Based on HFS VIKOR Method to Solve Mobile Learning APP Project Evaluation

Zhi-Fang GAO, Shi-Ya PAN, Ding-Hong PENG

Institute of Quality Development, Kunming University of Science and Technology, Kunming, China

Keywords: VIKOR; Hesitant fuzzy set; Decision making; Mobile learning APP.

Abstract. In order to help the mobile devices to choose the appropriate learning APP, so the hesitation fuzzy set VIKOR method is used in the mobile learning APP scheme selection. In order to fully consider the expert opinion, the hesitant fuzzy set is introduced, and it is combined with the VIKOR method to form a scientific and effective decision-making method. At the end of the paper, the feasibility of the method is illustrated by an example.

Introduction

With the popularity of Internet technology and mobile devices, people's habit of moving from PC terminal to mobile terminal has become a trend. All kinds of mobile learning APP have become the primary choice for everyone to learn in spare time. According to the 2016 mobile Internet Education user research analysis report, people's learning patterns are becoming mobile and fragmented. In order to avoid the loss of information in the process of bidding evaluation and simulate the uncertainty of decision making from the perspective of human beings, it is particularly important to introduce the hesitant fuzziness into the APP selection method of mobile learning in order to make the APP selection method of mobile learning avoid the uncertainty of information in the bidding process.

But in the process of decision making, it is difficult for experts to give an accurate value when evaluating the object, and there is a certain fuzziness in the process of decision making. In order to solve some fuzziness in decision-making process, Zadeh[1] put forward fuzzy set theory, which is closer to the actual decision-making process of human beings, and has been widely applied in real life. Since the introduction of the theory of fuzzy sets, it has attracted numerous scholars to study it deeply. Torra [2] proposes the concept of hesitant fuzzy sets on the basis of fuzzy multiple sets. The number of the membership values of the hesitant fuzzy set is uncertain, and the degree of hesitation of the people is represented by the degree of membership. Therefore, the theory, compared with other fuzzy theories, can more fully reflect the degree of hesitation in the process of dealing with things. Hesitation fuzzy sets can be used in decision-making to retain expert decision information to a greater extent, and it is of great significance in practical decision making.

The VIKOR method is a common multi criterion decision method. This method is a multiple attribute decision making method proposed by Opricovic[3] in 1998. The main idea is to determine the ideal solution and negative ideal solution first, and then screen the scheme by calculating the distance between the evaluation values of positive and negative ideal solution. This paper combines hesitate fuzzy sets and VIKOR methods combined to form a mobile learning APP program decision-making method.

Preliminaries

Hesitant Fuzzy Set

Definition 1[2]: Let X be a fixed set, a hesitant fuzzy set (HFS) on X is in terms of a function that when applied to X returns a subset of [0,1]. For the sake of ease of understanding, it can be expressed as: \( A = \{ x, h_A(x) \mid x \in X \} \), where \( h_A(x) \) is a set of values in [0,1], denoting the possible
membership degrees of the element \( x \in X \) to the set of \( A \). For convenience, \( h_a(x) = \{ \gamma | \gamma \in h_a(x) \} \) is called a hesitant fuzzy element (HFE).

Definition 2[3]: For a hesitant fuzzy element (HFE) \( h \), \( s(h) = \frac{1}{\# h} \sum_{\gamma \in h} \gamma \) is the score of \( h \), which \( \#h \) is the number of the element in \( h \).

Definition 3[4]: A hesitant fuzzy element (HFE) \( h_a(x) = \{ \gamma | \gamma \in h_a(x) \} \), its entropy can be expressed as:
\[
E_{h(a)} = 1 - \frac{2}{\# h} \sum |\gamma - 0.5|
\]

Definition 4[3]: For two hesitant fuzzy elements \( h_1 \) and \( h_2 \), if \( s(h_1) < s(h_2) \), then \( h_1 < h_2 \); if \( s(h_1) = s(h_2) \), then \( h_1 = h_2 \).

**The Basic Idea of the VIKOR**

The main idea of the VIKOR method is to determine the positive ideal solution (PIS) and the negative ideal solution (NIS) and then select the scheme according to the distance between the evaluation values of each plan and PIS.

VIKOR uses the aggregation function[4] developed by \( L_{pj} \):
\[
L_p = \left\{ \frac{\sum_{i=1}^{n} \left[ w_i \left( f_i^* - f_{ij} \right) \right]^p}{\sum_{i=1}^{n} \left[ f_i^* - f_{ij} \right]^p} \right\}^{1/p}, \text{which } 1 \leq p \leq \infty, \ j = 1, 2, \ldots, J, \ J \text{ represents the number of the evaluation objects, The evaluation object is expressed in } a_j. f_j^* \text{ represents the evaluation value of the } i \text{ evaluation index of the evaluation object } a_j, f_j^- \text{ expression of positive ideal solution, } f_j^- \text{ expression of negative ideal solution, } p \text{ refers to the parameter distance of the aggregation function (usually its range is from } 1, 2 \text{ or } \infty, \text{This article takes } 1), n \text{ express the number of evaluation indicators, } w_i \text{ Representing the weight of the evaluation index, } L_{pj} \text{ is the distance from the } a_j \text{ to the ideal solution.}

**Based on HFS VIKOR Method**

The characteristic of multiple attribute decision problem is how to make the decision-making process more consistent with the characteristics of people's incomplete rationality on the basis of not losing the information as much as possible. In this paper, first we use hesitant fuzzy sets to process decision information of experts, then transform the hesitant fuzzy matrix, and finally choose the best way by VIKOR method.

The specific steps are as follows:

Step 1: Establishing a hesitant fuzzy decision matrix based on expert decision information \( H = (h_i)_{n \times n} \);

Step 2: According to the definition3, reach hesitant fuzzy entropy \( E \) of the hesitant fuzzy decision matrix \( H = (h_i)_{n \times n} \). From the information entropy theory, it is known that the smaller the entropy, the more important the corresponding evaluation index is. Using the information entropy[6] to
calculate the weight of the index \( j \):
\[
\omega_j = \frac{1 - E_j}{n - \sum_{j=1}^{n} E_j}, \quad \text{which} \quad E_j = \frac{1}{n} \sum_{i=1}^{n} (E_{ij}).
\]

Step 3: Establishing score function matrix \( S \) according to definition 2. And according to the definition 4 comparison score matrix \( S_1 \). The positive ideal solution \( f_j^+ \) and negative ideal solution \( f_j^- \) of each index are obtained, which \( f_j^+ = \max f_{ij}, f_j^- = \min f_{ij} \).

Step 4: The group benefit value \( S_i \) and individual regret value \( R_i \) of each scheme are calculated, which
\[
\max_{i} S_i, \quad \min_{i} S_i, \quad \max_{i} R_i, \quad \min_{i} R_i.
\]

Step 5: Calculating the rate of interest for each scheme \( Q_i \).
\[
Q_i = v(S_i - S^+) + (1 - v)(R_i - R^+) - (R^- - R^+), \quad \text{which} \quad S^+ = \min S_i, \quad S^- = \max S_i, \quad R^+ = \min R_i, \quad R^- = \max R_i, \quad V \text{ is the coefficient of decision mechanism, Take } V=0.5 \text{ here, balancing this approach minimizes group utility maximization and negative impact.}
\]

Step 6: Sorting the \( S_i, R_i \), and \( Q_i \) of each scheme, the best in the front; When the following two conditions are met at the same time, the best scheme is arranged according to the \( Q \) value. The smaller the \( Q \), the better the scheme is.

Condition 1: \( Q(a^{(2)}) - Q(a^{(1)}) \geq \frac{1}{m-1} \), which \( a^{(1)} \) is the best evaluation object in the \( Q \) sort and \( a^{(2)} \) is the second best evaluation object in the \( Q \) sort.

Condition 2: \( a^{(i)} \) is the former evaluation object of \( S \) or \( R \).

If condition 1 is not satisfied, then scheme \( a^{(1)}, a^{(2)} \ldots a^{(t)} \) is a compromise solution which \( a^{(t)} \) satisfied
\[
Q(a^{(t)}) - Q(a^{(1)}) \geq \frac{1}{m-1}; \quad \text{If condition 2 is not satisfied, the scheme } a^{(1)} \text{ and } a^{(2)} \text{ are all compromise solution.}
\]

A Case of Study

A mobile learning APP company wants to develop new markets and design a mobile learning APP that meets the needs of young people. We have designed four mobile terminal schemes \( A_1, A_2, A_3, A_4 \). Through consultation, the following four indicators are chosen to judge the advantages and disadvantages of the 4 schemes: \( C_1 \) (Interface friendliness), \( C_2 \) (system reliability), \( C_3 \) (Functional comprehensiveness), \( C_4 \) (Safety and security).

Step 1: The score of the 4 schemes is given in the form of hesitation and fuzziness, and the following fuzzy expert scoring matrix is formed.

<table>
<thead>
<tr>
<th></th>
<th>( C_1 )</th>
<th>( C_2 )</th>
<th>( C_3 )</th>
<th>( C_4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( A_1 )</td>
<td>( {0.2,0.4} )</td>
<td>( {0.3,0.4,0.5} )</td>
<td>( {0.6} )</td>
<td>( {0.6,0.7} )</td>
</tr>
<tr>
<td>( A_2 )</td>
<td>( {0.6,0.8} )</td>
<td>( {0.4,0.5,0.6} )</td>
<td>( {0.4} )</td>
<td>( {0.7,0.8} )</td>
</tr>
<tr>
<td>( A_3 )</td>
<td>( {0.4,0.7} )</td>
<td>( {0.5,0.6,0.7} )</td>
<td>( {0.5} )</td>
<td>( {0.5,0.7} )</td>
</tr>
<tr>
<td>( A_4 )</td>
<td>( {0.3,0.6} )</td>
<td>( {0.2,0.4,0.5} )</td>
<td>( {0.3} )</td>
<td>( {0.4,0.5} )</td>
</tr>
</tbody>
</table>

Step 2: Based on definition 3, the hesitant fuzzy entropy matrix is obtained, Get the weight according to step 2:
\[
\sigma_1 = 0.319149, \quad \sigma_2 = 0.170213, \quad \sigma_3 = 0.170213, \quad \sigma_4 = 0.340426.
\]

Step 3: Calculation of the score matrix \( S \) according to definition 2
Table 2. Hesitant Fuzzy Entropy Matrix.

<table>
<thead>
<tr>
<th></th>
<th>C₁</th>
<th>C₂</th>
<th>C₃</th>
<th>C₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>A₁</td>
<td>0.6</td>
<td>0.8</td>
<td>0.8</td>
<td>0.7</td>
</tr>
<tr>
<td>A₂</td>
<td>0.6</td>
<td>0.8667</td>
<td>0.8</td>
<td>0.5</td>
</tr>
<tr>
<td>A₃</td>
<td>0.7</td>
<td>0.8</td>
<td>1.0</td>
<td>0.8</td>
</tr>
<tr>
<td>A₄</td>
<td>0.6</td>
<td>0.7333</td>
<td>0.6</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Table 3. Score Matrix.

<table>
<thead>
<tr>
<th></th>
<th>C₁</th>
<th>C₂</th>
<th>C₃</th>
<th>C₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>A₁</td>
<td>0.3</td>
<td>0.4</td>
<td>0.6</td>
<td>0.65</td>
</tr>
<tr>
<td>A₂</td>
<td>0.7</td>
<td>0.5</td>
<td>0.4</td>
<td>0.75</td>
</tr>
<tr>
<td>A₃</td>
<td>0.55</td>
<td>0.6</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>A₄</td>
<td>0.45</td>
<td>0.367</td>
<td>0.3</td>
<td>0.45</td>
</tr>
</tbody>
</table>

Step 4: According to definition 4, the positive and negative ideal solutions are found through table 2 and calculated $S_i$, $R_i$, $Q_i$

Table 4. Calculation Results.

<table>
<thead>
<tr>
<th></th>
<th>w₁</th>
<th>w₂</th>
<th>w₃</th>
<th>w₄</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.319149</td>
<td>0.170213</td>
<td>0.170213</td>
<td>0.340426</td>
</tr>
<tr>
<td>C₁</td>
<td>C₂</td>
<td>C₃</td>
<td>C₄</td>
<td>Sᵢ</td>
</tr>
<tr>
<td>A₁</td>
<td>[0.3,0.4]</td>
<td>[0.3,0.4,0.5]</td>
<td>[0.6]</td>
<td>[0.6,0.7]</td>
</tr>
<tr>
<td>A₂</td>
<td>[0.6,0.8]</td>
<td>[0.4,0.5,0.6]</td>
<td>[0.4]</td>
<td>[0.7,0.8]</td>
</tr>
<tr>
<td>A₃</td>
<td>[0.4,0.7]</td>
<td>[0.5,0.6,0.7]</td>
<td>[0.5]</td>
<td>[0.5,0.7]</td>
</tr>
<tr>
<td>A₄</td>
<td>[0.3,0.6]</td>
<td>[0.2,0.4,0.5]</td>
<td>[0.3]</td>
<td>[0.4,0.5]</td>
</tr>
<tr>
<td>$f_j^+$</td>
<td>[0.6,0.8]</td>
<td>[0.5,0.6,0.7]</td>
<td>[0.6]</td>
<td>[0.7,0.8]</td>
</tr>
<tr>
<td>$f_j^-$</td>
<td>[0.2,0.4]</td>
<td>[0.2,0.4,0.5]</td>
<td>[0.3]</td>
<td>[0.4,0.5]</td>
</tr>
</tbody>
</table>

It can be seen from the table that scheme 3 is the best one.

Conclusions

This paper combines the hesitant fuzzy set with the VIKOR method, and applies this method to the choice of mobile learning APP scheme. The hesitant fuzzy set preserves the uncertain information of the expert in the decision making, making the decision result more convincing. As a common multi attribute decision making method, VIKOR is evaluated on the basis of real evaluation data, which is relatively objective. The combination of the two methods can make the decision result more scientific. At the end of the paper, an example is given to verify the feasibility of the method proposed in this paper.

References