A Review Of MCDM Techniques

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Abstract- *As the real world problems are so tangled, so the task of decision making associated with them is equally complex. Therefore, some efficient techniques are required which limelight the best solution. For the choice of the optimal selection with respect to the given criteria, this paper has summarized three major and useful techniques of Multiple Criteria Decision Making (MCDM), namely, WSM (Weighted Sum Method), AHP (Analytic Hierarchy Process) and TOPSIS (Technique for Ordered Preference By Similarity to Ideal Solution). The paper highlights the basic steps involved in each of the techniques for choosing the most suitable alternative from among the varied options under consideration.*

Keywords- MCDM, WSM, AHP, TOPSIS.

I. INTRODUCTION

In order to attain an optimal solution in the presence of so many closely similar options, a strategic move is to be adapted. The alternatives are different but since they belong to the same real world set of entity, so the process of the choice of the best among the better options is tricky and requires some degree of insight. To optimize the process of the choice, there is a need for the basis which could help differentiating the alternatives and rank the given choices. For doing so, some qualitative and quantitative factors are to be selected which could help in discriminating the alternatives. Such set of factors are collectively known as criteria. For the optimal selection, the alternatives are compared against the selected criteria. Therefore, MCDM is the composition of set of multiple criteria, set of alternatives and their comparison in some manner. The problem which has been used as a reference in this paper, to describe various techniques- the alternatives are „the cars" from same or different companies; the criteria include both qualitative as well as quantitative criteria. Qualitative criteria include reliability and style whereas quantitative criteria include fuel economy and cost. These are the criteria against which the alternatives have to be compared. The alternative which suits in all the ways is chosen as the best resulting solution. The parameters for optimal choice of the car are as under: -

A. Reliability- Reliability is the probability of failure-free operation of a product for a specified time in a specified environment i.e. for how long the product will work effectively without any failure while the product is under use. So, greater will be the reliability, more will be the probability of failure free life of the product.

B.Style- Style includes the basic appearance, the design and the comfort level of the product. Style directly doesn'taffect the quality of the product and of course is a voluntary option. But as the priorities of the masses are being diverted from economical perspective to qualitative perspective, so style is being given greater importance.

C. Fuel Economy- Generally known as mileage, is a basic measure which tells about the fuel consumption per unit distance (km). It reveals how suitable and economical will be the product to the buyer. Lesser is the fuel consumption, higher will be the fuel economy.

D. Cost- Last but not the least rather a major quantitative criterion is the cost. Cost for a car includes actual showroom price, registration price, insurance and accessories price. For a better quality the cost is higher but usually the buyer has a limited budget and therefore the choice is very critical as it is difficult to compromise with the quality also. So, this quantitative factor needs a greater insight.

II. LITERATURE REVIEW

MCDM has a short history of about 40 years, during which this has been an interesting area among the researchers. Over this period, almost 70 MCDM techniques have been explored, [1]. MCDM can be divided into two categories: Multi-Attribute Decision Making (MADM) and Multi-Objective Decision Making (MODM). MADM implicate the selection of the "best" alternative from pre-specified alternatives described in terms of multiple attributes [8]. It is used for the solution of the problems having finite number of alternatives. MODM involves the design of alternatives which optimize the multiple objectives of Decision Maker (DM). The choices are usually infinite or very large and the best will be the one which satiates decision maker's constraints and priorities. Among the methods that have been evolved out for MCDM, each has varied underlying assumptions, information requirements, analysis models, and decision [9]. This implies that it is critical to select the most appropriate method to solve

the problem under consideration, since the use of unsuitable method always leads to misleading decisions. Consequently, incongruous decisions will result in heavy losses. Due to the large warehouse of the MCDM techniques, the selection of appropriate technique is itself a big question to ponder over. MCDM analysis has some unique characteristics such as the presence of multiple non-commensurable and conflicting criteria, different units of measurement among the criteria, and the presence of quite different alternatives. It is an attempt to review the various MCDM for empirical validation and testing of the various available approaches for the extension of MCDM into group decision-making situations for the treatment of uncertainty [9]. MODM and MADM problems can be further subdivided into two categories depending on the goal preference structure of the decision maker. (i) If there is a single goal-preference structure, the problem is referred to as individual decision making, regardless of the decision makers actually involved (ii). On the other hand, if individuals (interest group) are characterized by different goal-preference structures, the problem becomes that of group decision making [3].

A. ***Decision Making under Certainty versus Uncertainty***

1. MCDM under certainty: For the decision under certainty it is assumed that all relevant information about the decision situation is known and there is a known deterministic connection between every decision and the corresponding outcome.

2. MCDM under uncertainty: Two basic types of uncertainty may be present in a decision situation. First is the uncertainty associated with limited information about the decision situation and second is the uncertainty associated with fuzziness (impression) concerning the description of the semantic meaning of the events, phenomena, or statements themselves. Consequently, both MODM and MADM problems under uncertainty can be subdivided further into probabilistic and fuzzy decision-making problems, depending on the type of uncertainty involved.

B. Selecting MCDM techniques There is a great diversity in MCDM techniques, this diversity can be seen as a very strong point as well as a weak point too. Diversity facilitates the flexibility in the choice of appropriate technique for a given problem from a wide pool of options but such a huge diverse nature of these techniques makes the appropriate choice more complicated. Each of the technique has its own strengths and weaknesses [9]. In this paper, three techniques have been discussed in detail, lime lighting both their strengths and weaknesses. With reference to the car selection problem, the step by step computation of the choice of the best car has been depicted for each individual technique and the results have been compared mutually. Early in the evolution of MCDM the application of selection techniques for the problems was not considered but now it is clear that consequences of mismatches may lead to suboptimal results, discarding of useful models due to improper application (which means losses in time and money), and finally it may discourage potential users from applying MCDM techniques to real world problems. The WSM is the earliest and probably the most widely used method. The AHP is capable for solving more complex problems and TOPSIS is among the other widely used techniques.

III. STEPS IN MCDM METHODOLOGY

MCDM consist of various interrelated steps, that follow one after the other. In this paper, we have tried to present a generic model of MCDM, picturing out the basic concept of the methodologies using series of steps. It is a kind of decision support system which can help in moving along a strategic path to achieve an optimal solution at the end. Following is the Generic MCDM Model which is a flow graph depicting the steps which are essentially included in all the MCDM solutions, followed by the detailed elaboration of each of its step [2][3][4].

Step 1: State and Define the Problem Domain The characteristics of the decision making problem under consideration are addressed in the problem definition step, such as identifying the number of alternatives, attributes, and constraints etc. The available information about the decision making problem form the basis of choosing the most appropriate MCDM techniques and will be utilized to solve the problem.

Step 2: Elicit the criteria The proper determination of the applicable evaluation criteria is important because they have great influence on the outcome of the MCDM method selection process.However, simply using every criterion in the selection process is not the best approach because the more criteria used, the more information is required, which will result in higher computational cost. The defined evaluation criteria will be used as the attributes of a MCDM formulation and as the input data of decision matrix for method selection.

Step 3: Screen the alternatives *A*n alternative is dominated if there is another alternative which excels it in one or more attributes and equals it in the remainder. The dominated MCDM methods are eliminated by the dominance method, which does not require any assumption or any transformation of attributes. The sieve of dominance takes the following procedures: compare the first two alternatives and if one is

dominated by the other, discard the dominated one; then compare the un-discarded alternative with the third alternative and discard any dominated alternative; and then introduce the forth alternative and repeat this process until the last alternative has been compared. A set of non-dominated alternatives may possess unacceptable or infeasible attribute values. The conjunctive method is employed to remove the unacceptable alternatives, in which the DM set up the cut off values he/she will accept for each of the attributes. Any alternative which has an attribute value worse than the cut off values will be eliminated. The cut off values given by the DM play the key role in eliminating the alternatives. MCDM methods which can perform feasibility evaluation remain as the candidate MCDM methods for further selection.

Step 4: Define the preferences on evaluation criteria Usually, after the initial screening step is completed, multiple MCDM methods are expected to remain, otherwise we can directly choose the only one left to solve the decision making problem. This step enforces the prioritization of the criteria. It will help us in identification of the criteria that has the strongest priority and thus will have greatest impact in the final choice and vice-versa.

Step 5: Choose MCDM method for Selection This step includes the selection of one of the MCDM method from among the existing commonly used methods. The WSM is chosen as the most suitable MCDM method considering its simplicity and wide generic applicability. Similarly, for complex problems we can opt for the complex techniques. Before the final choice of the method, its cons and pros are necessary to be studied [9].

Step 6: Evaluation of the MCDM method The following mathematical formulation, Appropriateness Function (AF) proposed by Li, 2007, is used to rank the MCDM methods. The method with the highest AF, using equation (i), will be recommended as the most appropriate method to solve the problem under consideration.

$$AF = \sum w_i I_i \qquad \ldots(i)$$

$I_i = \{b_1, b_2, \ldots b_n\}$
$b_i = 1, \quad c_{ji} = a_i \quad$ or
$b_i = 0, \quad c_{ji} \neq a_i$
$I = 1, 2, \ldots n; j = 1, 2, \ldots m.$

where I is the number of evaluation criteria used to examine the decision making methods with respect to the given problem, and $W = W=W_1, W_2, W_3, \ldots W_n$, is the weighting vector on the evaluation criteria, b_i is the value of the i^{th}characteristic of the decision problem, and $C_{ij}$is the value of i^{th}characteristic of the j^{th}method. The MCDM method which has the highest AF will be selected as the most appropriate method to solve the given decision making problem.

Step 7:Apply selected Methodology on the Problem This step is the inclusion of all the mathematical computations that each of the technique has its own uniquely. In this paper, we have discussed the computations of WSM, AHP and TOPSIS.

Step 8: Results and their evaluation The final step is basically the serial outcome of all the above steps and basically of the penultimate step. This paper has analyzed the results of three different techniques. Sensitivity analysis should be performed on the MCDM method selection algorithm in order to analyze its robustness with respect to parameter variations, such as the variation of DM‟s preference information and the input data.

IV. TECHHNIQUES AND THEIR DESCRIPTION

As described above MCDM is a function of alternatives (available options), criteria (measuring parameters) and their comparison. All the techniques which help in reaching to an optimal state of result are more or less a combination of these essential ingredients only. Following are the three major techniques being discussed highlighting their major strengths, weaknesses and the basic steps.

A. Weighted Sum Method

The WSM is the one of the earliest and probably the simplest technique that is used in MCDM. Due to its simplicity, the technique is suitable for simple problems, as it basically supports single dimensional problems. WSM allows the comparison of the alternatives by assigning scores, and then using these scores, standard values are generated for the alternatives under consideration. So, overall the results are in the form of good, better and best. The criteria are given weights depending on the severity of each; sum of all these weights must be 1. Each alternative is assessed with respect to every attribute [5].

B. The AHP Method

The AHP technique was actually the result of the research work carried out by Thomas L. Satty in 80s [6]. With time researchers have produced variants of AHP but in this section of the paper the aim is to highlight the basic procedure of this technique with reference to the car selection problem. On the whole, the procedure here can be divided into 3 major parts namely, Decomposition of the Problem, Comparative Judgment and Generation of the priorities [5].

C. The TOPSIS Method

TOPSIS is another technique developed by HWANG and YOON in 80s, but is being used widely even today. Though the technique has same pet constituents but the principle is quite different The principle of TOPSIS is "The chosen Alternative should have the shortest distance from the ideal solution and the farthest from the negative-ideal solution" Therefore, the method stress on the calculation of the best i.e. the ideal case as well as the worst i.e. negatively ideal case. TOPSIS selects the alternative whose value is closest to the ideal solution and farthest from the negatively ideal solution [7]. Once these values have been found, the optimal case can be generated easily.

The major highlights of TOPSIS are-

1) It is very rational approach where each step of the calculation is very logical and understandable.
2) The calculation involved are simple and straight forward.
3) This technique involves the generation of the ideal and the negative ideal cases, in addition to the generation of most optimal (practically feasible solution).

V. MAJOR APPLICATION AREAS FOR MCDM

1. MCDM can be applied in all the areas of research and selection in the fields of management, manufacturing, planning, education, transportation, construction, logistic, medical, control and agriculture. MCDM is used in these areas for selection, ranking and evaluation [4][9] [10] [11].

VI. CONCLUSION AND FUTURE WORK

MCDM is can be applied anywhere anytime where the DM faces complexity in making a choice. Ranging from the everyday problems and till complex scientific issues, MCDM methodologies can be employed undoubtedly. It has become a powerful tool that can make the process of choice not only easier, but also accurate. Till date there have been so many methodologies explored and still there is lot to do. It can not only include new application areas but at a higher level a new efficient, fast and practically compatible technique can be evolved out. Particularly, highlighting the major research areas of computer science, it can be used in Software engineering, Networking, Robotics, Graphics etc.

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