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Computing and ICT no doubt form important pillars in the present day global modern technological processes and development. Although Africa can be said to have improved substantially in the quest for knowledge in this age, much structural advancement and progress in the larger part of the continent have not been noticed. This can be partly ascribed to the relatively meager investment and financial commitment to providing infrastructure for sustainable research. The effect of this is that the technological state and needs of the general African continent are not the same as those of the developed world. As such, research output which may be important for the present socio-econo-technological state of the continent may not quite appear useful in the developed world, and are thus usually not considered fit for their journals. Apart from this, there are relatively few journals based in the African continent that are devoted exclusively to papers on computing and ICT.

It is in the light of the above that the African Journal of Computing & ICT is born for the purpose of publishing nontrivial relevant research results in the fields of computer science/engineering, information technology(IT) and allied fields. Every submitted paper is multiple blind-reviewed for quality, relevance, depth and accuracy. We are committed to excellence in publishing and desire that the Afr, J of Computing and ICT will be a prime avenue for the dissemination of cutting edge research report by Africans, for Africa and all lovers of research and development all around the world. We intend to promote indigenous Computing and ICT development through the dissemination of cutting edge research and development report with a view of reducing the heavy dependence on importation of ICT-related products. The journal welcomes papers from African scholars and also from non-Africans whose papers address important issues that are relevant to Africa.

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This volume of the African Journal of Computing & ICT contain six (6) articles that have been subjected to rigorous peer review by experts in the subject domain. The articles articulate issues of Research and Development related to health informatics and modeling, information security, electronic learning, electronic voting, electronic designs, web functionalities, web ethics and online behavior. They definitely make for insightful reading.

The first paper by Tomar et al presents a Multi Media based Medical Decision Support System for diagnosis of occupational chronic lung diseases. Expert knowledge used was elicited through interview and literature search. A decision tree, along with literature derived probabilities and defined outcome values, were used to model given problem instances. Needed diagnostic knowledge was represented using diseases’ profile in the form of rules. Preliminary results from these efforts showed promising usage for the MM-MDSS in terms of correct and accurate diagnosis for the inexperienced pathologist as well as consistent and timely diagnoses for the range of chronic lung diseases that were investigated.

In the second paper, Adeyiga et al examined the challenges with the migration of most banking operations to online platform in Nigeria as impacting on consumer confidence. Their study applied neural network techniques to the bank fraud prediction problem using Nigerian banks as points of reference. A Neural Network-Based Model that employ multilayered Feed Forward Artificial Neural Network on database system for collecting training data for the Artificial Neural Network. They hope to test the Intelligence of the system on data extracted from statements of accounts from different banks in Nigeria in the future.

In the third article, Ebem and Longe characterize research efforts directed at determining speech quality through the use of comparative algorithms. Based on methodologies that calculate index value of quality using the Perceptual Evaluation of Speech Quality (PESQ) - ITU-T Recommendation P.862 and other measures, they benchmark speech quality, on the tonal language Igbo -a language spoken in south eastern- Nigeria. Results from their experiments shows a good correlation between the subjective and objective measurements on the tonal language Igbo with a correlation coefficient of \( r = 0.88 \) on the overall data set.

The fourth paper by Olaniyi et al presented the design and implementation of an integrated multilingual voting service infrastructure for conducting credible elections in rural and suburban communities in developing countries. The result of the testing done in Nigeria on the framework using Hypertext processor Web platform and Google Android mobile platform using local languages suggests that the implementation will assist in the conduct of free, fair, transparent, convenient and confidential electoral processes.

Iyalomhe in the fifth paper demonstrate the importance of a clear understanding of the variables for climate change and its consequences both human environment and livelihood in developing countries. He hinged the inability to tackle the problems of climate change in developing countries on several bio-physical and socio-economic processes. The paper concluded by showing how climate and human systems influence the level of vulnerability and adaptation to climate change based on a theoretical climate change vulnerability.

In the last paper, Uyinomen et al proposed an improvement to CAPTCHA DC algorithms by introducing unifying components that aids DC algorithms in effectively detecting the maximum and minimum allowable DC level for each CAPTCHA. The algorithm works by increasing DC for sparsely dense scenario and keeps track of tests that human users have failed to recognize CAPTCHA tests as a way of creating a knowledge base for future improvements. The proposed unifying algorithm is expected to capture and automatically generate any type of DC.

We appreciate and welcome feedbacks, comments and rejoinders.

With very best compliments

Longe O.B (PhD)
Managing/Production Editor
Multimedia Based MDSS For Chronic Lung Diseases Diagnosis Using Rule Based Technique

Prem Pal Singh Tomar, Ranjit Singh & P K Saxena (Rtd.)
Faculty of Engineering
Dayalbagh Educational Institute, Agra, India
singhppst@rediffmail.com, rsingh_dei@yahoo.com, premkumarsaksena@gmail.com

ABSTRACT
Detecting diseases at early stage can help to overcome and treat them accurately. Identifying the appropriate treatment depends on the method that is used in diagnosing the diseases. Rule Based technique of Artificial Intelligence (AI) is appropriate methodology for medical diagnosis. This paper presents an architecture of Multimedia based Medical Decision Support System (MM-MDSS) for diagnosis of occupational chronic lung diseases. The Expert knowledge was elicited through interview and literature search. A decision tree, along with literature derived probabilities and defined outcome values, were used to model MM-MDSS. The needed diagnostic knowledge was represented using diseases' profile in the form of rules. Microsoft Visual Basic .Net 2005 and Microsoft SQL Server 2005 were used for the design, implementation and evaluation of the system. 150 samples of 14 occupational chronic lung diseases were used for the system’s implementation, while a Consultant Physician’s interpretation for 24 new cases was used to evaluate the system. Results for Sensitivity, Specificity, Positive Prediction Value and the Negative Prediction Value are 97.7%, 95.0%, 99.2% and 86.3% respectively. Thus, the preliminary results showed promising usage for the MM-MDSS in terms of correct and accurate diagnosis for the inexperienced physician as well as consistent and timely diagnoses for the range of chronic lung diseases that were investigated.

Keywords- Multi Media based Medical Decision Support System (MM-MDSS), Expert Knowledge, Occupational Lung Diseases, Decision Tree, Decision Analysis.

1. INTRODUCTION

Expert systems technology is a product of the eighties [1]. Since 1981, however the emerging field of expert and knowledge-based systems has changed dramatically [2]. Expert system can be defined as those AI systems that solve complex systems in specialized area by emphasizing the domain-specific knowledge that underlies human expertise in those areas, rather than any domain-independent formal reasoning methods [3]. The three major components of ES are: Knowledge base (KB), inference engine (IE), and user interface (UI).

For better interaction with users an ES should preferably contain an explanation subsystem component or justifier [4] [5]. The knowledge base contains the relevant knowledge necessary for understanding and formulating the ES domain. In rule-based expert systems that are supported with a database, the knowledge base is modeled to include two components: (1) rule base of heuristic rules that are used to solve specific problems in a particular domain, and (2) database of domain’s data and facts. The inference engine is the component that provides a methodology for reasoning and formulating conclusions. The inference engine provides directions about how to use the system’s knowledge to solve problems. The user interface consists of all screens of interaction between the user and the ES. Explanation subsystem helps in justification of ES conclusions by tracing conclusions to their sources and showing how was a certain conclusion reached [6].
The medical information technology for emulation of human reasoning process and human expert problem solving is knowledge-based system. In literature survey, MYCIN [7] is an expert system for diagnose or remedy bacterial infections, PUFF [8] is developed to diagnose lung disease, ANGY helps physicians to diagnose the narrowing of coronary vessels by identifying and isolating coronary vessels in angiograms, BABY aids clinicians by monitoring patients in a newborn intensive care unit (NICU), MECS-AI helps physicians to make diagnoses and to suggest treatments for cardiovascular and thyroid diseases, PIP assists physicians by taking the history of the present illness of a patient with edema. In the absence of ample clinical evidences, many decision-makers have a natural tendency to make overly optimistic, uniformed decisions when faced with complex situation, these choices appear to be made more on the basis of intuition than rational weighing of outcomes and probabilities[9][10]. This phenomenon has created a need for the application of more objective decision-making techniques, among them being clinical decision analysis.

Pulmonary function tests, NEOMYCIN helps physicians diagnose and treat patients with meningitis and similar diseases, MED1 helps physicians diagnose diseases associated with chest pain. GUIDON for instruct in bacterial infections, and HEME helps physicians diagnose hematological diseases.

In clinical practice, making decision involves a careful analysis of harms and benefits associated with different treatment options. These decisions, often associated with high stake and important long term consequences, are frequently made in presence of limited resources and information and an incomplete clinical picture. Under such circumstances, a rigorous and objective analysis of outcomes and probabilities is essential to achieve the best possible decision given a specific clinical situation.

2. RULE BASED SYSTEM MODEL

A system whose knowledge base is represented as a set of rules and facts is called Rule Based System (RBS) (Figure 1). A RBS consists of a collection of IF-THEN rules, a collection of facts, and some interpreter controlling the application of the rules, given the facts. The rules are represented in following form:

\[
\text{IF } \text{<antecedent}> \text{ THEN } \text{<consequent>}
\]

When the antecedent part is NULL the rule becomes a fact, the rules are normally represented as Horn Clause, like

\[
P \rightarrow Q \quad \rightarrow P \lor Q
\]

\[
P \land Q \rightarrow R \quad \rightarrow P \lor Q \lor R
\]

![Figure 1: Rule Based System Architecture](image)

Inference machine is a machine that implements strategies to utilize the knowledge base and derive new conclusions from it. There are three phases in inference machine (1) Match phase (2) select phase/conflict resolution phase (3) Execute phase.

The conflict resolution phase comes in action when two or rules are triggered in the match phase i.e it decides which of the triggered rules in a particular stage should be fired. The conflict resolution can use various strategies as follows:

(1) First Come First Serve (rule ordering)
(2) Specificity ordering
(3) Fire all rules
(4) Heuristic measures (distance from the goal)
(5) Refractoriness
(6) Meta rules

The execute phase fires the rules once all its antecedents match. Essentially, the function of the execute state can be thought of as searching a path to the goal in a search space [5].

2.1 Advantages of Rule Based Systems:

1. Permanence - knowledge based systems do not forget, but human experts may.
2. Reproducibility - Many copies of an knowledge based system can be made, but training new human experts is time-consuming and expensive
3. Efficiency - can increase throughput and decrease personnel costs. Although knowledge based systems are expensive to build and maintain, they are inexpensive to operate. Development and maintenance costs can spread over many users.
4. The overall cost can be quite reasonable when compared to expensive and scarce human experts.

5. Humans are influenced by recency effects (most recent information having a disproportionate impact on judgment) primacy effects (early information dominates the judgment).

6. Documentation - A knowledge based system can provide permanent documentation of the decision process.

7. Completeness - A knowledge based system can review all the transactions, a human expert can only review a sample.

8. Timeliness - Fraud and/or errors can be prevented. Information is available sooner for decision making.

9. Consistency of decision making.

10. Documentation.

11. Achieve Expertise.

2.2 Disadvantages of Rule-Based Systems:

1. Common sense - In addition to a great deal of technical knowledge, human experts have common sense. It is not yet known how to give knowledge based systems common sense.

2. Creativity - Human experts can respond creatively to unusual situations, knowledge based systems cannot.

3. Learning - Human experts automatically adapt to changing environments; knowledge based systems must be explicitly updated.

4. Sensory Experience - Human experts have available to them a wide range of sensory experience; knowledge based systems are currently dependent on symbolic input.

5. Degradation - knowledge based systems are not good at recognizing when no answer exists or when the problem is outside their area of expertise [11].

1. KNOWLEDGE ACQUISITION

Knowledge acquisition is a process of acquiring, organizing and studying knowledge for the diseases. The data and knowledge of RBS are collected from different sources. The first primary source is, acquired from a physician. The second source is from specialized databases, books and a few electronic websites. This knowledge can be divided by important facts.

Decision analysis and the decision tree decision analysis is an objective, explicit method that uses models to represent specific decision problems. Factors involved in choosing a given strategy from a group of possible actions are quantitatively evaluated [12] [13]. Decision analysis requires the construction of a Decision tree, which illustrates all plausible relationships, alternatives and outcomes involved with a given decision[12][14]. Associated with each step in the decision tree is a corresponding probability and outcome value. Incorporating probabilities and outcome values, the decision analysis model expresses its conclusion in terms of an average expected result [13]. By using such a tree, a decision maker can accurately weigh and compare outcomes associated with a given decision, thus leading to a more informed clinical decision [12][15]. Decision analysis is most usefully applied in clinical decisions where there is uncertainty regarding appropriate clinical strategy and when a meaningful tradeoff of advantages and disadvantages is present in the clinical problems. The decision trees are adaptable and values represent a current and not static, benchmark on which further evolution can be critically evaluated [12].

Figure 2: The Various Modules of Proposed Architecture of MM-MDSS

3.1. Symptom Acquisition and Development
The various modules of the proposed architecture of MM-MDSS are shown in Figure 2. The details about the symptoms are collected from the users or patients. Various diseases will have symptoms which vary from each other. A questionnaire was designed to collect the data from 150 samples suffering from different 14 occupational chronic lung diseases. Microsoft Visual Basic .Net 2005 platform was used for the design and development of a Rule Based Diagnostic Medical Decision Support System with the advantage of Object
Oriented Programming technology. The Microsoft SQL server 2005 was used to develop the database module. Screenshots of the MM-MDSS are shown in Figure 3 and Figure 4 respectively.

![Microsoft Visual Basic .NET 2005, Symptom acquisition module window.](image)

![Microsoft SQL server 2005, database window](image)

3.2 Reasoning procedure:
The architecture (Figure 2) presented here adopts the Rule Based Reasoning (RBR) strategy. The inputs received from the user as symptoms and signs of the disease are fed into the RBR portion of the reasoning module. The strategy was verified by conducting several tests by the Domain expert of lung diseases. If diagnosis can be made, it is presented to the user. If a diagnosis cannot be made, the user is given the intimation that a diagnosis cannot be made, due to wrong symptoms input.

3.3 Diagnostic procedure:
Based on the symptoms entered by the user Diagnosis or the inference engine makes the diagnosis of the disease. Based on the results produced by the reasoning module, a conclusion is arrived at disease suffered by the patient. Based on conclusion, a diagnosis is made and the patient is given advice on the treatment that should be taken to cure his/her disease.

3.4 Explanation procedure:
The Explanation Module gives the path through which the diagnosis was reached. The diagnosis can be taken with the help of the Rule Based Reasoning module. This is analysed by the medical expert and if the route of diagnosis and the diagnosis is right else necessary changes are made to the rules so that a right diagnosis can be made.

4. MEDICAL MULTIMEDIA SUPPORT

Multimedia (MM) is an increasingly important tool in training and development for high-technology medical techniques and education [16]. A Medical Multimedia module (Figure 5) adds another important dimension i.e. use of Multi Media technologies in Medical Decision Support System to generate an excellent Multi Media environment by supporting alternate decisions through text, graphics, audio, images, animation and visual impressions and mitigates uncertainty by providing rich information that generate a totally new level of cognitive-style thinking in Clinical Decision Making for more effective and efficient medical decisions.
5. SYSTEM EVALUATION

Using a Consultant physician’s interpretation as a “gold standard” (reference test), the system’s parameters for diagnosing lung diseases were calculated [17].

(1) True positive (TP):
The diagnostic system yields positive test result for the sample and thus the sample actually has the disease; 

(2) False positive (FP):
The diagnostic system yields positive test result for the sample but the sample does not actually have the disease; 

(3) True negative (TN):
The diagnostic system yields negative test result for the sample and the sample does not actually have the disease; and 

(4) False negative (FN):
The diagnostic system yields negative test result for the sample but the sample actually has the disease.

The formulas used for calculating Sensitivity, Specificity, PPV and NPV are:

Sensitivity = \frac{TP}{TP+FN} \times 100\% \quad \ldots (1)

Specificity = \frac{TN}{TN+FP} \times 100\% \quad \ldots (2)

PPV = \frac{TP}{TP+FP} \times 100\% \quad \ldots (3)

NPV = \frac{TN}{TN+FN} \times 100\% \quad \ldots (4)

Using equations (1), (2), (3) and (4), respectively, the Sensitivity, Specificity, Positive Prediction Value (PPV) and the Negative Prediction Value (NPV) of the system are:

Sensitivity = 97.7\%;

Specificity = 95.0\%;

PPV = 99.2\%;

NPV = 86.3\%.

6. CONCLUSIONS

The Multi Media based Medical Decision Support System (MM-MDSS) using RBS has been designed and implemented for getting an appropriate diagnosis of occupational chronic lung diseases. The results of Rule based reasoning strategy indicated encouraging retrieval accuracy with correct symptoms.

The expert physician evaluated the system performance by testing it practically for 24 new cases where the system succeeded in estimating the correct diagnosis. This architecture can also be used in the diagnosis of other diseases like diabetes, cardiac diseases, anaemia etc. The rule-base can be enriched according to the new cases. It is evident that Rule Based technique of Artificial Intelligence (AI) is appropriate methodology for all medical domains and tasks for the following reasons: cognitive adequateness, explicit experience and subjective knowledge, automatic acquisition of subjective knowledge, and system integration. Rule Based technique presents an essential technology of building intelligent Multi Media based Medical Decision Support System for diagnosis that can aid significantly in improving the decision making of the physicians.

Future research involves more intensive testing using a larger database from local foundry and diesel engine industries to get more accurate results.

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REFERENCES


Author’s Briefs

Prempal Singh Tomar has extensive and well-rounded experience of eleven years in Technical Education at UG and PG level. He received his B.E (Electronics Engineering) from Nagpur University, Nagpur, India and M.Tech in Electronics Design and Technology from Uttar Pradesh Technical University, Lucknow, India in 2003. He served as Assistant Professor of Electronics & Communication at Hindustan College of Science & Technology, Mathura, India. He also served as Head of Department of Electronics & Communication Engineering for four years at ACET, Aligarh and MIT, Bulandshahr, India. He is presently pursing PhD in Decision Support System at Faculty of Engineering, Dayalbagh Educational Institute, Agra, India. He was the member of accreditation team of Uttar Pradesh Technical University, Lucknow, India in year 2004 and 2005. He was the team member for the E-Learning program for UG courses at Hindustan College of Science and Technology, Mathura, India. He designed and developed a SMPS to cancel EMI that followed the International standard for EMI (MIL-461 E). His research interests are Analog Integrated Circuits, Microwave Engineering, Software Engineering, Artificial Intelligence and Decision Support Systems. He has published six research papers in international journals and conferences.

Ranjit Singh has received his B.Sc. Engineering in Mechanical Engineering from Agra University and his M.Tech. in Production Engineering from I.I.T. Roorkee and obtained a Gold Medal and done Ph.D. from Dayalbagh Educational Institute in Flexible Automation. Presently, he is Professor in Mechanical Engineering at Dayalbagh Educational Institute, Dayalbagh, Agra. He has been involved actively in research and teaching since 1973. His research interests are intelligent manufacturing, foundry techno-log, ergonomics, bio-medical engineering, and soft computing applications in manufacturing. He has guided, and continues to guide, Ph.D.’s in the above fields and has completed successfully three research projects granted by the Government of India. He has been awarded the prestigious Ramanna Fellowship for the year 2006 by the Dept. of Science and Technology, Government of India, and has received the most coveted P. Banerjee Medal for the best technical paper in the Indian Foundry Journal, 2000. Presently he is working on a research project sanctioned by UGC, New Delhi, India. He has 80 publications to his credit in journals and conferences. In addition, he has co-edited the proceedings of the National Systems Conference - 1994. He is a life member of the Institution of Engineers (India) and the Systems Society of India. He has chaired technical sessions at various conferences and workshops in India and Abroad.

P. K. Saxena received his doctoral degree in Industrial Engineering from I.I.T. Delhi, New Delhi, India; his research interests include Non-Linear programming, Information Systems, Decision Support Systems and Bio-Medical Engineering. His publications have appeared in various leading national and International journals. He retired as Dean, Faculty of Engineering, Dayalbagh Educational Institute, Agra, India and also served as Professor and Head, Department of Mechanical Engineering, Faculty of Engineering, Dayalbagh Educational Institute, Agra, India. His e-mail address is premkumarsaksena@gmail.com.
A Neural Network Based Model for Detecting Irregularities in e-Banking Transactions

1 J.A Adeyiga, J.O. Ezike, A. Omotosho & W. Amakulor
Dept. of Computer Science
Bells University of Technology
Ota, Nigeria

1 Corresponding Author
jadeyiga@yahoo.com

ABSTRACT
With the migration of most banking operations to the online platform, predicting bank frauds and security failures has gained increased importance in preventing and reducing the negative effects such breaches will have on the economic system as a whole. Information system security views this challenge as a prediction problem that attempts to detect irregular transactions in the banking sector operations scenario. This study applies neural network techniques to the bank fraud prediction problem. Using Nigerian banks as a point of reference, we design a Neural Network Based Model that employs multilayered Feed Forward Artificial Neural Network on database system for collecting training data for the Artificial Neural Network. Future work will test the Intelligence of the system on data extracted from statements of accounts from different banks in Nigeria.

Keywords: Artificial neural network, transactions, bank fraud, financial institutions & cyber security

1. INTRODUCTION

It is incontrovertible that the banking system is the engine of growth in any economy, given its function of financial intermediation. Through this function, banks facilitate capital formation and promote economic growth. However, bank’s ability to render economic growth and development depends on the health, soundness and stability of the system [2]. It is, therefore, not surprising that the banking industry is one of the most regulated sectors in any economy. It is against this background that the Central Bank of Nigeria outlined as part of the first phase of its banking sector reforms, the assurance of a diversified, strong and reliable banking industry [15].

The primary objective of the reforms is to guarantee an efficient and sound financial system. The reforms are designed to enable the banking system develop the required resilience to support the economic development of the nation by efficiently performing its functions as the fulcrum of financial intermediation [11]. The objective is to ensure the safety of depositors’ money, position banks to play active developmental roles in the Nigerian economy, and become major players in the sub-regional, regional and global financial markets.

As more financial institutions in Nigeria moves towards information technology driven services, security issues need to be addressed before banks and customers can confidently take advantage of these platforms. Banks are afraid of losing their cash to fraudsters who can manipulate their system and get undue advantage, while customers are still not convinced that banking is totally secured. There is need for customers’ transactions to be monitored so as to notice and alert the bank officials of irregular and suspicious transactions on customer accounts.
Currently, transactions are usually manually monitored by bank personnel who look through the customers’ statement of accounts when unusual transactions are noticed. The process is often very tedious and inefficient mainly because of the number of transactions and customer base.

With the advent of computers and Information systems there is a possibility of an automated approach to the analysis of the customers’ statement of account for detecting irregularities in banking activities. However, considering the fast pace at which mainstream business rules changes, the definition of fraudulent transaction changes rapidly thereby making the design and development of such a system a rather complex process [1]. A solution paradigm is to explore automated approaches to irregularity detection using algorithmic approach and artificial intelligent System.

2. RELATED WORKS

In [7][12] an approach to fraud detection that is based on tracking calling behaviour on an account over time and scoring calls according to the extent that they deviate from patterns that resemble fraud are described. Account summaries are compared to threshold each period and an account whose summary exceeds a threshold can be queued to be analyzed for fraud. Thresholding has several disadvantages; it may vary with time of day, type of account and types of call to be sensitive to fraud investigation without setting off too many false alarms for legitimate traffic [12].

Fawcett and Provost [7] developed an innovative method for choosing account-specific threshold rather than universal threshold that apply to all accounts or all accounts in a segment. In the experiment, fraud detection is based on tracking account behaviour. Fraud detection was event driven and not time driven, so that fraud can be detected as it is happening. Second, fraud detection must be able to learn the calling pattern on an account and adapt to legitimate changes in calling behaviour. Lastly, fraud detection must be self-initializing so that it can be applied to new accounts that do not have enough data for training. The approach adopted probability distribution functions to track legitimate calling behaviour.

In [4] it was stated that that many financial institutions see the value of ANNs as a supporting mechanism for financial analysts and are actively investing in this arena. The models described provide the needed knowledge to choose the type of neural network to be used. The use of techniques of decision trees, in conjunction with the management model CRISP-DM, to help in the prevention of bank fraud was evaluated in [5]. The study recognized the fact that it is almost impossible to eradicate bank fraud and focused on what can be done to minimize frauds and prevent them. The research offered a study on decision trees, an important concept in the field of artificial intelligence. The study focused on discussing how these trees are able to assist in the decision making process of identifying frauds by the analysis of information regarding bank transactions. This information is captured with the use of techniques and the CRISP-DM management model of data mining in large operational databases logged from internet bank.

The Cross Industry Standard Process for Data-Mining - CRISP-DM is a model of a data mining process used to solve problems by experts. The model identifies the different stages in implementing a data mining project while, a decision tree is both a data representing structure and a method used for data mining and machine learning. [3] describes the Use of neural networks in analyzing the great increase in credit card transactions; credit card fraud has become increasingly rampant in recent years. This study investigates the efficacy of applying classification models to credit card fraud detection problems.

Three different classification methods, i.e. decision tree, neural networks and logistic regression were tested for their applicability in fraud detections. The paper provides a useful framework to choose the best model to recognize the credit card fraud risk. Detecting credit card fraud is a difficult task when using normal procedures, so the development of the credit card fraud detection model has become of significance, whether in the academic or business community recently. These models are mostly statistics-driven or artificial intelligent-based, which have the theoretical advantages in not imposing arbitrary assumptions on the input variables.

Other models that have been developed in research settings that have promising potential for real world applications include the Customer Relationship Model, Bankruptcy Prediction Model, Inventory Management Model, and Financial Market Model.
To increase the body of knowledge on this subject, an in-depth examination of important publicly available predictors of fraudulent financial statements was offered. They tested the value of these suggested variables for detection of fraudulent financial statements within a matched pair’s sample. Self-organizing Artificial Neural Network (ANN) AutoNet was used in conjunction with standard statistical tools to investigate the usefulness of these publicly available predictors.

The study resulted in a model with a high probability of detecting fraudulent financial statements on one sample[1][6]. The study reinforced the validity and efficiency of AutoNet as a research tool and provides additional empirical evidence regarding the merits of suggested red flags for fraudulent financial statements. [10] Reviews the various factors that lead to fraud in the Nigerian Banking industry. The problem of fraud in our banking system may have some attachment. Therefore, there must be some factors that may have led to this fraudulent act.

The problems are stated below:

Bank malpractices
i. Failure to appoint trusted and honest official as the banks representative in the clearing house
ii. Failure to change representative on regular basis
iii. Failure to provide locked boxes or bags for carrying cheques to and from the central banks
iv. Inadequate training facilities for clearing staff both in the offices and central bank
v. Negligence in checking clearing cheques from the banks to avoid a case of possible short change of cheque

This study is important due to the various guidelines that can be drawn in coming up with a solution based on the problems listed above.

3. METHODOLOGY

We perceive neural networks as tools that can recall and learn patterns of behaviour, detect changes in patterns, and detect fraud in a payment card environment. We research to do the following:

- Generate/ create a unique network for each account in the bank
- Generate patterns for the network using the client history.
- Train the network at user defined epoch value or till there error value is approximately 0.
- Once the network has learned, feeds the current transaction into the network to know if it is a fraud or not.

Components of The Irregularity Detection System
i. Neural network based detector
ii. Database
iii. Computer System

3.1.1 Neural Network Based Detector
The neural network based detector is a mathematical model or computational model based on biological neural networks, in other words, it is an emulation of biological neural system. A neural network is a massively parallel distributed processor that has a natural propensity for storing experiential knowledge and making it available for use. It resembles the brain in two respects [8].

1. Knowledge is acquired by the network through a learning process.
2. Interconnection strengths known as synaptic weights are used to store the knowledge.

3.1.2 Database
The data are typically organized to model relevant aspects of reality. Structured query language will be used for the data store. This is the region where the account statements will be lodged and details of all transactions that take place in each account are stored in the database. All transactions carried out in a customer’s account are stored in the database and can be retrieved when needed. The database serves as the knowledge base to the neural network, the network trains and generates results based on the information in the knowledge base.

3.1.3 Computer System
The Computer system consists of the platform in which the irregularity detection system will operate, neural network cannot exist on its own. It is usually implemented in computer systems and related devices. The computer also serves as the interface between the neural network based detector and the system user. The computer presents the input data (user query) to the neural network.
3.2 Layout of the Irregularity Detection System

The simplified activities that take place in the irregularity detection system:

1. The input data (customer credit/debit transaction) is presented by the interface (computer) to the database (knowledge base).
2. The network is fed by the knowledge base.
3. The network trains based on the data in the knowledge base.
4. If the network based detector detects any irregularity, the transaction is disallowed else the transaction is allowed. Whatever decision the network based detector arrives at is stored at the knowledge base (database).

![Relationship between the system components](image)

**Figure 1. Proposed System components**

3.3 The Network Training Model

Modeling was done using the unified modeling language (UML). The system is modeled to be able to look through a client’s transaction history and generate an intelligent pattern which will be used as standard for testing the next transaction.

For example consider:

i. A client that has made withdrawals about 1000 times from a particular branch of a bank is suddenly withdrawing from a farther (another) branch.

ii. A client transaction history can denote his maximum withdrawal/Deposit to be 5000 naira, and suddenly he/she withdraws/deposits 5,000,000 naira.

iii. A client withdrawal/deposit mode and transaction date difference can also be used as a pointer in identifying irregularities.

In training the multilayer perceptron network (MLP), five different entries will be inputted which are as follows;

Entry 1: difference between the current and last transaction based on the number of days.

Entry 2: percentage of last withdrawal/deposit to current transaction.
Entry 3: the branch the transaction is taking place (location)

Entry 4: patron that is; self or different person?

Entry 5: transaction date.

The network produces reasonable outputs for inputs it has not been taught how to deal with. The various entries are presented to the network in form of numeric values. Transaction mode for withdrawal can only be either cheque/slip, ATM, Credit Card. These values can only be presented with numeric values in order to generate a pattern. Fixed numbers are chosen at random with the condition of being centralized around zero. The numbers are chosen in order to have distinctive output when presented to the network. These random values assist in reducing the learning time of the MLP else the network might take a longer time to learn (training a Neural Network involves trial an error till the result generated matches the target output).

The same process is followed for branches though each branch a bank is uniquely identified by codes. Random values between -1 and +1 are used to represent the parameters. MLP learns well with values centered on zero. The amount involved in the transaction is represented as the percent of the last transaction amount to the current transaction amount; the date is captured by the system based on the system’s calendar and clock.

The training process and algorithm is thus described below;

3.4 The Training Algorithm

Supervised Back propagation training algorithm was used to train the neural network because of its effectiveness towards pattern recognition. Training set is a collection of training samples gathered. A training sample is a pair of input vector plus a desired output value (0.8 or -0.8). The network was provided with the training set and allowing it to learn by adjusting weights of its synapses by back propagating the error calculated as the disparity between the output neuron to the expected/target value.

3.5 The Actual Algorithm

1. Identify number of input neurons (same as number of elements in the input vector)
2. Identify number of hidden layers and number of neurons on each layer. (Minimum required for back propagation is one hidden layer but for faster training we used two hidden layers each with 10 neurons each).
3. Identify number of output neurons. We used one neuron on the output layer because we have one target value.
4. Initialize random weight values for the synapses connecting each neurons of preceding layer to the next layer. With back propagation, weight values should be restricted to between -0.5 and +0.5.
5. Choose a random training set from the training sample and assign input vector to the input neurons.
6. Propagate all neurons in the forward direction to obtain output at the output layer.
   a) The output of each neuron is a function of its inputs. In particular, the output of the i
      th neuron in any layer is described by two sets of equations on the right:  Uj = Σ (Xi .
      wij)………………………….(1)
   b) For every neuron, j, in a layer, each of the i inputs, Xi, to that Yj = Fth (Uj + t)
      layer is multiplied by a previously established weight, wij.
      These are all summed together, resulting in the internal value of this operation, Uj. This value is then biased by a previously established threshold value, tj, and sent through an activation function, Fth(tanh function).
   c) The resulting output, Yj, is an input to the next layer or it is a response to the neural network if it is the last layer.
7. Evaluate error values at the output neuron as the difference between obtained output and the desired output of the training set chosen.
8. Backpropagate the error, all the way up to the input layer.
   a. Back propagation starts from the output layer with the following equation.

\[ \Delta \omega_{ij} = w_{ij} + LR \cdot e_j \cdot X_i \] .................................(2)
b. For the input of neuron in the output layer, the weight \( w \) is adjusted by adding to the previous weight value, \( w'_{ij} \), a term determined by the product of a learning rate, \( LR \), an error term, \( e_j \), and the value of the input, \( X_i \). The error term, \( e_j \), for the output neuron is determined by the product of the actual output, \( Y_j \), its complement, \( 1 - Y_j \), and the difference between the desired output, \( d_j \), and the actual output.

\[ E_j = Y_j \cdot (1 - Y_j) \cdot (d_j - Y_j) \]  

b. The error term is generated by a slightly modified version of Equation in steps 9 above. This modification is:

\[ e_j = Y_j \cdot (1 - Y_j) \cdot \sum (\cdot k \cdot w''jk) \]  

12. Stopping criterion is until the error obtained at the output layer is at an acceptable value. (0.02)

3.6 The Transfer Functions of the Neural Network.

Activation function is used to obtain output from each neuron. Tangential Activation function was adopted.

The equation is \( Y = \tanh(x) \).

Input nodes shall be presented which are expected to yield a target output.

If the output is not correct, the weights are adjusted according to the formula:

\[ w_{new} = w_{old} + \alpha \cdot (desired - output) \cdot input \]  

where \( \alpha \) is the learning rate (Cheung and Cannons, 2002)

Using \( \tanh \) activation function on all neurons the network, the output of each neuron ranges between -1 and +1. Some training set in the training sample has a target value of 0.8 and some \( \pm 0.8 \).

Once the error at the output layer is at an acceptable level, the test data is fed into the network from the input layer and the output value is derived. The sensitivity bar ranges from -0.8 to 0.8 although presented to range from 0 to 100%. The transaction is committed if the output of the test data is greater than the value of the sensitivity bar, otherwise rolled back.

Figure 3. An illustration of the training sets for the multilayer perceptron network.
Source: (Werbos [16]; Rumelhart [14])
3.7 Training and Verification

The training set is not fixed based on all previous transactions with the bank. The training set (initials training set) is 70% of the previous transactions while the testing set (cross validation in the training process) is 30% of the transactions. Cross validation patterns are a fraction of the client history not used for training rather to check if the network has learned, the error ratio (cross validation error) is shown before training.

The function of the current transaction is therefore to test against the neural network to determine its performance.

A sensitivity bar will be included so that transactions with values heading towards accepted level that should be suspicious will not be successful. The training set is the set of all known samples broken into two orthogonal (independent) sets:

1. **Training set 1**: A group of samples used to train the neural network
2. **Testing set 2**: A group of samples used to test the performance of the neural network. It is also used to estimate the error rate

**Verification;**

i. Provides an unbiased test of the quality of the network
ii. Common error is to “test” the neural network using the same samples that were used to train the neural network.

Based on the testing set;

1. The network is optimized based on these samples, and will obviously perform well on them.
2. Verification doesn’t give any indication as to how well the network will be able to classify inputs that weren’t in the training set

**Epoch**

This is basically the number of times the neural network should train for a particular transaction.

i. One iteration through the process of providing the network with an input and updating the network’s weights.
ii. The amount of epochs needed for the neural network is not fixed. Typically many epochs are required to train the neural network.

Irregularities detected by the system based on the training set provided to it will be made known to the bank official, it then becomes the duty of the bank officials to decide if such transactions should continue or be discontinued.

4. CONCLUSION

In this work, the irregularity detection system Model has sought to reduce the risk level of fraudulent transactions that take place in the Nigerian banking industry thereby aiding in the decrement of bank fraud. This will bring about reduced fraudulent transactions if implemented properly. Neural network technology is appropriate in detecting fraudulent transactions because of its ability to learn and remember the characteristics of the fraudulent transactions and apply that “knowledge” when assessing new transactions.

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Validating Perceptual Objective Listening Quality Assessment Methods on the Tonal Language Igbo.

D.U. Ebem & O.B. Longe
Fellows & Research Scholars
MISTI Africa MIT Science and Technology Initiative
Massachusetts Institute of Technology, Cambridge USA

debem@mit.edu  longe@mit.edu

ABSTRACT
In recent years a great deal of effort has been expended to develop methods that determine speech quality through the use of comparative algorithms. These methods are designed to calculate an index value of quality that correlates to a mean opinion score given by human subjects in evaluation sessions. In this paper, we validate Perceptual Evaluation of Speech Quality (PESQ) - ITU-T Recommendation P.862 and the Netherlands’s Organization for Applied Scientific Research (TNO) proposal- Perceptual Speech Quality Measurement 2010 (PSQM2010) on the Perceptual Objective Listening Quality Assessment (POLQA) benchmark, which is the new ITU-T benchmarking for objective measurement of speech quality, on the tonal language Igbo -a language spoken in south eastern Nigeria. Experiments are done in super wideband mode and PESQ was applied to down sampled versions of the signals. The result on PESQ P.862.2 shows a good correlation between the subjective and objective measurements on the tonal language Igbo with a correlation coefficient of r = 0.88 on the overall data set. For Dutch, the model shows less correlation between the subjective and the objective measurements (r = 0.84) compared to the tonal language Igbo (r = 0.88). The PSQM2010 is optimized for western languages and the correlation for the Dutch super wideband database is 0.91. For Igbo our super wideband result shows a poor correlation of 0.70 between the subjective and objective measurements. For the tonal and non tonal sentences no big differences are found. The correlation between the subjective results for tone and non-tone sentences is 0.96. We conclude by making recommendations for research, policies and practices.

Keywords: Igbo language, tonal language, speech quality, measurement, perception and Nigeria

1. INTRODUCTION

During the past decades speech quality measurement methods have been developed using the perceptual approach. The best known ones are those that are standardized by the International Telecommunication Union (ITU) P.861 (PSQM) [2],[10] and its follow up P.862 (PESQ) [11]-[15]. Currently ITU is standardizing the follow up of PESQ called P.863 (POLQA) [16-19].

In the standardization process the optimization and validation of the models is mostly carried out using European languages including American English. It is known that tonal languages have significantly different signal features that are used in the perception. The tonal elements have to be extracted in order to be able to understand the meaning of the word. In this paper we will investigate the impact of using an African tonal language, Igbo, in the subjective and objective evaluation of speech quality. Igbo is a tonal language spoken by about 40 million people in south eastern Nigeria. The validation of PESQ/PSQM2010 for the tonal language Igbo is therefore necessary for the benefit of this enormous population. Also, if objective measurement systems predict the impact of distortions in the Igbo language, the result can be used in quality control in telecommunication services in the Igbo language.
In addition, it will equally provide the standard for service providers in order to make high quality services to the Igbo people. A first study towards application to tone languages was carried out in [1] [3].

The objectives of this research are firstly to find out if objective measurement algorithms for measuring speech quality as developed for western languages and that are standardized within the International Telecommunication Unit (ITU) can also be applied to the tonal language Igbo. Secondly to find out if there is a difference between the impact of speech distortions on tonal sentences and non-tonal sentences of the Igbo language. One can imagine that for example the steady state parts in tonal sequences are less affected by impulse distortions. This may then result in a difference in perceived quality for tonal and non-tonal sentences. If such a difference is found we can try to model it in the objective measurement domain.

The best known objective measurement algorithm is Perceptual Evaluation of Speech Quality (PESQ), ITU-T recommendation P.862. PESQ deals with narrow band speech and addresses the effects of filters, jitter and coding distortions. Currently ITU is benchmarking the follow up proposal of PESQ, known as Perceptual Objective Listening Quality Assessment (POLQA) benchmark. POLQA can deal with super wideband speech and can be used in a wide variety of distortions. TNO is one of the proponents with her PSQM2010 model. This new model is introduced due to the fact that the existing ITU-T P.862 (PESQ) is not or not fully approved for a wide range of network topology complexities and their speech processing components. In addition, PESQ cannot be used for measurements at the acoustical interfaces of a terminal. This paper investigates whether PESQ and PSQM2010 can be applied to the Igbo language under a wide variety of distortions. Experiments are done in super wideband mode and PESQ was applied to down sampled versions of the signals. The result on PESQ P.862.2 shows a good correlation between the subjective and objective measurements on the tonal language Igbo with a correlation coefficient of \( r = 0.88 \) on the overall data set. For Dutch, the model shows less correlation between the subjective and the objective measurements (\( r = 0.84 \)) compared to the tonal language Igbo (\( r = 0.88 \)).

The PSQM2010 is optimized for western languages and the correlation for the Dutch super wideband database is 0.91. For Igbo our super wideband result shows a poor correlation of 0.70 between the subjective and objective measurements. For the tonal and non tonal sentences no big differences are found. The correlation between the subjective results for tone and non-tone sentences is 0.96.

The remainder of this paper is organized as follows: In Section 2 we present subjective and objective measurement of speech quality. Section 3 presents the recording of the speech database. Section 4 deals with the experiment, in Section 5 we present our results while the paper is concluded in Section 6.

2. REVIEW OF METHODOLOGIES FOR THE MEASUREMENT OF SPEECH QUALITY.

In this section, we discuss the two testing methodologies that are often employed for the measurement of speech quality.

2.1 Subjective Measurement of Speech Quality

Subjective Measurement of Speech Quality is the assessment of speech quality by human beings who listen to live or recorded speeches and assign a rating to it. This rating can be either a single overall quality or a rating of a particular characteristic (such as clarity or listening effort) or a particular distortion (such as clipping, noise, packet loss, hum). The aim of subjective testing methodology is to measure the degradation contributed by a transmission path (linear and non-linear distortions) and to ensure that the performance of the system is satisfactory.

Usually, subjective tests require a pool of naive and/or trained listeners, and the test is divided into quality and intelligibility tests. The two classes are not disjoint. Good quality mostly implies good intelligibility [3]. Speech quality encompasses a broader scope that includes intelligibility. There exists a strong correlation between speech quality and intelligibility in that the level of intelligibility relates to the determination of quality. Although speech intelligibility possesses a narrower scope and can even be considered as a dimension of speech quality but it is by no means inferior since it is the intelligibility of the information content that is often of primary importance in speech [1].
The most popular and widely used intelligibility tests are the Consonant Vowel Consonant test (CVC), using three-letter nonsense words in silence, the Speech Reception Threshold test (SRT), using short everyday sentences in noise adaptive procedure, the Diagnostic Rhyme Test (DRT) and the Modified Rhyme Test (MRT). In the objective domain, the Articulation Index (AI) and the Speech Transmission Index (STI) are standardized and worldwide adopted methods for predicting the speech intelligibility for virtually any electro-acoustic situation.

The STI method is a quick and objective method for assessing the speech transmission quality of transmission channels. Using the STI method, the speech transmission index (STI) can both be measured and calculated from the impulse response and noise level of the system under test. The STI, a value between 0 and 1, indicates how well speech is transmitted through the transmission channel with respect to intelligibility. Using the STI-value, the speech intelligibility for different types of speech material (numbers, CVC-words, sentences) can be predicted, using a customized transformation for each type of speech [4].

Well known subjective quality tests include A/B forced comparison test, the Diagnostic Acceptability Measure (DAM) and the Mean Opinion Score (MOS which is an average quality score over a large set of subjects [3]). ITU-T Recommendation P.830 [5] describes in detail how to conduct a subjective test experiment, but the procedure can be summarized as follows: a panel of subjects listens to a set of speech samples, assigning to each sample an overall quality score ranging from 1 (Bad) to 5 (Excellent).

The average score of the panel for a given sample is that sample’s MOS [6]. MOS tests use human subjects to measure the perceived quality but it is time consuming and expensive. Some researchers or organizations may not have the resources to conduct the tests. Also, it cannot be used in any sort of real-time or online applications. Additionally, if the same subject is made to repeat the experiment his opinion may vary. That is, he may give a different MOS score. This is not so in an objective test measure. These shortcomings among other factors have led to the development of objective measures of speech quality.

2.2 Objective Measurement of Speech Quality

Objective measures use mathematical expressions to determine the speech quality. The Signal to Noise Ratio (SNR) related measures are better suited for waveform coders, while spectral distance measures better describe vocoders. Objective speech quality measures can be classified according to the domain in which it operates; these are time domain, spectral domain, or perceptual domain [7].

Time domain measures are usually applicable to analog or waveform coding systems in which the goal is to reproduce the waveform. SNR and segmental Signal to Noise Ratio (SNRseg) are typical examples of time domain measures. Spectral domain measures are more reliable than time domain measures and less sensitive to the occurrence of time misalignments and phase shifts between the original and the coded signals [3]. However, most spectral domain measures are closely related to speech codec design and are based on speech production models.

Their performance is limited both by the constraints of the speech production models used in codecs and by the failure of speech production models in general to adequately describe the listener’s auditory response. Perceptual domain measures, based on human auditory perception appear to have the best chance of predicting subjective quality of speech and other audio signals. These measures transform the signal into a perceptually relevant domain incorporating human auditory models.

Examples of perceptual domain measures are Bark Spectral Distortion (BSD), Perceptual Speech Quality Measure (PSQM), Modified Bark Spectral Distortion (MBSD), Measuring Normalizing Blocks (MNB), Perceptual Speech Quality Measure plus (PSQM+), Telecommunication Objective Speech Quality Assessment (TOSQA), Perceptual Analysis Measurement System (PAMS) and PESQ. The best known objective perceptual measurement method is PESQ and has been accepted by ITU-T as recommendation P.862 in 2001 [8] for the measurement of speech quality. Currently ITU is benchmarking the follow up proposal of PESQ, known as POLQA benchmark. POLQA can deal with super wideband speech and can be used in a wide variety of distortions.
The accuracy or effectiveness of an objective measure is determined by its correlation, usually the Pearson correlation, with MOS scores for a set of data. If an objective measure has a high correlation with MOS, then it is deemed to be an effective measure of perceived speech quality, at least for speech data and transmission systems with the same characteristics as those in the experiment.

Indeed, measures that work well under some conditions are not necessarily good predictors of perceived voice quality under other conditions [6]. It is generally agreed that listening to processed speech gives a better evaluation of the quality than any objective measurement using mathematical expressions. No single objective measure can predict subjective responses well enough to replace subjective testing entirely [3] and modern military and commercial applications still use subjective tests.

3. RECORDING OF THE SPEECH DATABASE

The speech database used for the experiment was recorded at the acoustical imaging and sound laboratory of Technical University Delft. There were four native Igbo speakers, two males and two females. Fifty five sentence pairs were recorded by each speaker, from which we selected the best fifty sentence pairs which we used in this research. We used Cool Edit Pro Software for our recording. Fifteen percent (15%) of the sentence pairs were tonal while the rest were general Igbo speeches. The recording, preprocessing and post processing of the speech database were done according to the specification set by ITU-T [9]. The sampling rate of the recorded speeches are 48kHz, 16 bit and in mono channel Intel bit order. Distance of speakers' surface from the microphone was 10cm, voice level loud and clear, room condition echo free measurement laboratory.

The duration of the sentence pairs are between 8 - 12 seconds. Before recording each sentence pair the speaker took a silence of about 1 second, read the first sentence then took another silence of about 2 seconds and then read the second sentence. After a silence of about 5 seconds the speaker read the next sentence pair. The speeches were recorded in stereo but were saved in mono. We used ‘full-scale database’ which covered the entire range of degradation dimensions, background noise and clean conditions as specified by ITU-T for POLQA. We applied fifty (50) degradation conditions to the recorded speech database.

4. THE SUBJECTIVE EXPERIMENT

All subjects used were native Igbo speakers with no hearing impairments. They were equally balanced both by gender and age. The total number of subjects was twenty four (24). Twelve (12) males and twelve (12) females and their ages were between eighteen (18) years to seventy (70) years. There were eight (8) subjects in the age group of eighteen (18) to twenty (29), eight (8) subjects in the age group of thirty (30) to forty nine (49) and finally eight (8) subjects in the age group of fifty (50) to seventy (70).

Before conducting the experiment each subject was trained. Each subject used the same practice-igbo.48k.pcm for practice. There were six random orders, four subjects received the same random order. For each random order there were ten runs and each run consists of 20 randomly selected speech samples. That is, each subject listened to 200 degraded speech samples and gave his/her scores for each speech sample. The MOS rating of bad = 1, poor =2, fair =3 ,good = 4 and excellent = 5 were used for the test.

5. RESULTS

In this research we used PESQ P.862.2 and PSQM2010 which are co-developed by TNO to assess the quality of the impaired speech samples. The results were compared with the MOS results of the subjective tests. Scatter plots of the results are presented in Sections 5.1 and 5.2.

5.1. Objective PESQ Results

In the statistical analysis a simple linear Pearson correlation, r is used. A correlation coefficient close to + or - 1.0 indicates a strong relationship, a correlation coefficient close to 0 indicates a weak relationship. The closer the correlation coefficient is to +1.0 the better the objective measure is at predicting the subjective rating [7].

As a start PESQ P.862.2 (wide band version of PESQ) is validated on the Igbo database as well as on the Dutch database that contains the same distortions. As PESQ is not suited for super wideband a first analysis was made on the downsampled signals. The original files with a bandwidth of 14 kHz (48 kHz sampling) were down sampled to 16kHz (7kHz audio bandwidth). Because speech only contains marginal information above 7 kHz this approximation can provide a first insight as to whether PESQ can be applied to the Igbo language or not.
Figure 1 gives the result of the evaluation for Igbo while Figure 2 gives the result for Dutch. With a correlation coefficient of 0.88 for Igbo the results are only slightly below the requirement of 0.9. For Dutch the correlation is lower, 0.84 and slightly too low in order to be able to make reliable predictions for super wideband speech. For Igbo there is one prominent outlier (this is indicated by the number 27 in Figure 1) which corresponds to a condition that used a reverberation degradation as found in medium sized reflective rooms. Igbo subjects find the room reverberation less disturbing than predicted by PESQ. For Dutch there are several outliers predominantly for noisy conditions where a major part of the degrading noise is outside the bandwidth used by PESQ. However, one would expect that wideband noisy conditions would be judged too optimistically by the PESQ model. Analysis shows that this is not the case. Apparently subjects could follow the strategy of hearing out the noise separately from the speech because of the natural bandwidth limitation of the speech. This can be interpreted as an auditory streaming effect. The results show that information above 7kHz is less important in Igbo than in Dutch.

5.2 Objective PSQM2010 Results
The same signals used in the subjective experiment were given to the PSQM2010 measurement algorithm (version 886 May 20, 2009). This algorithm was trained on a wide set of distortions in super wideband mode. The results are presented in Figures 3 and 4 below.
5.3 Comparison of the Subjective Results of the tonal and non-tonal Sentences.

For the experiment, nineteen conditions have tonal sentences as well as non-tonal sentences. For this set, a comparison is made between the tonal and non-tonal behaviour. For the down sampled signals condition 21 showed the most prominent difference with a subjective MOS of 4.8 for the tonal sentence and 4.0 for the non-tonal sentence. Statistical analysis shows that this difference is on the edge of statistical significance. Condition 21 is a frequency filter distortion that enhances the lower frequencies, thus changing the timbre of the voice. Apparently this change in timbre has more impact on the non tonal speech.

Overall, the differences between tonal and non-tonal sentences are too low to draw any final conclusions. Figure 5 shows a scatter plot of the subjective results of non-tonal versus tonal sentences. The correlation between the results of these two sets is 0.96 showing that the differences between the two sets are in general small.

6. CONCLUSION

In this paper, we validated PESQ and the TNO proposal on the POLQA benchmark, which is the new ITU-T benchmarking for objective measurement of speech quality, on the tonal language Igbo – a language spoken in south eastern-Nigeria. Our result on PESQ P.862.2 shows a good correlation between the subjective and objective measurements on the tonal language Igbo with a correlation coefficient of r = 0.88 on the overall data set. For Dutch, the model shows less correlation between the subjective and the objective measurements (r = 0.84) compared to the tonal language Igbo (r = 0.88). The results also show that information above 7kHz is less important in Igbo than in Dutch.

The PSQM2010 model does not predict the tonal language Igbo. Our result shows a poor correlation between the subjective and objective measurements with correlation coefficient of r = 0.70. For Dutch, the model shows a strong correlation between the subjective and the objective measurements with correlation coefficient of r = 0.91. From our statistical analysis on tonal and non-tonal sentences of the Igbo language there is only a marginal difference between them.
We equally made the following observations from the conducted experiment viz:

a) The PESQ wideband speech quality model does not take into account information above 7kHz and provides a better correlation for Igbo than for Dutch, especially in the low quality domain.

b) Igbo language is less sensitive to distortions above 7 kHz.

c) For Igbo room reverberation is less disturbing than for Dutch.

d) For Igbo low presentation levels are more disturbing than for Dutch.

e) Timbre distortions are probably more disturbing for non-tone sentences.

The results of this research can help innovators, inventors, service providers, developers, designers and regulatory bodies make informed decisions before providing communication systems for the Igbo people. This research has serious implications for research and practices in developing tools for speech transmission in indigenous languages particularly in the age of teleconferencing and online audio transmission for educational and other purposes.

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Framework for Multilingual Mobile E-Voting Service Infrastructure for Democratic Governance

Olaniyi, O.M, Adewumi D.O, Oluwatosin E.A, & Bashorun, M.A.
Department of Electronic and Electrical Engineering
Bells University of Technology, Ota, Ogun-state, Nigeria.

Arulogun, O.T.,
Department of Computer Science and Engineering
Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

Corresponding Author
engrolaniyi09@yahoo.com

ABSTRACT
In most developing countries, electoral processes preceding democratic governance is characterized with high rate of fraudulent practices ranging from stolen of ballots, falsification of vote counts or rigging, improper voting and votes lost through invalid ballot marks due to ignorance and inadequate prior awareness and negligence. In this paper, we present the design and generic implementation of a framework of an integrated multilingual voting service infrastructure for conducting credible elections in rural and suburban communities in developing countries. The result of the testing done in Nigeria on the developed voting framework using Hypertext processor Web platform and Google Android mobile platform in the citizens’ mother tongue shows promising results. These will ensure high level of citizen participation and conduct of free, fair, transparent, convenient and confidential electoral processes in future elections in these countries.

Keywords: Mobile Voting, Internet Voting, E-registration, Democracy, Governance

1. INTRODUCTION
In every endeavor where democratic leadership structure exists, those in the helm of affairs are usually elected into the office and this is predominantly done by voting. Voting is a method by which a group of people express their opinion over who will lead them for a specific period of time via electoral processes. Usually correctness, robustness to fraudulent behaviors, and coherence are all key requirements for the integrity of an election process [9].

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In electronic systems, some systems use punch cards where voters punch holes in computer readable ballot, others employed special-purpose computers such as voting machines where voters use touch screens or push buttons to select choices, which are stored and counted or processed by a special program on the same machine [9].

Electoral processes in most developing countries are marred with irregularities. For instance In Nigerian 2007 General Election, there were massive rigging of elections especially in the governorship and state assembly elections in opposition strongholds where many complained of lack of presence of electoral officers in their wards. Some leading party officials were alleged to have taken ballot boxes to private residences to thumb print candidates’ names. Many International observers declared that the results of the elections were below the minimum standards and were not true to the wishes of the Nigerian people [3].

Although, the visiting International election observers attest that the Nigerian 2011 general election was relatively free, fair and credible. The chairman of the Independent National Electoral Commission (INEC), Professor Attahiru Jega, agreed that conducting elections that are free, fair, peaceful and credible in a country such as Nigeria, given its size, large population, terrain and ethno-religious diversity, is a very difficult assignment given the circumstances in which the INEC had to conduct the 2011 voter registration and the election itself [11]. This crave for the need to provide integrated multilingual electronic voting system to assist and encourage more voters to participate in future electoral processes.

An integrated voting system is a system composed of three major platforms: an e-voting machine; wired internet and mobile internet [14]. A multilingual E-voting system is a presentation of an E-voting system in multiple languages of choice [3]. This system is peculiar because voters have the opportunity of selecting the language they best understand in the voting process. Electronic voting (E-voting) systems include a large variety of system, ranging from hand-held infrared devices, kiosk systems with touch screens machines used in polling stations to remote voting via the internet [3]. E-Voting is the preferred platform for future elections in the developed nations of the world. It is a system that has modernized the electoral processes and electorate are able to cast their votes through an electronic device as against the conventional manual system of voting. The three types of e-Voting include: Polling station, where voters cast their votes electronically on an electronic machine within the polling booth; Kiosk e-Voting, where voters cast their votes at pre-selected stations through ATM-like terminals; and Remote e-Voting, where voters cast their votes anywhere, and anytime, there is internet access; as well as Voting through mobile devices[5].

In this paper, we present frameworks, models, prototypes and mobile software systems to address above challenges in conducting free, fair, well participated elections in developing nations with emphasis on Nigerian experience.

1.1 Motivation and Justification
Democracy and voting are inseparable because the majority opinion determines the outcome of an election or policy. Voting is by far the most important means in democratic decision-making. Although numerous voting methods have been implemented since the dawn of democracy, a certain degree of trial and error could always be expected according to which voting method was used. For example “Plurality voting” (used in United States, United Kingdom, Canada and Nigeria) is simple plurality, first-past-the-post or winner-takes-all.

In this voting system, the single winner is the person with the most votes; there is no requirement that the winner gain an absolute majority of votes. Plurality voting is used for local and/or national elections in 43 of the 191 countries of the United Nations [16]. Other voting methods include Preferential systems (Condorcet methods, Bucklin voting, Coomb’s method) [17], Block voting (Plurality-at-large, Preferential block voting, General ticket) [18]. The biggest problem with the current conventional voting method is in the most significant loss in terms of manpower, time, and money. In addition, there is usually a great deal of dispute as to the validity of the votes cast and also the manual counting of ballots is usually time-consuming.
For instance in Nigeria, in the 2003 presidential election, there were 2,538,246 invalid votes recorded, representing 6.04% of the total votes [19]. This is substantial, hence an outright elimination of the traditional manual process is recommended. Elections have become a reason for war in some developing countries, therefore to make the world a better and safer place there is a need to put in place a credible voting system across different platforms in languages most citizens are familiar with.

2. REVIEW OF RELATED WORKS

A number of related works exist in literature in the area of electronic and mobile voting systems and democratic governance. In [1], authors emphasized the success factors in implementing an electronic voting system in Nigeria, reviewed the e-registration exercise by the Nigerian electoral body as a springboard for future e-voting implementation in Nigeria and proposed solutions to common problems associated with countries that vote electronically. The authors proposed system have the potential to eliminate the common electoral malpractices associated with the manual voting system; reduce the duration of the election which will directly lead to reduced overall costs. Some principles of voting have to be established for the proper functioning of elections. According to [12] the following principles are established a)

Correctness of the Results: Only eligible users can vote only once and all votes counted are valid votes and all valid notes are counted,

b) Verifiability of results by involved parties: Researchers have argued for ‘Voter verified audit trails’, which means that the voter’s choice is printed on a paper, which can be inspected (behind glass) and is automatically dropped in a ballot box afterwards. This enables manual recounts, if there are any doubts about the results and

c) Secrecy of Votes: Forced voting is prevented by making sure no one is able to derive a relation between the vote cast and the involved voter also sale of votes is prevented by making sure the voter is not able to prove the vote he casts.

An account of what a good electronic voting system’s result should look like was proposed in [5]. E-voting is a type of voting system that allows voters to vote and record secret ballot electronically and its implementation has been a major interest of countries including Nigeria. The authors emphasize the flaws of using electronic voting ranging from rigging to fraud, not allowing recounting of votes and monitoring the system is almost impossible hence the probability of rigging is intolerably high and unacceptable.

Although the fact that the amount of dataset involved in e-voting is usually large based on the population and the distribution of the area in question, [5] attempted to solve these problems by using a Tree Map based visualization technique to monitor the distributed balloting and voting processes in real time. However with this technique, events in the balloting process can be monitored which will act as a form of getting the overall information through the whole balloting process in real time and secured electronic voting that ensures faults and fraud can be noticed. Some problems of the proposed system include: The tree map is not adequate for large trees because the traditional nodes and link diagrams cannot be drawn adequately in a limited display space. Also, the map lacks content information because each node cannot have additional information due to the fact that it takes most of the display space therefore only a simple text is used as the label.

In [4], an algorithm for displaying the results of seven elections (Presidential, Gubernatorial, senatorial, Representatives, Chairmanship, Assembly and Council) held simultaneously by thirty six political parties in Nigeria was developed. This algorithm was implemented along the principle of one-man one vote on an embedded direct recording electronic voting machine system. With the system, a voter is permitted to press button corresponding to candidates or parties of their choice. The results for each candidate and for each election stored in particular elections locations of Electrically Erasable Programmable Read Only Memory (EEPROM) of a PIC18F2685 based Microcontroller are displayed on two 40x4 character LCD display modules.
Although the developed system ensures electoral process that enhances transparency of the elections as the result display is initiated by pressing a button on the voting machine, the insecurity of life and properties in most developing countries particularly in Nigeria during the election period and epileptic power supply to energize the developed system might defeat the principle of one man and one vote along which the system was developed and above all, the system was developed along the lingual franca of English language which might deny illiterates from exercising their franchise right in selecting candidates of their choice.

In [6], author proposed an integrated electronic voting through the internet and mobile platforms tested and used for over two years for six elections in Canton Zurich, Switzerland. This electronic voting system was achieved by modular and service oriented architecture (SOA) which allows easy integration of all platforms for electronic voting (via internet, mobile phone, television sets and any other digital technology) and existing software solutions without interfering with the high security standard set. The system has a service oriented structure which enables it to cover a wide range of voting concepts needed.

Also in [7], authors proposed secure mobile voting system based on GSM Mobile technology. By this, secure mobile authentication mechanisms are used which provides voter authentication and mobility. The system is developed using a GSM mobile voting scheme based on a blind signature voting scheme, other schemes used are digital signature and bit-commitment mechanisms. In [2], author presents the security considerations for remote electronic voting in public elections. The importance of security in elections cannot be overstated. The future of countries rests on public confidence that the people have the power to elect their own government.

Our proposition is premised along the provision of multilingual mobile e-voting service infrastructure for developing countries using major tribes in Nigeria-Yoruba, Igbo and Hausa as well as the National Lingua Franca as a vehicle of providing simple, cheaper, convenient, faster and credible electoral process in future democratic elections.

The proposed service infrastructure is capable of providing a platform that will that will give a free, fair, transparent, convenient and confidential electoral processes in future election. The infrastructure will provide platform for three major Nigerian languages (Igbo, Yoruba and Hausa) including the official English language to provide confidential result as well as speedy processing of the result and the capability to display instant result almost immediately after elections [21].

2.1 Analysis of Problems of Existing Voting System in Nigeria

The current voting system Nigeria is based on modified open ballot voting system in which voters carry out voting in an open booth. This manual voting system is based on the following processes:

a) Pre-registration of privileged voters.
b) Voters must queue up for proper accreditation using their registration cards.
c) The different parties' symbols or pictures of contesting candidates are displayed.
d) Voters are directed by the Electoral Officials to queue up for the candidates or parties of their choice.
e) Voters are counted openly and loudly and the number of people in each queue recorded on result sheet.
f) The result is announced to all present at the polling station.

Most citizens do not vote appropriately during 2011 election because of loss of confidence in previous leadership, inadequate awareness about proper voting measures and ignorance. Some other problems of the existing system are:

a.) Stuffing of ballot box with ballot papers- This is a common practice where there are no genuine securities and election monitors to guard the process; b.) Absconding with ballot boxes-There are instances where some overzealous voters snatch and make away with ballot boxes. This is usually the case where they feel that their supporters are losing; 3) Mutilation of election result sheets and falsification of election results: This means tampering with the election result by way of tearing it or trying to change the figures already recorded.
3. MATERIALS AND METHODS

The following scientific approaches were used to achieve the central idea of this work. They are: Requirement Definition and Infrastructural Modeling

3.1 Requirement Definition of the Proposed Service Infrastructure

i. Voters’ Management Requirement

This requirement follows from the assumption that in order to have a free, fair, transparent, convenient and confidential electoral processes; the system should: a) Be Unique and Secure: A voter should be of acceptable age range and should not be able to vote more than one time; b) Accurate: After the election, the system should record the votes correctly; c) Integrity: Votes casted should not be able to be modified, forged, or deleted without detection; d) Secrecy and Non-Forcibility: Voters should not be able to determine how any individual voted, and voters should not be forced to vote for any candidate or party; e) Convenience: Voters should be able to cast votes quickly with minimal equipment or skills; f) Verifiability: Election systems should be testable so that election officials have confidence that they meet the necessary criteria and Transparency: Voters should be able to possess a general knowledge and understanding of the voting process.

ii. Service Provision Requirement

The infrastructure should allow mobile voters to find registered voting services i.e. Presidential, Gubernatorial, senatorial, Representatives, Chairmanship, Assembly and Council voting service from recognized mobile service providers. The services delivered should be as required by the voter.

3.2 Infrastructural Model and Architect:

i. Overall System Architecture

The architecture used for the proposed infrastructure is based on the Three-tier architecture which consists of the front end, middle tier and back end as shown in Figure 3.1. The web browser (and/or Wireless Application Protocol for mobile devices) constitutes the first tier, a middleware engine using some dynamic web content technology such as: common gateway interface (CGI), Hypertext preprocessor (PHP), Java servlets or Java server page (JSP), Active Server Pages (ASP) constitute the middle-tier and the database end is the third tier. The middle-tier may be multi-tiered. That is, it can be composed of several other servers with designated responsibilities, hence the over-all architecture is said to be N-tier. A fundamental rule in 3-tier architecture is that the client has no direct line of communication with the data tier. All communications are routed through the middleware tier. The n-tier architecture allows for better utilization of resources, tiering generally involves placing code modules on different machines in a distributed server environment, tiers make it easy to secure internal systems and ensure security; firewalls are set up to filter all network traffic moving in and out of the enterprise.

The architecture is divided into three phases: the pre-election which is the front end, election and post-election phase which is the back end. The pre-election phase involves the registration of all necessary bodies needed for the election to take place they include: the administrator, citizens (voters), candidates, parties, posts, and languages. The election phase is where the actual voting takes place. The registration number given at the pre-election stage is needed to login and cast the desired vote. All the votes cast by each voter is sent to the database through the middle tier layer of the architecture. The post-election phase is where the results are being processed after the election is over. After a result has been collected the stated result goes through auditing (the votes are recounted) and the final result is shown on the “display result” page on the web. All information here is stored in the centralized server and can be used for future reference. The architecture is represented in the figure 3.

ii. Application framework Overview

Figure 2 gives the platform aware application framework of the proposed voting infrastructure. The architecture is based on client proxy server mobile computing model which uses existing 2G, 2.5G, 3G and emerging mobile wireless networks to provide different services using service oriented architecture (SOA).

iii. Requirement Specification

From the architecture, three main components are required for the development and implementation of the architecture:
a) **Voting devices:** The voting application resides on the voting terminal devices which can be mobile devices, Laptop and Computer with internet access.

b) **Mobile operator:** The mobile operator provides Mobile Web Services through 3G and 4G technology as well as General Packet Radio Service (GPRS) required by voting devices to transfer data.

c) **Application Server:** The application server ensures that the assumption stated in voters’ Management Requirement above is met, authorizes and authenticates privilege voters, ensure one-man-vote mechanism, responds to context of communication etc.

iv. **Application System Modelling**
The model is premised along the system requirement specifications and the architecture. The server is responsible for the voter authentication, authorization, data transfer and message switching. The application system model is divided into three tiers. These are the Presentation Tier, Web Services Tier and Application server Tier.

### Presentation Tier
This is the top most level of the application. The presentation tier displays information related to the clients which consists of Computers, laptops, mobile devices and the network operator. It communicates with other tiers by outputting results from the browser/client tier to the Application Server tier using the services provided by the web services tier.

### Application Server Tier
The Application Server consists of the backend Application component of Voting System Application which is responsible for execution of requests from the voters using any of the devices at the client end, processing it and sending response back to the client tier.

### Web Services Tier
The web services tier consists of the service registry which controls the voters’ information as well as the specific election service (presidential, gubernatorial, house of representative and local council) in the database for authentication and authorization.

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**PRE ELECTION PHASE**

**ELECTION PHASE:**

**POST ELECTION PHASE:**

![Figure 1: Model of the Proposed Service Oriented Mobile E-Voting Framework](image-url)
Figure 2: Overview of the Proposed Service Infrastructure Application Framework (Adapted from [20] and [8])

V. The Analysis of the Model
The structure of the proposed model can be analyzed using the Use-Case diagram, Class diagrams and the behavioral/sequence diagram. The use case scenario of the infrastructure is shown in figure 3 showing the interaction of the Voters, Administrator and Electoral commissioner on each tier of the model.

Figure 3 Use Case Diagram for E-Voting Service Infrastructure for Democratic Governance in Nigeria
In figure 3, there are three main actors: the Voter, the system Administrator and the Electoral commissioner. The registered voter login into the desired voting service, get authenticated and cast vote. At the end of the election period the results are processed, audited by the Election commissioner and the final result is shown on the “display result” page on the web. All information here is stored in the centralized server and can be used for future reference.

4.0 DEVELOPMENT/EXPERIMENTAL SYSTEM IMPLEMENTATION

The Google Android Emulator is used to simulate the mobile version of the e-voting system while the hypertext processor (PHP) embedded in HTML is used for the electronic web platform. The result of experimental interactive Client Proxy Server (CPS) mobile e-voting system deployed on our proposed framework is presented here. Starting the application depends on the choice of the user and the mobile version depends on the model of the mobile phone. The screen shot of the Web and Mobile interface for the e-voting system shown in figure 4, 5 and 6 as follows:

Login Interface
This interface welcomes the prospective voters to the system. It gives an overview of what the system should look like. It also gives the users opportunity to choose their preferred language (Igbo, Yoruba and Hausa including the official English language).
Registration Interface

On Figure 5.0 interface, the prospective voter is expected to supply his personal information; the voter gets the pass word and registration number needed for login into the voting page from this page.

This gives a registered citizen access into the voting page by the issuance of the registration number and password as authentication. The voter also selects the post he wants to vote for presidential, gubernatorial, and local council as shown in figure 7.0.
End User Awareness
To enable the effective use of the proposed system, end users should be trained appropriately. Orientation, prior media advertorials on TV and Radio, Handbills and user manual would help in ensuring that the voters/users receive adequate training on how to use the software along different platforms. Also, electoral commissions’ official may conduct seminars on how to use the system in villages.

Security Concern
Security is a vital aspect of the electronic voting system that may dissuade electorates from patronizing it. The objective of the security is to protect valuable or sensitive electronic voting information while making it readily available. Attackers trying to harm a system or disrupt normal voting processes exploit vulnerabilities in a computer system, security policy and controls by using various techniques, methods, and tools. Parties involved in the proposed voting system are the voter, the wireless mobile service provider and the electoral commission’s secure infrastructure. The traffic among the parties is wireless between the mobile voter, the mobile operator and wired from the mobile operator to the electoral commission’s secure infrastructure. Although, the security of vote can be guaranteed through a trusted third party involving the mobile operator and the electoral commission, future research direction should look into provision security of vote over open wireless channel of communication.

5. CONCLUSION
A framework for mobile e-voting service infrastructure for developing countries along the experience of its giant, Nigeria has been presented in this research. Some experimental web and mobile applications have been developed based on the framework. The integrated mobile e-voting system would give voters the opportunity of casting votes using the most convenient medium, thus increasing the level of participation and ensure a free, fair, transparent, convenient and confidential electoral processes in future election. The infrastructure provides platform for three major Nigerian languages (Igbo, Yoruba and Hausa) including the official English language to provide confidential result.

This can also speed-up the processing of the result and the capability to display instant result almost immediately after elections. This research will provide a cutting-edge solution to electoral voting services for rural communities where mobile wireless services exists as the mobile devices are more affordable than the PC technology to an average Nigerian citizen [8]. It is, therefore, recommended that electoral bodies in developing countries should take competitive advantages of deploying the proposed mobile e-voting service infrastructure into the conduct of future elections thereby involving mobile wireless providers into their current voting systems. Other areas of future research, therefore, include:
Quantitative performance metrics of the proposed software model in availability, reliability, response time, speed, throughput, etc.

Extension of the model to provide Quality of Service (QoS) support and management

Note:
This Manuscript is a revised draft of [21] presented at the 6th International Conference on ICT Applications, Application of ICT to Teaching, Research, and Administration (AICTTRA 2011), 11th -15th September 2011, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.

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Understanding Developing Countries Vulnerability and Adaptation to Climate Change Using Theoretical Change Vulnerability Framework

Iyalomhe F.†
University Ca’ Foscari Venice
Department of Environmental Sciences, Informatics and Statistics
Calle Larga S. Marta 2137, 30123, Venezia (Italy)
felix.iyalomhe@stud.unive.it

ABSTRACT
It is increasingly clear that climate variability and change is a reality that brings huge consequences to both human environment and livelihood. In the light of the Intergovernmental Panel on Climate Change (IPCC) projection for severe and extreme weather conditions in the 21st Century, the author identifies climate change as a phenomenon that brings severe consequences to both human environment and livelihood. The inadequacies of tackling the problem in developing countries are emphasized as dependent on several bio-physical and socio-economic processes. The paper is aimed at showing how climate and human systems influence the level of vulnerability and adaptation to climate change based on a theoretical climate change vulnerability framework by proposing the identification of determinants of vulnerability as basic that can facilitate the understanding of the dynamics of vulnerability and the timely incorporation of adaptation strategies into developmental policies.

Keywords
Vulnerability, Adaptation, Climate Change, Regional Determinants, Developing Countries

1. INTRODUCTION
It is increasingly clear that climate variability and change will place billions of people in developing countries, under severe consequences, great threat to human development and livelihood. As a result concerted effort is needed to ameliorate these effects in order for these countries to adapt to climate changes which are occurring and will worsen in the foreseeable future [4].

Moreover, the United Nations Framework Convention on Climate Change (UNFCCC) and the IPCC fourth assessment reports (AR4) [13] on developing countries further underscored climate change largely due to human activities will exacerbate severe impacts, such as food insecurity as a result of reduced crops yields in tropical areas; prolonged stress on water resources; spread of climate sensitive diseases like malaria and dengue fever; and possible extinction of 20-30 per cent of plant and animal species by 2020. In particular, up to 250 million people in the horn of Africa could be exposed to protracted water stress due to changes in hydrological regimes i.e. precipitation, river or stream flow and lake or reservoir water level [3].

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In another vein, millions of people living in the coastal areas will experience severe hydrodynamic impacts from coastal erosion, flooding and inundation due to sea level variations. Those in Small Island Developing States (SIDS) will see a complete inundation with constant threat of tropical storms and hurricanes that could cascade to other associated risks in regards to life and property damage [14].

Regardless of this, climate change will also present some favourable conditions to sectors in these regions; for example, the thawing of cryosphere resources in the northern hemisphere of Asia (Boreal) and Mount Kilimanjaro in Africa during summer will enhance agricultural productivity and reduce water scarcity and contamination. However the effects of climate change will out-weigh these opportunities especially in developing countries where all necessary aspects favour vulnerability. In consequence, the study of vulnerability and adaptation to climate change has been given urgent attention by numerous scientific studies in order to improve understanding within vulnerable societies and develop a means to reduce and adapt to its inevitable effects. It should be noted that baseline assessment of changes in determinants of vulnerability useful to understand the level of regional vulnerability to climate related hazards is still lacking in recent studies [19]; thus, the paper conceptualises improvement of knowledge-base of possible variations in vulnerability determinants which would not only enhance understanding of climate change impacts but help to avoid the impairment of the sustainable development scheme and the inability of developing countries to meet the United Nations Millennium Development Goals by 2015 [22]. Vitaly, many developing countries would increase capacity for adaptation action since climate change will not only affect human lives but will also undermines societal development at large [18] and [14].

For this purpose, the paper attempts a preliminary overview of climate change vulnerability and adaptation in the developing world (Latin America, SIDS, Asia and Africa), considering a theoretical framework of vulnerability in order to highlight how biophysical and socio-economic drivers could facilitate changes in vulnerability determinants (e.g. exposure, susceptibility and adaptive capacity) through complex interactions between two systems: climate and human. Accordingly, the paper is organised into several parts including introduction and review of relevant assessment reports, consideration of possible regional vulnerability dynamics based on the proposed theoretical framework application on determinants variation analysis and an overview of climate change vulnerability and adaptation of sectors in developing countries, followed by concluding remarks.

2. VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

Consistent with relevant scientific research, vulnerability is a fundamental aspect of impact and adaptation studies; it facilitates the understanding of present and potential impacts through detailed consideration of plausible exposure scenarios of hazards, susceptibility and adaptation aspects of the considered regions or systems. The extent of these impacts depends on the inherent relations between the dimensions of vulnerability (livelihood, socio-institutions, environmental resources etc.,) and adaptation processes, necessary to guarantee development outcomes [17]. Moreover, vulnerability is useful to identify robust adaptation strategies through baseline assessment of regional determinants in order to understand how bio-physical and socio-economic interactions shape developing countries’ vulnerability to climate related hazards. More salient within the argument of climate change adaptation is the comprehension of how regional vulnerability determinants vary in a future context – particularly in developing countries rather than the dynamics of specific societies within these countries [19]. This idea can be fittingly represented and encapsulated by the theoretical framework in Figure 1.

From [23] modified theoretical framework, climate and human systems are inherently intertwined and are influenced by relevant drivers which impose excitation on their state (e.g. solar radiation, ocean circulation, population trend and urbanisation).
Distinctively, the climate system in terms of vulnerability creates exposure to climate variability, change and related hazards - including socio-ecological impacts; while the human system aggravates susceptibility to these hazards or impacts due to unsustainable trends via socio-ecological phenomena that alters the extent of exposure and susceptibility of sectors within these regions.

This result in the formulation of adaptation strategies also referred to as local coping strategies, via the consideration of socio-economic and climatic scenarios. In more detail, the vulnerability of societies and sectors to environmental changes in the developing world depends largely on the interaction of both climate and human systems' results in climate related hazards and socio-ecological impacts. These impacts are often seen and assessed in sectors such as agriculture, water resources, coastal zones and terrestrial ecosystems.

The climate system is specifically driven by solar radiation, ocean circulation, Earth rotation and greenhouse gases (GHG) that determine typical climate variability and change in geography-dependent. In the developing world, this means huge consequential influences for sectors and societies through exposure to climatic hazards and impacts alike. Instead, the human system driven by population trends, urbanisation, technology development and cultural systems play a crucial role in determining the extent of exposure and susceptibility to climate variability and change.

Moreover, the interaction between climate and human systems potentially implies possible hazards and socio-ecological impacts (e.g. sea level variations, heat wave, hurricane, typhoon, drought and desertification); magnified, these impacts vary spatially within sectors of developing regions due to the variable states of regional vulnerability determinants.
This denotes that effective identification and evaluation of how these determinants vary within such regions suggests the necessity of an in-depth assessment of complex interactions. Climate and human systems, in this case, can improve our understanding of potential vulnerability within the developing world in relation to climate variability and change dependant not only on prevalent hazards but also on the countries or systems constituent [10] and [6]. Traditionally, vulnerability of a system or region could be described as a function of determinants represented by the scheme in Figure 2. However the state of these determinants depends on the interactions of the climate and human systems, as propose by the theoretical framework of climate change vulnerability; accordingly, their dynamics determines the degree of vulnerability to climate change effects within sectors of developing countries.

Furthermore, the interactions and feedbacks over time within these systems seem to present opportunities for adaptation useful in lessening adverse effects or benefits of climate change and related hazards. Since the adaptation process enables developing countries to better prepare and cope with uncertainty, the developing world per se, may benefit more from adapting local coping strategies which can enhance natural resilience than mitigation which requires resources like capital and technology that are mostly beyond reach.

In effect, Warrick’s modified theorem is a cyclic process which conceptualises climate change vulnerability and adaptation on the complex interaction of bio-physical and socio-economic processes at different spatial and temporal scales; it assembles order in a manner that estimates exposure, susceptibility and adaptive capacity as basic determinant of vulnerability [1]; [2]; [6]; [12]; [23] and [19].

This research reiterates and extends the usefulness of this theory in a global analysis by showing how climate and human systems shape vulnerability of developing countries through variation in regional determinants of vulnerability. Moreover, the changes and variations in this framework stipulate vulnerability in relation to the type of geographic location, prevalent hazards, climate and social systems of developing countries.

**Latin America**

Several decades ago Latin America began experiencing climatic related impacts via the increase of the El Nino southern oscillation (ENSO) effect; the ENSO is related to a high-heterogeneous climate system. A large portion of Latin America is located in the tropics in which the climate is dominated by convergence of zones, such as inter-tropical and south Atlantic, and in turn also dominated by the North and South America Monsoon system.

These coupled with its large freshwater resources make it a region more vulnerable to hazards relating to tropical storm flooding - across a large array of countries. In addition, extreme events like torrential rain, windstorms and hurricane have been prevalent in the low-lying coasts of much of the region (e.g. Argentina, Belize, Colombia, Costa Rica and El Salvador) - including large cities like Rio de Janeiro and Buenos Aires [9] and [14]. For example the 1998 hurricane Mitch caused 10,000 deaths and severe damage to infrastructure in which Honduras and Nicaragua were worst hit [8]. Traditional socio-economic activities alongside El Nino and La Nina, which is associated with drought-effects, makes tropical forests - especially the Amazon - more vulnerable to forest fragmentation and gradual replacement by savannah [14].

![Figure 2. Interactions of the basic determinants of vulnerability.](image-url)
Thus, the region’s vulnerability to these hazards emphasises a high risk factor to climate variability and change especially to traditional socio-economic activities within the Amazon forest.

**Small Island Developing States**

There are 51 countries within the small island of developing states and territories within the Pacific, Indian and Atlantic Oceans and Caribbean Sea [21]. The climate of SIDS is influenced by the significant ocean-atmosphere interactions, such as the trade wind, ENSO, hurricane and the regional monsoons systems as well as sea level rise. These coupled with huge urbanisation and socio-economic activities at or near the coast characterise the vulnerability of this region [20] and [10]. Moreover SIDS’ sectors like agricultural land, water resources and biodiversity are already under intense pressure from huge populations and unsustainable usage, which further increases vulnerability from climate related impacts than any region (e.g. sea-level rise, storm surge, inundation of land and coastal erosion).

In fact sea-level rise, increasing sea surface temperature or thermal expansion and acidification of the ocean will entail loss of arable land and mangrove forest cover. There has been an example in Cuba where 3 per cent of its mangrove forest potentially may be lost with one meter rise in sea-level. Instead in Grenada, a 50cm rise could lead to serious inundation with 60 per cent beaches in some areas being lost completely [16]. Whereas in the Maldives, a one meter rise in sea-level would mean the complete disappearance of the nation [15].

**Asia**

The Asian continent is the largest and most populous on Earth, it is bounded on the north by the Arctic Ocean, on the east by the Pacific Ocean, on the south by the Indian Ocean and west by the European Mediterranean, Black and Aegean seas. Accordingly, the region is divided into four climatic and geographic features: boreal, arid and semi-arid, tropical and temperate. These features are linked into a huge socio-economic environment which historically has connoted high population and low economic growth.

In determining the extent of climate change vulnerability, high precipitation and monsoon climate in boreal and temperate regions and drought periods during summer in the arid and semi-arid regions of Asia has been paramount. These varying regions’ vulnerability may be related to prevalent environmental and socio-economic problems which is due to increases in consumption of natural resources and associated wastes that contributed to the exponential growth in the region’s existing natural hazards (examples include: 2004 Indian Ocean Tsunami, 2005 Pakistan Earthquake and 2006 Landslides in the Philippines) [11]; [10] and [21]. A historical viewpoint within Asia linking vulnerability to climate change is relative to the environmental legacy of the Soviet Union and its government institutionalisation. During this era, environmental mismanagement can potentially be linked to the contributing factors relating to temperature increase and precipitation variations in temperate and boreal Asia.

These further undermine the ability of this region to cope with extreme events like tornadoes, thunderstorms, severe dust storms, tropical cyclone and intense rainfall - especially during the summer monsoon and heat waves. Moreover, a recent report from the Organisation for Economic Co-operation and Development (OECD) claimed that Asian megacities in the south, east and southeast would be vulnerable to severe coastal flooding, storm surge and sea-level rise associated impacts due to climate variability and change. The sporadic permafrost in the boreal region are used for agriculture, but the increase in mean monthly air temperature during summer with potential soil temperature increase will make the permafrost more vulnerable to changes and, as such, affect the boreal agriculture sector [21]. Accordingly, IPCC concludes that climate change couple with rapid industrialisation, urbanisation and economic development will impinge on sustainable development Asia-wide.

**Africa**

This is a continent already described as vulnerable to climate variability and change, due to variations in climate (i.e. tropical, hot and dry) that varies on spatial and temporal scales coupled with a limited availability to resources. In fact, there could be severe floods
and droughts in the Sahel and coastal regions throughout months in the same year. Furthermore the temperate climates exist within the extreme south and north and at high altitudes in between; within West Africa and the western part of central Africa which are humid almost year-round have substantial rainfall during the wet season but almost no rain during the dry season. Towards the extreme north from this zone is a large area of semi-arid climates and sub-Sahara Africa which permit marginal cropping during the wet season but is characterised by unreliable rainfall and few permanent water bodies and high population [24] and [7]. In consequence, two-thirds of its surface area is exposed to desert, droughts and intermittent floods that are projected to increase with climate change.

These coupled with lack of human and financial capacity, overexploitation of resources and conflicts, characterise the vulnerability of this region to climate change [7]; [22]; [3]; [21] and [17]. Moreover, societal conflicts in several regions of Africa for the past three decades undermine the abilities of nations to respond to climate change. The Africa continent is also burden with epidemic diseases (e.g. malaria, tryanosomiasis, typhoid and cholera) and poverty-related diseases (e.g. tuberculosis and HIV) which is linked with low capacity for state initiated interventions, in which high mortalities and great loss of productive potential is evident [22] and [24].

3. ADAPTATION STRATEGIES WITHIN THESE REGIONS

Considering the already seen and potential impacts of climate change in the developing world, careful efforts in characterising and understanding adaptation is therefore necessary - in order to adapt sectors and regions faced with severe risks and vulnerability [1] and [2]. Albeit developing countries experiences wide-ranging impacts from climate change due to variations in regional vulnerability determinants, there are crosscutting issues which apply throughout varying countries and regions discussed in this paper.

For instance, same sectors (e.g. agriculture, water resources, human health, coastal zones and terrestrial ecosystems) are affected by climate change, but to differing degrees. Thus local coping strategies have been adapted to the effects of environmental changes, especially those related to sectors more sensitive to climate change.

As it is not the focus of this paper to consider adaptation in all sectors, it has become apparent that it seems that agricultural sector in developing countries is most vulnerable due to the very high level of sensitivity it has to temperature variations mostly from global warming effects. Accordingly, different developing countries developed unique adaptive strategies in order to adapt this sector to the changes in climate. For example, African farmers practice what is called water conservation technique to cope with arid conditions, such as the Zai technique in Burkina Faso.

The Zai technique is where farmers dig pits in the soil to collect organic material carried by the wind during the dry season so that at the start of raining season they can add organic matter from animals to attract termite activity resulting in termite tunnels that can collect enough rain during rainy season - thereby increases soil fertility [20]. While Asian farmers employ various water conservation strategies including terracing, surface water and groundwater irrigation and also diversification in agriculture to deal with drought and soil fertility [5]. Moreover, farmers in Latin America (Mexico) adopt the Terrace Agro systems where food crops are grown on steep erosion-prone slopes, in order to artificially irrigate and fertilise the soil during drier periods. Reciprocal to this idea, the Timor Island farmers in SIDS developed their own varieties of major staple food crops that can withstand or adapt to the erratic rainfall and cyclones in order to ensure food security [3] and [20].
4. CONCLUSION

This is a conceptual attempt to present a preliminary overview of the developing world within the context of climate change vulnerability; in order to further reiterate the potential dynamics of vulnerability and adaptation as a result of variation in regional determinants of vulnerability due to the climate and human systems’ interactions. Changes in the climate system due to natural and anthropogenic drivers interacts with the human system that by-in-large alters socio-economic activities that further exacerbates already prevalent natural hazards and anticipated socio-ecological impacts.

The interaction of these systems reveals that regional determinants like exposure, susceptibility and adaptive capacity to a large extent determines the level of vulnerability and thereby the severity of impacts in developing countries. Accordingly, regional vulnerability determinants are necessary if not indispensable for the baseline assessment of the dynamics of vulnerability and adaptation. Vulnerability is shown to be linked to complex interaction within climate and human systems whose state and dynamics differ from place to place, and as such, generate different conditions of vulnerability and degrees of impact through the developing world. Societies thus are exposed to similar hazard-based phenomena that not necessarily are impacted in the same way.

Accordingly, regional vulnerability determinants do not only support the assessment of environmental impacts, but also improves upon the understanding of the dynamics of vulnerability and adaptation, thereby guaranteeing the achievements of the Millennium Development Goals with the advancement of robust sustainable societal progress. Moreover within the developing world, variations in these determinants consummate in the differences and commonalities of adaptation practices, and is linked to vulnerability - and considered - as an external regulator that can reduce adverse effects from prevalent hazards or exploitative beneficial opportunists. Therefore, the extent of vulnerability of sectors in the developing world depends on the types of local coping strategy or adaptation implemented. From the foregoing, a comprehensive evaluation of the effects of regional vulnerability determinants based on practical application of this theory in the developing world is indeed necessary in order to quantitatively and comparatively estimate vulnerability of sensitive sectors and their adaptation strategies which is useful to validate the efficacy of this theory.

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U.O. Ekong
Dept. of Computer Science
University of Uyo, Nigeria
uyiekong@yahoo.com

S.C. Chiemeke
Dept. of Computer Science
University of Benin, Benin City, Nigeria
schiemeke@yahoo.com

O.B. Longe
MIT MISTI Initiatives -Massachusetts Institute of Technology
Cambridge Massachusetts, USA.
longeolumide@fulbrightmail.org

Abstract
The research proposes an improvement to CAPTCHA DC algorithms by introducing a unifying components that assists DC algorithms to effectively detect the density of DC in particular CAPTCHAs and determine the maximum and minimum allowable DC level for each CAPTCHA. For sparsely dense scenario, the DC is increased and when it is otherwise, DC is reduced. The algorithm is expected to keep track of tests that human users have failed to recognize as a way of creating a knowledge base for future improvements. The proposed unifying algorithm will also have the capability to capture different types of DCs and automatically generate any type of DC.

Keywords: CAPTCHA, Algorithms, Cluttered, Distortions, Security.

1. INTRODUCTION
The Internet has become an essential part of our lives and daily activities. Millions of people daily utilize the web for various activities such as transfer/receive fund, shopping, information dissemination, communication, learning, sales and so on. Despite the convenience of anytime, anywhere access to information and services that the internet has provided, it has in recent times witnessed constant breakdown due to gross malicious attacks on the systems and the services they render.

Automated script attacks are the central threat to computer security [1, 2]. Malicious codes and other vulnerabilities have been developed to constitute menace (eavesdropping, destroy, transfer of vital information to unknown destination, etc.) on the system. Spam attack has currently become a fast growing problem as a result of large numbers of e-mail users. Thousands of users and businesses are the major target with the aim of sending unsolicited mails, unwanted advertisements and promotion to users- a major mechanism is the use of automated actions taken by computers. Spammers can program computers to create or open dozens upon dozens of different email accounts from legitimate message services providers [3]. Users, who are the primary beneficiary of the system, are denied effective accessibility and use of the system for the purpose it was developed.

In order to curb this prevailing challenges, Human Interactive Proofs (HIP) otherwise known as Completely Automated Public Turing test to tell Computers and Human Apart (CAPTCHA) was
introduced as an additional access control mechanism to distinguish between human users and automated script attacks. This further strengthens the authentication/authorization of web applications and email services. CAPTCHA is a test that humans can pass but computer programs cannot [4]. This technology often makes use of a hard, open artificial intelligence (AI) problem, and is now a common security mechanism for guiding against undesirable or malicious internet bot programs [5]. By using CAPTCHAs to communicate with human users, a web application can mitigate client-side attacks that intercept or modify the sensitive information that users type [6]. Companies such as Yahoo, Google, Hotmail, Microsoft and some specialized web sites have since adopted this mechanism.

However, the prevailing weaknesses of current CAPTCHAs have made the mechanism vulnerable to attacks. For example, in [7, 8, 9, 10] one or more types of the CAPTCHA test were broken with almost 100% success rate. Distortions and Clutters (DC) usage were introduced in CAPTCHA design to make them more robust and secure while being resistant to attacks. Unfortunately, the use of DC can also become too difficult for human users to recognize and easily pass the test presented.

2. Anti-CAPTCHAS ATTACK SCENARIOS

The incessant attack on web applications denies legitimate users from access to a system. This has prompted the development of CAPTCHAs. Although this mechanism to some extent has been able to control automated intrusion menace, and has been adopted by many websites it however, has two (2) major challenges. First, the constant anti-CAPTCHA attack on the scheme has made some service providers to lose interest on the mechanism. Secondly, the user friendliness to the usage of the scheme also has been grossly compromised by developers in the bid to make the scheme more resistance to attack. Users find it more difficult to recognize over-distorted or cluttered CAPTCHA. It is therefore pertinent that we develop a robust scheme that will be resistant to attack and at the same time usable and user friendly to human users. Also, a better CAPTCHA design means greater security for computing systems and the breaking of an existing CAPTCHA usually means the advancement of AI methodologies [11].

Consider a scenario where a user tries to gain access to a particular web service. After entering his/her username and password, he/she is denied access to the services of the system. The user access may be denied not because he/she is not a legitimate user but, because an attacker has taken over the system. This is a typical example of a common scenario in our everyday use of the internet and its services. Several security policies or mechanisms have been introduced, used, and have become a common task for organization to enforce [12]. The conventional Username and Password have been greatly abused and misused by attackers who want to gain an unauthorized access to an organization’s website and claim to be what they are not [13]. There is therefore need to enhance user authentication policies using techniques that can only be recognized by human users and not machines to curb the huge financial cost of maintaining web services from such attacks, prevent spams and improve security in general.

3. RELATED WORKS

Most research in CAPTCHA schemes have been based on algorithmic ability to handle noisy signals (occlusion, luminance, clutter, noise), most often to test robustness of recognition method. Also most distorted and cluttered text based CAPTCHAs that have been developed are systematically broken with a very high percentage of accuracy. [7] broke the EZ-Gimpy CAPTCHA with 92% success rate and the Gimpy CAPTCHA with a 33% success rate using object recognition algorithms. [8] also developed a distortion estimation technique to break EZ-Gimpy with a success rate of 99% and a 4-letter Gimpy-r CAPTCHA with a success rate of 78%. [9] successfully broke a number of visual CAPTCHAs taken from the web with machine learning algorithms, with a success rate from 4.89%-66.2%. [10] have broken a number of CAPTCHAs including those hosted at captchaservice.org with almost 100% success rate using pattern recognition algorithms.

DC plays a vital role in the development of a resistance to attack CAPTCHAs. However, the use of excessive and unmanaged distortion levels and methods may not only make CAPTCHAs unusable, but also will lower its security control because the system would have to allow multiple attempts for failed test [14]. Existing CAPTCHA algorithms lack proper management of the use of DC in their schemes. In 2003 a scheme for building secure authentication systems called mandatory human participation (MHP) was introduced [1]. The scheme is based on a character morphing algorithm for implementing an HIP otherwise known as CAPTCHA. Its main purpose was to transform a character string into its graphical form in such a way that makes it easy for humans to recognize the original string, while a computer program such as OCR will not be able to decipher it or make a correct guess with non-negligible probability. The algorithm generated a string of random characters embedded in a graphic image using a set of morphing and distortion primitives.
(stretched characters, font type, font size, style, rotation, scaling, sheaving, noise, and 3-D shadow) on the characters with random parameters. However, only the baseline version of the algorithm that made use of dot noise (black dots) and object noise (using triangles, circles, rectangles, etc.) was manually implemented. Consequently, the algorithm lacked the capability to control the density of the morphed characters. Thereby making the CAPTCHA either over-morphed or under-morphed, affecting user friendliness of the scheme. There is therefore need to implement a more sophisticated and enhanced version of the algorithm to meet the prevailing challenges of CAPTCHA.

In 2010, another methodology was developed to facilitate creating CAPTCHA challenges using Unique Alteration Technique in conjunction with an improved architecture that optimizes human user accuracy in solving CAPTCHA [3]. The algorithm introduced the use of random arcs as clutters and created caches to store intersecting and non-intersecting thick and thin arcs, as well as a warp field cache which are randomly selected, distributed and applied to a set of characters extracted from the character cache to be presented to the user. The algorithm handled the issue of proper placement of distortion and clutters on a CAPTCHA image so as to aid human readability with the help of usability maps. Usability map are character regions specific to each font which can be built or identified through human user studies. Usability maps can be used to control the introduced distortion and clutter density. User study is gathered from user success and failure data which are further scrutinized for future use. Regions not as important for human recognition can be subjected to greater DC density while regions of a character that are deemed more important for human recognition can be subject to lesser amount of distortion.

The design in [3] was based on proper placement of DC using warping and random arcs only. Other forms of DC were not addressed. Furthermore, the scheme in an attempt to increase user friendliness still introduces distortion in the CAPTCHA. For example, the DC in Figure 1 shows a poor user recognizable CAPTCHA. A poorly designed CAPTCHA indicates a poorly distorted/cluttered CAPTCHA. The need to effectively design a well distorted and cluttered CAPTCHA that is readable and easily visually recognized, while being difficult for computer programs to break, is of paramount importance. It is therefore imperative to enhance the complexity of CAPTCHAs to make them robust enough against automated attacks [15].

4. RESEARCH DIRECTION

We propose the development of an enhanced DC-CAPTCHA algorithm that manages the extent to which distorted and cluttered CAPTCHA character images are recognizable by humans, while being unrecognizable to automated programs. This proposition is premised on the following questions. First, is it possible to design a human friendly CAPTCHA that are easy for human but extremely and expensively difficult for computers to solve? Second, what makes the use of DC difficult for automated attackers and how do we effectively use DC in CAPTCHAs so as not to make them difficult for humans to recognize or to make them too easy for automated scripts or hackers to break? Third, when are DC considered to be disturbing to human users?. We will attempt to answer these questions by investigating and analyzing the level of human/machine perception in recognizing distorted and cluttered images and then developing an enhanced DC algorithm for an effective CAPTCHA scheme.

Our output will be an enhanced Distortion and Cluttered CAPTCHA (DC-CAPTCHA) algorithmic system that evaluates the extent to which distorted and cluttered CAPTCHA character images are recognizable by humans, while being unrecognizable to automated programs for CAPTCHA developers. It will therefore serve as a tool that will validate the resilience and robustness of potential CAPTCHA systems.

5. RESEARCH FRAMEWORK

Mathematical deformation models will be adopted to simulate physical defects (noise, blur, and so on) of the characters ([16]. The platform for the development of this algorithm will be MATLAB (Matrix Laboratory). The choice of MATLAB is because of its powerful computation, visualization and programming capabilities coupled with an easy to use environment where problems and solutions are expressed in formal mathematical notations.

Fig. 1: Example of a poor human recognizable CAPTCHA
Also, MATLAB’s Image Processing Toolbox will enable us to effectively degrade (adding distortions and clutters) and restore images to their original form and estimate or control the level, time and storage of DCs on the image CAPTCHA.

The various transformation processes of the algorithm will be modelled using the Unified Modelling Language (UML). This is an object oriented modelling tool with functionalities for specifying, visualizing, constructing and documenting all parts of the algorithm ([17]. The validation of the effectiveness and efficiency of the algorithm will be achieved by subjecting it to some tests. This will further be compared with some well known existing CAPTCHA to demonstrate the efficiency and applicability of the proposed technique. The tests will be in two folds:

a. A controlled user study will be conducted to collect challenge-responses from human users. This will enable us measure the level of recognizability of the DC-CAPTCHA image. An image I is randomly sampled from \( X \) (a set of possible CAPTCHA images) which is subjected to some form of DC \( \delta \) and then presented to a user. Since it is difficult to get user responses for each DC type over all images in \( X \), we measure the average recognizability for a given distortion using the following equation:

If \( U(\delta) \) is the set of all images presented to users subjected to \( \delta \),

\[
\bar{\rho}(\delta) = \frac{1}{|U(\delta)|} \sum_{i=1}^{n} \Gamma(\text{user responds correctly})
\]

where,

\( \Gamma \) is the indicator function, \( \bar{\rho}(\delta) \) the average human recognizability under distortion \( \delta \). Recognizability is measured as the fraction of times the various users made the correct choice.

b. To test the efficacy of the algorithm on machine, it will be subjected to attack by using various optical character recognition (OCR) programs such as ABBYY Fine Reader 6.0 and Tesseract 3.0, to ascertain the level of recognition by automated programs. This will enable us ascertain if our proposed algorithm actually meets the expected goal.

6. THE PROPOSED DC-CAPTCHA MODEL

In this study, we proposed an enhanced distortion/cluttered CAPTCHA model. The functional architecture of the model is presented in Figure 2. A web user initiates a dialog using a web browser with a known web service provider. The secure interface of the web service presents a challenge and response test to authenticate the validity of the user, before access is allowed to the web resources.

A CAPTCHA test is presented to the user as part of the authentication mechanism to ascertain if it is a human or an automated script program (bot) that is accessing the web server. If the presented CAPTCHA test is passed, it is assumed that the user is a human, and access is granted to the web resources. However, a failed test means that the user is unable to recognize all elements of the CAPTCHA test, and this presents two scenarios; (a) the CAPTCHA element are not easily recognized by the user, (b) an automated program is attempting to gain access to the system. An initialized counter \( c \) is incremented by one \( (c+1) \). Multiple challenges are presented to the user, and the number of attempt captured by the counter \( (c=c+1) \). After a stipulated number of failed attempts, access is denied. If a particular test is failed for a specified number of times \( k \), then the test is sent to the DC database where the distortion and clutters used in the image is accessed, modified and further sent to the dynamic CAPTCHA database for future use.
The DC generator enables for easy generation of distortion and clutters. This section comprises of an integrated distortion and clutter database where all the CAPTCHA primitives, parameters, minimum and maximum allowable DC usage are stored for easy use by developers.

**7. CONCLUDING REMARKS**

The study of user authentication as it relates to Challenge-Response Protocol such as CAPTCHAs and its use in web services has gained apt attention in the field of web security, Artificial Intelligence, machine learning, computer vision and human computer interaction. CAPTCHAs have been used in recent times to prevent automated programs from gaining access to email account, abusing online polls, spamming innocent users, downloading materials such as books and more.

It has enhanced the use of online services by building trust, convenience, integrity and total confidence on systems. Most attempts at building robust CAPTCHA schemes have been based on designing systems that are resistant to attacks as presented in [18, 19, 20, 21]. Other methods based on compromising CAPTCHAs schemes utilize segmentation, machine learning, and pattern recognition algorithms as shown by [10, 9, 7, 8] and [22].

Distortion and clutter usage in CAPTCHA schemes basically form the bedrock for the effective resistance to automated attacks. Recent studies show that most CAPTCHAs developed using distortions and clutters do not indicate their limits. This research is significant in this guise, based on the pioneer attempt by [3] to address these problems.

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**Fig. 2: Functional Architecture of the proposed DC CAPTCHA**

The DC generator enables for easy generation of distortion and clutters. This section comprises of an integrated distortion and clutter database where all the CAPTCHA primitives, parameters, minimum and maximum allowable DC usage are stored for easy use by developers.
The study of how distortions/clutters are effectively placed on CAPTCHAs, and to what extent their usage appeals to human users is of paramount importance since it will enhance the present scheme to work far better. We expect that our efforts will contribute significantly to the development of a unifying algorithm that will effectively and efficiently manage the use of DC in CAPTCHA development and provide an enhancement to user authentication mechanism by implementing a prototype that incorporates a DC-CAPTCHA.

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