Evaluation of Travel Websites: A Fuzzy Analytical Hierarchy Process approach

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Abstract *The increased usage of internet for day-to-day activities starting from scheduling a meeting to online buying has expanded the scope for planning travels online. In the current era, customers prefer e-ticketing but finding the best travel website as well as the factors determining it are of utmost importance as the travel industry offers numerous services through multiple websites and their promotions. This article explores the factors that determine the quality of a travel website in Indian context and the method for evaluating it for end users. Fuzzy Analytical Hierarchy Process (Fuzzy AHP) has been used in the current study with Fuzzy Extent Theory and CFCS (Converting Fuzzy Data into Crisp Scores) method for ranking the selected travel websites.*

Keywords Fuzzy AHP; Fuzzy Extent Theory; Converting Fuzzy data into Crisp Scores; Travel Websites ranking

1. Introduction

Internet usage has increased to a great extent in recent times and it has moved to homes, schools, businesses and many other fields. Internet has changed the lifestyle and the way of carrying out business. With easy market entry in online business, the competition among players has inflated which requires innovative strategies to attract and retain customers. Travel industry has also followed the same trend with online presence, which requires customers to carefully choose the optimal website based on certain website parameters.

WebQual™ is a measure of website quality and captures the aspects that influence the online customers' intention to revisit the website [1]. The factors described in WebQual™ should be considered while designing an effective website. The factors, Ease of Use, Usefulness, Complementary Relationship and Entertainment are studied in the initial higher level category while Usefulness, Trust, Response Time, Ease of Use and Entertainment are examined in the second order factor [2]. The study showed that among the five factors, response time, usefulness and entertainment deserve more attention and are the primary indicators of website quality. Delone and McLean [3] have proposed information systems' success factors which consist of information quality, service quality, systems quality and vendor specific quality.

This paper uses six quality parameters or criteria --Response Time, Security, Reliability, Ease of Use, Communication facilities and Awareness to evaluate a travel website. Response time falls under service quality and refers to how quickly the system provides results to a customer. Security, Reliability and Ease of Use are the sub criteria of system quality. Security refers to how secure the website is in terms of third party affiliation, security and privacy policy, and encryption techniques. Ease of Use refers to the ease of reading and understanding the content, and navigating the website. Communication Facilities criteria is added in the Indian context and refers to the facilities of a website to communicate via SMS, email etc. after performing any transaction in the website. Awareness falls under vendor specific quality and refers to being aware of the website. Other criteria such as entertainment are not taken into consideration as they are not apt for travel websites. Six Travel websites are selected based on Alexa ranking[1], and are ranked using Fuzzy AHP based on the selected criteria.

2. Background Work

Analytical Hierarchy Process (AHP) is a Multi-Criteria Decision Making (MCDM) tool developed by Saaty [5] which structures a problem in the form of a hierarchy to choose the best alternative based on certain defined criteria. From the survey, pairwise comparison matrices of criteria as well as alternatives for each criterion are obtained. The method not only ranks the alternatives, but also calculates the consistency ratio (CR) of the matrix. Consistency ratio greater than 0.1 indicates the matrix is not consistent and requires further change in the responses. Even though AHP is widely used for multi criteria decision making problems, it is criticized for the use of discrete scale from one to nine for pair wise comparison matrices which cannot address the ambiguity and uncertainty in deciding the priorities among different attributes. To address the vagueness of thought in real life, a fuzzy version of AHP is used in pairwise comparisons and in ranking the alternatives [6]. In Fuzzy-AHP, the preferences are assigned by the decision makers in a Fuzzy linguistic manner, and fuzzy weights are calculated applying the basic fuzzy set theory [7]. Out of several Fuzzy AHP methods, Chang's Extent Analysis is widely accepted and used. This paper illustrates Extent Analysis and

[1] Alexa ranking is used to rank website traffic and calculated based on parameters such as reach and page reviews

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Converting Fuzzy data into Crisp Scores (CFCS) method for ranking the travel websites and comparing the results from both the methods.

Fuzzy AHP has been used in numerous multi-criteria decision making problems. Kahraman, Cebeci and Ulukan [8] have used Fuzzy AHP for supplier selection problem in identifying the best supplier using Fuzzy Extent Theory. Fuzzy AHP has also been used in selecting government sponsored technology development projects in public sector and evaluating the criteria that are most important for technical committees [9]. Pan [10] has studied Bridge construction methods and applied Fuzzy AHP to overcome the shortcomings of conventional AHP in selecting the most suitable bridge construction operation. Law [11] has proposed a fuzzy AHP approach to formulate the problem of evaluation of travel websites and provided insights for website development. Vahidnia, Alesheikh and Alimohammadi [12] have used three methods namely fuzzy extent analysis, centre of area defuzzification and α-cut method of Fuzzy AHP to evaluate the decision factors and their impact on alternative sites for a new hospital.

This paper evaluates and ranks travel websites in Indian context based on six quality parameters by using two methods of Fuzzy AHP namely fuzzy extent analysis and CFCS (Converting Fuzzy sets into Crisp Scores) method.

3. Fuzzy Extent Theory

Chang's Extent Analysis depends on the degrees of possibilities of superiority of each criterion over the other [13]. A triangular fuzzy value (l,m,u) representing lower, middle and upper values is obtained from each response in the form of linguistic variables in the questionnaire and a pair wise comparison matrix is constructed for each level of the hierarchy. The steps followed in Fuzzy Extent Theory are given by:

Step 1: Calculation of Fuzzy Synthetic Extent value

The value of Fuzzy Synthetic Extent with respect to i[th] object is defined as

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{i} \right]^{-1} \quad (1)$$

Where M_{gi}^{j} is the Extent Analysis value for each criterion, gi is the goal set, and all $\sum_{j=1}^{m} M_{gi}^{j}$ are the triangular fuzzy numbers. The computation of equation (1) can be done by

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j , \sum_{j=1}^{m} m_j , \sum_{j=1}^{m} u_j \right) \quad (2)$$

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{i} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} u_{ij}} , \frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} m_{ij}} , \frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} l_{ij}} \right) \quad (3)$$

Step 2: Calculate the degree of possibility of superiority of every fuzzy synthetic extent value from the others. It is represented by equation (4)

$$V(M_2 \geq M_1) = \begin{cases} 1, & m_2 \geq m_1 \\ 0, & l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 \geq u_2) - (m_1 \geq l_1)}, & otherwise \end{cases} \quad (4)$$

Step 3: The degree of possibility of a convex fuzzy number being greater than other k fuzzy numbers is defined by

$$V(M \geq M_1, M_2, \dots, M_k) = min\, V(M \geq M_i), i = 1, 2, \dots, k \quad or\ d'(A_i) = min\, V(S_i \geq S_k) \quad (5)$$

Step 4: Normalize the weight vectors obtained from equation (5)

$$W = (d(A_1), d(A_2), \dots, d(A_n))^T \quad (6)$$

Here, W obtained is a non-fuzzy number and is used to compare or rank the attributes.

4. CFCS (Converting Fuzzy Data into Crisp Scores) Method

This method of defuzzification developed by Opricovic and Tzeng [14] is based on the procedure of obtaining the left and right scores by fuzzy-min and fuzzy-max and the total score is obtained as a weighted average according to the membership functions defined. The CFCS method takes into consideration the same pairwise comparison matrix but different defuzzification method for converting the fuzzy values to crisp scores. The steps followed for this method are:

Step 1: Calculate L, R and Δ values for k-th criteria for the fuzzy set of values obtained from equation (2) as

$$L = min(l_k), \quad R = max(u_k), \quad \Delta = R - L, where\ k = 1, 2, \dots, n$$

$$x_{lk} = \frac{l_k - L}{\Delta}, x_{mk} = \frac{m_k - L}{\Delta} \text{ and } x_{uk} = \frac{u_k - L}{\Delta} \quad (7)$$

Step 2: Calculate the left score and right score normalized values

$$x_k^{ls} = \frac{x_{mk}}{1+x_{mk}-x_{lk}} \text{ and } x_k^{rs} = \frac{x_{uk}}{1+x_{uk}-x_{mk}} \quad (8)$$

Step 3: Calculate total normalized crisp value

$$x_k^{crisp} = \left[x_k^{ls} \times (1 - x_k^{ls}) + x_k^{rs} \times x_k^{rs}\right] / \left[1 - x_k^{ls} + x_k^{rs}\right] \quad (9)$$

Step 4: Compute the final crisp value as

$$B_k^{crisp} = L + x_k^{crisp} \times \Delta \quad (10)$$

5. Proposed Model

This paper uses aforementioned six website quality parameters to evaluate the ranks of travel websites by using Fuzzy AHP. The evaluation or ranking is done for alternatives or travel websites A1, A2, A3, A4, A5 and A6. The pairwise comparison matrix is obtained by collection of responses (from survey) followed by evaluating the ranks of criteria as well as ranks for alternatives for each criterion. Fig. 1 depicts the proposed model for selecting a travel website (alternatives) based on six criteria -- Response Time, Security, Reliability, Ease of Use, Communication Facilities and Awareness.

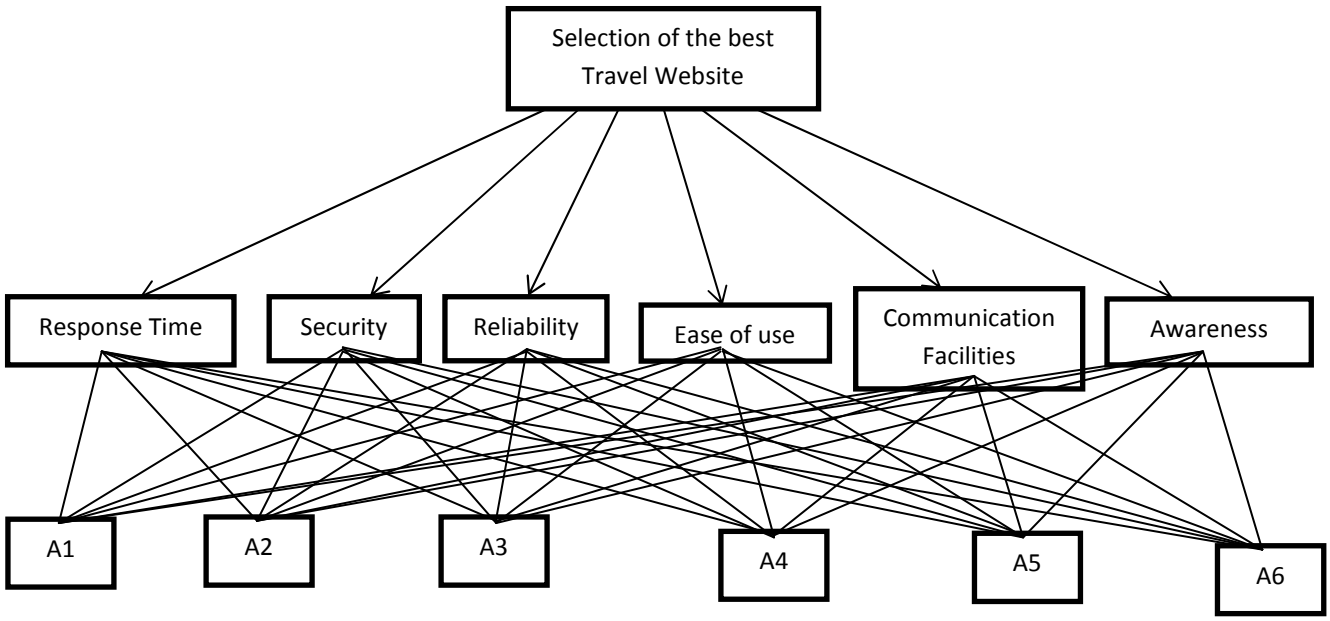

Figure 1: Selection of a Travel Website

5.1. Data Collection

After determining the criteria from literature review and analysis, an online questionnaire (see Appendix) has been prepared for capturing the ranking of criteria as well as alternatives for each criterion from around three hundred responses. Since all the fields in the questionnaire had validations, no pre-processing was required for the data. Mode based group decision making is applied while creating the matrices from large set of responses for pairwise comparisons of criteria, and alternatives for each criterion. Fuzzy linguistic variables used in the questionnaire to take responses of comparisons are -- Absolute (3.5, 4, 4.5), Very Strong (2.5, 3, 3.5), Fairly Strong (1.5, 2, 2.5), Weak (0.67, 1, 1.5) and Equal (1,1,1). The Fuzzy reciprocal scales taken are (1/u, 1/m, 1/l), where l, m and u are the lower, middle and upper values.

5.2. Result

Table 1 represents the fuzzy pairwise comparison matrix for criterion Response Time. After constructing the pairwise comparison matrix for the criterion Response Time, the fuzzy Extent Theory is applied. Firstly, the fuzzy Synthetic Extent values are calculated using equation (1), (2) and (3) which is followed by Degree of possibility of superiority using equation (4) and (5), and then normalized weight vector is calculated by using equation (6). The significance of normalized weights in Table 1 is A2 or website 2 has the highest ranking as compared to other websites for criterion Response Time. Similarly the normalized weights for all

pairwise comparison matrices are calculated by following steps 1-6.

After obtaining the weights for all pairwise comparison matrices, the alternatives can be ranked by multiplying the alternatives' ranking matrices for each criterion with the criteria ranking. Table 2 shows the ranks given to all the alternatives (or travel websites) based on Fuzzy Extent Theory. The ranking shows that alternative 1 is the best travel website based on all the six criteria used to rank the alternatives.

Table 1: Fuzzy Pairwise comparison matrix for Response Time

	A1	A2	A3	A4	A5	A6	Normalised Weights
A1	(1,1,1)	(0.4,0.5,0.67)	(1.5,2,2.5)	(1.5,2,2.5)	(2.5,3,3.5)	(2.5,3,3.5)	0.324
A2	(1.5,2,2.5)	(1,1,1)	(1.5,2,2.5)	(1.5,2,2.5)	(1.5,2,2.5)	(2.5,3,3.5)	0.348
A3	(0.4,0.5,0.67)	(0.4,0.5,0.67)	(1,1,1)	(2.5,3,3.5)	(2.5,3,3.5)	(2.5,3,3.5)	0.305
A4	(0.4,0.5,0.67)	(0.4,0.5,0.67)	(0.29,0.33,0.4)	(1,1,1)	(1,1,1)	(2.5,3,3.5)	0.012
A5	(0.29,0.33,0.4)	(0.4,0.5,0.67)	(0.29,0.33,0.4)	(1,1,1)	(1,1,1)	(2.5,3,3.5)	0.011
A6	(0.29,0.33,0.4)	(0.29,0.33,0.4)	(0.29,0.33,0.4)	(0.29,0.33,0.4)	(0.29,0.33,0.4)	(1,1,1)	0

Table 2: Ranking the alternatives- Fuzzy Extent Theory

	Response Time	Security	Reliability	Ease of Use	Communication Facilities	Awareness		Criteria			Rank
A1	0.324	0.682	0.52	0.535	0	0.4		0.2855		0.53971	1
A2	0.3475	0.318	0.48	0.327	0.313	0.29		0.4671		0.3665	2
A3	0.305	0	0	0	0.313	0.1	*	0.2474	=	0.08708	3
A4	0.0117	0	0	0.138	0.374	0.21		0		0.00334	4
A5	0.0113	0	0	0	0	0		0		0.00323	5
A6	0	0	0	0	0	0		0		0	6

Ranking through CFCS method is performed by using equations 7-9 to calculate normalized crisp values by using defuzzification method and then multiplying the matrices of normalized crisp values (or alternative ranking) for each criterion with the criteria ranking (normalized crisp values for pairwise comparison matrix for criteria). Table 3 shows the ranking of alternatives by using CFCS method.

Table 3: Ranking the alternatives-CFCS Method

	Response Time	Security	Reliability	Ease of Use	Communication Facilities	Awareness		Criteria			Rank
A1	0.23	0.29	0.29	0.3	0.13	0.27		0.22		0.26	1
A2	0.24	0.21	0.27	0.23	0.23	0.23		0.29		0.24	2
A3	0.22	0.15	0.14	0.12	0.23	0.16	*	0.21	=	0.17	3
A4	0.13	0.13	0.12	0.18	0.25	0.2		0.11		0.15	4
A5	0.13	0.13	0.12	0.1	0.08	0.09		0.1		0.12	5
A6	0.05	0.09	0.06	0.06	0.07	0.06		0.08		0.07	6

Ranking the alternatives by using CFCS method shows alternative 1 is the best travel website based on six criteria used for the analysis. Fig. 2 depicts that the ranks obtained by both the methods (i.e., Fuzzy Extent Theory and CFCS method) of Fuzzy AHP are same for all the alternatives which provides a self-validation for the method.

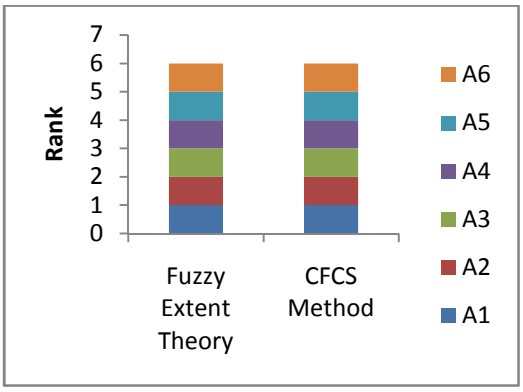

Figure 2: Comparison of Rankings

6. Conclusion and Future Research Scope

The Travel websites can be selected based on the ranking from Fuzzy AHP as it helps in multi-criteria decision making by taking the vagueness of thought in the real world into consideration. The ranks obtained for the Travel websites are same by using both the methods i.e., Fuzzy Extent Theory and CFCS method which validates the ranking method.

The study can further use TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) or Fuzzy TOPSIS to calculate the ranks based on closeness to positive ideal solution and farness from negative ideal solution for alternatives by using the weights calculated from Fuzzy AHP. The Cost criteria (quantitative) can be used along with the qualitative criteria in TOPSIS for better results. Since the survey sample is limited with respect to the demography, the result may be biased. More criteria and sub-criteria can be taken into consideration for improving the results. Travel Website selection can also be done by using swarm optimization techniques.

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Appendix

The questionnaire facilitates the comparison of criteria and alternatives given in Table 3 and Table 4. The questionnaire contains 6 criteria which forms a total of 15 distinct combinations among themselves shown in Table 3 for pairwise comparison matrix. In the comparison between C1 and C2, the tick mark indicates C2 is fairly strong as compared to C1. Similarly, for the comparison between C1 and C3, the tick mark indicates C1 is fairly strong as compared to C3.

Table 3: Importance of one criteria over another

Criterion	Absolute (3.5,4,4.5)	Very Strong (2.5,3,3.5)	Fairly Strong (1.5,2,2.5)	Weak (0.67,1,1.5)	Equal (1,1,1)	Weak (0.67,1,1.5)	Fairly Strong (1.5,2,2.5)	Very Strong (2.5,3,3.5)	Absolute (3.5,4,4.5)	Criterion
C1							√			C2
C1			√							C3
C1			√							C4
C1			√							C5
C1		√								C6
C2			√							C3
C2		√								C4
C2		√								C5
C2		√								C6
C3		√								C4
C3		√								C5
C3			√							C6
C4			√							C5
C4					√					C6
C5			√							C6

Table 4 shows the importance of one alternative (travel websites) over the other for Criterion C1. Similarly five more matrices can be formed for other 5 criteria -- C2, C3, C4, C5 and C6.

Table 4: Importance of one alternative over the other for Criterion C1 (similar tables for criteria C2,C3, C4, C5 and C6)

Alternative	Absolute (3.5,4,4.5)	Very Strong (2.5,3,3.5)	Fairly Strong (1.5,2,2.5)	Weak (0.67,1,1.5)	Equal (1,1,1)	Weak (0.67,1,1.5)	Fairly Strong (1.5,2,2.5)	Very Strong (2.5,3,3.5)	Absolute (3.5,4,4.5)	Alternative
A1							√			A2
A1			√							A3
A1			√							A4
A1		√								A5
A1		√								A6
A2			√							A3
A2			√							A4
A2			√							A5
A2		√								A6
A3		√								A4
A3		√								A5
A3		√								A6
A4					√					A5
A4		√								A6
A5		√								A6