Hotel Website Performance Evaluation: A Fuzzy Analytic Hierarchy Process Approach

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Abstract—Previous studies on hotel website performance have relied on frequency counting, content analysis or user behavioral approaches [1]. These studies cannot accurately calculate hotel website performance in terms of user assessments of dimension/attribute weighting and performance ratings. The aim of this research is to develop a scientific model that integrates a set of website evaluation dimensions for evaluating websites performance. Unlike previous studies, this research proposes a novel framework for evaluating website performance by using Fuzzy Analytic Hierarchy Process (Fuzzy AHP). Since human judgments are often uncertain and vague, using fuzzy set theory instead of exact numbers could integrate a decision maker’s uncertainty. This proposed method could rectify this limitation and provide a more accurate overall evaluation result.

Keywords - Hotel website evaluation; Fuzzy AHP

I. INTRODUCTION

Without any time limits and geographical constraints, the Internet has developed rapidly in general. In the hospitality industry, it has changed the way hotel rooms are sold and promoted [2]. Although there are numerous hotel websites, there are no existing standardized guidelines or measurements to evaluate the performance of these websites [1].

Prior studies on hotel website performance have focused on using frequency counting, content analysis or user behavioral approaches, but these studies have some limitations. A major limitation of the prior studies is that they assumed different dimensions and attributes were of equal variance. It is thus unable to quantify the actual variance between dimensions or attributes [3]. Also, these studies cannot reflect the actual performance of hotel websites since human judgments are subjective and imprecise. Hence, this research proposes a novel model to analyze the performance of hotel websites by using Fuzzy Analytic Hierarchy Process (hereafter, Fuzzy AHP). This model would be useful for evaluating websites in the hotel industry because by using this formal systematic method, the approach solves human subjective assessments into fuzzy set theory which reflects factuality and strongly represents reality. In this paper, the main objective is to present a fuzzy multicriteria analysis model that systematically integrates hotel guests’ preference and fuzzy assessments of website dimensions/attributes.

II. THE PROPOSED METHODOLOGY

Instead of using a single normal value, Fuzzy AHP used a range of values to integrate a decision maker’s uncertainty. From this range, the decision maker can select the most appropriate value to reflect his/her confidence [4]. The attitude can be classified into optimistic, pessimistic or moderate [5]. Optimistic attitude is referred to the highest values while pessimistic attitude is represented by the lowest values.

Fuzzy extent analysis is used in this research in order to solve the fuzzy reciprocal matrix for the calculation of the criteria importance and alternative performance [6]. The alpha-cut analysis is used to transform the total weighted performance matrices into interval performance matrices [7]. This analysis avoids the uncertainty in the fuzzy range chosen.

Steps for Fuzzy AHP
Modified from [5], [6]

1. Obtain the Normal Pairwise Comparison Matrices (PCM)
2. Convert the Normal PCM to Fuzzy PCM
3. Use Fuzzy Extent Analysis for Calculation of Performance Ratings
4. Adopt Weightage Multiplication from Hierarchy
5. Perform Weight Summation
6. Apply Alpha Cut Analysis to Avoid the Complex and Unreliable Process of Comparing Fuzzy
7. Utilize Lambda Function for Embedding Attitude of the Decision Maker
8. Normalize the Results to Normal Values
**Step 1 and 2 Obtaining Normal PCM and Converting the Normal PCM to Fuzzy PCM**

In the Fuzzy AHP as adopted in this research, a triangular fuzzy number is adopted for the fuzzification of the normal PCM to Fuzzy PCM [4]. The normal PCM is converted to the triangular fuzzy number \( f = (l, m, u) \) by using the table of conversion as indicated below [6]. The \( l \) (lower bound) and \( u \) (upper bound) represent the fuzziness of the data evaluated.

**TABLE 1 CONVERSION OF NORMAL PCM TO FUZZY PCM**

Adopted from [6]

<table>
<thead>
<tr>
<th>Normal PCM Value</th>
<th>Fuzzy PCM Value</th>
<th>Normal PCM Value</th>
<th>Fuzzy PCM Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(1, 1, 1)</td>
<td>1</td>
<td>(1, 1, 1)</td>
</tr>
<tr>
<td>2</td>
<td>(1, 2, 4)</td>
<td>1/2</td>
<td>(1/4, 1/2, 1)</td>
</tr>
<tr>
<td>3</td>
<td>(1, 3, 5)</td>
<td>1/3</td>
<td>(1/5, 1/3, 1)</td>
</tr>
<tr>
<td>4</td>
<td>(2, 4, 6)</td>
<td>1/4</td>
<td>(1/6, 1/4, 1/2)</td>
</tr>
<tr>
<td>5</td>
<td>(3, 5, 7)</td>
<td>5</td>
<td>(1/7, 1/5, 1/3)</td>
</tr>
<tr>
<td>6</td>
<td>(4, 6, 8)</td>
<td>1/6</td>
<td>(1/8, 1/6, 1/4)</td>
</tr>
<tr>
<td>7</td>
<td>(5, 7, 9)</td>
<td>1/7</td>
<td>(1/9, 1/7, 1/5)</td>
</tr>
<tr>
<td>8</td>
<td>(6, 8, 10)</td>
<td>1/8</td>
<td>(1/10, 1/8, 1/6)</td>
</tr>
<tr>
<td>9</td>
<td>(7, 9, 11)</td>
<td>1/9</td>
<td>(1/11, 1/9, 1/7)</td>
</tr>
</tbody>
</table>

The Fuzzy PCM as followed,

\[
\begin{pmatrix}
(a_{ij}, a_{1j}, a_{2j}, a_{3j}) \\
(a_{ij}, a_{1j}, a_{2j}, a_{3j}) \\
(a_{ij}, a_{1j}, a_{2j}, a_{3j}) \\
(a_{ij}, a_{1j}, a_{2j}, a_{3j})
\end{pmatrix}
\]

where \( i = 1, 2, 3 \ldots p, j = 1, 2, 3 \ldots q \) and \( k = p, or k = q \), depending upon the element under operation, whether it is the performance ratings of alternatives or the weights of the criteria involved [5].

\[
\tilde{X}_i = \begin{pmatrix}
X_{11}, X_{1m}, X_{1u} \\
X_{21}, X_{2m}, X_{2u} \\
\cdots \\
X_{q1}, X_{qm}, X_{qu}
\end{pmatrix}
\]

This fuzzy extent analysis is going to obtain the fuzzy decision or performance matrix (\( \tilde{P} \)) and fuzzy weights (\( \tilde{W} \)) [6]. By multiplying the weight vector with the decision matrix, a fuzzy weighted performance matrix (\( \tilde{P} \)) can thus be achieved [6].

\[
\tilde{P} = \tilde{X}_i \ast \tilde{W} = \begin{pmatrix}
W_{11}X_{1111}, W_{1m}X_{11m}, W_{1u}X_{11u} \\
W_{21}X_{2111}, W_{2m}X_{21m}, W_{2u}X_{21u} \\
\cdots \\
W_{qm}X_{q1}, W_{qm}X_{qm}, W_{qu}X_{qu}
\end{pmatrix}
\]

Step 3, 4 and 5 Fuzzy Extent Analysis for Calculation of Performance Ratings, Weight Multiplication from Hierarchy and Weight Summation

By applying the fuzzy extent analysis, the above fuzzy PCM is going to form the fuzzy performance matrix. The aim of fuzzy extent analysis is to get the corresponding criteria weights and alternative performance ratings [5].

\[
\tilde{X}_i = \frac{\sum_{j=1}^{k} d_j}{\sum_{j=1}^{k} \sum_{i=1}^{q} d_{ij}}
\]

Weight summation is adopted in next step where the weighted performance matrix (\( \tilde{P} \)) for each alternative under each criteria context is added to get a total weighted performance matrix for each alternative [6].

**Step 6 (Part i) Applying Alpha Cut Analysis to Avoid the Complex and Unreliable Process of Comparing Fuzzy**

This step is to apply the alpha cut analysis to the total weighted performance matrices for each alternative while the value of \( \alpha \) represents the decision maker’s confidence degree.
in assessing his/her fuzzy numbers regarding alternative ratings and criteria weights [5]. The larger an $\alpha$ value is, the more confident that the decision maker has. It means that the decision maker’s assessments are closer to the most possible value $m$ of the triangular fuzzy numbers $(l, m, u)$ [5].

**Step 6 (Part ii) Alpha Cut Analysis for Confidence Level Representation**

In order to transform the fuzzy performance matrix representing the overall performance of all alternatives with respect to each criterion into an interval performance matrix, an alpha cut analysis is applied [6]. Since the alpha cut can avoid the uncertainty in the chosen fuzzy range, decision makers can express their personal confidence about this range [6].

**Alpha Cuts Analysis**

$\text{Alpha}_\text{Left} = [\alpha \ast (\text{Middle}_\text{fuzzy} – \text{Left}_\text{fuzzy})] + \text{Left}_\text{fuzzy}$

$\text{Alpha}_\text{Right} = \text{Right}_\text{fuzzy} – [\alpha \ast (\text{Right}_\text{fuzzy} – \text{Middle}_\text{fuzzy})]$  

$$\sim P_{\alpha} = \begin{pmatrix} p_{1\alpha} & p_{1\alpha} \\ p_{2\alpha} & p_{2\alpha} \\ \vdots & \vdots \\ p_{i\alpha} & p_{i\alpha} \end{pmatrix}$$

where $l$ and $r$ represent the left and right values of the interval set.

**Steps 7 and 8 Adoption of Lambda Function and Values Normalization**

After the application of alpha cut analysis, two values including $\text{Alpha}_\text{Right}$ (Maximum range) and $\text{Alpha}_\text{Left}$ (Minimum range) are obtained. By then, these two values need to be transformed into the normal values by applying the Lambda function which reflects the attitude of the decision maker [6].

The decision maker has an optimistic, moderate, or pessimistic view respectively. An optimistic decision maker would prefer higher value of his/her fuzzy assessments, a moderate person would pick the medium value, and a pessimistic decision maker would take the lower value [5]. The concept of optimism index, $\lambda$, is used to calculate the normal values [6].

$\text{Normal value} = \lambda \ast \alpha_{\text{Right}} + [(1- \lambda)\ast \alpha_{\text{Left}}]$  

$C_m = \lambda \ast p_r \alpha + (1- \lambda)\ast p_l \alpha,$

where $\lambda = [0, 1]$  

$C_{\lambda} = \begin{pmatrix} C_{1\lambda} \\ C_{2\lambda} \\ \vdots \\ C_{i\lambda} \end{pmatrix}$

Finally, the normal values are going to be normalized as the elements of the PCM do not have the same rating. It is critical to point out that elements can be compared if they have the uniform rating [6].

$$C_{i\lambda} = \frac{C_{i\lambda}}{\sum C_{i\lambda}}$$

**III. RESEARCH SIGNIFICANCE**

**Theoretical Contribution**

Although many published articles focused on the evaluation of website performance, the existing literature has no published articles that use scientific models which numerically evaluate hotel website users’ perception in pairwise comparison values. Hence, the result of this study is expected to contribute to different stakeholders in the hospitality industry. Furthermore, Fuzzy AHP would be used to evaluate the relative importance of all dimensions/attributes in website performances. Since each dimension/attribute possesses its own individual significance and meaning, it is unreasonable to assume that the importance of each is equal [8]. Previous studies assumed equal variance in all dimensions and attributes, yet, by applying Fuzzy AHP approach in this research, this drawback can be rectified. Lastly, this research would contribute to website performance evaluation by applying a Multiple Criteria Decision Making Model.
Practical Contribution

In view of the continuous growth of the applications of the Internet to the hospitality industry, hoteliers should take advantage of this technology and keep improving the contents of their websites. Since functionality is the critical part of the usefulness of websites [9], hotels should put more effort in website performance to remain competitive in this striving business market. Besides, [10] pointed out that an effective hotel website can achieve higher profits from online bookings. Therefore, putting appropriate contents on a hotel website can generate more revenues. Apart from these, amid the recent financial crisis, hotel operators are hit by falling occupancy rates and high operating costs [11]. The establishment of websites not only lowers the distribution costs, but also gains higher profits and reaches larger potential market [12]. The findings of this research would thus provide practical information to hoteliers on how to develop and improve their websites in order to remain competitive during the global financial downturn.

IV. REFERENCES


