ISSN 2278-3091
Volume 9 No.2, March - April 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse145922020.pdf
https://doi.org/10.30534/ijatcse/2020/145922020

An Intelligent Neural Model for Assessing Web Systems Performance

Ala Aldeen Al-Janabi[1], Kamal M. Alhendawi [2], AbdulRahman A. Alsewari [3]
[1] Military College, Qatar, alaaljanabi@abmmc.edu.qa
[2] Faculty of Management, Israa University, Gaza, Palestine, Hindawi.Kamal@yahoo.com
[3] Faculty of Computing, University Malaysia Pahang, Malaysia, alsewari@ump.edu.my

ABSTRACT

The information systems evaluation studies have frequently used the old-style tools such as questionnaires in assessing the effectiveness and performance of Web Systems (WS). Very few studies discussed the employment of artificial tools in the evaluation of such systems based on quality attributes because of lack of WS features data set. Consequently, this study is one of the fewest to evaluate WS performance using Artificial Neural Network ANN). To do this, the study builds a data set of 200 records of WIS quality metrics using questionnaire as a data collection tool where each instance consists of 22 standard quality and performance metrics. A percentage of 80 % (160 records) of data subjects are used in the training phase. The results analysis indicates that proposed ANN model has correctly predict the Web system performance at a percentage of 75%. Also, the results show that the quality and Web users benefits attributes influence the Web system performance positively. Finally, the function approximation of neural network is properly estimating such nonlinear relationships, and thus provide a valuable information about Web system performance.

Key words: Artificial Neural Network (ANN); Web System (WS); Artificial Intelligence (AI); WIS performance; Effectiveness; MathLAB.

1. INTRODUCTION

The Web quality attributes are most commonly used as metrics for evaluating and diagnosing the Web Information System (WIS) Performance [1]. In the recent decade, most of organizations employed the WIS in their work in order to integrate the important Web features and technology with their functions [2].

Furthermore, the number of web sites and users have recently tremendously increased and it is expected to be increased more in the upcoming years [1]. Accordingly, it is essential to investigate the quality factors or metrics that affect the WIS performance, and thus, make it effective for end users whereas the users rate the performance of Web sites based on their net benefits [3]. Thus, it is significant to specify what makes end users satisfied with WS performance where the performance of WS is subject to its impact on end user performance and benefits. This leads that it is difficult to use conventional statistical methods such as regression in predicting and estimating the WS performance. For this, the current research aims at employing the neural network model as a new model in predicting the Web performance in terms of users' benefits.

In particular, this research attempts to determine the relationship of Web performance with respect to a set of quality evaluation metrics. It also utilizes the results of a quantitative survey based on questionnaires where 200 Web users are asked to fill the questionnaires. The results indicated that there is a strong association between the quality metrics and WS performance (i.e. user benefits). Thus, the current research tries to estimate the performance based on quality metrics by using the neural network models. The research paper is organized as follows. In section two, the theoretical foundations are provided. Section 3 explains the methodology followed by researchers including the quantitative survey and intelligent neural network model. Section 4 demonstrates the results of the research while section 5 provides the conclusion and practical implications.

2 THEORETICAL FOUNDATIONS

2.1 Quality Factors

This section discusses the conceptual background of quality factors. Information quality, and interaction design quality are the main factors influencing WBMIS effectiveness; whereas interaction design is a two dimensional factor including user interface quality and communication quality.

- **Information Quality**

Several researchers such as Sedera and Gable [4] showed the six measures including: availability, usability, understandability, relevance, format and conciseness in their definition. Gable et al. [5] suggested a set of measures for evaluating the information quality such as availability, conciseness, accuracy, timeliness, understandability, format, uniqueness, usability, and relevance. Gorla et al. [6] pointed out three measures for assessing information quality:

completeness, consistency, and consistency. Laudon et al. [7] identified the seven measures for evaluating information quality: accuracy, integrity, consistency, completeness, validity, accessibility, and timeliness. Table 1 reveals a sample of information quality measures in accordance with recent literature review.

Table 1: The Sample Measures of Information

No.	Author	Measures
1.	[8]	Timeliness, format, easy to understand, relevance
2.	[7]	Accuracy, integrity, consistency, completeness, validity, accessibility, and timeliness
3.	[9]	Content, accuracy, format, timeliness
4.	[10]	Soundness (error free, complete consistent), ease of use, usefulness (understandability and appropriateness), dependability (up-to-date, secure)
5.	[6]	Completeness, consistency, consistency
6.	[5]	Availability, conciseness, accuracy, timeliness, understandability, format, uniqueness, usability, relevance,
7.	[11]	Completeness, accuracy, format, currency
8.	[12]	Accuracy, precision, consistency, timeliness, format
9.	[13]	Completeness, accuracy, format, currency
10.	[14]	Accuracy, relevance
11.	[15]	Content, access, reliability, flexibility, usefulness
12.	[16]	Content variety, completeness, timeliness, accuracy, reliability, format
13.	[4]	Relevance, understandability, format, usability, conciseness, availability,

- **The interaction design**

It is conceptualized as: the extent to which WS provide the employees with the ability to engage in Web information exchange with their other colleagues or users through the facilities included in the user interface design. The facilities that can be provided are: e-mail contacts, profiling, web layout, and graphic in addition to the other communication tools including discussion form, feedback form, FAQ page, and group subscription [17,18]. Accordingly, the quality of interaction will be assessed using two measurements where the metrics of this quality factor are adapted from several standard instruments [17,19,20].

The interface quality is defined as the degree to which the facilities provided by interface Layout such as profiling and links allows the employees to properly interact with the Web information system. The communication quality is defined as the extent to which the WIS makes the online interaction tools available in order to allow the knowledge exchange between employees where the most commonly used tools are: FAQ , discussion forum, and feedback facilities.

Table 2 explains the definition and measures of interaction design quality.

Table 2: Concept and measures of Interaction Design Factor

Quality of Interaction design	Measures	Source
User Interface Quality.	Email Links, Complexity of access, Appearance, Graphs, Profiling	[17],[19],[20]
Communication Quality.	feedback, discussion forum, Group Subscription, Chat tool, communication skills and FAQ	[17]

2.2 WS Performance or Effectiveness

In this study, the effects of the quality factors on the Web Systems (WS) performance are investigated through developing assessment model based on D&M03. Therefore, the Web user benefits represent the performance of WS, and it should be measured in terms of performance. To comprehensively evaluate the WIS performance in terms of Web users' benefits, it is important to conceptualize the WS performance as a two dimensional factor including task performance and contextual performance [21]. In Particular, task performance measures are adapted from Torkzadeh and Doll [22] and Williams and Anderson [23]. The assessment measures of contextual performance (i.e. task innovation and personality skills) are adapted from standard scales [22,24].

2.3 Neural Networks

Neural network is considered as one of the efficient artificial approach for modeling and forecasting the non-linear system [25]. Moreover, Tsai & Lu [26] pointed out that neural network is superior approach for prediction because of two reasons. The first reason is that the development of neural network does not need the knowledge of the relationship between the inputs and outputs, and this is actually needed for the current research as it aims at finding the pattern of relationship in an accurate manner. The second reason, the violation in assumptions such as multi-collinearity and normality don't affect the performance of neural network [27].

3. METHODOLOGY

To achieve the research objectives, the authors adopt a methodology of four stages including survey, building dataset, neural network learning and prediction accuracy. Figure 1 demonstrates the research methodological steps.

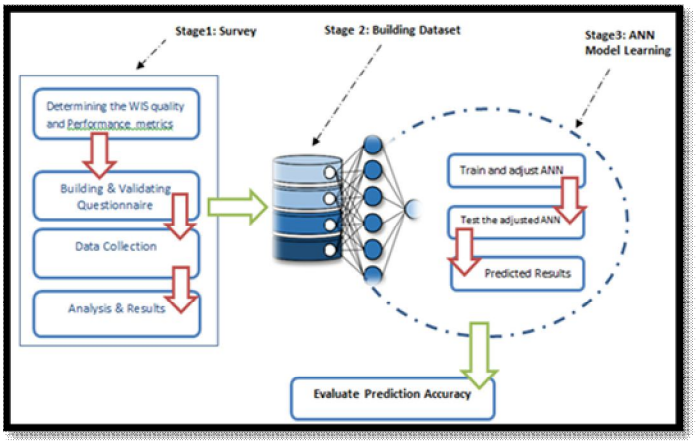

Figure 1: The Research Methodology

3.1 Stage 1:Survey

In this stage, an instrument or questionnaire of 3 study variables (i.e. factors) was built to include the information quality, interaction quality and performance metrics of the WIS. The instrument has a reasonable reliability and validity.

3.2 Measures

Table 3 shows the study instrument which consists of 22 items/ metrics in order to validate the relationship between quality factors and WS performance.

Table 3:. The Sample metrics of the quality and performance

Web Users Benefits	
1	It increases productivity.
2	It saves time.
3	It improves the quality of work.
4	It helps in trying out innovative ideas..
5	It is useful in performing the job.
6	It enables working as part of a group/Team..
Information Quality	
7	The information provided through this system is clear.
8	The system provides sufficient information.
9	It helps in the provision of the needed information in time.
10	The system provides reports that seem to be just about exactly what you need.
11	The system provides detailed information.
12	It offers enough satisfaction.
Interaction Quality	
13	The users can check profile information via the WIS.
14	The system offers an organized list of specific e-mail link.
15	The system provides a discussion form.
16	The system provides a feedback form.
17	The system presents a page of FAQ (frequent asked questions)
18	The system provides a form to subscribe to related news groups.
19	The provided services are accessed easily.
20	The system's appearance is clear.
21	There graphics (colors, graphs, images) and content are compatible.
22	General the system contributes to the interactive capacity of the organization.

Scaling

A Likert scale of 7 points is used in order to measure the response of WS users regarding the quality and performance metrics. The metrics are rated by users from strongly agree to strongly disagree.

Data Collection

The research includes the survey of 200 Web users about their satisfaction with the performance of the WS whether it is effective or ineffective performance. The survey includes the perceptions of Web users regarding 22 metrics: 6 information quality metrics, 10 interaction quality metrics and 6 Web effectiveness metrics.

Reliability

The result of reliability test shows that the reliability of the study scales was high. The value of Cronbach's Alpha of the study scales as a whole was 0.930. The value of Cronbach's Alpha for the study scales of WS performance, information quality, interaction quality were 0.920, 0.877, 0.911 respectively. Therefore, as shown in Table 4, the reliability analysis indicates high stability of the questionnaire [28].

Table 4: Cronbach's Alpha of Study Variables

Variable	Cronbach's Alpha
Information Quality	0.877
Interaction Quality	0.911
WS Performance	0.920

3.3 Building Dataset

According to the above survey study analysis, there are two causal factors or classifiers (information and interaction quality) and one target (WS performance). The two factors includes three dimensions with 22 metrics. Because we have used a Likert scale of 7 points, we consider the mean of WS performance to evaluate whether the Web system is performance is effective or not; if the WS performance mean >= 0.7 then WS performance is effective otherwise it is ineffective. The values of quality factors range from 1 to 7 while the value of target (i.e. WS performance) is one if the Web system performance is effective; and 0 otherwise. WS performance (WSP) = Function (22 information and interaction quality and Web user benefits metrics).

3.4 Neural Model Learning

The feed-forward neural networks are type of Artificial Neural Model (ANN) with a considerable success in classification problems Haykin [29,30,31], and thus, the

model applied in this study is a feed-forward multi-layer network as well as the fully connected network. Figure 2 presents the network that consists of three layers which they are as the input layer, the hidden layer, and the output layer.

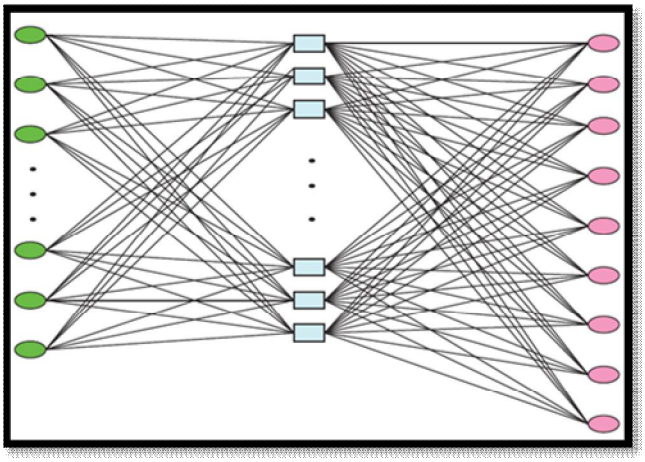

Figure 2: The Artificial Neural Network Architecture

Prediction Accuracy

The final step towards achieving the research objectives is to validate the accuracy of the proposed neural network model. To do so, the predicted WS performance value which is obtained from the neural model will be compared to that one obtained from the survey.

For accuracy check, it is important to mention that this research uses the below equation to evaluate Mean Square Error (MSE) where the better neural network performance can be obtained when SME is small.

Where N denotes the number that presents the exemplars in the dataset, as well as P denotes the number of possessing elements. Yij and tij are desired network outputs and outputs, respectively.

$$\text{MSE} = \sum_{j=0}^{P} \sum_{i=0}^{N} (tij - Yij)^2 / \text{NP}$$

4. EXPERIMENTAL RESULTS & FINDINGS

It is found by several researchers that the use of the Back Propagation (BP) model and the Levenberg-Marquardt algorithm during ANNs training is better than using other models in the classification. Thus, in this research a feed-forward multi-layer network with the fully connected network and Levenberg-Marquardt (trainlm) have been utilized.

The proposed ANN model is trained by 200 records where the training data set includes 160 records. For validating and testing purposes, the researchers used 40 records: 20 records for validation and the remaining 20 was used as testing data set. For testing which is very important for modelling the nonlinear functions, TANSIG function is used to connect the neurons of the input layer with those of hidden layer. The learning algorithm for training is back-propagation learning rule. The research variables including information and interaction quality and WS performance are categorical 7-point Likert with 22 metrics. Thus, it is more preferably to consider the input layer with at least 22 neurons; or otherwise multiple of 22 in order to decide regarding the optimum neural network. We used the MSE as a measure for the optimal ANN structure, Table 5 shows the experiments results:

Table 5: MSE of ANNs

Neurons	MSE
22	0.000173
44	0.000000779
66	0.0000227
88	0.0000995
110	0.0000375
132	0.000016
154	0.00000382
176	0.0000351
198	0.0000114

Based on Table 5, it is found that the least MSE, and thus, it confirm that the ANN is best performing at 44 neurons. Then, testing phase will be applied to test and evaluate the accuracy of the ANN model based on the selected dataset. The objective of testing is to assess the accuracy of forecasted results.

Table 6: The ANN performance evaluation for test set

Case ID	Predicted value	Actual Value	Prediction Status(1/0)
C1	6	6	1
C2	6	6	1
C3	6	6	1
C4	4	4	1
C5	6	6	1
C6	5	5	1
C7	5	6	0
C8	6	6	1
C9	4	4	1
C10	5	5	1

C11	6	6	1
C12	5	5	1
C13	6	6	1
C14	5	6	**0**
C15	3	3	1
C16	1	2	**0**
C17	5	2	**0**
C18	3	3	1
C19	2	2	1
C20	3	2	0

Table 6 explains that the suggested artificial model has the capability to forecast 75% of test set records; this means that the proposed ANN correctly predicts 15 out of 20 targets. Thus the neural network model successfully predicted 15 target values or WS performance values (i.e. predicted values with status = 1). Based on the results, the correlation between the actual outputs and ANN network output is (r = 0.894). This value (r = 0.894) is relatively high and supports the aspect that the WS performance depends on the quality attributes and WS benefits.

The following charts in Figures 3, 4 and 5 shows the relationship between the WS performance and its predictors. The x-axis represents the performance of quality or user benefit attributes. In particular, Figure 4 shows that the attribute of information quality factor significantly affects the WS performance.

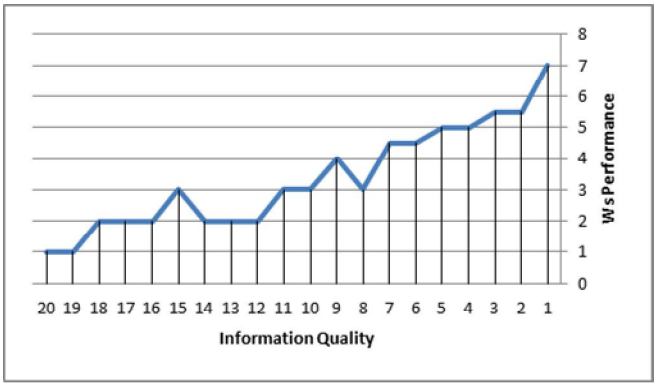

Figure 3: The Impact of information quality on WS performance

Also, figures 4 and 5 demonstrate that interaction quality and user benefits attributes follow the same pattern, i.e. as the interaction quality and user benefits increased the WS performance increased

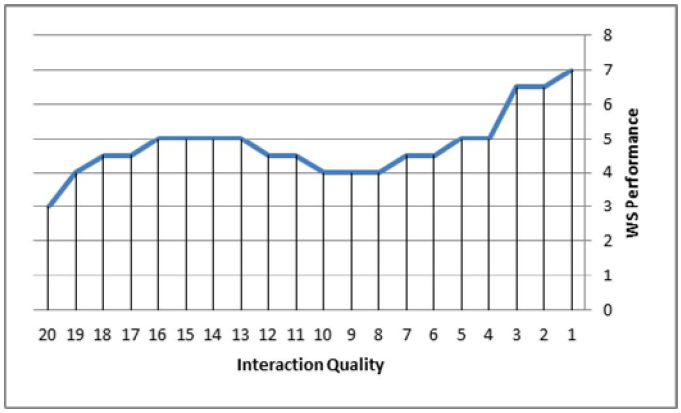

Figure. 4: The Impact of interaction quality on WS performance

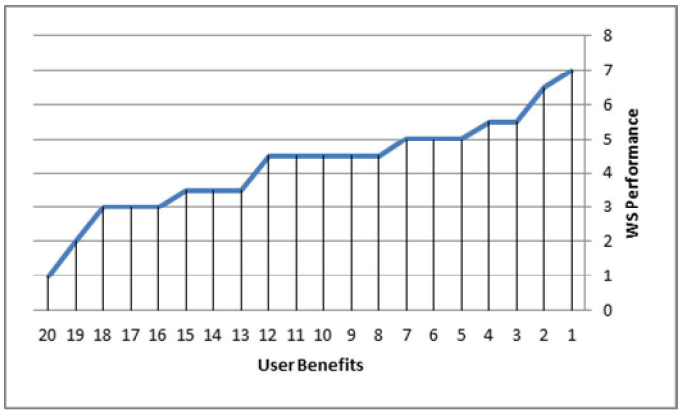

Figure 5: The Impact of user benefits on WS performance

Based on the correlation analysis of test data set, it is found the three groups of metrics can be classified based on the correlation of these groups with the predicted value of WS performance. The highest correlation is for attributes of user benefits, then correlation with information quality and the lowest is for the interaction quality (r = 0.392, 0.376 and 0.118 respectively).

5.CONCLUSION AND DISCUSSION

This research aims at investigating the effects of quality and benefits attributes on the Web system performance. The questionnaire is used for gathering the data regarding the research variables.

The collected records were used as a dataset to train the proposed ANNs in order to predict the Web performance based on the quality and user benefits attributes or metrics. Practically, a new approach using artificial neural network was proposed for identifying the relationships among study variables by function approximation.

In this research, a multiple layer neural network with architecture of feed-forward with 44 input neurons have been used. To train and validate the proposed ANN model the Levenberg-Marquardt training algorithm with MSE was also employed. The ANN model accuracy evaluation have been done by using a dataset of 20 records. The obtained results provided an evidence that the results of the proposed ANN models are suitable for handling the nonlinear relationships. Moreover, as the proposed ANN model correctly predicted 15

target values out of 20 (i.e. correct prediction percentage = 75 %), based on the results, the neural network is useful in predicting the WS performance.
Furthermore, information quality, interaction quality and Web user benefits attributes influence the Web system performance where the attributes of user benefits have the highest correlation with Web system performance.

The main contributions of this research as follows: First, the research demonstrates the aspect of WS performance prediction based on quality and benefits metrics. Second, the ANN model is employed to predict the WS performance, and thus much the cost and time of Web systems evaluation was minimized. Third, this research is one of the fewest to consider the user benefits as one of Web performance predictors. Fourth, the study help the decision makers to decide regarding the development of their electronic services, which in turn increase the Web users satisfaction and benefits.

One of the major limitations of the research was that the proposed ANN model did not consider all Web performance predictors. Second, the accuracy of prediction is reasonable (i.e. %75), and thus, more improvement can be applied on the proposed ANN through including other quality attributes.

Accordingly, the researchers propose to include the service quality and user satisfaction as predictors in the upcoming research.

REFERENCES

1.Alhendawi K., Baharudin A. The Impact of Interaction Quality Factors on the Effectiveness of Web-based System: The Mediating Role of User Satisfaction. Journal of cognition technology & Work., 2014.
https://doi.org/10.1007/s10111-013-0272-9
2.Alhendawi K, Baharudin A. Evaluating the Effectiveness of Web-based Management Information System from the Perception of Educationalists: An Exploratory Study. Information Technology Journal, Vol. 12, No. 6, pp. 1068-1078, 2013.
https://doi.org/10.3923/itj.2013.1068.1078
3.AlHendawi , K. Relationship Between Knowledge Management Processes and ERP Effectiveness: Testing the Mediating Role of User Satisfaction Using PLS. Research Journal of Business Management, 14: 1-6., 2020.
https://doi.org/10.3923/rjbm.2020.1.6
4. Sedera, D., & Gable, G. G. A factor and structural equation analysis of the enterprise systems success measurement model. *Paper presented at the Proceedings of the Twenty-Fifth International Conference on Information Systems (ICIS)*, Washington, USA, 2004.
5.Gable, G.G., Sedera, D., & Chan, T. Re-conceptualizing information system success: the IS impact measurement model. *Journal of the Association for Information Systems*, 9(7), 377-408, 2008.
https://doi.org/10.17705/1jais.00164
6.Gorla, N., Somers, T.M., & Wong, B. Organizational impact of system quality, information quality, and service quality. *The Journal of Strategic Information Systems*, 19(3), 207-228, 2010.
7.Laudon, K. C., Laudon, J. P., & Brabston, M. E. Management information systems: managing the digital firm (6 ed.). Pearson education Canada, 2012.
8.Balaban, I., Mu, E., & Divjak, B. (2013). Development of an electronic Portfolio system success model: An information systems approach. *Computers & Education*, 60(1), 396-411, 2013.
9.Tona, O., Carlsson, S., & Eom, S. An Empirical Test of DeLone and McLean's Information System Success Model in a Public Organization. Paper is presented in the proceedings of 18th Americas *Conference* on Information Systems (AMCIS 2012), Washington, USA, 2012.
10.Chua, A. Y. K., & Goh, D. H. A study of Web 2.0 applications in library websites. *Library & Information Science Research*, 32(3), 203-211, 2010.
https://doi.org/10.1016/j.lisr.2010.01.002
11.Wixom, B. H., & Todd, P.A. A theoretical integration of user satisfaction and technology acceptance. *Information Systems Research*, 16(1), 85–102, 2005.
https://doi.org/10.1287/isre.1050.0042
12.Iivari, J. An empirical test of DeLone-McLean model of information systems success. *The Data Base for Advances in Information Systems*, 36(2), 8–27, 2005.
13.Nelson, R. R., Todd, P. A., & Wixom, B. H. Antecedents of information and system quality: an empirical examination within the context of data warehousing. Journal of Management Information Systems, 21(4), 199-235, 2005.
14.Cao, M., Zhang, Q., & Seydel, J. B2C e-commerce web site quality: an empirical examination. *Industrial Management & Data Systems*, 105(5), 645-661, 2005.
https://doi.org/10.1108/02635570510600000
15.Chang, H. H., & Chen, S. W. Consumer perception of interface quality, security, and loyalty in electronic commerce. *Information & Management*, 46(7), 411-417, 2009.
https://doi.org/10.1016/j.im.2009.08.002
16,Ahn, T., Ryu, S., & Han, I. The impact of Web quality and playfulness on user acceptance of online retailing. *Information & Management, 44*(3), 263-275, 2007.
17 Lawson-Body A., Willoughby, L., & Logossah, K. Developing an instrument for measuring E-commerce dimensions. *Journal of Computer Information Systems*, 51(2), 2–13, 2010.
18. Albrecht, C. C., Dean, D. L., & Hansen, J. V. Marketplace and technology standards for B2B e-commerce: progress, challenges, and the state of the art. *Information & Management, 42*(6), 865-875, 2005.
19. Muylle, S., Moenert, R., & Despontin, M. The conceptualization and empirical validation of website user satisfaction. *Information & Management*, 41(5), 543-560, 2004.

29. Yoo, B., & Donthu, N. Developing a scale to measure the perceived quality of internet shopping site (SiteQual). *Quarterly Journal of Electronic Commerce*, 2(1), 31-45, 2001.
21. Ling, Y. Y. A conceptual model for selection of architects by Project managers in Singapore. *International journal of project management*, 21(2), 135-144, 2003.
22.Torkzadeh, G., & Doll, W.J. The development of a tool for measuring the perceived impact of information technology on work. *Omega—The International Journal of Management Science*, 27(3), 327–339, 1999.
https://doi.org/10.1016/S0305-0483(98)00049-8
23. Williams, L. J., & Anderson, S. E. Job satisfaction and organizational commitment as predictors of organizational citizenship and in-role behaviors. *Journal of management*, *17*(3), 601-617, 1991.
https://doi.org/10.1177/014920639101700305
24.McMurtrey, M. E., Downey, J. P., Zeltmann, S. M., & Friedman, W. H. Critical skill sets of entry-level IT professionals: An empirical examination of perceptions from field personnel. *Journal of Information Technology Education*, *7*, 101-120, 2008.
https://doi.org/10.28945/181
25.Prakash, A., R. Mohanty, and S. Kallurkar. "Service Quality Modelling for Life Insurance Business Using Neural Networks." *International Journal of Productivity and Quality Management* 7 (3): 263–286, 2011.
https://doi.org/10.1504/IJPQM.2011.039348
26.Tsai, C. F., and Y. H. Lu. "Customer Churn Prediction by Hybrid Neural Networks." *Expert Systems with Applications* 36 (10): 12547–12553, 2009
https://doi.org/10.1016/j.eswa.2009.05.032.
27.Davies, F., L. Moutinho, and B. Curry. "ATM User Attitudes: A Neural Network Analysis." *Marketing Intelligence & Planning* 14 (2): 26–32, 1996.
https://doi.org/10.1108/02634509610110778
28Sekaran, U., & Bougie, R. Research Methods for Business: A Skill-Building Approach (5 ed.). London: John Wiley & Sons, 2009.
29.Haykin, S. Neural networks: a comprehensive foundation. 1999. *Mc Millan, New Jersey*, 1-24, 2010.
30.Sagar, G. V. R., & Sheela, K. A. Optimization of architecture design in artificial neural network. International Journal of Advanced Trends in Computer Science and Engineering (IJATCSE), Vol.2 , No.5, Pages : 01-07, 2013.
31.Kumar, K., Kumar, G., & Singh, J. An Effective Combination Technique for Artificial intelligence based Ensembles for Intrusion detection. International Journal of Advanced Trends in Computer Science and Engineering (IJATCSE), 2(5), 29-36, 2019.