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Multi-Attribute Decision Making For Selection of Best High School Results Using TOPSIS Method

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ABSTRACT
In the real world the decisions are frequently made by a group of decision makers. Decision making (DM) can be regarded as a process of selecting or ranking alternatives from set, based on the decision information under the acting condition. In real life many DM problems in the practice of management science, operation research, and industrial engineering usually require to resolve multi-attribute decision making (MADM) issues at the same time. The fundamental procedure of TOPSIS (technique for order performance by similarity to ideal solution) method, the ranking position of an alternative depends on the relative closeness to the positive ideal solution (PIS) and the negative ideal solution (NIS), respectively. This method is capable of dealing with an imperfect setting of each DM can define independently the criteria set, the weight vector to use in each criterion. We use a numerical example to demonstrate the methodology of the suggested approach.
Keywords:-DM, Interval numbers, MADM, NIS, PIS, TOPSIS,

I. INTRODUCTION

Among the aforementioned MADM techniques, TOPSIS introduced by Hwang and Yoon [1], as a best developed method for MADM problems on account of simple computation process and high flexibility. The policy of this method is based on selecting the most desirable alternative with considering the shortest distance from the positive from the positive ideal solution and the farthest distance from the negative ideal solution.

In the recent years**,** TOPSIS has been applied to the various fields such as product design [2], human resources management [3], quality control [4], location planning [5], human spaceflight mission simulators [6], risk assessment [7], and sustainability evaluation of the government bond funds [8]. The TOPSIS method made a great contribution to the field, but it still presents serious limitations. In its formulation, TOPSIS only deals with a single decision maker. In the several situations in the real world, decisions are not made by one person only. Instead, they are made by a group of decision makers. TOPSIS method is a unique technique to identify the ranking order of all alternatives in the motioned data. This method consists of two artificial alternatives hypothesis, which are "Ideal Alternative" and "Negative Ideal Alternative". "Ideal Alternative" represents the best level of all attributes as well as "Negative Ideal Alternative" represented the worst attributes values. These two hypotheses, sets of calculations using eigenvector, square root, and summations to obtain a relative closeness value of the criteria tested. These values of relative closeness, TOPSIS ranking by selecting the highest value of the relative closeness as the best attributes in the system. In this method the DM and weight vectors are determined as crisp values and a PIS and a NIS are obtained from the DM.

In the other hand, PIS is a best value of criteria and NIS is a set of worst values achievable of criteria. This method is applied to make wide-ranging evaluation of samples, measured the distances between the index value of each sample and ideal solution along with negative ideal solution of the comprehensive evaluation [9]. By [10] describes multiple DM as multiple DM is applied to preferable decision between available classified alternatives over the multiple attributes or criteria, assume each criteria requires be maximizing or minimizing. Consequently, the positive ideal and negative ideal values of each criteria are identified and each alternative against this information. In the summarised information of the research projects related to TOPSIS method as Wang and Chang [11] developed an approach in evaluating initial training aircraft under a fuzzy environment for the Taiwan Air Force Academy. Sun and Lin [12] used TOPSIS for evaluating the competitive advantages of shopping websites. Wang et al. [13] Applied TOPSIS to supplier selection.

Krohling and Campanharo [14] did a case study of accidents with oil spill in the sea by using TOPSIS approach. Chamodrakas and Martakos [15] applied TOPSIS method for energy efficient network selection in heterogeneous wireless networks. Another limitation of the standard TOPSIS is that it only deals with crisp numbers. Naturally, several generalizations of the TOPSIS to deal with interval number [16]. The ranking results would not differ as if he has no performance for these two separations. The complexity of the decision making problems is not restricted to the necessity of processing different types of information. In many situations, the rank of the alternatives may depend on uncontrollable factors or even change over time.

II. PRELIMINARIES

A. Definitions

Definition1. The objects $b=[b^L, b^U]$ where $b^L \le b^U$, defined on the real line is called interval number. The values b^L and b^U stand for the lower and upper bounds of b respectively. The center and the width of an interval number $b=[b^L, b^U]$ are given by

$$m(b)=\frac{b^L+b^U}{2} \text{ and } w(b)=\left(b^U-b^L\right) \text{ respectively.}$$

Definition 2. Let $b=[b^L, b^U]$ and $c=[c^L, c^U]$ be two interval numbers. The Euclidean distance between b and c is given by

$$d(b,c)=\sqrt{\frac{1}{2}\left[\left(b^L-c^L\right)^2+\left(b^U-c^U\right)^2\right]}$$

Definition 3. Let $b=[b^L, b^U]$ and $c=[c^L, c^U]$ be two interval numbers. The degree of preference of b and c is given by

$$P(b>c)=\frac{\max\{0,b^U-c^L\}-\max\{0,b^L-c^U\}}{b^U-b^L+c^U-c^L}$$

Definition 4. Let $b=[b^L, b^U]$ and $c=[c^L, c^U]$ be two interval numbers. We say that b is superior to c, denoted by $b>c$, if $P(b>c)>P(c>b)$. If $P(b>c)=P(c>a)$, then we say that b is in different to c, denoted by $b=c$.

Definition 5. Let $s_{ij}=[s_{ij}^L, s_{ij}^U]$ be an interval numbers used to evaluate the ith alternative with respect to jth criterion. The normalization of the interval number is given according to the following expressions

$$p_{ij}^L=\frac{s_{ij}^L}{\max_i s_{ij}^U}, \quad i=1,\cdots,m$$

$$p_{ij}^U=\frac{s_{ij}^U}{\max_i s_{ij}^U}, \quad i=1,\cdots,m$$

B. Topsis Method

The TOPSIS method is one of the most widely used multi-criteria decision analysis methods by [17-19]. It was proposed by [10] and extended by [20]. In this method, the best alternative is the one nearest to the positive ideal solution and farthest from the negative ideal solution. Positive ideal solution is hypothetical alternative that maximizes the benefit criteria and simultaneously minimizes the cost criteria. On the NIS maximizes the cost criteria and simultaneously minimizes the benefit criteria. The alternative which has the least Euclidean distance from PIS while being farthest from NIS is the best one of all by [21]. With the above hypotheses, calculations involving eigenvector, square rooting and summations are used for obtaining a relative closeness value of the criteria tested. TOPSIS ranks these values of relative closeness of the whole system by assigning the highest value of the relative closeness to the best attributes in the system. By various linguistic rating applied to represent the performances under certain alternative criteria [22-25]. For calculation of TOPSIS values, we have to go through the following Algorithm.

The main steps of this methodology are (i) Decision matrix construction, (ii) Normalized decision matrix construction, (iii) Weighted normalized decision matrix construction, (iv) Determining the PIS and NIS, (v) Calculating the distances of each alternative to the positive and negative ideal solutions, (vi) Calculating the Closeness Coefficient aggregation function, (vi) Ranking the alternatives.

C. Algorithm

The foundations of the TOPSIS method were presented in the work of Hwang, Yoon, 1981. The basis of the analysis is the decision matrix D_{mn} including ratings of considered alternatives $\alpha=1,2,\cdots,m$ in the context of the accepted criteria $\beta=1,2,\cdots,n$

Step-1 Construct a Decision matrix,

$$D_{mn} = A_{\alpha}\left(d_{\alpha\beta}^{C_{\beta}}\right)_{m\times n}$$

where A_{α} , $\alpha = 1,\cdots,m$ are alternatives and C_{β} , $\beta = 1,\cdots,n$ are criteria, $d_{\alpha\beta}$ are original scores indicates the rating of the alternative A_{α} with respect to criteria C_{β}. The weight vector $w = (w_1, w_2, \cdots, w_n)$ is composed of the individual weights w_{β} $(\beta = 1,2,\cdots,n)$ for each criteria C_{β}. Generally, the criteria are classified into two types: benefit and cost. The benefit criterion is higher value while a cost criterion is valid for opposite value.

Step-2 Construct normalized decision matrix $N_{\alpha\beta}$, where $N_{\alpha\beta} = d_{\alpha\beta} \Big/ \sqrt{\sum d_{\alpha\beta}^2}$ for $\alpha = 1,\cdots,m;\ \beta = 1,\cdots,n$, where $d_{\alpha\beta}$ and $N_{\alpha\beta}$ are original and normalized score of decision matrix, respectively.

Step-3 Construct the weighted normalized decision matrix:

$V_{\alpha\beta} = w_{\beta} N_{\alpha\beta}$, where w_{β} is the weight for β^{th} criteria and $\sum w_{\beta} = 1$.

Step-4 Compute the positive ideal solution and negative ideal solution.

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

where $v_{\beta}^{+} = \{\max_{\alpha} V_{\alpha\beta} | \beta \in J_1; \min_{\alpha} V_{\alpha\beta} | \beta \in J_2\}$

and $v_{\beta}^{-} = \{\min_{\alpha} V_{\alpha\beta} | \beta \in J_1; \max_{\alpha} V_{\alpha\beta} | \beta \in J_2\}$

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 alternative A_{α} respectively:

$$Ed_{\alpha}^{+} = \sqrt{\sum_{\beta}\left(v_{\beta}^{+} - V_{\alpha\beta}\right)^2}$$ and

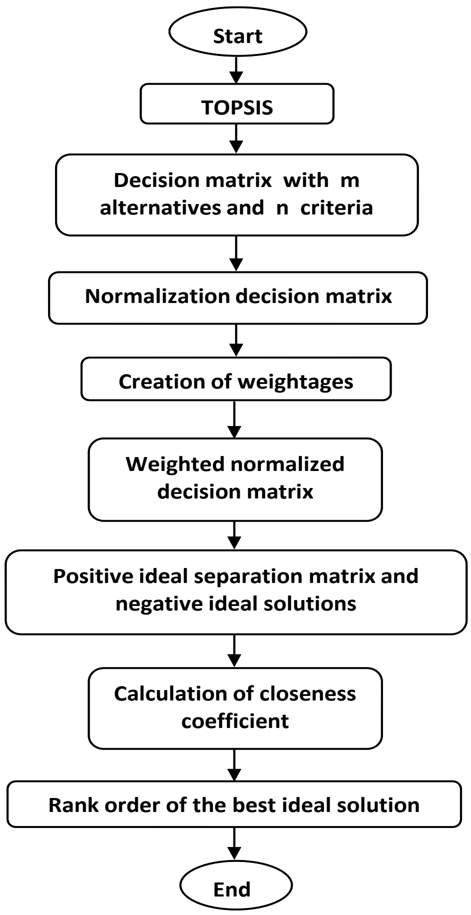
$$Ed_{\alpha}^{-} = \sqrt{\sum_{\beta}\left(v_{\beta}^{-} - V_{\alpha\beta}\right)^2}$$ with $\alpha = 1,\cdots,m$

Step-6 Compute the relative closeness coefficient Ω_{α} for each alternative A_{α} with respect to positive ideal solution A^{+} as given by

$$CC_{\alpha} = Ed_{\alpha}^{-} \Big/ \left(Ed_{\alpha}^{-} + Ed_{\alpha}^{+}\right), \text{ where } \alpha = 1,\cdots,m.$$

The value of Ω_{α} lies in the interval $0 \le \Omega_{\alpha} \le 1$, where $\alpha = 1,\cdots,m$. If $\Omega_{\alpha} = 0$, alternative A_{α} would be negative ideal solution. In contrast, $\Omega_{\alpha} = 1$ denotes A_{α} to be positive ideal solution. An alternative A_{α} gets closer to the negative ideal solution as Ω_{α} approaches 0, whereas alternative A_{α} gets closer to the ideal solution and farther from the negative ideal solution as Ω_{α} approaches 1.

D. Flow Chart



III. EVALUATION FRAMEWORK

In the Central Board of Secondary Education (CBSE) syllabi pattern different type of subjects are included. In this way also different type of inter-curricular and extra-curricular activities are included. Therefore the Students are expert in different fields including teaching learning process. Teachers are creating and motivating the students for these purposes. In academic systems students are giving examination test in different criterion subjects like Mathematics (MAT), Physics (PHY), Chemistry (CHE), Biology (BO), Information Technology (IT), Computer Sciences (CS), First Language (FL), Second Language (SL), Third Language (TL) etc. to the interview for selecting engineering admission. The numbers of students are choosing as a alternatives subject expert. The given subjects, determine which the overall performance of all the subjects get better results and selected for admission in engineering courses according to the values of alternative and criterion. The MADM problem, a number of alternatives can determine and compared to using the different criteria. The aim of MADM problem is to provide support to the decision-maker in the process of making the choice between alternatives. The ranking order of a set of alternatives according to their closeness coefficients and best alternative is found from the set of alternatives. Also, Table-1 defines the weighted (W), negative weighted (NW), positive weighted (PW), euclidean (E), negative euclidean (NE) and positive euclidean (PE) distance for each and every alternative.

Table-I The euclidean and weighted distance of different alternatives

Alt.	W	NW	PW	E	NE	PE
SL1	v_1	v_1^-	v_1^+	Ed_1	Ed_1^-	Ed_1^+
SL2	v_2	v_2^-	v_2^+	Ed_2	Ed_2^-	Ed_2^+
SL3	v_3	v_3^-	v_3^+	Ed_3	Ed_3^-	Ed_3^+
SL4	v_4	v_4^-	v_4^+	Ed_4	Ed_4^-	Ed_4^+
SL5	v_5	v_5^-	v_5^+	Ed_5	Ed_5^-	Ed_5^+
SL6	v_6	v_6^-	v_6^+	Ed_6	Ed_6^-	Ed_6^+
SL7	v_7	v_7^-	v_7^+	Ed_7	Ed_7^-	Ed_7^+
SL8	v_8	v_8^-	v_8^+	Ed_8	Ed_8^-	Ed_8^+
SL9	v_9	v_9^-	v_9^+	Ed_9	Ed_9^-	Ed_9^+

IV. ILLUSTRATIVE EXAMPLES:

In this section, use the different data set from the 12th board examinations in the year 2018. In academic systems students are giving examinations test in different criterion subjects like Physics (PHY), Chemistry (CHE), Mathematics (MAT), Biology (BIO), Information Technology (IT)/Computer Sciences (CS), First Language (FL), Second Language (SL), Third Language (TL) etc. to the interview for selecting engineering admission. Now consider NINE different schools in Bhubaneswar say $SL_1, SL_2, SL_3, SL_4, SL_5, SL_6, SL_7, SL_8, SL_9$. The numbers of students are choosing as alternatives subject expert. In the different schools the average marks of the subjects mentioned the tabular form. The given subjects determine which the overall performance of all the subjects get better results and selected for admission in engineering courses according to the values of alternative and criterion. Here work out a numerical example to illustrate the TOPSIS method for decision making problem with crisp data. The MADM problem, a number of alternatives can determine and compared to using the different criteria. The aim of MADM problem is to provide support to the decision-maker in the process of making the choice between alternatives. The ranking order of a set of alternatives according to their closeness coefficients and best alternative is found from the set of alternatives.

Table-II The decision matrix and weights of alternatives

Alt.\Cri.	PHY	CHE	MAT	BIO	IT	FLO	SLE	TL
SL1	63	68	72	65	82	75	76	85
SL2	68	81	70	81	85	65	62	82
SL3	78	75	89	76	85	87	76	76
SL4	75	79	76	79	83	65	87	65
SL5	83	76	69	86	78	76	74	78
SL6	81	69	65	78	69	54	75	76
SL7	76	82	82	75	87	88	68	76
SL8	73	76	78	76	89	76	74	78
SL9	86	79	88	77	78	87	88	87
Wights	0.12	0.16	0.1	0.14	0.15	0.1	0.12	0.11

Table-III Normalized decision matrix

Alt.\Cri.	PHY	CHE	MAT	BIO	IT	FLO	SLE	TL
SL1	0.276	0.297	0.312	0.281	0.333	0.331	0.334	0.362
SL2	0.297	0.354	0.303	0.35	0.346	0.287	0.272	0.349
SL3	0.341	0.328	0.385	0.328	0.346	0.384	0.334	0.323
SL4	0.328	0.345	0.329	0.341	0.337	0.287	0.382	0.277
SL5	0.363	0.332	0.299	0.371	0.317	0.335	0.325	0.332
SL6	0.354	0.302	0.281	0.337	0.281	0.238	0.329	0.323
SL7	0.332	0.358	0.355	0.324	0.354	0.388	0.298	0.323
SL8	0.319	0.332	0.338	0.328	0.362	0.335	0.325	0.332
SL9	0.376	0.345	0.381	0.333	0.317	0.384	0.386	0.37

Table-IV The weighted normalized decision matrix

Alt.\Cri.	PHY	CHE	MAT	BIO	IT	FLO	SLE	TL
SL1	0.033	0.048	0.031	0.039	0.05	0.033	0.04	0.04
SL2	0.036	0.057	0.03	0.049	0.052	0.029	0.033	0.038
SL3	0.041	0.052	0.039	0.046	0.052	0.038	0.04	0.036
SL4	0.039	0.055	0.033	0.048	0.051	0.029	0.046	0.03
SL5	0.044	0.053	0.03	0.052	0.048	0.034	0.039	0.037
SL6	0.043	0.048	0.028	0.047	0.042	0.024	0.04	0.036
SL7	0.04	0.057	0.036	0.045	0.053	0.039	0.036	0.036
SL8	0.038	0.053	0.034	0.046	0.054	0.034	0.039	0.037
SL9	0.045	0.055	0.038	0.047	0.048	0.038	0.046	0.041

Table-V For ideal solution

Alt.\Cri.	PHY	CHE	MAT	BIO	IT	FLO	SLE	TL
SL1	0.0121	0.0098	0.0074	0.013	0.004	0.0057	0.0063	0.0009
SL2	0.0094	0.0007	0.0082	0.003	0.002	0.0101	0.0137	0.0023
SL3	0.0042	0.0049	0	0.006	0.002	0.0004	0.0063	0.0051
SL4	0.0058	0.0021	0.0056	0.004	0.004	0.0101	0.0005	0.0103
SL5	0.0016	0.0042	0.0087	0	0.007	0.0053	0.0074	0.0042
SL6	0.0026	0.0091	0.0104	0.005	0.012	0.015	0.0068	0.0051
SL7	0.0052	0	0.003	0.007	0.001	0	0.0105	0.0051
SL8	0.0068	0.0042	0.0048	0.006	0	0.0053	0.0074	0.0042
SL9	0	0.0021	0.0004	0.005	0.007	0.0004	0	0

Table-VI For worst solution

Alt.\Cri.	PHY	CHE	MAT	BIO	IT	FLO	SLE	TL
SL1	0	0	0.003	0	0.008	0.0093	0.0074	0.0094
SL2	0.0026	0.0091	0.0022	0.01	0.01	0.0049	0	0.008
SL3	0.0079	0.0049	0.0104	0.007	0.01	0.0146	0.0074	0.0051
SL4	0.0063	0.0077	0.0048	0.008	0.009	0.0049	0.0132	0
SL5	0.0105	0.0056	0.0017	0.013	0.005	0.0097	0.0063	0.0061
SL6	0.0094	0.0007	0	0.008	0	0	0.0068	0.0051
SL7	0.0068	0.0098	0.0074	0.006	0.011	0.015	0.0032	0.0051
SL8	0.0052	0.0056	0.0056	0.007	0.012	0.0097	0.0063	0.0061
SL9	0.0121	0.0077	0.01	0.007	0.005	0.0146	0.0137	0.0103

Table-VII Closeness coefficients

IS\Alt.	SL1	SL2	SL3	SL4	SL5	SL6	SL7	SL8	SL9
Ed_{α}^{+}	0.0234	0.0216	0.0123	0.0176	0.0155	0.0258	0.0148	0.015	0.0089
Ed_{α}^{-}	0.0173	0.0192	0.025	0.0215	0.0225	0.015	0.0248	0.0213	0.0299

Table-VIII Ranking order

Alt.	SL1	SL2	SL3	SL4	SL5	SL6	SL7	SL8	SL9
CC_{α}	0.425	0.471	0.671	0.55	0.592	0.367	0.626	0.588	0.77
Ranking	8	7	2	6	4	9	3	5	1

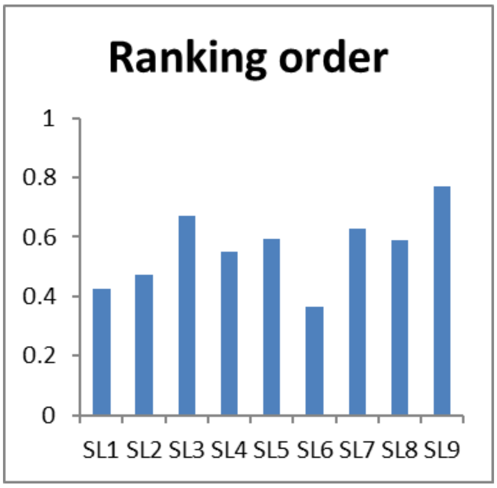


Fig.1 Ranking alternative with respect to relative closeness by applying TOPSIS decision making

The data vector of corresponding weight of each criteria, the normalized DM, weighted normalized DM, ideal solution, worst solution are given in Table-II, Table-III, Table-IV, Table-V, Table-VI, respectively. The closeness coefficients which are defined to determine the ranking order of all alternatives by calculating the distance to both the positive IS and negative IS are given in Table-VII and Table-VIII, respectively. According to the closeness coefficients, ranking the order preference, order of these alternatives is also given in Table-VII. Table-VIII shows the results obtained for the above by using the proposed approach and Figure 1 shows the best school represented by histograph using different criteria, and finite number of alternatives. So the ranking order of nine different schools perform their results in the year 2018, best results of this year selected is as follows.

$$SL6 < SL1 < SL2 < SL4 < SL8 < SL5 < SL7 < LS3 < SL9$$

The best results of the school in the year 2018 of the city Bhubaneswar in the given alternatives, the selected school is $SL9$.

V. CONCLUSION

There is enormous scope of research on TOPSIS in various directions. Several opportunities can be created involving the distance from the positive and negative solutions and relative closeness to the ideal solution. MADM has found wide applications in the solution of real world decision making problems. The solution of the most MADM problems includes both quantitative and qualitative criteria using erroneous data and human awareness. The input data, Flow chart and algorithm of TOPSIS approach are discussed. In this paper, we purpose a methodology to provide a simple approach to find the best alternative months based on temperature and help of decision makers to select the best one of among the month.

FUTURE RESEARCH:

The standard TOPSIS method made a great contribution to the field, but it still presents serious limitations. In its standard formulation, TOPSIS only deals with a single decision maker. In the several situations in the real world, decisions are not made by one person only. Instead, they are made by a group of decision makers. The several techniques have been introduced with the TOPSIS and many other new techniques involving TOPSIS not yet been explored.

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