Implementation of DSS for Electronic Device Selection Using TOPSIS Method

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Abstract

A Decision Support System(DSS) is an interactive computer based system or subsystem intended to help decision makers use communications technologies, data, documents, knowledge and/or model to identify and solve problems, complete decision process tasks, and make decisions. In many situations, one may be able to make decision based on the different decision factors. TOPSIS method becomes quantitative method for decision alternatives and multiple criteria. TOPSIS is called technique for order preference by similarity to ideal solution. It is very effective in multi-attribute decision analysis. In this system, TOPSIS is applied can help the users to make their decisions more easily and correctly in choosing electronic devices by using TOPSIS method. The result shows TOPSIS is a good method and has great practical value.

1. Introduction

A management information system (MIS) is a system or process that provides information needed to manage organizations effectively. Management information systems are regarded to be a subset of the overall internal controls procedures in a business, which cover the application of people, documents, technologies, and procedures used by management accountants to solve business problems such as costing a product, service or a business-wide strategy. Management information systems are distinct from regular information systems in that they are used to analyze other information systems applied in operational activities in the organization. Academically, the term is commonly used to refer to the group of information management methods tied to the automation or support of human decision making, e.g. Decision Support Systems, Expert systems, and Executive information systems. The role of information in decision making cannot be overemphasized. Effective decision making demands accurate, timely and relevant information. Where the relevant information required for planning are not available at the appropriate time, there is bound to be poor planning, inappropriate decision making, poor priority of needs, defective programming or scheduling of activities. Poor management information system has been identified as a bottleneck in the successful management. [3]

There are a variety of multiple criteria techniques to aid selection in conditions of multiple criteria. The acronym TOPSIS stands for technique for preference by similarity to the ideal solution. TOPSIS was initially presented by Hwang and Yoon, Lai et al, and Yoon and Hwang. [2]TOPSIS is attractive in that limited subjective input is needed from decision makers. The only subjective input needed is weights. TOPSIS has been applied to a number of applications, although it is not nearly as widely applied as other multi-attribute methods. A variant of TOPSIS was used for selection of grippers in flexible manufacturing. TOPSIS was applied to financial investment in advanced manufacturing systems. In other manufacturing applications, it has been used in a case selecting a manufacturing process and in an application selecting robotic processes. Neural network approaches to obtain weights for TOPSIS have been applied, and fuzzy set extensions implemented. TOPSIS has also been used to compare company performances and financial ratio performance within a specific industry. [1]

2. TOPSIS

TOPSIS is called technique for order preference by similarity to ideal solution. It is very effective in multi-attribute decision analysis. It uses normalized matrix to find the superior project and inferior project (that is ideal solution and non-ideal solution), then calculates the solution, gets the relative closeness to the ideal solution. [5]

This method considers three types of attributes or criteria

- Qualitative benefit attributes/criteria
- Quantitative benefit attributes
- Cost attributes or criteria [6]

Its basic approach is to find an alternative which is closest to the ideal solution and farthest to the negative-ideal solution in a multi-dimensional computing space. This multi-dimensional computing space is specified by a set of evaluation criteria as dimensions. The ideal solution represents a virtual alternative with a set of possibly best synthetic scores in terms of each criterion, while the negative-ideal solution is a virtual alternative with a set of worst scores. Physically, they are two points in the computing space with extreme values as dimensions. [6]

2.1 TOPSIS Method

The idea of TOPSIS can be expressed in a series of steps.

(1) Obtain performance data for n alternatives over k criteria. Raw measurements are usually standardized, converting raw measures into standardized measures .

(2) Develop a set of importance weights wk, for each of the criteria. The basis for these weights can be anything, but, usually, is ad hoc reflective of relative importance. Scale is not an issue if standardizing was accomplished in Step 1.

(3) identify the ideal alternative (extreme performance on each criterion) and the nadir alternative (reverse extreme performance on each criterion) .

(4) Develop a distance measure over each criterion to both ideal (D+) and nadir (D-).

(5) For each alternative, determine a ratio R equal to the distance to the nadir divided by the sum of the distance to the nadir and the distance to the ideal.

$$R = \frac{D^-}{D^- + D^+}$$

(6) Rank order alternatives by maximizing the ratio in Step 5.

Thus, TOPSIS minimizes the distance to the ideal alternative while maximizing the distance to the nadir. There are a number of specific procedures that can be used for Step 2 (developing weights), and for Step 5 (distance measures). Additionally, different conventions can be applied to defining best performance (Step 3) and worst performance (Step 4).

A number of distance metrics can be applied. Traditional TOPSIS applied the Euclidean norm (minimization of square root of the sum of squared distances) to ideal and nadir solutions, a second power metric (P2). TOPSIS2 is a variant where distance was measured in least absolute value terms, a first power metric (P1). Another commonly used metric is the Tchebychev metric, where the minimum maximum difference is the basis for selection. This coincides with an infinite power-term (P∞).

A relative advantage of TOPSIS is the ability to identify the best alternative quickly. TOPSIS has been comparatively tested with a number of other multi-attribute methods. The other methods primarily focused on generating weights (Step 2 in the prior description), with one method including a different way to combine weights and distance measures. TOPSIS was found to perform almost as well as multiplicative additive weights and better than analytic hierarchy process in matching a base prediction model. When there were few criteria, TOPSIS had proportionately more rank reversals. When there were many criteria, TOPSIS differed more from simple additive weight results, and TOPSIS was also affected more with diverse sets of weights. TOPSIS performed less accurately than AHP on both selecting the top ranked alternative and in matching all ranks in this set of simulations. [4]

2.2 Input to TOPSIS

TOPSIS assumes that it has m alternatives (options) and n attributes/criteria and it has the score of each option with respect to each criterion.

- Let x_{ij} score of option i with respect to criterion j. And the matrix $X = (x_{ij})$ m×n matrix.
- Let J be the set of benefit attributes or criteria (more is better)
- Let J' be the set of negative attributes or criteria (less is better)

3. Steps of TOPSIS

3.1 Construct normalized decision matrix

This step transforms various attribute dimensions into non-dimensional attributes, which allows comparisons across criteria.

Normalize scores or data as follows:

$$r_{ij} = x_{ij} / \sqrt{\textstyle\sum_{i=1}^{m}} \quad \text{for } i = 1, \ldots, m;\ j = 1, \ldots, n$$

where r_{ij} = normalize scores of data

x_{ij} = the rating score of the i^{th} alternative in terms of the j^{th} criterion.

3.2 Construct weighted normalized decision matrix

Assume we have a set of weights for each criteria w_j for j = 1,…n.

Multiply each column of the normalized decision matrix by its associated weight.

An element of the new matrix is:

$$v_{ij} = w_j r_{ij}$$

where v_{ij} = weighted normalized of the i^{th} and j^{th}.
w_j = weight of the criteria.
r_{ij} = normalize score of data.

To evaluate , first compute and then to find .

$$e_j = -\frac{1}{\ln n}\sum_{i=0}^{n} r_{ij}\ln r_{ij} \quad , where\ j = 1,2,\ldots,m$$

$$w_j = -\frac{1-e_j}{\sum_{i=0}^{n}(1-e_j)} \quad , where\ j = 1,2,\ldots,m$$

Where = entropy value of the criteria
= no of alternatives
= normalize scores of data
= no of criteria

3.3 Determine the ideal and negative ideal solutions

The A* and A' are calculated in terms of the weight normalized values, which is defined as

Ideal Solution,

A* = { $v_1^*, v_2^*, \ldots$ }
Where, = { $max_i(v_{ij}) \mid j \in$; $min_i(v_{ij}) \mid j \in$ }

Negative Ideal Solution,

A'= { $v_1^*, v_2^*, \ldots$ }
Where = { $max_i(v_{ij}) \mid j \in$; $min_i(v_{ij}) \mid j \in$ }

3.4 Calculate the Separation Measure for each Alternatives

Calculation of the indicate distances between the ideal and the non-ideal solutions can be carried out by n-dimensional Euclidean distance. The distance from each indicate to the ideal solution A* is s*, and from the non-ideal solution is , the formula is as follows.

The separation from the ideal alternative is:

$$s_i^* = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^*)^2} \ , i = 1,2,\ldots,m$$

$$s_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2} \ , i = 1,2,\ldots,m$$

Where v_j^* and v_j^- mean the distances from the j^{th} attribute to the ideal and non-ideal solution, v_{ij} is the weight normalized value of the j^{th} attribute. s^* Means the degree of similarity between every evaluate solution to the ideal solution, the smaller s^* is, the smaller distances to the ideal solution, the better the solution is.

3.5 Calculate the relative closeness to the ideal solution

$$C_i^* = \frac{s_i^-}{(s_i^* + s_i^-)} \ , i = 1,2,\ldots,m$$

Note that $0 \le C_i^* \le 1$.
When $C_i^* = 0, A_i = A^-$;
$when\ C_i^* = 1, A_i = A^*$.
The option with C_i^* which is closest to 1 is the best option.

3.6 Rank order alternatives by maximizing the ratio

The Rank alternatives are ordered according to C^* in descending order. The larger $C^*$is, the better the solution is, and the solution which has the maximum C^* is the best.

4. The Proposed System

This system will advise the customers which electronic device is the best to choose by using TOPSIS method. This system uses seven criteria.

1. Quality Certification System
2. Quality Certification Department
3. Price
4. Technique Maturity
5. Warranty
6. Service after selling and
7. Customer Satisfaction

Alternative about on this system is depending on user input.

In this system implemented three device types are show. These types are TV, Refrigerator and Washing machine. In the type of TV this system have LCD, FLAT and TV, the type of the Refrigerator this system has 1Door, 2Door, 3Door and 4Door. And the types of the Washing machine have fully auto and semi auto. This system totally implemented nine types of devices.

Figure 1 shows the system flow of the proposed system using TOPSIS (Technique for order preference by similarity to ideal solution) method.

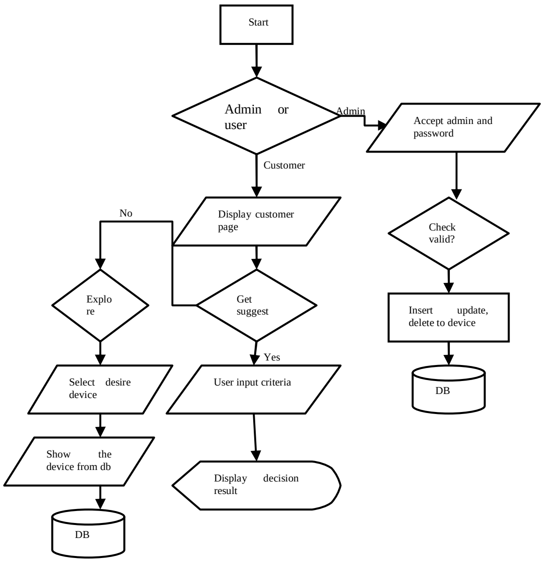

Figure 1.Folw diagram of the system

The customers only need to input the type of the device, category, brand and price. Figure 2 shows the example of the user input.

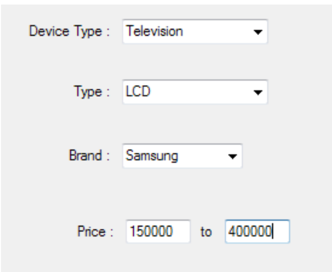

Figure 2. The User Input

If the user inputs this information, the system retrieves the all possible records for the current user input from the database. This is the normalized matrix. Figure 3 shows the retrieving all possible records for the user input from Figure 2. There are qualitative indices and quantitative indices. So, these should be needed to standardize.

MODEL	QCS	QCD	PRICE	TECHNIQUE MATURITY	WRRANTY	SERVICE AFTER SELLING	CUSTOMER SATISFACTION
B-350	PASS	YES	375000	MATURE	YES	VERY GOOD	GOOD
B-250	NOT PASS	YES	220000	NOT MATURE	NO	BAD	BAD
C-220	PASS	YES	180000	MATURE	YES	GOOD	GOOD

Figure 3. All Possible Devices

All the evaluation indices except price are categorized in five classes; there are five indices that are worse, bad, normal, good, and very good. And these indices are scored according to the range of values, which is given in table 1. For the price, it is already quantitative, so it is not needed to change. But it should be negated because the less price better to choose than others.

Table 1. range of value of the evaluation indices

Worse	Bad	Normal	Good	Very Good
1-2	3-4	5-6	7-8	9-10

Then create the normalized matrix, by normalizing the original data from Figure 3. The resulted normalized matrix is given as Figure 4.

INDICE	QCS	QCD	PRICE	TECHNIQUE MATURITY	WRRANTY	SERVICE AFTER SELLING	CUSTOMER SATISFACTION
B-350	7	7	375	7	7	9	7
B-250	5	7	220	5	5	3	3
C-220	7	7	180	7	7	7	7

Figure 4. The Normalized Matrix

Firstly, normalize the original data, then calculate normalize rating, and then calculate normalized weight rating and weight. The normalized rating result is given in Figure 5.

	11.09	12.124	470.558	11.09	11.09	11.789	10.344

INDICE	QCS	QCD	PRICE	TECHNIQUE MATURITY	WRRANTY	SERVICE AFTER SELLING	CUSTOMER SATISFACTION
B-350	0.631	0.577	0.796	0.631	0.631	0.763	0.676
B-250	0.45	0.577	0.467	0.45	0.45	0.254	0.29
C-220	0.631	0.577	0.382	0.631	0.631	0.593	0.676

e1 = 0.856003192888499 w1 = 0.12559286976978
e2 = 0.866456196067662 w2 = 0.11647584354317
e3 = 0.823593596673979 w3 = 0.153860261792644
e4 = 0.856003192888499 w4 = 0.12559286976978
e5 = 0.856003192888499 w5 = 0.12559286976978
e6 = 0.786769771081599 w6 = 0.185977709566799
e7 = 0.808634375181842 w7 = 0.166907575788046

Previous Next

Figure 5. Normalized Rating and Weight Results

Then calculate the normalized weight rating and determine the ideal and negative ideal solutions. This result is shown in Figure 6.

INDICE	QCS	QCD	PRICE	TECHNIQUE MATURITY	WRRANTY	SERVICE AFTER SELLING	CUSTOMER SATISFACTION
B-350	0.079	0.067	0.122	0.079	0.079	0.141	0.112
B-250	0.056	0.067	0.071	0.056	0.056	0.047	0.048
C-220	0.079	0.067	0.058	0.079	0.079	0.11	0.112
A^+	0.079	0.067	0.058	0.079	0.079	0.141	0.112
A^-	0.056	0.067	0.122	0.056	0.056	0.047	0.048

Figure 6. Normalized Weight, Ideal, and Negative Ideal

Then calculate the separation measures for each alternative and the relative closeness to the ideal solution C_i^*. This is shown in Figure 7.

INDICE	S^+	S^-	C^+
B-350	0.064	0.120494813166...	0.653106778984...
B-250	0.137054733592...	0.130843417870...	0.488407318811...
C-220	0.140516902897...	0.175692913915...	0.555621313993...

Figure 7. Separation Measures and Relative Closeness

Then the relative closeness values are ordered in descending order and produce as the final result. The Figure 8 is the final result for the user, by using this advice user can choose the best thing to buy.

No	MODEL NO	SIZE	BRAND	TYPE	PRICE
1	B-350	32	Samsung	LCD	375000
2	C-220	22	Samsung	LCD	180000
3	B-250	22	Samsung	LCD	220000

Figure 8. The Final Result

The result shows that: Model No B-350 > Model No C-220 > Model No B-250, that is Model No B-350 is the best, Model No C-220 after it, and B-250 is the worst. So, user can select the Model No B-350 as the best for buying.

5. Conclusion

The scheme evaluation of the electronic device selection is a multi-attribute decision support system. TOPSIS is one of the most widely used methods to solve this problem. The final result of using TOPSIS method is showed in Figure 8. Using this method, reasonable evaluation indices model is needed to build and it is needed to set the exact weight factors of every evaluation index. The practice prove that: TOPSIS method is a better method to evaluate the multi-attribute decision. It not only improves present evaluation methods and avoids their simplification, but also reduces the influence of expert subjective factors to the decision of scheme. At the same time this method can avoid the complex calculation and can be used easily in practice.

6. References

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