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Selection of Engineering Materials (Cousrell) Lec-4

Preference selection index (PSI) method

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Preference Selection Index method to solve the problem of material selection (MCDM). In contrast to most methods (MCDM). Actually, the Preference Selection Index Method determines the weight of the criteria only by using the information provided in the decision matrix, that is, using an objective approach to determine the weight of the criteria. This method is also proper when there is a conflict in determining the relative importance between attributes

The steps involved in the Preference Selection Index method are as follows:

Step 1. Identify the goal. Find out all possible the candidate (alternatives), selection attributes and its measures for the given application.

Step 2. Establish the MADM decision matrix. The solving each MADM problem begins with constructing decision matrix. Let $X=\{x_1, x_2, \ldots, x_m\}$ be a set of alternative, $O=\{o_1, o_2, \ldots, o_n\}$ be a set of decision attributes or criteria, a_{ij} is the performance of alternative x_i on the attribute o_j. Then the machine selection problem can be expressed with the decision matrix form $A=(a_{ij})_{m\times n}$

Step 3. Normalize the decision matrix A into normalization decision matrix $R=(r_{ij})_{m\times n}$.

The process of transforming attributes value into a range of [0,1] is called normalization and it is required in MADM methods to transform performance rating with different data measurement unit in a decision matrix into a compatible unit[15]. The normalization method adopted from the paper [16], and the formulas are given as follows: If the the j-attribute is benefit attribute, then $r_{ij}=a_{ij}/\max\limits_{1\le i\le m}\{a_{ij}\}$; If the j-attribute is cost attribute attribute, then $r_{ij}=\min\limits_{1\le i\le m}\{a_{ij}\}/a_{ij}$.

Step 4. Compute preference variation value (PV_j), which is defined as: $PV_j = \sum_{i=1}^{m} (r_{ij} - \bar{r}_j)^2$, where $\bar{r}_j = \sum_{i=1}^{m} r_{ij} / m$ is the mean of normalized value of attribute j.

Step 5. Determine overall preference value (Ψ_j) for each attribute. To get the overall preference value, it is required to find deviation (Φ_j) in preference value (PV_j) and the deviation in preference value for each attribute is determined using the following equation: $\Phi_j = 1 - PV_j$, and overall preference value (Ψ_j) is determined using following equation: $\Psi_j = \Phi_j / \sum_{j=1}^{n} \Phi_j$ .The total overall preference value of all the attributes should beone, i.e. $\sum_{j=1}^{n} \Psi_j = 1$.

Step 6. Calculate the PSI (I_i), where $I_i = \sum_{j=1}^{n} r_{ij} \times \Psi_j$, for each alternative.

Step7. Rank all the alternatives according to the PSI. After calculation of the PSI (I_i), alternatives are ranked according to descending or ascending order to facilitate the managerial interpretation of the results, i.e. an alternative is ranked/selected first whose PSI (I_i) is highest and an alternative is ranked/selected last whose PSI (I_i) is the lowest and so on.

Case Study

Use the following Table to select the best material from different materials (1,2,3,...10) which have the different properties (*O1, O2, O3 and O4*) Using Preference selection index (PSI) method .

No.	Evaluation attribute values			
	o_1	o_2	o_3	o_4
1	581818	54.49	3	5500
2	595454	49.73	3	4500
3	586060	51.24	3	5000
4	522727	45.71	3	5800
5	561818	52.66	3	5200
6	543030	74.46	4	5600
7	522727	75.42	4	5800
8	486970	62.62	4	5600
9	509394	65.87	4	6400
10	513333	70.67	4	6000

No.	Evaluation attribute values			
	o_1	o_2	o_3	o_4
1	0.8370	0.8389	1.0000	0.8594
2	0.8178	0.9192	1.0000	0.7031
3	0.8309	0.8921	1.0000	0.7813
4	0.9316	1.0000	1.0000	0.9063
5	0.8668	0.8680	1.0000	0.8125
6	0.8968	0.6139	0.7500	0.8750
7	0.9316	0.6061	0.7500	0.9063
8	1.0000	0.7300	0.7500	0.8750
9	0.9560	0.6939	0.7500	1.0000
10	0.9486	0.6468	0.7500	0.9375

The specific calculation steps of the proposed method are given as follows:

Step 1. The normalized attribute values are reported in Table1;

Step 2. The vectors of preference variation value (PV_j), deviation (Φ_j), and overall preference variation value (Ψ_j) are respectively obtain as:

$$PV = (0.0379, 0.1967, 0.1736, 0.0701);$$

$$\Phi = (0.9621, 0.8033, 0.8264, 0.9299);$$

$$\Psi = (0.2732, 0.2281, 0.2347, 0.2640).$$

Step 3. The preference selection index (I_i) are calculated as $I = (0.8816, 0.8534, 0.8714, 0.9566, 0.8840, 0.7921, 0.8080, 0.8467, 0.8595, 0.8302)$. Then the ranking order is 4 - 5 - 1 - 3 - 9 - 2 - 8 - 7 - 10 - 6,

The desirable material is the material No.4.

Finally ,a case study is use to demonstrate and validate the application of the proposed method.