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A New Approach for Selection of Candidate by TOPSIS Technique

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Abstract

The *Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)* is a multi-criteria decision analysis method which is currently one of the most popular methods and has been shown to provide helpful outputs in various application areas. In this paper, we identify the set of important parameters of the decision making system and concept of *TOPSIS*, and calculate the distance of each alternative from the *shortest geometric distance from positive ideal solution (SGDFPIS)* and *longest geometric distance from negative ideal solution (LGDFNIS)*. Finally, we use a numerical experiment to illustrate the procedure of the proposed approach.

Key words: MCDM, TOPSIS, SGDFPIS, LGDFNIS.

1 Introduction

The *Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)* is a multi-criteria decision analysis method, which was originally developed by Hwang and Yoon in 1981¹ with further developments by Yoon in 1987², and Hwang, Lai and Liu in 1993³. *TOPSIS* is based on the concept that the chosen alternative should have the SGDFPIS⁴ and the LGDFNIS⁴. It is a method of compensatory aggregation that compares a set of alternatives by identifying weights for each criterion, normalising scores for each criterion and calculating the geometric distance between each alternative and the ideal alternative, which is the best score in each criterion. An assumption of *TOPSIS* is that the criteria are monotonically increasing or decreasing. Normalisation is usually required as the parameters or criteria are often of incongruous dimensions in multi-criteria problems^{5,6}. Compensatory methods such as *TOPSIS* allow trade-offs between criteria, where a poor result in one criterion can be negated by a good result in another criterion. This provides a more realistic form of modelling than non-

compensatory methods, which include or exclude alternative solutions based on hard cut-offs⁷.

Krohling & Campanharo¹⁰ conducted a case study of accidents with oil spill in the sea by using *TOPSIS* approach. Wang *et al.*^{19,22} applied *TOPSIS* to supplier selection. Sun & Lin¹⁷ used *TOPSIS* for evaluating the competitive advantages of shopping websites. Wang & Chang²⁰ developed an approach in evaluating initial training aircraft under a fuzzy environment for the Taiwan Air Force Academy. Chamodrakas & Martakos¹ applied *TOPSIS* method for energy efficient network selection in heterogeneous wireless networks.

In the following section, we discuss preliminaries involving different types of decision making problem and briefly introduce the *TOPSIS* methodology and an algorithm associated with it. In this paper, we define the PIS, NIS and their distances from the respective alternatives by applying the *TOPSIS* methodology. Moreover, here we define a closeness coefficient to determine the ranking order of the alternative.

2 Preliminaries and Literature Survey :

2.1 Multi-criteria decision making :

There are many cases where decisions are desirable and satisfactory for their makers which are examined and analyzed on the basis of several criteria. For instance, when choosing a career, one considers criteria such as monthly income, place of work, social status etc. and when planning the production, one considers objectives such as maximizing incomes, minimizing costs, reducing wastages, increasing satisfaction of employees etc. Only one criterion, such as profit, cost, efficiency, time etc. is considered in models such as linear planning, integer planning, nonlinear planning, allocation, and most classical models of operational research. On the other hand, in MCDM models, several criteria are simultaneously used to determine the best choice. Criteria may be quantitative or qualitative and may be incomparable because there are different measurement scales. In determination of different options of a decision, by criteria we mean factors that are considered by the decision maker to increase desirability and self satisfaction. In other words, criteria constitute standards and rules used for judgment and to indicate effectiveness of decisions. Criteria may be presented as objectives or attributes.

2.2 Multi-objective decision making

Objectives involve desires or wishes of the decision maker which may be expressed with terms such as maximizing profit, minimizing costs, etc. When encountered with problems, decision makers may follow simultaneously several objectives. Such problems may be examined as “MODM”. In dealing with such problems, the decision maker’s objectives are expressed as several functions of objectives and solution constitutes the optimization of such functions. Objectives may be expressed with different measurement scales such as money, time, number etc. For example an objective may be the minimization of costs and another may be maximization of production. Another point is that objectives may differ in terms of importance and priority and this point should be taken into account while finding solution of problems¹³.

2.3 Multi-attribute decision making :

Attributes are characteristics, qualities or parameters of operations considered for selection of options of decisions. Attributes may be quantitative or qualitative. Qualitative attributes are usually expressed using words. Words such as few, many, average, low price, high price, small, big etc., represent how much an attribute is achieved. To examine or compare qualitative attributes, we may convert them to numbers. To do so we first arrange the words such as few, average, many, so many and then assign the numbers to the beginning and end. We compare attributes to determine the importance of every one of them in the selection of options. Finally, after determination of the weights of attributes in decision making, the selection will be made in view of points an option has as compared with other options. If a decision is made on the basis of several attributes, then we are encountered with issues known as “MADM”.

3 TOPSIS Methodology :

The TOPSIS technique was initially improved by Hwang and Yoon in 1981⁹. It is a unique technique to identify the ranking of all alternatives considered. The standard TOPSIS technique attempts to choose alternatives that simultaneously have the SGDFPIS and the LGDFNIS. The SGDFPIS maximizes the benefit criteria and minimizes the cost criteria. The LGDFNIS maximizes the cost criteria and minimizes the benefit criteria. TOPSIS ranks these values of relative closeness of the whole system by selecting the highest value of the relative closeness as the best attributes in the system. For the calculation of TOPSIS values, we have to go through the following Algorithm⁹.

Algorithm:

Step-1 Choose decision matrix R which consists of alternative and criteria is described by

$$R = \begin{pmatrix} r_{11} & \cdots & r_{1j} \\ \vdots & \ddots & \vdots \\ r_{i1} & \cdots & r_{ij} \end{pmatrix}$$

where $A_i, i = 1, \dots, m$ are alternatives and $C_j, j = 1, \dots, n$ are criteria, r_{ij} are original scores indicates the rating of the alternative A_i with respect to criteria C_j . The weight vector $w = (w_1, w_2, \dots, w_n)$ is composed of the individual weights $w_j (j = 1, 2, \dots, n)$ for each criteria C_j .

Step-2 Construct normalized decision matrix N_{ij} , where $N_{ij} = r_{ij} / \sqrt{\sum r_{ij}^2}$ for $i = 1, \dots, m;$
 $j = 1, \dots, n$ where r_{ij} and N_{ij} are original and normalized score of decision matrix, respectively.

Step-3 Construct the weighted normalized decision matrix: $V_{ij} = w_j N_{ij}$, where w_j is the weight for j^{th} criteria and $\sum w_j = 1$.

Step-4 Determine the PIS and NIS.

$$A^+ = (v_1^+, v_2^+, \dots, v_n^+) \text{ and } A^- = (v_1^-, v_2^-, \dots, v_n^-)$$

$$\text{where } v_j^+ = \{\max_i V_{ij} | j \in J_1; \min_i V_{ij} | j \in J_2\} \text{ and } v_j^- = \{\min_i V_{ij} | j \in J_1; \max_i V_{ij} | j \in J_2\}$$

where J_1 and J_2 represents the benefit criteria and cost criteria respectively.

Step-5 Compute the Euclidean distances from the positive ideal A^+ and negative ideal A^- solutions for each alternatives A_i respectively:

$$d_i^+ = \sqrt{\sum_j (\Delta_{ij}^+)^2} \text{ and } d_i^- = \sqrt{\sum_j (\Delta_{ij}^-)^2} \text{ where } \Delta_{ij}^+ = (v_j^+ - V_{ij}) \text{ and } \Delta_{ij}^- = (v_j^- - V_{ij})$$

with $i = 1, \dots, m$

Step-6 Compute the relative closeness Ω_i for each alternative A_i with respect to positive ideal solution A^+ as given by $\Omega_i = d_i^- / (d_i^- + d_i^+)$ where $i=1, \dots, m$.

4 Numerical Example :

In this section, we work out a numerical example to illustrate the *TOPSIS* method for decision making problems with cripes data. Assume that college "U" desires to find the best faculty form the college. A committee of expert decision makers to conduct the interview with **eight** eligible candidates according their students feedback. Suppose that we have **six** criteria C_1, \dots, C_6 are identified and eight alternatives A_1, \dots, A_8 are identified as the evaluation criteria for these alternatives. Six criteria's are considered: Knowledge, expertise and confidence to explain the learning objective C_1 , Ability to clear doubts and correlate concepts with practical examples C_2 , Communication skill and clarity C_3 , Punctuality and regularity in taking class to syllabus coverage C_4 , Attitude towards students and Motivating students and creating interest on subject taught C_5 , Timely evaluation of internal assessment papers C_6 . The proposed method is applied to solve this problem.

Table-1 The decision matrix and weights of ten alternatives

Alt.\Cri.	C_1	C_2	C_3	C_4	C_5	C_6
A ₁	0.9	0.8	0.7	0.5	1.0	0.8
A ₂	1.0	0.5	0.9	0.8	0.6	0.9
A ₃	0.6	0.8	1.0	0.7	0.8	0.9
A ₄	1.0	0.6	0.8	1.0	0.9	0.5
A ₅	0.9	0.6	0.5	0.8	1.0	0.9
A ₆	1.0	0.8	0.9	0.6	0.7	0.8
A ₇	0.9	1.0	0.7	0.9	0.8	1.0
A ₈	0.9	0.9	1.0	0.8	0.7	0.9
Weight	0.1	0.25	0.12	0.18	0.15	0.2

Table-2 The normalized decision matrix

Alt.\Cri.	C_1	C_2	C_3	C_4	C_5	C_6
A ₁	0.3503	0.4446	0.3734	0.2275	0.4291	0.3330
A ₂	0.3892	0.2223	0.3734	0.3640	0.2575	0.3747
A ₃	0.2335	0.3556	0.4149	0.3185	0.3433	0.3747
A ₄	0.3892	0.2667	0.3319	0.4550	0.3862	0.2082
A ₅	0.3503	0.2667	0.2074	0.3640	0.4291	0.3747
A ₆	0.3892	0.3556	0.3734	0.2730	0.3004	0.3330
A ₇	0.3503	0.4446	0.2904	0.4095	0.3433	0.4163
A ₈	0.3503	0.4001	0.4149	0.3640	0.3004	0.3747

Table-3 The weighted normalized decision matrix

Alt.\Cri.	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆
A ₁	0.0350	0.1111	0.0448	0.0410	0.0644	0.0666
A ₂	0.0389	0.0556	0.0448	0.0655	0.0386	0.0749
A ₃	0.0234	0.0889	0.0498	0.0573	0.0515	0.0749
A ₄	0.0389	0.0667	0.0398	0.0819	0.0579	0.0416
A ₅	0.0350	0.0667	0.0249	0.0655	0.0644	0.0749
A ₆	0.0389	0.0889	0.0448	0.0491	0.0451	0.0666
A ₇	0.0350	0.1111	0.0348	0.0737	0.0515	0.0833
A ₈	0.0350	0.1000	0.0498	0.0655	0.0451	0.0749

Table-4 Closeness coefficients

	A ₁	A ₂	A ₃	A ₄	A ₅	A ₆	A ₇	A ₈
d_i^+	0.0447	0.0641	0.0397	0.0620	0.0543	0.0474	0.0217	0.0291
d_i^-	0.0701	0.0485	0.0572	0.0514	0.0513	0.0498	0.0793	0.0670

Table-5 Ranking order

	A ₁	A ₂	A ₃	A ₄	A ₅	A ₆	A ₇	A ₈
Ω_i	0.6107	0.4306	0.5905	0.4529	0.4860	0.5127	0.7852	0.6968
Rank	3	8	4	7	6	5	1	2

These data and also the vector of corresponding weight, of each criteria, linguistic weights, the normalized decision matrix and weighted normalized decision matrix are given in Table 1, Table 2, and Table 3, respectively. The closeness coefficients, which are defined to determine the ranking order of all alternatives by calculating the distance to both the SGDFPIS and LGDFNIS, are given in Table 4. According to the closeness coefficient, ranking the order preference, order of these alternatives is also given in Table 5.

Table 5 shows the results obtained for the above example by using the proposed approach. So the ranking orders of 8 candidates are selected as follows:

$$A_7 > A_8 > A_1 > A_3 > A_6 > A_5 > A_4 > A_2$$

The best selection in the given alternatives, the selected candidate is A_7 .

5 Conclusion

Here we provide a thorough and systematic review of the existing MCDM methods. Theoretical background as well as the algorithm is presented for this method. Here, we consider the SGDFPIS and LGDFNIS. *i.e.* the less distance from the PIS and the more distance from the NIS. In this paper, we propose a new methodology to provide a simple approach to find best alternative faculty and help decision makers to select the best one.

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