APPROACH OF FUZZY ANALYTIC HIERARCHY PROCESS TO EVALUATE E-COMMERCE WEBSITES

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With the fast development of internet and computers, economic commerce has become a significant way of running business over the Internet. Evaluation of a website is not so straightforward since many parameters or criteria are considered in judging of websites, especially for economic commerce websites. Due to the imprecise nature of the problem, this assessment cannot be addressed using the traditional Boolean logic. Three evaluated indexes include design, usability and reliability, which are chosen as effect factors to evaluate websites and the member function and fussy rules of factors are discussed. Analytic hierarchy process is a kind of common used multi-criteria decision making methods, which integrates subjective and personal preferences in performing analyses. It has been widely used in evaluating various kinds of multi-criteria decision making method problems in both academic researches and practices. However, due to the uncertainty and vagueness on subjective judgments of the decision makers, the crisp pair wise comparison in the conventional analytic hierarchy process seems too insufficient and imprecise to capture the right judgments of decision makers. In conclusion fuzzy method analytic hierarchy process is presented to evaluate electronic commerce websites.

Key words: fuzzy logic, AHP, fuzzy inference, electronic commerce website

INTRODUCTION

Electronic commerce (E-commerce), commonly known as e-commerce, eCommerce or e-comm, refers to the buying and selling of products or services over electronic systems such as the Internet and other computer networks. Nowadays, E-commerce provides more convenient, faster and cheaper way of shopping, internet banking, employing etc. The amount of trade conducted electronically has grown extraordinarily with widespread Internet usage. As the result, it becomes necessary for both companies and customers to evaluate the e-commerce websites. However evaluation of an e-commerce website is not familiar with most of people. It includes quite a lot of technical and professional knowledge.

As well as the evaluation method is not the tradition one which is using Boolean logic. However it is a kind if logic related artificial fuzzy logic [1]. Fuzzy logic reflects how people think [2]. Fuzzy inference systems have been successfully applied in fields such as automatic control, data classification, decision analysis, expert systems, and computer vision.

In the evaluation process, there are many criteria and even sub-criteria. So it is natural to bring in Analytic hierarchy process (AHP) [3], which is one of the most commonly used multiple criteria decision making methods (MCDM). It is a structured technique for organizing and analyzing complex decisions. AHP has been used in weighting the importance. Rather than prescribing a "correct" decision. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. Users of the AHP first decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. The elements of the hierarchy can relate to any aspect of the decision problem estimated. [3, 4]

To achieve the previous aims, we decided to research an approach of evaluating e-commerce website based on Fuzzy-AHP. Furthermore a major study is undertaken to determine the weights of criteria and sub-criteria for e-commercial website evaluation.

FUZZY INFERECE FOR E-COMMERCE WEBSITES EVALUATION

Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic. The mapping then provides a basis from which decisions can be made, or patterns discerned. The process of fuzzy inference involves all of the pieces that are described in the previous sections: Membership Functions, Logical Operations, and If-Then Rules [5].

As our selection theory, fuzzy set theory can deal with the degree of truth. It can deal the cases where observations are unclear or vague. Inference systems that use fuzzy logic are known as fuzzy inference systems. Also it can be used to develop a decision support system for multi-criteria based assessment of student project [6].

Information flows from left to right, from two inputs to a single output. The parallel nature of the rules is one of the more important aspects of fuzzy logic systems. Instead of sharp switching between modes based on breakpoints, logic flows smoothly from regions where the system's behavior is dominated by either one rule or another.

Fuzzy inference process comprises of five parts: fuzzification of the input variables, application of the fuzzy operator (AND or OR) in the antecedent, implication from the antecedent to the consequent, aggregation of the consequents across the rules, and defuzzification. These sometimes cryptic and odd names have very specific meaning that are defined in the following steps [2].

We settled on cataloguing e-commerce websites' characteristics into three criteria: design, usability and reliability. And each of these criteria can be derived into several attributes (detailed rules). Design can be evaluated by aspects: aesthetic features, contents, layout, and standard conformance. Usability is a quality objective that concerns the characteristics that allow use of the e-commerce website in the most diverse situations [7]. Evaluation criteria and criteria structure has been shown in figure 1.

FUZZY-AHP METHOD FOR E-COMMERCE WEBSITES EVALUATION

The normal AHP method, and its extension Fuzzy-AHP [4], proved to be an efficient tool for approaching performance evaluation. The crisp AHP only uses the pair-wise comparison matrix to evaluate the ambiguity in MCDMM. problems as in formula (1):

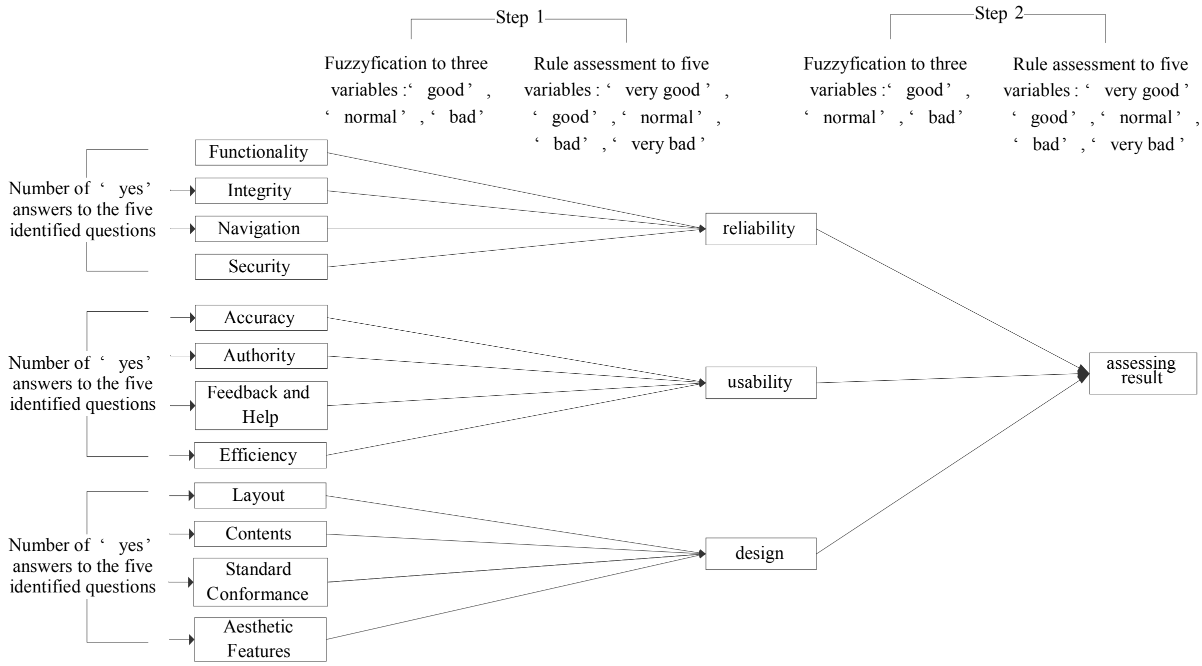

Fig.1. Evaluation criteria and criteria structure

$$A=[a_{ij}]=\begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{array}\begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \end{array}, \quad (1)$$

where C_1, C_2, ..., C_n denote the set of elements, while aij represents a quantified judgment on a pair of elements C_i, C_j. The relative importance of two elements is rated using a scale with the values 1, 3, 5, 7, and 9, where "1" represents that two elements are equally important, while the other extreme "9" represents that one element is absolutely more important than the other.

Although the discrete scale of 1–9 has the advantages of simplicity and easiness for use, it does not consider the uncertainty associated with the mapping of one's perception or judgment to a number. Since each number in the pair-wise comparison matrix represents the subjective opinion of decision makers and is an ambiguous concept, it consequently raises the need for exploring fuzzy-based approaches. Therefore, Fuzzy-AHP has emerged. In Fuzzy-AHP, triangular fuzzy numbers are substituted into the pair-wise comparison matrix to deal with criteria measurement and determine the fuzzy consensus problem in judgment.

There are several possible ways to represent fuzzy numbers. One special class of fuzzy numbers is triangular fuzzy numbers, which is relatively easy to model and works well with most application. Geometric mean is used as the model for triangular fuzzy numbers. In this study, we use triangular fuzzy numbers to represent subjective pair-wise comparisons of evaluation process in order to capture the vagueness. A triangular fuzzy number is denoted simply as (L, M, U). The parameters L, M and U, respectively, denote the smallest possible value, the most probable value and the largest possible value describing a fuzzy event [4].

The triangular fuzzy numbers $\tilde{u}_{ij}$ are established as follows:

$$\tilde{u} = (L_{ij}, M_{ij}, U_{ij}), \tag{2}$$

where $L_{ij} \le M \le U_{ij}$ and $L_{ij}, M_{ij}, U_{ij} \in [1/9,1] \cup [1,9]$.

$$L_{ij} = \min(B_{ijk}), \tag{3}$$

$$M_{ij} = \sqrt[n]{\prod_{k=1}^{n} B_{ijk}}, \tag{4}$$

$$U_{ij} = \max(B_{ijk}), \tag{5}$$

where B_{ijk} represents a judgment of expert k for the relative importance of two elements C_i and C_j. The triangular fuzzy numbers, $\tilde{1} - \tilde{9}$, are utilized to improve the conventional nine-point scaling scheme. The procedure of Fuzzy-AHP method involves the following steps.

Step 1. Hierarchical modeling.

Defining the evaluative criteria used to evaluate the E-Commerce website, and establish a hierarchical framework.

Step 2. Comparing pair-wise and constructing each fuzzy judgment matrix.

Triangular fuzzy numbers are used to indicate the relative strength of each pair of elements in the same hierarchy. The relative strength can be the relative priority of criteria as well as the relative importance of factors associated with each criterion. By using triangular fuzzy numbers, via pair-wise comparison, the fuzzy judgment matrix Γ is constructed as given below:

$$\Gamma = [\tilde{a}_{ij}] = \begin{matrix} & C_1 & C_2 & \cdots & C_n \\ C_1 & 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ C_2 & \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ C_n & \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{matrix}, \tag{6}$$

where $\tilde{a}_{ij}$ denotes a triangular fuzzy number for the relative strength of two elements C_i and C_j.

Step 3. Defuzzification.

The defuzzification method adopted in this study was derived from [5] and [8]. As shown in Eq. (7), this method can clearly express fuzzy perception. Owing to the ability of this method to explicitly display the preference (a) and risk tolerance (λ) of decision makers, decision makers can more thoroughly understand the risks they face in different situations.

$$\left(a_{ij}^{\alpha}\right)^{\lambda} = \left[\lambda \cdot L_{ij}^{\alpha} + (1-\lambda) \cdot U_{ij}^{\alpha}\right], \tag{7}$$

$$0 \le \lambda \le 1,\ 0 \le \alpha \le 1,\ i < j,$$

where $L_{ij}^{\alpha} = (M_{ij} - L_{ij}) \cdot \alpha + L_{ij}$ represents the left-end value of α-cut for a_{ij} and $U_{ij}^{\alpha} = U_{ij} - (U_{ij} - M_{ij}) \cdot \alpha$ represents the right-end value of α-cut for a_{ij}.

$$\left(a_{ij}^{\alpha}\right)^{\lambda} = 1 \Big/ \left(a_{ji}^{\alpha}\right)^{\lambda},\ 0 \le \lambda \le 1,\ 0 \le \alpha \le 1,\ i > j. \tag{8}$$

Here, α can be viewed as a stable or fluctuating condition [9, 10]. It reflects the uncertainty of the judgment and ranges from 0 to 1. Eleven values, 0, 0.1, 0.2, ... , 1 are used to emulate the uncertainty. The range of uncertainty is the greatest when $\alpha = 0$. $\alpha = 0$ represents the upper-bound U_{ij} and lower-bound L_{ij} of triangular fuzzy numbers, and $\alpha = 1$ represents the geometric mean M_{ij} in triangular fuzzy numbers. λ can be viewed as the degree of pessimism of decision maker and ranges from 0 to 1. $\lambda = 0$ means that the decision maker is more optimistic and, thus, the expert consensus is upper bound U_{ij}. On the contrary, $\lambda = 1$ means that the decision maker is pessimistic [11, 12]. The single pair-ware comparison matrix can be expressed as following:

$$[(A^{\alpha})^{\lambda}] = [(a_{ij}{}^{\alpha})^{\lambda}] = \begin{bmatrix} 1 & (a_{12}{}^{\alpha})^{\lambda} & \cdots (a_{1n}{}^{\alpha})^{\lambda} \\ (a_{21}{}^{\alpha})^{\lambda} & 1 & \cdots (a_{2n}{}^{\alpha})^{\lambda} \\ \vdots & \vdots & \vdots \quad \vdots \\ (a_{n1}{}^{\alpha})^{\lambda} & (a_{n2}{}^{\alpha})^{\lambda} & \cdots \quad 1 \end{bmatrix}. \qquad (9)$$

Step 4. Calculation of the eigenvalue and eigenvector.

Notably, $\overline{\lambda}$ is assumed to be the eigenvalue of the single pair-ware comparison matrix $(A^{\alpha})^{\lambda}$ [12].

Using the comparison matrix, the eigenvectors were calculated according to Eqs. (10) and (11).

$$(A^{\alpha})^{\lambda} \cdot W = \overline{\lambda} \cdot W \qquad (10)$$

$$[(A^{\alpha})^{\lambda} - \overline{\lambda}] \cdot W = 0 \qquad (11)$$

where W denotes the eigenvector of $(A^{\alpha})^{\lambda}$, $0 \le \lambda \le 1$, $0 \le \alpha \le 1$.

Step 5. Overall rating.

Calculate the overall level hierarchy weighs by combining the relative priority of the elements of each level to determine the synthesis value of each alternative.

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