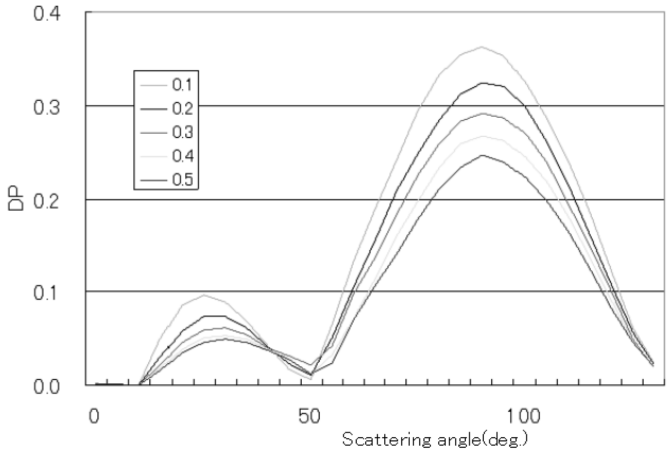


Fig. 2. Single scattering albedo as functions of real and imaginary parts of refractive index

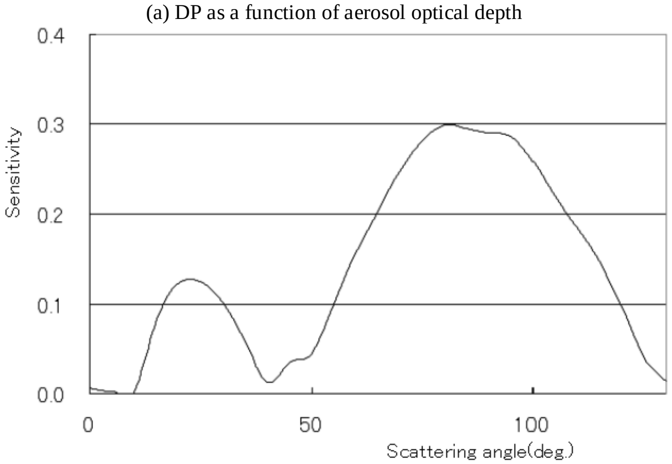
D. DP Dependency on Aerosol Optical Depth, and Surface Reflectance

DP decreases in accordance with increasing of aerosol optical depth due to the fact that multiple scattering increases with increasing of aerosol optical depth results in decreasing of DP. Meanwhile, DP decreases in accordance with increasing of surface reflectance due to the almost same reason for aerosol optical depth. Averaged DP sensitivity of aerosol optical depth and surface reflectance shows two peaks at 20 and 90 degrees for aerosol optical depth while at 35 and 90 degrees for surface reflectance so that it would be better to measure DP at the second peak at 90degree which is much sensitive to DP rather than 20 and or 35 degrees.

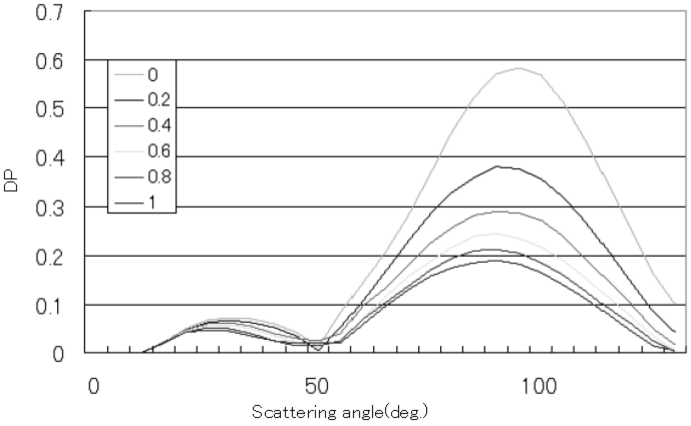
DP as function of aerosol optical depth and surface reflectance as well as DP sensitivity of aerosol optical depth and surface reflectance are shown in Figure 3.



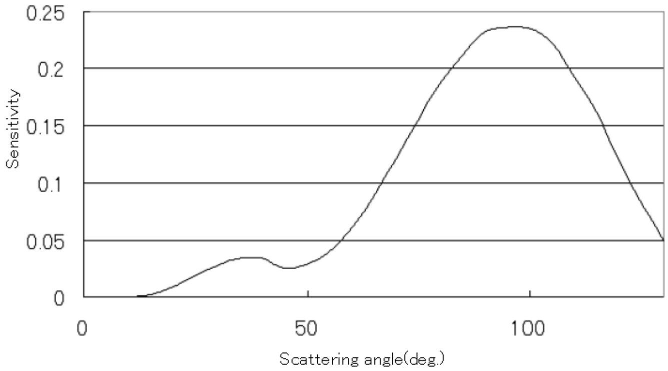
(a) DP as a function of aerosol optical depth



(b) DP sensitivity of aerosol optical depth



(c) DP as a function of surface reflectance

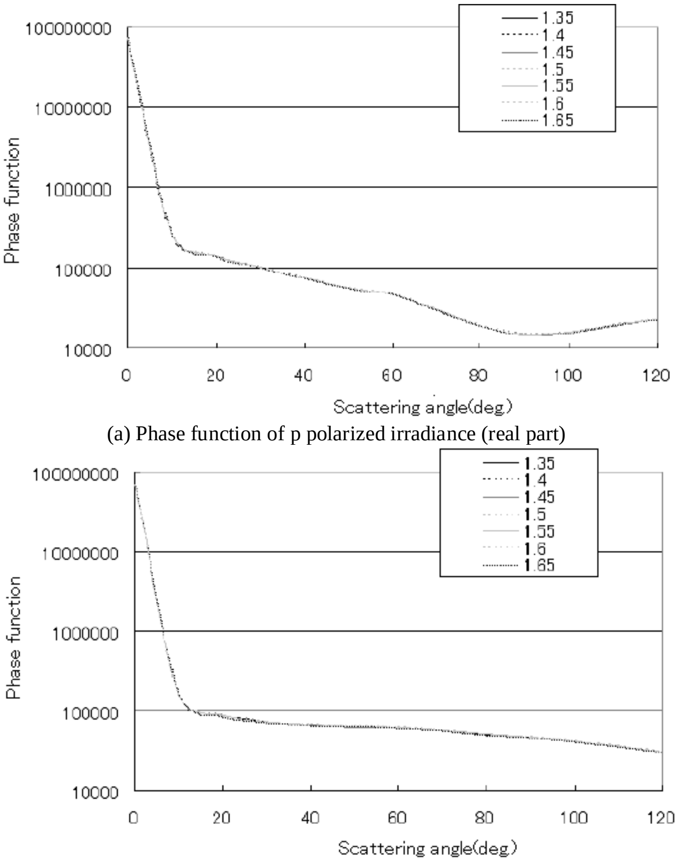


(d) DP sensitivity of surface reflectance

Fig. 3. DP as function of aerosol optical depth and surface reflectance as well as DP sensitivity of aerosol optical depth and surface reflectance.

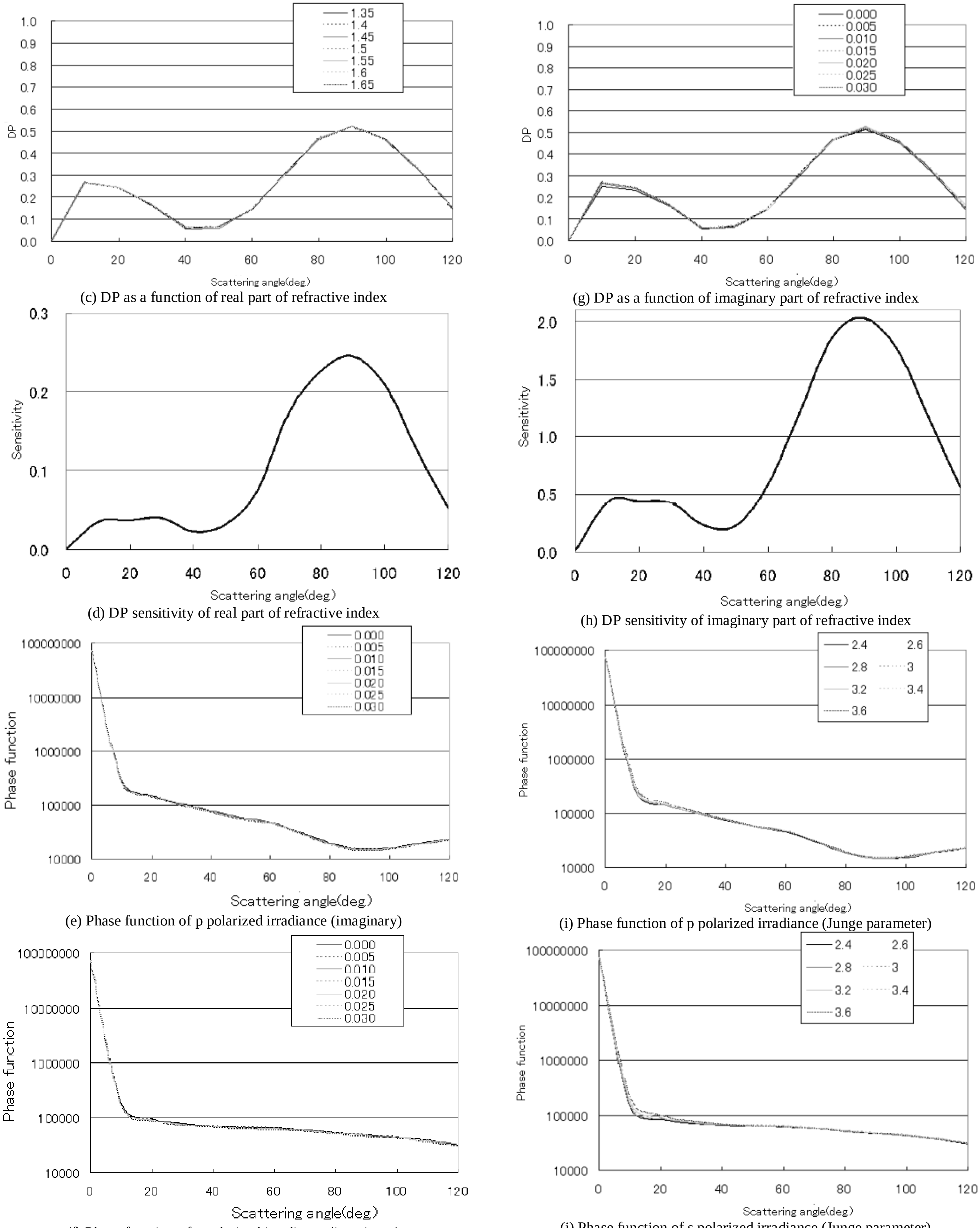
E. Phase Function, DP and Sensitivity

Phase function of p and s polarized irradiance, DP as functions of aerosol refractive index and Junge parameter, and DP sensitivity of refractive index and Junge parameter are estimated. It is found that the sensitivities of real and imaginary parts of refractive index are greater than that of Junge parameter as is shown in Figure 4. Also it is found that there are two peaks in sensitivity at around 20 and 90 degrees of scattering angle. Therefore, it would be better to measure DP at the scattering angle of 90 degree for refractive index and Junge parameter estimation.



(a) Phase function of p polarized irradiance (real part)

(b) Phase function of s polarized irradiance



(c) DP as a function of real part of refractive index

(d) DP sensitivity of real part of refractive index

(e) Phase function of p polarized irradiance (imaginary)

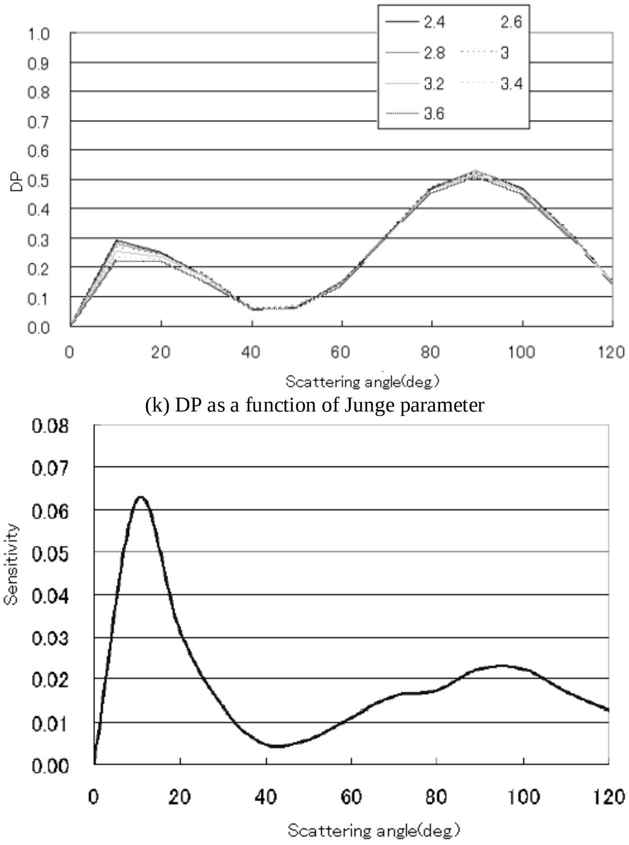
(f) Phase function of s polarized irradiance (imaginary)

(g) DP as a function of imaginary part of refractive index

(h) DP sensitivity of imaginary part of refractive index

(i) Phase function of p polarized irradiance (Junge parameter)

(j) Phase function of s polarized irradiance (Junge parameter)



(k) DP as a function of Junge parameter

(l) DP sensitivity of Junge parameter

Fig. 4. Estimated phase function of p and s polarized irradiance, DP as functions of aerosol refractive index and Junge parameter, and DP sensitivity of refractive index and Junge parameter.

F. *Estimation of refractive index and size distribution*

Figure 5 shows the flowchart for refractive index and size distribution estimation. Using assumed Re, Im and Jp, p and s polarized phase function is estimated based on mie2new of software code included in MODTRAN. Then DP at 60, 70, 80, 90, 100, 110, and 120 degrees of scattering angles is calculated. On the other hand, measured DP that is acquired at the corresponding scattering angles in the principal plane is compared to the calculated DP. To minimize the difference between both, Re, Im and Jp is changed by using golden section method. It is obvious that the golden section method of optimization cannot reach to a global optimum so that there is possibility to reach one of local minima.

III. Validation

A. *Test Sites*

In order to validate the proposed method for refractive index and Junge parameter estimation with DP measurements, field campaigns were conducted at the test sites, Roach Lake in Nevada (35:38'N, 115:22'W) during from 8:00-8:20 on 3 December 2008 and Coyote Lake in California (35:04'N, 116:45'W) during 9:50-10:10 on 10 December 2008. Major characteristics of aerosol optical depth, molecule optical depth, surface reflectance (p and s polarizations), and solar zenith angle for both test sites are shown in Table 2.

TABLE II. Major Characteristics of the Test Sites

(a) Roach Lake playa

Wave	*τaero*	*τmol*	*Refp*	*Refs*	*Sunθ*
500nm	0.055	0.1630	0.364	0.354	63
675nm	0.026	0.0534	0.494	0.442	63
870nm	0.042	0.0127	0.580	0.549	63

(b) Coyote Lake playa

Wave	*Taero*	*Tmol*	*Refp*	*Refs*	*Sunθ*
500nm	0.033	0.135	0.309	0.249	63
675nm	0.011	0.0399	0.443	0.368	63
870nm	0.017	0.0143	0.430	0.309	63

Measured p and s polarized solar diffuse irradiance for the test site at Roach Lake and calculated DP are shown in Figure 6 (a), (b), and (c) while those for Coyote Lake are also shown in Figure 6 (d), (e), and (f), respectively.

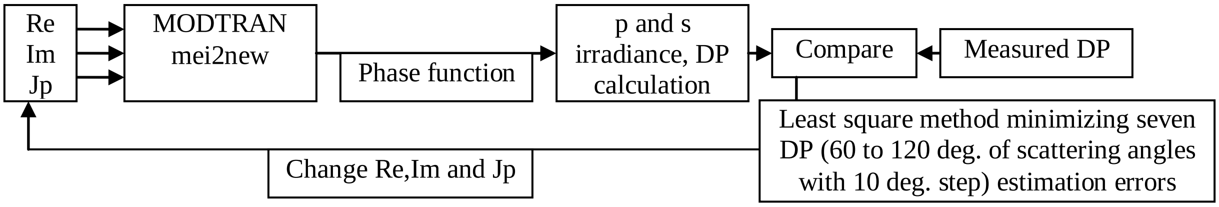

Re
Im
Jp
MODTRAN
mei2new
Phase function
p and s
irradiance, DP
calculation
Compare
Measured DP
Least square method minimizing seven
DP (60 to 120 deg. of scattering angles
with 10 deg. step) estimation errors
Change Re,Im and Jp

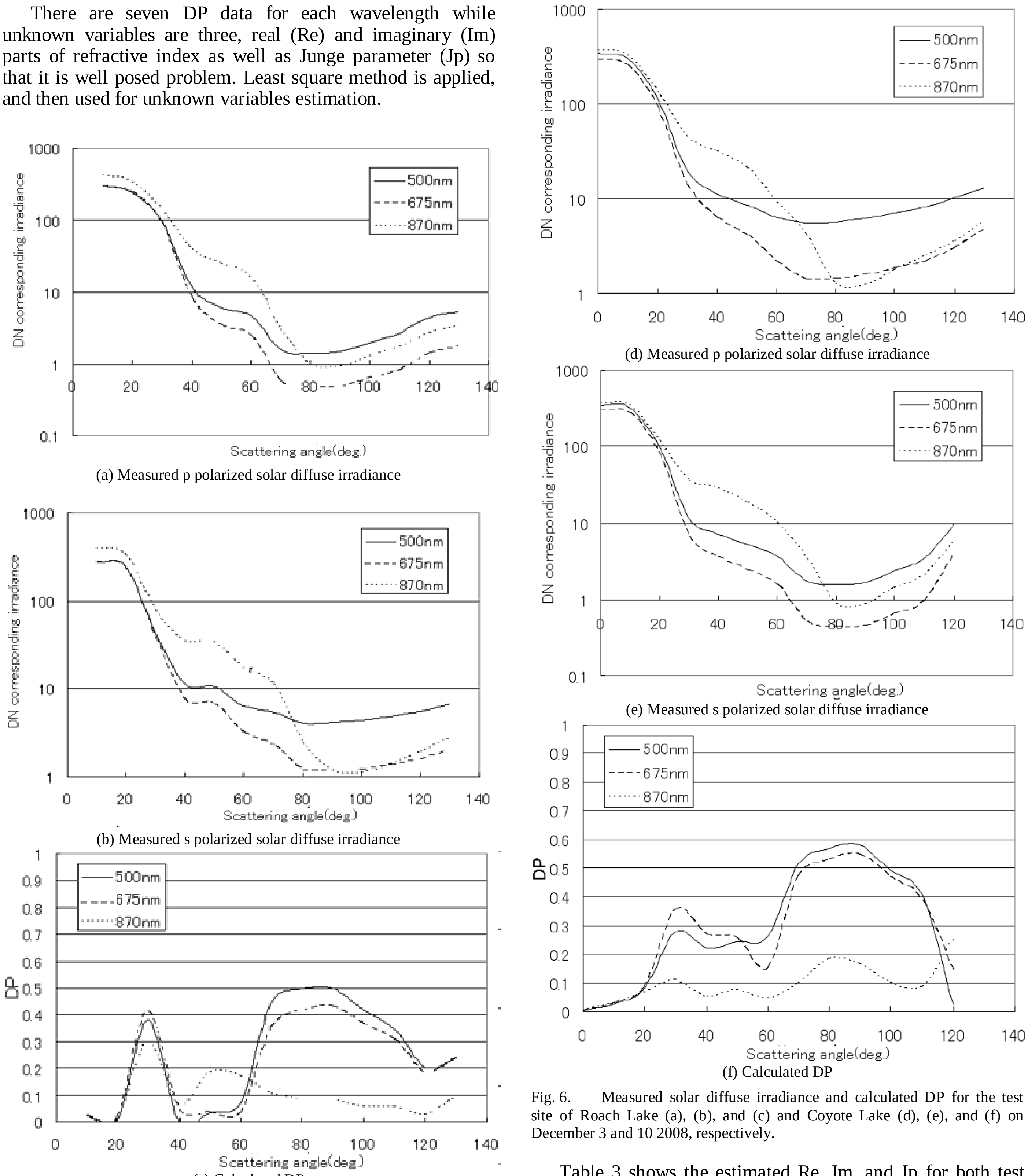
Fig. 5. Flowchart of the proposed method for refractive index and size distribution estimation process

DP for the scattering angle ranged from 60 to 120 at the wavelength of 500nm shows specific feature while that of scattering angle ranged from 0 to 60 and that of 870nm show unclear feature so that seven scattering angles of DP are used for aerosol refractive index and Junge parameter estimations.

B. *Measured and Estimated DP*

Figure 7 also shows the measured and the simulated DP. The simulated DP is calculated by means of MODTRAN with all the possible combination of refractive index and Junge parameters. The numbers of parameters of real and imaginary parts of refractive index as well as Junge parameter are seven so that the number of combinations is 343. DP that is shown in Figure 7 is the most resemble, or most appropriate curve in least square means. From these measured DP, DP corresponding to the scattering angles from 60 to 120 is selected with 10-degree step for estimation of refractive index and Junge parameter more precisely.

There are seven DP data for each wavelength while unknown variables are three, real (Re) and imaginary (Im) parts of refractive index as well as Junge parameter (Jp) so that it is well posed problem. Least square method is applied, and then used for unknown variables estimation.



(a) Measured p polarized solar diffuse irradiance

(b) Measured s polarized solar diffuse irradiance

(c) Calculated DP

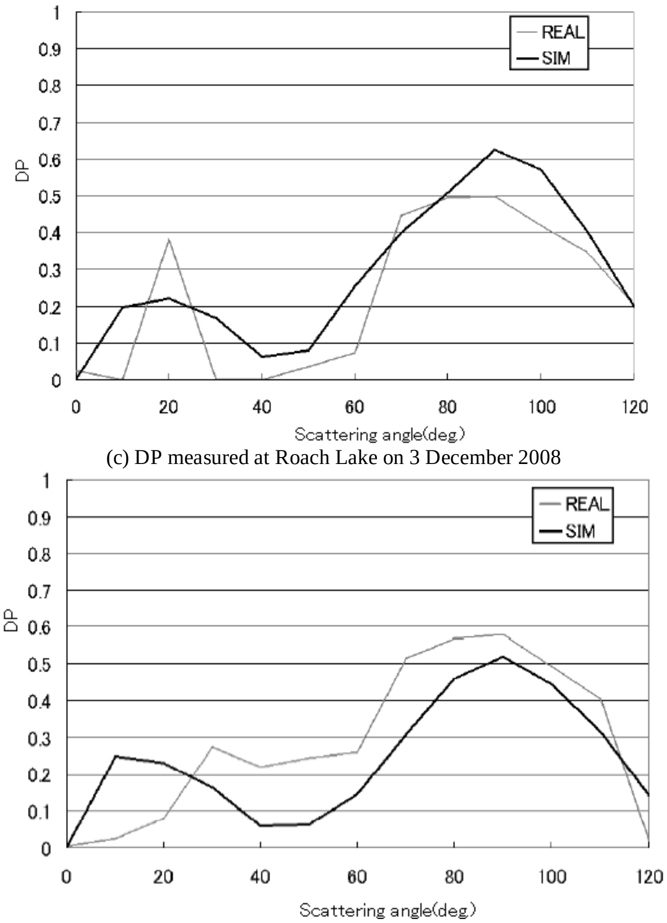
(d) Measured p polarized solar diffuse irradiance

(e) Measured s polarized solar diffuse irradiance

(f) Calculated DP

Fig. 6. Measured solar diffuse irradiance and calculated DP for the test site of Roach Lake (a), (b), and (c) and Coyote Lake (d), (e), and (f) on December 3 and 10 2008, respectively.

Table 3 shows the estimated Re, Im, and Jp for both test sites based on the proposed method with measured DP together with calculated Re, Im and Jp derived from skyradiometer data, solar direct, diffuse and aureole based on skyradpack which allows estimations of refractive index and size distribution (volume spectrum). Estimation error of imaginary part of refractive index is greater than the other two parameters due to the fact that imaginary part is essentially small.



(c) DP measured at Roach Lake on 3 December 2008

(d) DP measured at Coyote Lake on 10 December 2008

Fig. 7. Satellite images of the test sites, Roach Lake and Coyote Lake and measured (REAL) and simulated (SIM) DP.

TABLE III. ESTIMATION ERRORS FOR REFRACTIVE INDEX AND JUNGE PARAMETER AT 870 NM OF WAVELENGTH

Roach Lake on 3 December 2008				Coyote Lake on 10 December 2008			
Parameter	Skyradiometer	Estimated with DP	Error (%)	Parameter	Skyradiometer	Estimated with DP	Error (%)
Re	1.5459	1.4740	-4.650	Re	1.5428	1.5824	2.566
Im	0.00031	0.000292	-5.862	Im	0.006457	0.006705	3.846
Jp	3.3718	3.3653	3.653	Jp	5.2128	5.2132	0.013

IV. CONCLUSION

It is found that the measured DP and calculated DP derived from MODTRAN show a good coincidence with below 10% of discrepancy. Also it is found that the estimated aerosol refractive index and size distribution (Junge parameter) based on the proposed method and those derived from the skyradiometer data of solar direct, diffuse, and aureole based on skyradpack with below 6% of discrepancy. It is concluded that the proposed method is validated.

The estimated refractive index and size distribution using the proposed DP based method shows a good coincidence with the estimated those by the conventional skyradiometer (POM-01 which is manufactured by Prede Co.Ltd.), or aureole meter based method so that the proposed method does work well. The Junge parameter estimated by skyradiometer based method is derived from Angstrome exponent that is calculated with aerosol optical depth measured with skyradiometer while that by the proposed DP based method is derived from Angstrome exponent that is calculated with aerosol optical depth measured with polarized irradiance measuring instrument (MS720 which is manufactured by EKO Co.Ltd.). The difference between both is caused by the difference of gain/offset of the two instruments, POM-1 and MS720. On the other hand, the differences of estimated refractive index between skyradiometer based and the proposed DP based methods are mainly caused by the estimation methods, inversion of radiance to refractive index for skyradiometer based method while least square method minimizing the discrepancy between the actual and simulated DP at the seven different scattering angles based on MODTRAN.

It is obvious that skyradiometer and aureole meter is typically large and heavy in comparison to the polarized irradiance measuring instruments. It is possible to bring the polarized irradiance measuring instrument at anywhere easily. p and s polarized irradiance measurement at the seven different scattering angle takes around three minutes so that it has to be assumed that the atmosphere is stable for more than three minutes. p and s polarized irradiance is sensitive to the surface reflectance so that it is recommendable to use the proposed method for widely homogeneous ground cover targets.

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Visualization of Learning Processes for Back Propagation Neural Network Clustering

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***Abstract*—Method for visualization of learning processes for back propagation neural network is proposed. The proposed method allows monitor spatial correlations among the nodes as an image and also check a convergence status. The proposed method is attempted to monitor the correlation and check the status for spatially correlated satellite imagery data of AVHRR derived sea surface temperature data. It is found that the proposed method is useful to check the convergence status and also effective to monitor the spatial correlations among the nodes in hidden layer.**

Keywords-neural network; error back propagation; convergence process; spatial correlation

I. INTRODUCTION

Back Propagation Neural Network: BPNN is widely used method for machine learning and optimization method. One of the problems of BPNN is that it cannot ensure to find global optimum solution and can find one of local minima. Also it is difficult to check convergence status; residual error can be monitored though. Method for visualization of convergence processes and spatial correlation of nodes in hidden layer of BPNN is proposed.

II. PROPOSED METHOD

A. Back Propagation Neural Network

The activation is differentiable function of total input, given by equation (1) and (2),

$$y_k^p = \mathcal{F}(s_k^p) \tag{1}$$

$$s_k^p = \sum_j w_{jk} y_j^p + \theta_k \tag{2}$$

where W$_{jk}$ can be known as the weight of the connection from unit *j* to unit *k*. It is convenient to represent the pattern of connectivity in the network by a weight matrix whose elements are the weights W_{ik}. In addition, the unit calculates the activity by using some function of the total weighted input. Typically we use the sigmoid function:

$$y^p = \mathcal{F}(s^p) = \frac{1}{1+e^{-s^p}} \tag{3}$$

The error measure E^p is defined as the total quadratic error for pattern "*p*" at the output units:

$$E^p = \frac{1}{2}\sum_{o=1}^{N_o}(d_o^p - y_o^p)^2 \tag{4}$$

where d_o^p is the desired output for unit "*o*" when pattern "*p*" is clamped. We further set as the sum square error.

$$E = \sum_p E^p \tag{5}$$

The error derivative of the weights is computed to recognize that how the error changes as each weight is increased or decreased slightly. We can write as equation (6),

$$\frac{\partial E^p}{\partial w_{jk}} = \frac{\partial E^p}{\partial s_k^p}\frac{\partial s_k^p}{\partial w_{jk}} \tag{6}$$

Thus, the error signal for an output unit can be written as equation (7),

$$\delta_o^p = (d_o^p - y_o^p)\,\mathcal{F}_o{}'(s_o^p) \tag{7}$$

Also the error signal for a hidden unit is determined recursively in term of error signals of the units to which it directly connects and the weights of those connections which is shown in equation (8),

$$\delta_h^p = \mathcal{F}'(s_h^p)\sum_{o=1}^{N_o}\delta_o^p w_{ho} \tag{8}$$

Therefore, the weights could be modified by using the past weights as follows,

$$\Delta w_{jk}(t+1) = \gamma\delta_k^p y_j^p + \alpha\Delta w_{jk}(t) \tag{9}$$

The back propagation process can be explained as: when a set of desired input data and desired output data are ready, spare weights matrix which represent for the connection between “input layer and hidden layer” or “hidden layer and output layer”, will be created in random real numbers. While these matrixes are creating, the desired weights are also given define values.

When the preparation is finished, we will start learning process. In the beginning, the all actual input data will be given to equation (2), these results can be called the *nets*. The *nets* now can be used to figure out the actual output of the input nodes or actual input of hidden nodes through sigmoid equation (3) which is mentioned before. Equation (4) is useful for computing the error E^p which is the different between the actual output and the desired output. Follow the function is presented before; the error signal is able to calculate with equation (7) and (8). Thus then we have enough data to move to the next step which the weights can be changed by using equation (9).

The total error is able to compute by equation (5) above during the learning process. After the weights in neural network are changed, the total error will be compared with the value which is decided before. Therefore, if the total error is acceptable, the training process can be stopped. However, almost all the neural network can not finish its learning process after only several times. Thus, maybe it requires that we should train the network with a big enough number of times, and then the total error might be small enough to be acceptable.

B. Proposed All Node Linked Neural Network: ANLNN

In back propagation algorithms, an important consideration is the learning rate. If the learning rate is too small, it will take a long time to converge. However, when the learning rate is too large, we may end up bouncing around the error surface out of control, the algorithms diverges. This often ends with an overflow error.

Beside the learning rate, momentum also plays an important role in back propagation process. Adding the momentum, is one of the ways to avoid oscillation at large learning process and when no momentum term is used, it properly takes a long time before the global minimum has been reached with a low learning rate. Moreover, the number of hidden units is one of the reasons which cause effect on the network.

A large number of hidden units lead to a small error on the training set. However, even if increasing the number of hidden units can help the neural network escape from a trap at local minimum but it will not guarantee that neural network again can find the global minimum, when number of hidden units is over the demand. As the network trains, the weights can be adjusted to very large values. The total input of a hidden unit or output unit can therefore reach very high (positive or negative either) values and because of the activation function which we use in this research, is sigmoid function, the unit will have an activation very close to zero or very close to one. Thus, in the back-ward stage the error signal will be close to zero and the learning process can come to a virtual standstill. The answer for this problem is that the suitable momentum maybe select in order to support the process becomes normal.

We also use the other neural network which has a structure different from a typical one, with the purpose is able to clearly recognize the trend following weight’s images. A new structure is described as: normally in typical structure neural network, all the nodes from one layer will completely link to all the other nodes of connected layer. The neural network which will be call All Nodes Linked Neural Network: ANLNN hereafter, does not have the same structure like a typical one, each node on a layer will only link to a specify node or specify nodes on connected layer. The nodes of a layer on the ANLNN is sorted like a matrix, from this matrix a smaller matrix will be picked up and linked to other specify nodes on the other layer whose nodes are also sorted in the same way.

The ANLNN and typical structure neural network will be tried to apply in recognizing integer numbers. Firstly, the desired input and desired output are selected from a set of integer numbers. The same problem happens like before, when the data is fed into neural network, nothing is done, neural network becomes virtual standstill. Thus, the data obviously has to normalize before it is given to a network. We know that all the integer numbers are 2 bytes digits, from this indication we can normalize the data by the same way which is mentioned above, like when we carried out the experiments with Multi Channel Sea Surface Temperature; MCSST data. All of the integer numbers will be divided into 1023 before they are brought to the neural network. The weight’s values are adjusted after each step is taken during the training process. Using these results, an image which displays how different the new weight’s values are, can be drawn. The initial values are absolutely free to choose between [-1, +1].

As we know, the highly correlated data which can be referred to AVHRR MCSST data or a set of integer numbers in turn from “0” until “9”, might be used in order to lead the weight’s images to the same trend if a global minimum is found when we keep changing the initial weight’s values for several times. Therefore, we can work out whether neural network converges at the local minimum or not by comparing the characteristic of the image.

We also use the other neural network which has a structure different from a typical one, with the purpose is able to clearly recognize the trend following weight’s images. A new structure is described as: normally in typical structure neural network, all the nodes from one layer will completely link to all the other nodes of connected layer. The neural network which will be call ANLNN neural network from now, does not have the same structure like a typical one, each node on a layer will only link to a specify node or specify nodes on connected layer. The nodes of a layer on the SL neural network are sorted like a matrix, from this matrix a smaller matrix will be picked up and linked to other specify nodes on the other layer whose nodes are also sorted in the same way.

The ANLNN neural network and typical structure neural network will be tried to apply in recognizing integer numbers. Firstly, the desired input and desired output are selected from a set of integer numbers. The same problem happens like before, when the data is fed into neural network, nothing is done, neural network becomes virtual standstill. Thus, the data obviously has to normalize before it is given to a network. We know that all the integer numbers are 2 bytes digits, from this indication we can normalize the data by the same way which is mentioned above, like when we carried out the experiments with MCSST data. All of the integer numbers will be divided into 1023 before they are brought to the neural network.

C. Visualization of Weighting Coefficients as an Image for ANLNN

Layered structure of the proposed ANLNN is shown in Figure 1. Because all the input nodes are linked to the hidden layer nodes and the hidden layer nodes are linked to the output layer nodes, the number of weighting coefficients is n^2 where n is the number of input layer nodes as well as the number of output layer nodes. Then weighting coefficients between input and hidden layers and those between hidden and output layers can be displayed as an image. AVHRR band 4 imagery data is assumed to be input data of the ANLNN while MCSST of imagery data is also assumed to be desired output for the output layer. Then learning process begins.

Although it is possible to take a look at residual error, it is still difficult to decide convergence situations. Because BPNN utilizes steepest descent method for learning process, it is not possible to reach a global optimum for weighting coefficients. Because the aforementioned reason, input data of neighboring nodes are highly correlated and output data of neighboring nodes are also highly correlated. That is same thing for weighting coefficients image. The weighting coefficients between input and hidden layers of neighboring nodes are highly correlated while the weighting coefficients between hidden and output layers of neighboring nodes are also highly correlated. Therefore, if we take a look at correlation among weighting coefficients, then it is possible to decide the convergence status.

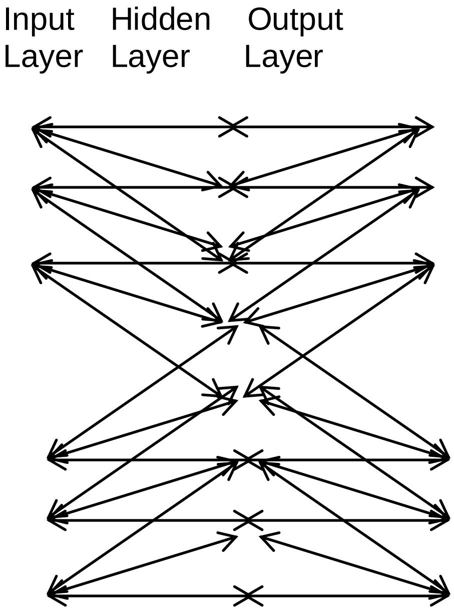


Fig. 1. Layered structure of the proposed ANLNN

III. EXPERIMENTS

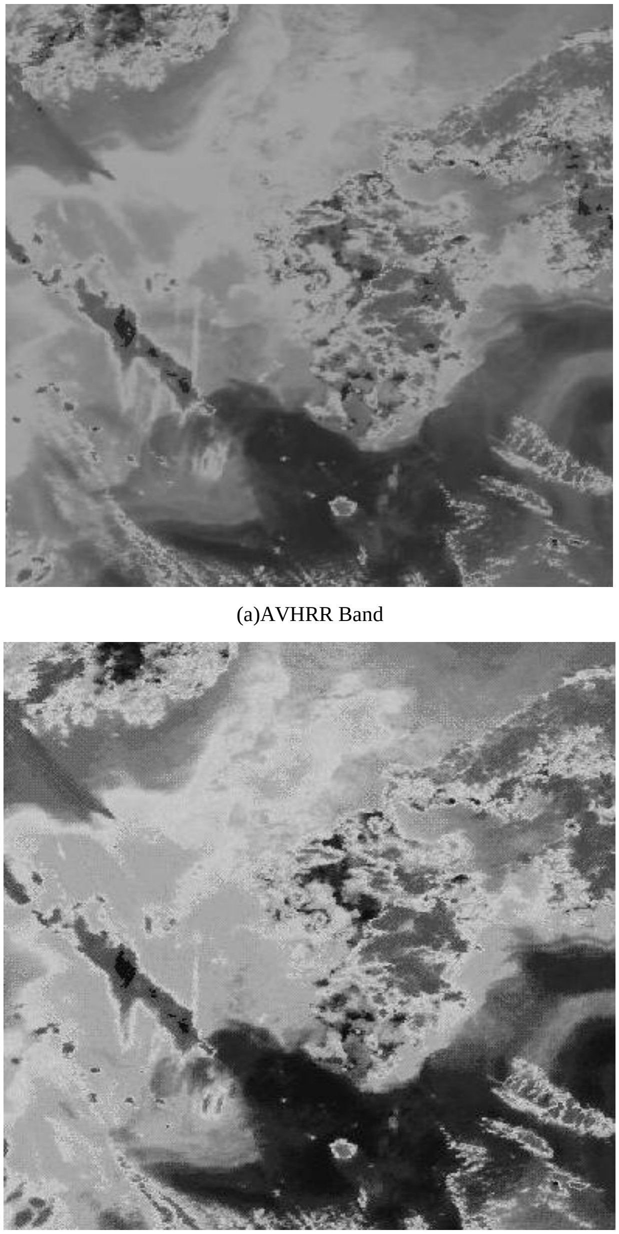
A. Data Used

The AVHRR MCSST data is given to the process in order to figure out the essence of neural network which is acquired the back propagation algorithms. The data from band 4 and corresponding MCSST data are used this time.

MCSST can be estimated through regressive analysis with Advanced Very High Resolution Radiometer: AVHRR of Band 4 and 5 of thermal infrared images.

$$MCSST=a\ DN4 + b\ DN5 + c \quad (1)$$

where MCSST, DN4 and DN5 denotes SST, Digital Number: DN of Band 4 and 5. Also a, b and c are regressive coefficients. If training samples, sets of MCSST, DN4 and DN5 are available, then a, b and c can be estimated. After that SST can be estimated with the regressive equation for another DN4 and DN5. Figure 2 and 3 show an example of AVHRR Band 4 and 5 and estimated MCSST images.



(a)AVHRR Band

(b) Band 5

Fig. 2. An example of AVHRR Band 4 and 5 images of Kyushu which are acquired on 20 May 2002

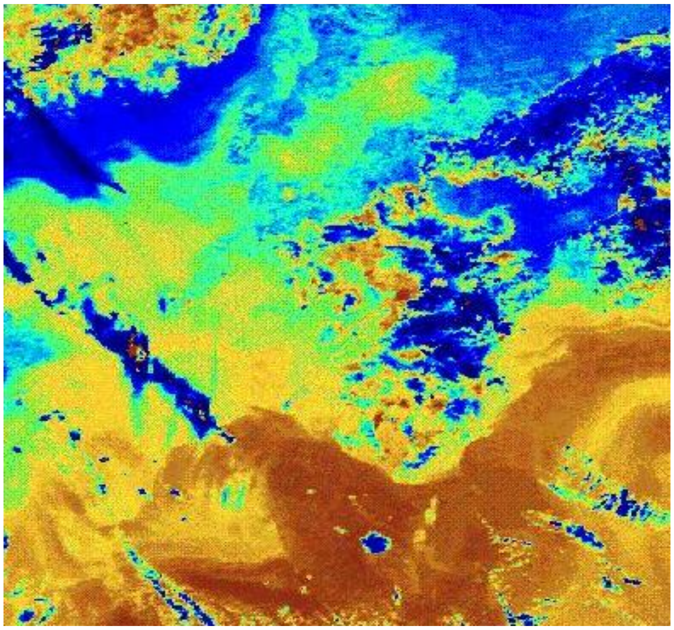


Fig. 3. SST estimated through a regressive analysis with sets of SST, DN4 and DN5 of training data

B. Node Images Derived from the Proposed Method

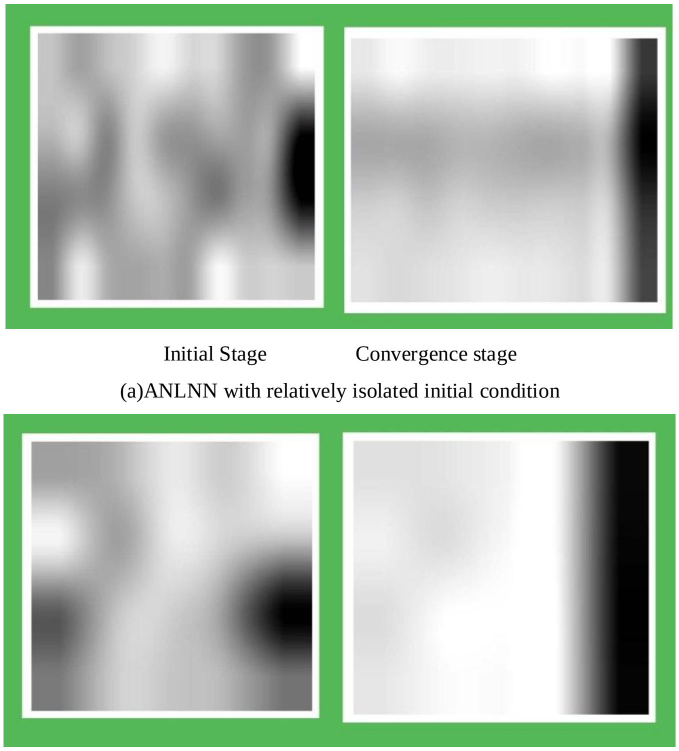
In the beginning, the experiment showed that there is no remarkable change in average error's value or weight's values either. The neural network becomes virtual standstill. After checking carefully all the steps, we realize that because the value of AVHRR MCSST data is quite big, thus it is necessary to normalize the data otherwise nothing will be done because almost all the results which are an output of hidden nodes or output nodes, error signal, will close to 0 or close to 1. As we know MCSST data is 10 bit data, therefore when we prepare a set of desired input and desired output, MCSST data can be normalized by dividing each MCSST data into 1023 which is means that totally there are 1024 elements, from 0 until 1023

We start to display weight images in order to confirm whether the initial image is different from the result image after learning process or not. As the images are shown below, we see that the initial image does not have anything special, it does not show any characteristic but the result image does. It is not difficult to recognize that through the training process, weight's values are adjusted and they are modified with a remarkable amount because of shape and also the dark, bright color on the result image.

C. Experimental Resuts

Figure 4 shows weight coefficients image for between input and hidden layers at initial stage and convergence stages. Because the number of input nodes is 3 by 3 of AVHRR band 4 of data, the number of weighting coefficients is 81 by 81. Therefore, the weighting coefficients image of Figure 4 consists of 81 by 81, accordingly.

At the initial stage, all the weighting coefficients are determined with the random numbers derived from Mersenne Twister random number generator. This is referred as comparatively isolated weighting coefficients. By using averaging filter, relatively correlated initial conditions of weighting coefficients are also determined. There is an initial condition dependency for convergence processes. That is because of preparation of two sets of initial weighting coefficients, relatively isolated and comparatively correlated initial conditions. The weight's initial values of this network are in turn given -1, 0, 1 and random numbers while a set of desired input, output data also is tried with integer numbers and MCSST data. We suppose that if the network converges at the global minimum, all the weight's images will show the same trend even the initial images or initial weight's values are different. In addition, the momentum plays an important role in effecting weight's values while desired input and desired output also decide the value of average error, the speed of neural network when it converges. These doubtful questions are proved when an experiment above is conducted.



Initial Stage Convergence stage

(a)ANLNN with relatively isolated initial condition

Initial Stage Convergence stage

(b)ANLNN with comparatively correlated initial condition

Fig. 4. Weight coefficients image of ANLNN with the different initial conditions for weighting coefficients between input and hidden layers for 9 input nodes

Figure 5 shows example of convergence processes with residual error while Figure 6 shows the average correlation coefficient for all the weighting coefficients which situate in between input and hidden layers. In accordance with increasing of the iteration number, residual error goes down together with increasing of the averaged correlation coefficient. This is because there are high correlations among the input nodes. Therefore, it is possible to determine convergence of learning processes with referencing the averaged correlation coefficient rather than referring to the residual error. Furthermore, it is also possible to monitor convergence processes by looking at the weighting coefficients image.

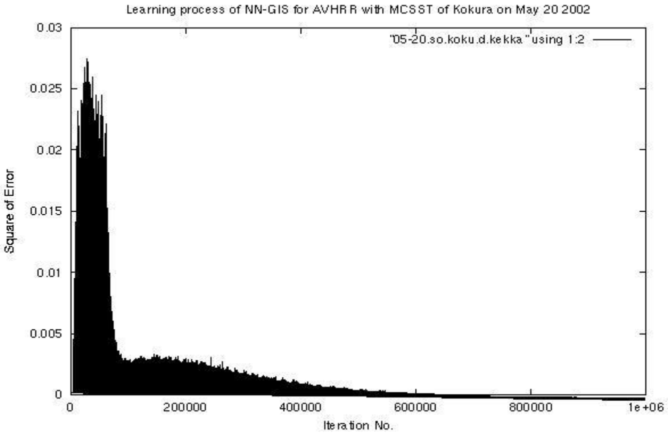


Fig. 5. Residual errors in convergence process of the ANLNN

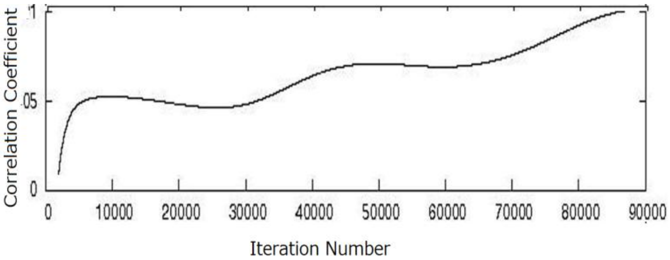


Fig. 6. Averaged correlation coefficient among the weighting coefficients between input and hidden layer.

IV. Conclusion

Method for visualization of learning processes for back propagation neural network is proposed. The proposed method allows monitor spatial correlations among the nodes as an image and also check a convergence status. The proposed method is attempted to monitor the correlation and check the status for spatially correlated satellite imagery data of AVHRR derived sea surface temperature data. It is found that the proposed method is useful to check the convergence status and also effective to monitor the spatial correlations among the nodes in hidden layer

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Data Fusion Between Microwave and Thermal Infrared Radiometer Data and Its Application to Skin Sea Surface Temperature, Wind Speed and Salinity Retrievals

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***Abstract*—Method for data fusion between Microwave Scanning Radiometer: MSR and Thermal Infrared Radiometer: TIR derived skin sea surface temperature: SSST, wind speed: WS and salinity is proposed. SSST can be estimated with MSR and TIR radiometer data. Although the contribution ocean depth to MSR and TIR radiometer data are different each other, SSST estimation can be refined through comparisons between MSR and TIR derived SSST. Also WS and salinity can be estimated with MSR data under the condition of the refined SSST. Simulation study results support the idea of the proposed data fusion method.**

Keywords-data fusion; simulataneous estimation

I. Introduction

Microwave Scanning Radiometer: MSR onboard remote sensing satellites allow estimations of salinity, soil moisture, ocean wind speed, precipitable water, rainfall rate, air temperature (profile), atmospheric pressure, and Skin Sea Surface Temperature: SSST. On the other hands, Thermal Infrared Radiometer: TIR onboard remote sensing satellites allow estimations of SSST [1]. There are remote sensing satellites which carries both MSR and TIR radiometers such as Tropical Rainfall Measurement Mission: TRMM/VIRS (Visible to Thermal Infrared radiometer) and TMI (TRMM Microwave Imager) [2]. It is possible to improve estimation accuracy by using both radiometer data which is known as data fusion.

There are some atmospheric and ocean surface models in the microwave wavelength region. Therefore, it is possible to estimate at sensor brightness temperature (microwave radiometer) with the geophysical parameters. The real and the imaginary part of dielectric constant of the calm ocean surface is modeled with the SST, salinity (conductivity). From the dielectric constant, reflectance of the ocean surface is estimated together with the emissivity (Debue, 1929 [3]; Cole and Cole, 1941 [4]). There are some geometric optics ocean surface models (Cox and Munk, 1954 [5]; Wilheit and Chang, 1980 [6]). According to the Wilheit model, the slant angle against the averaged ocean surface is expressed by Gaussian distribution function.

There is a relation between ocean wind speed and the variance of the Gaussian distribution function as a function of the observation frequency. Meanwhile the influence due to foams, white caps on the emissivity estimation is expressed with the wind speed and the observation frequency so that the emissivity of the ocean surface and wind speed is estimated with the observation frequency simultaneously. Meanwhile, the atmospheric absorptions due to oxygen, water vapor and liquid water were well modeled (Waters, 1976 [7]). Then atmospheric attenuation and the radiation from the atmosphere can be estimated using the models. Thus the at-sensor-brightness temperature is estimated with the assumed geophysical parameters.

Sea surface temperature estimation methods with AMSR data are proposed and published [8] while ocean wind retrieval methods with AMSR data are also proposed and investigated [9]. Furthermore, water vapor and cloud liquid estimation methods with AMSR data are proposed and studied [10]. The conventional geophysical parameter estimation method is based on regressive analysis with a plenty of truth data and the corresponding microwave radiometer data [11].

Both radiometers observe same sea surface through same atmosphere. Also atmospheric model and sea surface model for both thermal infrared wavelength region and microwave wavelength region are known. Therefore, both radiometer data can be used for improvement of the estimation accuracy. One of the well known week points is sea surface emissivity model. As is mentioned above, surface emissivity depends on dielectric constant of the sea water as functions of sea surface temperature, salinity, etc., ocean wave shape distribution, foams (white caps appears when ocean wind is greater than 7 m/s), and so on.

The proposed method of data fusion between thermal infrared and microwave radiometers is eliminate influences due to emissivity changes by ocean winds based on the aforementioned models. Through simulation studies using Community Radiative Transfer Model: CRTM [12] of atmospheric code which covers from visible to microwave wavelength regions, it is found that the proposed data fusion is useful.

The following section describes the proposed data fusion method followed by simulation studies. Then conclusion is described together with some discussion.

II. Proposed Method

A. Process Flow of the Proposed Data Fusion Method

Process flow of the proposed data fusion method is shown in Figure 1. Assuming both of TIR and MSR radiometers are onboard same remote sensing satellite and observe the same sea surface through the same atmosphere.

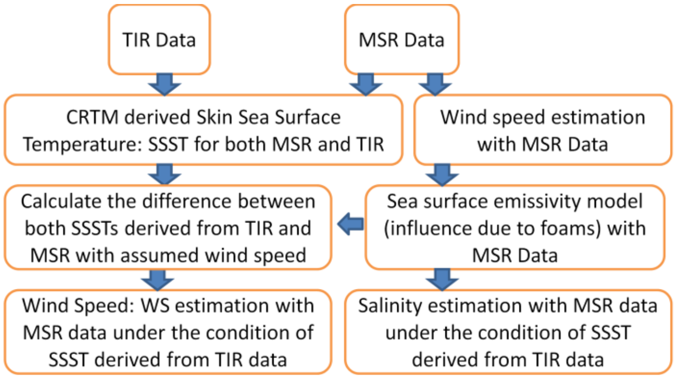

TIR Data
MSR Data
CRTM derived Skin Sea Surface Temperature: SSST for both MSR and TIR
Wind speed estimation with MSR Data
Calculate the difference between both SSSTs derived from TIR and MSR with assumed wind speed
Sea surface emissivity model (influence due to foams) with MSR Data
Wind Speed: WS estimation with MSR data under the condition of SSST derived from TIR data
Salinity estimation with MSR data under the condition of SSST derived from TIR data

Fig. 1. Process flow of the proposed data fusion method

B. Basic Idea of the Proposed Data Fusion Method

SSST is estimated with both TIR and MSR data separately. There is discrepancy between both SSST_TIR and SSST_MSR due to the fact that influences on emissivity due to ocean wind speed are difference between both. Emissivity in TIR wavelength region is affected by wind speed a little while that in microwave wavelength region is changed so much. Moreover emissivity in MSR wavelength region may change SSST and salinity (in relatively lower frequency below 10 GHz in particular). Therefore, such these influence might be possible to estimate by using the discrepancy between SSST_TIR and SSST_MSR. On the other hands, ocean wind speed can also be estimated with MSR data together with SSST. Therefore, wind speed can be refined using the discrepancy iteratively. Furthermore, salinity is estimated with estimated SSST as well as the refined wind speed.

C. Theoretical Background

Radiative transfer equation of MSR is expressed in equation (1).

$$I_\nu = \epsilon_\nu B_\nu(T_s)\tau_\nu(0,Z,\theta) + \int_0^z B_\nu(T(z))\frac{\partial \tau_\nu(z,Z,\theta)}{\partial z}dz$$
$$-(1-\epsilon_\nu)\tau_\nu(0,Z,\theta)\int_0^Z B_\nu(T(z))\frac{\partial \tau_\nu(0,z,0)}{\partial z}dz \quad (1)$$

The first term of equation (1) represent the contribution from the sea surface while the second term expressed the contribution from the atmosphere. The third term is the contribution from the reflected atmosphere and extraterrestrial contribution at the sea surface. In general, the first term is largest contribution followed by the second and the third term.

Sea surface reflectance for vertical and horizontal polarizations is expressed in equation (2) and (3), respectively.

$$\rho v = \left|\frac{\epsilon_r \cos\theta - \sqrt{\epsilon_r - \sin^2(\theta)}}{\epsilon_r \cos\theta + \sqrt{\epsilon_r - \sin^2(\theta)}}\right|^2 \quad (2)$$

$$\rho h = \left|\frac{\cos\theta - \sqrt{\epsilon_r - \sin^2(\theta)}}{\cos\theta + \sqrt{\epsilon_r - \sin^2(\theta)}}\right|^2 \quad (3)$$

where θ denotes observation angle, or incident angle. The sea surface reflectance is illustrated in Figure 2 as a function of incident angle. Meanwhile, sea surface emissivity in vertical and horizontal polarizations is represented in equation (4).

$$ev = 1 - \left|\frac{\epsilon_r \cos\theta - \sqrt{\epsilon_r - \sin^2(\theta)}}{\epsilon_r \cos\theta + \sqrt{\epsilon_r - \sin^2(\theta)}}\right|^2$$
$$eh = 1 - \left|\frac{\cos\theta - \sqrt{\epsilon_r - \sin^2(\theta)}}{\cos\theta + \sqrt{\epsilon_r - \sin^2(\theta)}}\right|^2 \quad (4)$$

Where ε_r denotes dielectric constant of sea water.

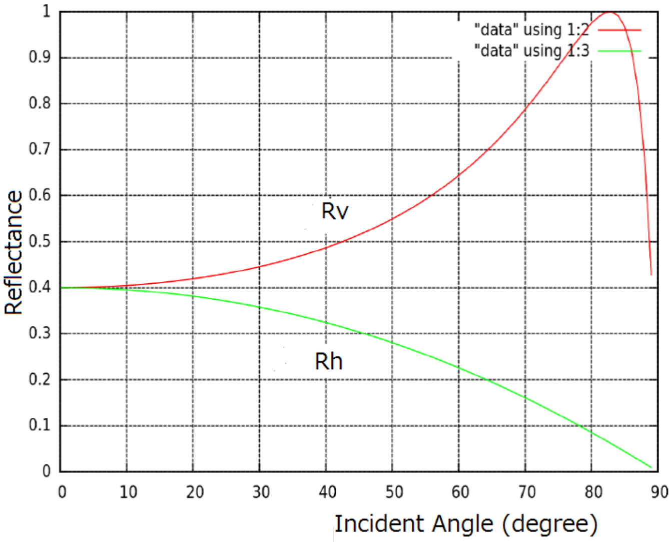


Fig. 2. Sea surface reflectance as a function of incident angle

III. Simulation Studies

A. Radiance

Simulation parameters are set as follows,

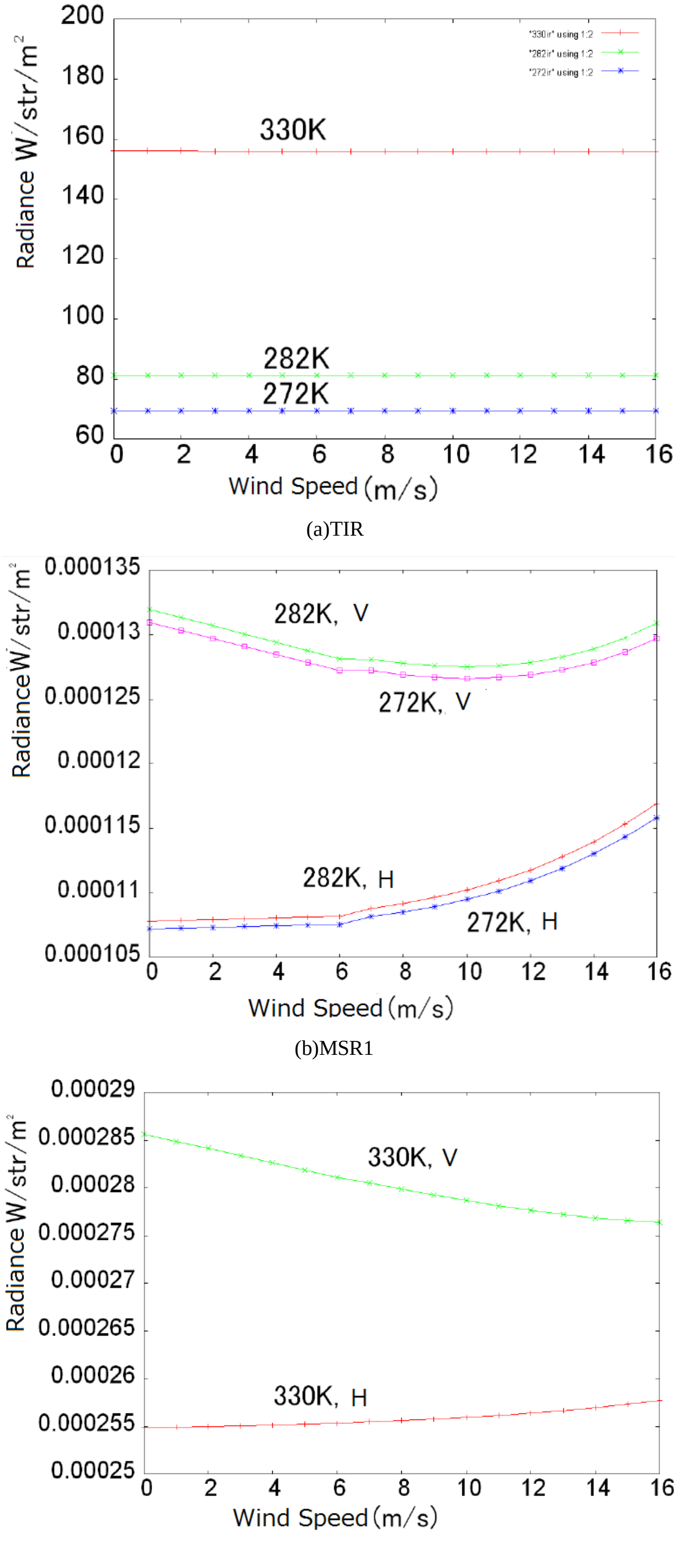
1) Wavelength: 11 micrometer for TIR, 5GHz for MSR

2) Atmospheric condition: US standard atmosphere 1976

3) Observation target: sea surface with 272K, 282K, 330K of SSST

4) Observation zenith angle: 30 degree

Figure 3 shows calculated radiance using CRTM atmospheric software code while Figure 4 shows the radiance as a function of observation zenith angle.

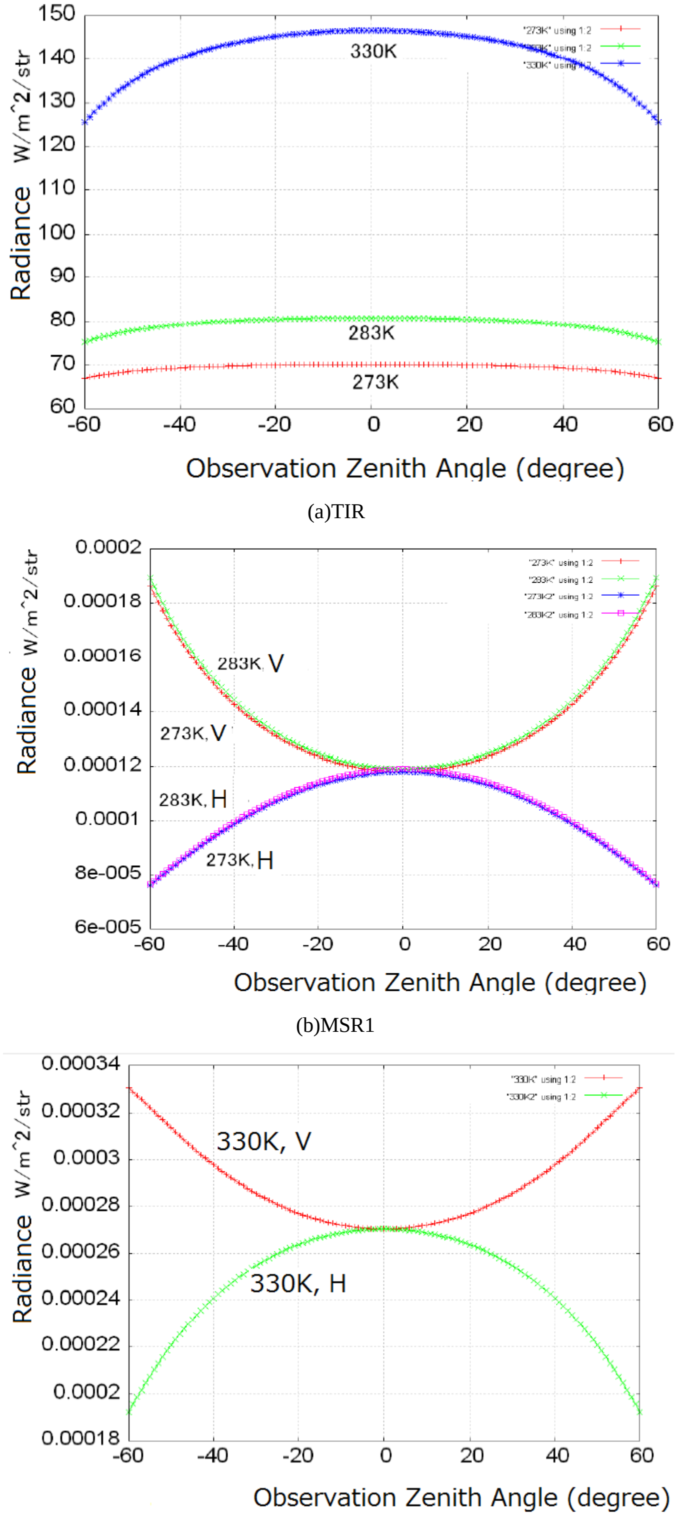


(a)TIR

(b)MSR1

(c)MSR2

Fig. 3. Calculated radiance for TIR and MSR wavelength regions as a function of wind speed



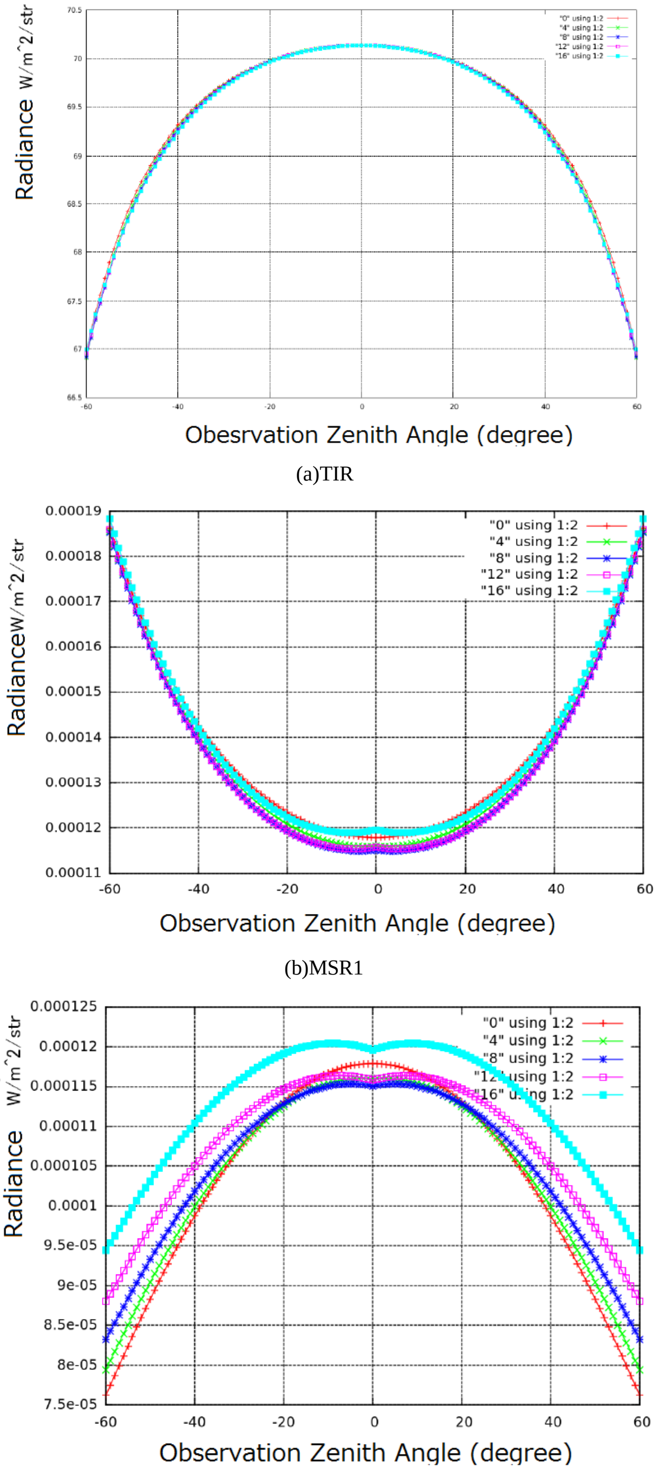
(a)TIR

(b)MSR1

(c)MSR2

Fig. 4. Calculated radiance for TIR and MSR wavelength region as a function of observation zenith angle

TIR radiance at large observation zenith angle, limb darkening appears. Meanwhile, Figure 5 shows calculated radiance with the parameters of wind speed ranged from 0 to 16m/s.



(a)TIR

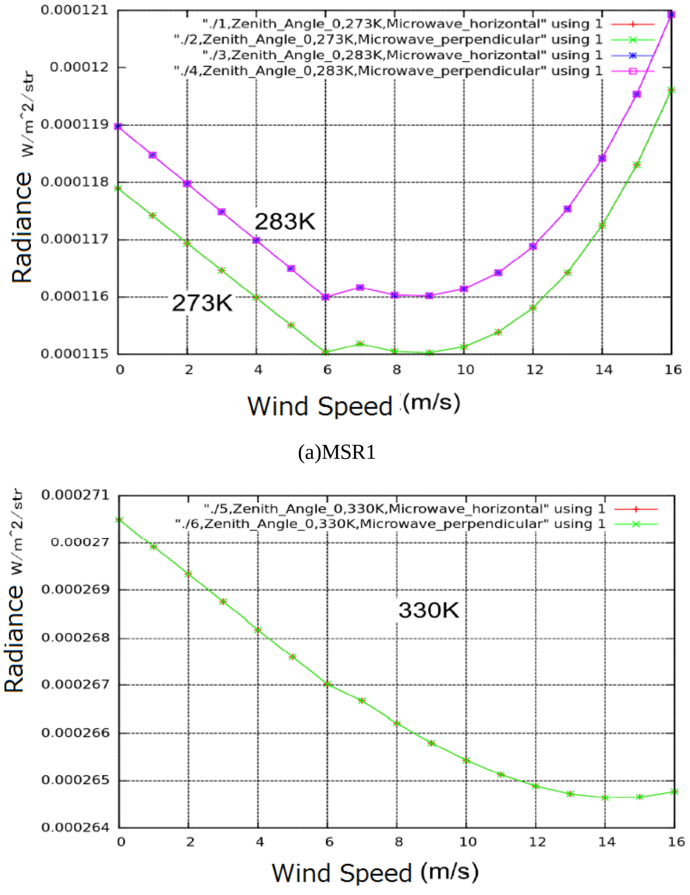
(b)MSR1

(c)MSR2

Fig. 5. Calculated radiance for TIR and MSR as parameters of wind speed ranged from 0 to 16 m/s

There is quite small difference among the calculated radiance for the different wind speed for TIR while that for MSR differ from each other, in particular for the 330K of sea surface temperature (Figure 5 (c)). The relations between observation zenith angle and radiance depend on SSST.

Figure 6 shows the calculated radiance for nadir viewing of observation zenith angle as a function of wind speed. The relations between wind speed and radiance depend on SSST.

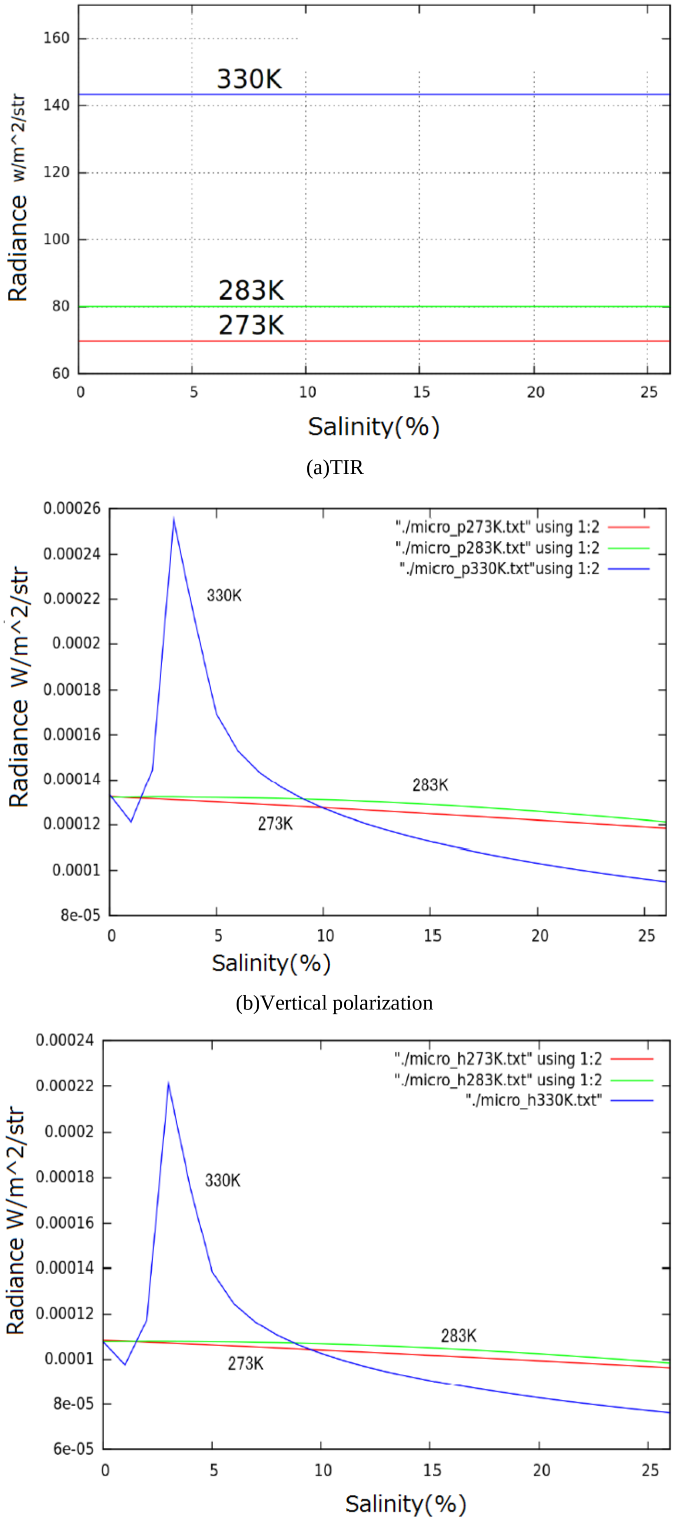


(a)MSR1

(b)MSR2

Fig. 6. Calculated radiance for nadir viewing of observation zenith angle as a function of wind speed

Meanwhile, Figure 7 shows calculated radiance as a function of salinity. It is obvious that there is no change of the calculated radiance for TIR while there is a relatively large change for MSR, in particular for vertical polarization.



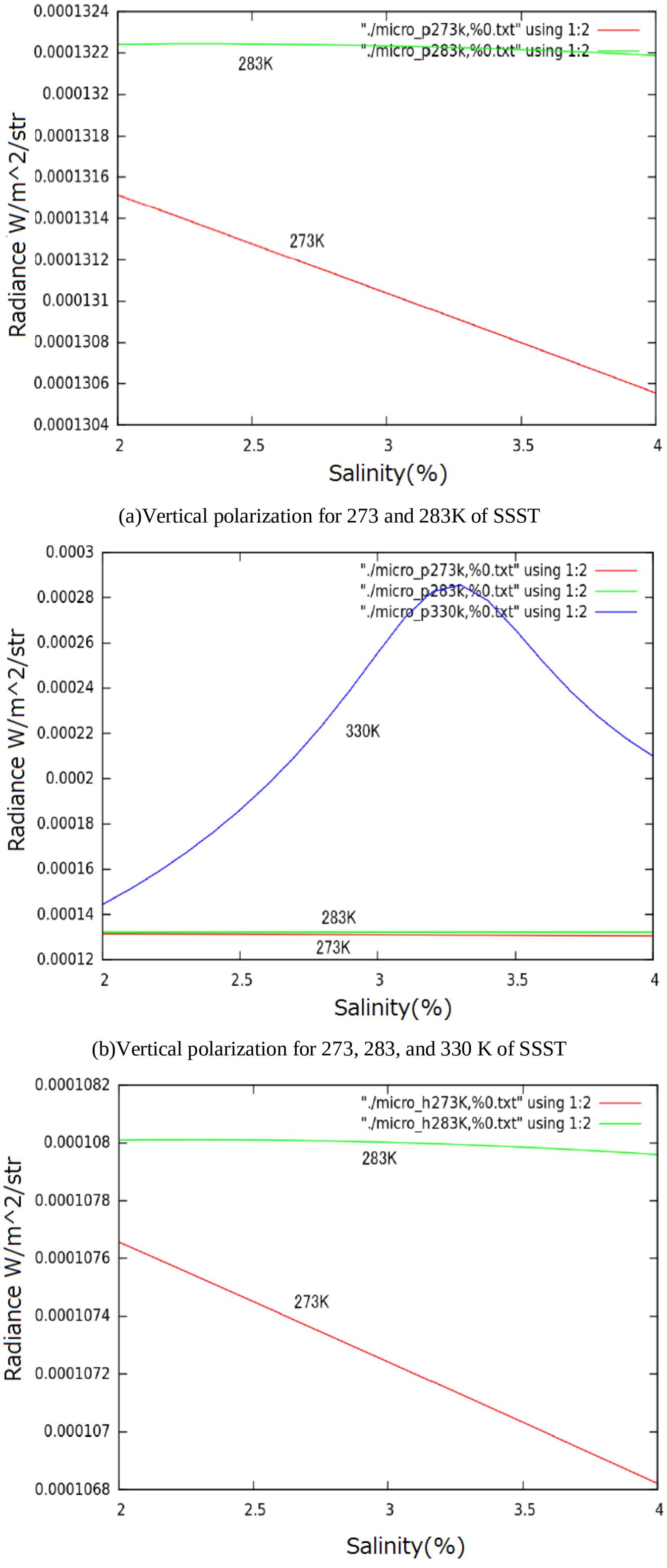
(a)TIR

(b)Vertical polarization

(c)Horizontal polarization

Fig. 7. Calculated radiance as a function of salinity

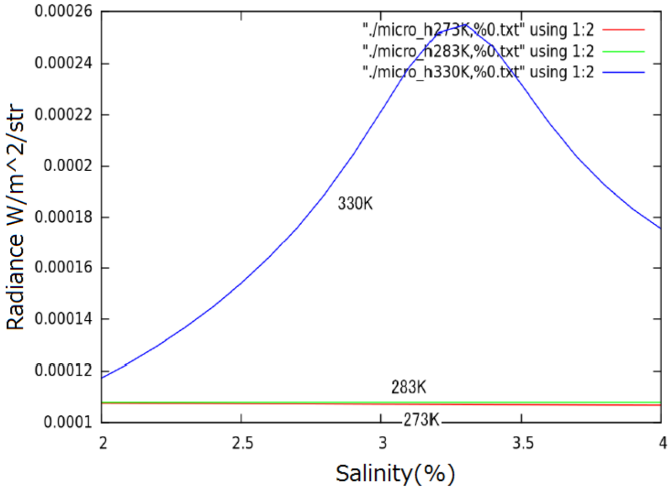
In more detail, calculated radiance for the salinity ranged from 2 to 4 % is shown in Figure 8.



(a)Vertical polarization for 273 and 283K of SSST

(b)Vertical polarization for 273, 283, and 330 K of SSST

(c)Horizontal polarization for 273, 283K of SSST



(d)Horizontal polarization for 273, 283, 330K of SSST

Fig. 8. Calculated radiance as a function of salinity

From these figure, it is found that salinity estimation is possible if the calculated radiance difference between horizontal and vertical polarization. Also it is promising that salinity is estimated for relatively large SSST, much greater than 330K.

IV. Conclusion

Method for data fusion between Microwave Scanning Radiometer: MSR and Thermal Infrared Radiometer: TIR derived skin sea surface temperature: SSST, wind speed: WS and salinity is proposed. SSST can be estimated with MSR and TIR radiometer data. Although the contribution ocean depth to MSR and TIR radiometer data are different each other, SSST estimation can be refined through comparisons between MSR and TIR derived SSST. Also WS and salinity can be estimated with MSR data under the condition of the refined SSST. Simulation study results support the idea of the proposed data fusion method. In particular, SSST and WS can be estimated with refined SSST. Furthermore, it also is promising that salinity estimation with MSR data.

Acknowledgment

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Authors Profile

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A Gaps Approach to Access the Efficiency and Effectiveness of IT-Initiatives In Rural Areas: case study of Samalta, a village in the central Himalayan Region of India

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Abstract:-**This paper focuses on the effectiveness and efficiency of IT initiatives in rural areas where topology creates isolation to developmental activities. A village is selected for the study and information is gathered through interviews of village dwellers. These collected responses are then analyzed and a gaps model is proposed.**

Keywords: KDJ-Gaps Model; Efficiency; Effectiveness; IT-Initiatives

I. Introduction

It is now an all accepted fact that computers have the potential of changing the world in a big way. The latter half of the previous century i.e. 20th century saw an upsurge in the adoption of computing technologies. The countries which embarked on the computing technologies and applications forged ahead in bringing about efficiency and effectiveness in their developmental programmes. All around the world what we witness today are technological interventions. The impact has been so overpowering that the world we are living in has become a techno-world. Information has become the most powerful tool and therefore, Information Technology has acquired unprecedented dimensions. We need technology to get the information as per our needs and requirement.

Over the years, it has blended seamlessly into our psyche, and there are hundreds of tasks that we do every day but do not think about it likewise making a simple phone call, answering an email, video chatting with someone from across the globe, paying bills, automating tasks, and finding information [1].

IT initiatives play an important role in formulating development strategies for a state, organization or country. The involvement of these initiatives in development is crucial. It may be for economic development, job-creation, rural development and poverty-alleviation etc. These initiatives have great potential to bring in the desired social transformation by enhancing its access to people, services, information and other technologies. Opportunities for the people can be enhanced by introducing IT applications by improving their access. Similarly citizens can be empowered by these initiatives through reaching out to them ensuring social and financial inclusion [2]. These initiatives can elevate living standards in remote and rural areas by providing important commercial, social and educational benefits [3].

We wanted to study the level of IT at grass root level and identify what constraints the monsoon of IT to enter rural India and flourish it. We started with identification of the village and then using interviews to assess the factors.

II. Selection of the village

The selection of village was done after a careful evaluation of many factors.

1) Proximity to the technological hub: The village should be near the capital Dehradun which is a thriving city of educational institutes; the hub of policy making and a very developed city of Uttarakhand. We wanted to see the conditions in a nearby village and then move towards other regions.

2) The hilly state: Uttarakhand being a hilly state the choice of our village should reflect the difficult geographical terrain as is the case with other villages of the state.

3) Agro based: The village should be agro based Samalta satisfied all these conditions and hence was an ideal choice for the study.

III. Scope of the study

a) The study is carried out in Samalta Village
b) It uses the qualitative method of research

IV. Objective

To identify the impact of Information technology in rural lives

V. Research Questions

1) What is the level of awareness with regards to IT?

2) What is the role of IT in Rural Areas?

3) Identification of Rural Needs for bottom up solutions through IT

4) Identifying possible visibility measures for rural resources.

VI. METHODOLOGY

UNIT OF ANALYSIS

Individual residents of the village were interviewed.

DESIGN OF THE STUDY

The village 'Samalta' is a mixed populated village with a population of about 1500. It is located about 75 K.m. away from Dehradun in the tehsil of Kalsi. In most of the cases, one or two male members from each family work outside the village for gainful employment. Agriculture and livestock are the traditional prime occupations. Contracting has been another common occupation usually carried out by the males.

Initially we visited the Gram Pradhan to know about the village and conduct a preliminary study.

Keeping the social, political, interpersonal and economic aspects in mind the interview method was followed where descriptive answers were received. With the dimensions identified by interviews with many experts, few factors were shortlisted to carry out the study in this remote village to measure the influence of the IT on village folk.

A principle of full disclosure was followed in order to make them feel comfortable and put them at ease to answer the questions. Each person spent about 15 minutes of their time to share their experience on their transition prior to and after IT initiatives. A personal narrative method of qualitative study was carried out with interview being semi structured and open ended.

The elements of the research were to:

a) *Identify the shared experience.*
b) *Explore the nature of the experience.*
c) *Examine the essence and the perspective of the phenomenon*

All the villagers shared their experience on the same phenomenon expressing their emotional, cognitive and gut feelings. The open-ended responses permit one to understand the world as seen by the respondents. We focused on use of open ended interviews to build up through personal narratives to determine if and how villagers see the role of IT. They were asked a series of questions about themselves, IT, their family and their household. In order to capture the actual words of the person being interviewed, their responses were recorded over the cell phone, Video camera and a few written notes. The recorded voice files enabled to give full attention to the respondents, build up eye contact and rapport and also be reflexive in terms of framing and reframing the questions in accordance with the responses. The villagers slowly shared their experiences, views and opinions and gradually revealed some of their innermost anguishes and aspirations in the course of the interviews.

Firstly, the recorded interviews which were in the local dialect of Hindi were transcribed and then translated into English and typed out. There were a few responses which were not translatable and hence the words and phrases were retained along with the translated version, to give a full flavour to the responses. The responses were grouped into categories best captured and to which they could fit into. The repetitive phrases or words in the responses were identified by the themes culled out by knowing what, which, where and how of the data. Textural description giving an idea of what they experienced and a structural description of how they experienced totally depicting the essence of the phenomena was identified.

VII. FINDINGS

The important outcomes of the interviews are summarized in different headings

INFORMATION ABOUT IT

We found that none of them could totality define IT the closest one dealt with information exchange. They were though of the view that IT is and could be beneficial.

"IT is all about information exchange"-Resp. 2

They had very little information about IT and its uses. They were of a notion that IT is all about transferring information from one person to another.

LACK OF AWARENESS: THE BARRIER TO IT REVOLUTION

We found that people especially above 25 years are not aware about many IT tools and Govt. initiatives. This factor sprang up through many respondents

"Here people are not aware about IT" –Resp. 1

They admitted the lack of awareness among people about IT and related issues. Many referred to themselves and the other village folk when acknowledging the unawareness to IT initiatives and tools.

"We lack in awareness here"-Resp. 2

They were highly unaware about IT and its various applications.

"I don't have any knowledge about computer"-Resp. 4

They were of the view that there might be many tools and initiatives but also knew that the information would not reach them.

"People are not aware of the projects initiated by the Govt."-Resp. 9

They had no idea about the various projects and schemes launched by the Government. Also they were of the view that the schemes only benefit and reach to the urban population.

ECONOMIC CONSTRAINTS: INHIBITOR OF IT WAVE:

Financing is a major problem to adopt IT. Even mobile is seen as convenient but expensive.

"Use of mobile can be a costly affair"-Resp. 7

They all had a common notion that usability of mobile is a costly affair. The comparative wealth of village is perceived to be lower than the urban setup.

“Financial status of the people is not up to the mark here”-Resp. 9

Computer is still perceived to be a costly machine and its usage in nearer to nil.

“Computer is a costly affair”-Resp. 8

“Villagers are not in a condition to afford computers”-Resp. 9

Financial status of the people is not up to the mark in Samalta. Therefore they were of the view that they cannot afford computer and its maintenance.

Disfigured Connectivity: Crippled life of IT

The connectivity wired and wireless is very poor and one of the major factor for stopping the free flow of information.

“There is a problem of internet connectivity here”-Resp. 2

“Connectivity is very poor here”-Resp. 9

They were of the view that connectivity is the major problem here and it hampers the free flow of communication.

Straddling a population of 740 million that logs in a GDP of over Rs. 600,000 cores, rural India presents enormous potential in thrusting India at the forefront of the most powerful nations of the 21st century. Connectivity is the key to harnessing the potential of its enormous human resources [4].

Geographical Conditions: Preventing IT penetration

We found that people of the village though being so close to the state capital find themselves isolated and deserted.

“We represent one of the remotest parts of Uttarakhand”-Resp. 1

A certain dissonance can be seen in people when they compare themselves to their urban counterparts, thus Geography has also induced this inferiority complex among villagers.

“We are still far behind when we compare ourselves to the metro cities and urban part of India” - Resp. 1

Because of the adverse geographical conditions, they are still forced to live in the absence of basic amenities. The pace of development has been slogging due to the difficult terrain and connectivity to this area.

“I think due to the geographical conditions of this region, the speed of IT revolution is very slow here” - Resp. 1

They also admitted that the geographical conditions of the area create an obstacle in the way to IT and related development.

India is a land of geographical diversities, WiMAX connectivity could play major role in improving the quality of public services and could bring substantial improvement in rural areas [5].

Receptive and Optimistic about IT: Hopes for change

They are of the view that IT has the capability to change their lives and thus help in personal and societal progress.

“People are more enthusiastic here”-Resp. 2

Even elders have an urge to learn and share the benefits of IT

“Yes why not, I would like to learn computers”-Resp. 3

They were passionate about learning computers. Elders showed the great interest in learning new technologies. They see IT education and benefits to be pervasive and for everyone.

“I think everybody should have knowledge of computers”-Resp. 5

They were of the view that the knowledge of computer is of utmost importance.

“Yes I would like to use computers”-Resp. 7

They are willing to undergo training to be at par with their urban counterparts.

“We would like to be a part of any training initiative”-Resp. 8

They really wanted to learn computers. They were of the view that training programmes must be conducted for them. They realise that IT has the potential to change and elevate their living standards.

“The use of tech will definitely help us; people are passionate about learning new things” -Resp. 9

“IT is very beneficial” - Resp. 1

They agreed upon the importance and advantages of IT. They also acknowledged the power of IT as a change agent.

Initial fear of IT: Inertia for a change

The initial fear of using a new technology was evident in some cases.

“Before, I uses to be afraid of using mobile”-Resp. 4

The fear lowered after prolonged exposure to the IT device.

“I had to struggle a lot about its (computer) handling and I was scared at that time”-Resp. 5

Further research is recommended to provide a more holistic view of rural communities and their needs and of ways to develop ICT in these areas. Given the impact on attitudes to school and engagement with it as a result of the projects, research is also called for to explore how deep-seated antipathy to formal learning can be changed by community-based initiatives [6].

IT THE TIME SAVER: QUICKNESS IS THE KEY

Mobile is seen as a portable source of communication and entertainment

“Yes, Mobile saves time”-Resp. 3

They agreed upon the view that mobile is a time saving device.

“Computer saves time and we can watch movies” Resp. 4

“Now we can talk to our relatives and dear ones through mobile and it saves lot of time”-Resp. 7

Those who use ATM see it as an easy and quick access to money.

“ATM saves lot of my time” -Resp. 9

“It helps us a lot .It saves our time it is beneficial in out day to day activities”-Resp. 5

Technology can help you save time, especially when you use the right technology and take the time to learn how to use it.

IT AS BOOSTER OF THEIR PROFESSION:

People of the area are mostly farmers and even though they are not using IT they are hopeful that it will aid in their professional development.

“We can spread awareness about our products through computers”-Resp. 4

The knowledge of computer can prove to be an aid in their professions.

“It can be of great use in agricultural field also, in this hilly region most of us are dependent on agriculture as our livelihood” - Resp. 1

They believe that if they are connected to their customers they can eliminate middlemen who suck up a lot of chunk of the profit.

“Connectivity will add to our business prospects” -Resp. 9

They were of the view that proper connectivity will enhance their business prospects.

And it will also add to their economic status. They look forward to training from the Govt. to improve and re-engineer their work practices.

“Govt. should provide proper training to upgrade our business”-Resp. 3

They were of the view that Government should take initiative to conduct training programmes for their professional elevation and socio-economic development. The main profession being agriculture in village *IT for fields* could be the need of the grass roots.

“IT will create awareness about various innovative techniques in agricultural development” - Resp. 1

The application of Information and Communication Technology (ICT) in agriculture is increasingly important-Agriculture is an emerging field focusing on the enhancement of agricultural and rural development through improved information and communication processes. More specifically, e-Agriculture involves the conceptualization, design, development, evaluation and application of innovative ways to use information and communication technologies (IT) in the rural domain, with a primary focus on agriculture. E-Agriculture is a relatively new term and we fully expect its scope to change and evolve as our understanding of the area grows.

The Veterinary Department of Malaysia's Ministry of Agriculture introduced a livestock-tracking program in 2009 to track the estimated 80,000 cattle’s all across the country. Each cattle is tagged with the use of RFID technology for easier identification, providing access to relevant data such as: bearer's location, name of breeder, origin of livestock, sex, and dates of movement. This program is the first of its kind in Asia, and is expected to increase the competitiveness of Malaysian livestock industry in international markets by satisfying the regulatory requirements of importing countries like United States, Europe and Middle East. Tracking by RFID will also help producers meet the dietary standards by the halal market. The program will also provide improvements in controlling disease outbreaks in livestock [7].

IT AS MIGRATION PREVENTER: STOPS THE OUTFLOW

They believe that if IT enables them to get visibility they would love to stay in the village instead of moving out to the cities.

“If we get better opportunities here then I don’t think people will migrate to cities” - Resp. 1

The main reason of migration is lack of awareness and proper opportunities. They were of the view that people migrate in the absence of job prospects and better opportunities.

By 2030, India’s urban population is set to reach 590 million, an addition of approximately 300 million to India’s current urban population. Much of this growth will be due to rural-urban migration. The success of the Indian urbanization agenda will be hugely dependent on the poor migrants’ integration as urban citizens [8].

LACK OF RESOURCES: CURTAILING IT TO MASSES

The villagers are aware and disgruntled with the fact that lack of resources has kept them away from taking benefits of many IT tools and initiatives

“We lack in practical implementation of IT, we don’t have sufficient resources here” - Resp. 1

Electricity, Mobile coverage, roads etc. are major resources which are needed for IT to flourish but these are in deficiency here.

“No I have never made my reservation done here, there is a problem of electricity here” - Resp. 1

“We had to struggle for even basic necessities like electricity and transport”-Resp. 4

They were of the notion that we had to even struggle for basic facilities like electricity, proper transportation facilities etc.

Despite several policy initiatives by the Government of India (GoI) and progress in extending the National grid, 56 % of rural households still do not have access to electricity. And even When they do, many have opted not to connect because of poor reliability and inadequate supply [9].

“Here we don’t have good facilities”-Resp. 9

Resource, knowledge, status and technology are important factors for the development of Rural India. Rural folk have largely been ignorant to this fact as they were either confined to their immediate livelihood incomes they have been gaining through manual labour [10].

Govt.’s Role: What should be done?

Creating awareness and then usability could be seen as key challenges for Govt.; Good policy-making is only half of the solution. In the absence of proper execution or enforcement, it becomes mere eyewash, failing to help the most excluded.

“Govt. should help, motivate and make people aware here” - Resp. 1

Capacity building can be done through providing training to few who could impart it to others.

“There should a specialist to teach computers in schools” - Resp. 1

An important aspect of maintainability of a measure taken by Govt. is highlighted.

“I think proper implementation of policies is very important, after framing policy it must be maintained properly” - Resp. 1

They were of the view that there should be proper implementation of the policies designed by the Government. Uniformity in implementation of policies will plug in the discrepancies

“Policies framed by the govt. must be implemented uniformly and properly. Facilities must reach villages”-Resp. 2

Subsidised training and IT equipment can be very beneficial.

“Govt. should do something for BPL families”-Resp. 3

“We should be equipped with computer”-Resp. 4

“Govt. must educate us about new trends in technological developments”-Resp. 5

“Govt. should frame good policies for the development of villages”-Resp. 6

“Yes…Govt. should train us”-Resp. 7

The need of the training is quite visible. They had ample of enthusiasm about learning new things. Also they were of the view that good training programmes must be conducted for them.

“We want proper connectivity here” -Resp. 9

Need for Training: The need of the hour

The need for training sprang up in many interviews; the bottom up demand from the grass roots can be cited as training and education.

“Yes…I see lots of benefits of training programmes and I think govt. must train villagers about new technologies and its use.”-Resp. 2

“We should be trained in IT and its use”-Resp. 3

Training is linked to the level of awareness and thus prospect of use.

“Yes…why not, Govt. must focus on training people here as it leads to awareness” - Resp. 1

“Govt. must educate and train us towards this”-Resp. 5

“Yes the Govt. must train us, it would be beneficial for us”-Resp. 6

They see training as an important enabler for IT to touch their lives.

“We can’t brush aside the importance of training”-Resp. 7

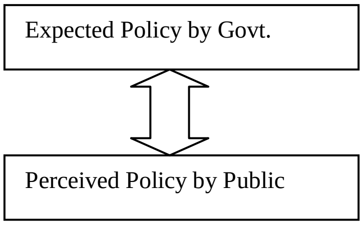
“Govt. should take initiative to start training program for us” -Resp. 9

VIII. Conclusion: Proposed Gaps Model

We identified many gaps between Govt and Public which are summarised below in the form of Gaps. A gap is evident only there is a mismatch between sending and receiving end. If there is a perfect match there will be no gap.

The KDJ[1]-Gaps model

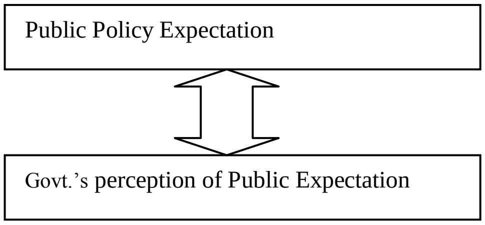
Gap 1: The Govt.-Public Gap



We find that there is a huge gap between the expected policy by Govt. and how it is perceived by Public. Govt. expects a policy like Aadhar for social inclusion of the deprived but we found many of them see it as just substitute to Ration card.

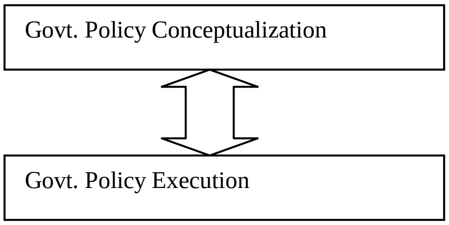
[1] KDJ refers to the authors’ initials

GAP 2: THE PUBLIC GOVT. GAP


Public Policy Expectation
Govt.'s perception of Public Expectation

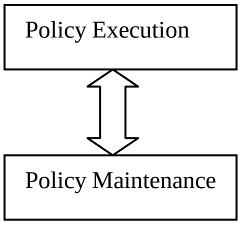
Public expects policies to be tailored to their needs but Govt. due to lack of research perceives the need differently and designs mismatching policies which don't benefit public at large.eg. Computers were provided at the village Samalta but no training on computers was provided either to villagers or teachers.

GAP 3: THINKING ACTION GAP



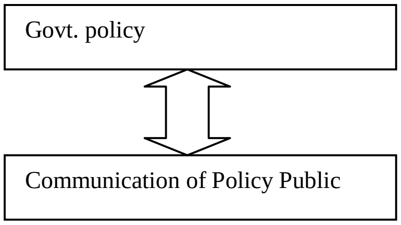
The conceptualization of a policy may be best but the execution makes it worst. The execution kills the essence of a policy.

GAP 4: MAINTAINABILITY GAP



The poor maintenance of the policy eventually leads to non-execution of the policy. We found in our study that the computers for the village school were dumped because they were not being maintained.

GAP 5: COMMUNICATION GAP



The distortion in communication or sometimes no communication has been major cause of low awareness towards IT initiatives.

We can conclude that the Govt.'s pull of policies towards public is not equal to the demand or pull by public and hence the cause of discrepancies.

Govt Push !=Public Pull

ACKNOWLEDGEMENT

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An Efficient Algorithm for Resource Allocation in Parallel and Distributed Computing Systems

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Abstract*— Resource allocation in heterogeneous parallel and distributed computing systems is the process of allocating user tasks to processing elements for execution such that some performance objective is optimized. In this paper, a new resource allocation algorithm for the computing grid environment is proposed. It takes into account the heterogeneity of the computational resources. It resolves the single point of failure problem which many of the current algorithms suffer from. In this algorithm, any site manager receives two kinds of tasks namely, remote tasks arriving from its associated local grid manager, and local tasks submitted directly to the site manager by local users in its domain. It allocates the grid workload based on the resources occupation ratio and the communication cost. The grid overall mean task response time is considered as the main performance metric that need to be minimized. The simulation results show that the proposed resource allocation algorithm improves the grid overall mean task response time. *(Abstract)

Keywords-grid computing; resource management; load balancing; performance evaluation; queuing theory; simulation models (key words)

I. Introduction

As a result of advances in wide-area network technologies and the low-cost of computing resources, currently, a wide variety of parallel and distributed computing systems are available to the user community. These varieties range from the traditional multiprocessor vector systems to clusters or networks of workstations and even the geographically dispersed meta-systems connected by high-speed Internet connections (Computing Grid). Computing Grid is hardware and software infrastructure that provides dependable, consistent, pervasive, and inexpensive access to high-end computational capabilities. It enables coordinated resource sharing within dynamic organizations consisting of individuals, institutions, and resources, for solving computationally intensive applications. Such applications include, but not limited to meteorological simulations, data intensive applications, research of DNA sequences, and nanomaterials. It supports the sharing and coordinated use of resources, independently of their physical type and location, in dynamic virtual organizations that share the same goal. Thus computing grid is designed so that users won't have to worry about where computations are being performed [1-4].

Basically, grid resources are geographically distributed computers or clusters (sites), which are logically aggregated to serve as a unified computing resource. The primary motivation of grid computing system is to provide users and applications with pervasive and seamless access to vast high performance computing resources by creating an illusion of a single system image [1, 3, 5-7]. Grid Computing is becoming a generic platform for high performance and distributed computing due to the variety of services it offers such as computation services, application services, data services, information services, and knowledge services. These services are provided by the servers or processing elements in the grid computing system. The servers and the processing elements are typically heterogeneous in the sense that they have different processor speeds, memory capacities, and I/O bandwidths [5,8].

The recent development of grid computing technologies has provided us a means of using and sharing heterogeneous resources over local/wide area networks, and geographically dispersed locations. However, the Grid dynamic framework nature where resources are subjected to changes due to system performance degradation, node failure, allocation of new nodes in the infrastructure, etc. Hence, a grid resource management system (RMS) should be capable of adapting to these changes and take appropriate decisions to improve performance of users computing applications. A resource consumer is defined as an agent that controls the consumer. A RMS is defined as a service that is provided by a distributed computing system that manages a pool of named resources that is available for computing such that a system- or job-centric performance metric is optimized.

At the same time, the decisions for resource sharing should be made while maintaining the autonomy of their environments and geographical locations. Thus, the RMS should provide a highly scalable and configurable approach for sharing and securely accessing the resources [9].

To increase the system throughput, it is desired to allocate the tasks of a distributed (parallel) application program to the PEs to some objectives, ranging from the minimization of task execution time and communication cost [10–13], to the maximization of system reliability and safety [14-16]. Moreover, the system components (PEs and communication links) may be capacitated with limited amount of resources which constrains the demand of the allocated modules.

Resource allocation in heterogeneous parallel and distributed computing systems is the process of assigning (scheduling) tasks to processing elements (computers or processors) for execution such that some performance objective is optimized. For example, a common objective in resource allocation is to minimize the total response time required to complete a set of tasks [11, 12, 16, 17].

Basically, a Grid scheduler (GS) receives applications from Grid users, selects feasible resources for these applications according to acquired information from the Grid Information Service Module (GISM), and finally generates application-to-resource mappings, based on certain objective functions and predicted resource performance [18]. Unlike what happens in traditional parallel and distributed systems, GS usually cannot control Grid resources directly, but work like brokers. They are not necessarily located in the same domain with the resources which are visible to them.

In this paper, we propose a new resource allocation algorithm that would allow users to carry out their tasks by transparently accessing autonomous, distributed, and heterogeneous resources and improves the Grid computing performance in terms of mean task response time. The proposed algorithm takes into account the heterogeneity of the grid computational resources. It distributes the workload based on the resources occupation ratio and the communication cost. As in [19], we focus on the steady-state mode, where the number of tasks submitted to the grid is sufficiently large and the arrival rate of tasks does not exceed the grid overall processing capacity. The class of problems addressed by the proposed policy is the computation-intensive and totally independent tasks with no communication between them. A simulation model is built to evaluate the performance of the proposed policy. Through simulation, the performance of the proposed resource allocation algorithm is evaluated and compared with that of similar algorithms.

The rest of this paper is organized as follows: Section II presents related work. Section III describes the Grid computing model and assumptions. Section IV introduces the proposed resource allocation algorithm. Section V presents the simulation environment and results. Finally, Section VI summarizes this paper.

Related works and motivations

Resource allocation problem has been studied intensively in the traditional distributed systems literature for more than two decades. Various policies and algorithms have been proposed, analyzed, and implemented in a number of studies [20-22]. It is more difficult to achieve resource allocation in Grid computing systems than in traditional distributed computing ones because of the heterogeneity and the complex dynamic nature of the Grid systems [18--23].

Many papers have been published recently to address the problem of resource allocation in Grid computing environments. Some of the proposed algorithms for the Grid computing environments are modifications or extensions to the traditional distributed systems resource allocation algorithms. In [24], a decentralized model for heterogeneous grid has been proposed as a collection of clusters. In [17], the authors presented a tree-based model to represent any Grid architecture into a tree structure. The model takes into account the heterogeneity of resources and it is completely independent from any physical Grid architecture. However, they did not provide any task allocation procedure. Their resource management policy is based on a periodic collection of resource information by a central entity, which might be communication consuming and also a bottleneck for the system. In [18], the authors proposed a ring topology for the Grid managers which are responsible for managing a dynamic pool of processing elements (computers or processors).The resource allocation algorithm was based on the real computers workload. In [25], the authors proposed a hierarchical structure for grid managers rather than ring topology to improve scalability of the grid computing system. They also proposed a task allocation policy which automatically regulates the job flow rate directed to a given grid manager. In [26], Aram proposes a resource allocation policy using reinforcement learning by creating multiple agents. In [27], the author presents dynamic resource allocation mechanisms by using service level agreement, best fit algorithm and process migration. In [28], Tibor introduces a resource allocation protocol for providing quality of service by using probability tree modeled as an AND/OR tree and the execution of a process is carried out through a search of a solution tree. In [29], Manpreet presents a resource oriented ant algorithm using ant colony as its key allocation strategy. In [30], Rouhollah and Hadi proposed an Analytic hierarchy process (ARA) by using Multi-Criteria Decision Making (MCDM), static and dynamic methods. In [31], Adil et al. proposed a bidding-based grid resource selection by applying a single reservation mechanism. In [32], Dawei, introduces an optimizing grid resource allocation by combining fuzzy clustering with application preference. He applied a novel heuristic, min-min algorithm and ACO (Ant Colony) algorithm.

In this paper, we developed a distributed task resource allocation algorithm that can cater for the following unique characteristics of practical Grid Computing environment:

- Large-scale: As a grid can encompass a large number of high performance computing resources that are located across different domains and continents, it is difficult for centralized model to address communication overhead and administration of remote workstations.
- Heterogeneous grid resources: The Grid resources are heterogeneous in nature, they may have different hardware architectures, operating systems, computing power, resource capacity, and network bandwidth between them.
- Effects from considerable transfer delay: The communication overhead involved in capturing load information of local grid managers before making a dispatching decision can be a major issue negating the advantages of task migration. We should not ignore the considerable dynamic transfer delay in disseminating load updates on the Internet.
- Tasks are non-preemptable: Their execution on a grid resource can't be suspended until completion.
- Tasks are independent: There is no communication between tasks.

- Tasks are computation intensive (CPU-bounded): Tasks spend more time doing computations.

II. Computing Grid Model

We consider a computing grid model which is based on a hierarchical geographical decomposition structure. It consists of a set of clusters or sites present in different administrative domains. For every local domain, there is a Local Grid Manager (LGM) which controls and manages a local set of sites (clusters). Every site owns a set of processing elements (PEs) and a Site Manager (SM) which controls and manages the PEs in that site. Resources within the site are interconnected together by a Local Area Network (LAN). The LGMs communicate with the sites in their local domains via the corresponding SMs using a High-Speed network. LGMs all over the world are connected to the global network or WAN by switches.

Grid users can submit their tasks for remote processing (remote tasks) through the available websites browsers using the Grid Computing Service (GCS) to the LGMs. This makes the job submission process easy and accessible to any number of clients. The Global Scheduler (GS) at the LGMs distributes the arriving tasks to the SMs according to a task allocation policy which is based on the available information about the SMs. Also, any local site or cluster user can submit his computing tasks (local tasks) directly to the SM in his domain. Hence, any SM will have two kinds of arriving tasks namely, remote tasks arriving from its associated LGM and local tasks submitted directly to the SM by the local users. We assume that local tasks must be executed at the site in which they have been submitted (i.e., they are not transferred to any other site). The Local Scheduler at the SM in turn distributes the arriving tasks on the PEs in its pool according to a task allocation policy which is based on the PE's load information. When the execution of the tasks is finished, the GCS notify the users by the results of their tasks.

A top-down three level view of the considered computing grid model is shown in Fig. 1. It can be explained as follows:

- **Level 0:** Local Grid Manager (LGM)

Every node in this level, called Local Grid Manager (LGM), is associated with a set of SMs. It realizes the following functions:

1) It manages a pool of Site Managers (SMs) in its geographical area (domain).

2) It collects information about its corresponding SMs.

3) New SMs can join the GCS by sending a join request to register themselves at the nearest parent LGM.

4) LGMs are also involved in the task allocation and load balancing process not only in their local domains but also in the whole grid.

5) It is responsible for balancing the accepted workload between its SMs by using the GS.

6) It sends the task allocation decisions to the nodes in the level 1 (SMs).

- **Level 1:** Site Manager (SM)

Every node in this level, called Site Manager (SM), is associated with a grid site (cluster). It is responsible for:

1) Managing a pool of processing elements (computers or processors) which is dynamically configured (i.e., processing elements may join or leave the pool at any time).

2) Registering a new joining computing element to the site.

3) Collecting information such as CPU speed, Memory size, available software and other hardware specifications about active processing elements in its pool and forwarding it to its associated LGM.

4) Allocating the incoming tasks to any processing element in its pool according to a specified task allocation algorithm.

- **Level 2:** Processing Elements (PE)

At this level, we find the worker nodes (processing elements) of the grid linked to their SMs. Any private or public PC or workstation can join the grid system by registering within the nearest parent SM and offer its computing resources to be used by the grid users. When a computing element joins the grid, it starts the GCS system which will report to the SM some information about its resources such as CPU speed, memory size, available software and other hardware specifications.

Every PE is responsible for:

1) Maintaining its workload information.

2) Sending instantaneously its workload information to its SM upon any change.

3) Executing its load share decided by the associated SM based on a specified task allocation policy

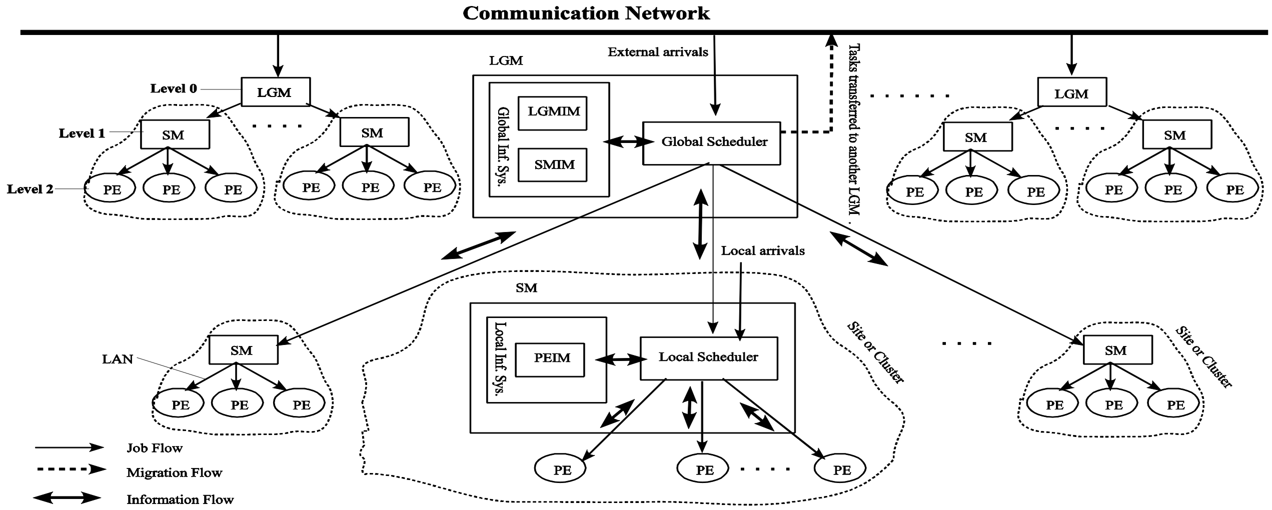

Fig. 1. Computing Grid Model Architecture

As it could be seen from this decomposition, adding or removing SMs or PEs becomes very easy, flexible and serves both the openness and the scalability of proposed grid computing model. Also, the proposed model is a completely distributed model. It overcomes the bottleneck of the hierarchal models presented in [1, 33] by removing the Grid Manager or Global node which centralizes the global load information of the entire grid. The Grid manager node can be a bottleneck and therefore a point of failure in their models. The proposed model aims to reduce the overall mean response time of tasks and to minimize the communication costs.

Any LGM acts as a web server for the grid model. Clients (users) submit their computing tasks to the associated LGM using the web browser. Upon a remote task arrival, according to the available load information, the LGM accepts the incoming task for proceeding at any of its sites or immediately forwards it to the fastest available LGM. The accepted rate of tasks will be passed to the appropriate SM based on the proposed task allocation algorithm. The SM in turn distributes these computing tasks according to the available PEs load information to the fastest available processing element for execution.

A. System parameters

For each resource participating in the grid the following parameters are defined which will be used later in the task allocation process.

*1) **Task parameters:** Every Task is represented by a task Id, number of task instructions NTI, and a task size in bytes TS.*

*2) **PEs parameters:** CPU speed, available memory, workload index which can be calculated using the total number of jobs queued on a given PE and its speed.*

*3) **Processing Element Capacity (PEC):** Number of tasks per second a PE can process. It can be calculated using the CPU speed and an average number of instructions per task.*

*4) **Total Site Manager Processing Capacity (TSMPC):** Number of tasks per second the site can process. It can be calculated as the sum of the PECs of all the processing elements of that site.*

*5) **Total Local Grid Manager Processing Capacity (LGMPC):** Number of tasks that can be executed under the responsibility of the LGM per second. The LGMPC can be calculated by summing all the TSMPCs for all the sites managed by the LGM.*

*6) **Total Grid Processing Capacity (TGPC):** Number of tasks executed by the whole grid per second. The TGPC can be calculated by summing all the LGMPCs for all the LGMs in the grid.*

*7) **Network Parameter:** Bandwidth size*

*8) **Performance Parameters:** The overall mean task response time is used as the performance parameter.*

III. PROPOSED TASK RESOURCE ALLOCATION ALGORITHM

A two-level task resource allocation algorithm for the multi-cluster grid computing environment, where clusters are located in different local area networks, is proposed. This algorithm takes into account the heterogeneity of the computational resources. It distributes the system workload based on the fastest available processing elements load balancing policy. We assume that the tasks submitted to the grid system are totally independent tasks with no inter-process communication between them, and that they are computation intensive tasks. The FCFS scheduling policy is applied for tasks waiting in queues, both at Global scheduler and Local scheduler. FCFS ensures certain kind of fairness, does not require advance information about the task execution time, do not require much computational effort, and is easy to implement. Since the SMs and their PEs resources in a site are connected using a LAN (very fast), only the communication cost between the LGMs and the SMs is considered.

The proposed task allocation algorithm is explained at each level of the grid architecture as follows:

A. Local Grid Manager Level

A LGM is responsible of managing a group of SMs as well as exchanging its load information with the other LGMs. It has Global Information System (GIS) which consists of two information modules: Local Grid Managers Information Module (LGMIM) and the Sites Managers Information Module (SMIM). The LGMIM contains all the needed information about the other LGMs such as load information and communication bandwidth size. The LGMIM is updated periodically by the LGMs. Similarly, the SMIM has all the information about the local SMs managed by that LGM such as load information, memory size, communication bandwidth, and available software and hardware specifications. Also, the SMIM is periodically updated by the SMs managed by that LGM. Since the LGMs communicate using the global network or the WAN (slow internet links) while the LGM communicates with its SMs using a High Speed network (fast communication links), the periodical interval for updating LGMIM t_G is set to be greater than the periodical interval for updating the SMIM (t_S i.e., $t_G > t_S$) to minimize the communication overhead. The GS uses the information available in these two modules in taking the task allocation decisions.

When an external (remote) task arrives at ith LGM, its GS does the following steps:

Step 1: Workload Estimation

1) To minimize the communication overhead, based on the information available at its SMIM which is more frequently updated than the LGMIM (since $T_G>T_S$), the GS accepts the task for local processing at the current LGM$_i$ ***if*** *that LGM is in the steady state (i.e., ρ_i <1) and goto step 2*

else

begin {else}

a) Check the task size S in MB.

b) Based on the information available at the LGMIM, for every LGM$_K$, K≠i compute the following:

$$C_K = R_K + \frac{S}{LinkSpeed(LGM_i, LGM_k)},$$

K=(1,2,…,i-1,i+1,…,L)

where:

- $R_K = \frac{N_K}{\mu_k}$ is the occupation ratio at the LGM$_K$; where N_K is the total number of tasks at the LGM$_K$, and μ_K is the total processing capacity of the LGM$_K$.
- $LinkSpeed(LGM_i, LGM_k)$ is the speed (in Mbps) of communication link between the current LGM$_i$, and the other LGM$_K$, K≠i.
- L is the number of LGMs in the whole grid.

a. Detecting the fastest available LGM to send the task to it

1) Find the LGM$_K$, K=1,2,…,i-1,i+1,…,L having the lowest value of C_K.

2) Forward the task immediately to the LGM$_K$, update the LGMIM at the GIS and goto step 1 for servicing a new task.

end {else}

Note: We assume that a transferred task from LGM$_i$ to LGM$_K$ for remote processing receives its service at the LGM$_K$ and is not transferred to other LGMs (i.e., each task is forwarded at most once to minimize the communication cost).

Step 2: Distributing the workload accepted for processing at the LGM$_i$ on its SMs.

Based on the information available on the SMIM, for every SM number j managed by the LGM$_i$, compute the following:

$$C_{ij} = R_{ij} + \frac{S}{LinkSpeed(LGM_i, SM_j)}, \; j=(1,2,\ldots,m)$$

where:

- S is the task size in MB.
- $R_{ij=}\frac{N_{ij}}{\mu_{ij}}$ is the occupation ratio at the jth SM managed by the LGM$_i$; where N_{ij} is the total number of tasks at the jth SM managed by the LGM$_i$, and μ_{ij} is the total processing capacity of jth SM managed by the LGM$_i$.
- $LinkSpeed(LGM_i, SM_j)$ is the speed (in Mbps) of communication link between the jth SM and the LGM$_i$.
- m is the number of SMs managed by the LGM$_i$.

1) Find the SM$_j$ having the lowest value of C_{ij} (fastest available SM), j=1,2,.., m.

2) Schedule the task for processing at SM$_j$.

3) Finally update the SMIM at GIS and goto step 1 for servicing a new task.

B. Site Manager Level

As it is explained earlier, the SM or master node is responsible of monitoring a dynamic pool of heterogeneous processing elements (PEs) that are connected via a LAN and taking the task allocation decisions to distribute the workload on the PEs in its pool. It has Local Information System which handles all the information about all the PEs managed by that SM such as load information, memory size, and available software and hardware specifications. This information is stored in what is called Processing Elements Information Module (PEIM). Since the SM and the PEs within its site are interconnected via a LAN which is regularly very fast, the PEIM is instantaneously updated by the PEs when any change occurs in their state and the communication cost within a site is ignored.

To be close to reality, any local site or cluster user can submit its computing tasks (local tasks) directly to the SM. Hence, any SM will have two different kinds of arriving tasks namely, remote tasks arriving from the associated LGM and local tasks submitted directly to the SM by the local users. To limit the communication cost, we assume that local tasks will be executed at the site in which they have been submitted as long as the site is in the steady state otherwise, the LS forwards the exceeded rate to the associated LGM. The SM periodically updates the GIS at the LGM with its load and resources information. The SM periodically updates the GIS at the LGM with its load and resources information. The LS at the SM will use a task allocation policy similar to that used by the GS at LGM. This means that the site workload will be distributed among its group of PES based on the fastest available PE policy. Using this policy, the utilization of PEs will be maximized, and hence their throughput will be improved which leads to improve whole system performance.

The LS schedules the arriving tasks, either remote or local, based on the FCFS policy. For any arriving task, the LS does the following:

Step 1: Workload Estimation

(i) Based on the information available at the PEIM, the LS, for every PE_K, k=1,2,…,n, computes the occupation ratio:

$R_{ijk} = \frac{N_{ijk}}{\mu_{ijk}}$, j=1,2,…,m and k=1,2,…,n for m SMs.

where:

- N_{ijk} is the total number of tasks in the queue of the kth PE at jth SM managed by ith LGM (LGM_i).
- μ_{ijk} is the processing capacity of kth PE at jth SM managed by ith LGM (LGM_i).

Step 2: Decision Making (Finding the fastest PE available to process the task in it)

1) Find the PE_K, K=1,2,…,n having the lowest value of R_{ijk}

2) Schedule the task for processing at that PE_k and goto step 1 to schedule a new task.

C. Performance Metrics

We refer to the length of time between the instant from the task arrival time to the grid and the instant when it leaves the grid, after all processing and communication are over as the task response time. Let r_j be the response time of $task_j$, hence the overall mean response time RT is given by: $RT = \frac{1}{N}\sum_{j=1}^{N} r_j$, where *N* is the total number of processed tasks.

IV. Simulation Results and Discussion

A. Simulation Tool and Environment

Even though there are many available tools for simulating scheduling algorithms in Grid computing environments such as Bricks, OptorSim, SimGrid, GangSim, Arena, Alea, and GridSim, see [34] for more details, the simulation was carried out using the GridSim v4.0 simulator [35]. It provides facilities for modeling and simulating entities in grid computing environments such as heterogeneous resources, system users, applications, and resource load balancers which are used in designing and evaluating load balancing algorithms. In order to evaluate the performance of the proposed task allocation algorithm, a heterogeneous grid environment was built using different resource specifications. The resources differ in their operating systems, RAM, and CPU speed. In GridSim, tasks are modeled as Gridlet objects which contain all the information related to the task and the execution management details. All the needed information about the available grid resources can be obtained from the Grid Information Service (GIS) entity that keeps track of all resources available in the grid environment.

B. Simulation Tool and Environment

Even though there are many available tools for simulating scheduling algorithms in Grid computing environments such as Bricks, OptorSim, SimGrid, GangSim, Arena, Alea, and GridSim, see [34] for more details, the simulation was carried out using the GridSim v4.0 simulator [35]. It provides facilities for modeling and simulating entities in grid computing environments such as heterogeneous resources, system users, applications, and resource load balancers which are used in designing and evaluating the task allocation algorithms. In order to evaluate the performance of the proposed algorithm, a heterogeneous grid environment was built using different resource specifications. The resources differ in their operating systems, RAM, and CPU speed. In GridSim, tasks are modeled as Gridlet objects which contain all the information related to the task and the execution management details. All the needed information about the available grid resources can be obtained from the Grid Information Service (GIS) entity that keeps track of all resources available in the grid environment.

All simulations experiments have been performed on a PC (Dual Core Processor, 3.2 GHz, 2GB RAM) running on Windows xp OS. The bandwidth speed between LGMs (low capacity link) was set to 10Mbps, and the bandwidth speed between LGMs and SMs (high capacity link) varies from 50Mbps to 100Mbps. All time units are in seconds.

C. Performance evaluation and Analysis

Both of the external (remote) tasks and local tasks arrive sequentially to the LGMs and the SMs respectively with inter-arrival times which are independent, identically, and exponentially distributed. Simultaneous arrivals are excluded. The service times of LGMs are independent and exponentially distributed. Task parameters (size and service demand) are generated randomly. Each result presented is the average value obtained from 5 simulation runs with different random numbers seeds.

Experiments 1:

On a heterogeneous grid model consisting of 3 LGMs having 4, 2, 1, 5 SMs respectively. The total grid processing capacity is set to 1000 task/second (t/s). For this model to be stable, total task arrival rate (remote arrivals plus local arrivals) must be less than 1000 t/s.

During experiments explanation, task allocation and load balancing are used interchangeably. In this experiment, we focused on the results related to objective parameter (i.e., overall mean task response time) according to various numbers of tasks. During the experiment, 20 % from the total tasks arrived to the SMs are local tasks. In Fig. 3, we compare between the grid overall mean task response time obtained under the proposed load balancing (task allocation) policies (PLBPs) and that obtained without using any load balancing policies at all (No. LB). From that figure, we can see that as the number of tasks increases the overall mean task response time increases. The increase of grid overall mean task response time is less in PLBPs as compared to the increase in the grid overall mean task response time without using any load balancing policies.

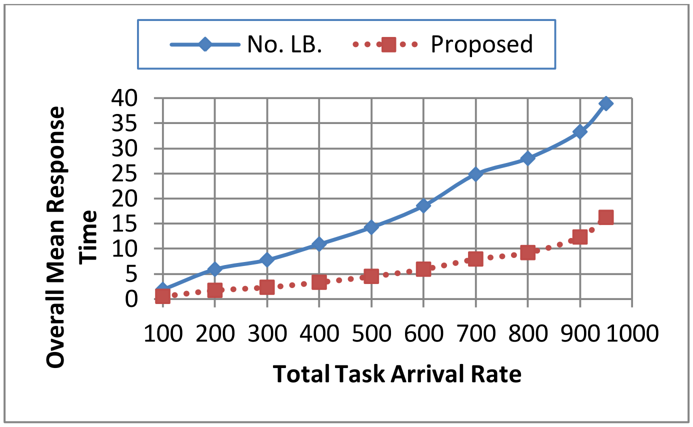

Fig. 3. Grid Overall Mean Task Response Time Of Plbps Vs. No. LB

To evaluate how much improvement is obtained in the grid overall mean task response time as a result of applying the PLBPs, we computed the improvement ratio $(T_N - T_P)/T_N$, where T_N is the grid overall mean task response time without using any balancing polices, and T_P is the grid overall mean task response time under PLBPs, see Fig. 4. From that figure, one can see that the improvement ratio gradually decreases as the grid workload increases, and it decreases rapidly as the grid workload approaches the saturation point (i.e., traffic intensity $(\lambda/\mu)\approx 1$). The maximum improvement ratio is about 73% and is obtained when the grid workload is low. This result was anticipated since the PLBPs distribute the grid workload based on the resources occupation ratio and the communication cost which leads to maximizing grid resources utilization and as a result the grid overall mean task response time is minimized. In contrast, the distribution of the grid workload on the resources without using any loads balancing policies (No. LB.) leads to unbalanced workload distribution on the resources, which leads to poor resources utilization and hence, the grid performance is affected.

Experiments 2:

In this experiment, the performance of the PLBPs is compared with that of Random_GS and Random_LS policies described in [33], and Min_load and Min_cost policies described in [36]. Our model is limited to approach their models by reducing the number of LGMs to 1 and setting the Local Tasks Arrival Rate (LTAR) to 0 (i.e., no local arrivals is allowed). In this case the LGM represent the Grid Manager (GM) or Global Scheduler (GS) in their models. During the experiment, we set the number of SMs to 4 with total processing capacity of 550 t/s.

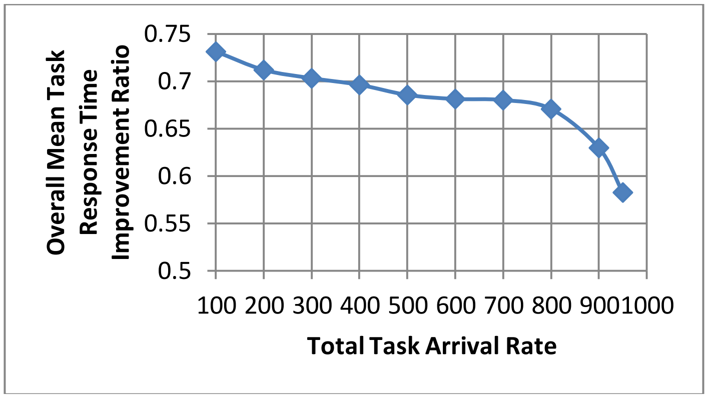

Fig. 4. Grid overall mean task response time improvement ratio

For this model to be stable, external arrival rate must be less than 550 t/s. Each simulation ends after 550,000 tasks are completed. Fig. 5 shows the overall mean task response time obtained under the Random_GS and Random_LS, Min_Load and Min_Cost, and the proposed load balancing policies. From that figure, we can see that the grid overall mean task response time obtained by all policies increases as the total arrival rate increases. Also from that figure, we can see that the PLBPs outperforms the Random_GS and Random_LS, and Min_Load and Min_Cost policies in terms of grid overall mean task response time.

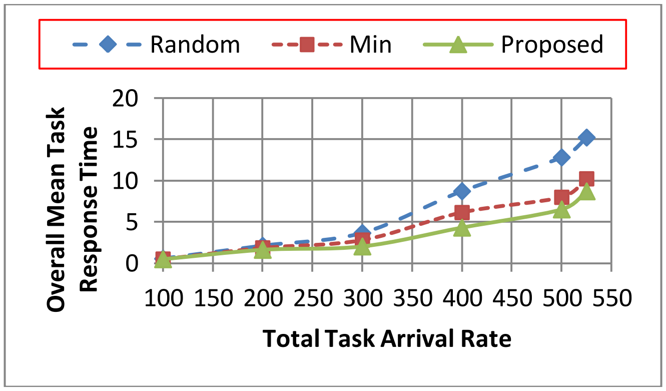

Fig. 5. Grid overall mean task response time of Random_GS and Random_LS, Min_Load and Min_Cost, and the proposed load balancing policies.

To evaluate how much improvement is obtained in the grid overall mean task response time as a result of applying the PLBPs over the other policies, we computed the improvement ratios $(T_R - T_P)/T_R$, and $(T_M - T_P)/T_M$ where T_R, T_M, and T_P are the grid overall mean task response time obtained using the Random_GS and Random_LS, Min_Load and Min_Cost, and the PLBPs, see Fig. 6. From that figure, one can see that the PLBPs outperforms the Random_GS and Random_LS, and Min_Load and Min_Cost policies in terms of grid overall mean task response time and the maximum improvement is bout 50% and 30% respectively. The improvement ratio gradually increases as the grid workload increases until the workload becomes moderate where the maximum improvement ratio is obtained and after that the improvement ratio decreases gradually as the grid workload increases approaching the saturation point (i.e., traffic intensity (λ/μ)≈1).

This result was anticipated since the PLBPs distribute the grid workload based on the resources occupation ratio which leads to maximizing the resources utilization and as a result, the grid overall mean response time is minimized. In contrast, the Random_GS and Random_LS load distribution policies distribute the workload on the resources randomly without putting any performance metric in mind which may lead to unbalanced workload distribution.

This situation leads to poor resources utilization and hence, the grid performance is degraded. Also, Min_Load and Min_Cost load balancing policies suffer from higher communication cost compared to the PLBPs. Notice that in the PLBPs, once a task is accepted by a LGM, it will be processed by any of its sites and it will not be further transferred to any other LGM. In contrast to the Min_Load and Min_Cost load balancing policies where a task may circulate between the grid resources leading to higher communication overhead. To be fair, we must say that according to the obtained simulation results, the performance of the Min_Load and Min_Cost load balancing policies is much better than that of the Random_GS and Random_LS distribution policies.

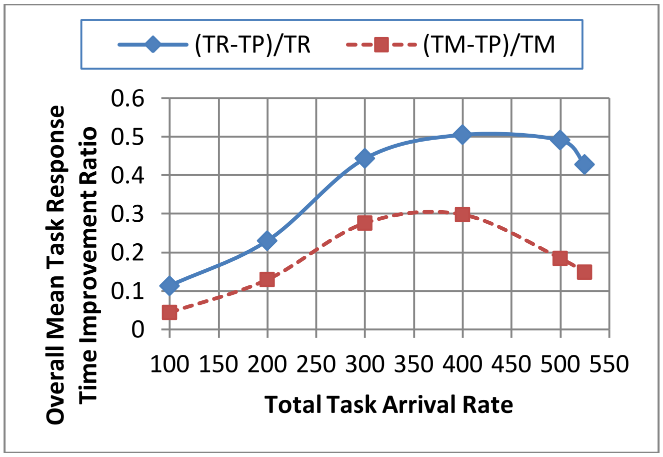

Fig. 6. Improvement ratio obtained by the proposed load balancing policies over Random_GS and Random_LS, and Min_Load and Min_Cost policies.

Experiments 3:

This experiment is done to study the effect of the local arrival rate on the performance of the PLBPS. During the experiment, the same grid parameters setting of the second experiment is used, and we set the ratio of the LTAR=0% , LTAR=10% and 25% form the TTAR to the grid. As it can be seen form Fig. 7, the overall mean task response time decreases as the LTAR ratio from the TTAR increases. This result is obvious since the LTAR arrives directly to the SMs and don't suffer from any transmission delay at all.

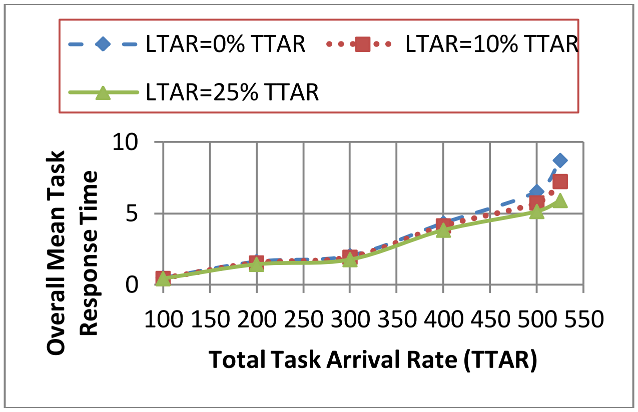

Fig. 7. Grid overall mean task response obtained for different ratios of LTAR from TTAR.

V. Conclusion and Future Work

In this paper, we proposed a decentralized two-level task allocation algorithm for allocating the workload in a multi-cluster grid environment where clusters are located at administrative domains. The proposed algorithm takes into account the heterogeneity of the grid computational resources, and it resolves the single point of failure problem which many of the current policies suffer from. The task allocation decisions in this policy are taken at the local grid manager and at the site manager levels. The proposed policy allows to any site manager to receive two kinds of tasks namely, remote tasks arriving from its associated local grid manager, and local tasks submitted directly to the site manager by the local users in its domain, which makes this policy closer to reality and distinguishes it from any other similar policy. It allocates the workload based on the resources occupation ratio and the communication cost which leads to minimize the grid overall mean task response time. To evaluate the performance of the proposed task allocation policy a simulation model is built. In this model, the grid overall mean task response time is considered as the main performance metric that need to be minimized. The simulation results show that the proposed algorithm improves the grid performance in terms of overall mean task response time.

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Reliable Global Navigation System using Flower Constellation

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***Abstract*—For many space missions using satellite constellations, symmetry of satellites distribution plays usually a key role. Symmetry may be considered in space and/or in time distribution. Examples of required symmetry in space distribution are in Earth observation missions (either, for local or global) as well as in navigation systems. It is intuitive that to optimally observe the Earth a satellite constellation should be synchronized with the Earth rotation rate. If a satellite constellation must be designed to constitute a communication network between Earth and Jupiter, then the orbital period of the constellation satellites should be synchronized with both Earth and Jupiter periods of revolution around the Sun. Another example is to design satellite constellations to optimally observe specific Earth sites or regions. Again, this satellites constellation should be synchronized with Earth's rotational period and (since the time gap between two subsequent observations of the site should be constant) also implies time symmetry in satellites distribution. Obtaining this result will allow to design operational constellations for observing targets (sites, borders, regions) with persistence or assigned revisit times, while minimizing the number of satellites required.**

Constellations of satellites for continuous global or zonal Earth coverage have been well studied over the last twenty years, are well known and have been well documented [1], [2], [7], [8], [11], [13]. A symmetrical, inclined constellation, such as a Walker constellation [1], [2] provides excellent global coverage for remote sensing missions; however, applications where target revisit time or persistent observation are important lead to required variations of traditional designs [7], [8]. Also, few results are available that affect other figures of merit, such as continuous regional coverage and the systematic use of eccentric orbit constellations to optimize“hang time” over regions of interest. Optimization of such constellations is a complex problem and the general-purpose constellation design methodology used today is largely limited to Walker-like constellations.

As opposed to Walker Constellations [1], [2], which were looking for symmetries in inertial reference frame, Flower Constellations [11] were devised to obtain symmetric distributions of satellites on rotating reference frames (e.g., Earth, Jupiter, satellite orbit). Since the theory of Flower Constellations has evolved with time the next section is dedicated to the summary of the theory up to the current status. The FCs solution space has been recently expanded with the Lattice theory [13], [14], encompassing all possible symmetric solutions.

I. Flower Constellations Theory

The FC theory, devised and developed at Texas A&M [11], is a natural extension of the theory of compatible orbits. When an orbit is compatible, the satellite trajectory in the rotating frame becomes a closed-loop trajectory. The original theory defines a Flower Constellation a set of N_s satellites following the same (closed) trajectory with respect to a rotating reference frame fixed to the Earth. This condition implies

1) The period of revolution, T_p, of each satellite about the Earth is a rational multiple of the period of rotation of the Earth, T_d. That is, $N_p T_p = N_d T_d$ for some positive (coprime) integers N_d and N_p.
2) The orbital parameters a, e, i and ω are the same for all the satellites.
3) The mean anomaly at epoch M_i and the right ascension of the ascending node Ω_i of the orbit of each satellite satisfy $N_p \Omega_i = -N_d M_i \mod (2\pi)$.

The first item guarantees that the trajectory in the rotating frame is closed (loop completed by the repetition period, $T_{\text{rep}} = N_p \, T_o = N_d \, T_\oplus$). In particular, in the Earth-Centered Earth-Fixed (ECEF) rotating frame, the compatible orbit becomes a repeating ground-track orbit.. The second and third item are necessary and sufficient conditions to have all the satellites on the same trajectory (a complete proof of this fact is given in [32]). To capture the key idea of FCs let's consider Fig. 1. This figure shows a FC made of 4 satellites moving in 8 hr equatorial orbits with the four major axes orthogonal. Since 24/8 = 3, each satellite passes through 3 apogees per day. By judicious phasing, the satellites all move on the same Earth-Fixed (EFEC) relative trajectory (red curve with the 3 apogees 120° apart in Fig. 1). Furthermore, the three apogee loops in an ECEF frame are traversed very slowly with a hang time of

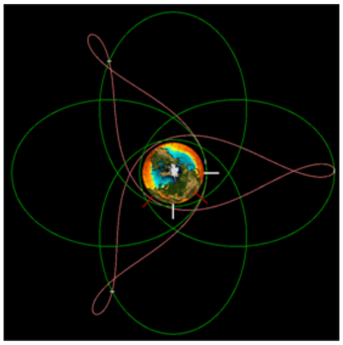

Fig. 1. All 4 satellites are on the same space track (red trajectory; fixed in ECEF).

about 5.3 hr for each satellite to traverse its 3 apogee loops per day, therefore each of the 4 satellites spends about 2/3 of a day near apogee. Notice these loops lie in a small region in ECEF, and through intelligent design, 3 satellites are always in the apogee loops, and the 4-th is en-route from perigee to replace the satellite ready to exit the apogee loop. This pattern of always having 3 satellites near apogee enables 24/7 persistence over three regions with only 4 MEO satellites. This is one of an infinite family of possibilities, and optimizing over these constellations is the first step of the proposed research.

A. From original theory to Lattice theory

In addition to a resonant period $T_p = \frac{N_d}{N_p} T_d$ we can impose the relation $N_p \Omega = -N_d M$ for all satellites. This condition gives some degrees of freedom for selecting the locations of the satellites in the (Ω, M)-space, to get symmetries in space by using phasing parameters (F_n, F_d, and F_h). This procedure allows a maximum of $N_d F_d / G$ satellites in a FC, where $G = \gcd(N_d, N_p F_n + F_d F_h)$. A FC with the maximum number of satellites allowed by the previous formula is called a Harmonic FC (HFC). The satellites in a HFC exhibit a shape-preserving dynamic, thus behaving like a true rigid body in space. The use of phasing parameters to design FC and HFC is simple, but some number-theoretic problems have been recently found [28] to generalize the theory. The following list describes some of these problems:

1) *Equivalency Problem*. Many combinations of input parameters can give the same FC. For HFC a complete solution of this problem has been found [1]. It has been shown that 3 invariants are sufficient to uniquely characterize them: the number of satellites per orbit N_{so}, the number of orbits $N_o = F_d$, and a configuration number, N_c. Formulas to compute these invariants are known.
2) *Similarity Problem*. Two equivalent HFC with a different N_p/N_d ratio may have the same relative dynamics while rotating at different velocities. Reference [1] provides a complex algorithm to compute all similar (homotetic) HFC with given invariants (N_{so}, N_o, N_c).
3) *Geometric properties of HFC*. The number of perigees and apogees of a HFC is time invariant. How to compute these geometric invariants requires further research. This problem is connected with the problem of computing the number of axial symmetries of rigid bodies.
4) *Time and space uniform FC*. The satellites of a FC are all located in a single closed-loop trajectory in the rotating frame that depends only on the ratio N_d/N_p. By dividing this relative orbit in equally spaced time intervals, we obtain a FC whose time gap between 2 subsequent observations of the same target is constant (time-uniform). This is achieved by introducing a new mean anomaly (Flower Anomaly) to map the (Ω, M)-space in time [1] by direct application of the Chinese Remainders Theorem. Space-uniform FCs for world-wide targets are obtained through optimization of the Thompson problem (uniformly points distribution over a sphere).

All these problems have been addressed using the phasing parameters has and have been recently solved [9] with a new FC theory (Lattice FC). The new approach decouples the compatibility condition and the shape parameters. The -space satellite locations (mathematically described as a torus) are given by all the solutions of a modular system of equations.

$$LP_k = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{Bmatrix} \Omega_k \\ M_k \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix} \bmod (2\pi)$$

The four integer parameters in these equations (a, b, c, d) give a new meaningful matrix associated with the FC. The number of orbits N_Ω, the number of satellite per orbits N_{so}, and the configuration number N_c can be derived from the Lattice matrix (L) by computing it Smith-Hermite normal form

$$H = \begin{bmatrix} N_\Omega & 0 \\ N_c & N_{so} \end{bmatrix} \quad \text{where} \quad H = LU, \quad \text{and} \quad U \in GL_2(\mathbb{Z})$$

All the possible ratios N_d/N_p for the FC come from this matrix. With the new Lattice theory the solutions of problems 1-3 are straightforward, and all the possible symmetric FC can be defined with a given number of satellites.

II. Constellation Design Considerations

The 2D Lattice theory has then evolved into a 3D Lattice theory [14] allowing to design satellite constellations at *any* inclination using elliptical orbits and under the J_2 effect. The satellites phasing is obtained as solution of the 3×3 Hermite normal form

$$\begin{bmatrix} N_o & 0 & 0 \\ N_c^3 & N_\omega & 0 \\ N_c^1 & N_c^2 & N'_{so} \end{bmatrix} \begin{Bmatrix} \Omega_{ijk} - \Omega_1 \\ \omega_{ijk} - \omega_1 \\ M_{ijk} - M_1 \end{Bmatrix} = 2\pi \begin{Bmatrix} i \\ k \\ j \end{Bmatrix} \qquad (1)$$

However, designing an 3D Lattice Flower Constellation (3D-LFC) requires more than selecting the six integer parameters in Eq. (1). The semi-major axis (a), eccentricity (e), and inclination (i) that are in common to all satellites must be selected. Additionally, the RAAN (Ω_1), argument of perigee (ω_1), and mean anomaly (M_1) of the first reference satellite can also be selected arbitrarily without affecting the relative phasing within the constellation.

Thus, an 3D-LFC requires six integer parameters and six continuous parameters. Essentially, the six continuous parameters define the orbit elements of the first satellite, and the six integer parameters phase all other satellites relative to that one. Each of the continuous parameters is subject to particular considerations as described in the following sections.

A. Semi-major axis and eccentricity

The orbit semi-major axis and eccentricity are common among all satellites in the constellation, and are typically bounded by some minimum and maximum altitudes. Typically these bounds are a result of sensor or antennae limitations. Requiring hardware that can operate at varying altitudes is a significant limitation on the use of elliptic orbits.

The semi-major axis can also be chosen to provide repeating ground-tracks as in the Walker or in the 2D-LFC theories. Satellites with the same argument of perigee can also be placed on the same repeating ground-track through judicious selection of the parameters (N_p, N_d).

B. Inclination

The inclination of the orbits has significant impact on the coverage provided by a 3D-LFC. Even in circular orbit constellations, certain inclinations result in satellites colliding, whereas others permit near perfect phasing as a satellite from one plane passes directly between two satellites from another plane.

Considering two satellites in circular orbits with the same altitude, the closest approach between the two satellites, $\rho_{\min}$, can be analytically computed from the equations [26]

$$\left\{\begin{array}{rcl} \Delta F & = & \Delta M - 2\arctan\left[-\tan(\Delta\Omega/2)\cos i\right] \\ \cos\beta & = & \cos^2 i + \sin^2 i \cos\Delta\Omega \\ \rho_{\min} & = & 2\left|\sqrt{\dfrac{1+\cos\beta}{2}}\sin\left(\dfrac{\Delta F}{2}\right)\right| \end{array}\right. \tag{2}$$

where ΔM and $\Delta\Omega$ are the difference in orbit elements of the two satellites and i is the inclination angle common to both. Note that $\rho_{\min}$ must be scaled by the orbit radius to find the physical approach distance. The minimum distance encountered within a constellation of circular orbits can be computed by calculating this approach distance for all pairs of satellites. Perfect juggling requires that no two satellites are ever closer than half the distance between two consecutive satellites in the same orbit. We can scale the minimum approach distance such that zero corresponds to collision and one corresponds to perfect juggling. Using this scaling, the results for the 27/3/1 Walker constellation are plotted in Fig. 2 as a function of inclination angle. Note the peak near an inclination of 56°, the chosen inclination for the Galileo GNSS system [27]. This clearly indicates that even though inclination is technically a continuous parameter, there exist discrete values of inclination that maintain high levels of uniformity in the distribution of satellites. Equation (2) only applies to circular orbits, but similar derivations can be made for elliptic orbits with same value of perigee argument

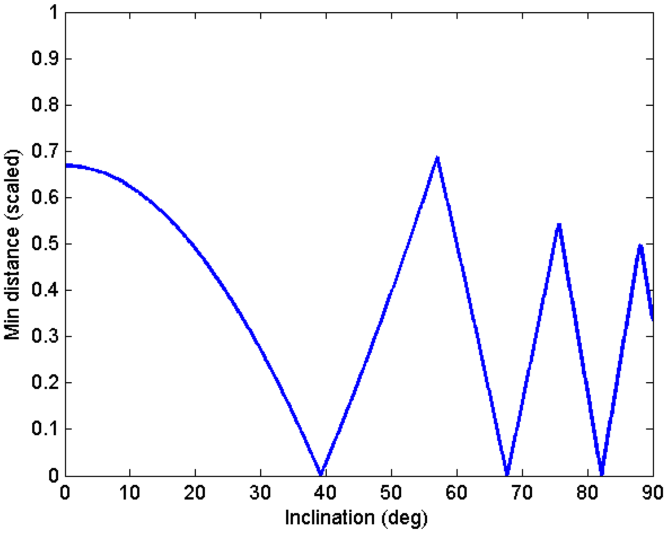

Fig. 2. Minimum encounter distance in the 27/3/1 Walker constellation as a function of inclination.

C. Selecting Ω_1, ω_1, and M_1

The values of $(\Omega_1, \omega_1, M_1)$ provide the three angular elements of the reference satellite $(i, j, k) = (0, 0, 0)$. Though each of them could be drawn from $[0, 2\pi)$, each can be further bounded by constellation considerations once the 6 integer parameters have been chosen.

Ref. ? has proven thal 3D-LFC can be described using values of (Ω_1, ω_1, M_1) in the ranges

$$\left\{\begin{array}{rcl} \Omega_1 & \in & \left[0, \dfrac{2\pi}{N_o}\right) \\ \omega_1 & \in & \left[0, \dfrac{2\pi}{N_o N_\omega}\gcd(N_o, N_c^3)\right) \\ M_1 & \in & \left[0, \dfrac{2\pi}{N_s}\gcd(N_o N_\omega, N_c^2 N_o, N_\omega N_c^1 - N_c^2 N_c^3)\right) \end{array}\right. \tag{3}$$

All 3D-LFC can be described by values within these ranges due to their uniform, symmetric nature. For general 3D-LFC with a global coverage mission, the design parameters $(\Omega_1, \omega_1, M_1)$ can simply be taken as zero. When zonal or regional coverage is required, these variables significantly effect coverage. Clearly, ω_1 is significant for critically inclined orbits, even when global coverage is considered, but has no meaning when dealing with circular orbits.

If one is considering global coverage, these ranges may not only be used for design purposes, they can also be used as limits on orbit propagations, thereby substantially reducing computation time. This is especially important given the rotation of the apsidal lines requires significantly more propagation than required for circular orbits. The optimal bounds can reduce the computation time by a factor of N_o for ω and a factor of $N_o N_\omega$ for M for a total possible reduction factor of $N_o^2 N_\omega$. In the global navigation example of the next section, with 27 satellites in 3 orbital planes, the optimal bounds of Eq. (3) reduce propagation time by a factor of ≈ 7.5 over these naive bounds when averaged over all 117 3D-LFC tested. Some of those 117 3D-LFC see a reduction in propagation time of a factor of 81 ($N_o = 3, N_\omega = 9$). The 150 3D-LFC with 25 satellites and 5 orbital planes improve propagation times by a factor of ≈ 13.5 on average, with a few improving by a factor of 125 ($N_o = 5, N_\omega = 5$)!

To complete the picture with respect to other design methods, Walker's phasing parameter in Ref. [3] is equivalent to our M_1. Dufour includes an ω_1 in his elliptical Walker constellations that is a multiple of another integer parameter he introduces, but the range of ω_1 is limited to $[-\pi/2, \pi/2]$ rather than the full allowable range of $[-\pi, \pi]$ [24], [25]. The continuous parameter used here clearly includes the discrete values of Ref. [24], [25].

III. Global Navigation Satellite System

To examine the effectiveness of the 3D-LFC framework for designing a global coverage constellation, we first use the example of global navigation. Flower Constellations were first studied for use in GNSS by Park [19], who found improvements over the Galileo GNSS constellation by using a combination of two Harmonic Flower Constellations found by trial and error. Tonetti [22] ran a Genetic Algorithm (GA) to improve upon Park's results. Both of these Flower Constellations were designed for 30 satellites and utilized large numbers of orbital planes (15 and 30 respectively), which is unattractive from a launch and operational standpoint. Alternatively, Bruccoleri [21] found a Harmonic Flower Constellation with 24 satellites that showed improved performance over the GPS constellation. All three studies considered only circular orbits rather than be restricted to a critically inclined Flower Constellation with elliptic orbits. In this paper, in order to validate the proposed design methodology, we consider both 27 and 25 satellite 3D-LFC. We have not considered the combination of two or more 3D-LFC into the same constellation, as was done in Ref. [19], but this may yield additional improved results.

A. Cost Function

As a cost function to drive these design studies, we consider the Geometric Dilution Of Precision (GDOP), a measure of the accuracy of a GNSS solution. The lower the value of GDOP, the more accurate is the GNSS solution. GDOP is dependent entirely on the geometry of the satellites within view of a specific ground site and relies on the visibility matrix, given by

$$A^{\mathrm{T}} = \begin{bmatrix} \hat{\mathbf{r}}_1 & \hat{\mathbf{r}}_2 & \cdots & \hat{\mathbf{r}}_n \\ 1 & 1 & \cdots & 1 \end{bmatrix} \tag{4}$$

where $\hat{\mathbf{r}}_i$ is the unit vector from ground site to the i-th satellite and n is the number of visible satellites. We defined a minimum elevation angle of 10° to determine satellite visibility in this simulation. We define the matrix $H = A^{\mathrm{T}}A$. GDOP can then be calculated

$$\text{GDOP} = \sqrt{\text{tr}\,(H^{-1})}. \tag{5}$$

This compact equation is simple, but requires a matrix inverse for every point (in time and space) that needs to be evaluated, so here we derive a new equation with faster computation. Since the trace of a matrix is the sum of its eigenvalues, and the eigenvalues of a matrix inverse are the inverses of the original matrix eigenvalues, we can rewrite the computation of GDOP as

$$\text{GDOP} = \sqrt{\sum_i \frac{1}{\lambda_i}} \tag{6}$$

where λ_i are the eigenvalues of H. Note that $\sum_i \lambda_i = 2n$. This alternate form of GDOP calculation reduced computation time in MATLAB by more than a factor of two.

To evaluate the accuracy of a given GNSS constellation, 1,000 points were distributed uniformly around a spherical Earth using an iterative electrostatic repulsion method (also known as the Thomson problem). The constellation was propagated using an initial argument of perigee of zero with 5° steps in mean anomaly, and GDOP was calculated for all ground sites at each of those times. The initial argument of perigee was then rotated in 5° steps with mean anomaly propagation performed at each step. This is a useful approximation of the behavior of the constellation due to the low rate of rotation of argument of perigee as compared to mean anomaly. The values of GDOP from all of these evaluations were then averaged, and we sought to minimize this mean GDOP value.

B. Design Study: 27 Satellites

In this paper, we compare performance to the Galileo constellation, designed as a 27/3/1 Walker constellation at 56° inclination and semi-major axis of 29,600 km [27], [28]. Initial design studies based on a variety of performance and operational considerations led to this particular selection of the number of satellites and number of orbital planes, so those were held constant in this design paper. Once those numbers are fixed, the Walker constellation framework allows for just two design variables: the phasing parameter F and the inclination angle. The phasing parameter is restricted to just 3 possible values. In contrast, the new 3D-LFC framework allows for 117 unique combinations of the parameters $\{N_\omega, N'_{so}, N_c^1, N_c^2, N_c^3\}$ and permits eccentricity to vary in addition to the inclination angle. Additionally, elliptic orbits are cheaper to launch into than circular orbits of the same semi-major axis, so holding launch cost constant allows 3D-LFC with higher altitudes. Thus, the search space is significantly expanded, yet still contains the original Galileo constellation design.

Preliminary analysis to reduce the design space consisted of evaluating all 117 3D-LFC over four values of eccentricity and eleven values of inclination:

$$e \in [0.1,\ 0.2,\ 0.3,\ 0.4], \qquad \text{and} \qquad i \in [45°,\ 47°,\ \cdots,\ 65°].$$

Circular orbits were not considered because they all collapse to C-LFC/Walker constellations. The inclination range was chosen to place the Galileo optimal inclination of 56° in the middle. The semi-major axis was held fixed at 29,655 km, corresponding to a repetition time of 17 orbits in 10 days. A satellite was considered in view if it was at least 10° above the horizon (grazing angle).

The constellations were evaluated for both mean GDOP and maximum GDOP encountered throughout the propagation. As a first cut, only solutions with a maximum GDOP below 6 were accepted (corresponding to the original requirements for the GPS constellation [29], [30]). There were 9 3D-LFC out of the original 117 that satisfied this requirement at a variety of inclinations and eccentricities, all of the form

$$\begin{bmatrix} N_o & 0 & 0 \\ N_c^3 & N_\omega & 0 \\ N_c^1 & N_c^2 & N'_{so} \end{bmatrix} = \begin{bmatrix} 3 & 0 & 0 \\ N_c^3 & 9 & 0 \\ N_c^1 & 0 & 1 \end{bmatrix}$$

All of the minima for mean GDOP occurred in the inclination range $i \in [53°, 59°]$ over the full range of eccentricity.

This initial analysis was completed at a fixed altitude, but one advantage of elliptical orbits is their ability to launch into larger orbits for the same launch cost. The GIOVE-A and GIOVE-B satellites, launched as test vehicles for Galileo, launched into 190 km altitude circular parking orbits at an inclination of 51.8° [31]. They were then boosted into their final orbit using a simple two-burn maneuver. Using the limiting case of a 60° final inclination, a minimum eccentricity required to launch into an orbit of a given semi-major axis with the same two-burn maneuver cost as Galileo can be calculated.

Following the design guidelines laid out by the Galileo constellation design engineers, we seek a constellation with a repeating ground-track with repetition times between 5 and 10 days. Shorter repetition times lead to the build up of perturbations as the satellites pass over the same gravitational disturbances repeatedly, whereas longer repetition times pose operational challenges. Given these limitations and the desire to keep the apogee below GEO, we selected nine values of semi-major axis. Table I shows the different values of semi-major axis, minimum eccentricity (for the same launch cost), and maximum eccentricity (for apogee below GEO). Only values of semi-major axis larger than the planned Galileo system were considered because Ref. [28] shows that performance improves as altitude increases (though with diminishing returns, and they considered only circular orbits).

TABLE I
VALUES OF SEMI-MAJOR AXIS USED FOR GNSS OPTIMIZATION

N_p	N_d	a (km)	$e_{\min}$	$e_{\max}$
17	10	29,655	0.045	0.424
13	8	30,561	0.078	0.382
8	5	30,878	0.089	0.368
11	7	31,252	0.101	0.351
14	9	31,464	0.107	0.342
13	9	33,057	0.151	0.277
10	7	33,302	0.157	0.268
7	5	33,753	0.168	0.251
11	8	34,161	0.177	0.236

For the second stage of the design study, another brute force grid search was completed with inclination selected from $i \in [52°,\ 53°,\ \cdots,\ 60°]$, semi-major axis and $e = e_{\min}$ selected from Table I, and the 3D-LFC parameters selected from the 9 3D-LFC down-selected in the first stage.

After selecting the optimal inclination angle for each 3D-LFC at each altitude, one 3D-LFC outperformed all others at all altitudes:

$$\begin{bmatrix} N_o & 0 & 0 \\ N_c^3 & N_\omega & 0 \\ N_c^1 & N_c^2 & N'_{so} \end{bmatrix} = \begin{bmatrix} 3 & 0 & 0 \\ 2 & 9 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

As expected, the best performance occurred at the maximum altitude with $a = 34,161$ km and $e = 0.177$. The optimal inclination was the same as that of Galileo: 56°. The mean GDOP of Galileo was calculated to be 2.32, whereas the mean GDOP of this 3D-LFC designed constellation is 2.24 - an improvement of 3.5%. Given an inclination of only 56° (as opposed to 60°), the minimum eccentricity to achieve the same launch cost to this much larger orbit is 0.15. The mean GDOP varies only slightly (by 0.005) over the allowable eccentricity range, so eccentricity can be chosen based on other considerations. For instance, small eccentricity is attractive from an operational perspective, whereas larger eccentricity increases the allowable on-orbit satellite dry mass.

This 3D-LFC exhibits an interesting property: the satellites share the same geometry of the Galileo constellation at all times, they simply vary in altitude over time. The geometry is not an exact match, as the rotation of the argument of perigee perturbs it somewhat, but the two constellations bear great resemblance to one another. This "breathing" behavior, where the 3D-LFC mimics a C-LFC but with varying altitude, will occur for any 3D-LFC of the form

$$\begin{bmatrix} N_o & 0 & 0 \\ N_c^3 & N_\omega & 0 \\ N_c^1 & N_c^2 & N'_{so} \end{bmatrix} = \begin{bmatrix} N_o & 0 & 0 \\ N_c & N_{so} & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

where N_o, N_{so}, and N_c are the parameters of the associated C-LFC.

The results of this study indicate that the Galileo constellation, at a semi-major axis of almost 30,000 km and 27 satellites, is very nearly optimal. The original designers chose a design point near the knee of the curve where increasing number of satellites or altitude met with diminishing returns [27], which is why the 3D-LFC design could only slightly improve upon the original Galileo design.

C. Design Study: 25 Satellites

The ultimate goal of a constellation designer is a constellation that maximizes performance while minimizing total system cost. Toward that end, reducing the number of satellites in a constellation, thereby eliminating its hardware and launch vehicle costs is one of the most effective means of reducing costs. We consider here the problem of designing an 3D-LFC with 25 satellites, divided into 5 orbital planes, to see what performance can be achieved while reducing the number of satellites by two.

The design approach is the same as in the previous section. For the 25 satellite, 5 plane case, there exist 150 unique 3D-LFC, and these were all studied over a range of eccentricities and inclinations at the original Galileo altitude. The maximum GDOPs encountered by the 25 satellite constellations were significantly higher than the original 27 satellite study, so the initial results were pared down by requiring the mean GDOP to be less than 3 and the maximum GDOP to be less than 16. This left 8 different 3D-LFC which were effective at a variety of eccentricities and inclinations. Table II shows the configuration parameters for these 8 3D-LFC, all of which had $N_\omega = 5$.

TABLE II
ELLIPTICAL FLOWER CONSTELLATION PARAMETERS FOR 25 SATELLITE GNSS

N_c^1	N_c^2	N_c^3
0	2	3
3	2	2
4	2	2
3	3	4
4	3	3
3	4	3
4	4	2
4	4	4

When the altitude was allowed to vary as in the previous section (with $e = e_{\text{min}}$), the maximum altitude was again the most effective. Unlike the 27 satellite case, however, there was significant variation in GDOP as a function of eccentricity, so each of the 8 3D-LFC were analyzed over a range of eccentricities at the maximum altitude.

The best 25 satellite constellation was found to be inclined at 55° with an eccentricity of 0.207 and 3D-LFC parameters

$$\begin{bmatrix} N_o & 0 & 0 \\ N_c^3 & N_\omega & 0 \\ N_c^1 & N_c^2 & N'_{so} \end{bmatrix} = \begin{bmatrix} 5 & 0 & 0 \\ 4 & 5 & 0 \\ 4 & 4 & 1 \end{bmatrix}$$

The mean GDOP experienced with this constellation was 2.49, compared to the 2.24 of the 27 satellite 3D-LFC in the previous section. This 10% reduction in mean accuracy is significant, but may be warranted given the reduced costs of a 25 satellite constellation. Of course, if the spare satellite strategy employed is to place one spare satellite in every orbital plane, then both the 27 satellite, 3 plane constellation and this 25 satellite, 5 plane constellation require 30 total satellites on orbit. The major shortcoming of the 25 satellite constellation is its maximum GDOP of 9.11, compared to a maximum GDOP of 3.87 for the 27 satellite 3D-LFC. A value above 6 is considered unusable [29], so there are times at which users would be unable to get a fix using this system.

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Algorithm Selection for Constraint Optimization Domains

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Abstract—**In this paper we investigate methods for selecting the best algorithms in classic distributed constraint optimization problems. While these are NP-complete problems, many heuristics have nonetheless been proposed. We found that the best method to use can change radically based on the specifics of a given problem instance. Thus, dynamic methods are needed that can choose the best approach for a given problem. We found that large differences typically exist in the expected utility between algorithms, allowing for a clear policy. We present a dynamic algorithm selection approach based on this realization. As support for this approach, we describe the results from thousands of trials from Distributed Constraint Optimization problems that demonstrates the strong statistical improvement of this dynamic approach over the static methods they are based on.**

I. Introduction

When multiple agents operate within a joint environment, inter-agent constraints typically exist between group members. Assuming these agents operate within a cooperative environment, the team must decide how to coordinate satisfying as many of these constraints as possible [21]. Instances of such problems are classic distributed planning and scheduling domains including specific applications such as supply chain management, disaster rescue management, Personal Data Assistant (PDA) scheduling, and military conflict planning [9], [19]. However, solving these real-world problems are challenging as they are known to be of NP-complete, or worse, complexities [10], [12], [19].

Despite the computational complexity inherent in these problems, a variety of algorithms have been suggested [4], [10], [11], [12], [15], [17], [21]. These algorithms differ in what and how agents communicate to attempt to find an optimal assignment. Each of these approaches have different resource cost requirements (e.g., time, number of messages), and are often useful in different problem classes. Thus, an important task for designers of these planning and scheduling systems is to find the algorithm that will work best for a given problem instance.

In this paper we claim that an algorithm selection approach is helpful in dictating which type of approach to use. The key to this approach is that differences between algorithms are typically quite large, and can be locally measured. This allows agents to locally control what information to transfer to group members. To demonstrate the effectiveness of this approach we study a general Distributed Constraint Optimization Problem (DCOP) domain [10], [11], [21]. We performed thousands of trials involving a variety team sizes and problem parameters and found that the described algorithm selection approach was effective in significantly outperforming the static methods they were based on.

II. Domain Formalization and Algorithms Description

In this section, we formally present a general Distributed Constraint Satisfaction and Optimization Problem domain (DCSP and DCOP respectively). The goal within a DCSP or DCOP problem is for distributed agents, each with control of some variables, to either satisfy (in DCSP) or to optimize (in DCOP) a global utility function. DCOP is a generalization of the DCSP problem as the goal is to minimize the number of non-fulfilled constraints, and is thus more suitable for most real-world problems [9]. The DCOP problem has been previously defined as follows [4], [10]:

- A set of N agents A = A_1, A_2 . . . , A_N
- A set of n variables V = x_1, x_2 . . . , x_n
- A set of domains D = D_1, D_2 . . . , D_n where the value of x_i is taken from D_i. Each D_i is assumed finite and discrete.
- A set of cost function f = f_1, f_2 . . . , f_m where each f_i is a function f_i: $D_{i,1} \times \ldots \times D_{i,j} \rightarrow$ N $\cup$ ∞. Cost functions represent what must be optimized and are typically referred to as *constraints*.

- A distribution mapping Q : V $\rightarrow$ A assigning each variable to an agent. Q(x_i) = A_i denotes that A_i is responsible for choosing a value for x_i. A_i is given knowledge of x_i, D_i and all f_i involving x_i.
- An objective function F defined as an aggregation over the set of cost functions. Summation is typically used.

DCOP problems are often represented as connected graphs where nodes must be assigned one of k colors. For simplicity, the assumption is typically made that one assigns an agent to every node within the graph to decide how these nodes should be colored. Thus, the notation A_i and x_i can be used interchangeably [4]. In the DCSP variation the goal of the problems is for every node be assigned a color such that no connected node (often referred to as a neighbor within the graph) has the same color. There is a cost function of ∞ for having two connected nodes with the same color, or in other words, the DCSP contains a hard constraint between nodes (agents). The DCOP problem is a relaxation of this problem. Here the group's utility is based on minimizing the number of constraints that have not been satisfied. According to the DCOP formalization this referred to as F [11].

A range of algorithms exist for solving DCSP and DCOP problems. Well-known algorithms include distributed breakout (DBO) [21], asynchronous backtracking (ABT) [20], asynchronous weak-commitment (AWC) [20] and the Optimal Asynchronous Partial Overlay (OptAPO) [10]. In general, the DBO, ABT, and AWC algorithms are fully distributed algorithms. As such, each algorithm focuses on finding a solution without sending constraint information beyond the local agents (nodes in the graph) with which they have direct communication. These algorithms differ in what local information should be communicated between neighboring nodes, and how neighboring nodes should be prioritized to first attempt a solution. In contrast, the OptAPO requires merging semi-centralized solutions. This algorithm has a "mediator" stage where agents are allowed to directly communicate constraint information of non-local agents. This mediator agent can recommend a potential solution to a set of agents for which it mediates[1], allowing for a solution to be found much more quickly [10]. Thus, these algorithms not only differ in what constrain information is communicated, but also as the degree of problem centralization is used [4].

As the degree of centralization between OptAPO and other DCOP algorithms differs, debate exists how performance should be measured. The most common performance measure, which we based our experiments on, is how many cycles were needed to solve a given problem instance [20]. Within this measure, one unit of "time" is taken as the series of actions where agents process all incoming messages, process those messages, and send a response. In our experiments, we chose the more accepted cycle based measure to evaluation performance[2].

For example, Figure 1 provides an example of a simple DSCP (or DCOP) problem with 6 agents (nodes) and binary constraints (either black or white colors). At left, one finds the original problem state, and the right side provides a solution (or in the DCOP variation F = 0, or no constraints are broken).

We expected that different algorithms perform best in different problem and domain attributes. These attributes can include factors relating to the structure of the problem instance such as the number of nodes (agents), the total number of allowed node colors, and the density of connections between nodes (forming the problem constraints). Additionally, attributes that are external to the graph structure but are domain factors are also likely to be important in deciding which algorithm to use. These factors include the cost of communication between agents, if non-local communication is allowed and if so at what cost, and the time to find a solution.

[1] Note that this set of agents is typically of some size between the number of local agents and the total number of agents [4]. Thus, while OptAPO does not constitute a distributed, local solution, it does not constitute a classic centralized solution either.

[2] Other measures besides cycles have been proposed to evaluate the DCOPs' performance. Meisel et al. [7] have argued that performance should be measured based in terms of the number of computations each distributed agent performs and proposed a concurrent constraint checks measure (ccc) to quantify this amount. A hybrid measure, proposed by Davin and Modi [4], suggest using a Cycle-Based Runtime (CBR) measure that is parameterized between latency between cycles and computation speed as measured by the concurrent constraint checks measure. In their opinion, this measure between accounts for differences in centralization in DCOP algorithms. Note that if one chooses the ccc or CBR measures, or if new DCOP algorithms are found with better performance within the cycle based measure, they can be substituted to study the relative performance of the algorithms under consideration.

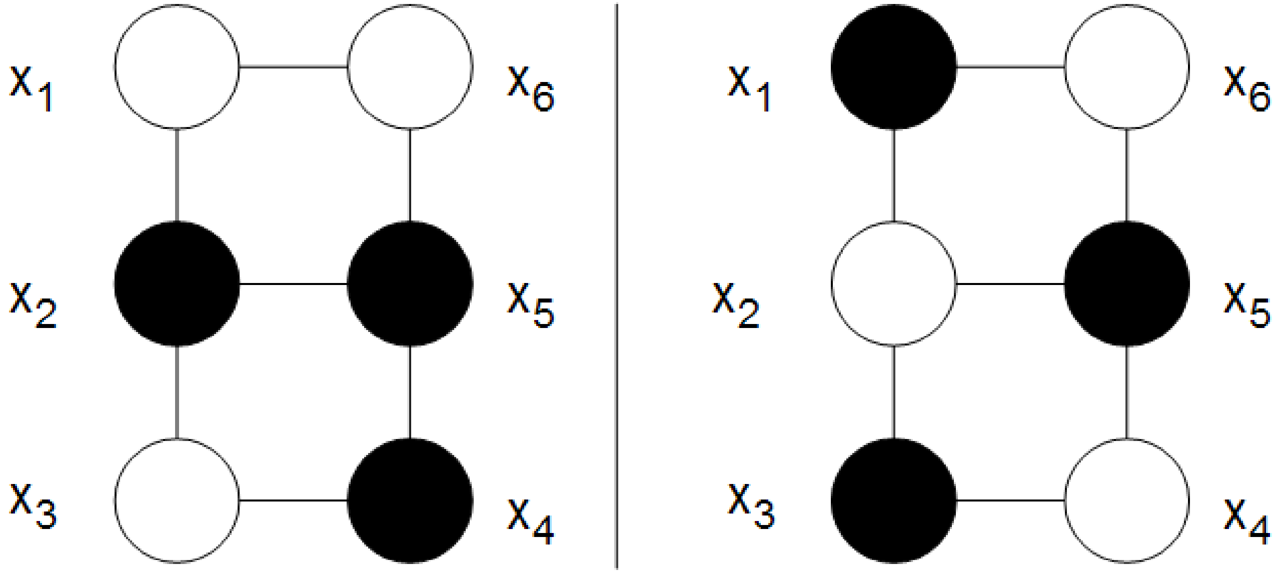

Fig. 1. A sample DCSP problem with 6 nodes (N=6) and 2 colors. The original problem state is at left, with one possible solution at right.

III. Using Phase Transitions to aid Algorithm Selection

This paper focuses on developing an algorithm selection approach for constraint optimization problems. Previously, Rice generally defined the algorithm selection problem as the process of choosing the best algorithm for any given instance of a problem from a given set of potential algorithms [16]. We define the constraint optimization coordination selection process used in this paper as follows: Let $GR = \{a_1, \ldots, a_N\}$ be a group on N agents engaged in some cooperative behavior. Each agent, a, can choose out of a library of coordination algorithms, $\{CA_1 \ldots CA_k\}$. We denote this selection CA_{a_j}, where $1 \leq a_j \leq k$.

Using CA_{a_j} affects the group's utility by a certain value, $\mathcal{UT}^a(CA_{a_j})$. $\mathcal{UT}^a(CA_{a_j})$ is composed of a gain, $\mathcal{G}(CA_{a_j})$, that the group will realize by using algorithm CA_{a_j}, and the agent's cost, $\mathcal{C}(CA_{a_j})$, by using that same algorithm. As this paper assumes the agents within these problems are cooperative, the goal is to maximize $\sum_{a=1}^{N} \mathcal{UT}^a(CA_{a_j})$. To achieve this, each agent must select the algorithm CA_{a_j} from the k possible algorithms in the library whose value $\mathcal{G}(CA_{a_j})$ - $\mathcal{C}(CA_{a_j})$ is highest.

One possible solution involves performing no learning in advance and instead attempts to identify the best algorithm exclusively during run-time. For example, Allen and Minton [1] suggest running all algorithms $\{CA_1 \ldots CA_k\}$ in the portfolio for a short period of time on the specific problem instance. Secondary performance characteristics are then compiled from this preliminary trial to select the best algorithm. Gomes and Selman [5] suggest running several algorithms (or randomized instances of the same algorithm) in parallel creating an algorithm portfolio. However, assuming running each algorithm incurs costs $\mathcal{C}(CA_1) \ldots \mathcal{C}(CA_k)$, these approaches are likely to be inefficient as the cumulative costs of running all algorithms are likely to be higher than the potential gain of finding even the optimal choice.

Instead, we claim that the best algorithm within these problems can be quickly identified based on finding phase transitions within these types of problem instances. The basis of this claim is the previous findings that NP-complete problems are not all equally difficult to solve [3], [13]. Many instances of NP-complete problems can still be quickly solved, while other similar instances of problems from the same domain cannot. They found that phase transitions are a well known phenomenon across which problems display dramatic changes in the computational difficulty and solution character [13].

The concept of phase transitions has been applied to differentiate classes of these "easy" and "hard" NP-complete problem instances [13]. Within distributed constraint satisfaction problems (DCSP), these problems can typically be broken into an easy-hard-easy pattern [11], [13]. The first set of easy problems represent a category of under-constrained problems. All DCSP algorithms typically find an optimal solution quickly for these instances. At the other extreme, the second easy category of problems are those that are over-constrained. Within these problems, the same algorithms can typically demonstrate that no solution exist, and thus these algorithms end in failure. The hardest DCSP problems to solve are those within the phase transition going from under to over-constrained problems, a category of problems also called "critically constrained". These problems are the hardest to solve, with no solution often being found [13].

One may view the DCOP problem as a generalization of the more basic DCSP decision form of the problem. Again, in problems where there are few cost constraints, the optimization requirements are low, and an optimal solution can be quickly found. The "hard" problems exist where optimization requirements are high. However, debate exists if a third set of problems exist similar to the third "easy" problem set where DSCP problems can be quickly shown to have no solution. It would seem that even over-constrained DCOP instances cannot be easily optimized and still comprise "hard" problems [22]. Consequently, DCOP problems should be divided only into Easy-Hard categories (instead of Easy-Hard-Easy) or those easy problems to solve before the problem's phase transition, and "hard" problems after this point [14], [22]. Others have claimed [14] that certain optimization problems may in fact follow an easy-hard-easy distribution. However, this debate is not central to our thesis. According to both opinions, problem clusters do exist, and the difference of opinion revolves around the number of these clusters. If we follow the easy-hard model we should expect to see two clusters of problems with a transitionary phase between the two, but following the easy-hard-easy model should yield three such clusters with two transitionary phases.

Despite the computation complexity in solving all but trivial DCOP problems, a variety of algorithms can be used for attempting a solution in this domain. These algorithms impact when constraints are communicated between agents, thus impacting how the agents attempt to minimize F. We can formally expand the classic DCOP model into an algorithm selection based model by modeling the selection of algorithms $\{CA_1 \ldots CA_j\}$ that each agent can choose in deciding what and how to communicate while attempting a solution. The intrinsically different approaches used by algorithms $\{CA_1 \ldots CA_j\}$ makes them best suited for problems of differing levels of complexity.

This realization significantly simplifies the process of finding those problems instances where a given DCOP algorithm, CA_{a_j}, will be superior to other algorithms within $\{CA_1 \ldots CA_j\}$. Based on this knowledge, we expect to find attributes that separate between fundamentally different types of problems. Assuming each algorithm is best suited for different clusters of problems, a clear policy will be evident as to which algorithm to select, even when agents are confined to using only locally available information. Instead of viewing all domain problems as an enormous state space where we must map the relative effectiveness of algorithms $\{CA_1 \ldots CA_j\}$, we instead focus on finding the problem attributes that differentiate these algorithms, significantly reducing the state space. After these attributes have been found, we expect to be able to further cluster problems as "easy" or "hard" types of interactions. One type of algorithm will then be dominant within the easy problems, followed by phase shift(s)[3] where differences between algorithms are smaller and less apparent, followed by another large problem cluster where a second algorithm becomes dominant. As a result, our research focuses on two important questions: 1. What are the attributes that differentiate between algorithms $\{CA_1 \ldots CA_j\}$? 2. At what attribute values should one switch between algorithms?

IV. Results

Our first step was to implement the algorithm library of the ABT, AWC, DBO, and OptAPO within the previously defined DCOP domain. To do this, we used the Farm simulation environment [6] to create randomized instances of 3-color optimization

[3] We refer to differences in problem instance clusters as phase shifts instead of phase transitions. This follows the distinction made by Brueckner and Parunak [2] who reserve the term "phase transition" to clusters that have been analytically derived and refer to "phase shifts" to describe problem clusters that have been emperically found. As this work derives these problem sets based on emperical observation, we use the second term.

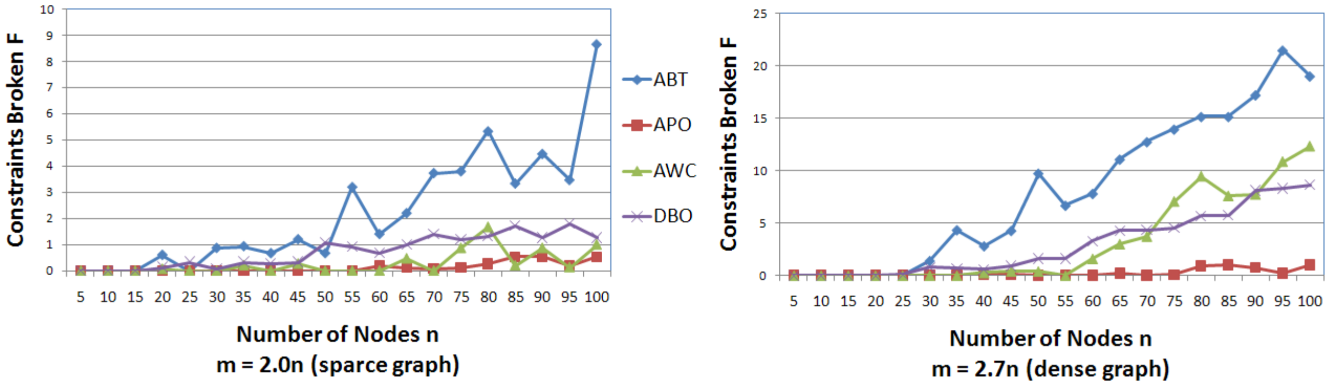

Fig. 2. Graph coloring performance with ABT, AWC, DBO, and OptAPO algorithms with random graphs with 5-100 nodes (X-axis) and edges = 2.0n (left) and 2.7n (right). Each datapoint represents averaged results from 30 runs with 100 cycles per run.

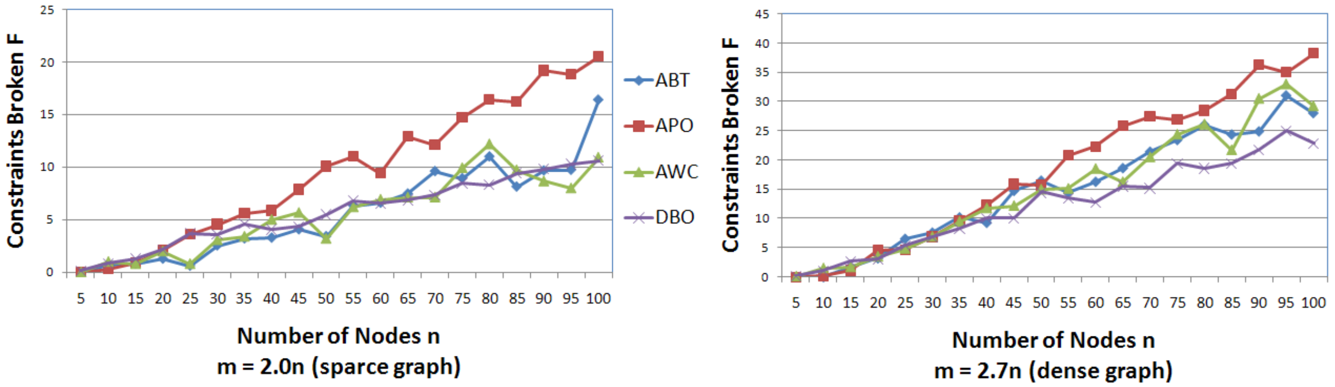

Fig. 3. Graph coloring performance with ABT, AWC, DBO, and OptAPO algorithms with random graphs with 5-100 nodes (X-axis) and edges = 2.0n (left) and 2.7n (right). Each datapoint represents averaged results from 30 runs with 10 cycles per run.

problems. We first varied parameters such as the number of nodes (agents) and edges (which control the number of constraints) within these problems. Specifically, we studied “sparse” coloring graph problems where the number of edges (m), is two times the number of nodes (n), and “dense” graph problems with 2.7 times the number of edges (m) to nodes (n). Traditionally, these parameters were thought to control if a problem instance would be “easy” or “hard” [10].

Figure 2 represents the performance results of the ABT, AWC, DBO, and OptAPO within problem instances. We measured the number of non-fulfilled constraints (F) after 100 cycles. The agents using each of the algorithms did not know in advance how much time would be available to reach a solution. As a result, after each cycle, the system would check if the global utility (F) had improved. If it had, it created a snapshot of this solution, so that the process could be interrupted at any time, and still return the best solution yet found. This allows for creating an interruptible anytime version of these algorithms as per previous definitions of anytime algorithms [23]. Note that in the easiest problems (with 30 or less nodes in both problem sets), no significant differences existed between algorithms as all algorithms were able to solve these problems equally (with the notable exception of ABT). Beyond this point, the OptAPO algorithm on average outperformed all other algorithms. This result is consistent with previous finding demonstrating the effectiveness of the OptAPO algorithm in solving challenging DCOP problems regardless of the number of nodes or constraints (edges) within the problem [10].

However, we found that the best algorithm to use also differed radically based on parameters such as the time allotted to solve a problem instance. In Figure 3 we again ran the ABT, AWC, DBO, and OptAPO algorithms but allotted only 10 cycles of runtime. Note how the APO algorithm performs significantly worse than the other algorithms (in problems with $>$ 40 nodes) with the DBO algorithm performing significantly better, especially in dense graphs with more than 60 nodes. This result is not surprising as the OptAPO is fundamentally different from other algorithms in the amount of problem centralization used. Evidently, this algorithms needs an initialization period in order that its "mediator" nodes have enough information about non-local nodes in order to attempt an effective solution. As such, in these cases this algorithm underperformed that of other purely localized algorithms that had no such overhead.

Communication costs can also radically affect which algorithm we should select. Recall that the goal of our algorithm selection model is to maximize $\sum_{a=1}^{N} \mathcal{UT}^a(CA_{a_j})$ where $\mathcal{UT}^a(CA_{a_j})$ is the gain $\mathcal{G}(CA_{a_j})$ the group achieves by using that algorithm minus the cost, $\mathcal{C}(CA_{a_j})$, paid by using the same algorithm. Again, the OptAPO algorithm is fundamentally different from other algorithms in that it uses non-local communication, giving this algorithm a potential cost $\mathcal{C}(CA_{a_j})$ not existent in other algorithms. Assuming such cost is significant – say because of privacy concerns or communication link cost, the OptAPO algorithm should also be avoided even if unlimited time exist to solve these problems. Indeed we found that the best of the breed of the localized algorithms, (such as the DBO or AWC algorithms), clearly outperforms OptAPO in these types of problem instances.

Figure 4 demonstrates the impact of non-local communication cost on algorithm selection. In this graph we compared the performance of the OptAPO and DBO algorithms in dense graph problems with 100 cycles allotted. When communication was free the APO algorithm (APO-100 Cost 0) did significantly outperform DBO. However, once non-local communication had a cost of 0.02 quality units per communication link, the DBO algorithm outperform OptAPO (APO-100 Cost 0.2)

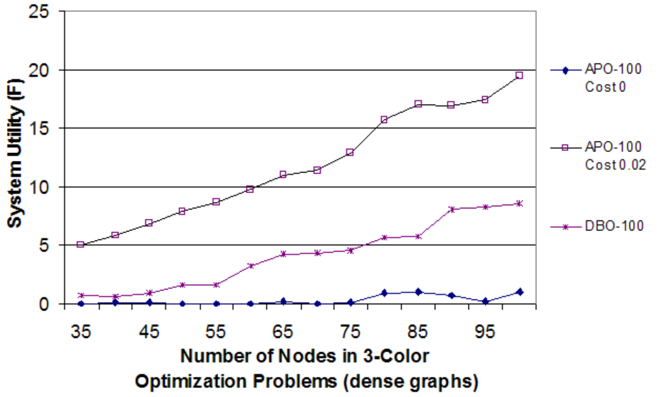

Fig. 4. The impact of non-local communication cost on algorithms studied

Because of the radically different performance of these algorithms, the selection policy is often quite clear. Let us assume that agents are aware of performance limitations such as the time to complete the task, or the cost of non-local links. A clear policy typically becomes immediately evident. For example, assume there is no communication cost and agents need to find the best DCOP solution given a relative long period of time (e.g. 100 cycles or more). OptAPO is then clearly the best choice. Conversely, assuming communication is costly (e.g. cost of 0.02 or more), or only a very short period of time is allocated (e.g. time of 10 cycles or less), the best of the local algorithms, e.g. DBO, was selected. In cases with problem attributes between those with a clearly defined policy (e.g. 50 cycles of time to solve the problem), we considered two possibilities. In the first possibility, a random selection is taken between the borderline algorithms. A second possibility is to calculate the midpoint within the attribute space between these algorithms and to choose the first algorithm for instances before the midpoint and use the second algorithm after this point. While random selection or midpoint heuristics will not likely form the optimal choice in many of these instances, we hypothesized the difference between algorithms in these cases is not large as this the transitional range for this attribute. Thus, the difference between optimal and non-optimal choices within these types of problems was not expected to deviate significantly from the optional choice.

Figure 5 demonstrates the effectiveness of the *Selection* algorithm just described. For comparison, we also display the average group utility (F) as taken from the the static DBO and OptAPO algorithms. We also created an *Optimal* group could run all

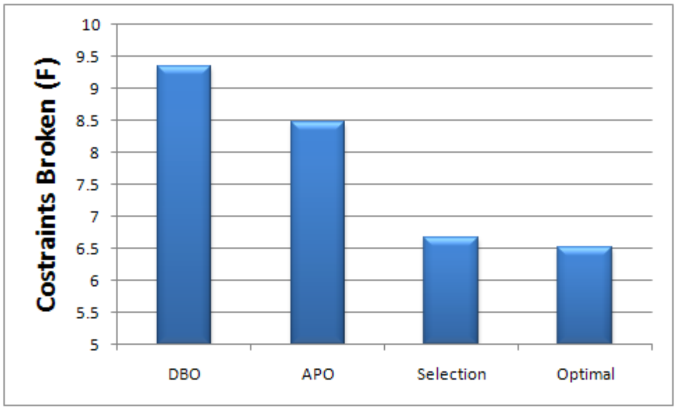

Fig. 5. Comparing the effectiveness of the *Selection* algorithm policy versus the static DBO and OptAPO algorithms

static algorithms without cost, and then accept the algorithm that returned the highest utility. The results in Figure 5 were generated from a total of 100 DCOP 3-color graph problems with random problem attributes in the time to solve the problem, the number of nodes and edge constraints, and non-local communication costs. As these problems instances were randomly selected, many of these problems had problem attributes fell within the problem space where a clear policy existed. Such instances included: instances with long times to solve the problem, very short times, or where non-local communication had a significant cost. In order to strengthen the significance of this experiment, we ensured that at least 25 percent of the problem instances were taken from the category when no clear policy existed. Notice that the *Selection* approach closely approximated the optimal choice, and significantly outperformed statically choosing either DBO or OptAPO. In order to evaluate the statistical significance of these findings, we performed a two-tailed t-test to compare the *Selection* approach to the static DBO and OptAPO methods. The resulting p-score was well below 0.05 (0.02), supporting the significance of the presented approach. Similarly, we compared the dynamic approach with the optimal selection policy and found only an insignificant difference (p-score greater than 0.8) between these values. This supports the claim that randomly selecting between algorithms in borderline cases does not significantly hurt performance.

V. Conclusion and Future Work

In this work we present an algorithm selection approach for solving constraint optimization problems. We focused on two factors: what attributes differentiate between the algorithms and how can we build a selection policy based on those attributes. We present strong empirical evidence of the success of this approach in a general DCOP domain, suggesting the generality of this work.

For future work, several directions are possible. In this work, we manually found the attributes that differentiated the coordination algorithms within the domains we studied. We hope to study how algorithms can be created to automate this process so that novel interaction measures may be learned for quantifying coordination in other domains.

The success of our coordination selection approach was rooted in the realization that different clusters of problems can be created based on the hardness of different agent interactions. We drew upon the "phase transition" concept used to describe some constraint satisfaction problems [13]. However, following Brueckner and Parunak [2] we reserve the term "phase transition" to refer to a term used by physicists for mathematically describable behavior within the system, and instead term the clusters of problems we empirically observed as phase shifts. We hope to study in the future what formal models can be created that can predict where and when these transitions should occur. We believe this study could strengthen the theoretical basis of the work we present.

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Reliable Network Traffic Collection for Network Characterization and User Behavior

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***Abstract*—This paper presents a reliable and complete traffic collection facility as a first and crucial step toward accurate traffic analysis for network characterization and user behavior. The key contribution is to produce an accurate, reliable and high fidelity traffic traces as the valuable source of information in the passive traffic analysis approach. In order to guarantee the traces reliability, we first detect the bottlenecks of the collection facility, and then propose different monitoring probes starting from the ethernet network interface and ending at the packet trace. The proposed facility can run without stop for long time instead of one-shot periods, therefore, it can be used to draw a complete picture of network traffic that fully characterize the network and user behavior. The laboratory experiments conclude that the system is highly reliable, stable and produces reliable traces attached with different statistics reports that come from the installed monitoring probes.**

I. Introduction

Presently, Internet supports wide variety of applications via many protocol architecture instead of just data transfer. For example, data, voice signals, images and videos are supported by the same network infrastructure [1]. Due to the mixing nature of network traffic with targeted high speed connections, the understanding of the traffic behavior has become a difficult task. Traffic collection and analysis is considered as the right way for the network understanding and management [2].

Passively collected traffic traces include huge amount of information that is useful for the measuring of almost all network related activities. The analysis of packet traces provides information from user, network and service perspectives. It allows the identification and measurement of general trends of many different metrics useful for engineering, management and provisioning of the gigabit ethernet networks. The accuracy and reliability of the collected traffic traces have a direct impact on the outcome of different trace-based operations such as network characterization, traffic engineering [3], traffic modeling and user behavior estimation [4].

The accuracy and the reliability are two key issues of passive traffic collection. Collecting reliable packet traces without packet loss can be a difficult operation on gigabit ethernet networks under the usage of commodity based hardware and software. Conducting traffic analysis over incomplete and unreliable traffic traces leads to inaccurate results unless data losses are explicitly considered before the analysis process [5].

According to the resource constrains, the available collection facilities collect only one-shot of the network traffic that does not contain enough amount of information that reflexes the accurate characterization of the network. Additionally, these collection systems do not provide any reliability reports about the collected traces, and hence, the analysis results of these traces may be inaccurate and unreliable. A reliable packet capturing facility must be equipped with a mechanism to accurately report the time and amount of packet loss during the trace collection operation [6].

The usage of on-the-shelf hardware and software for packet capturing on a high-speed (1 Gbps or higher) is sensible to packet losses. Most of the carried out researches with the commodity equipments is directed toward enhancing the performance of packet capturing with respect to software [7], and hardware [8] in order to cope the network line speed [9]. Data Acquisition and Generation (DAG) [10] is a dedicated hardware solution for reliable packet capturing on high-speed networks with high cost compared to the commodity solutions.

This paper focuses on the reliability of the collection facility, and presents a reliable and complete traffic collection facility using commodity hardware and softwares. The efficient usage of the produced facility provides a very useful information for different network users [4]. Network users be categorized into Internet Service Providers (ISPs), devices and hardware manufacturers, network administrations and network researchers. ISPs use traffic analysis results for billing their customers, identifying the dominant applications, and hence they can build an accurate Service Level Agreement (SLA)[11]. Moreover, ISPs can use the traffic analysis for network management, provisioning and troubleshooting recovery. Hardware providers use traffic analysis results for measuring devices behavior under different conditions, and hence they can make decisions to enhance or redesign the current network devices. Traffic analysis will be useful for network administrators to detect the up normal behavior of the network traffic. Researchers use network traffic analysis to understand and developing different traffic models.

The reminder part of this paper is organized as follows. Section II demonstrates the structure of the generic collection facility with bottleneck points, and emphasising the proposed network interface monitoring approach. Section III explains the implementation of the network interface monitoring approach. Section IV shows the exhaustive evaluation of the reliable facility in terms of resources overhead and accuracy. Conclusions and future work are reported in section V.

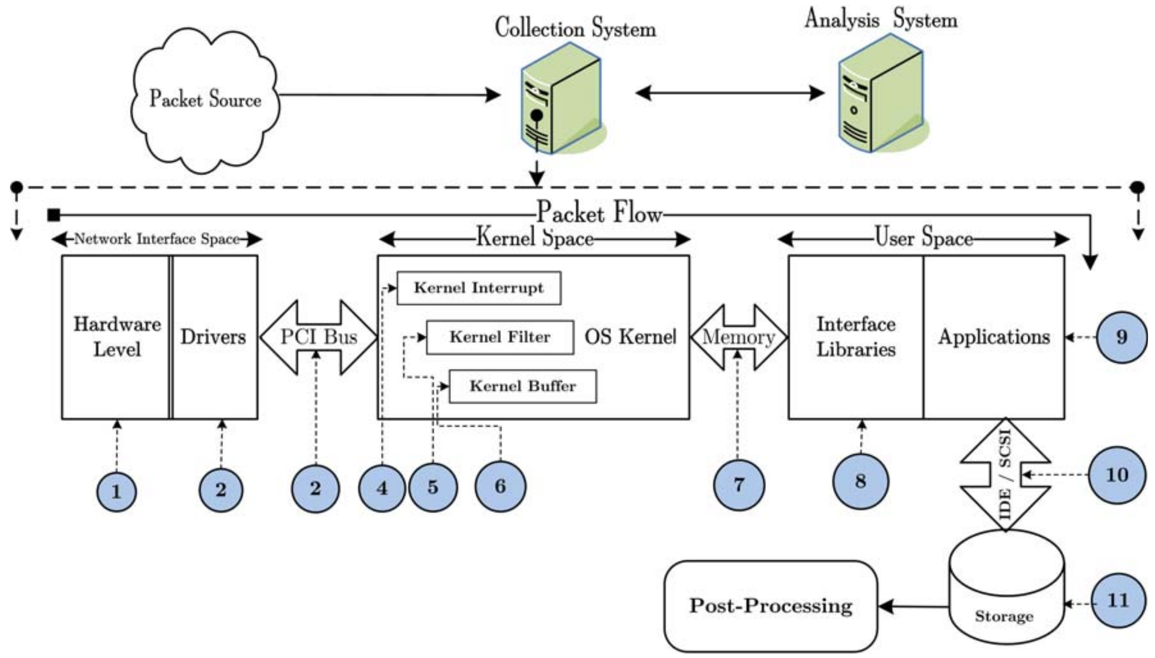

Fig. 1. A Complete traffic collection facility with bottleneck points marked in circles. The bottlenecks diffuse in almost all system spaces.

II. Reliable Network Traffic Collection

This research focuses on the passive traffic measurement methodology to address the traffic collection and analysis problem in the residential networks. However, it is not easy to do continuous passive measurement, but on the other hand, passive measurement provides a complete picture about network traffic. Moreover, different traffic analysis phases can be conducted on the traffic traces from different perspectives. The performance metric of any passive collection is the lossless packet capturing at link speed. Dropped packet will produce problem in the next processes (anonymization, analysis, etc.). Each component in the collection facility has its own characteristics and limitations. Therefore, the bottlenecks are distributed over all components. Fig. 1 shows the bottlenecks through the packet journey through all collection facility components.

A closed look at Fig. 1 shows that the traffic collection facility suffers from many bottleneck points starting from network interface, passing though kernel space, and ends with the packet capturing applications in the user space. Every system bottleneck point can lead to packet drops without any feedback information to the system operator. Unreported packet drops deteriorates the reliability of the traffic collection facility especially at the 1 Gbps link speed.

The available solutions of the collection bottlenecks are designed to overcome one point to enhance the collection performance in terms of packet loss and scalability to link speed. Those solutions can be divided into software-based such as Driverdump [12] and Interrupt Coalescence (IC) technique [13], kernel patching [14] and hardware-based solutions such as Network Processor (NP) [8], [15], [16], and special purpose DAG card [10]. Some solutions try to build special purpose facilities, but those solutions are cost inefficient. The problem with the previous solutions is that they have been designed for special purpose or enhancing a particular point. Additionally, the implementations of those solutions may become difficult due to some coding problems or the high cost. We have built a new solution for bottlenecks and insure the system reliability by installing monitoring probe for each system bottleneck using commodity based hardware and software. The most important probe is the network interface monitoring approach.

A. Network Interface Monitoring Approach

Network interface card is the first contact point inside the collection machine that can hold all packets including the correct and the erroneous ones at 1 Gbps link speed. Network interface monitoring approach uses network interface capability to monitor all coming in and out packets to the collection machine before its pumping up to the upper levels. We could correlate the produced report with the trace file in the post processing to detect the packet loss, and judging the packet trace reliability for the collection session.

The idea behind monitoring the ethernet network interface is considered as two folded process: (1) Open a socket for direct communication with the network interface drivers, and (2) Information exchange between network interface drivers and the monitoring tool agent in the user interface. In order to retrieve statistics directly from hardware, the proposed monitoring approach takes advantage of the support provided by the Ethtool Linux utility [17]. Ethtool is a GNU/Linux tool that allows obtaining information and diagnostics about ethernet card settings related to media, link status, and more. Precisely, the `ethtool_stats` data structure provided by its API enables dumping the network interface specific statistics to the user space, and store them in a statistics file.

III. Implementation Phase

The proposed monitoring approach has been fully implemented with the C programming language and under Linux environment. Beside different additional functions, the implemented core function is `do_gstats()` which is responsible for consulting the network interface hardware via its drivers, open a User Datagram Protocol (UDP) socket and retrieving back the available statistics.

The simplified interconnections diagram of the implemented functions is shown in Fig. 2. The `main()` function has a direct connection to the `do_metatrace()` which is responsible for creating the output file name, print file headers and arrange the spaces between columns. The time stamp is calculated using `delta_time()` before each hardware check. The `delta_time()` has a time stamp sensitivity up to 1 microsecond, therefore, the proposed approach is able to read the network interface hardware statistics values every 1 microsecond. The function `do_print()` is used for printing the output results to a statistics file or directly to the screen based on the way of its call and the passed parameters. The function `main()` can also directly call `do_gstats()` and print the results directly to the screen instead of writing it to an output file.

A. The Function `do_gstats()`

The function `do_gstats()`is the most important one inside the implementation structure, and it is declared as `do_gstats(char *ifname, int s_order)`. While `ifname` is a pointer to the network interface name, and `s_order` is the order of the statistic indicator inside the data array. The `do_gstats()` function returns an `unsigned long long` statistic values depend on the input parameter `s_order`. The sequence of `do_gstats()` instructions starts with setting all parameters and access all data structures, then open a UDP data socket through network interface drivers to access hardware statistics. Through the opened socket, the hardware statistics are dumped to an array, then the `do_gstats()` returns the selected element to be recorded in the statistics file. Fig. 2 shows the calling methods of `do_gstats()` and its relation with the other functions. As a general remark, in order to implement the method outlined in this section, the implementation code should include `<linux/netdevice.h>`, `<linux/etherdevice.h>`, and `<linux/ethtool.h>` Linux headers files.

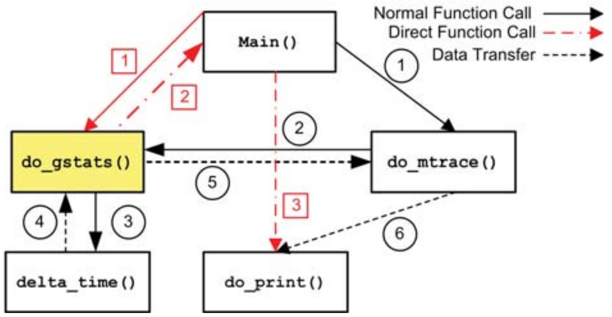

Fig. 2. Functions interconnection diagram of the monitoring approach

IV. Experimental Evaluation

The presented results in this section have been obtained from experiments that have been conducted in a controlled environment constructed from one PC and one Laptop. The PC works as a traffic collector and equipped with Intel Pentium® 4 Processor 3 GHz, 1 GB of RAM, Intel gigabit ethernet card, and 160 GB hard disk. The Laptop works as traffic generator and equipped with Intel Core 2 Due$^{\text{TM}}$ 2.5 GHz Processor, 4 GB of RAM, and Intel Gigabit Ethernet card. The two computers are directly connected through a gigabit ethernet cards via special type UDP cable. Both machines have been equipped with an implementation of the network interface monitoring approach.

The collector machine has been installed with Ubuntu Linux kernel $2.16.18-1.2200$, PF_RING patched kernel [14], Tcpdump version 3.9.4 with Libpcap version 0.9.4 [18]. It is worth noticing that Libpcap has been recompiled with the PF_RING toolkit modifications, also the Tcpdump has been recompiled against the PF_RING modified by Libpcap. The generator machine has been installed with the same Ubuntu Linux kernel. The traffic is generated with the open source PackETH as a packet generator toolkit [19].

A. Monitoring Approach Overhead Test

We first considered the CPU overhead introduced by the periodical (1 second) monitoring granularity. We have run two independent tests: (I) Tcpdump packet capturing with monitoring approach enabled, and (II) Tcpdump capturing with proposed loss monitoring enabled. We have sent a fixed amount of generated packets, (2 millions packets), into the collector machine. Fig.3 shows the CPU utilization of both experimental scenarios. From that figure, running the monitoring technique in parallel with Tcpdump does not introduce high extra CPU overhead, and hence, the proposed monitoring approach does not provide a resource limitation at the network interface saturation point.

B. Facility Overall Accuracy Test

This test is carried out to check the facility performance with enhanced Linux kernel using PF_RING explained in [14]. Fig. 4 shows the generated packet rates for each packet

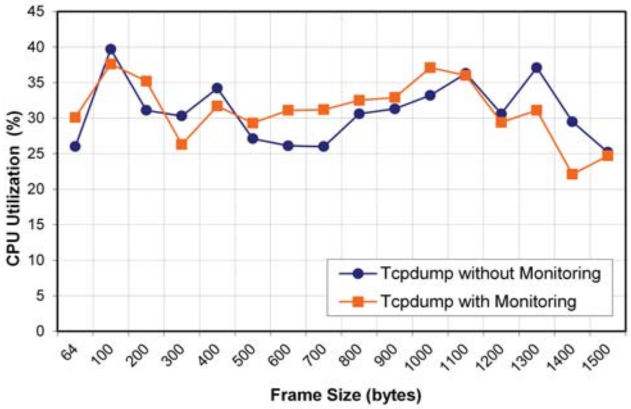

Fig. 3. CPU utilizations for one collection session with monitoring approach.

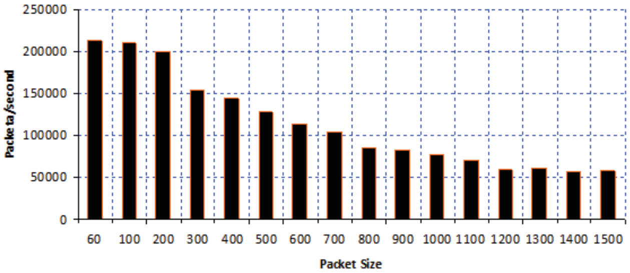

Fig. 4. Packet generation rates measured in generator side.

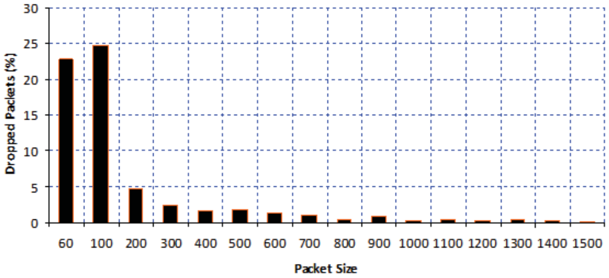

Fig. 6. The accuracy of the collection facility in terms of packet loss.

sizes. The plotted data have been taken from the statistics file produce by the monitoring approach in the traffic generator side. Additionally, from the collector point of view, Fig. 5 shows the percentage of the collected packets for each packet size. The figure proves the high packet losses at short packet sizes. The overall accuracy can be predicted by finding the difference between the generated and the collected packets. Of course, the packet trace reliability is determined according to the amount of dropped packets compared to the generated ones. The dropped packets are directly reported by the monitoring approach (values in the statistic files). While the kernel drops are measured as the difference between captured packets and packets received by the network interface (deduced from statistics information). From Fig. 6, the proposed monitoring approach is always reporting the total generated packets (received + erroneous) with 100% accuracy, and hence, the reliability of the packet trace can be measured by correlating the reported packets by the proposed approach and the actual collected packets in the trace file.

C. Discussion

Although the related work shows many special purpose hardware and software solutions for packet drop problem, the presented results in this section prove the superiority of using commodity based hardware and software in the proposed solution with invented monitoring probes at every bottleneck in the collection facility. The statistic files produced by each monitoring probe can be correlated with the actual recorded packets in the trace file, and hence, we get knowledge about where and when the packet was dropped. The actual packet trace is then sanitated further to remove the gaps of the dropped packets which finally produces a reliable packet trace. Once we got a reliable and accurate passively collected packet trace with attached monitoring reports, the traffic analysis for network characterization and user behavior will be the next phase of this research.

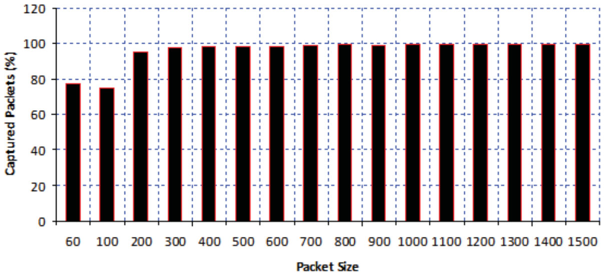

Fig. 5. Packet collection percentage (%) measured in collector side.

V. Conclusion and Future Work

This paper was directed toward enhancing the reliability of traffic collection facility. It has presented a new network interface monitoring approach in order to increase the reliability of the collected packet trace. The evaluation results have proved that the proposed mechanism is non-intrusive for the traffic trace collection with respect to CPU consumption, packet generation and packet collection. The experimental works conclude that purposed monitoring approach is a feasible and practical tool for reliable packet trace collection. As a future work, the proposed approach can be extended for different ethernet cards and implemented for wire and wireless network interfaces on different Linux platforms.

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