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Designing Software Usability Measurement Using Fuzzy Set Conjoint Model

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[1]**Abstract.** This paper presents the design of fuzzy set conjoint model in software usability measurement. Software Usability Measurement Through Web-based Evaluation (SUTWE) is developed as an online measurement tool which is based on a questionnaire to assist developers and users in checking the usability and satisfaction level of a website. The questionnaire is based on ten heuristics as introduced by Jacon Nielsen and each questions are evaluated based on 5-point Likert scale. Respondents need to choose a response from a scale of 1 to 5. Despite the fuzziness and vague statements from the questionnaire, respondents may have some uncertain choices of answers other than agree or disagree. Fuzzy set conjoint model is used in this research to overcome the above problems. This model has been employs in many studies which involving the use of Likert scale.

Keywords: Fuzzy Set Conjoint Model, Likert scale, Software Usability.

1. Introduction

Usability can be defined as a quality attribute that assesses how easy user interfaces are to use [1]. It is measured by how easily and how effectively it can be used by a specific set of tasks in a defined set of environment. It is a measurable characteristic of a product user interface that is present to a greater or lesser degree. One broad dimension of usability is how easy to learn the user interface is for novice and casual users. According to ISO 9241-11: Guidance on Usability [2], usability is the extent to which a product can be used by specified users to achieve goals with effectiveness, efficiency and satisfaction in a specified context of use. It can be seen that the needs of the user play an important role in the success of certain software. At present, usability is a fundamental part of software engineering [3]. It can reveal the lack of functionalities and qualities of a certain product. It is an important indicator of quality that should be easily quantitatively expressed by a meaningful value. Unfortunately, many establishments are not keen to incorporate usability aspects in the development of their products, due to costly commercial usability measurement tool and lack of expertise in usability principles and methodologies. Therefore SUTWE (Software Usability Measurement Through Web-based Evaluation) [4] is developed as an online measurement tool which is based on a questionnaire to assist developers and users in checking the usability and satisfaction level of a website. Currently, the value for each evaluation criteria is fixed.

As the user perception is abstract, vague and subjective, the usage of conventional metrics might not always give the best result in usability measurement. There is no clear consensus on how to measure

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usability obtaining a significant score for the web site usability, taking also in mind that users' language is full of vague expressions, ambiguities and uncertainty [4]. Different people have different view or opinion in evaluating. What would be the answer if the question was "To what degree is the website navigation is consistent? ". It is possible to state the answer in the form of scale such as 0-5. But would this number have significant level of accuracy or it is just an opinion about the state.

It is much appropriate to answer in the form of "very well" or "quite well". These evaluations are vague and subjective because they do not hold any single value.

Fuzzy set conjoint model can be adapted into the metrics to ease the user's ability to evaluate the usability by using natural language, which is full of vague and subjective expressions. This paper will describe the designing usability evaluation based on the application of fuzzy set theory. Fuzzy sets theory provides a mathematical model in which vague and subjective expressions can be precisely quantified. The proposed approach is going to be integrated in SUTWE.

2. Software Usability Measurement through Web-Based Evaluation (SUTWE)

Software Usability Measurement through Web-Based Evaluation (SUTWE) has been developed as an online measurement tool which is based on a questionnaire to assist users in checking the usability and satisfaction level of a product in use. SUTWE used questionnaires for acquiring user feedback on the usability of the system being tested. The questions are based on the ten heuristics as introduced by Jacob Nielsen [3]. Ten questions are carefully formulated for each heuristics with the total of 100 questions. The list below shows the elements of usability from the then heuristics that is measured by SUTWE. An example of statement is given in Table 1 [3].

Table 1. Example of Statement for Each Heuristics and the Comments

No.	Usability Heuristics	Statement (Comment)
1	Visibility of System Status	Users are given appropriate feedback for every action. (Not enough feedback for every action)
2	Match between System and the Real World	Icons used are familiar. (Icons used can be confusing)
3	User Control and Freedom	Users can cancel out operations in progress. (Users cannot cancel out operations in progress)
4	Consistency and Standards	Field labels are consistent from one data entry screen to another. (Field label is not consistent in term, format and location)
5	Error Prevention	Any colour-coding information is amply supplemented by redundant cues.(Added cues are not provided for colour-coding information)
6	Recognition Rather than Recall	Optional data entry fields are clearly marked. (No labels provided to indicate choice or options)
7	Flexibility and Efficiency of Use	User guidance is flexible and can be customized by users of different level of skills. (User guidance is not flexible and support one level of user only)
8	Aesthetic and Minimalist Design	All icons in a set are visually and conceptually distinct. (Items on the screen are not group into logical zones)
9	Help Users Recognize, Diagnose and Recover from Errors	Users can get out of an undesirable state easily. (User cannot get out of an undesirable state easily)
10	Help and Documentation	The information is accurate, complete and understandable. (The information is not accurate, incomplete and hard to understand)

Each question is worded in a positive manner and subjected to a 5-point Likert scale. Every item is stated in the form of a statement in which the respondents have to choose a response from a scale of 1 to 5. Each of the points in the scale is given a value in ascending order is shown in Table 2. When a respondent choose a response, he or she may have some uncertain choices. For example, the choices could be partially agree, probably or don't know. Furthermore the statement might be vague and imprecise. This is where fuzzy set theory can be applied to overcome the problem.

Table 2. Likert Scale Points

Available Options	Assigned Value
Strongly Disagree	1
Disagree	2
Undecided	3
Agree	4
Strongly Agree	5

3. Fuzzy Set Theory

A fuzzy set approach has been developed to solve problems in which the descriptions of activities are imprecise, vague and uncertainty. Let X be the universe of discourse and its elements be denoted as x. In classical set theory, crisp set A in the universal set X is a collection of well-defined objects and is characterized by the function fA(x) : X → 0,1 such that fA(x) = 1 if x ∈ A and fA(x) = 0 if x ∉ A. This set maps universe X to a set of two elements. For any element x of universe X, characteristic function fA(x) is equal to 1 if x is an element of set A, and is equal to 0 if x is not an element of A. Zadeh proposed the idea of a fuzzy set as an expansion of the classical set theory to deal with uncertainties [5]. In the fuzzy theory, fuzzy set A of universe X is defined by function μA(x) called the membership function of set A μA(x): X → [0,1], where μA(x) = 1 if x is totally in A; μA(x) = 0 if x is not in A; 0 < μA(x) < 1 if x is partly in A. Fuzzy set theory can represent the uncertainty or vagueness inherent in the definition of linguistic variables [5].Linguistic variables are represented by words such as "strongly agree", "agree", "undecided", "disagree", "strongly disagree" rather than quantitative variables. Figure 1 shows an example of fuzzy sets for visibility.

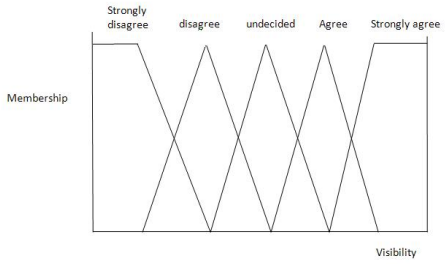

Figure 1. Fuzzy Sets for Visibility

3.1. Fuzzy Set Conjoint Model

This research will analyze the evaluation using fuzzy set conjoint model adapted from Turksen and Willson [6]. This model has been employs in many studies which involving the use of Likert scale to represent linguistic terms [7], [8], [9], [10]. Turken and Wilson [6] applied this model in investigating customers' preferences and satisfaction on products and services. One of the studies was done by Mohtar et al. [7],showed that the model has worked well and produced good results in estimating overall preferences of customer satisfaction on services provided by a shopping mall. Mohd Tawil et. Al. [8] has used this model in his study which aims to find the agreeable level of Kuala Lumpur's high-rise residents toward service charges and quality for services given to them by Management Corporation.

Fuzzy set conjoint model has also been applied in education research sector. Lazim and Abu Osman [9] had studied on the application of fuzzy set in measuring teachers's belief about mathematics and it has showed that using fuzzy set for the research has led them to useful conclusion concerning the strength of teacher's belief about mathematics. Furthermore, Rasmani and Shahari [10] had applied this model for evaluating job satisfaction amongst academic staff in a higher education institution. Their study has shown that the analysis using the fuzzy approach gave good results and provided more information than the statistical analysis based on percentage.

Turksen and Willson [6] have laid a theoretical ground for works using fuzzy set conjoint model. By using this model, a fuzzy set R is representing the hierarchy of all respondent against the specific attributes. The degree of membership for each element, yj (y=1,2,3,….l) in fuzzy set R is defined as

$$\mu_R(y_j, M) = \sum_{i=1}^{n} W_i \ \mu_{Ri}(x_j, M) \qquad (1)$$

where

$\mu_R(x_j, M)$: degree of membership of domain element x_j in linguistic evaluation R by i-th respondent against attribute M for each element in the fuzzy set R_i, $x_j=1,2,3…l$.

$R_i \in$: {strongly disagree (L_1), disagree (L_2), undecided (L_3), agree (L_4), strongly agree (L_5) by i-th respondent, $i = 1, 2, 3….n$.

W_i : weight for i-th respondent and for $W_i = \frac{w_i}{\sum_{k=1}^{n} w_k}$ as w_i is a score of linguistic values given by i-th respondent.

l : number of linguistic values used (in this research, $l = 5$).

$\mu_R(y_j, M)$: approximate overall degree of membership of the linguistic value R for all factor M attributes.

M : factor attributes.

n : number of respondents.

3.2. Linguistic Variables

Linguistic variable is a variable whose values are not numbers but are in linguistic words or sentence in a natural language. In this research, there are five linguistic variables with 5-point Likert scale. Membership functions for linguistic variables for this research are defined in Table 3.

Table 3. Membership for Likert scale

Linguistic variables	Linguistic Value
Strongly disagree	{1/1, 0.75/2, 0.5/3, 0/4, 0/5}
Disagree	{0.5/1, 1/2, 0.75/3, 0.25/4, 0/5}
Undecided	{0/1, 0.5/2, 1/3, 0.5/4, 0/5}
Agree	{0/1, 0.25/2, 0.75/3, 1/4, 0.5/5}
Strongly agree	{0/1, 0/2, 0.5/3, 0.75/4, 1/5}

3.3. Degree of Similarity

For each attribute M, the calculation of degree similarity between the fuzzy set representing the whole respondents with every fuzzy set that represented by five linguistic values (Lk, k = 1,2,3,4,5) was executed using Euclidean distance formula. Turksen and Willson [6] proposed a formula for calculating degree of similarity which involved the calculation of Euclidean distance between fuzzy sets given as:

$$Sim(R, Lk) = \frac{1}{\left[1 + \sqrt{\sum_{j=1}^{7} \left(\mu_{R(j,M)} - \mu_{LK(j)}\right)^2}\right]} \qquad (2)$$

where $\mu_{LK(j)}$ is the fuzzy set defined for linguistic value and $\mu_{R(j,M)}$ is the calculated set for attribute M from equation (1).

4. Evaluation Framework

Figure 2 shows the proposed evaluation framework using fuzzy set conjoint model for SUTWE implementation. There are six steps to be considered in measuring the website usability.

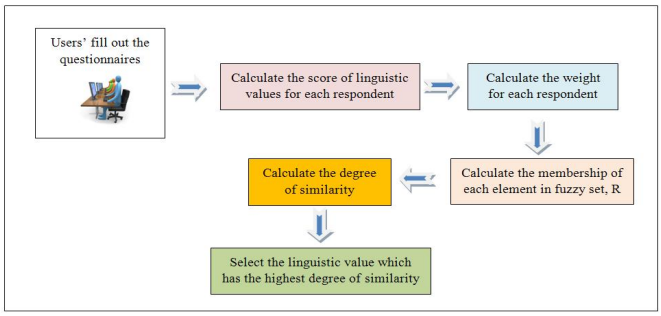

Figure 2. Proposed Evaluation Framework for SUTWE

5. Conclusion

SUTWE [4] is developed as an online measurement tool which is based on questionnaire to check the website usability. The questionnaire was constructed based on the ten heuristics as introduced by Jacob Nielsen [5]. Each question is evaluated using 5-point Likert scale. Respondents have to choose a response from a scale of 1 to 5. When a respondent fill out a questionnaire, he or she may have some uncertain choices other than agree or disagree. Furthermore, sometimes the statement in the questionnaire could be vague and subjective. This research has proposed a fuzzy set conjoint model to overcome the vagueness and uncertainties in the questionnaire. This model has been employs in many studies which involving the use of Likert scale to represent linguistic terms.

6. References

[1] Usability. http://en.wikipedia.org/wiki/usability

[2] ISO 9241 Parts 1-17 (1992-2001). *Ergonomics of Human-System Interaction*.

[3] Nielsen, J. *Usability Engineering*. San Francisco: Morgan Kaufmann Publishers Inc. 1995.

[4] Mohamad, N. *SUTWE : Software Usability Measurement Through Web-Based Evaluation*. Unpublished Master Thesis. 2004.

[**5**] Zadeh, L.A. *Fuzzy Set, Information and Control*, 338 -353, 1965.

[6] Turksen, I.B., and Willson, I.A., *Fuzzy Set Preference Model for Consumer Choice*. Fuzzy Sets and Systems. 1994, 68:253-353.

[7] Mohtar, Z.I., Abdullah, M.L., Md Tap, A.O., Kamaruddin, A.R., *Penilaian Secara Conjoin Kabur Dalam Menentukan Tahap Kepuasan Pelanggan*, Prosiding Simposium Kebangsaan Sains Matematik ke-16, 2008, 333-342.

[8] Mohd Tawil, N., Ramli, A., Che Ani, A. I., Usman, I.M.S., Tahir, M.M., Zain, M.F.M,, Zaharim, A., *Service Charge Collection of High-Rise Residential In Kuala Lumpur, Malaysia:Owner's Perspective*, European Journal of Social Science, 2009, Vol.10, No.1.

[9] Lazim, M.A. and Abu Osman, M.T., *Measuring Teacher's Beliefs About Mathematics: A Fuzzy Set Approach*, International Journal of Social Sciences. 2009, Vol. 4, No. 1.

[10] Rasmani, K.A., and Shahari, N.A., *Job Satisfaction Evaluation Using Fuzzy Approach*, Proceedings of Third International Conference on Natural Computation, 2007, Hainan, China.