Web Based Fuzzy Multicriteria Decision Making Tool

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Abstract

In this paper, we developed a web-based decision making tool which utilizes fuzzy analytic hierarchy process (AHP) methodology to solve daily complicated decision making problems. Fuzzy concepts are used to enhance the traditional AHP, which is mainly applied in crisps decision environment. Fuzzy linguistic term approach is applied to capture the fuzziness and subjectiveness of decision makers' judgements. Due to simplicity and effectiveness, we selected triangular fuzzy numbers as a reference to indicate the influence strength of each element in the hierarchy structure. α-cut-based method has been utilized to prevent the controversial of fuzzy number ranking process. The confidence level and the optimistic level of decision maker are captured by using α-cut-based fuzzy number results. A numerical example is demonstrated to illustrate the fuzzy approach. The fuzzy approach exhibits a more appropriate and flexible result compared to the traditional approach.

Keywords: Decision Making, Analytic Hierarchy Process (AHP), Fuzzy Linguistic, α-cut-based method

1. Introduction

Decision making tool aims to realize conflicts that occur due to various different opinions and subjective assessments by decision makers. Unlike simple decision making problem (where it involves one criteria most of the time), in real world, we are considering more than one criterion and alternative as well. With this consideration, our decision making tool is based on one of the multicriteria decision making (MCDM) in Turban (1991); namely Analytical Hierarchy Process (AHP). AHP is able to handle these typical scenarios.

With this tool, it helps us make better decisions and improve the decision making process. However, AHP face a weakness in capturing the vague, uncertainty and imprecise judgment by different users. This may caused by level of experiences, lacking of experimental data and other undecided factors. Therefore, a variation of AHP named Fuzzy AHP comes into implementation. It is being explored to overcome the compensatory approach and the inability of the AHP in handling proper linguistic variables.

Inherently, fuzzy set theory has proven advantages within vague, imprecise and uncertain contexts. In Z.Y. Yang (2003), one basic application of fuzzy set theory is fuzzy synthetic evaluation (FSE), which is a decision-making approach within a fuzzy environment. At the same time, AHP can give a comprehensive and consistent analysis on the weights of all factors; therefore, many
works on the integration of FSE and AHP have been performed to obtain the benefits from both. In Bojadziev (1997), some researchers use a membership function to describe how the alternatives satisfy the criteria (factors) and then use an AHP to make the decision. Some works use the AHP to get the weights of the factor only, fuzzify the weights, and then use fuzzy synthesis evaluation (FSE) or ranking as the decision-making strategy. Van Laarhoven and Pedrycz (1983) employed triangular fuzzy to represent a pairwise comparison ratio in AHP instead of exact numbers and a new decision-making methodology called fuzzy AHP came to exist.

Based on the brief fuzzy explanation of previous paragraph, we integrate the fuzzy set theory approach into our Decision Making tool specifically in one of the common area of human decision making problem. By applying the fuzzy set theory, we are able to come up with more precise and reliable result thus is fundamental of decision making tool.

The proposed decision making tool features the traditional AHP and Fuzzy AHP. End user can optimize the decision benefit from these two approaches to deal with the problem of inconsistency as well as vagueness in human judgment. It also let the end user to compare the result and performance from these two methods in one glance. In addition, the decision making tool will also provide an integrated domain reference channel via database connection to assist the end user obtain some updated information regarding the problem domain before construct the problem hierarchy in AHP. Hence, our decision making tool combines the characteristic of real time information retrieval through internet and MCDM problem analytical processing logic.

2. Methodology of Fuzzy AHP

2.1 Introduction to Fuzzy AHP

Inability of traditional AHP to deal with the imprecision and subjectiveness in the pairwise comparison process have been improved in Fuzzy AHP. Instead of single crisp value, Fuzzy AHP used a range of value to incorporate decision maker’s uncertainty. From this range, decision maker can select the value that reflects his confidence and also he can specify his attitude like optimistic, pessimistic or moderate (Jeganathan, 2003). Optimistic attitude is represented by the highest value of range, moderate attitude is represented by the middle value of the range and pessimistic attitude is represented by the lowest value of the range.

In the fuzzy set terminology, the ratio supplied by the decision maker is a fuzzy number described by a membership function. Here, a membership function describes the degree with which elements in the judgment interval belong to the preference set. In norm, triangular fuzzy number is used to represent the decision maker’s assessment on alternatives with respect to each criterion. The concept of fuzzy extent analysis is applied to solve the fuzzy reciprocal matrix for determining the criteria importance and alternative performance. In Prakash (2003), the alpha-cut analysis is used to transform the fuzzy performance matrix representing the overall performance of all alternatives with respect to each criterion into an interval performance matrix, to avoid the complex and unreliable process of comparing fuzzy utilities.

2.2 A Brief Introduction to Fuzzy Set Theory

Fuzzy set theory is a mathematical theory designed to model the vagueness or
imprecision of human cognitive processes that pioneered by Zadeh (Lootsma, 1997). This theory is basically a theory of classes with unsharp boundaries. What is important to recognize is that any crisp theory can be fuzzified by generalizing the concept of a set within that theory to the concept of a fuzzy set. The stimulus for the transition from a crisp theory to a fuzzy one derives from the fact that both the generality of a theory and its applicability to real world problems are enhanced by replacing the concept of a crisp set with a fuzzy set (Zadeh, 1994). Generally, the fuzzy sets are defined by the membership functions. The fuzzy sets represent the grade of any element $x$ of $X$ that have the partial membership to $A$. The degree to which an element belongs to a set is defined by the value between 0 and 1. If an element $x$ really belongs to $A$ if $\mu_A(x) = 1$ and clearly not if $\mu_A(x) = 0$. Higher is the membership value, $\mu_A(x)$, greater is the belongingness of an element $x$ to a set $A$. In norm, fuzzy number is represented by a cap on top

The Fuzzy AHP presented in this paper applied the triangular fuzzy number through symmetric triangular membership function. A triangular fuzzy number is the special class of fuzzy number whose membership defined by three real numbers, expressed as $(l, m, u)$. According to Tae-heon Moon (1999), the triangular fuzzy numbers is represented as follows.

$$
\mu_A(x) = \begin{cases} 
(x-l)/(m-l), & l \leq x \leq m, \\
(u-x)/(u-m), & m \leq x \leq u, \\
0, & \text{otherwise}
\end{cases}
$$

![Triangular Membership Function](image1.png)

Figure 1-1. Triangular Membership Function

![Symmetric Triangular Membership Function](image2.png)

Figure 1-2. Symmetric Triangular Membership Function
2.3 Fuzzy AHP Workflow

(Figure 1-3. Fuzzy Analytical Hierarchy Process (AHP) Workflow)

(Step 1) Acquisition of Crisp PCM and Fuzzyfying the Crisp PCM to Fuzzy PCM

In the fuzzy AHP, the triangular fuzzy number \( f = (l,m,u) \), which fuzzified the original PCM using the conversion number as indicated in the table below. The \( l \) (lower bound) and \( u \) (upper bound) represents the uncertain range that might exist in the preferences expressed by the decision maker or experts.

Table 1- Conversion of Crisp PCM to Fuzzy PCM

<table>
<thead>
<tr>
<th>Crisp PCM value</th>
<th>Fuzzy PCM value</th>
<th>Crisp PCM value</th>
<th>Fuzzy PCM value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(1,1,1) if diagonal; (1,1,3) otherwise</td>
<td>1/1</td>
<td>(1,1,1) if diagonal; (1,1,3) otherwise</td>
</tr>
<tr>
<td>2</td>
<td>(1,2,4)</td>
<td>1/2</td>
<td>(1/4,1/2,1/1)</td>
</tr>
<tr>
<td>3</td>
<td>(1,3,5)</td>
<td>1/3</td>
<td>(1/5,1/3,1/1)</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>1/5</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>
Crisp PCM, \( A \),

\[
A = \begin{bmatrix}
    a_{11} & a_{12} & \cdots & a_{1n} \\
    a_{21} & a_{22} & \cdots & a_{2n} \\
    \vdots & \vdots & \ddots & \vdots \\
    a_{m1} & a_{m2} & \cdots & a_{mn}
\end{bmatrix}
\]

The fuzzy PCM, \( \tilde{A} \) will be as follows,

\[
\tilde{A} = \begin{bmatrix}
    (a_{11} a_{12m} a_{1l1u}) & (a_{12} a_{12m} a_{1l2u}) & \cdots & (a_{1n} a_{12m} a_{1lnu}) \\
    (a_{21} a_{22m} a_{2l1u}) & (a_{22} a_{22m} a_{2l2u}) & \cdots & (a_{2n} a_{22m} a_{2lnu}) \\
    \vdots & \vdots & \ddots & \vdots \\
    (a_{m1} a_{m2m} a_{ml1u}) & (a_{m2} a_{m2m} a_{ml2u}) & \cdots & (a_{mn} a_{mnm} a_{mlnu})
\end{bmatrix}
\]

\textbf{(Step 2) Fuzzy Extent Analysis for Calculation of Performance Ratings, Weight Multiplication and Summation}

Then, the fuzzy extent analysis is applied on the above fuzzy PCM to obtain the fuzzy performance matrix. The purpose of fuzzy extent analysis is to obtain the criteria importance and alternative performance by solving these fuzzified reciprocal PCMs.

\[
\tilde{X}_j \text{ or } \tilde{W}_j = \frac{\sum_{i=1}^{k} \tilde{a}_{ij}}{\sum_{i=1}^{k} \sum_{j=1}^{k} \tilde{a}_{ij}}
\]

where \( i = 1, 2, 3, \ldots, p \) and \( j = 1, 2, 3, \ldots, q \) and \( k = p \) or \( k = q \), depending upon the element under operation, whether it is an alternative or criteria (the number of rows and columns in the PCM)

\[
\tilde{X}_j = \begin{bmatrix}
    (x_{11j} x_{11m} x_{11u}) \\
    (x_{21j} x_{21m} x_{21u}) \\
    \vdots \\
    (x_{ijj} x_{ijm} x_{iju})
\end{bmatrix}
\]

Fuzzy extent analysis is applied to get the fuzzy decision or performance matrix \( (\tilde{X}_j) \) and fuzzy weights \( (\tilde{W}) \). After that, a fuzzy weighted performance matrix \( (\tilde{P}) \) can thus be obtained by multiplying the weight vector with the decision matrix.

\[
\tilde{P} = \tilde{X}_j * \tilde{W} = \begin{bmatrix}
    (w_1 x_{11j} x_{11m} x_{11u}) \\
    (w_2 x_{21j} x_{21m} x_{21u}) \\
    \vdots \\
    (w_n x_{njj} x_{njm} x_{nju})
\end{bmatrix}
\begin{bmatrix}
    P_{11} P_{1m} P_{1u} \\
    P_{21} P_{2m} P_{2u} \\
    \vdots \\
    P_{n1} P_{nm} P_{nu}
\end{bmatrix}
\]

The next step will be weight summation where the weighted performance matrix \( (\tilde{P}) \) for each alternative under each criteria context is sum up to obtain a total weighted performance matrix for each alternative.

\textbf{(Step 3) Check Fuzzy Ranking with Alpha-Cuts-Based Method 1}

According to Wang (1997), in order to make a crisp choice among the alternatives, alpha-cuts-based method 1 is needed for checking and comparing fuzzy number. The alpha-cuts-based method 1 stated that if let A and B be fuzzy numbers with \( \alpha \)-cuts, \( A_{\alpha} = [a_{\alpha}^-, a_{\alpha}^+] \) and \( B_{\alpha} = [b_{\alpha}^-, b_{\alpha}^+] \). It say \( A \) is smaller than \( B \), denoted by \( A \leq B \), if \( a_{\alpha}^- < b_{\alpha}^- \) and \( a_{\alpha}^+ < b_{\alpha}^+ \) for all \( \alpha \in (0, 1] \). The advantage of this method is the conclusion is less controversial.

Here, apply the alpha cut analysis to the total weighted performance matrices for each alternative, and checking for the ranking
consistency for each alternative under different alpha level circumstances.

(Step 4) Alpha Cut Analysis for Confidence Level Representation

The alpha cut analysis is applied to transform the total weighted performance matrices into interval performance matrices. The alpha cut is to account for the uncertainty in the fuzzy range chosen. In this case, the decision maker expressed personal confidence about this range. The confidence value ranges between 0 and 1, from the least confidence to the most confidence.

**Alpha Cuts Analysis**

\[
\alpha_{Left} = [\alpha \times (\text{Middle}_\text{fuzzy} - \text{Left}_\text{fuzzy})] + \text{Left}_\text{fuzzy}
\]

\[
\alpha_{Right} = \text{Right}_\text{fuzzy} - [(\alpha \times (\text{Right}_\text{fuzzy} - \text{Middle}_\text{fuzzy}))]
\]

\[
\tilde{P}_{\alpha} = \begin{pmatrix}
\{P_{1\alpha}, P_{1\alpha}\} \\
\{P_{2\alpha}, P_{2\alpha}\} \\
\cdot \\
\cdot \\
\{P_{n\alpha}, P_{n\alpha}\}
\end{pmatrix}
\]

where \( l \) and \( r \) represent the left and right value of the interval set.

(Step 5) Lambda Function and Crisp Values Normalization

Through the alpha cut analysis, it will get two values namely Alpha Right (maximum range) and Alpha Left (minimum range) which need to be converted into a crisp value. It is done by applying the Lambda function which represents the attitude of the decision maker. The attitude of the decision maker is maybe optimistic, moderate or pessimistic. Decision maker with optimistic attitude will take the maximum values of the range; the moderate person will take the medium value and the pessimistic person will take the minimum value of the range. Here, the concept of optimism index, \( \lambda \), is introduced to obtain the crisp output.

\[
\text{Crisp}_{\text:value} = \lambda \times \alpha_{\text{Right}} + [(1 - \lambda) \times \alpha_{\text{Left}}]
\]

\[
C_{\lambda} = \lambda \times P_{\alpha} + (1 - \lambda) \times P_{\alpha}
\]

where \( \lambda \in [0,1] \)

\[
C_{\lambda} = \begin{pmatrix}
C_{1,\lambda} \\
C_{2,\lambda} \\
\cdot \\
\cdot \\
C_{n,\lambda}
\end{pmatrix}
\]

Finally, the crisp values need to be normalized, because the elements of the PCM do not have the same scale. It is important to note that elements can be compared if they have the uniform scale.

\[
C_{i,\lambda} = \frac{C_{i,\lambda}}{\sum C_{i,\lambda}}
\]

3. Decision Making Tool

We developed a web base decision making tool using web technology; ASP.NET. In our decision making tool, we used C#.NET for supporting the algorithm. When users are first directed to the webpage (Figure 1-4), they are required to input their problem domain, goal, criteria and alternatives.
After key-in the input, users are directed to next page which is computation for pairwise comparison (Figure 1-5.).
Users are required to do evaluation on the criteria and alternatives. They are able to evaluate either numerically or verbally. For numerical approach, users are allowed to select from the drop down box to rank them (ranges from 1 to 9) accordingly. Besides, users are also provided to assess verbally (e.g. more important, equally important and less important) on them. After the evaluation, users are required to choose mode of operation; traditional AHP or Fuzzy AHP (Figure 1-6.). Then, users will be directed to result page. In the result page, confidence and optimistic level of Fuzzy AHP operation are provided for user customization. From there, users are able to see the different output generated which shown in graphical view. Most importantly, this tool generate best alternative among all the others which users have provided at the first place.

Figure 1-6. MCDM Approach Option

4. **Numerical Evaluation**

A numerical example is demonstrated in this section. Consider a fresh graduate student would like to choose a job that can provide overall satisfaction in term of benefits, colleagues, location and reputation. The available jobs are job A, B and C. The hierarchy for the job selection problem is depicted as below.

![Hierarchy Diagram]

Then, the traditional and Fuzzy AHP are applied respectively.
4.1 Assessment using Traditional AHP

From the fuzzified PCM (Table 5 – 9), we can convert to the crisp PCM for the criteria, and alternative under each criteria context. Then, perform the traditional AHP operations, and we can obtain the final score and ranking for each alternatives.

### Table 2- Score of each Alternative

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.5445</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>0.3442</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>0.1113</td>
<td>3</td>
</tr>
</tbody>
</table>

In order to check for the consistency of the pairwise comparison matrix, we need to perform consistency index (CI) and consistency ratio (CR) computation.

Given the pairwise comparison matrix of criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Benefits</th>
<th>Colleagues</th>
<th>Location</th>
<th>Reputation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefits</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Colleagues</td>
<td>1/3</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Location</td>
<td>1/6</td>
<td>1/3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Reputation</td>
<td>1/8</td>
<td>1/4</td>
<td>1/2</td>
<td>1</td>
</tr>
</tbody>
</table>

Local weight | 0.5937 | 0.2439 | 0.1010 | 0.0614 |

\[
\lambda_{\text{max}} = 4.0417
\]

Consistency Index, CI = 0.0139

Given random Index, RI, n = 4; RI = 0.90,
Consistency Ratio, \( CR = \frac{0.0139}{0.90} = 0.0154 \)

Since the Consistency Ratio (CI/CR) < 0.10, so the degree of consistency is satisfactory. The decision maker’s comparison is probably consistent enough to be useful.

4.2 Assessment using Fuzzy AHP

To perform assessment using Fuzzy AHP, the original crisp PCM should fuzzified by referring to the fuzzy number conversion table.

### Table 3- Fuzzified Pairwise Comparison of Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Benefits</th>
<th>Colleagues</th>
<th>Location</th>
<th>Reputation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefits</td>
<td>(1,1,1)</td>
<td>(1,3,5)</td>
<td>(4,6,8)</td>
<td>(6,8,10)</td>
</tr>
<tr>
<td>Colleagues</td>
<td>(1/5,1/3,1/1)</td>
<td>(1,1)</td>
<td>(1,3,5)</td>
<td>(2,4,6)</td>
</tr>
<tr>
<td>Location</td>
<td>(1/8,1/6,1/4)</td>
<td>(1/5,1/3,1/1)</td>
<td>(1,1,1)</td>
<td>(1,2,4)</td>
</tr>
<tr>
<td>Reputation</td>
<td>(1/10,1/8,1/6)</td>
<td>(1/6,1/4,1/2)</td>
<td>(1/4,1/2,1/1)</td>
<td>(1,1,1)</td>
</tr>
</tbody>
</table>
Table 4- Fuzzified Pairwise Comparison of Alternatives in the Context of Benefits

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>(1,1,1)</td>
<td>(1,3,5)</td>
<td>(4,6,8)</td>
</tr>
<tr>
<td>B</td>
<td>(1/5,1/3,1/1)</td>
<td>(1,1,1)</td>
<td>(2,4,6)</td>
</tr>
<tr>
<td>C</td>
<td>(1/8,1/6,1/4)</td>
<td>(1/6,1/4,1/2)</td>
<td>(1,1,1)</td>
</tr>
</tbody>
</table>

Table 5- Fuzzified Pairwise Comparison of Alternatives in the Context of Colleagues

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>(1,1,1)</td>
<td>(1/5,1/3,1/1)</td>
<td>(1,3,5)</td>
</tr>
<tr>
<td>B</td>
<td>(1,3,5)</td>
<td>(1,1,1)</td>
<td>(3,5,7)</td>
</tr>
<tr>
<td>C</td>
<td>(1/5,1/3,1/1)</td>
<td>(1/7,1/5,1/3)</td>
<td>(1,1,1)</td>
</tr>
</tbody>
</table>

Table 6- Fuzzified Pairwise Comparison of Alternatives in the Context of Location

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>(1,1,1)</td>
<td>(4,6,8)</td>
<td>(1,3,5)</td>
</tr>
<tr>
<td>B</td>
<td>(1/8,1/6,1/4)</td>
<td>(1,1,1)</td>
<td>(1,6,1/4,1/2)</td>
</tr>
<tr>
<td>C</td>
<td>(1/5,1/3,1/1)</td>
<td>(2,4,6)</td>
<td>(1,1,1)</td>
</tr>
</tbody>
</table>

Table 7- Fuzzified Pairwise Comparison of Alternatives in the Context of Reputation

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>(1,1,1)</td>
<td>(1,2,4)</td>
<td>(4,6,8)</td>
</tr>
<tr>
<td>B</td>
<td>(1/4,1/2,1/1)</td>
<td>(1,1,1)</td>
<td>(1,3,5)</td>
</tr>
<tr>
<td>C</td>
<td>(1/8,1/6,1/4)</td>
<td>(1/5,1/3,1/1)</td>
<td>(1,1,1)</td>
</tr>
</tbody>
</table>

After obtaining the fuzzified pairwise comparison matrices, the Fuzzy extent analysis is applied as following this procedure:

For the fuzzified pairwise comparison of criteria,

Total sum of the whole fuzzy PCM:-

\[
\text{Left} = (1+1+4+6+1/5+1+1+2+1/8+1/5+1+1+1/10+1/6+1/4+1) \\
= 20.0417 \ (b_1)
\]

\[
\text{Middle} = (1+3+6+8+1/3+1+3+4+1/6+1/3+1+2+1/8+1/4+1/2+1) \\
= 31.7083 \ (b_2)
\]

\[
\text{Right} = (1+5+8+10+1/1+1+5+6+1/4+1/1+1+4+1/6+1/2+1/1+1) \\
= 45.9167 \ (b_3)
\]
The first row sum (for Benefits)  

\[
\text{Left} = (1+1+4+6) = 12 (a_1) \\
\text{Middle} = (1+3+6+8) = 18 (a_2) \\
\text{Right} = (1+5+8+10) = 24 (a_3)
\]

First row sum / Total sum  

\[
\text{Left} = \frac{a_1}{b_3} = \frac{12}{45.9167} = 0.2613 \\
\text{Middle} = \frac{a_2}{b_2} = \frac{18}{31.7083} = 0.5677 \\
\text{Right} = \frac{a_3}{b_1} = \frac{24}{20.0417} = 1.1975
\]

The same calculation above applies to other criteria- colleagues, location and reputation.

Table 8- Overall Weight of each Criterion (after Fuzzy Extent Analysis)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Overall Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left</td>
</tr>
<tr>
<td>Benefits</td>
<td>0.2613</td>
</tr>
<tr>
<td>Colleagues</td>
<td>0.0915</td>
</tr>
<tr>
<td>Location</td>
<td>0.0506</td>
</tr>
<tr>
<td>Reputation</td>
<td>0.0330</td>
</tr>
</tbody>
</table>

Table 9- Performance of each Alternative (after Fuzzy Extent Analysis)

<table>
<thead>
<tr>
<th>Performance</th>
<th>Benefits</th>
<th>Colleagues</th>
<th>Location</th>
<th>Reputation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>(0.2526,0.5970,1.3344)</td>
<td>(0.0985,0.2915,0.8194)</td>
<td>(0.2526,0.5970,1.3344)</td>
<td>(0.2697,0.6000,1.3577)</td>
</tr>
<tr>
<td>B</td>
<td>(0.1347,0.3184,0.7625)</td>
<td>(0.2239,0.6054,1.5217)</td>
<td>(0.0544,0.0846,0.1668)</td>
<td>(0.1011,0.3000,0.7311)</td>
</tr>
<tr>
<td>C</td>
<td>(0.0544,0.0846,0.1668)</td>
<td>(0.0601,0.1031,0.2731)</td>
<td>(0.1347,0.3184,0.7625)</td>
<td>(0.0596,0.1000,0.2350)</td>
</tr>
</tbody>
</table>

Table 10- Weighted Performance of each Alternative

<table>
<thead>
<tr>
<th>Performance</th>
<th>Weighted Performance ($P=X_i^rW$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Benefits</td>
</tr>
<tr>
<td>A</td>
<td>(0.0660,0.3389,1.5979)</td>
</tr>
<tr>
<td>B</td>
<td>(0.0352,0.1808,0.9131)</td>
</tr>
<tr>
<td>C</td>
<td>(0.0142,0.0480,0.1997)</td>
</tr>
</tbody>
</table>

Table 11- Total Weighted Performance

<table>
<thead>
<tr>
<th>Total Weighted Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
</tbody>
</table>
From the $\alpha$-cut-based Method 1, the result is consistent enough to show job A has the highest fuzzy ranking at all alpha level following by job B and C respectively.

Table 14- Comparison of Traditional AHP and Fuzzy AHP Results

<table>
<thead>
<tr>
<th>Traditional AHP</th>
<th>Fuzzy AHP ($\alpha = 0.5$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 0.5445</td>
<td>0.5069 0.5059</td>
</tr>
<tr>
<td>B 0.3442</td>
<td>0.3739 0.3752</td>
</tr>
<tr>
<td>C 0.1113</td>
<td>0.1192 0.1189</td>
</tr>
</tbody>
</table>

The score of each alternative under traditional AHP and Fuzzy AHP is consistent where job A, B and C’s final score are approximate 0.5, 0.3 and 0.1 respectively. Hence, both approaches indicated that job A is the alternative that can provide the highest job satisfaction.
Figure 1-7. Pessimistic Decision Maker for the Job Selection Problem

Figure 1-8. Moderate Decision Maker for the Job Selection Problem

Figure 1-9. Optimistic Decision Maker for the Job Selection Problem
The three graphs above indicated the fuzzy number ranking of Fuzzy AHP is consistent at different alpha level for a pessimistic, moderate and optimistic decision maker. The job A always obtained the highest score compared to job B and job C.

5. Conclusion

In this paper, fuzzy set theory and AHP have been deployed to capture the decision making process by users to provide reliable and efficient decision. Most importantly, user is spoilt with user friendly interface provided in the tool. This achieved program simplicity and abstraction of the algorithm that works behind the scene. User would hardly need to have any matrix knowledge to run this tool to solve their decision making. Besides, this tool provides web base feature for user to access this tool regardless where they are which enhances portability. We are also integrating the domain information repository into the tool to provide user with the raw data and meaningful attributes (criteria and alternatives) for several common problem domain. Hence, user who is first timer in using this tool can refer to their specified problem domain which matches with the existing repository on possible available attributes and data. User can obtained reliable and best desired decision conveniently and efficiently by using this tool. Indeed, our proposed paper will bring a new breathe to decision making field to the society overall.

References


