INTEGRATED USABILITY EVALUATION FRAMEWORK FOR UNIVERSITY WEBSITES

By

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ABSTRACT

The importance of usability of websites in this contemporary era of information communication by universities and other allied academic institutions worldwide is very crucial. This has necessitated the urge and drive for usable websites to be developed by these institutions in order to improve ease of use. However, the need to measure usability of websites effectively have also prompted many researchers to develop different usability evaluation model. Even though there are numerous research efforts in this direction, there is still no universally acceptable usability evaluation model. In this paper, a framework based on integration of a Multi Criteria Decision Making (MCDM) approach with an artificial intelligence technique is being proposed to effectively evaluate university websites usability. The criteria used are; speed, navigation, ease of use, content, accessibility, aesthetic, and security. Thus a new model incorporating fuzzy analytical processing with artificial neural network is proposed.

Keywords: Fuzzy AHP, ANN, Usability, University Website, Website Evaluation.

INTRODUCTION

The Internet is the easiest way to find information about any kind of organization, and the first impression about an organization is almost always based on its website (Ismailova & Kimsanova, 2017). From internet world stats (Internet World Stats, 2017), the number of internet users in the world is over 3.5 billion from 360 million in the 2000 with 51.7% penetration rate. In Nigeria, the number of internet users has grown from 200,000 in 2000 to over 90 million in June, 2017 with penetration rate of 47.7%. As a result, accessing different types of websites is inevitable for different users in the world.

For academic institutions, websites are expected to provide information to a wide range of users, which may be prospective and enrolled students, staff, parents as well as other users. These websites not only serve as a platform for the stakeholders, but also serve as communication tools and help to shape its image (Mentes & Turan, 2012; Abdallah & Jaleel, 2015; Galovicova, Kremenova, & Fabus, 2016).

Millions of people are searching for information on academic institution websites annually of which university websites is one. These include, prospective students looking for schools on potential courses available, area of expertise, fees information among others. Enrolled students search for course information, lecture location, materials and times, account access, results updates, schools calendars, fees payment, news update, teacher's information. Prospective applicant may search for job prospect, vacancies, available facilities, research output, funded projects, sample thesis, and project. The main underlining issue is that users should find what they are searching for easily and the content should be easy to understand (Sarsarabi & Sarsarabi, 2015).

Users of any websites are always confronted with two major issues - how to find the information being sought with ease and retrieving the information in a timely fashion. To achieve this, a high level of usability which is one of the important criteria in measuring website quality

is required (Roy & Pattnaik, 2014; Aziz & Kamaludin, 2015). According to International Standard Organisation (ISO 9241-11), usability can be defined as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use". It is the "effectiveness, efficiency, and satisfaction specified goals by the users to achieve in particular environments" (Speicher, 2015).

From websites context, usability is a quality attribute that describes the ease with which users navigate through the website. In other words, it is the extent to which a user can successfully achieve a goal by learning and using a product. To disseminate information to the public, a functioning website is required by every organisation. University website, which is one of the specific genre of websites, requires special attention in terms of usability because it serves as a virtual gateways to students from all over the world (Yerlikaya & Durdu, 2017). One core component of web quality is web usability and once the usability features are not good, the web quality will always be poor (Tripathi, Pandey, & Bharti, 2010).

Usability has been shown to be one of the most important issues in ICTs (Pearson, Pearson, & Green, 2007; Manzoor, Hussain, Ahmed, & Iqbal, 2012; Djordjevic, Rancic, & Vulic, 2013; Mvungi & Tossy, 2015). Till date, one of the challenges faced by HCI researchers is how best to measure usability or evaluate website usability. As a result of this, several researchers have proposed different models for website usability evaluation. Most of these models are based on inspection method and formal experimental test which are generally known as the traditional approach. However, in usability there are several criteria involved and determining which one contributes more to usability is a complex decision making process. This therefore necessitates that the problem of usability be formulated using a Multi-Criteria Decision Making (MCDM) approach. Website evaluation hence, belongs to MCDM field, which involves making a preference decision, such as evaluation or selection over the available alternatives using a set of criteria. In MCDM, several alternatives are usually involved, among which the Decision-makers (DMs) have to give weights to each criterion (Ağırgün, 2012).

However, to get better results from MCDM, there is a need to incorporate computational intelligence techniques into it. This research therefore proposes a methodology based on integrating Fuzzy set theory with an MCDM approach, Analytical Hierarchical Processing (AHP), and Artificial Neural Network (ANN).

1. Literature Review

1.1 Website Usability Evaluation

Usability Evaluation (UE) entails assessing the ease of use of a product so as to discover the usability problems. This will eventually lead to obtaining the measures of overall usability. The evaluation is necessary in order to improve the usability or to determine whether usability objectives have been achieved or not. In usability engineering, UE for any software is composed of various methodologies (Paz & Pow-Sang, 2014; Nagpal, Mehrotra, & Bhatia, 2017).

UE is broadly divided into inspection and empirical methods according to (Fernandez, Insfran, & Abrahão, 2011; Adepoju & Shehu, 2014). Empirical methods involve capturing and analysing usage data from real end-users. More so, a set of predefined tasks are completed in the presence of either tester (human or specific software) who is involved in recording the outcomes of their work. On the other hand, in inspection methods, expert evaluators or designers carry out the evaluation by comparing the conformance of the interface with some established standards and guidelines. However, due to advancement in technology and computing field, UE methods are now classified into six categories which is Evaluator based, User based, Tool based, Model based, Multi Criteria Decision Making (MCDM) based, and Soft Computing based (Nagpal et al., 2017).

1.2 Fuzzy Analytical Process Hierarchy (FAHP)

Fuzzy AHP is a combination of classical AHP and fuzzy set theory. Equation (1) defines a triangular fuzzy number. AHP as proposed by Saaty (Internet World Stats, 2017; Mentes & Turan, 2012), is a traditional powerful decision-making methodology. It is being used to determine the priorities

among different criteria by comparing alternatives for each criterion, and determining an overall ranking of the alternatives. AHP produces the best choice among decision alternatives as the final outcome (Srichetta & Thurachon, 2012).

Basically, AHP has three components which are : Hierarchy Construction, Priority Analysis, and Consistency verification (Ravankar, Ravankar, Kobayashi, & Emaru, 2017).

At the top of the hierarchy is the overall goal of the decision problem. The intermediate levels are represented by the criteria and sub-criteria affecting the decision. The bottom level represents the possible alternatives.

Pairwise comparison matrix is used to calculate the relative importance weights of decision criteria in each level of the hierarchy. To get this done, the decision maker uses the fundamental scale or weight between 1 (equal importance) and 9 (extreme importance) defined by Saaty (Saaty, 2008) to assess the priority score for each pair of criteria in the same level.

That is, the pair-wise comparison matrix (see equation 2) is constructed where the elements a_{ij} in the matrix is interpreted as the degree of the precedence of the i^{th} criterion over the j^{th} criterion. Thereafter, the average weight for each normalized criterion is computed.

The decision alternatives are evaluated by taking into account the weights of decision criteria. The alternative scores are then combined with the criterion weights in order to get an overall score for each alternative.

In fuzzy AHP, triangular fuzzy numbers are used to represent common sense linguistic statements used in the pair-wise comparison (Djordjevic et al., 2013). The final step is to now obtain the overall priorities by aggregating the pair-wise comparison and the synthesizing the priorities (Srichetta & Thurachon, 2012). In conventional AHP, it is difficult to deal with imprecise or vague nature of linguistic assessment as it is common in usability evaluation.

Hence, fuzzy AHP are applied when the pairwise comparisons are imprecise due to inability of the decision makers to make exact preferences. This may be due to some uncertain and unknown information in the decision making process.

1.3 The Triangular Fuzzy Numbers (TFNs)

The TFNs used in the pair-wise comparison are defined by three real numbers expressed as a triple (l, m, u) where

$l \le m \le u$ for describing a fuzzy event is represented as,

$$\mu\left(\frac{x}{\tilde{M}}\right)=\begin{cases}0, & x<l\\ \dfrac{(x-l)}{(m-l)}, & l\le x\le m\\ \dfrac{(u-x)}{(u-m)}, & m\le x\le u\\ 0, & x>u\end{cases} \quad (1)$$

The linguistic description is shown in Figure 1.

1.4 Fuzzy Pair-Wise Comparison Matrix

Fuzzy judgment matrix $\tilde{A} = \{\tilde{a}_{ij}\}$ of n criteria or alternatives is depicted as follows:

$$\tilde{A}=\begin{bmatrix}1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n}\\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n}\\ \cdots & & \cdots & \cdots\\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1\end{bmatrix} \quad (2)$$

where, $\tilde{a}_{ij}$ is a fuzzy triangular number, $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$, and $\tilde{a}_{ji} = 1/\tilde{a}_{ij}$. For each TFN, $\tilde{a}_{ij}$ or M = (l, m, u), its membership function $\mu_{\tilde{a}}(x)$ or $\mu_M(x)$ is a continuous mapping from real number $-\infty \le x \le \infty$ to the closed interval [0, 1] and can be defined by equation (1).

Figure 2 shows the steps involved in fuzzy AHP, which has been described.

1.5 Artificial Intelligence Application in Website Usability

There have been only a few researches on applications of AI methods like fuzzy logic, Artificial Neural Network (ANN) (Saaty, 2008), and Genetic Algorithm (GA) in website usability evaluation research till date. In the work of Sohrabi, Mahmoudian, and Raeesi (2012), GA and ANN were employed to improve the performance of e-commerce websites. This is aimed at making the websites more flexible and highly functional. Oztekin, Delen,

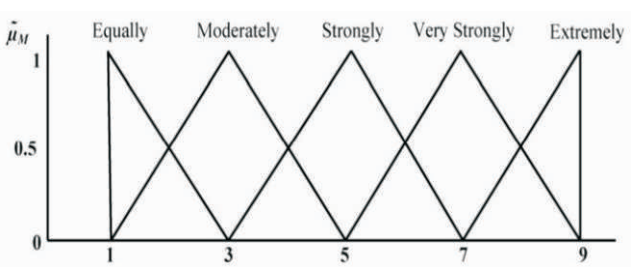

Figure 1. Fuzzy Set Definition with Triangular Membership Function

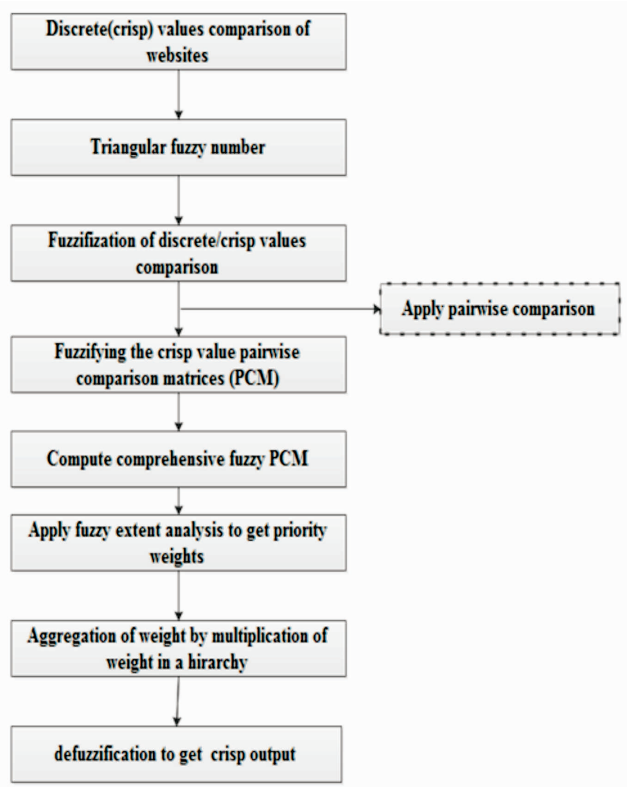

Figure 2. Fuzzy AHP Steps

Turkeyilmaz, and Zaim (2013) in their work developed an evaluation model for assessing e-Learning systems usability. The model was based on different machine learning techniques like support vector machine, ANN, and Decision Trees. Website users experience assessment was carried with the aid of ANN by Amanatiadis, Mitsinis, and Maditinos (2015).

1.6 Web Usability Evaluation Model

There have been several efforts by researcher all over the globe to formulate models for university usability evaluation. While most papers focus on academic website quality (Dominic & Jati, 2010; Devi & Sharma, 2016a; Devi & Sharma 2016b; Rochimah, 2016), there is considerable few papers that have targeted usability. Some of the studies which have provided general overview for web usability evaluation model are discussed next.

Shakel model (Shackel, 1991) is made up of four usability evaluation criteria which are learnability, flexibility, effectiveness, and user attitude. Nielsen's model (Nielsen, 1999), which is cited frequently in the usability engineering identified five attributes of usability as learnability; efficiency; memorability; low error rate (easy error recovery); and subjective satisfaction.

International Organization for Standardization (ISO) model base usability on as effectiveness, efficiency, and satisfaction. A more recent ISO 9126 (Botella et al., 2004) model formulated usability as dependent on understandability, learnability, operability, attractiveness, and usability compliance. Another model for academic library websites usability proposed by Joo (Joo, Lin, & Lu, 2011) identified effectiveness, efficiency, and learnability as the usability construct.

Some studies have proposed different academic website usability evaluation models and they are discussed as follows. WUEM model was developed by Manzoor and Hussain (2012) to evaluate the usability of ten top ranking engineering universities in Asia. It was based on web design, page design, navigation, and accessibility. Delice and Güngör (2009) proposed a method integrating the use of heuristic evaluation with AHP in order to identify usability problems in a university website. It was evaluated based on design consideration, website operation, and website user accordance.

Usability ranking of some universities were carried through the use of fuzzy AHP and Fuzzy integrated with technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) by Nagpal, Mehrotra, Bhatia, and sharma (2015b). Response time, ease of use, ease of navigation and informative were user as the criteria in the evaluation. In another study by Nagpal, Mehrotra, Bhatia, and Bhatia (2015a) fuzzy AHP was used to rank some educational websites based on usability criteria of response time, ease of use, ease of navigation and informative as done earlier in their previous work (Nagpal et al., 2015a). Furthermore, a combination of fuzzy AHP and entropy approaches was used by Nagpal, Mehrotra, and Bhatia (2016) to evaluate the usability of some academic websites. Roy, Pattnaik, and Mall (2017) proposed a new model integrating objective and subjective approach by using fuzzy AHP and entropy method to evaluate usability ranking.

Clearly from the review, only very few studies have

adopted the use of MCDM approach in website usability studies, especially in university websites. Even those studies which attempted to use it have not incorporated the use of AI techniques as widely adopted in other area like inventory classification (Kabir & Akhtar Hasin, 2013), machine tool selection (Taha & Rostam, 2011), (Sadeghian & Sadeghian, 2016), banks performance prediction evaluation (Wanke, Kalam Azad, Barros, & Hadi-Vencheh, 2016) , vendor selection (Lakshmanpriya, Sangeetha, & Lavanpriya, 2013) among others.

2. Proposed Framework

The proposed methodological framework for the new integrated model is shown in Figure 3. This provides the stage by stage procedure in which the model is constructed.

In the first stage, the goal of the research goal is defined. The goal of the research is to develop an integrated model for university website evaluation. Step 2 involves the identification of the criteria to be used in the evaluation. This is established based on extensive literature review and classification. Several authors made use of different criteria for evaluation usability in different genre of websites as discussed earlier in the paper. This divergent criteria mainly depend on the type of evaluation to be done as well as the websites to be evaluated. It was based on this that the authors identified seven main criteria, which is very important in contemporary university websites. They are speed, navigation, ease of use, accessibility, aesthetic, and security.

Speed has to do with how fast the website is able to load when accessed by the users. It also involves the swiftness at which users are able to retrieve information from the websites when requested. Ease of use is the comfort at which users can access information and communicate with the websites without too much efforts. Navigation deals with the ability of the users to interact and move around easily within the webpages in the websites. Accessibility is the ability of the websites to be easily used by different types of users irrespective of any form of disability. It also involves provision of adequate tools that

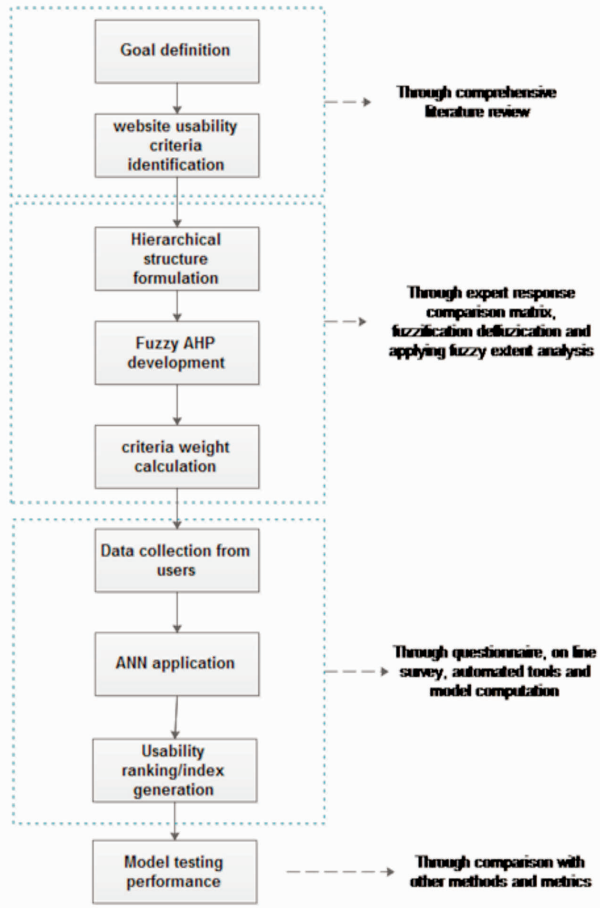

Figure 3. Methodological Framework of the Proposed Model

allows disabled users to use the websites without any constraint. Aesthetic deals with the visual appeal of the websites to the users or how attractive and pleasing the website appears to the users. Lastly, security on the other hand is the ability to use the websites without the fear of any form of vulnerability and intrusion into privacy. This paper incorporates security as one of the key criteria, which many authors in the past neglected.

Stage three involves the formulation of the hierarchical structure in AHP. The structure is presented in Figure 4.

Here, the structure is broken into three components; goal, criteria, and alternatives. The goal is already formulated and the criteria has been identified as stated above. The alternatives are the university websites to be used. In this case, a total of six university websites with good web visibility bases on world webometric ranking will be considered.

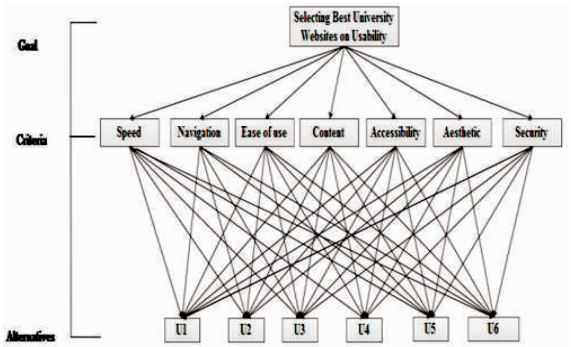

Figure 4. Hierarchical Structure of FAHP Model

The pairwise comparison is to be done by experts as well users of the websites via questionnaire. This will be used to construct the appropriate comparison matrix, which is of the form given earlier in equation (1).

The last stage involves feeding of the criterion obtained from Fuzzy AHP model into ANN network as inputs. Once the weight of each factor has been determined from the Fuzzy AHP model, the corresponding data of each website evaluation criteria will be collected in order to train the neural network.

Figure 5 shows the ANN structure with the input layers (obtained from FAHP weight), the hidden layer, and output layer.

In the last stage, the model will be compared with other existing usability evaluation methods. Also standard machine learning performance metrics will be used to test the performance of the proposed model in addition to sensitivity analysis.

Conclusion

Usability university websites is of utmost concern to every

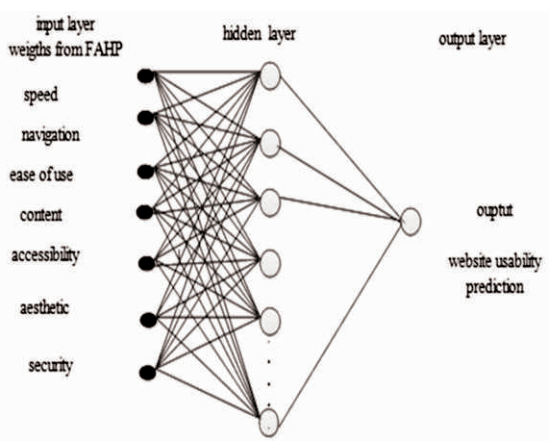

Figure 5. The Integrated Model with ANN Structure

stakeholder in the university community. While efforts have made in the time past to develop models for usability evaluation in general, only little has not been done for University website evaluation. Due to diversity of websites and its usage by different categories of users, different evaluation models have been proposed. However, there are still not a generally acceptable model, hence the need for a more wholistic one as proposed in this study.

The integrated approach proposed in this study will handle both the subjective and objective aspect of usability evaluation thereby eliminating bias exhibited by human being during evaluation. This will further ensure a better ranking and classification of the usability of the selected websites. The research is ongoing and in the future work the model will be implemented and the appropriate performance analysis will be done.

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