Online ISSN : 0975-4172
Print ISSN : 0975-4350

Global Journal

of Computer Science and Technology: G

Interdisciplinary

Highlights

Multi-Modal Biometrics

Cost Effective Software

Integrating Reviewers Own Prejudice

Augmented Biometrics System

Discovering Thoughts, Inventing Future

VOLUME 15 ISSUE 2 VERSION 1.0

Global Journal of Computer Science and Technology: G
Interdisciplinary

Global Journal of Computer Science and Technology: G
Interdisciplinary

Volume 15 Issue 2 (Ver. 1.0)

Open Association of Research Society

Incorporation No.: 0423089
License No.: 42125/022010/1186
Registration No.: 430374
Import-Export Code: 1109007027
Employer Identification Number (EIN):
USA Tax ID: 98-0673427

Global Journals Inc.

*(A Delaware USA Incorporation with "Good Standing"; **Reg. Number: 0423089**)*

Sponsors: *Open Association of Research Society*
Open Scientific Standards

Publisher's Headquarters office

Global Journals Headquarters
301st Edgewater Place Suite, 100 Edgewater Dr.-Pl,
Wakefield MASSACHUSETTS, Pin: 01880,
United States of America
USA Toll Free: +001-888-839-7392
USA Toll Free Fax: +001-888-839-7392

Offset Typesetting

Global Journals Incorporated
2nd, Lansdowne, Lansdowne Rd., Croydon-Surrey,
Pin: CR9 2ER, United Kingdom

Packaging & Continental Dispatching

Global Journals
E-3130 Sudama Nagar, Near Gopur Square,
Indore, M.P., Pin:452009, India

Find a correspondence nodal officer near you

To find nodal officer of your country, please email us at *local@globaljournals.org*

eContacts

Press Inquiries: *press@globaljournals.org*
Investor Inquiries: *investors@globaljournals.org*
Technical Support: *technology@globaljournals.org*
Media & Releases: *media@globaljournals.org*

Pricing (Including by Air Parcel Charges):

For Authors:
22 USD (B/W) & 50 USD (Color)
Yearly Subscription (Personal & Institutional):
200 USD (B/W) & 250 USD (Color)

Integrated Editorial Board
(Computer Science, Engineering, Medical, Management, Natural Science, Social Science)

Dr. Bart Lambrecht
Director of Research in Accounting and FinanceProfessor of Finance
Lancaster University Management School
BA (Antwerp); MPhil, MA, PhD (Cambridge)

Dr. Carlos García Pont
Associate Professor of Marketing
IESE Business School, University of Navarra
Doctor of Philosophy (Management), Massachusetts Institute of Technology (MIT)
Master in Business Administration, IESE, University of Navarra
Degree in Industrial Engineering, Universitat Politècnica de Catalunya

Dr. Fotini Labropulu
Mathematics - Luther College
University of ReginaPh.D., M.Sc. in Mathematics
B.A. (Honors) in Mathematics
University of Windso

Dr. Lynn Lim
Reader in Business and Marketing
Roehampton University, London
BCom, PGDip, MBA (Distinction), PhD, FHEA

Dr. Mihaly Mezei
ASSOCIATE PROFESSOR
Department of Structural and Chemical Biology, Mount Sinai School of Medical Center
Ph.D., Etvs Lornd University
Postdoctoral Training,
New York University

Dr. Söhnke M. Bartram
Department of Accounting and FinanceLancaster University Management SchoolPh.D. (WHU Koblenz)
MBA/BBA (University of Saarbrücken)

Dr. Miguel Angel Ariño
Professor of Decision Sciences
IESE Business School
Barcelona, Spain (Universidad de Navarra)
CEIBS (China Europe International Business School).
Beijing, Shanghai and Shenzhen
Ph.D. in Mathematics
University of Barcelona
BA in Mathematics (Licenciatura)
University of Barcelona

Philip G. Moscoso
Technology and Operations Management
IESE Business School, University of Navarra
Ph.D in Industrial Engineering and Management, ETH Zurich
M.Sc. in Chemical Engineering, ETH Zurich

Dr. Sanjay Dixit, M.D.
Director, EP Laboratories, Philadelphia VA Medical Center
Cardiovascular Medicine - Cardiac Arrhythmia
Univ of Penn School of Medicine

Dr. Han-Xiang Deng
MD., Ph.D
Associate Professor and Research
Department Division of Neuromuscular Medicine
Davee Department of Neurology and Clinical NeuroscienceNorthwestern University
Feinberg School of Medicine

Dr. Pina C. Sanelli
Associate Professor of Public Health
Weill Cornell Medical College
Associate Attending Radiologist
NewYork-Presbyterian Hospital
MRI, MRA, CT, and CTA
Neuroradiology and Diagnostic Radiology
M.D., State University of New York at Buffalo,School of Medicine and Biomedical Sciences

Dr. Roberto Sanchez
Associate Professor
Department of Structural and Chemical Biology
Mount Sinai School of Medicine
Ph.D., The Rockefeller University

Dr. Wen-Yih Sun
Professor of Earth and Atmospheric SciencesPurdue University Director
National Center for Typhoon and Flooding Research, Taiwan
University Chair Professor
Department of Atmospheric Sciences, National Central University, Chung-Li, TaiwanUniversity Chair Professor
Institute of Environmental Engineering, National Chiao Tung University, Hsin-chu, Taiwan.Ph.D., MS The University of Chicago, Geophysical Sciences
BS National Taiwan University, Atmospheric Sciences
Associate Professor of Radiology

Dr. Michael R. Rudnick
M.D., FACP
Associate Professor of Medicine
Chief, Renal Electrolyte and Hypertension Division (PMC)
Penn Medicine, University of Pennsylvania
Presbyterian Medical Center, Philadelphia
Nephrology and Internal Medicine
Certified by the American Board of Internal Medicine

Dr. Bassey Benjamin Esu
B.Sc. Marketing; MBA Marketing; Ph.D Marketing
Lecturer, Department of Marketing, University of Calabar
Tourism Consultant, Cross River State Tourism Development Department
Co-ordinator , Sustainable Tourism Initiative, Calabar, Nigeria

Dr. Aziz M. Barbar, Ph.D.
IEEE Senior Member
Chairperson, Department of Computer Science
AUST - American University of Science & Technology
Alfred Naccash Avenue – Ashrafieh

Contents of the Issue

i. Copyright Notice
ii. Editorial Board Members
iii. Chief Author and Dean
iv. Contents of the Issue

1. Detecting Sentiments from Movie Reviews by Integrating Reviewer's Own Prejudice. *1-6*
2. Secure on-Line Transaction through Augmented Biometrics System. *7-13*
3. Multi-Modal Biometrics: Applications, Strategies and Operations. *15-28*
4. Evolutionary Computing based an Efficient and Cost Effective Software Defect Prediction System. *29-43*

v. Fellows and Auxiliary Memberships
vi. Process of Submission of Research Paper
vii. Preferred Author Guidelines
viii. Index

Global Journal of Computer Science and Technology: G Interdisciplinary
Volume 15 Issue 2 Version 1.0 Year 2015
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Detecting Sentiments from Movie Reviews by Integrating Reviewer's Own Prejudice

By Kalpana Yadav, Sumit K. Yadav & Swati Gupta
Indira Gandhi Delhi Technical University, India

Abstract- Presently, sentiment analysis algorithms are widely used to extract positive or negative feedback scores of various objects on the basis of the text/reviews. But, an individual may have a certain degree of biasness towards a certain product/company and hence may not objectively review the object. We try to combat this biasness problem by incorporating the positive and negative bias component in the existing sentiment score of the object. This paper proposes several algorithms for a new system of implementing individual bias in the corpus of data i.e. movie reviews in this case. Each review comment has an unadjusted sentiment score associated with it. This unadjusted score is refined to give an adjusted score using the positive and negative bias score. The bias score is calculated using certain parameters, the weightage of which has been determined by conducting a survey. We lay emphasis on the degree of biasness an individual has towards or against the review parameters for the movie reviews corpus namely actor, director and genre. We equip the system with the capability to handle various scenarios like positive inclination of the user, negative inclination of the user, presence of both positive and negative inclination of the user and neutral attitude of the user by implementing the formulae we developed.

Keywords: *natural language processing, sentiment analysis, opinion mining, text classification, online customer reviews, social network analysis.*

GJCST-G Classification: *I.3.3*

Strictly as per the compliance and regulations of:

Detecting Sentiments from Movie Reviews by Integrating Reviewer's Own Prejudice

Kalpana Yadav[α], Sumit K. Yadav[σ] & Swati Gupta[ρ]

Abstract- **Presently, sentiment analysis algorithms are widely used to extract positive or negative feedback scores of various objects on the basis of the text/reviews. But, an individual may have a certain degree of biasness towards a certain product/company and hence may not objectively review the object. We try to combat this biasness problem by incorporating the positive and negative bias component in the existing sentiment score of the object. This paper proposes several algorithms for a new system of implementing individual bias in the corpus of data i.e. movie reviews in this case. Each review comment has an unadjusted sentiment score associated with it. This unadjusted score is refined to give an adjusted score using the positive and negative bias score. The bias score is calculated using certain parameters, the weightage of which has been determined by conducting a survey. We lay emphasis on the degree of biasness an individual has towards or against the review parameters for the movie reviews corpus namely actor, director and genre. We equip the system with the capability to handle various scenarios like positive inclination of the user, negative inclination of the user, presence of both positive and negative inclination of the user and neutral attitude of the user by implementing the formulae we developed. Hence, the system computes an objective score sans any individual bias for several scenarios making inferences better.**

Keywords: natural language processing, sentiment analysis, opinion mining, text classification, online customer reviews, social network analysis.

I. Introduction

Sentiment analysis or opinion mining is the field of natural language processing dedicated to the computational analysis of opinions for the purpose of decision making (Kim, & Hovy, 2004). An opinion is a statement about a subject which expresses the sentiments and emotions of the opinion maker on the subject.

The main objective of sentiment analysis is to extract relevant information about the various sentiments articulated by authors about a particular subject, forming relationship patterns between the sentiments and the subject and helping users by presenting the huge volume of unstructured Web data in a structured form. (Wu, Wang, & Yi, 2013). In the present Internet age there is a plethora of information available to the users in every possible arena. Users are exposed to various sources of information like blogs, online reviews, and social sites.

The current trend is to look up reviews, expert opinions and discussions on the Web, so that one can make an informed decision pertaining to day-to-day tasks and purchases. (Cui, Mittal, & Datar, 2003). With so much information around, the user finds it difficult to process all of it and make an informed and rational decision. Here, sentiment analysis plays an important role by analysing all the data available and providing an over-all positive or negative feedback. (K. Dave, S. Lawrence, & D. Pennock, 2003).

Presently, Internet is extensively used as a platform for shaping up (Zuniga, Puig-I-Abril, & Rojas, 2009) views of people in diverse fields like politics (Park, Ko, Kim, Liu, & Song, 2011), (Larsson, & Moe, 2011) religious ideology, business marketing, tourism (Claster, Cooper, & Sallis, 2010) book reviews(Lin, Fang, & Wang, 2013) etc. Hence, it becomes imperative to have a mechanism to sift through this prejudiced information and get a collective objective consensus on the whole. For this evaluation, the validity of the source becomes equally important along with the content expressed.

The content authors can be classified into three types: promoters, the users who are positively prejudiced towards the object; detractors, the users who are negatively prejudiced against the object and passives, the users who are neither positively nor negatively inclined towards the object. (Wen, Dai, & Zhao, 2012). The bias or prejudice mentioned above refers to the inclination of temperament to hold a partial perspective and a refusal to even consider the possible merits of alternate points of view. The different forms of bias that have already been explored in sentiment analysis field include herd behavior, (Chen, 2008) first impression bias, (Deffuant, & Huet, 2009) sequential bias, (Piramuthu, Kapoor, Zhou, & Mauw, 2012).

The system we propose aims to deal with the individual bias in order to evaluate the validity of the content sources and hence get an objective consensus rather than the subjective (Liu, 2010) one that we are previously exposed to. Our work focuses on movie

Author α : Kalpana Yadav, Assistant professor in Information Technology Department at Indira Gandhi Delhi Technical University, Delhi. e-mail: kyadav11@yahoo.com
Author σ : Sumit K Yadav, Assistant professor in Computer Science Department at Indira Gandhi Delhi Technical University, Delhi.
e-mail: sumitarya007@gmail.com
Author ρ : Swati Gupta, Student in Computer Science Department at Indira Gandhi Delhi Technical University, Delhi.
e-mail: gupta.swati1992@gmail.com

reviews corpus dataset as it provides a wholesome sample data from varied demographics since movies are watched by everyone.

II. Related Work

In this section, we focus on the related work on various types of bias and sentiment classification especially in the field of online reviews.

a) Sentiment Classification

The sentiment analysis has evolved over the period of time be it examining semantic orientation (Hatzivassiloglou, & McKeown, 1997) of adjectives, of adverbs,(Turney, & Littman, 2003) of emoticons (M, A. K. K., 2011) of different languages, (Martín-Valdivia, Martínez-Cámara, Perea-Ortega, & Ureña-López, 2013) of compound sentences using sentence level analysis (Mishra, & Jha, 2013), usage of appraisal groups (Whitelaw, Garg, & Argamon, 2005). and unsupervised techniques. The granularity of data mining has also evolved from document level, (Pang, Lillian, & Shivakumar, 2002) (Turney, 2002) sentence level (Riloff, & Janyce, 2006) to object level (Hu, Minqing, & Liu, 2004) techniques.

In (Cui, Mittal, & Datar, 2003), the efficiency of high order n-grams is enhanced using discriminating classifier. Also, the possibility of getting a consolidated result even with the data set comprising of varied products and authors is explored in this paper. (Dou, & Hu, 2012) explores an automated method incorporating semantic analysis and align technique to extract structured data form web pages has been developed. (Huang, & Lin, 2013) has dealt with a system where product reviews are evaluated on three parameters: product reviews, product popularity, and product release month and a proficient product ranking system is created. In (Jusoh, & Alfawareh, 2013) the sentiment classification using possibility theory has been implemented in order to determine varied degree of positive and negative sentiment score.

b) Bias Reviews

Various types of bias have also been discovered in the papers. In (Bencz, A. 2012), bi-clustering has been used along with kernel methods and baseline text classifiers to improve trust, bias and factuality classification over Web data on the domain level. The main aim is to aid researchers in obtaining large data that originates from trustworthy sources.

In (Sikora, & Chauhan, 2012), the first impression bias i.e. the tendency of the individuals to modify their opinions on the basis of first- third person review that he/she views which has been eliminated using the Kalman filtering technique. In (Schweiger, Oeberst, & Cress,2014), the confirmation bias in web based search was studied. The two data samples taken were psychotherapy and pharmacotherapy both of which are scientifically equally effective for depression treatments but the former was considered to be more effective by the public. The blog entries by experts and tag clouds were recommended to counter biased information processing on these entries. In (Wood, & Dellarocas, 2006), the reporting bias of the traders and its effects on the public feedback have been studied. The basic assumption dealt with here is that the traders are more likely to report or give a feedback when the experience has been positive rather than when it is negative. Hence, the lack of negative feedback doesn't necessarily mean the absence of it. In (Hu, Bose, Gao, & Liu, 2011), a simple statistical method has been developed in order to detect the online product reviews which are biased and how they affect the consumer reaction to the products. The two parameters on which review manipulation were judged were manipulation through ratings and manipulation through sentiments. The consumers were found to have detected successfully only the former.

In (Piramuthu, Kapoor, Zhou, & Mauw, 2012) sequential bias in the online product of the recommender systems are found and eliminated. In (Sikora, & Liangjun, 2014) the various methods used by traders to alter their reputation score in the online market have been studied. Here, the concept of replicator dynamics is used to study the evolution of different types of sellers and buyers in the market. In (Chen, & Lin, 2013), decision tree along with correlation analysis and extracted knowledge rules has been used to improve the detection of the online review manipulation by introducing eight review manipulation attributes. In (Hu, Bose, Gao, & Liu, 2011) the study on the increase in propensity of biasness in the book reviews increases with the passage of time has been explored. In (Cipriani, Guarino, & Antonio,2012), the herd behavior in financial markets has been studied and eliminated using structural estimation framework.

The paper (Knight, & Chiang, 2008) investigates the media bias and the influence the media has on casting of votes during election time. The paper concludes that although newspapers do influence the opinion formation of the voters, it is limited by the degree and direction of the bias. In (Wang, Zhang, X. M., & Hann, 2010), the social bias in online product ratings has been explored. The degree of social influence was found to be greater for the books with that were popular, if the rating was from less experienced user, the rating was given at a later stage of review cycle and if the rating was given by a user with small social network.

After the literature review, we find that individual bias though mentioned in various papers has never been worked upon or researched on before. Since, individual bias is one aspect that can greatly modify the sentiment score, hence, we decided to concentrate on

this topic as our area of work and present the user with an objective score.

III. Proposed Methodology

The proposed system has seven major steps which start from extraction of corpus for the formulae to be applied upon. The next step is to extract the user data which are the likes from his/her Facebook® profile and the profile URL and manage the database hence, created. This serves as input for the mathematical modeling of the system. The corpus extracted is fed to ALCHEMY API to give an unadjusted score for the corpus. Further, steps include mathematical modeling and application of the developed formulae to calculate adjusted and unadjusted score for the corpus. In the end, we present the user with an unadjusted score which is an objective score i.e. sans any individual bias. Framework of proposed approach is shown in Figure 1.

Step 1: Extraction of Movie Reviews (Sentimental Data) for Social Media

Movie reviews are collected from social media, weblogs, bloggers, social networking sites like Facebook®, Twitter etc. for further processing.

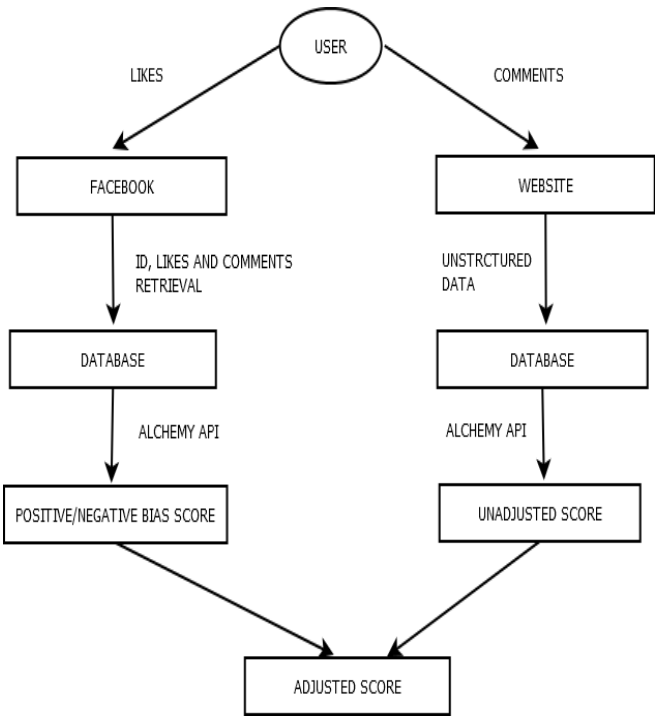

Figure1: Framework of the proposed methodology

Step 2 : Extraction of User Data

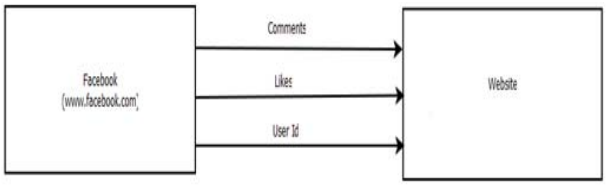

Figure 2 : Bidirectional Flow

In order to track the preferences and compute the likes and dislikes, the data related to the user i.e. the user's likes, their comments, the user ID, etc. is extracted from Facebook® in form of tokens. It is then sent to the website for further computation.

Step 3: Database Management

The comments, the likes, the user information and id are stored in *Phpmyadmin* database management system. The calculated sentiment score and bias score is also stored in the database. Next, unadjusted score is calculated using ALCHEMY API.

Step 4: Alchemy Api

The system makes use of a text analysis tool called ALCHEMY API (http://www.alchemyapi.com/). This tool provides the real-time text analysis through the method of entity and keyword extraction and provides the degree of positive and negative connotation they have.

It works on diverse document types including news articles, blog posts, product reviews, comments and Tweets.

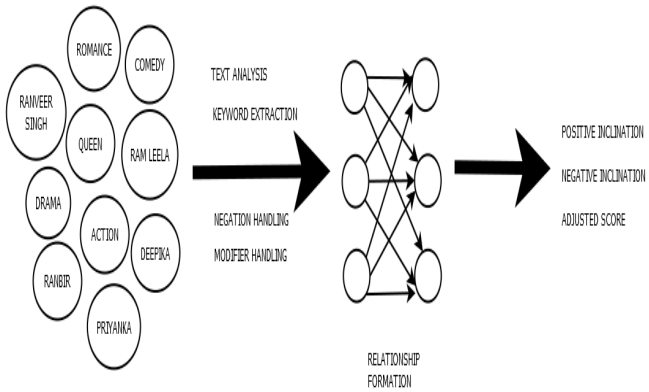

Figure 3 : Alchemy API Flow

The basic idea behind this framework is that it targets unstructured data, forms relationship between the keywords and the data and gives the relevant structured result. Figure 3 showcases the working of the ALCHEMY API.

The keywords in this figure are of three types: the keywords representing Bollywood actor/actress namely Ranbir, Deepika, Priyanka, Ranveer Singh; the

keywords representing Bollywood movie names namely Ramleela and Queen; the keywords representing movie genre namely Action, Comedy, Drama and Romance.

The ALCHEMY API applies multiple algorithms of text analysis, keyword extraction, negation handling and modifier handling on these keywords and gives a structured relationship between them. The final result is in the form of positive and negative bias score.

Step 5: Mathematical Modeling

To determine the relevant parameters and their corresponding weightage to analyze the corpus a preference survey of the varied sample of a movie audience was conducted.

Thus, the movie reviews are analyzed on two major factors namely genre and actor/director of the movie in order to determine the bias of an individual.

a) Genre

The genre refers to the style or category of the movie for example Drama, Romance, Action, among others.

b) Actor/Director

The user inclination towards or against certain actors and director in the movie can make a user biased towards the movie as well.

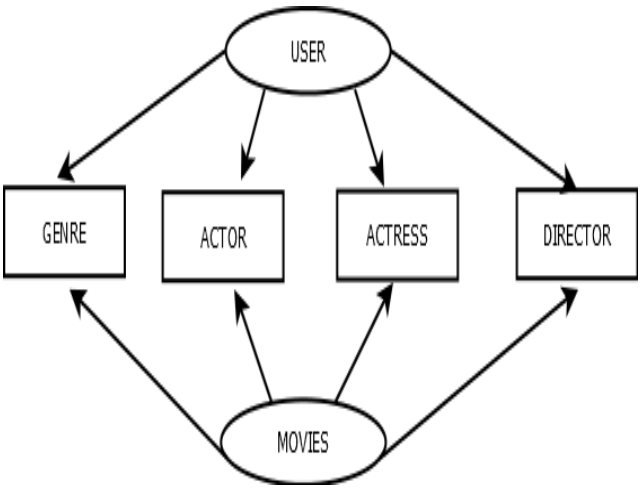

Figure 4 : Program Factors

The mathematical formulae used to calculate the positive and negative bias is given by Ψ, which represents the bias present in the data.

$$\Psi = 0.54\alpha + 0.46\beta \quad \ldots(1)$$

Here, 'α' refers to the Genre Score and 'β' refers to the Actor/ Director Score.

The impact ratio of genre to director/actor score i.e. 54: 46 has again been inferred using the user survey sample conducted for over thousands Facebook® users. Given below is the step-by-step process for the implementation flow of the framework.

Algorithm 1: To calculate the Adjusted Sentiment Score.

i. *Input*
A corpus of movie review comments.

ii. *Variables*
An initially empty set of comments c,An initially empty set of tags t, which comprise of the three keyword types described above i.e. the keywords representing actor/actress, movie names and movie genre. An initially empty set of sentiments s.

iii. *Output*
Adjusted Sentiment Score *A*

1. $C \leftarrow$ retrieve_comments(c_i)
2. For each $c_i \in C$ do
3. $s_i \leftarrow$ retrievesentiment(c_i);
4. $pos_i \leftarrow$ retrievepos(c_i);
5. $neg_i \leftarrow$ retrieveneg(c_i);
6. $A \leftarrow$ adjsentscore(s_i, pos_i, neg_i)
7. return 'A'

The movie comments are collected in a set *c*. The index *i* refers to the fact that i^{th} comment is being processed. The total number of comments is taken to be *n*. For each comment in the set the keyword extraction is done and tags are collected in another set *t*. These tags are used to get the negative inclination score. Each comment is also manipulated to extract the sentiment types which are collected in a set *s*. The variables defining the positive bias score, negative bias score and sentiment are passed on to the adjusted score function to get the composite score.

Step 6: Unadjusted Score Calculation

The unadjusted score gives the subjective score of the user sentiments. This score needs to be refined to get an objective adjusted score.

The unadjusted score is calculated using ALCHEMY API framework that is incorporated in the movies reviews website. This score is calculated by applying the ALCHEMY API algorithm on the user comments in the website.

The unadjusted score thus calculated is given by *S*. Here, the number of users is taken to be m, while of multiple posts by a single user a variable n is used to keep a count of comments. The score of a single user is hence represented by,

$$S = \frac{\sum_{i=1}^{n} y_i}{n} \quad \ldots(2)$$

Step 7: Adjusted Score Calculation

To incorporated individual bias we look at three different possible aspects. Firstly, the positive inclination or the positive bias which shows overtly promoting behavior of the source. Secondly, the negative inclination or negative bias, which shows the detractor behavior of the source. Thirdly, when there is a mixed response of both positive and negative inclination by the source.

iv. *Alchemy Api*

The ALCHEMY API is then used to evaluate the unadjusted score for the user. The bias is incorporated in the score after the implementation of the positive and negative bias algorithms.

IV. Conclusion

The current systems lack the ability to objectively review a product based on user comments. This is because of the inherent biasness present in their comments. We combat this biasness problem by incorporating the positive and negative bias component in the existing unadjusted sentiment score of the object using various proposed algorithms. We calculated the degree of biasness an individual has towards or against the review parameters for the movie reviews corpus namely actor, director and genre. Finally, the system functions well in various scenarios like presence of only positive inclination of the user, presence of only negative inclination of the user, presence of both positive and negative inclination of the user and neutral attitude of the user. Hence, our system computes an objective score sans any individual bias.

V. Future Scope

The principal contribution of our research is the implementation of individual bias in the existing sentiment analysis algorithms. This can be used in various fields like business, journalism, product development among others. The research can be implemented across different algorithms and languages too.

The future endeavor in this direction would be implementation of unexplored biases in the system like selection bias, cognitive bias, first impression bias, herd bias, etc.

References Références Referencias

1. Kim, S., & Hovy, E. (2004). Determining the sentiment of opinions. In Proceedings of the international conference on computational linguistics (COLING 2004) East Stroudsburg, PA,1367.
2. Cui, H., Mittal, V., & Datar, M. (2003). Comparative Experiments on Sentiment Classification for Online Product Reviews, 1265–1270.) S, S. K. (2013). Sentiment Analysis Based Approaches for Understanding User Context in Web Content Dept of Information Technology. doi:10.1109/CSNT. 2013.130
3. K. Dave, S. Lawrence, and D. Pennock. Mining the peanut gallery: Opinion extraction and semantic classification of product reviews. In Proceedings of the 12th international conference on World Wide Web, pages 519–528. ACM, 2003
4. Wu, M., Wang, L., & Yi, L. (n.d.). A Novel Approach Based on Review Mining for Product Usability Analysis, (71), 942–945.
5. Gil De Zuniga, H., Puig-I-Abril, E., & Rojas, H. (2009). Weblogs, traditional sources online and political participation: An assessment of how the internet is changing the political environment. New Media and Society, 11, 553–574 Sciences, S., Lin, Y., Margolin, D., Keegan, B., & Lazer, D. (n.d.). Voices of Victory : A Computational Focus Group Framework for Tracking Opinion Shift in Real Time Categories and Subject Descriptors, 737–747.
6. Park, Ko, Kim, Liu, & Song, 2011) in Kontopoulos, E., Berberidis, C., Dergiades, T., & Bassiliades, N. (2013). Ontology-based sentiment analysis of twitter posts. Expert Systems with Applications, 40(10), 4065–4074. doi:10.1016/j.eswa.2013.01.001
7. Larsson, A., & Moe, H. (2011). Studying political microblogging: Twitter users in the 2010 Swedish election campaign. New Media and Society, 14, 727–747.
8. Lin, E., Fang, S., & Wang, J. (2013). Mining Online Book Reviews for Sentimental Clustering. 2013 27th International Conference on Advanced Information Networking and Applications Workshops, 179–184. doi:10.1109/WAINA.2013.172
9. Wen, B., Dai, W., & Zhao, J. (2012). Sentence Sentimental Classification Based on Semantic Comprehension. 2012 Fifth International Symposium on Computational Intelligence and Design, 458–461. doi:10.1109/ISCID.2012.275
10. Yi-Fen Chen, Herd behavior in purchasing books online,, Computers in Human Behavior 24 (5) (2008) 1977–1992.
11. Guillaume Deffuant, Sylvie Huet, Collective increase of first impression bias,Complexity 15 (5) (2009) 25–3362
12. Piramuthu, S., Kapoor, G., Zhou, W., & Mauw, S. (2012). Input online review data and related bias in recommender systems. Decision Support Systems, 53(3), 418–424. doi:10.1016/j.dss.2012.02.006
13. Liu, B. (2010). Sentiment analysis and subjectivity. Handbook of Natural Language Processing.Liu, Y., Huang,
14. Wu, M., Wang, L., & Yi, L. (n.d.). A Novel Approach Based on Review Mining for Product Usability Analysis, (71), 942–945.
15. Mishra, N., & Jha, C. K. (2013). Restricted Domain Opinion Mining in Compound Sentences. 2013 International Conference on Communication Systems and Network Technologies, 616–620. doi:10.1109/CSNT.2013.132
16. Bencz, A. (2012). Content-Based Trust and Bias Classification via, 41–47.
17. Cipriani, M., & Guarino, A. (2012). Estimating a Structural Model of Herd Behavior in Financial

Markets. SSRN Electronic Journal. doi:10.2139/ssrn.2080234
18. Sikora, R. T., & Chauhan, K. (2012). Estimating sequential bias in online reviews: A Kalman filtering approach. Knowledge-Based Systems, 27, 314–321. doi:10.1016/j.knosys.2011.10.011
19. Wang, C. A., Zhang, X. M., & Hann, I. (n.d.). Social Bias in Online Product Ratings : A Quasi-Experimental Analysis, (February 2010), 1–35.
20. Piramuthu, S., Kapoor, G., Zhou, W., & Mauw, S. (2012). Input online review data and related bias in recommender systems. Decision Support Systems, 53(3), 418–424. doi:10.1016/j.dss.2012.02.006
21. Jusoh, S., & Alfawareh, H. M. (2013). Applying fuzzy sets for opinion mining. 2013 International Conference on Computer Applications Technology (ICCAT), 1-5. doi:10.1109/ICCAT.2013.6521965
22. Lin, E., Fang, S., & Wang, J. (2013). Mining Online Book Reviews for Sentimental Clustering. 2013 27th International Conference on Advanced Information Networking and Applications Workshops, 179–184. doi:10.1109/WAINA.2013.172
23. Huang, Y., & Lin, H. (2013). Web product ranking using opinion mining. 2013 IEEE Symposium on Computational Intelligence and Data Mining (CIDM), 184–190. doi:10.1109/CIDM.2013.6597235
24. Wu, M., Wang, L., & Yi, L. (n.d.). A Novel Approach Based on Review Mining for Product Usability Analysis, (71), 942–945.
25. Mishra, N., & Jha, C. K. (2013). Restricted Domain Opinion Mining in Compound Sentences. 201363

Global Journal of Computer Science and Technology: G Interdisciplinary
Volume 15 Issue 2 Version 1.0 Year 2015
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Secure on-Line Transaction through Augmented Biometrics System

By Adegboye Adegboyega
Achievers University Owo, Nigeria

Abstract- Internet and its facilities facilitate on-line shopping by allowing shoppers to browse the online stores and obtain their needs with minimum effort. This is not possible with familiar traditional system of buying and selling. This advantage offered by the internet is restricted by issue arising from on-line security and payment systems. Although research has been conducted and several approaches have been devised to reduce this restriction but there is need for further improvement. As a result, this research work proposes a new solution that combines biometrics technology (Finger Print) together with (password) to provide secure on line transaction through multiple factors security solution. It makes, verifying process and verification for shopper's identity more secured by recognize individual based on measurable biological characteristics (Fingerprint) and provision of a link to identify the authorized user, this minimizes frauds. This addresses and reduced the security problems that are associated with existing on line transaction and e-payments. The design was implemented using Visual Basic.Net and SQL because of their supports for implementing web-based security systems. Samples of (130) on line shoppers were used for this research work to capture fingerprints from index and thumb fingers of left and right hands, also the attitudes of the customers in terms of password selection and management.

Keywords: *password, security, e-payment, fingerprint, biometric technology, on line transaction and shopper.*

GJCST-G Classification: *K.4.4*

Strictly as per the compliance and regulations of:

Secure on-Line Transaction through Augmented Biometrics System

Adegboye Adegboyega

Abstract- Internet and its facilities facilitate on-line shopping by allowing shoppers to browse the online stores and obtain their needs with minimum effort. This is not possible with familiar traditional system of buying and selling. This advantage offered by the internet is restricted by issue arising from on-line security and payment systems. Although research has been conducted and several approaches have been devised to reduce this restriction but there is need for further improvement. As a result, this research work proposes a new solution that combines biometrics technology (Finger Print) together with (password) to provide secure on line transaction through multiple factors security solution. It makes, verifying process and verification for shopper's identity more secured by recognize individual based on measurable biological characteristics (Fingerprint) and provision of a link to identify the authorized user, this minimizes frauds. This addresses and reduced the security problems that are associated with existing on line transaction and e-payments. The design was implemented using Visual Basic.Net and SQL because of their supports for implementing web-based security systems. Samples of (130) on line shoppers were used for this research work to capture fingerprints from index and thumb fingers of left and right hands, also the attitudes of the customers in terms of password selection and management. The empirical results reveal above 80% password management practices, more than 85% for fingerprint recognition rate and 96.30% participation. The combined strengths of this scheme present on line shoppers a secure and usable authentication scheme. Although on line shopping is used in this research work, it can be adapt to perform airline ticket booking; do financial deals like pay bills via internet banking and online brokering to buy shares.

Keywords: password, security, e-payment, fingerprint, biometric technology, on line transaction and shopper.

I. Introduction

Modern software application computer programs enable ones to carry out on-line transaction irrespective of location and time, however, the issue arising from Security and payment systems like "the use of spyware and virus that allows usernames and passwords to be stolen for unauthorized access are impeding the adoption of these online applications especially those involving sensitive data like financial transactions" (Stavrou et al, 2002).

According to (Chandra and Calderon, 2005; Költzsch, 2008), "extra security measures are needed in order to protect consumers from on-line fraud and Biometric technology is increasingly being seen as a potential solution that will adequate address this problem", also (Jain et al, 2000 and Gunajit and Pranav, 2010) point out that "Biometrics provide very powerful tools for the problems requiring positive identification and provide enabling technology that have potential to make our society safer, reduce fraud and lead to user convenience".

Compared to other security measures, application of biometric technology may provide a better method to curb on line fraud, since it uses certain physical and behavioral traits that are distinctive to an individual to identify and verify the person through authentication; other forms of authentication methods have presented problems of improper authentication to users, for adequate on-line data protection and authentication, there is need to offer improved solution through biometric system (Shouvik et at, 2012,P.4,Okediran O. O., et al 2014, P. 2).

According to (Selina and Oruh, 2012), "Institutions offering Internet-based products and services to their customers should use effective methods to authenticate the identity of customers using those products and services", also (Amtul, 2011) affirmed that "fingerprint technology in particular, can provide a much more accurate and reliable user authentication method". This research work has detailed the development of a biometric identification scheme something you have (fingerprint) combined with something you know (password) for electronic payment. The combined strengths of these scheme present computer users a secure and usable authentication scheme, that reduces fraudulent practices in the payment of on line transaction payment and provides better solution.

II. Review of Existing on Line Payment Methods

a) Online cash systems

Online cash systems such as Virtual BBVA in Spain and PAY offered by SNAP in Italy, Austria and Australia have been designed and implemented. The wider usage of these on-line cash payment system is limited because of inability to secure on-line payments and transaction process over the internet making user inconvenience.

Author: Dept. of Mathematical Science Achievers University, Owo, Ondo State, Nigeria. e-mail: akanbi2090@yahoo.co.uk

b) Debit cards, otherwise called ATM cards

Debit cards, otherwise called ATM cards are still the most common e-banking product used by most Nigerians. It is of great importance for all economic agents, since it enables fast and efficient payments in the national economy as well as internationally. The ability to complete payments with confidence is critical to the efficient functioning of the on-line electronic transaction and this efficiency has not been fully achieved due to existence of the various forms of crimes such as fraud and identity theft problems that are affecting on-line payment. Figure 1 shows ATM card.

Figure 1: ATM card

c) Online Credit Card Payment System

According to (Laudon and Traver, 2002),"This payment system has been widely accepted by consumers and merchants throughout the world, and the most popular methods of payments especially in the retail markets". It offers several advantages over the traditional modes of payment; the consumers and merchants still faced challenges of third party involvement. Figure 2 shows Credit Card Payment Form.

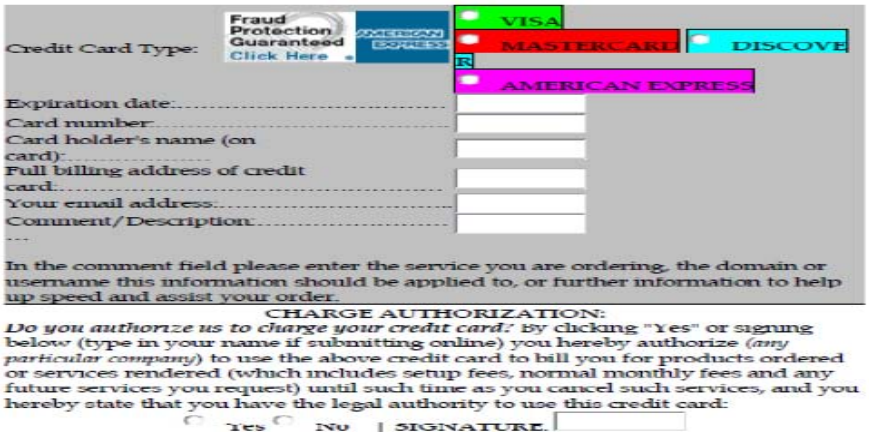

Figure 2 : Credit Card Payment Form Sample

d) Electronic Cheque Payment System

Digital cheque payment system seeks to extend the functionality of existing chequing accounts for use as online shopping payment tools. Electronic cheque system has many advantages: (1) they do not require consumers to reveal account information to other individuals when setting an auction (2) they do not require consumers to continually send sensitive financial information over the web (3) they are less expensive than credit cards and (4) they are much faster than paper based traditional cheque. The disadvantage of electronic cheque system includes their relatively high fixed costs, their limited use only in virtual world and the fact that they cannot protect the users' anonymity. Therefore, it is not very suitable for the retail transactions by consumers.

e) Smart Cards based Electronic Payment System

(Chakrabarti et al K, 2002) described Smart Cards based Electronic Payment System as "Plastic card that contained memory chips or embedded microprocessors of greater storage and inbuilt transaction processing capability", Smart cards are better protected from misuse than conventional credit cards, because the smart card information is encrypted. Currently, the two smart cards based electronic payment system- Mondex36 and Visa Cash are incompatible in the smart cards and card reader specification. Not knowing which smart card system will become market leader; banks around the world are unwilling to adopt either system, let alone other smart card system. Therefore, establishing a standard smart

card system, or making different system interoperable with one another is critical success factors for smart card based payment system.

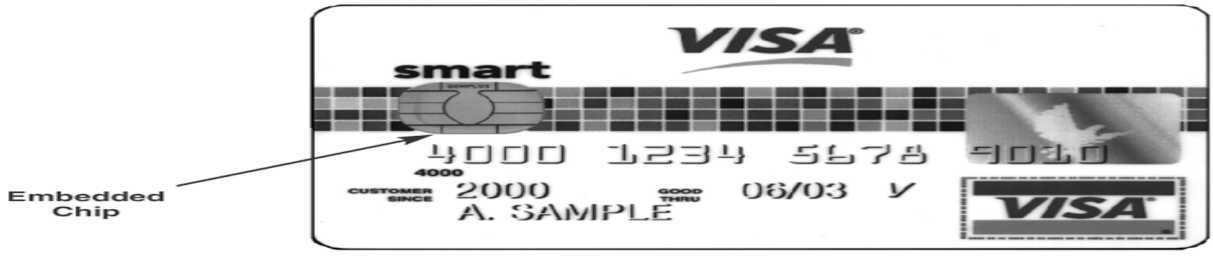

Figure 3 : Smart Card based Electronic Payment System

(Sumanjeet , 2009),reported that " Users tend not to trust existing systems due to the long history of fraud, misuse or low reliability, that resulted to non positive reputation, also potential customers often mention this risk as the key reason why they do not trust this payment system", therefore, they do not make Internet purchases with it.

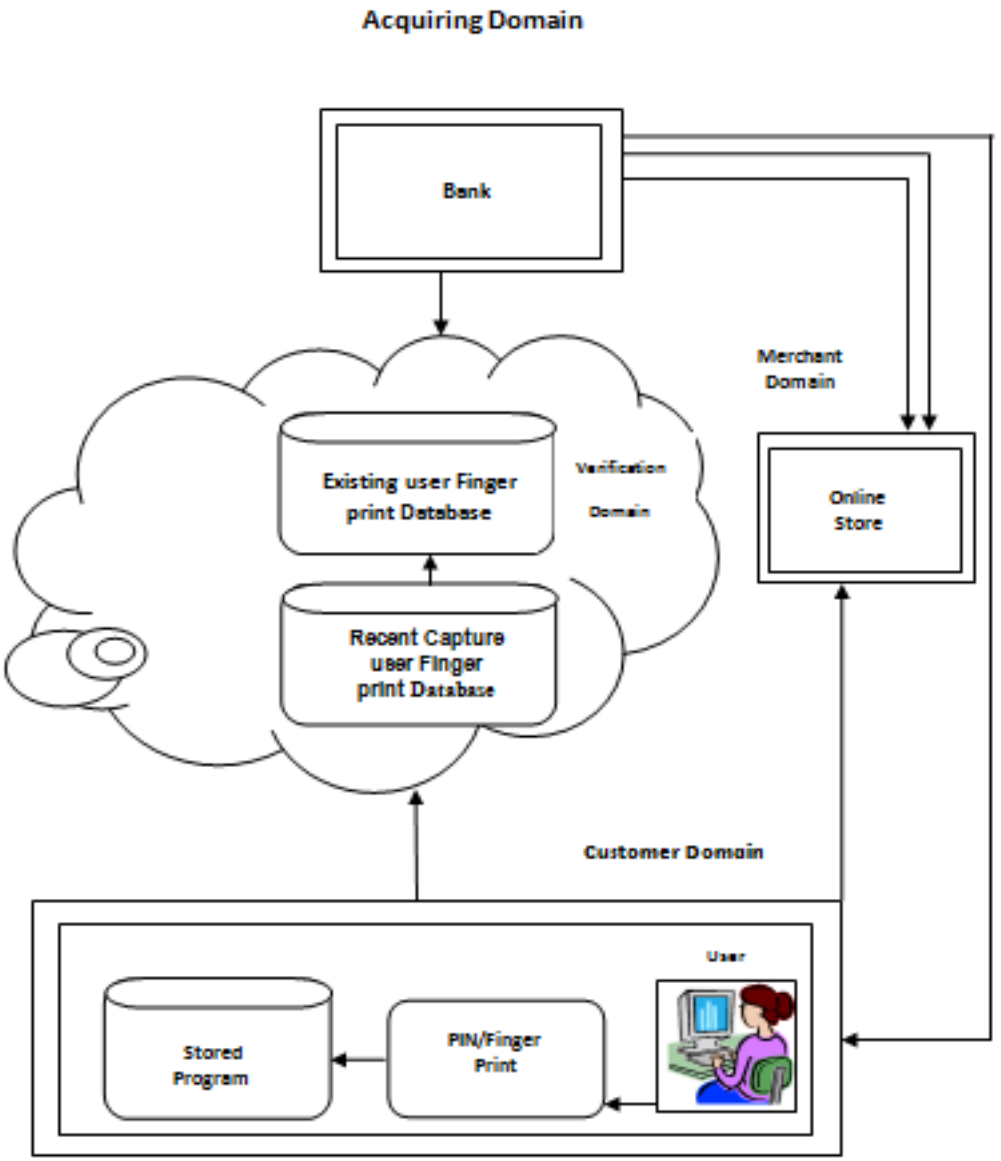

Figure 4 : Proposed Model Architecture of Secure On-Line Transaction Augmented Biometrics System

III. Description of the Proposed System

The proposed model gives the flexibility to perform any online payment or transaction, the model is based on, three-tier security comprising the Password, provided link and finger print. The architecture aims to, makes, online payment or transaction verifying process and verification for shopper's identity more secured as much as possible. The user will be presented with a registration page for first time of use, after his registration, he will be required to scan his finger print, which will then be submitted into the fingerprint database through provided link. For subsequently use the consumer, log into his system (PC/Laptop/Phone) using (PINS), then do fingerprint using fingerprint device and send the captured information via a provided link, he browses, the online stores, when he is ready to pay for his shopping, the on line-store contacts his bank and the bank, compared his captured fingerprint to a compact and expressive digital representation of the user fingerprints already stored as a template on a cloud database. If a match is found and the user has enough fund is granted to carry out the on line transaction payment, deduction is made from the consumer's account , otherwise, the payment is denied, which ever case an applicable information is send to the consumer and the on line store to respond as appropriate.

IV. Implementation and Results

Hypertext markup language was employed in the Microsoft visual studio integrated development environment. The overall system was developed on the Microsoft.NET framework using Visual Studio.NET (visual C#) and MS SQL Server 2008. Samples of (130) on line shoppers were used for this research work to capture fingerprints from index and thumb fingers of left and right hands, also the attitudes of the customers in terms of password selection and management. Some of the graphical user interface of the developed system is depicted in Figures 2 - 5. The empirical results reveal more than 80% password management practices and above 85% of fingerprint recognition rate. The combined strengths of this scheme present on line shoppers a secure and usable authentication scheme.

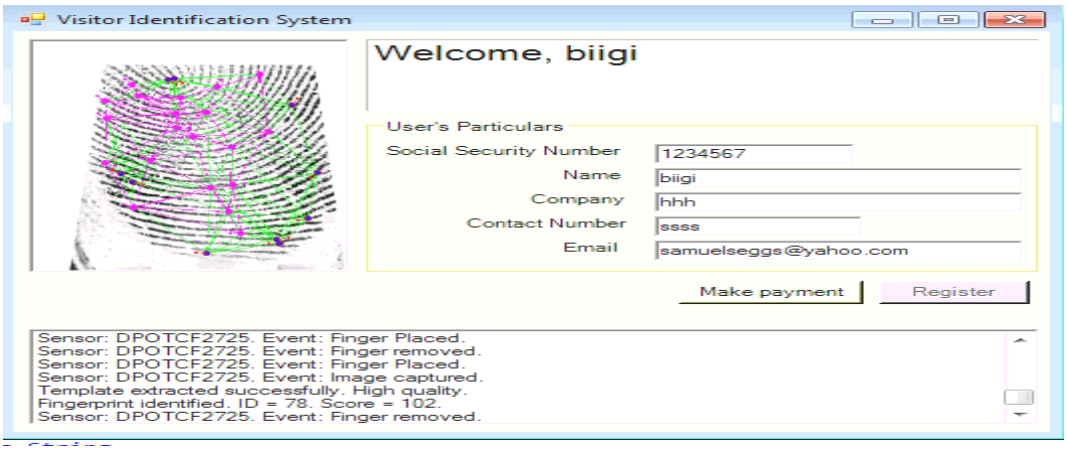

Figure 4 : Shopper information interface

Serial	Name	Price	Qty	Amount	Options
1	View Sonic LCD	$ 250	1	$ 250	Remove
Order Total: $250			Clear Cart	Update Cart	Place Order

Figure 5 : Shopping Cart information interface

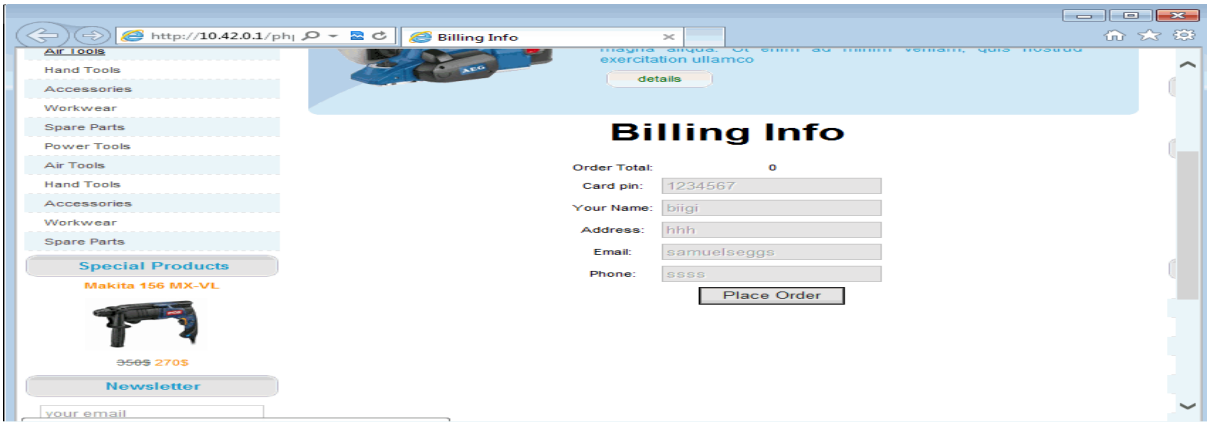

Figure 6 : Billing information interface

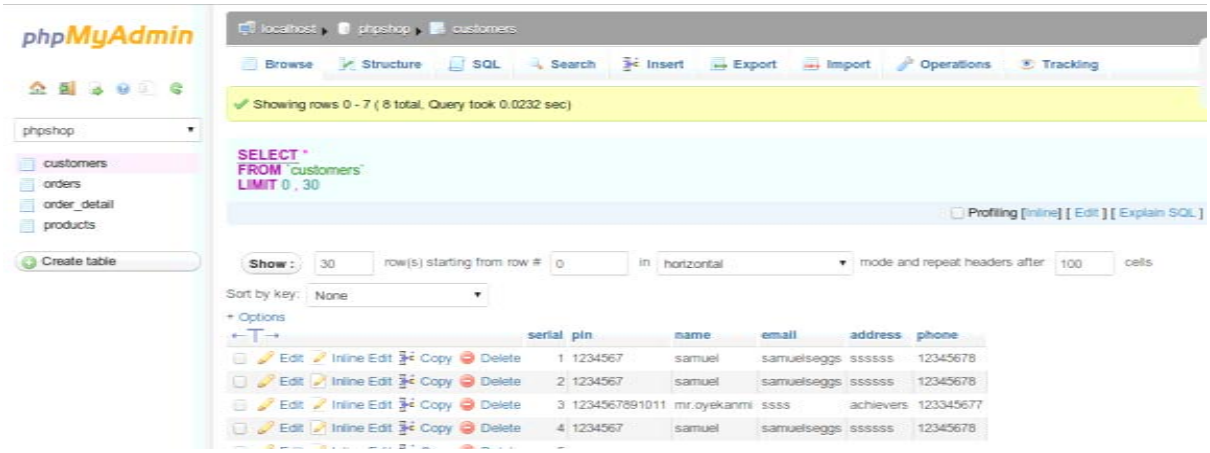

Figure 7 : Validation of Payment Account Interface

V. Evaluation of The Secure Augmented Biometrics System

a) *Research Design*

The descriptive survey design was adopted which involved the collection of primary and cross sectional data through the use of a structured questionnaire. A preliminary study visit was made to a community-Based ICT Centre Ewekoro Abeokuta Nigeria in April 2015 to find out about the feasibility of the study. The sample frame for this study comprised exhaustive list of the ICT Centre units. The purposive sampling method was adopted in selecting the respondents so as to ensure that selected individuals were those that had adequate knowledge of online shopping.

b) *Instrument for Data Collection*

Data were collected with a structured questionnaire designed in a four point Like scale, comprised four sections: Section A elicited information about units in the ICT Centre. Section B asked questions about ICT resources available in each Unit. While section C sought to ascertain the stage of ICT Global Standard in the Centre. Section D, the last section, contained questions that enquired about the challenges encountered by the units in the ICT online transaction adoption and implementation processes. The instrument was validated through face and content validity. It was subjected to thorough scrutiny by three experts in Biometric System research and two others in the field of password selection and management. Modifications were made on the instrument based on their assessments. Copies of the questionnaire were distributed to the respondents by the researchers who had initially sought the permission of the Director of the ICT Centre. A total of 135 copies of the questionnaire were distributed but 130 copies were completed and returned. This constituted 96.30% and was used for data analyses.

c) *Data Analysis*

The Statistical Package for Social Science (SPSS) software was used to carry out the analysis. The variables used to assess the Secure On-Line Transaction Augmented Biometrics System using 4-point like scale was re-coded. Strongly Agree and Agree were re-coded as high while disagree and strongly Disagree were re-coded as Low. Next, a frequency distribution table was generated for all the variables.

Table 1 : Distribution of variables concerns the Secure Augmented Biometrics System

		PASSWORD SELECTION		PASSWORD MANAGEMENT		FINGERPRINT LEFT(*index and thumb)*		FINGERPRINT RIGHT(*index and thumb)*		OPERATIONAL EFFICIENCY	
		Freq.	%	Freq	%	Freq	%	Freq	%	Freq.	%
Valid	Low	20	15.38	23	17.69	16	12.31	15	11.54	18	13.85
	High	110	84.62	107	82.31	114	87.69	115	88.46	112	86.15
	Total	130	100	130	100	130	100	130	100	130	100

The distribution of variables as relates to the Secure Augmented Biometrics System is as presented in table 1.The Password selection and Password management are more than 80%,this may due to initial training giving to the user concerned password protection. While Finger Print (Index and Thumb) recorded more than 85 % .Operational efficiency is more than 85% this is owed to ease of use that make user to easily acquired sufficient knowledge and skills on the use of the system and can result to increase in number of on-line transaction. A total of 135 copies of the questionnaire were distributed to Participants but 130 copies were completed and returned. The system shows 130/135 (96.30%) participation. From the evaluation, we can conclude that the Secure Augmented Biometrics System is highly efficient, effective and satisfactory to the target users (On-line shoppers).

VI. Discussion And Recommendation

Internet shopping, unlike traditional retailing systems shoppers browse the online stores and obtain their needs with minimum effort. Internet shopping has been one of the mostly used facilities of the Internet. Security in online shopping and payment systems has been a wide research area since the early days of the Internet and several approaches have been devised. This research work proposes a new solution that combines password with finger print recognition. The Password selection and Password management are more than 80%, this may due to initial training giving to the user concerned password protection. While Finger Print (Index and Thumb) recorded more than 85 % .Operational efficiency is more than 85% this is due to ease of use that makes user to easily gained sufficient knowledge and skills on the use of the system this will increase on line shopping and mobile payments for goods and services through online transaction when the system is fully adopted. The system shows 130/135 (96.30%) participation. From the evaluation, we can conclude that the Secure Augmented Biometrics System is highly efficient, effective and satisfactory to the target users (On-line shoppers). It makes, verifying process and verification for consumer identity more secured by recognize individual based on measurable biological characteristics (Fingerprint) and provision of a link to identify the authorized user, this minimizes frauds. The result of this research work has demonstrated that finger print uniqueness provides adequate authentication. In this work, will combine text based password and biometrics (finger Print), the combined strengths of these scheme present on line shoppers a secure and usable authentication scheme. Although the on line shopping was used in this research work, it can be apply to perform airline ticket booking; do financial deals like pay bills via internet banking and online brokering to buy shares.

References Références Referencias

1. Amtul Fatima (2011): E-Banking Security Issues – Is There A Solution in Biometrics ? Journal of Internet Banking and Commerce, vol. 16, no.2 Pp 1-9.
2. Chakrabarti, Rajesh and Kardile, Vikas (2002), *E-Commerce: The Asian Manager's Handbook*, New Delhi: Tata McGraw Hill.
3. Chandra, A., & Calderon, T. (2005).Challenges and constraints to the diffusion of biometrics in information systems. *Communications of the ACM, 48*(12), 101-106.
4. Gunajit Sarma1 and Pranav Kumar Singh (2010): Internet Banking: Risk Analysis and Applicability of Biometric Technology for Authentication. *Int. J. Pure Appl. Sci. Technol.*, 1(2) (2010), pp. 67-78.
5. Jain, A.K., Prabhakar, S., Hong, L. and Pankanti, S. (2000), "Filterbank-based fingerprint matching" IEEE Trans. on Image Processing, pp.846-859.
6. Laudon, C. Kenneth and Traver, Carol (2002), *E-Commerce*, New Delhi: Pearson Education.
7. Okediran O. O., et al (2014) A Biometric Identification Based Scheme for Secured E-Payment. Journal of Computation in Biosciences and Engineering. Volume 1/ Issue 2 Pp .1-5
8. Selina Oko and Jane Oruh (2012): Enhanced ATM security system using biometrics. International Journal of Computer Science Issues, Vol. 9, Issue 5, No 3, Pp 355-363.
9. Shouvik Biswas, Anamitra Bardhan Roy,Kishore Ghosh, Nilanjan Dey (2012) : A Biometric Authentication Based Secured ATM Banking System. International journal of Advanced Research in Computer Science and software Engineering.Volume 2,Issue 4,April 2012 Pp. 178-182.
10. Stavrou, A, Benjamin, P, May, J., (2002): "E-Commerce and Poverty alleviation in South Africa; An Input Paper to the Government Green Paper – Unpublished", pp 27- 44, available at http://docweb.pwv.gov.za/Ecomm-debate/myweb/greenpaper/academics/stavrou.html

11. Sumanjeet S (2009). Emergence of Payment Systems in the age of Electronic Commerce: The State of Art, Global J. Bus. Res., 2(2): 17- 36.
12. Sumanjeet Singh *(2009)* Emergence of payment systems in the age of electronic commerce: the state of art *Asia Pacific Journal of Finance and Banking Research Vol. 3. No.3. 2009.Pp 18-40.*

This page is intentionally left blank

Global Journal of Computer Science and Technology: G Interdisciplinary
Volume 15 Issue 2 Version 1.0 Year 2015
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Multi-Modal Biometrics: Applications, Strategies and Operations

By Iwasokun G. B., Udoh S. S & Akinyokun O. K
Federal University of Technology, Nigeria

Abstract- The need for adequate attention to security of lives and properties cannot be over-emphasised. Existing approaches to security management by various agencies and sectors have focused on the use of possession (card, token) and knowledge (password, username)-based strategies which are susceptible to forgetfulness, damage, loss, theft, forgery and other activities of fraudsters. The surest and most appropriate strategy for handling these challenges is the use of naturally endowed biometrics, which are the human physiological and behavioural characteristics. This paper presents an overview of the use of biometrics for human verification and identification. The applications, methodologies, operations, integration, fusion and strategies for multi-modal biometric systems that give more secured and reliable human identity management is also presented.

Keywords: biometrics, human identity management, human verification and authentication, security, multi-modal.

GJCST-G Classification: D.4.2 F.4.3

Strictly as per the compliance and regulations of:

Multi-Modal Biometrics: Applications, Strategies and Operations

Iwasokun G. B. [α], Udoh S. S [σ] & Akinyokun O. K [ρ]

Abstract- The need for adequate attention to security of lives and properties cannot be over-emphasised. Existing approaches to security management by various agencies and sectors have focused on the use of possession (card, token) and knowledge (password, username)-based strategies which are susceptible to forgetfulness, damage, loss, theft, forgery and other activities of fraudsters. The surest and most appropriate strategy for handling these challenges is the use of naturally endowed biometrics, which are the human physiological and behavioural characteristics. This paper presents an overview of the use of biometrics for human verification and identification. The applications, methodologies, operations, integration, fusion and strategies for multi-modal biometric systems that give more secured and reliable human identity management is also presented.

Keywords: biometrics, human identity management, human verification and authentication, security, multi-modal.

I. Introduction

Biometrics refers to human characteristics and traits related metrics [1]. They are the distinctive, measurable and naturally endowed characteristics used to label and describe individuals. Any of the human physiological or behavioural characteristics is a biometric provided it satisfies some criteria that include universality, uniqueness, permanence, collectability, performance, acceptability and circumvention [2, 3]. Universality implies that every individual should possess the characteristic while uniqueness means that no two persons should be the same in terms of the characteristics. Permanence denotes that the characteristics should be invariant with time. By collectability, quantitative measurement of the characteristic must be possible and with ease while performance refers to achievable identification/ verification accuracy with different working or environmental conditions. Acceptability indicates the extent to which people are willing to accept the characteristic while circumvention refers to how difficult it is for fraudulent techniques to fool a system that is based on the characteristic. The relative comparison of the performance of the existing biometric characteristics based on these criteria is presented in Table 1 [4].

Author α ρ : Department of Computer Science, Federal University of Technology, Akure, Nigeria. e-mail: maxtunde@yahoo.com
Author σ : Department of Computer Science, University of Uyo, Uyo, Nigeria. e-mail: udohss@yahoo.com

Physiological characteristics (shown in Figure 1) are related to the shape of the body and incluttern Recognitionde fingerprint, palm prints, face, deoxyribonucleic acid (DNA), hand geometry, iris recognition, retina and odor/scent. Behavioural characteristics (also shown in Figure 1) include handwriting (typing rhythm), signature, gait and voice which are all related to the pattern of behaviour of a person. The traditional human identity management methods which include possession (such as identity and smart cards) and knowledge (such as Personal Identification Number (PIN) and password) based human identification schemes suffer various limitations including theft, forgery, unauthorized access and forgetfulness. Several private and public organizations often consider strengthening their knowledge-based security systems using longer and dynamic (changing) passwords, which often requires individuals documenting their passwords in unsecured manners. The compromise of a re-used password on different systems may lead to theft, privacy intrusion and other consequences [5]. Biometric-based human identity management systems have emerged as reliable, secure and dependable solutions to these limitations and have been deployed in numerous government and private applications [6]. The high confidence and success levels recorded for biometric-based systems have been attributed to some advantages that biometrics maintain over other methods. The advantages include strict and direct covert observation of biometric information, non-sharability, not-transferable and regeneration within short period when damaged or mutilated. In addition, biometrics-based systems are very easy to use, very friendly and repudiation-proof [7].

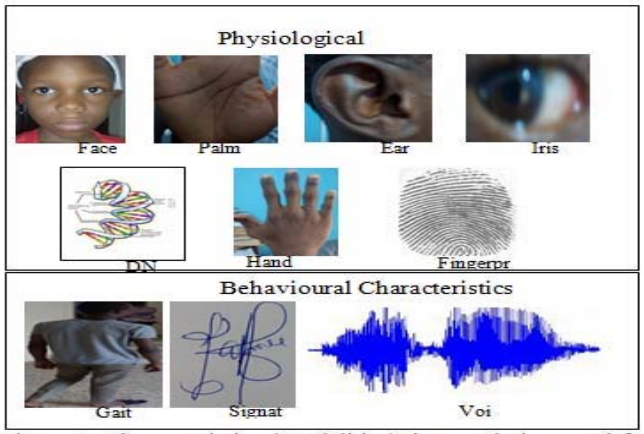

Table 1: Comparison of various biometric characteristics (A=Universality, B=Uniqueness, C=Permanence, D=Collectability, E=Performance, F=Acceptability, G=Circumvention, H=High, M=Medium, L=Low)

Characteristics	A	B	C	D	E	F	G
Face	H	L	M	H	L	H	L
Fingerprint	M	H	H	M	H	M	H
Hand Geometry	M	M	M	H	M	M	M
Keystroke Dynamics	L	L	L	M	L	M	M
Hand veins	M	M	M	M	M	M	H
Iris	H	H	H	M	H	L	H
Retina	H	H	M	L	H	L	H
Signature	L	L	L	H	L	H	L
Voice	M	L	L	M	L	H	L
Facial thermogram	H	H	L	H	M	H	H
DNA	H	H	H	L	H	L	L

A biometric system that is based on a single characteristic is called a uni-modal system while multi-modal biometric systems rely on multiple characteristics to function. Uni-modal biometric systems rely on the evidence of a single source of information for human authentication and they are susceptible to the following limitations [8-13]:

(a) Noisy data from sensors: this often leads to inaccurate matching and ultimately, false rejection.

(b) High intra-class variation: This results from variation between the acquired and template biometric data during verification. Large intra-class variations ultimately increase the False Rejection Rate (FRR).

(c) High interclass similarities: This arises from substantial similarity or correspondence between the feature characteristics of biometrics from multiple sources (individuals). It ultimately increases the False Acceptance Rate (FAR).

d) Non-universality: Due to illness or disabilities, some individuals may lack the required standalone biometrics.

(e) Non-individuality: This may be genetically induced for a small proportion of the population leading to very identical biometric characteristics (such as facial appearance) as may be observed for mother and daughter, father and son and identical twins. It impacted negatively on a biometric system by increasing its False Match Rate (FMR).

(f) Non-invariant representation: This is an intra-class variation arising from varied interactions of the user with the sensor. It may be due to angular, translational, pressure, pose and expression variations when a characteristic is repeatedly captured on a sensor. Other sources include the use of different sensors during enrolment and verification, changes in the ambient environment conditions and the inherent changes arising from wrinkles or scars in the biometric trait. These variations usually increase the False Non-Match Rate (FNMR) of a biometric system.

(g) Spoofing: Some biometric systems (especially those based on facial images) can be imitated or forged.

Multi-modal approach to human authentication and verification has been considered as the most reliable method for the elimination of these limitations. Multi-modal biometric systems integrate two or more types of biometric characteristics for consolidation and meeting stringent performance requirements. Most importantly, it is extremely difficult for an intruder to spool multiple biometric traits simultaneously [5, 11]. This paper presents the motivations, strategies and limitations of fingerprint, voice, iris and other biometrics modes for human identity management. Synopses of the integration techniques, fusion levels and scenarios, modes of operations and evaluation strategies of multi-modal systems are also presented.

II. Unimodal Biometric Systems

A uni-modal biometric system comprises of any of the biometrics shown in Figure 1 and contains five integrated components conceptualized in Figure 2 [12, 14]. The enrolment component is a sensor that acquires the biometric data and converts into a digital format. The image-processing unit uses specified algorithms to enhance the image and extracts meaningful feature set to form a biometric template. The biometric database is a repository of the extracted templates, which are necessary data for future reference from several images. The matching unit is responsible for performing algorithm-based comparison of a reference biometric image with the template image in the database and generate a matching score. The decision component uses the results from the matching component to make a system-level decision.

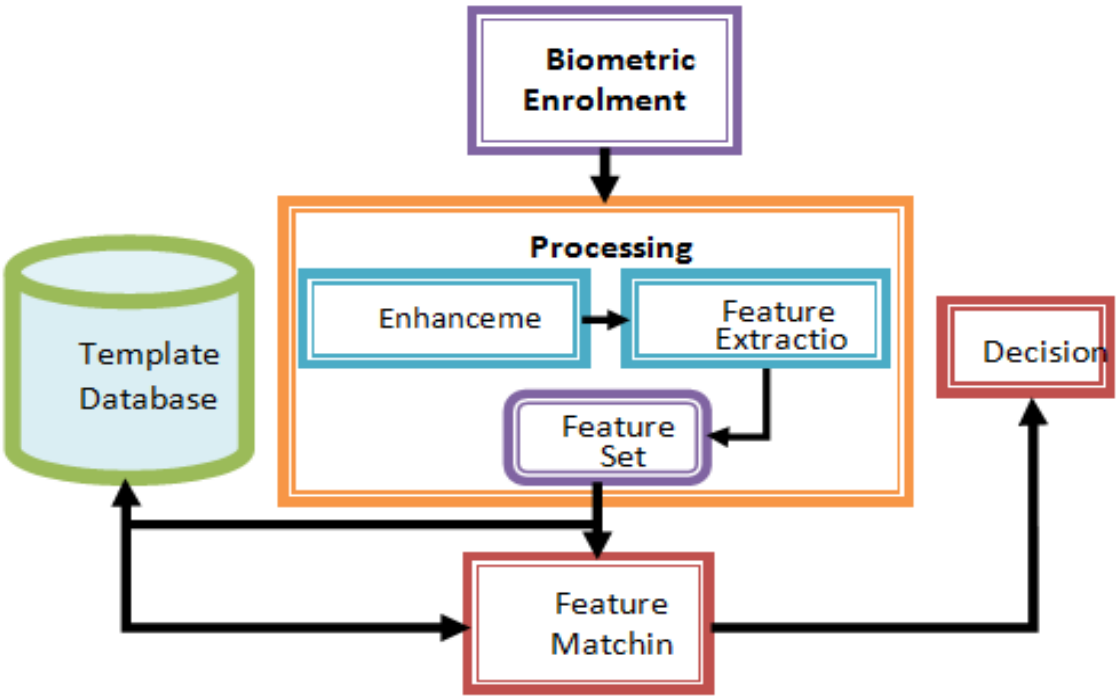

Figure 2 : Integrated components of unimodal biometric system

a) Fingerprint Verification System

Fingerprint is an impression that is formed through deposit of minute ridges and valleys when a finger touches a surface. Facts exist that the ridges and valleys do not change for lifetime no matter what happens and in a case of injury or mutilation, they reappear within a short period. The five commonly found fingerprint ridge patterns are arch, tented arch, left loop, right loop and whorl (Figure 3) [15, 16]. The uniqueness of friction ridges implies that no two fingers or palm prints are exactly alike [17]. Fingerprint identification involves making a comparison between two or more fingerprints to determine if they originated from the same finger under some threshold scoring rules.

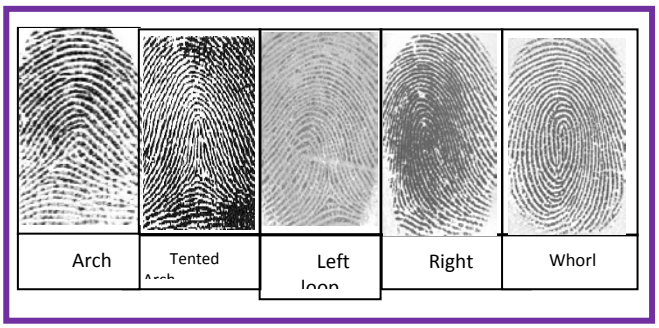

Figure 3 : Types of fingerprints patterns

Fingerprint enrolment could be performed based on ink and live scan devices. Fingerprint enrolment via inked cards, till the mid 1990's, was the only means of acquiring the thumbprint of an individual and was primarily used by law enforcement agencies. Human verification based on fingerprint was then carried out electronically by extracting the fingerprint patterns after scanning the inked image with high-resolution page scanners. In recent years, the need for fast and reliable fingerprint verification systems has necessitated the shift from the ink card method to live scan devices, which are categorized into optical sensors [18, 19], electrical sensors [18-20] and ultrasonic sensors [18, 21, 22]. Fingerprint image enhancement is performed to remove the enrolment attracted noise and it requires a number of processes including normalization, segmentation, ridge orientation and frequency estimation, filtering, binarization and thinning. Several algorithms had been proposed in [20, 23-27] for these processes. Existing fingerprint feature extraction algorithms include Crossing Number [19, 27-30], Adaptive Flow Orientation [31], Orientation Maps [32], Gabor Filter [33], Mathematical Morphology [34] and Minutiae Maps and Orientation Collinearity [35]. Others are Poincare Index [36-39], Curvature [40] and Multi-Resolution [41]. Several studies on fingerprint matching have produced several algorithms that are correlation, minutiae and ridge feature-based [42-50]. Fingerprint matching algorithms were also proposed in [51-53] on the basis of Delaunay triangulation (DT) in computational geometry.

The matching of two minutiae sets based on these algorithms is usually posed as a point pattern matching problem and the similarity between them is proportional to the number of matching minutiae pairs. Although the minutiae pattern of each finger is quite unique, contaminants and distortion during the acquisition and errors in the minutia extraction process result in a number of missing and spurious minutiae.

Due to difficulty in obtaining minutiae points from poor quality fingerprint images, other ridge features like the orientation and the frequency of ridges, ridge shape and texture information have formed the bedrock for several fingerprint matching algorithms. However, several of these methods suffer from low identification capability. In correlation-based fingerprint matching, the template and query fingerprint images are spatially correlated to estimate the degree of similarity between them. If the rotation and displacement of the query with respect to the template are not known, then the correlation must be computed over all possible rotations and displacements, which is computationally very expensive. Furthermore, the presence of non-linear distortion and noise significantly reduce the global correlation value between two impressions of the same finger. To overcome these problems, correlation is locally done around the high curvature, minutia information and other interesting regions of the fingerprint image. One main shortcoming for fingerprint identification systems is that the presence of small injuries and burns may cause disproportionate results due to presence of false minutiae points. In fact, injury, whether temporary or permanent, can interfere with the scanning process. For example, bandaging a finger for a short period of time can impact the fingerprint scanning process. Ordinarily, a burn to the identifying finger could make the fingerprint identification process fail [54-55] while daily work can also affect or sometimes damage some of fingerprint ridges.

b) Voice/Speaker Recognition

Voice is a combination of physiological and behavioural biometrics [2, 56, 57] and it is the natural means of communication for human beings. While speech recognition is concerned with the interpretation of what the speaker says, speaker recognition focuses on verifying the speaker's identity [58]. The two are based on the analysis of the vibrations created in the human vocal tract which is unique in shape, larynx, size and so on and also determines the resonance of the voice across individuals. A voice recognition system uses a microphone to record the voice, which is digitised for authentication. The speech can be acquired from the user enunciating a known text (text dependent) or speaking (text independent) [4]. A text-dependent voice recognition system is based on the utterance of a fixed predetermined phrase while text-independent voice recognition system recognizes the speaker independent of what is said. A text-independent system is more difficult to design than a text-dependent system but offers more protection against fraud [57]. The first task of an Automatic Voice/ Speaker Recognition system is the collection of speech samples that contain the discriminating features and their vectors from the speakers. Features are then extracted from collected speech samples base on any of the existing voice feature extraction methods which include Spectral Centrod, Spectral Roll Off, Spectral Flux and Mel Frequency Cepstral Coefficient (MFCC). The extracted features are then trained to extract feature vectors from the speech signals of several speakers and building the MFCC vectors, which is a small codebook that represents all the vectors in the minimum mean square sense. The spectral distance between testing utterance feature and code vectors obtained during training is then determined and the utterance is classified to its nearest speaker [59-61].

Voice/speaker recognitions have been used in variety of assistive contexts, including home computers and various mobile, public and private telephone services [11]. This is attributed to non-use of specific grammar and language independent natures; hence allowing callers to speak a particular phrase in any language of choice [62]. In addition, voice needs inexpensive equipment for capturing and can be deployed with ease for applications where other biometric modes experience difficulties [63]. Despite having lots of potentials and its growing popularity, voice/speaker recognition technologies are still not easily employed for individuals (such as older adults) with speech or communication disorders [64]. Human emotion is so unstable that accurate simulation or recognition of voice at different emotional states is highly impractical [65]. Furthermore, human voice is generated through a complex process of interactions among several body parts, especially the lungs, larynx and mouth and a temporarily or permanent damage to any of these body parts can lead to a voice disorder with significant effect on the identification process. The possibility of hacking into a system using a tape recording is another problem [10].

c) Iris Recognition

The iris begins to form in the third month of gestation with patterns that depend on the initial environment of the embryo. It is unchangeable after the age of two or three and highly distinct among individuals, hence making it a unique feature. The iris is isolated and protected from external environment and it is impossible to surgically modify it without unacceptable risk to vision [55]. It appears as a circular diaphragm located between cornea and lens of the human eye and controls the amount of light entering through the pupil. The average diameter of iris is 12 mm and pupil size can be 10% to 80% of the diameter [11, 66, 67]. Iris recognition identifies a person by analyzing the "unique" random and visible patterns within the iris of an eye to form an iris code that is compared to iris templates in a database. Its often involves the process of image acquisition (which involves capturing of high-quality iris image while remaining non-invasive to the human operator), iris localization (which involves the detection of the edges and pupil of the iris) and normalization of the size of the iris region. Normalization

is for ensuring consistency between eye images despite the stretching of the iris induced by the pupil's dilation. It also involves unwrapping of the normalized iris region into a rectangular region, extraction of discrimination features in the iris pattern, so that a comparison between templates can be done and encoding of iris features using wavelets to construct the iris code to which input templates are compared during matching [68, 69]. Challenges that are currently facing iris recognition include growing difficulty for distance larger than a few meters and it requires absolute cooperation from the individual to be identified [55]. It is also susceptible to low performance for poor quality images [70].

d) Face Recognition

Sometimes, faces are used in un-attended authentication applications, which are developed for human recognition by several organizations including universities, government and private agencies such as banks. Many of these organizations have facial images stored in large databases making many commercial and law-enforcement applications feasible given a reliable facial recognition system. Success in computing capability over the past few years have facilitated the development of several face-based recognition systems with simple geometric models or sophisticated mathematical representations and matching processes [55, 71, 72]. Face recognition systems detect patterns, shapes, and shadows in the face, perform feature extraction and recognition of facial identity. In the broader view, it encompasses all types of facial processing such as tracking, detection, analysis and synthesis. Existing techniques for face recognition include eigenfaces (Figure 4) and fisher-faces, which use the image of the whole face as raw input and are based on principal component analysis with higher-order statistics. Other techniques depend on extracting and matching certain features from the face, such the mouth and eyes. Some other approaches use data from the whole face as well as specific features to carry out the recognition [2, 73]. While face recognition is non-intrusive, and may experience high performance and user acceptance in controlled environments, robust face recognition in non-ideal situations continues to pose challenges [74, 75]. Facial images of a person can be collected with little cooperation and may perform with very high error rates when deployed in the real world, especially for long-range recognition [55]. Facial recognition systems may also underperform when identifying the same person with different illuminations, smiling, makeup, occlusion, pose, gestures, age, and accessories (moustache, glasses) conditions [2, 11].

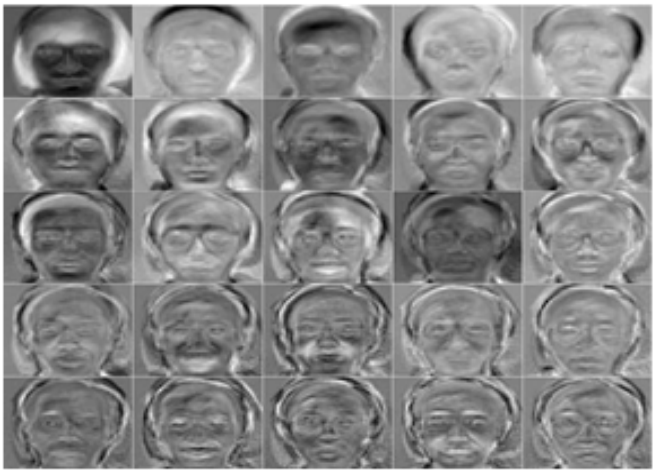

Figure 4: Images generated by Eigenfaces approach [55]

e) Gait Recognition

Gait analysis focuses on the systematic study of animal locomotion, more specifically, the study of human motion, augmented by instrumentation for measuring body, its mechanic and the activity of its muscles [76]. The gait of a person can be extracted without the user knowing they are being analysed and without any cooperation from the user in the information gathering stage. It can be captured at a distance, does not require high quality images and it is difficult to disguise [77]. Gait analysis is used to assess, plan, and treat individuals with conditions affecting their ability to walk while gait recognition is the process of identifying individuals based on their walking characteristics and it encompasses quantification and interpretation. Quantification is concerned with the introduction and analysis of measurable parameters of gaits while interpretation involves drawing various conclusions about health, age, size, weight, speed, and so on from gait pattern. Gait recognition involves the capturing of human walking image, pre-processing of the raw image, extraction of gait features (main leg angle and frame) and feature recognition. Existing feature extraction techniques include Hidden Markov Model (HMM) and an Exemplar-based HMM [78], Radon transform with Linear Discriminant Analysis (LDA) [79], Support Vector Machine (SVM) [80], Principal Components Analysis (PCA) and Maximization of Mutual Information (MMI) [81]. The block diagram for gait recognition system is presented in Figure 5.

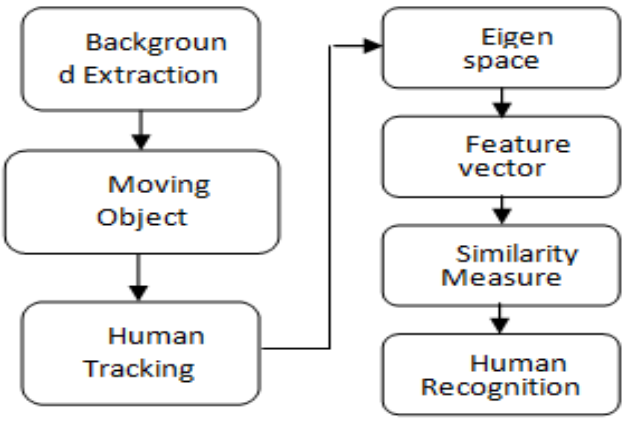

Figure 5: Block diagram for a gait recognition system

Recent gait recognition approach involves having a physical device, such as an accelerometer, attached to one's physical body to collect data about one's gait. The new sensor-based approaches, however, give up gait's potential to identify from a distance [82]. Difficulty in deliberately copying someone else's way of walking remains one of the strong motivations for gait recognition [64]. However, being a biometric, an individual's gait will be affected by certain factors including drugs and alcohol (which affect the way in which a person walks) and physical changes such as pregnancy, accident, disease and severe weight gain or loss. It is also affected by mood and clothing [74]. In addition, gait recognition is still in its infancy and has not face severe or thorough tests, especially for potential attacks [83].

f) Signature Recognition

A signature is the dynamics of a person's handwritten and comprises of special characters and flourishes, which in several cases, make them unreadable. Intra-personal variations and differences make the analysis of signatures as complete images rather than letters and words important and unique. This also accounts for the wide acceptance of signatures by government, legal, and commercial transactions as a method of verification [75]. Signature recognition technology consists primarily of interconnection of a pen, specialized writing tablet and local or central computer for template processing and verification. In the enrolment process, an individual is requested to sign his or her name several times on the tablet. The robustness of the enrolment template is a direct function of the quality of the writing tablet that is utilized. A high quality writing tablet will capture all the behavioural variables (timing, pressure, and speed) of the signature, whereas a lower end writing tablet may not. The constraints faced in signature acquisition include the clause that signature cannot be too long or too short. Too long signature causes too much behavioural data which results in difficulty in identifying consistent and unique data points while too short signature experiences shortage of data that increases the rate of false acceptance. Furthermore, same type of environment and conditions (standing, sitting, arm position, etc) is needed for the completion of the enrolment and verification processes. The extraction of the unique features such as the time and speed utilized for signing, the pressure applied from the pen to the writing tablet, the overall size of the signature and the quantity and the various directions of the strokes in the signature proceeds the enrolment phase. The biggest advantage that signature recognition offers is its very high resistance to imposters. Although, a wide range of signatures can be forged, it is still very difficult to "mimic" the behavioural patterns associated when signing. Compared to other biometric technologies, signature recognition is non-invasive and as a result, experiences high acceptance rate with no privacy rights issues. More importantly, the dynamics of signature can be changed during cases of hacking or stolen templates. In terms of weaknesses, a person's signature changes with time and is highly affected by the physical and emotional conditions of the signatories. More importantly, successive signatures by the same person can show significant differences resulting in increased error rates [2, 55].

g) Hand Geometry Recognition

Hand geometry of individuals is based on the shape of their hands and it is a stable biometric whose physical characteristics are not susceptible to major biological changes (except for conditions of arthritis, swelling, or deep cuts). Hand geometry recognition has been among the oldest and has established itself as a viable technology. During a hand geometry-based recognition, the subject's hand is placed onto a platen which then captures the ridges (black images) and valleys (white images) of the top and sides of the hand. Moderately unique features which include the finger thickness, length and width, the distances between finger joints, the hand's overall bone structure and so on are located in the structure of the images. Hand geometry recognition is often seen as one of the easiest to use, administer and environmental friendly biometric technologies. It is the least susceptible to privacy rights issues primarily because of its simple enrolment and verification procedures. Hand geometry is not distinctive, especially when applied to a large population. Thus, it is most suitable for purposes of verification rather than identification. Hand geometry may not be an ideal biometric to use for a population, which includes children whose hand-geometry template may vary during their growth period [84]. In addition, most hand-geometry systems perform with procedures that restrict the positional freedom of the hand [55, 85].

h) Palm Print Recognition

Just like fingerprint recognition, palm print technology uses the information presented in a friction ridge impression for human identification. This information combines ridge flow, ridge characteristics, and ridge structure of the raised portion of the epidermis. The data represented by these friction ridge impressions allows a determination that corresponding areas of friction ridge impressions either originated from the same source or could not have been made from the same source. The uniqueness and high permanence levels of fingerprint and palm print have been used as a trusted form of identification. However, palm recognition has been a slower automated system due to limitations in computing capabilities and live-scan technologies. Palm identification, just like fingerprint identification, is based on the aggregate information presented in a friction ridge impression. A palm recognition system is designed to interpret the flow of the overall ridges to

assign a classification and then extract the minutiae detail as a subset of the total amount of information obtained from a coordinated search of a large repository of palm prints. Minutiae information includes the flow of the friction ridges, the presence or absence of features along the individual ridge paths and their sequences as well as the intricate detail of a single ridge. Minutiae are limited to location, direction and orientation of the ridge endings and bifurcations (splits) along a ridge path [86].

i) Deoxyribonucleic Acid (DNA) Recognition

DNA is a well-known double helix structure present in every human cell. DNA fingerprint is produced as a robust and unchangeable (by surgery or any other known treatment) human attribute which is the same for every single cell of a person. The molecular structure of DNA can be considered as a zipper with the letters: A (Adeline), C (Cytosine), G (Guanine) and T (Thymine) representing each tooth and with opposite teeth forming one of two pairs, either A-T or G-C [87]. The sequence of letters along the zipper determines the DNA information [2, 88] and presents unique differences in the DNA fragments and molecules resulting in different biological pattern between individuals. DNA is widely used in the diagnosis of disorders, paternity tests and criminal identification and very high level of success and accuracy has been reported [55]. The use of DNA however experiences computational complexity with enormous time requirements. It is often considered as a violation of privacy and not always unique between monozygotic twins [11, 57].

III. Multi-Modal Biometric Systems

Some of the limitations imposed by unimodal biometric systems can be addressed through multi-modal sources (MMS) of information for establishing identity [89]. MMS are expectedly more reliable due to their multiple, (fairly) independent pieces of evidence [90]. They also provide stringent performance requirements imposed by various applications and also address the problem of non-universality, since multiple traits ensure sufficient population coverage. They also deter spoofing since it would be difficult for an impostor to spoof multiple biometric traits of a genuine user simultaneously. Furthermore, they facilitate a challenge-response mechanism by requesting the user to present a random subset of biometric traits thereby ensuring that a 'live' user is indeed present at the point of data acquisition [91]. A generic biometric system is presented in Figure 6 with four important modules; namely sensor, feature extraction, matching and decision modules [91, 92].

The sensor module captures the trait (raw biometric data), while the feature extraction module processes the data to extract a feature set that is a compact representation of the trait. The main function of the matching module is to generate the matching scores based on comparison of the extracted feature set with the templates in the database by a classifier. Based on a matching score, the decision module rejects or confirms a claimed identity. Important considerations for the design of multi-modal biometric system include architecture, choice of biometric modality, total number of modalities, level of accumulation of evidences, level and methods for fusion, safety and user friendliness and cost versus the matching performances. Others are level of security and reliability, mode of operations, assigning weights to biometrics and multimodal database [11, 93]. Challenges confronting multimodal biometric systems include failure of sensors to show consistency in various operating environments, poor design due to lack of proper understanding of biometric technologies and public confidence. Other challenges are complex and unverifiable matching algorithms, misleading results due to poor scalability and lack of standard guidelines for auditing biometric system and records [94].

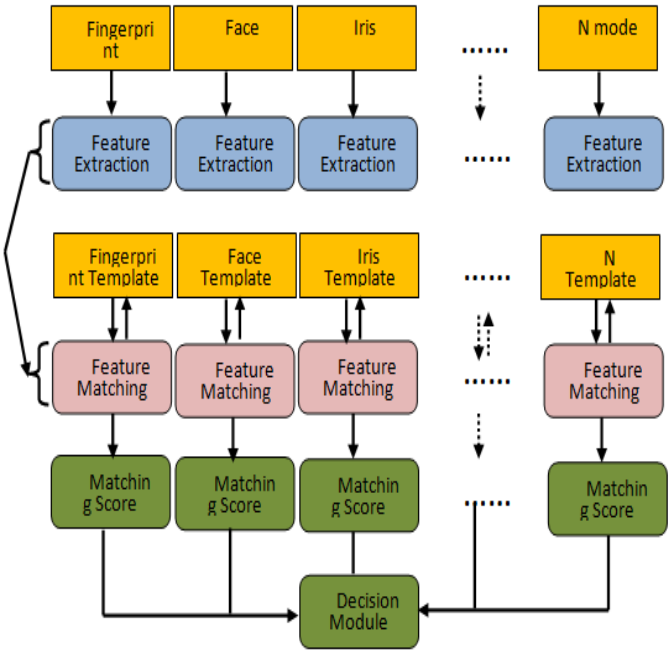

Figure 6 : Structural view of a typical multi-modal biometric

a) Fusion levels

In a multi-modal biometric system, information reconciliation may be attained via the fusion of the raw data, extracted features or the matching scores. Information may also be obtained at the decision levels. While fusion at the data or feature level is performed when either the data or the feature sets originating from multiple sensors/sources are fused, fusion at the match score level involves an integration of the scores obtained by multiple classifiers pertaining to different modalities. When the final information is obtained from the fusion of different decision levels, the final output of the multiple classifiers is consolidated using majority voting or any other suitable method [95]. Biometric systems that integrate information at an early stage

(using features set) perform better than those that perform integration at a later stage [91, 92]. This is attributed to the richer information offered by the features when compared to the matching score or the output decision of a matcher. However, in practice, fusion at the feature level is difficult to achieve due to complexities that trail the task of providing a common feature set for various modalities. Fusion at the decision level on its own is believed to be rigid due to its limited information. Thus, for its relatively easy access, fusion at the match score level is usually preferred.

b) Fusion Scenarios

As shown in Figure 7, existing multi-modal biometrics fusion scenarios depend on the number of traits, sensors and feature sets and are classified into the following categories:

a. Single biometric trait, multiple sensors: Multiple sensors record the same biometric trait to obtain different raw biometric data [96, 97].
b. Single biometric trait, multiple classifiers: This involves only a single sensor and multiple classifiers, each of which either operates on the same extracted feature set or generates its own feature sets [98-102].
c. Single biometric trait, multiple units: In the case of iris (or ear), it is possible to integrate information presented by two iris (or both ears) of a single user. This scenario provides an inexpensive methodology for improving system performance as it does not entail deploying multiple sensors nor incorporating additional feature extraction and/or matching modules.
d. Multiple biometric traits: This involves the use of two or more biometric traits of an individual for identity management. Such systems employ multiple sensors to acquire data pertaining to different and independent traits towards ensuring that a significant improvement in performance is obtained [1, 6, 9, 102 107].

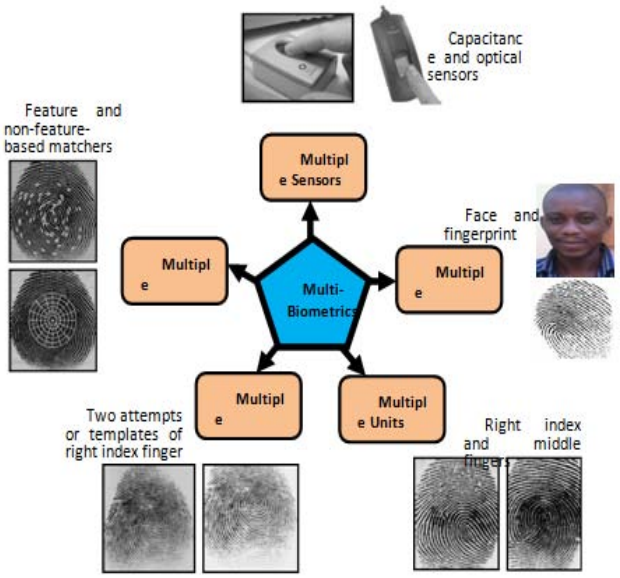

Figure 7 : Scenarios in a multi-modal biometric system

The existing biometrics fusion algorithms include Score Normalization [1, 102], Minimum Average Correlation Energy Filter [105], Neyman-Pearson (Product) Rule and Gaussian Copla Models [108], Principal Components Analysis (PCA), Fisher's Linear Discriminate Methods [109] and Geometry Preserving Projection [106]

c) Modes of Operation

The existing modes of operation for a multi-modal biometrics scheme are serial, parallel and hierarchical which are presented in Figure 8. The output of one modality is traditionally used to determine if the next modality will be used in the serial mode. This implies that simultaneous acquisition from multiple sources of information (such as multiple traits) is not required and final decision could be made with any modality. For the parallel mode, simultaneous acquisition of multiple modalities takes place and final decision is based on the integration of information (output) from the various modalities. The hierarchical scheme combines individual classifiers in a treelike structure and it is only applicable for large number of classifiers [91, 102, 110].

d) Integration Strategies

Fusion at the feature and matching score levels are the two major strategies for the integration of multi-modal systems. Fusion at the feature level is accomplished through the concatenation of two compatible feature sets before a feature selection or reduction technique is employed for handling any dimensionality problem [91]. The authors in [1, 12, 102, 105, 111, 112] had carried out detailed studies on fusion at the match score level. Base on robust and efficient normalization techniques [9, 59, 102, 106, 112, 113, 116], scores from multiples matchers are transformed

into a common domain prior to consolidating them. In the context of verification, the feature vector is constructed using the matching scores output of the individual matchers and then classified into accept (genuine user) or reject (impostor) [91]. Fusion of individual matching scores generates a single scalar score that is used for taking the final decision [116, 117]. General strategies for combining scores from multiple classifiers include principal component analysis [109], majority voting [95], behaviour knowledge space method [118], weighted voting based on the Dempster-Shafer theory of evidence [119], AND/OR rules [120] and Score normalization [121]. Others are simple sum rule [89], weighted product, bayes' rule, mean fusion, Linear Discriminant Analysis [LDA], k-nearest neighbour [KNN] and hidden Markov model [HMM].

e) Evaluation Strategies

The evaluation of multi-modal biometrics systems provides basis for establishing their performance and adequacy levels. Benchmarked evaluation strategies include False Rejection Rate (FRR), False Acceptance Rate (FAR), Receiver Operating Characteristics (ROC) Curve, Equal Error Rate (EER), Cumulative Match Curve (CMC) and Average Matching Time (AMT). If an imposter score exceeds the threshold, it results in a false accept, while genuine score that falls below the threshold results in a false reject. FRR is therefore the rate of occurrence of a scenario of two biometrics (same mode) from the same source (subject) failing to match and FAR is the rate at which two biometrics (same mode) from different sources (subjects) are found to match. An ROC curve measures the overall performance of a multi-modal biometric system base on the plot of FRR against FAR for all possible matching thresholds. In the ideal case, both FAR and FRR should be zero and the genuine and imposter distributions should be disjoint. In such cases, an 'acceptable' ROC curve presents a step function at the zero FAR. On the other extreme, if the genuine and imposter distributions are equal, then the ROC curve is a line segment with 45o slope and an end-point at zero FAR. In practice, the ROC curve falls between these two extremes [122]. For each matching threshold i, EER is presented as the value at which FAR (i) and FRR (i) are equal. CMC is another indicator that is similar in nature to ROC curve [123, 124].

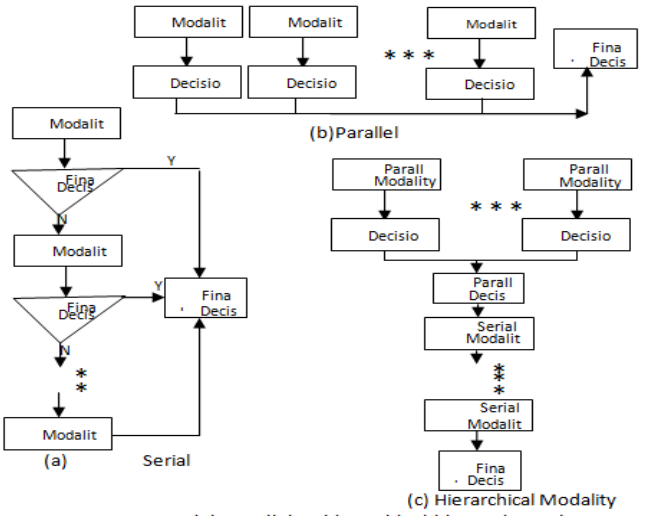

Figure 8 : Serial, parallel or hierarchical biometric modes

IV. Conclusion

The motivations, methodologies, strengths and weaknesses of the physiological and behavioural modes for human identity management had been presented. The integration, fusion and evaluation strategies for multi-modal approach to human identity management are also presented. Multi-modal biometric systems have performed well in addressing the problems of unimodal systems by combining information from different sources and improve the systems performance, raise the scope, discourage spoofing, and promote indexing. Improved performance has been noticed with uncorrelated traits and integration of parameters that are user's specific in multimodal systems. Without doubt, the widespread deployment of biometric systems in government and private establishments across the world will offer more secured and reliable human identity management.

References Références Referencias

1. M. M. Kazi., Y. S. Rode, S. B. Dabhade., N. N. H. Al-Dawla, A. V. Mane, R. R. Manza and K. V. Kale, "Multimodal Biometric System Using Face and Signature: A Score Level Fusion Approach", Advances in Computational Research, Volume 4, Issue 1, pp.-99-103, 2012, Available online at http://www.bioinfo.in/contents.php?id=33
2. M. Soltane and M. Bakhti, "Multi-Modal Biometric Authentications: Concept Issues and Applications Strategies", International Journal of Advanced Science and Technology, Vol. 48, 2012
3. A. K. Jain, S. Prabhakar, and S. Chen, "Combining multiple matchers for a high security fingerprint verification system," Pattern Recognition Letters, Vol. 20, pp. 1371–1379, 1999.
4. Y. W. Yun, "The '123' of Biometric Technology", Synthesis Journal, pp. 83-95, 2002.

5. K. Pellerin, Increasing Accuracy in Multimodal Biometric Systems", GIAC Security Essentials Certification (GSEC), 2004
6. S. S. Yadav, J. K. Gothwal , R. Singh, "Multimodal Biometric Authentication System: Challenges and Solutions", Global Journal of Computer Science and Technology, Vol. 11, No. 16, 2011
7. M. Devi, Secure Crypto Multimodal Biometric System for the Privacy Protection of User Identification", International Journal of Innovative Research in Computer and Communication Engineering Vol.2, Special Issue 1, 2014
8. P. S. Sanjekar and J. B. Patil, "An Overview of Multimodal Biometrics", Signal & Image Processing : An International Journal (SIPIJ), Vol.4, No.1, 2013.
9. K.Sasidhar, V. L. Kakulapati, K. Ramakrishna & K. K. Rao, "Multimodal Biometric Systems –Study to Improve Accuracy and Performance", International Journal of Computer Science & Engineering Survey (IJCSES) Vol. 1, No. 2, 2010
10. C. Lupu and V. Lupu, "Multimodal Biometrics for Access Control in an Intelligent Car", 3rd International Symposium on Computational. Intelligence and Intelligent Informatics – ISCIII 2007 - Agadir, Morocco, March 28-30, 2007.
11. N. Khatoon, M. K Ghose, "Multimodal Biometrics: A Review", *International Journal of Computer Science and Information Technology & Security, Vol. 3, No.3, 2013*
12. A. A. Fathima, S.Vasuhi, T. M. Treesa, N.T. Naresh-Babu, V. Vaidehi, "Person Authentication System with Quality Analysis of Multimodal Biometrics", WSEAS Transactions on Information Science and Applications, Vol. 10, No. 6, 2013
13. G. H. Kumar, M. Imran, "Research Avenues in Multimodal Biometrics", *IJCA Special Issue on"Recent Trends in Image Processing and Pattern Recognition", RTIPPR, 2010*
14. K. Hurst, "Biometrics Overview", NSTC Subcommittee on Biometrics, Article 6 of the Data Protection Directive, 2006
15. J. Bo, H. P. Tang and M. L. Xu, "Fingerprint Singular Point Detection Algorithm by Poincaré Index", WSEAS Transactions on Systems, Vol. 7, No. 12, 2008.
16. L. Yount, "Forensic Science: From Fibres to Thumbprints", Chelsea House Publisher, 2007
17. D.R. Ashbaugh, "Ridgeology", *Journal of Forensic Identification*, Vol. 41, No. 1, pp 16-64, 1991.
18. S. Nanavati, M. Thieme and R. Nanavati, "Biometrics, Identifying Verification in a Networked World", John Wiley & Sons, Inc., pp15-40, 2002
19. N. Sara, D. Sergie, V. Gregory, "User interface design of the interactive fingerprint recognition (INFIR) System", 2004, Available on: http://www.researchgate.net/profile/Sara_Nasser2/z publication/221199370_User_Interface_Design_of_the_Interactive_Fingerprint_Recognition_(INFIR)_System/links/0fcfd509c0e72c9b2c000000.pdf.Accessed 12/11/2013.
20. M. Mihir, "DSP Implementation of a Fingerprints-based Biometric Authentication System", *Part 4 Final Project Report, De partment of Electrical & Computer Engineering, University of Auckland, New Zealand, pp7-12,* 2004
21. D. R. Setlak, "Advances in fingerprint sensors using RF imaging techniques", Automatic Fingerprint Recognition Systems, N. Ratha and R. Bolle, Springer-Verlag, New York, 2004.
22. N. Ratha and R. Bolle, "Automatic Fingerprint Recognition Systems", Springer-Verlag, New York, 2004.
23. A. Jain, and S. Pankanti, "Fingerprint Classification and Matching", 2004. http://www.research.ibm.com/ecvg/ pubs/sharat-handbook.pdf, 2004 .
24. L. Hong and A. Jain, "Fingerprint Enhancement", Automatic Fingerprint Recognition Systems, N. Ratha and R. Bolle, Springer-Verlag, New York, 2004.
25. G. B. Iwasokun, O. C. Akinyokun, B. K. Alese and O. Olabode, "Fingerprint Image Enhancement: Segmentation to Thinning", *International Journal of Advanced Computer Science and Applications (IJACSA), Vol 3, No. 1, Pages 15 – 24, 2012.*
26. G. B. Iwasokun, O. C. Akinyokun and O. Olabode, "A Mathematical Modeling Method for Fingerprint Ridge Segmentation and Normalization". *International Journal of Computer Science and Information Technology and Security (IJCSITS), ISSN 2249-9555, Vol. 2, No. 2, pp 263-267, 2012*
27. T. Raymond, "Fingerprint image enhancement and minutiae extraction", Postgraduate Thesis Submitted to School of Computer Science and Software Engineering, University of Western Australia; 2003. Available on: www.peterkovesi.com/studentprojects/raymondthai/RaymondThai. Pdf. Accessed 16/05/2009.
28. G. B. Iwasokun, "Development of a hybrid platform for the pattern recognition and matching of thumbprints", PhD Thesis, Department of Computer Science, Federal University of Technology, Akure, Nigeria (unpublished), 2012.
29. G. B. Iwasokun, O. C. Akinyokun, B. K. Alese and O. Olabode, "Adaptive and Faster Approach to Fingerprint Minutiae Extraction and Validation", International Journal of Computer Science and Security, Vol 5, No. 4, pp 414-424, 2011
30. M. Tico, P. Kuosmanen, "An algorithm for fingerprint Image Post-processing", "proceedings of the 34th Asilomar Conference on Signals, Systems and Computers, Vol. 2, pp 1735–1739, 2000.

31. N. Ratha, S. Chen, A. K. Jain, "Adaptive Flow Orientation Based Feature Extraction in Fingerprint Images", Pattern Recognition, Vol. 28, No. 11, pp 1657-1672, 1995.
32. S. Wang, W. Zhang, "Fingerprint Classification by Directional Fields", Proceedings of the Fourth IEEE International Conference on Multi-modal Interfaces, 1995 Available on: http://aya.technion .ac.il/projects /2005winter/ Fingerprint1.pdf. Accessed 13/08/2012.
33. A. Jain, B. Ruud, P. Sharath, "Biometrics-Personal Identification", Journal of Networked Society, Kluwer Academic Publishers, Dordrecht, 1998. Available on: http://www.amazon.com/Biometrics-Personal Identificat ion-Networked-Society/dp/0387285393. Accessed 24/ 08/2013.
34. V. Humbe, S. S. Gornale, K. Ramesh, V. Kale, "Mathematical Morphology Approach for Genuine Fingerprint Feature Extraction", International Journal of Computer Science and Security, Vol. 1, No. 2,. 2007.
35. U. Rajanna, E. Ali, B. A. George, "Comparative Study on Feature Extraction for Fingerprint Classification and Performance Improvements Using Rank-Level Fusion", Pattern Anal Application, Springer-Verlag London; 2009.
36. L. Hong, A. K. Jain, "Classification of Fingerprint Image", Proceedings of Eighth Scandinavian Conference on Image Analysis, Kangerlussuaq, Greenland. 1999. Available on: http://www.cse.msu.edu/biometrics/Publications/Fingerprint/clas.pdf.Accessed 24/06/2012
37. Karu K, Jain A. Fingerprint classification. Pattern Recognition, Vol. 18, No. 3, pp 389–404, 1996
38. D. Weng, Y. Yilong, Y. Dong, "Singular Points Detection Based on Multi-Resolution in Fingerprint Images", Journal of Neuro-Computing, Vol. 74, pp 3376–3388, 2011.
39. M. Kawagoe, A. Tojo, "Fingerprint Pattern Classification", Journal of Pattern Recognition, Vol. 17, No. 3, pp 295-303, 1984
40. W. M. Koo, A. Kot, "Curvature-Based Singular Points Detection", Proceedings of 3rd International Conference on Audio and Video-Based Biometric Person Authentication, Lecture Notes in Computer Science, Vol. 2, No. 9, pp 229–234, 2001
41. A. K. Jain, S. Prabhakar, L. Hong, S. Pankanti, "Filterbank-Based Fingerprint Matching", IEEE Transaction on Image Processing, Vol. 9, No. 5, pp 846-859, 2000
42. S. Weiguo, G. Howells, M. Fairhurst, and F. Deravi, "A Memetic Fingerprint Matching Algorithm", IEEE Transactions on Information Forensics and Security, Vol. 2, No. 3, 2007
43. K. Nandakumar, "Fingerprint Matching Based On Minutiae Phase Spectrum", Proceedings of ICB2012, 2012
44. K. Mali, S. Bhattacharya, "Fingerprint Recognition Using Global and Local Structures, International Journal on Computer Science and Engineering (IJCSE), Vol. 3 No. 1
45. Andrej KISEL, Alexej Kochetkov, Justas Kranauskas (2008), Fingerprint Minutiae Matching Without Global Alignment Using Local Structures, INFORMATICA, *Institute of Mathematics and Informatics, Vilnius,* Vol. 19, No. 1, pp 31–44, 2011
46. L. H. Tha and H. N. Tam, "Fingerprint Recognition Using Standardized Fingerprint Model", IJCSI International Journal of Computer Science Issues, Vol. 7, Issue 3, No 7, 2010
47. W. Zhang, Y. Wang, "Core-Based Structure Matching Algorithm of Fingerprint Verification, IEEE, 2002
48. H. Khazaei, A. Mohades, "Fingerprint Matching and Classification using an Onion Layer algorithm of Computational Geometry", International Journal of Mathematics and Computers in Simulation, Issue 1, Volume 1, 2007
49. M. Vatsa, R. Singh, A. Noore and S. K. Singh, "Quality Induced Fingerprint Identification Using Extended Feature Set", Edited Book, IEEE, 2008
50. R. D. Labati, V. Piuri, F. Scotti, "A Neural-based Minutiae Pair Identification Method for Touch-less Fingerprint Images", unpublished, Available: *piurilabs.di.unimi.it/ Papers/PID2035945.pdf, Accessed 18/06/2014*
51. G. Bebis, T. Deaconu and M. Georgiopoulos, "Fingerprint Identification Using Delaunay Triangulation, Available: http://fmi.dreamlords.org/2kurs/2%20kurs%202%20sem/topology/projects/materials/Fingerprint%20Identification%20Using%20Delaunay%20Triangulation.pdf
52. N. Liu, Y. Yin, H. Zhang, "A Fingerprint Matching Algorithm Based On Delaunay Triangulation Net", Proceedings of the Fifth International Conference on Computer and Information Technology (CIT'05), 2005
53. X. Liang, T. Asano, A. Bishnu, "Distorted Fingerprint Indexing Using Minutia Detail and Delaunay Triangle", 2007, Available: http://www.jaist. ac.jp/ jinzai/Paper18/ ISVD2006.pdf, Accessed 25/08/2013
54. R. Jamieson, G. Stephen and S. Kuma, "Fingerprint Identification: An Aid to the Authentication Process", *Information Systems Audit and Control Association*, Vol. 1, 2005.
55. F. Karray, J. A. Saleh, M. N. Arab and M. Alemzadeh, "Multi Modal Biometric Systems: A State of the Art Surve". Available: *watsup.Uwaterloo.ca/pub/ malemzad/Biometrics.pdf* . Accessed 13/05/2013
56. I. Simpson "Biometrics: Issues and Applications", 6th Annual Multimedia Systems, Electronics and

Computer Science, University of Southampton, 2006.

57. A. K. Jain, A. Ross and S. Prabhakar (2004), "An Introduction to Biometric Recognition", IEEE Transactions on Circuits and Systems for Video Technology, Vol. 14, No. 1, 2004.
58. P. J. Phillips, A. Martin and C. L. W. M. Przybocki, "An Introduction to Evaluating Biometric Systems", National Institute of Standards and Technology, IEEE, 2000
59. S. Asha, C. Chellappan, "Adaptive Multimodal Biometric Authentication using Fingerprint, Palmprint and Voice Biometrics", European Journal of Scientific Research ISSN 1450-216X Vol. 95, No 1, pp 40-49, 2013 http://www.Europeanjournalofscientificresearch.com
60. B. C. Kovoor, M. H. Supriya and K. P. Jacob, "A Prototype for a Multimodal Biometric Security System Based on Face and Audio Signatures", International Journal of Computer Science and Communication, Vol. 2, No. 1, pp. 143-147, 2011
61. J. Deny, M. Sudhararajan, "Efficient Methods of Multimodal Biometric Security System-Fingerprint Authentication, Speech and Face Recognition", International Journal of Electrical and Electronics, Vol. 2, Issue 2, pp 78-83, 2011, www.researchpublish.com
62. Voice Recognition and Speech Recognition (VRSR) Software and Vendors Guide, "Biometric identification", http://www.voice-commands.com/510.htm, visited on 15/10/2007.
63. A. Kounoudes, N. Tsapatsoulis, Z. Theodosiou and M. Milis, "POLYBIO: Multimodal Biometric Data Acquisition Platform and Security System", Lecture Notes In Computer Science, Vol. 5372, pp 216-227, 2008.
64. L. Wang, H. Ning, T. Tan and W. Hu, "Fusion of static and dynamic body biometrics for gait recognition", *IEEE Transactions on Circuits and Systems for Video Technology*, Vol. No. 2, pp 149-158, 2004.
65. M. Kaur, A. Girdhar, M. Kaur, "Multimodal Biometric System Using Speech and Signature Modalities" International Journal of Computer Applications, Vol. 5, No.12, 2013
66. M. Abdolahi, M. Mohamadi, M. Jafari, "Multimodal Biometric system Fusion Using Fingerprint and Iris with Fuzzy Logic", International Journal of Soft Computing and Engineering, Vol. 2, Issue-6, 2013
67. S. Barde, "A Certificate of Identification Growth through Multimodal Biometric System", *International Journal of Emerging Trends & Technology in Computer Science (IJETTCS),* Vol. 2, Issue 2, 2013
68. J. Daugman, "How iris recognition works", *IEEE Transactions on Circuits and Systems for Video Technology*, Vol. 14, No. 1, pp 21-30, 2004.
69. Y. G. Kim, K. Y. Shin, E. C. Lee and K. R. Park, "Multimodal Biometric System Based on the Recognition of Face and Both Irises", International Journal of Advanced Robotic Systems, Vol. 9, No. 65, 2012
70. J. Daugman, "The importance of being random: statistical principles of iris recognition", *Pattern Recognition*, Vol. 36, No. 2, pp 279-291, 2003.
71. S. Z. Li, "Face Recognition: Methods and Practice", Center for Biometrics and Security Research (CBSR) & National Lab of Pattern Recognition (NLPR) Institute of Automation, Chinese Academy of Sciences: ICB Tutorial Delhi, India, 2012
72. P. Buyssens and M. Revenu, "Fusion Levels of Visible and Infrared Modalities for Face Recognition", (GREYC Laboratory – CNRS UMR 6072 ENSICAEN, University of Caen, Caen, France), Avaialble: www.researchgate.net, Accessed19/06/2013
73. J. Ortega-Garcia, J. Bigun, D. Reynolds and J. Gonzalez-Rodriguez, "Authentication gets personal with biometrics", *Signal Processing Magazine, IEEE*, Vol. 21, No. 2, pp 50-62, 2004.
74. A.C. Weaver, "Biometric authentication", *Computer*, Vol. 39, No. 2, pp 96-97, 2006
75. J.F. Vélez, Á. Sánchez and A.B. Moreno, "Robust off-line signature verification using compression networks and positional cuttings", *Proceedings of the 2003 IEEE Workshop on Neural Networks for Signal Processing*, pp 627-636, 2003
76. D. F. Levine, J. Richards, M. Whittle, "Whittle's Gait Analysis", Elsevier Health Sciences, 2012
77. M. R. Dawson, "Gait Recognition", Master of Engineering Thesis submitted to the Department of Computing, Imperial College of Science, Technology & Medicine London, 2002, Available: http://rageuniversity.org/DISGUISETECH/files/Gait%20Recognition%20REPORT.PDF, Accessed 14/03/2013
78. J. Gu, X. Ding, S. Wang, and Y. Wu, "Action and gait recognition from recovered 3-d human joints," *IEEE Trans. Syst., Man, Cybern. B*, Vol. 40, No. 4, pp. 1021–1033, 2010.
79. N. V. Boulgouris and Z. X. Chi, "Gait recognition using radon transform and linear discriminant analysis," *IEEE Trans. Image Process.*, Vol. 16, No. 3, pp. 857–860, 2007.
80. S. Yu, T. Tan, K. Huang, K. Jia, and X. Wu, "A Study on Gait-Based Gender Classification," *IEEE Trans. Image Process.*, Vol. 18, No. 8, pp. 1905–1910, 2009.
81. M. Hu, Y. Wang, Z. Zhang, and Y. Wang, "Combining Spatial and Temporal Information for Gait Based Gender Classification," *Proceedings of IEEE/IAPR Int. Conf. Pattern Recog.*, pp. 3679–3682, 2010.

82. D. Gafurov, K. Helkala and T. Søndrol, "Biometric gait authentication using accelerometer sensor", *Journal of Computers*, Vol. 1, No. 7, pp 51-59, 2006
83. D. Gafurov, E. Snekkenes and P. Bours, "Spoof attacks on gait authentication system", *IEEE Transactions on Information Forensics and Security*, Vol. 2, No. 3, pp 491-502, 2007
84. K. Delac and M. Grgic, "A survey of biometric recognition methods", *Electronics in Marine, 2004, Proceedings Elmar 2004, 46th International Symposium*, pp 184-193, 2004
85. G. Boreki and A. Zimmer, "Hand geometry: a new approach for feature extraction", *Proceedings of the Fourth IEEE Workshop on Automatic Identification Advanced Technologies*, pp 149-154, 2005
86. Palm Print Recognition (www. http://www.fbi.gov/about-us/cjis/fingerprints_biometrics/biometric-center-of-excellence/files/palm-print-recognition.pdf. Accessed 23/02/2014
87. J. Wambaugh, "The Blooding", William Morrow, N.Y., 1989
88. D. Betch, "DNA Fingerprint in Human Health and Society", Biotechnology Information Series (Bio-6), Available: http://archive.ndsj.org/c lasses/ evashenk /bio2/ assignments/DNA/DNA Fingerprinting Human Health Society. pdf, Accessed 19/11/2014
89. A. Ross and A. K. Jain, "Information fusion in biometrics," Pattern Recognition Letters, Vol. 24, pp. 2115– 2125, 2003
90. L. I. Kuncheva, C. J. Whitaker, C. A. Shipp, and R. P. W. Duin, "Is independence good for combining classifiers?," *Proceedings of Int'Conf. on Pattern Recognition (ICPR)*, Vol. 2, (Barcelona, Spain), pp. 168–171, 2000.
91. A. Ross and A. K. Jain, "Multimodal Biometrics: An Overview", Proceedings of 12th European Signal Processing Conference (EUSIPCO), (Vienna, Austria), pp. 1221-1224, 2004
92. M. S. Ahuja and S. Chabbra, "A Survey of Multimodal Biometrics", *International Journal of Computer Science and its Applications*, pp. 157-160.
93. G. C. Chandran, R. S. Rajesh, "Performanance Analysis of Multimodal Biometric System Authentication", IJCSNS-International Journal of Computer Science and Network Security, Vol. 9, No. 3, 2009
94. V. M. Mane and D. V. Judhav, "Review of Multimodal Biometrics: Applications, Challenges and Research Areas". International Journal of Biometric and Bioinformatics, Vol. 3, Issue 3
95. Y. Zuev and S. Ivanon, "The Voting as a way to increase the decision reliability," Foundations of Information/ Decision Fusion with Applications to Engineering Problems, (Washington D.C., USA), pp. 206–210, 1996
96. K. I. Chang, K. W. Bowyer, and P. J. Flynn, "Face recognition using 2D and 3D facial data", Proceedings of Workshop on Multimodal User Authentication, (Santa Barbara, CA), pp. 25–32, 2003
97. A. Kumar, D. C. M. Wong, H. C. Shen, and A. K. Jain, "Personal verification using palmprint and hand geometry biometric," in Proc. of 4th Int'l Conf. on Audio and Video-based Biometric Person Authentication (AVBPA), (Guildford, UK), pp. 668–678, 2003.
98. S.Ribaric, D. Ribaric and N. Pavesic, "Multimodal Biometric User Identification System for Network Based Applications," IEEE Proceeding of Vision, Image and Signal Processing, Vol. 150, No.6, pp.409-416, 2003.
99. G. L. Marcialis and F. Roli, "Experimental Results on Fusion of Multiple Fingerprint Matchers," Proceedings of 4th Int'l Conf. on Audio and Video-based Biometric Person Authentication (AVBPA), (Guildford, UK), pp. 814–820, 2003.
100. A. Ross, A. K. Jain and J. Reisman, "A Hybrid Fingerprint Matcher, Pattern Recognition, Vol. 36, pp. 1661–1673, 2003
101. X. Lu, Y. Wang and A. K. Jain, "Combining Classifiers for Face Recognition," Proceedings of IEEE International Conference on Multimedia and Expo (ICME), Vol. 3, (Baltimore, MD), pp. 13–16, 2003
102. A. Jain, K. Nandakumar, A. Ross, "Score Normalization in Multimodal Biometric Systems", Pattern Recognition Vol. 38, 2005
103. R. Brunelli and D. Falavigna, "Person identification using multiple cues," IEEE Transactions on PAMI, Vol. 12, pp 1995
104. E. Bigun, J. Bigun, B. Duc and S. Fischer, "Expert Conciliation for Multimodal Person Authentication Systems Using Bayesian Statistics" Proceedings of First International Conference on AVBPA, (Crans-Montana, Switzerland), pp. 291–300, 1997
105. A. Meraoumia, S. Chitroub and A. Bouridane, "Multimodal Biometric Person Recognition System based on Iris and Palmprint Using Correlation Filter Classifier", ICCIT, 2012
106. T. Zhang, X. Li, D Tao, J. Yang, "Multimodal Biometrics Using Geometry Preserving Projections", Pattern Recognition, Vol. 41, pp 805 – 813, 2008
107. C. Lupu, "Car Access Using Multimodal Biometrics", The Annals of The Ştefan cel Mare University of Suceava. Fascicle of The Faculty of Economics and Public Administration, Vol. 10, 2010
108. S. C. Dass, K. Nandakumar and A. K. Jain, "A Principled Approach to Score Level Fusion in Multimodal Biometric Systems", Available: http://biometrics.cse.msu.edu/Publications/Multibiometric

Based Applications," IEEE Proceeding of Vision, Image and Signal Processing, Vol. 150, No.6, pp.409-416, 2003.

99. G. L. Marcialis and F. Roli, "Experimental Results on Fusion of Multiple Fingerprint Matchers," Proceedings of 4th Int'l Conf. on Audio and Video-based Biometric Person Authentication (AVBPA), (Guildford, UK), pp. 814–820, 2003.

s/DassNandakumarJain_GLRF_AVBPA05. pdf , Acc essed 23/02/2014

109. T. A. Albert, S. Ganesan, "Applications of Principal Component Analysis in Multimodal Biometric Fusion System", European Journal of Scientific Research, Vol. 67 No. 2, pp 248-259, 2012, Available: http:// www.europeanjournalofscientificresearch.com, Acc ess 03/03/2013
110. L. Hong and A. K. Jain, "Integrating Faces and Fingerprints for Personal Identification," IEEE Transactions on PAMI, Vol. 20, pp. 1295–1307, 1998.
111. R. Snelick, U. Uludag, A. Mink, M. Indova and A. Jain, "Large Scale Evaluation of Multimodal Biometric Authentication Using State-of-the-Art Systems", IEEE Transactions on Pattern Analysis and Machine Intelli-gence, Vol. 27, No. 3, pp. 450-455, 2005
112. K. A. Toh, X. Jiang, W. Y. Yau, "Exploiting Global and Local Decisions for Multimodal Biometrics Verification," *IEEE Transactions on Signal Processing,* Vol. 52, pp. 3059-3072, 2004
113. M. I. Ahmad, "Feature Extraction and Information Fusion in Face and Palmprint Multimodal Biometrics", A PhD Thesis Submitted to the Faculty of Science, Agriculture and Engineering, Newcastle University, 2013
114. M.N. Eshwarappa, M. V. Latte, Multimodal Biometric Person Authentication using Speech, Signature and Handwriting Features, *(IJACSA) International Journal of Advanced Computer Science and Applications, Special Issue on Artificial Intelligence*
115. S. Soviany, C. Soviany, M. Jurian, "A Multimodal Approach for Biometric Authentication with Multiple Classifiers", World Academy of Science, Engineering and Technology Vol. 59, 2011
116. U. Dieckmann, P. Plankensteiner and T. Wagner, "Sesam: A biometric Person Identification System Using Sensor Fusion," Pattern Recognition Letters, Vol. 18, No. 9, pp. 827–833, 1997.
117. S. Ben-Yacoub, Y. Abdeljaoued, and E. Mayoraz, "Fusion of Face and Speech Data for Person Identity Verification", IEEE Transactions on Neural Networks, Vol. 10, pp. 1065–1074, 1999
118. L. Lam and C. Y. Suen, "Optimal Combination of Pattern Classifiers", Pattern Recognition Letters, Vol. 16, No. 9, pp. 945–954, 1995
119. L. Xu, A. Krzyzak, and C. Suen, "Methods of Combining Multiple Classifiers and their Applications to Handwriting Recognition", IEEE Transactions on Systems, Man and Cybernetics, Vol. 22, No. 3, pp. 418–435, 1992
120. J. Daugman, "Combining multiple biometrics," http://www.cl.cam.ac.uk/users/jgd1000/ combine/
121. M. Nageshkumar, M.N. ShanmukhaSwamy, "An Adaptive Multimodal Biometric Recognition Algorithm for Face Image using Speech Signal", International Journal of Computer Applications Volume 7, No.1, 2010
122. A. K. Jain, F. Jianjiang, N. Karthik, "Fingerprint Matching", IEEE Computer Society, pp 36-44, 2011.
123. S. Shekhar, V. M. Patel, M. N. Nasrabadi and R. Chellappa, "Joint Sparse Representation for Robust Multimodal Biometrics Recognition", IEEE Transactions on Pattern Analysis and Machine Intelligence, 2013
124. Y. Elmir, Z. Elberrichi and R. Adjoudj, "A Hierarchical Fusion Strategy based Multimodal Biometric System", Proceedings of the *International Arab Conference on Information,* 2013

Global Journal of Computer Science and Technology: G Interdisciplinary
Volume 15 Issue 2 Version 1.0 Year 2015
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Evolutionary Computing based an Efficient and Cost Effective Software Defect Prediction System

By Racharla Suresh Kumar & Prof. Bachala Sathyanarayana
Sri Krishnadevaraya University, India

Abstract- The earlier defect prediction and fault removal can play a vital role in ensuring software reliability and quality of service. In this paper Hybrid Evolutionary computing based Neural Network (HENN) based software defect prediction model has been developed. For HENN an adaptive genetic algorithm (A-GA) has been developed that alleviates the key existing limitations like local minima and convergence. Furthermore, the implementation of A-GA enables adaptive crossover and mutation probability selection that strengthens computational efficiency of our proposed system. The proposed HENN algorithm has been used for adaptive weight estimation and learning optimization in ANN for defect prediction. In addition, a novel defect prediction and fault removal cost estimation model has been derived to evaluate the cost effectiveness of the proposed system. The simulation results obtained for PROMISE and NASA MDP datasets exhibit the proposed model outperforms Levenberg Marquardt based ANN system (LM-ANN) and other systems as well. And also cost analysis exhibits that the proposed HENN model is approximate 21.66% cost effective as compared to LM-ANN.

Keywords: *software defect prediction, artificial neural network, adaptive genetic algorithm, levenberg marquardt, object oriented software metrics, cost estimation.*

GJCST-G Classification: *D.4.8*

Strictly as per the compliance and regulations of:

Evolutionary Computing based an Efficient and Cost Effective Software Defect Prediction System

Racharla Suresh Kumar [α] & Prof. Bachala Sathyanarayana [σ]

Abstract- The earlier defect prediction and fault removal can play a vital role in ensuring software reliability and quality of service. In this paper Hybrid Evolutionary computing based Neural Network (HENN) based software defect prediction model has been developed. For HENN an adaptive genetic algorithm (A-GA) has been developed that alleviates the key existing limitations like local minima and convergence. Furthermore, the implementation of A-GA enables adaptive crossover and mutation probability selection that strengthens computational efficiency of our proposed system. The proposed HENN algorithm has been used for adaptive weight estimation and learning optimization in ANN for defect prediction. In addition, a novel defect prediction and fault removal cost estimation model has been derived to evaluate the cost effectiveness of the proposed system. The simulation results obtained for PROMISE and NASA MDP datasets exhibit the proposed model outperforms Levenberg Marquardt based ANN system (LM-ANN) and other systems as well. And also cost analysis exhibits that the proposed HENN model is approximate 21.66% cost effective as compared to LM-ANN.

Keywords: software defect prediction, artificial neural network, adaptive genetic algorithm, levenberg marquardt, object oriented software metrics, cost estimation.

I. Introduction

With the increase in information technologies and associated software applications, the inevitable requirement of software reliability has alarmed scientific societies, industries as well as academician to develop certain optimal paradigm to ensure defect free software applications for long run reliability.

Furthermore, the cost factor for software products and services also suggests the defect free software solutions, so as to eliminate probability of faults in future and iterative maintenance. In order to accomplish these objectives, the efficient software defect prediction (SDP) systems are of great significance. In order to ensure optimal software reliability, the defect prediction has become an inevitable part of software development life cycle (SDLC) that intends to eliminate the probability of software failure in run time. The earlier defect prediction can enable software professional to identify fault-prone modules and thus can debug the defects to ensure quality of service provisioning. In recent years the application of open source software has increased tremendously and professional prefer to customize software modules and implement as per need. Still, these modules are prone to defect in real time scenarios, thus demanding for fault prediction and verification [1, 2, 3, 4] before introducing product to the users. The SDP might be functional on the basis of certain software metrics [3, 4, 5] like changes in source code, earlier defect or fault etc. Typically, software metrics do represent certain quantitative factor that characterizes the properties of software source code, which can be employed to predict fault proneness of software during function. On the other hand, in recent years majority of software applications are being developed using Object-Oriented (OO) paradigm. The object oriented paradigm enables certain metrics that that can be employed to examine the quality of software application and associated fault proneness. Some of the predominantly proposed software metrics are MOOD [6], QMOOD [7], Bieman and Kang [8], Briand et al. [9], Etzkorn et al. [10], Halstead [11], Henderson-sellers [12], L and H metrics suite [13], McCabe [14], Tegarden et al. [15], Lorenz and Kidd [16] and CK metric suite [17]. The implementation of object oriented metrics enables software practitioners to examine quality of software in terms of precision, accuracy, fault-resilience, reliable functionality, adaptability, supportability, usability, portability, and cost effectiveness etc. In fact, it makes testing enhanced for large scale software applications. This is the matter of fact that a number of researches have been made for defect prediction. Some of the predominantly employed SDP techniques are based on machine learning and artificial neural network [18, 19, 20, 21, 22], clustering techniques, statistical method, data mining based fault identification, random forest [23, 24, 25] approaches etc. However, the emerging software complexities, critical software applications, reliable service assurance, quality oriented service provisioning, and cost effective or economical solutions etc., motivate researchers to develop certain

Author α: Research Scholar, Department of Computer Science, Sri Krishnadevaraya University, Andhra Pradesh, India.
e-mail: suresh_sku@yahoo.com
Author σ: Professor, Department of Computer Science, Sri Krishnadevaraya University, Andhra Pradesh, India.
e-mail: bachalasatya@yahoo.com

cost effective defect prediction solution. In recent years, primarily, support vector machine (SVM) and artificial neural network (ANN) approaches are being explored for SDP utilities. The emergence of artificial intelligence based applications have motivated researchers to explore ANN based defect prediction that works based on the human brain functions, while encompassing multiple neurons and directed edges possessing certain weights values between input and output layers. In fact, ANN is a complex non-linear mapping process that employs output as the input for learning certain complex non-linear input-output relationship between input and output layers. In function ANN encompasses data sets to optimize key factors such as weight parameters, risk minimization mechanism for stopping training once the learning error enters in expected margin level. Although, ANN has established itself as a potential candidate for prediction and classification applications, still its limitations in terms of slow learning ability, local minima and convergence can't be ignored. In order to enhance the performance of ANN based defect prediction some researchers [26, 27] have suggested evolutionary computing paradigm that could enable optimal classification and prediction without introducing any computational complexity and premature convergence.

Considering efficiency of evolutionary computing techniques such as Genetic Algorithm (GA) in this paper a robust Adaptive genetic algorithm based ANN learning algorithm has been developed, which has been used for software defect prediction. In addition, to enhance the performance of GA for huge data elements and efficient performance, the genetic parameters (crossover and mutation probability) have been selected dynamically that makes overall system much robust as compared to conventional approaches. In order to examine the performance of the proposed HENN system, a Levenberg Marquardt based ANN (LM-ANN) algorithm has been developed and the comparative performance analysis with the object oriented software metrics, CK metrics [17] has revealed that the proposed HENN algorithm provides better fault detection as compared to LM-ANN. Furthermore, the fault removal cost analysis for both the algorithms has stated that the proposed system is cost effective and can be used for real time defect prediction utilities.

The remaining sections discusses, related work in Section II, the research contributions and problem definitions for the proposed software defect prediction model are presented in III, which has been followed by proposed HENN and LM-AMM based SDP model discussion and implementation in Section IV. Section V presents the results and analysis and conclusion has been discussed in Section VI. The references used in this paper are given at the last of the manuscript.

II. Related Work

Software reliability is of course an inevitable need for quality service provisioning. The reliability oriented software defect prediction (SDP) has motivated researchers to develop optimal system for cost efficient defect prediction. Researchers examined the relationship between object oriented software metrics and associated faults [28, 29, 30, 31, 32, 33] by means of machine learning algorithms and detected fault proneness of software. To achieve better prediction some other approaches such as decision trees, naïve Bayes, and 1-rule [34] based fault detection scheme were developed, where the standard datasets such as NASA MDP was used to examine classification accuracy of the SDP approaches. Chug et al [35] demonstrated fault identification using data mining and employed conventional J48, Random Forest, and Naive Bayesian Classifier (NBC) schemes for performance comparison but still couldn't employ the benefits of advanced classification approaches. To optimize conventional random forest based defect prediction Pushphavathi et al [36] incorporated a hybrid random forest (RF) and Fuzzy C Means (FCM) clustering model for software defect prediction. Unfortunately, these approaches could not address the issue of unbalanced datasets, which motivated researchers to come up with Adaboost. Nc [37] which implemented a number of class imbalance approaches, re-sampling, threshold variations, and ensemble algorithms. Exploring insight, this approach can be found to be complicate and not a cost effective solution for large scale dynamic data. Researchers used SVM based defect prediction scheme [38, 39] and a dynamic SVM model was proposed that intended to detect faults in source code by means of error data and faulty code execution. In [40, 41]an ANN based defect prediction model was developed. A defect severity model using conventional back-propagation learning based ANN was developed in [42]. Similarly in [43] a Radial Basis ANN was used for SDP. ANN based SDP for Halstead data metrics has been done in [44]. In [45] the Bayesian Regularization (BR) technique based ANN model was developed for software fault detection. Almost all ANN based defect prediction model employs conventional learning and weight estimation techniques that confines applicability with huge datasets with dynamic functional environment. The conventional learning and weight estimation approaches can't eliminate the key issues of local minima and convergence issue that limit the performance of generic ANN. The enhancement of learning scheme and further optimization through certain evolutionary computing approaches can make ANN robust for SDP applications. In fact, cost feasibility is one of the key factors that decide employability of certain SDP model, but till no any research work has addressed the issue of cost estimation of the defect prediction model. This paper

has considered these limitations as motivation and has developed an evolutionary computing A-GA based SDP model which has been compared with Levenberg Marquardt based ANN and respective fault removal cost estimation has been done.

III. Our Contribution

In SDLC the fault resilience and reliability is of great significance. The implementation of efficient SDP strengthensearly fault detection and thus it enables software practitioner to remove faults to ensure reliability and QoS of the software solution. The predominant question in this paper is whether the implementation of Adaptive Genetic Algorithm can enable efficient and cost effective SDP solutions? In this paper, object oriented software metrics [17] has been considered for defect prediction and using proposed SDP models, the fault proneness of metrics data has been retrieved, whether the data is faulty or non-faulty. In order to perform classification of faulty and non-faulty data, initially the conventional ANN learning scheme with Leven berg Marquardt (LM) algorithm [45] has been developed and respective performance towards software defect prediction with NASA defect datasets has been done. This is the matter of fact that LM based ANN performs better as compared to other approaches such as back-propagation or feed-forward learning based NN, still it suffers due to prime limitations of ANN, such as local minima and weight update issues. Thus, considering higher employability of artificial intelligence techniques and respective limitations for critical software applications, in this paper an evolutionary computing based optimization scheme called Genetic Algorithm has been used for weight estimation during ANN learning. Further to ensure optimal performance of GA, in this paper a novelty has been introduced in terms of adaptive GA parameter (Crossover and Mutation probability) selection. The proposed Adaptive Genetic Algorithm (A-GA) performs adaptive weight estimation and learning optimization so as to ensure optimal fault classification and accuracy. The A-GA optimization scheme alleviates the issue of premature convergence and local minima. Such enhancement has lead better classification and accuracy for fault detection in huge datasets.

In order to examine the performance of the proposed SDP model, the object oriented software metrics (here, CK metrics [17]) has been considered. The implemented metrics characterizes various software features. In this paper, six predominant software metrics have been considered in fault identification. The considered metrics are WMC, NOC, DIT, CBO, RFC, and LCOM. The individual metrics has been feed as the input of the ANN and performing learning with the proposed HENN model the classification for faults has been done. The discussion of the proposed A-GA based ANN (HENN) has been discussed in the next section of the presented manuscript. In this paper, in order to examine the cost effectiveness of the developed SDP models, certain cost efficiency model can be used [46, 47, and 48] and with certain standard threshold the applicability of the proposed SDP model for large scale software data can be examined. The performance analysis of the proposed model has been done in terms of accuracy, precision, recall, F-Measures and fault removal cost efficiency. The discussion of the proposed SDP models and its implementation is discussed in the following sections.

IV. System Model

In this section, the proposed Levenberg Marquardt learning based ANN and our proposed HENN based software defect prediction schemes and its algorithmic implementation have been discussed.

a) Artificial Neural Network based Software Defect Prediction

This is the matter of fact that the Artificial Neural networks (NN) have seen an explosion of interest over the years, and it has been implemented across a range of problem domains, specifically classification and prediction. In fact, the major problems dealing with prediction and classification, ANN is considered to be the dominating solution. For SDP scenario, ANN can be used with different learning schemes like Gradient Descent (GD), Gauss Newton, and Levenberg Marquardt (LM) etc. Unfortunately majority of existing learning paradigm are ineffective to alleviate the key limitations of ANN such as local minima and convergence issue. Even though, researches have revealed that Levenberg Marquardt (LM) can be a potential candidate for ANN learning due to its stable nature and flexible implementation. In this paper, in addition to LM-ANN algorithm, an evolutionary computing technique called Adaptive Genetic Algorithm (A-GA) has been used for dynamic weight estimation for prediction enhancement. In the proposed ANN model and ultimately intended SDP system, it has been intended to find relation between object oriented software metrics and fault prone classes of the six CK metrics; WMC, NOC, DIT, RFC, CBO, LCOM, which has been considered as independent variable. The fault data has been taken as the dependent data. Figure-1 illustrates the architecture of our proposed ANN model comprising three layers i.e., input layer, hidden layer and output layer. Here, 6 input nodes have been defined that takes six CK matrix [17] having multiple classes as individual input. Since, in the proposed ANN model, the expected outputs are either FAULTY or NO-FAULTY, therefore only one output node is needed. Here, we have considered 8 hidden layers so as to avoid unwanted computational complexity. Thus in the defined ANN architecture, 56 weights $(input\ node +$

$Output\ Node) * hidden\ node)$ are required to be estimated for fault prediction and classification. At the input layer, the linear activation function has been used that enables the output of the output layer same as the input of the input layer($O_o = I_i$).

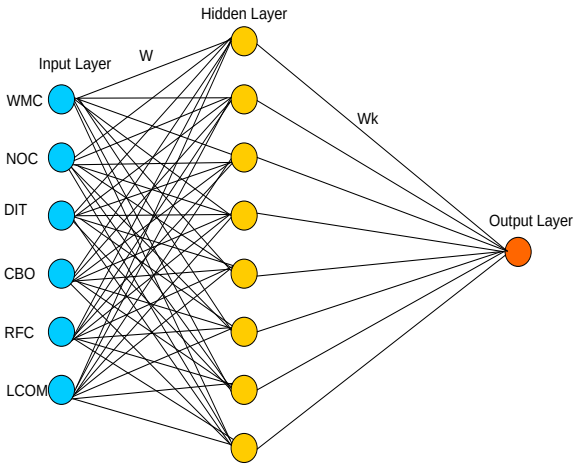

Figure 1 : ANN model for Defect prediction

In our model, the sigmoid function has been used at the hidden layerO_h and thus the output of the hidden nodes O_h with inputI_h would be $O_h = \frac{1}{1+e^{-I_h}}$. The final output at the output node come of output nodes O_o can be obtained as mathematically by $O_o = \frac{1}{1+e^{-O_i}}$.

Generally, the ANN model is defined in terms of a function$Y' = f(W, X)$where Y'states for the output vector and$W$ and Xrepresent the weight vector and the input vector respectively. In learning process, the weight factor $W$is updated iteratively so as to minimize the Root Mean Square Error (RMSE), which can be estimated by:

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(y_i' - y_i)^2 \quad (3)$$

Where $y$depicts the actual output andy_i' represents the expected output.

In order to make computation efficient and to process multidimensional data with ANN, it is inevitable to perform the normalization. In the proposed ANN based SDP models; the data normalization has been done using Min-Max approach, which is discussed as follows:

i. *Data normalization*

In this paper, normalization has been performed on the defect datasets that strengthens the proposed ANN based software detect prediction systems for better readability and classification. In the proposed SDP model, the data normalization has been done over the range of [0, 1] so as to adjust the defined range of input feature value and avoid the saturation of neurons. There a number of normalization approaches such as Min-Max normalization, Z-Score normalization and decimal scaling etc. We have normalized the defect data using Min-Max normalization scheme that performs a linear transformation on the original data and then maps individual data x_i of attribute X to the normalized value x'_iin the range of [0, 1]. The normalization using Min-Max approach has been done using following equation:

$$Normalized(x_i) = x_i^{''} = \frac{x_i - min(X)}{max(X) - min(X)} \quad (4)$$

where $max(X)$ and $min(X)$ are the maximum and minimum values of the attribute X respectively. In the proposed SDP model, performing data normalization the ANN model has been implemented for fault classification.

In ANN based systems, the efficient weight estimation and learning approach is of great significance. Till a number of approaches have been developed for learning optimization in ANN based artificial intelligence applications. Some of the predominant approaches are: Gauss Newton, Gradient descent, Levenberg Marquardt (LM) etc. Interestingly LM can work as both gradient descent as well as gauss Newton. Some researchers also have advocated that LM can outperform other existing learning schemes in ANN. Thus considering significance of LM for effective learning for SDP, in this paper initially LM based ANN (LMANN) has been developed for SDP model. The discussion of the proposed LMANN model for SDP application is given as follows:

b) *Levenberg Marquardt (LM) Learning based ANN for Software Defect Prediction*

The prime scope for ANN optimization is the enhancement of its weight estimation and respective learning optimization. Therefore, considering these factors, a number of algorithms have been proposed for weight update in ANN learning (Table-1). In this paper, considering the higher efficiency of Levenberg Marquardt (LM) algorithm, we have used this algorithm for weight update (W) during ANN training for defect prediction.

Table 1 : Specifications of varied Weight Update algorithms

Algorithm	Weight Update Rules	Convergence	Computation Complexity
EBP Algorithm	$W_{k+1} = W_k - \alpha g_k$	Stable, Low	Gradient
Newton Algorithm	$W_{k+1} = W_k - {H_k}^{-1} g_k$	Unstable, Fast	Gradient and Hessian
Gauss-Newton Algorithm	$W_{k+1} = W_k - \left({J_k}^T J_k\right)^{-1} J_k e_k$	Unstable, Fast	Jacobian
Levenberg-Marquardt Algorithm	$W_{k+1} = W_k - \left(J_k^T J_k + \mu I\right)^{-1} J_{k^e k}$	Stable, Fast	Jacobian
NBN Algorithm	$W_{k+1} = W_k - {Q_k}^{-1} g_k$	Stable, Fast	Quasi Hessian

Levenberg Marquardt (M) algorithm performs localization of the bare minimum value of multivariate function in a repetitive manner, which is expressed as the sum of squares of non-linear real-valued functions. Similar to GD algorithm, in HENN, LM algorithm updates the weights during NN learning process. Considering the performance novelty, the proposed LM algorithm comprises the functional ability of Steepest Descent and Gauss Newton method. The proposed LM algorithm can update the weight vector by following expression:

$$W_{k+1} = W_k - (J_k^T J_k + \mu I)^{-1} J_{k^e k} \quad (1)$$

Where W_{k+1} is the updated weights, W_k is the current weights, I represents the identity or unit matrix, J is the Jacobian matrix and μ, the combination coefficient is always positive. With μ as very small, it functions as Gauss Newton method while making μ as very large makes it functional as Gradient descent method. The Jacobian matrix derived as given as:

$$J = \begin{bmatrix} \frac{d}{dW_1}(E_{1,1}) & \frac{d}{dW_2}(E_{1,1}) & \cdots & \frac{d}{dW_N}(E_{1,1}) \\ \frac{d}{dW_1}(E_{1,2}) & \frac{d}{dW_2}(E_{1,2}) & \cdots & \frac{d}{dW_N}(E_{1,2}) \\ \vdots & \vdots & & \vdots \\ \frac{d}{dW_1}(E_{P,M}) & \frac{d}{dW_2}(E_{P,M}) & \cdots & \frac{d}{dW_N}(E_{P,M}) \end{bmatrix} \quad (2)$$

Where N refers the weight counts and the input patterns are P. The output patterns are indicated by M. The overall training function by the proposed LM algorithm is presented in the following figure.

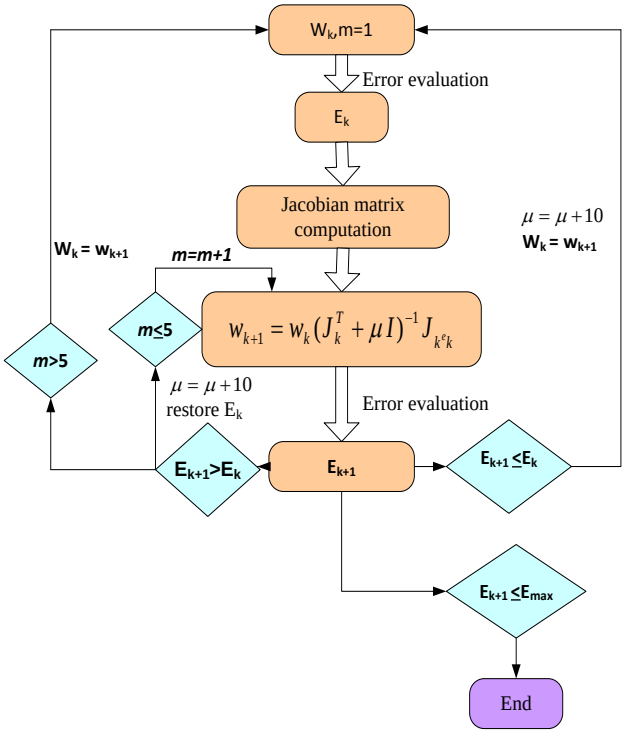

Figure 2 : Levenberg–Marquardt algorithm based HENN training: W_k is the current weight, W_{k+1} is the next weight, E_{k+1} is the current total error, and E_k is the final error

In the proposed SDP model, in the initial phase the LM algorithm has been used to estimate the weights for the learning scheme. Figure 3 represents the adaptive weight estimation approach using LM algorithm. The weights are updated dynamically so as to reduce RMSE and satisfying the stopping criteria, the classification has been done for fault prediction. On the basis of fault classification, the confusion matrix has been obtained which has been employed further to examine performance of the proposed SDP model.

This is the matter of fact that LM-ANN has been employed for varied classification utilities but considering the specific requirements of fault prediction and robust function with huge data sets in real time software utilities, the local minima problem and convergence issues of ANN can't be ignored. Thus, considering these limitations, in this paper, the evolutionary algorithm Adaptive-Genetic Algorithm (A-GA) has been used for parameter optimization that can strengthen the function of the proposed system to yield more precise, accurate and efficient outputs. The implementation of A-GA for ANN based SDP utility has been discussed in the following section

c) HENN: Hybrid Evolutionary Computing Based Neural Network for Software Defect Prediction

In recent years a number of optimization schemes have been developed on the basis of the concept of human evolution and Genetic Algorithm (GA) is one of the predominant one. GA is an adaptive search approach based on the evolutionary concepts of natural selection that intends to find certain optimal or near optimal solutions. In fact, the basic concept of GA is based on the philosophy of natural selection and Darwin principle of the survival of fittest. In function, GA at first performs random population generation, where population represents certain set of solutions. In fact, these solutions are nothing else but a chromosome possessing a form of binary strings where all the comprising parameters are supposed to be encoded. Performing population generation, GA calculates the fitness value, also known as fitness function for the individual chromosome. The fitness value represents a user-defined function that provides the estimation results for individual chromosome, and thus a higher fitness value signifies the chromosome to be the dominant one. On the basis of retrieved fitness values, the offspring are generated by means of genetic operators called crossover and mutation. Implementing genetic operators the population generation continues until the stopping criteria is achieved. Here, it must be noted that after every generation, chromosomes having fitness value more than defined threshold are considered for next generation otherwise are mutated out of competition.

As depicted in Figure-1, the developed HENN model [59] encompasses $i-h-o$ network configuration having i input layer, h hidden layer and O output layer or nodes. In the proposed ANN model, all the six CK metrics under consideration have been fed as input to the individual input nodes, where the individual metrics can have multiple classes depending on the size of software and dimensions. As already discussed with the considered 6-8-1 ANN configuration, the total number of weights, N to be calculated are:

$$N = (i+O)*h \tag{5}$$

In the proposed model the individual weight is considered as a gene in the chromosomes and is a real number. Consider l, the gene length or the number of digits be l, then the length of the chromosome L_{Chrom} can be obtained using following equation:

$$L_{Chrom} = N*l = (i+O)*h*l \tag{6}$$

In the proposed A-GA based scheme all chromosomes are considered as the population and for each chromosomes the fitness values and weights are estimated. In our proposed model, the weights (W_k) has been obtained using following equation:

$$W_k = \begin{cases} if\ 0 \le x_{kl+1} < 5 \\ -\dfrac{x_{kl+2*}10^{l-2} + x_{kl+3*}10^{l-3} + \cdots + x_{(k+1)l}}{10^{l-2}} \\ if\ 5 <= x_{kl+l} <= 9 \\ +\dfrac{x_{kl+2*}10^{l-2} + x_{kl+3*}10^{l-3} + \cdots + x_{(k+1)l}}{10^{l-2}} \end{cases} \tag{7}$$

To perform A-GA based weight estimation in ANN, the fitness values for individual chromoseomes are needed to be obtained. The algorithm developed for fitness value estimation is given in the following figure (Figure-3).

Algorithm for Fitness Estimation

Input: $\bar{I}_i = (I_{1i}, I_{2i}, I_{3i}, \cdots, I_{li})$

Output: $\bar{T}_i = (T_{1i}, T_{2i}, T_{3i}, \cdots, T_{ni})$

Where $\bar{I}_i, \bar{T}_i$ state the input and output pairs of the $i-h-o$ configuration of neural network.

Phase-1 :Calculate weights $\bar{W}_i$ for C_i by:

$$W_k = \begin{cases} if\ 0 \le x_{kd+1} < 5 \\ -\dfrac{x_{kd+2*}10^{d-2} + x_{kd+3*}10^{d-3} + \cdots + x_{(k+1)d}}{10^{d-2}} \\ if\ 5 <= x_{kd+d} <= 9 \\ +\dfrac{x_{kd+2*}10^{d-2} + x_{kd+3*}10^{d-3} + \cdots + x_{(k+1)d}}{10^{d-2}} \end{cases}$$

Phase-2: Assuming $\bar{W}_i$ be a constant weight, perform training of N input instances and calculate output O_i

Phase-3: Calculate MSE E_j for all input instance j, $E_j = (T_{ji} - O_{ji})$

Phase-4: Calculate RMSE of chromosome C_i

$$E_i = \sqrt{\frac{\sum_{j=1}^{j=N} E_j}{N}}$$

Where N is the number of training data

Phase-5: Calculate the fitness value for chromosome C_i

$$F_i = \frac{1}{E_i} = \frac{1}{\sqrt{\frac{\sum_{j=1}^{j=N} E_j}{N}}}$$

Figure 3 : Fitness generation using A-GA

Genetic algorithm (GA) has been considered as a potential global optimization approach for major applications; still this approach can be further optimized to alleviate issues of premature convergence. In this paper, in order to alleviate these issues, the genetic parameters, cross over probability (P_c) and mutation probability (P_m) has been selected dynamically so as to get optimal or sub-optimal solution efficiently without converging. To update P_c and P_m the following mathematical equations has been used:

$$(P_c)_{k+1} = (P_c)_k - \frac{C_1 * n}{5}$$

$$(P_m)_{k+1} = (P_m)_k - \frac{C_2 * n}{5} \qquad (8)$$

where $(P_c)_{k+1}$ and $(P_m)_{k+1}$ denote the updated crossover probability and mutation probability respectively. The other variables $(P_c)_k$ and $(P_m)_k$ are the current crossover and mutation probability, C_1 and C_2 can be any positive constant and n represents the number of chromosome having similar fitness value. In the proposed HENN model, the A-GA continues functioning till 95% of chromosomes are having similar fitness value. Once the stopping criterion is achieved the A-GA terminates and the final output at output layer O_o is obtained. If the final estimated output is more than 0.5, it signifies class as FAULTY otherwise NON-FAULTY. On the basis of retrieved FAULTY and NON-FAULTY data, a confusion matrix is obtained, which is further used for performance assessment. Figure-4 represents the flow diagram of the proposed HENN based SDP model.

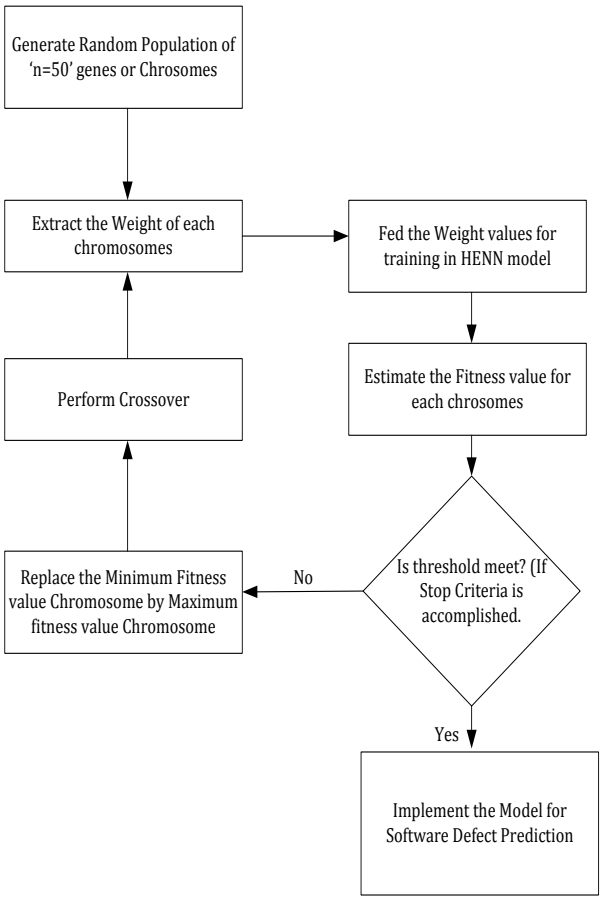

Figure 4 : Proposed HENN Scheme for Software Defect Prediction

The overall discussion of the proposed HENN model is given as follows:

- *HENN-SDP Simulation*

Since, the proposed HENN model operates on the basis of genetic algorithm principle; it also encompasses processes such as, population generation, selection, crossover, fitness estimation, and mutation. A brief discussion of the implemented HENN simulation model is given as follows:

Step-1 Population Initialization: In our model randomly 50 chromosomes are selected randomly to perform competition. These randomly selected chromosomes perform crossover with defined crossover and mutation probability.

Step-2 Weight Estimation: HENN estimates weight W_k for each selected chromosomes as input to the hidden layer and hidden layer to the output layer using equation (7).

Step-3 Fitness Estimation: On the basis of weight estimated, the fitness value is obtained for individual chromosome with an intention to minimize the root mean square error (RMSE) obtained at the output node of ANN.

Step-4 Chromosome Ranking and Mutation: On the basis of fitness values for the individual chromosomes, the ranking is performed which is followed by mutation of the chromosomes having lower fitness values and chromosomes with higher ranking replaces chromosomes with lower fitness.

Step-5 Crossover: In the proposed HENN model, the two point crossover is performed with the selected chromosomes. Here to enhance computational efficiency the GA parameters, P_c and P_m are varied adaptively, as per equation(6). Initially, P_c and P_m have been assigned as 0.6 and 0.1 respectively and $n$refers the number of chromosome having similar fitness value.

- *Stopping Criteria:* The process of weight estimation using HENN algorithm continues till the stopping criteria is not achieved and the 95% chromosomes in gene pool achieves unique fitness value, as beyond it the fitness level of chromosomes get saturated.

Step 6 Fault Classification: Considering step-3, and stopping criteria, with the optimal RMSE, the final output at output layer of ANN is obtained that more than 0.5 signifies towards FAULTY class otherwise NON-FAULTY.

Step 7 Confusion Matrix: On the basis of FAULTY and NON-FAULTY label of comprising classes, a Confusion Matrix is derived that is used for performance evaluation.

Thus, implementing the above mentioned approaches, the proposed HENN model performs Software Defect Prediction.

This is the matter of fact that a number of SDP systems have been developed but only prediction accuracy and precision can't be the justification for a system to be employable in real time scenarios. Industries demands for certain cost effective and efficient system for defect prediction. A system with higher computational efficiency with minimal cost of fault detection and removal can be of great significance and can be suggested to be used in real time SDP applications.

Thus, considering the need of a novel cost analysis mechanism, in this paper a novel cost estimation approach has been developed which has been used to assess the computational (Fault detection and removal) cost analysis for both our proposed HENN based SDP as well as reference, LM-ANN based SDP model. The discussion of the proposed cost estimation model is given as follows:

d) Software Fault Estimation and Removal Cost analysis

In this paper, a novel cost estimation approach has been developed that estimates the cost of fault detection and removal, as the efficiency to be considered as a criterion that decides whether the system should be used or not in real time applications. The proposed cost estimation model has been derived from [46]. In the developed cost estimation approach, certain constraints have been assumed such as, varied testing phases might take different cost for certain fault removal as different softwares are developed in varied software platform and with varied development standards, and it is impractical to perform comprising unit testing on all the associated modules [47]. In the proposed cost estimation model, the identification efficiency model proposed in [48] has been incorporated that suggests following efficiencies to be used for cost estimation model.

Table 2 : Cost Estimation for different testing approaches (Staff hour per faults)

Testing	Min	Max	Median
Unit	1.5	6	2.5
System	2.82	8.37	6.2
Field	3.9	27.24	27

In this paper, the following notations have been used to formulate mathematical model for fault estimation and removal cost.

Table 3 : Cost Estimation Metrics

$\mathrm{Cost}_{\mathrm{Estm\_SDP}}$	Estimated fault removal cost of the software when fault prediction is performed
$\mathrm{Cost}_{\mathrm{Estm\_WSDP}}$	Estimated fault removal cost of the software without using fault prediction approach
$\mathrm{Cost}_{\mathrm{Norm}}$	Normalized Estimated fault removal cost of the software when fault prediction is utilized
C_i	Initial setup cost of used fault-prediction technique
C_u	Normalized fault removal cost in unit testing
C_S	Normalized fault removal cost in system testing
C_f	Normalized fault removal cost in testing
M_p	percentage of classes unit tested
FP	Number of false positive
FN	Number of false negative
TP	Number of true positive
TN	Number of true negative
TC	Total number of classes
FC	Total number of faulty classes
δ_u	Fault identification efficiency of unit testing
δ_s	Fault identification efficiency of system testing

The derived cost estimation expressions are given as follows:

$$\begin{aligned}\text{Cost}_{\text{Estm\_SDP}} &= C_i + C_u * (FP + TP) + \delta_s \\ &* C_s \\ &* (FN + (1 - \delta_u) * TP) \\ &+ (1 - \delta_s) * C_f \\ &* (FN + (1 - \delta_u) * TP)\end{aligned} \quad (9)$$

$$\begin{aligned}\text{Cost}_{\text{Estm\_WSDP}} &= M_p * C_u * TC + \delta_s * C_s \\ &* (1 - \delta_s) * FC + (1 - \delta_s) \\ &* C_f * (1 - \delta_u) * FC\end{aligned} \quad (10)$$

$$\text{Cost}_{\text{Norm}} = \frac{Cost_{Estm\_SDP}}{Cost_{Estm\_WSDP}} = \begin{cases} < 1, & Significant\ SDP\ System \\ \geq 1 & \text{Not Suitable} \end{cases} \quad (11)$$

Here, $\text{Cost}_{\text{Estm\_SDP}}$ represents the estimated fault removal cost for software with fault prediction scheme, $\text{Cost}_{\text{Estm\_WSDP}}$ is the fault removal cost without using any SDP system. The variable $\text{Cost}_{\text{Norm}}$ refers the normalized cost with the SDP models. As illustrated in above expression, the minimal normalized cost signifies better employability of a defect prediction system. In this paper, the cost analysis for both the proposed HENN as well as Levenberg Marquardt based ANN (LMANN) has been done. The results obtained are given in Table 7.

V. Result and Analysis

This section discusses the experimental setup, benchmark fault data, results and performance analysis.

In this paper, the overall algorithms for artificial neural network, Levenberg Marquardt based ANN, Adaptive Genetic Algorithm and its implementation with ANN for defect prediction, etc have been developed using MATLAB2012b software model. In addition, the toolboxes of machine learning and artificial neural network have been considered to perform simulation. In order to examine the performance of the proposed HENN model, object oriented software metrics suite, CK Metrics [17] has been considered, which has been derived from the fault data taken from PROMISE [49] and NASA MDP [50] fault data repository. The software metrics from the fault datasets (*JEdit, Ant, Camel* and *IVY*)have been derived using Chidamber and Kemerer Java Metrics tool (CKJM) tool that extracts software metrics by executing byte code of compiled Java cases and assigns a definite weight of the comprising classes having feature vectors. In this paper, six predominant CK metrics have been considered as depicted in the Table-4.

Table 4 : Object Oriented Software Metrics (CK Metrics [17])

WMC	Overall complexities of the methods in comprising classes
NOC	Number of sub-classes subordinate to a class in the class hierarchy
DIT	Maximum height of the class hierarchy
CBO	Number of other classes to which it is allied with
RFC	A set of approaches that can be executed in response to a message received by an object of that class
LCOM	Dissimilarity measurement of varied methods in a class using instanced attributes/variables

In our work, the six software metrics have been considered as the independent data while the fault data has been taken as dependent variable.

The considered data *JEdit, Ant, Camel* and *IVY* comprise static code measures along with varied modules sizes, defective modules and defect rates. In the proposed SDP models the respective extracted weights and features of the data classes have been taken as input to the ANN as illustrated in Figure-1. On the basis of final outcome of the both SDP models, LM-ANN as well as HENN for individual datasets, the confusion matrix has been obtained. A confusion matrix comprises two rows and columns representingtrue positive (TP), false negatives (FN), false positive (FP) and true Negative variables. The variables in confusion matrix represent the faulty and non-faulty data and its severity. As depicted in Table-5, TP depicts modules which are classified as FAULTY, FN represents the modules which are FAULTY but are classified incorrectly as NON-FAULTY. Similarly, FP represents the modules which are non-faulty but are classified as faulty.

Table 5 : Confusion Matrix

	Predicted Defective	Predicted Defect Free
FAULTY	True Positive	False Negative
NON-FAULTY	False Positive	True Negative

In this paper, the performance of the proposed HENN as well as LM-ANN SDP models has been examined in terms of fault prediction accuracy, precision, F-measure, recall, specification and fault detection and removal cost. The mathematical expression for considered performance parameters are given in Table-6.

Table 6 : Performance Parameters

Construct	Mathematical Expression
Recall	$TP/(TP+FN)$
Precision	$TP/(TP+FP)$
Specification	$TN/(TN+FP)$
F-measure	$2.\frac{Recall.Precision}{Recall+Precision}$
Accuracy	$(TN+TP)/(TN+FN+FP+TP)$

a) Result Analysis

The following section represents the results obtained from the proposed HENN based SDP model and a reference model based on Leven berg Marquardt based ANN. Here, from the results obtained it can be found that the proposed HENN based SDP model performs better than Leven berg Marquardt algorithm based ANN (LMANN). Here, it can be found that the average fault prediction accuracy of the proposed HENN model is 87.23%, on contrary, the LM-ANN based SDP models delivers 75.48% and hence the proposed system outperforms the existing and till most efficient ANN model, LMANN. In addition, the analysis results states that the proposed system provides 98.2% precision, 92.74% F-measure, 88.55% of recall, which is 87.7% 85.7%, and 85.4% for LMANN based SDP system, respectively. The following figures (Figure 5-8) represent the average performance of the proposed system with four benchmark datasets (*JEdit, Ant, Camel* and *IVY*). The performance results for the developed SDP models with individual datasets are given in Table-7. Considering cost effectiveness of HENN and LMANN based SDP models, Figure 9 depicts that the proposed HENN based system is most cost efficient as compared to LMAMM, and hence it can be implemented for real time applications intending software defect prediction and removal.

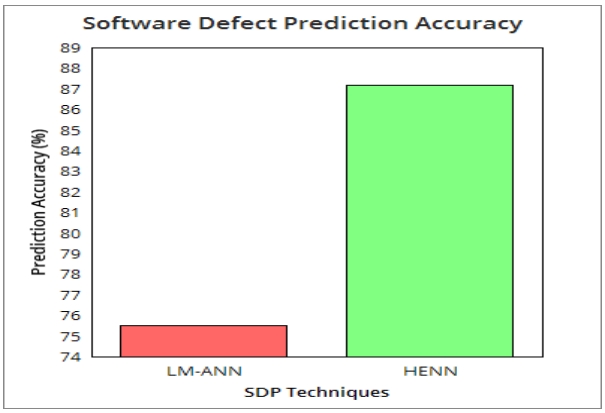

Figure-5 : Accuracy analysis of software defect prediction

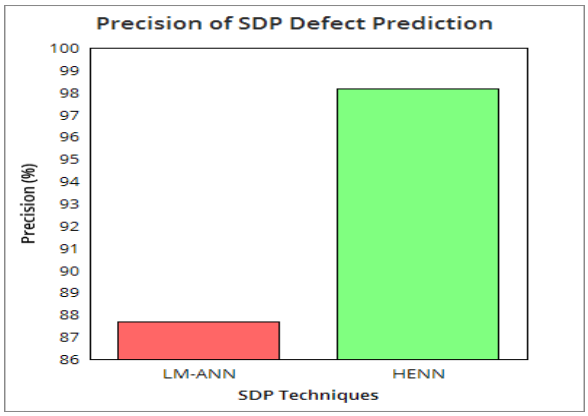

Figure-6 : Precision analysis of Software defect prediction precision

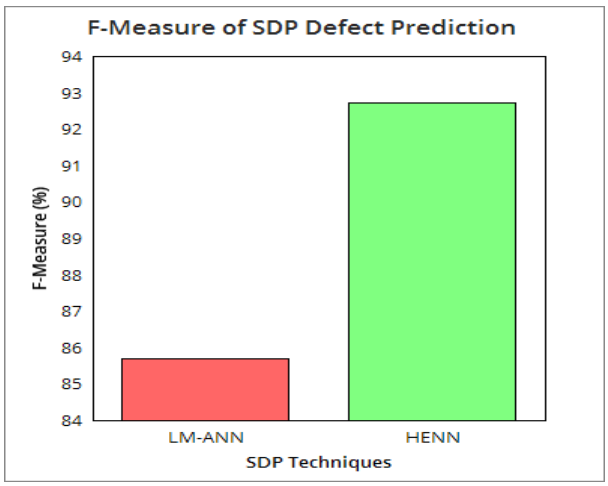

Figure-7 : F-Measure analysis of software defect prediction

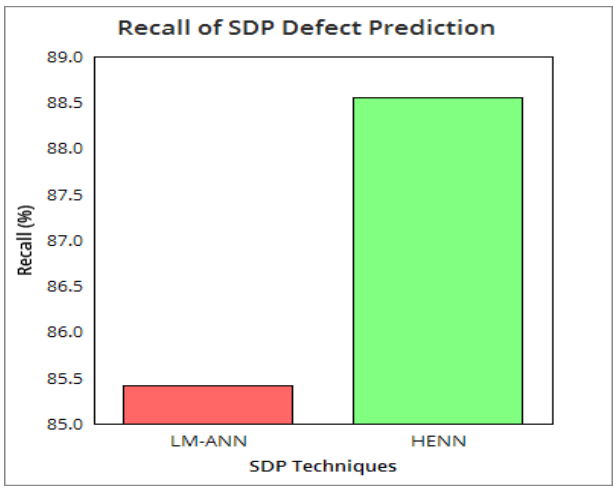

Figure-8 : Recall Analysis of Software defect prediction

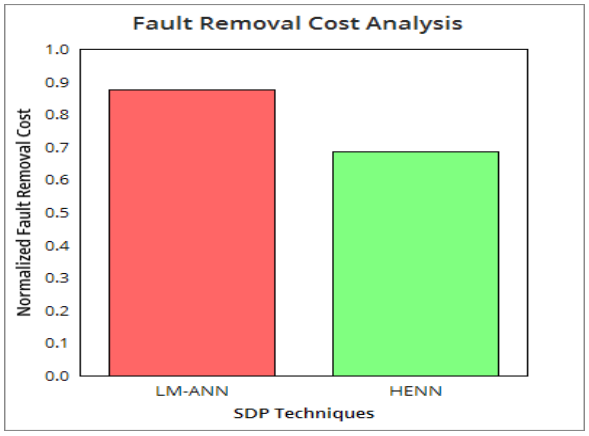

Figure -9 : Fault detection and removal cost analysis

The cost analysis results depict that the proposed HENN based SDP model is approximately 21.66% cost efficient as compared to LMANN based SDP system.

Table 7 : Performance analysis of the proposed HENN model and LM-ANN based SDP system

Data	Modules	Tech.	Accuracy	Precision	F-Measure	Recall	Specification	Norm. Fault Removal Cost (Norm.)
JEDIT	492	HENN	**0.9799**	**1**	**0.9897**	**1**	**0.9756**	**0.2406**
		LMANN	0.8394	0.8503	0.9119	0.9832	0.0526	0.2927
ANT	744	HENN	**0.8145**	0.9343	**0.8867**	**0.8438**	**0.6346**	**0.9149**
		LMANN	0.7675	0.9879	0.8684	0.7748	0	0.9763
IVY	352	HENN	**0.8835**	**0.9936**	**0.9380**	**0.8883**	**0.3333**	**0.7115**
		LMANN	0.6278	0.6955	0.7681	0.8577	0.0404	0.8936
CAMEL	965	HENN	**0.8114**	**1**	**0.8952**	**0.8102**	**1**	**0.8771**
		LMANN	0.7845	0.9743	0.8792	0.8011	0	1.3401

Table 7 depicts that the proposed defect prediction approach is highly robust and efficient as compared to Levenberg-Marquardt based ANN system, which is supposed to be the most effective ANN system till. The proposed HENN model has exhibited better cost effectiveness for the fault detection and removal than LMANN. Further to explore effectiveness of the proposed HENN model as compared to other existing systems, a comparison has been done (Table-8) and results revealed that the proposed system can be the best optimal solution for defect prediction for object oriented software applications.

Table 8 : Performance comparison for different SDP schemes

SDP Techniques	Accuracy (%)	Precision (%)	F-Measure (%)
LLE-SVM[51]	81.1	82.5	80.4
SVM [51]	69.4	68.1	69.7
SVM [52]	55.3	88.0	83.2
Natural Gas [57]	94.2	-	-
Symbolic Regression [57]	89.50	-	-
RBP-NN [57]	80.0	-	-
LP [52]	86.6	86.6	87.4
Naive Based [52]	85.6	83.1	83.9
CPSO[53]	69.2	67.6	-
T-SVM [54]	75.8	84.1	80.9
GANN[53]	73.4	81.6	-
AdaBoost [53]	79.1	82.3	-
Random Forest [58]	91.4	-	-
k-NN [56]	91.8	-	-
C4.5 [56]	88.3	-	-

J 48 [56]	90.9		
Levenberg-Marquardt-NN [56]	88.0	-	-
NNEP-Evolutionary [53]	88.8	81.2	-
PSO [55]	78.7	-	-
PSO-NN [57]	97.7	-	-
HENN SDP	**97.9**	**1**	**98.9**

VI. Conclusion

In order to ensure optimal software reliability and quality of service the earlier prediction of faults and its removal is of great significance. In addition, the cost effective solution for defect prediction and fault removal has motivated industries as well as academician to develop a novel SDP solution that could ensure cost effective and optimal defect prediction solutions. In this paper, an object oriented software matrix based defect prediction model has been developed.

Considering the limitations of artificial intelligence techniques such as artificial neural network, in this paper an evolutionary computing technique named Adaptive Genetic Algorithm (A-GA) has been developed for ANN dynamic weight estimation and learning optimization. The proposed Hybrid Evolutionary computing based Neural Network (HENN) based system has been employed for SDP system. Furthermore, Levenberg Marquardt algorithm based ANN algorithm (LMANN) has been developed for defect prediction. Considering cost effectiveness of the defect prediction systems, a novel mathematical model has been derived and the cost analysis results confirms that the proposed HENN model is cost effective as well as performs better as compared to other existing systems. The simulation results obtained with PROMISE and NASA MDP datasets exhibits that the proposed model performs on average 87.23% accuracy and the best classification accuracy obtained is 97.99% with 100% precision. The proposed model delivers 98.97% of F-measure. The cost analysis exhibits that the proposed HENN model is approximate 21.66% cost effective as compared to LMANN. The comparative analysis in this paper reveals that the proposed HENN model performs better as compared to other existing techniques. This paper could perform cost analysis of only HENN and LMANN, hence in future other defect prediction models can also be examined for their cost effectiveness for real time applications.

References Références Referencias

1. Zuse H., "A Framework of Software Measurement, Walter de Grutger Publish" 1998.
2. University of Texas, Software Quality Institute Report, May 2002.
3. Rosenberg, L., S. B., Sheppard, "Metrics in Software Process Assessment, Quality Assurance and Risk Assessment", 2nd International Symposium on Software Metrics, London, October, 1994.
4. Boehm, B. W., Software Engineering Economics, Prentice-Hall, 1981.
5. L.C. Briand, W.L. Melo, J. Wu st, "Assessing the Applicability of Fault-Proneness Models Across Object-Oriented Software Projects," IEEE Trans. Software Eng., vol. 28, no. 7, pp. 706-720, July 2002.
6. F. B. E. Abreu, R. Carapuca, "Object-Oriented software engineering: Measuring and controlling the development process," in Proceedings of the 4th International Conference on Software Quality, vol. 186, 1994.
7. J. Bansiya, C. G. Davis, "A hierarchical model for Object-Oriented design quality assessment," ACM Transactions on Programming Languages and Systems., vol. 128, pp. 4–17, August 2002.
8. B. K. Kang and J. M. Bieman, "Cohesion and reuse in an Object-Oriented system," in Proceedings of the ACM SIGSOFT Symposium on *software reusability*, pp. 259–262, Seattle, March 1995.
9. L. C. Briand, J. Wust, J. W. Daly, D. V. Porter, "Exploring the relationships between design measures and software quality in Object-Oriented systems," *The Journal of Systems and Software*, vol. 51, pp. 245–273, May 2000.
10. L. Etzkorn, J. Bansiya, and C. Davis, "Design and code complexity metrics for Object-Oriented classes," *Object-Oriented Programming*, vol. 12, no. 10, pp. 35–40, 1999.
11. M. Halstead, *Elements of Software Sciencel*. New York, USA: Elsevier Science, 1977.
12. B. Henderson-Sellers, *Software Metrics*. UK: Prentice-Hall, 1996.
13. W. Li and S. Henry, "Maintenance metrics for the Object-Oriented paradigm," in *Proceedings of First International Software Metrics Symposium*, pp. 52–60, 1993.
14. T. J. McCabe, "A complexity measure," IEEE Transactions on Software Engineering, vol. 2, pp. 308–320, December 1976.
15. D. P. Tegarden, S. D. Sheetz, D. E. Monarchi, "A software complexity model of Object-Oriented systems," Decision Support Systems, vol. 13, no. 3, pp. 241–262, 1995.
16. M. Lorenz and J. Kidd, Object-Oriented Software Metrics. NJ, Englewood: Prentice-Hall, 1994.

17. S. R. Chidamber and C. F. Kemerer, “A metrics suite for Object-Oriented design,” IEEE Transactions on Software Engineering on June 1994, vol. 20, pp. 476–493.
18. Kutlubay O., A. Bener, “A Machine Learning Based Model for Software Defect Prediction,” working paer, Boaziçi University, Computer Engineering Department 2005.
19. Bo. Yang, Xiang Li, “A study on software reliability prediction based on support vector machines”, The Annual IEEE International Conference on Industrial Engineering and Engineering Management, pp. 1176-1180, 2-4 Dec. 2007.
20. Sandhu, Parvinder Singh, Sunil Kumar, Hardeep Singh, “Intelligence System for Software Maintenance Severity Prediction”, Journal of Computer Science, Vol. 3 (5), pp. 281-288, 2007.
21. Gondra, "Applying machine learning to software fault-proneness prediction," Journal of Systems and Software, vol. 81, no. 2, pp. 186-195, Feb. 2008.
22. Q. P Hu, Y. S. Dai, M. Xie, S. H. Ng., “Early software reliability prediction with extended ANN model,” Proceedings of the 30th Annual International Computer Software and Applications Conference (COMPSAC’06), Vol. 2, pp. 234-239, September 2006.
23. Chug, A., Dhall, S., "Software defect prediction using supervised learning algorithm and unsupervised learning algorithm, "Confluence 2013: The Next Generation Information Technology Summit, pp.173-179, 26-27 Sept. 2013.
24. Armah, G.K., Guangchun Luo, Ke Qin, "Multilevel data preprocessing for software defect prediction," Information Management, Innovation Management and Industrial Engineering (ICIII), 2013 6th International Conference, vol.2, pp.170-174, 23-24 Nov. 2013.
25. Mohamad Mahdi Askari, Vahid Khatibi Bardsiri, “Software Defect Prediction using a High Performance Neural Network”, International Journal of Software Engineering and Its Applications, Vol. 8, No. 12, pp. 177-188, 2014.
26. M. Harman, “Why the Virtual Nature of Software makes it Ideal for Search Based Optimization”, Fundamental Approaches to Software Engineering, 2010.
27. C. Grosan, and A. Abraham, “Hybrid Evolutionary Algorithms: Methodologies, Architectures, and Reviews”, Studies in Computational Intelligence, vol. 75, pp. 1-17, 2011.
28. Saida Benlarbi, Khaled El Emam, Nishith Geol (1999), “Issues in Validating Object-Oriented Metrics for Early Risk Prediction”, by Cistel Technology 210 Colonnade Road Suite 204 Nepean, Ontario Canada K2E 7L5.
29. Lanubile F., Lonigro A., Visaggio G. “Comparing Models for Identifying Fault-Prone Software Components”, Proceedings of Seventh International Conference on Software Engineering and Knowledge Engineering, pp. 12-19, June 1995.
30. Fenton, N. E. and Neil, M., “A Critique of Software Defect Prediction Models”, Bellini, I. Bruno, P. Nesi, D. Rogai, University of Florence, IEEE Trans. Softw. Engineering, vol. 25, Issue no. 5, pp. 675-689, 1999.
31. Giovanni Denaro, ”Estimating Software Fault-Proneness for Tuning Testing Activities” Proceedings of the 22nd International Conference on Software Engineering, Limerick, Ireland, June 2000.
32. Manasi Deodhar, “Prediction Model and the Size Factor for Fault-proneness of Object Oriented Systems”, MS Thesis, Michigan Tech. University, Dec. 2002.
33. Bellini, P., “Comparing Fault-Proneness Estimation Models”, 10th IEEE International Conference on Engineering of Complex Computer Systems (ICECCS'05), pp. 205-214, 2005
34. Khoshgoftaar, T.M., K. Gao and R. M. Szabo, “An Application of Zero-Inflated Poisson Regression for Software Fault Prediction. Software Reliability Engineering”, ISSRE 2001. Proceedings of 12th International Symposium, pp: 66 -73, 27-30 Nov. 2001.
35. Chug, A., Dhall, S., "Software defect prediction using supervised learning algorithm and unsupervised learning algorithm," Confluence 2013: The Next Generation Information Technology Summit, pp.173-179, 26-27 Sept. 2013.
36. Pushphavathi, T.P.; Suma, V.; Ramaswamy, V., "A novel method for software defect prediction: Hybrid of FCM and random forest," Electronics and Communication Systems (ICECS), 2014 International Conference, vol., no., pp.1,5, 13-14 Feb. 2014.
37. Wang, S.; Yao, X., "Using Class Imbalance Learning for Software Defect Prediction," Reliability, IEEE Transactions, vol.62, no.2, pp.434-443, June 2013.
38. Brun, Y. and D. E. Michael, “Finding Latent Code Errors via Machine Learning over Program Executions”, Proceedings of the 26th International Conference on Software Engineering, May, 2004.
39. F. Xing, P. Guo, M. R. Lyu, “A novel method for early software quality prediction based on support vector machine,” Software Reliability Engineering, International Symposium, pp. 213–222, 2005.
40. Cai K Y, 0n the Neura1 Network Approach in Software Reliability Modeling, Journal of Systems and Software, pp 47-62, 2001.
41. S.A. Rojas and D. Fernandez-Reyes, “Adapting multiple kernel parameters for support vector machines using genetic algorithms,” The 2005 IEEE Congress on Evolutionary Computation, vol. 1, pp. 626-631, September, 2005.

42. Jianhong, Z., Sandhu, P.S., Rani, S., "A Neural network based approach for modeling of severity of defects in function based software systems," International Conference on Electronics and information Engineering, vol.2, pp.568- 575, 1-3 Aug. 2010.
43. Jindal, R., Malhotra, R. and Jain, A., "Software defect prediction using neural networks," in 3rd International Conference on Reliability, Infocom Technologies and Optimization (ICRITO), pp.1-6, 8-10 Oct, 2014.
44. Yousef A.H., "Extracting software static defect models using data mining", Ain Shams Engineering Journal, Vol. 6, pp. 133–144, 2015.
45. Mahajan R., Gupta S., Bedi R.K., "Design Of Software Fault Prediction Model Using BR Technique", Procedia Computer Science, Vol. 46, pp. 849 – 858, 2015.
46. W. S, "A literature survey of the quality economics of defect-detection techniques," in Proceedings of the ACM/IEEE International Symposium on Empirical Software Engineering (ISESE), pp. 194–203, 2006.
47. R. Huitt and N. Wilde, "Maintenance support for object-oriented programs," IEEE Transactions on Software Engineering, vol. 18, no. 12, pp. 1038–1044, 1992.
48. J. C, "Software quality in 2010: a survey of the state of the art," in Founder and Chief Scientist Emeritus, 2010.
49. http://mdp.ivv.nasa.gov/.
50. http://promisedata.googlecode.com/svn/trunk/defect/
51. Shan C., Chen B., Hu C., Xue J., Li N., "SOFTWARE DEFECT PREDICTION MODEL BASED ON LLE AND SVM" Communications Security Conference; pp 1-5, 22-24 May 2014.
52. Xia Y., Yan G., Jiang X., Yang Y., "A new metrics selection method for software defect prediction," Progress in Informatics and Computing (PIC), International Conference, pp.433-436, 16-18 May 2014.
53. Malhotra, R., Pritam, N., Singh, Y., "On the applicability of evolutionary computation for software defect prediction," Advances in Computing, Communications and Informatics (ICACCI, 2014 International Conference, pp.2249-2257, 24-27 Sept. 2014.
54. Chug, A., Dhall, S., "Software defect prediction using supervised learning algorithm and unsupervised learning algorithm, "Confluence 2013: The Next Generation Information Technology Summit, pp.173-179, 26-27 Sept. 2013.
55. Verma, R., Gupta, A., "Software defect prediction using two level data pre-processing," Recent Advances in Computing and Software Systems (RACSS), International Conference, pp.311-317, 25-27 April 2012.
56. Singh M., Salaria D.S., "Software Defect Prediction Tool based on Neural Network", International Journal of Computer Applications, Volume 70– No.22, pp-0975 – 8887, May 2013.
57. Shrivastava A., Shrivastava V., "A Hybrid Model of Soft Computing Technique for Software Fault Prediction", International Journal of Current Engineering and Tech. Vol. 4, No. 4, Aug 2014.
58. Askari, M.M, Bardsiri, V.K., "Software Defect Prediction using a High Performance Neural Network", International Journal of Software Engineering and Its Applications, Vol. 8, No. 12, pp. 177-188, 2014.
59. Racharla Suresh Kumar, Bachala Satyanarayana, "Adaptive Genetic Algorithm Based Artificial Neural Network for Software Defect Prediction", Global Journal of Computer Science and Technology : D, Vol. 15, Issue No. 1,Version 1.0, pp. 23-32, 2015.

Global Journals Inc. (US) Guidelines Handbook 2015

www.GlobalJournals.org

FELLOW OF ASSOCIATION OF RESEARCH SOCIETY IN COMPUTING (FARSC)

Global Journals Incorporate (USA) is accredited by Open Association of Research Society (OARS), U.S.A and in turn, awards "FARSC" title to individuals. The 'FARSC' title is accorded to a selected professional after the approval of the Editor-in-Chief/Editorial Board Members/Dean.

- The "FARSC" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

FARSC accrediting is an honor. It authenticates your research activities. After recognition as FARSC, you can add 'FARSC' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, and Visiting Card etc.

The following benefits can be availed by you only for next three years from the date of certification:

FARSC designated members are entitled to avail a 40% discount while publishing their research papers (of a single author) with Global Journals Incorporation (USA), if the same is accepted by Editorial Board/Peer Reviewers. If you are a main author or co-author in case of multiple authors, you will be entitled to avail discount of 10%.

Once FARSC title is accorded, the Fellow is authorized to organize a symposium/seminar/conference on behalf of Global Journal Incorporation (USA).The Fellow can also participate in conference/seminar/symposium organized by another institution as representative of Global Journal. In both the cases, it is mandatory for him to discuss with us and obtain our consent.

You may join as member of the Editorial Board of Global Journals Incorporation (USA) after successful completion of three years as Fellow and as Peer Reviewer. In addition, it is also desirable that you should organize seminar/symposium/conference at least once.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The FARSC can go through standards of OARS. You can also play vital role if you have any suggestions so that proper amendment can take place to improve the same for the benefit of entire research community.

As FARSC, you will be given a renowned, secure and free professional email address with 100 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders, Auto-Responders, Email Delivery Route tracing, etc.

The FARSC will be eligible for a free application of standardization of their researches. Standardization of research will be subject to acceptability within stipulated norms as the next step after publishing in a journal. We shall depute a team of specialized research professionals who will render their services for elevating your researches to next higher level, which is worldwide open standardization.

The FARSC member can apply for grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A. Once you are designated as FARSC, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria. After certification of all your credentials by OARS, they will be published on your Fellow Profile link on website https://associationofresearch.org which will be helpful to upgrade the dignity.

The FARSC members can avail the benefits of free research podcasting in Global Research Radio with their research documents. After publishing the work, (including published elsewhere worldwide with proper authorization) you can upload your research paper with your recorded voice or you can utilize chargeable services of our professional RJs to record your paper in their voice on request.

The FARSC member also entitled to get the benefits of free research podcasting of their research documents through video clips. We can also streamline your conference videos and display your slides/ online slides and online research video clips at reasonable charges, on request.

The FARSC is eligible to earn from sales proceeds of his/her researches/reference/review Books or literature, while publishing with Global Journals. The FARSC can decide whether he/she would like to publish his/her research in a closed manner. In this case, whenever readers purchase that individual research paper for reading, maximum 60% of its profit earned as royalty by Global Journals, will be credited to his/her bank account. The entire entitled amount will be credited to his/her bank account exceeding limit of minimum fixed balance. There is no minimum time limit for collection. The FARSC member can decide its price and we can help in making the right decision.

The FARSC member is eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get remuneration of 15% of author fees, taken from the author of a respective paper. After reviewing 5 or more papers you can request to transfer the amount to your bank account.

MEMBER OF ASSOCIATION OF RESEARCH SOCIETY IN COMPUTING (MARSC)

The ' MARSC ' title is accorded to a selected professional after the approval of the Editor-in-Chief / Editorial Board Members/Dean.
The “MARSC” is a dignified ornament which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., MARSC or William Walldroff, M.S., MARSC.

MARSC accrediting is an honor. It authenticates your research activities. After becoming MARSC, you can add 'MARSC' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, Visiting Card and Name Plate etc.

The following benefitscan be availed by you only for next three years from the date of certification.

MARSC designated members are entitled to avail a 25% discount while publishing their research papers (of a single author) in Global Journals Inc., if the same is accepted by our Editorial Board and Peer Reviewers. If you are a main author or co-author of a group of authors, you will get discount of 10%.

As MARSC, you will be given a renowned, secure and free professional email address with 30 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders, Auto-Responders, Email Delivery Route tracing, etc.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The MARSC member can apply for approval, grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A.

Once you are designated as MARSC, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria.

It is mandatory to read all terms and conditions carefully.

AUXILIARY MEMBERSHIPS

Institutional Fellow of Open Association of Research Society (USA)-OARS (USA)

Global Journals Incorporation (USA) is accredited by Open Association of Research Society, U.S.A (OARS) and in turn, affiliates research institutions as "Institutional Fellow of Open Association of Research Society" (IFOARS).

The "FARSC" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as "Institutional Board of Open Association of Research Society"-(IBOARS).

The Institute will be entitled to following benefits:

The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA) The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.

The author fees of such paper may be waived off up to 40%.

The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of "Open Association of Research Society, U.S.A (OARS)" so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

Open Association of Research Society (US)/ Global Journals Incorporation (USA), as described in Corporate Statements, are educational, research publishing and professional membership organizations. Achieving our individual Fellow or Associate status is based mainly on meeting stated educational research requirements.

Disbursement of 40% Royalty earned through Global Journals : Researcher = 50%, Peer Reviewer = 37.50%, Institution = 12.50% E.g. Out of 40%, the 20% benefit should be passed on to researcher, 15 % benefit towards remuneration should be given to a reviewer and remaining 5% is to be retained by the institution.

We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth $ 2376 USD.

Other:

The individual Fellow and Associate designations accredited by Open Association of Research Society (US) credentials signify guarantees following achievements:

- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.

- In addition to above, if one is single author, then entitled to 40% discount on publishing research paper and can get 10%discount if one is co-author or main author among group of authors.
- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
- The Fellow can become member of Editorial Board Member after completing 3yrs.
- The Fellow can earn 60% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.
- Fellow can also join as paid peer reviewer and earn 15% remuneration of author charges and can also get an opportunity to join as member of the Editorial Board of Global Journals Incorporation (USA)
- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in–depth understanding of the application of suitable techniques to a particular area of research practice.

Note :

"

- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

Process of submission of Research Paper

The Area or field of specialization may or may not be of any category as mentioned in 'Scope of Journal' menu of the GlobalJournals.org website. There are 37 Research Journal categorized with Six parental Journals GJCST, GJMR, GJRE, GJMBR, GJSFR, GJHSS. For Authors should prefer the mentioned categories. There are three widely used systems UDC, DDC and LCC. The details are available as 'Knowledge Abstract' at Home page. The major advantage of this coding is that, the research work will be exposed to and shared with all over the world as we are being abstracted and indexed worldwide.

The paper should be in proper format. The format can be downloaded from first page of 'Author Guideline' Menu. The Author is expected to follow the general rules as mentioned in this menu. The paper should be written in MS-Word Format (*.DOC,*.DOCX).

The Author can submit the paper either online or offline. The authors should prefer online submission.Online Submission: There are three ways to submit your paper:

(A) (I) First, register yourself using top right corner of Home page then Login. If you are already registered, then login using your username and password.

(II) Choose corresponding Journal.

(III) Click 'Submit Manuscript'. Fill required information and Upload the paper.

(B) If you are using Internet Explorer, then Direct Submission through Homepage is also available.

(C) If these two are not convenient, and then email the paper directly to dean@globaljournals.org.

Offline Submission: Author can send the typed form of paper by Post. However, online submission should be preferred.

Preferred Author Guidelines

MANUSCRIPT STYLE INSTRUCTION (Must be strictly followed)

Page Size: 8.27" X 11'"

- Left Margin: 0.65
- Right Margin: 0.65
- Top Margin: 0.75
- Bottom Margin: 0.75
- Font type of all text should be Swis 721 Lt BT.
- Paper Title should be of Font Size 24 with one Column section.
- Author Name in Font Size of 11 with one column as of Title.
- Abstract Font size of 9 Bold, "Abstract" word in Italic Bold.
- Main Text: Font size 10 with justified two columns section
- Two Column with Equal Column with of 3.38 and Gaping of .2
- First Character must be three lines Drop capped.
- Paragraph before Spacing of 1 pt and After of 0 pt.
- Line Spacing of 1 pt
- Large Images must be in One Column
- Numbering of First Main Headings (Heading 1) must be in Roman Letters, Capital Letter, and Font Size of 10.
- Numbering of Second Main Headings (Heading 2) must be in Alphabets, Italic, and Font Size of 10.

You can use your own standard format also.
Author Guidelines:

1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

1. GENERAL

Before submitting your research paper, one is advised to go through the details as mentioned in following heads. It will be beneficial, while peer reviewer justify your paper for publication.

Scope

The Global Journals Inc. (US) welcome the submission of original paper, review paper, survey article relevant to the all the streams of Philosophy and knowledge. The Global Journals Inc. (US) is parental platform for Global Journal of Computer Science and Technology, Researches in Engineering, Medical Research, Science Frontier Research, Human Social Science, Management, and Business organization. The choice of specific field can be done otherwise as following in Abstracting and Indexing Page on this Website. As the all Global

Journals Inc. (US) are being abstracted and indexed (in process) by most of the reputed organizations. Topics of only narrow interest will not be accepted unless they have wider potential or consequences.

2. ETHICAL GUIDELINES

Authors should follow the ethical guidelines as mentioned below for publication of research paper and research activities.

Papers are accepted on strict understanding that the material in whole or in part has not been, nor is being, considered for publication elsewhere. If the paper once accepted by Global Journals Inc. (US) and Editorial Board, will become the copyright of the Global Journals Inc. (US).

Authorship: The authors and coauthors should have active contribution to conception design, analysis and interpretation of findings. They should critically review the contents and drafting of the paper. All should approve the final version of the paper before submission

The Global Journals Inc. (US) follows the definition of authorship set up by the Global Academy of Research and Development. According to the Global Academy of R&D authorship, criteria must be based on:

1) Substantial contributions to conception and acquisition of data, analysis and interpretation of the findings.

2) Drafting the paper and revising it critically regarding important academic content.

3) Final approval of the version of the paper to be published.

All authors should have been credited according to their appropriate contribution in research activity and preparing paper. Contributors who do not match the criteria as authors may be mentioned under Acknowledgement.

Acknowledgements: Contributors to the research other than authors credited should be mentioned under acknowledgement. The specifications of the source of funding for the research if appropriate can be included. Suppliers of resources may be mentioned along with address.

Appeal of Decision: The Editorial Board's decision on publication of the paper is final and cannot be appealed elsewhere.

Permissions: It is the author's responsibility to have prior permission if all or parts of earlier published illustrations are used in this paper.

Please mention proper reference and appropriate acknowledgements wherever expected.

If all or parts of previously published illustrations are used, permission must be taken from the copyright holder concerned. It is the author's responsibility to take these in writing.

Approval for reproduction/modification of any information (including figures and tables) published elsewhere must be obtained by the authors/copyright holders before submission of the manuscript. Contributors (Authors) are responsible for any copyright fee involved.

3. SUBMISSION OF MANUSCRIPTS

Manuscripts should be uploaded via this online submission page. The online submission is most efficient method for submission of papers, as it enables rapid distribution of manuscripts and consequently speeds up the review procedure. It also enables authors to know the status of their own manuscripts by emailing us. Complete instructions for submitting a paper is available below.

Manuscript submission is a systematic procedure and little preparation is required beyond having all parts of your manuscript in a given format and a computer with an Internet connection and a Web browser. Full help and instructions are provided on-screen. As an author, you will be prompted for login and manuscript details as Field of Paper and then to upload your manuscript file(s) according to the instructions.

To avoid postal delays, all transaction is preferred by e-mail. A finished manuscript submission is confirmed by e-mail immediately and your paper enters the editorial process with no postal delays. When a conclusion is made about the publication of your paper by our Editorial Board, revisions can be submitted online with the same procedure, with an occasion to view and respond to all comments.

Complete support for both authors and co-author is provided.

4. MANUSCRIPT'S CATEGORY

Based on potential and nature, the manuscript can be categorized under the following heads:

Original research paper: Such papers are reports of high-level significant original research work.

Review papers: These are concise, significant but helpful and decisive topics for young researchers.

Research articles: These are handled with small investigation and applications.

Research letters: The letters are small and concise comments on previously published matters.

5. STRUCTURE AND FORMAT OF MANUSCRIPT

The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

Papers: These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

(a)Title should be relevant and commensurate with the theme of the paper.

(b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.

(c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.

(d) An Introduction, giving necessary background excluding subheadings; objectives must be clearly declared.

(e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.

(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

(h) Brief Acknowledgements.

(i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and to make suggestions to improve briefness.

It is vital, that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

Format

Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.

Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than 1.4 × 10-3 m3, or 4 mm somewhat than 4 × 10-3 m. Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

Structure

All manuscripts submitted to Global Journals Inc. (US), ought to include:

Title: The title page must carry an instructive title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) wherever the work was carried out. The full postal address in addition with the e-mail address of related author must be given. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining and indexing.

Abstract, used in Original Papers and Reviews:

Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy and planning a list of possible keywords and phrases to try.

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

Acknowledgements: Please make these as concise as possible.

References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

The Editorial Board and Global Journals Inc. (US) recommend that, citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

Tables, Figures and Figure Legends

Tables: Tables should be few in number, cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g. Table 4, a self-explanatory caption and be on a separate sheet. Vertical lines should not be used.

Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.

Preparation of Electronic Figures for Publication

Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. Please give the data for figures in black and white or submit a Color Work Agreement Form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution (at final image size) ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs) : >350 dpi; figures containing both halftone and line images: >650 dpi.

Color Charges: It is the rule of the Global Journals Inc. (US) for authors to pay the full cost for the reproduction of their color artwork. Hence, please note that, if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a color work agreement form before your paper can be published.

Figure Legends: Self-explanatory legends of all figures should be incorporated separately under the heading 'Legends to Figures'. In the full-text online edition of the journal, figure legends may possibly be truncated in abbreviated links to the full screen version. Therefore, the first 100 characters of any legend should notify the reader, about the key aspects of the figure.

6. AFTER ACCEPTANCE

Upon approval of a paper for publication, the manuscript will be forwarded to the dean, who is responsible for the publication of the Global Journals Inc. (US).

6.1 Proof Corrections

The corresponding author will receive an e-mail alert containing a link to a website or will be attached. A working e-mail address must therefore be provided for the related author.

Acrobat Reader will be required in order to read this file. This software can be downloaded

(Free of charge) from the following website:

www.adobe.com/products/acrobat/readstep2.html. This will facilitate the file to be opened, read on screen, and printed out in order for any corrections to be added. Further instructions will be sent with the proof.

Proofs must be returned to the dean at dean@globaljournals.org within three days of receipt.

As changes to proofs are costly, we inquire that you only correct typesetting errors. All illustrations are retained by the publisher. Please note that the authors are responsible for all statements made in their work, including changes made by the copy editor.

6.2 Early View of Global Journals Inc. (US) (Publication Prior to Print)

The Global Journals Inc. (US) are enclosed by our publishing's Early View service. Early View articles are complete full-text articles sent in advance of their publication. Early View articles are absolute and final. They have been completely reviewed, revised and edited for publication, and the authors' final corrections have been incorporated. Because they are in final form, no changes can be made after sending them. The nature of Early View articles means that they do not yet have volume, issue or page numbers, so Early View articles cannot be cited in the conventional way.

6.3 Author Services

Online production tracking is available for your article through Author Services. Author Services enables authors to track their article - once it has been accepted - through the production process to publication online and in print. Authors can check the status of their articles online and choose to receive automated e-mails at key stages of production. The authors will receive an e-mail with a unique link that enables them to register and have their article automatically added to the system. Please ensure that a complete e-mail address is provided when submitting the manuscript.

6.4 Author Material Archive Policy

Please note that if not specifically requested, publisher will dispose off hardcopy & electronic information submitted, after the two months of publication. If you require the return of any information submitted, please inform the Editorial Board or dean as soon as possible.

6.5 Offprint and Extra Copies

A PDF offprint of the online-published article will be provided free of charge to the related author, and may be distributed according to the Publisher's terms and conditions. Additional paper offprint may be ordered by emailing us at: editor@globaljournals.org .

You must strictly follow above Author Guidelines before submitting your paper or else we will not at all be responsible for any corrections in future in any of the way.

Before start writing a good quality Computer Science Research Paper, let us first understand what is Computer Science Research Paper? So, Computer Science Research Paper is the paper which is written by professionals or scientists who are associated to Computer Science and Information Technology, or doing research study in these areas. If you are novel to this field then you can consult about this field from your supervisor or guide.

TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

1. Choosing the topic: In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. Evaluators are human: First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

3. Think Like Evaluators: If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

4. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

5. Ask your Guides: If you are having any difficulty in your research, then do not hesitate to share your difficulty to your guide (if you have any). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work then ask the supervisor to help you with the alternative. He might also provide you the list of essential readings.

6. Use of computer is recommended: As you are doing research in the field of Computer Science, then this point is quite obvious.

7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

8. Use the Internet for help: An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

9. Use and get big pictures: Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

10. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right! It is a good habit, which helps to not to lose your continuity. You should always use bookmarks while searching on Internet also, which will make your search easier.

11. Revise what you wrote: When you write anything, always read it, summarize it and then finalize it.

12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. Pick a good study spot: To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.

- Do not give permission to anyone else to "PROOFREAD" your manuscript.

- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

Criterion for Grading a Research Paper (Compilation) by Global Journals Inc. (US)

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals Inc. (US).

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

Index

A

Abeokuta · 17
Alfawareh · 3, 9
Argamon · 3

D

Dellarocas · 4
Deoxyribonucleic · 28

E

Ewekoro · 17

J

Janyce · 3

L

Liangjun · 4

M

Martínez · 3
Monozygotic · 28

O

Okediran · 11, 18

S

Schweiger · 3

save our planet

Global Journal of Computer Science and Technology

Visit us on the Web at www.GlobalJournals.org | www.ComputerResearch.org
or email us at helpdesk@globaljournals.org

ISSN 9754350