WEB-BASED SIMULATION MODEL FOR MULTI-ATTRIBUTE STRUCTURED DECISION SUPPORT SYSTEM

Heung-Suk Hwang* , **Gyu-Sung Cho***
* Department of Industrial Engineering, Dongeui University,
San 24 Gaya-dong Pusanjin-ku Pusan, 614-714, KOREA
Tel : +82-51-890-1657, Fax : +82-51-890-1619

ABSTRACT

This paper is concerned with development of a multi-attribute structured decision model. In this study, we used AHP(analytic hierarchy process) and fuzzy set ranking methodology to overcome the multi-attributes structured decision problems ; such as multi-objective, multi-criterion, and multi-attributes. We proposed a 2-step approach : 1) individual evaluation and 2) integration of individual evaluations. In the first step, we define the performance factors and construct analysis structure, and in the second step performance evaluation by individual evaluators, and in second step, the results of individual evaluations are integrate. Also we developed a systematic and practical computer program to solve the problems according to the proposed methods. The proposed approach was known to be effective through a set of sample problems.

Keywords : Web-based Simulation model, Fuzzy AHP, Decision Analysis

1. INTRODUCTION

The purpose of this study is to develop a decision support system in the view of multi-attribute structured system. A great deal of researches have been under taken to determine the proper alternatives for example, operations research, mathematical models and decision theory, while these technologies provide invaluable methods in the view of multi-dimensional goal and multi-attribute structure of decision support systems.

Most of the conventional concepts used in decision support systems do not seem to appropriate for modeling the kind of the multi-attribute characteristics. Those are : effectiveness, efficiency, quality, productivity, innovation, profitability, and quality of work life. Recently a new multi-attribute analysis method is one of the evident areas of important points especially in production decision problems such as : 1) improved quality, 2) increased flexibility, 3) reduced inventory, 4) organizing along production line, 5) increased automation, and 6) more effective use of information. This paper is concerned with development of decision support system and its software model for the multi-attribute structured decision problems. We used a two-step approach : 1) in step 1, we construct decision alternatives and implemented the individual analysis using AHP and fuzzy set ranking methodologies to overcome the special decision problems; those of multi-objective, multi-criterion, and multi-attribute, and 2) in step 2, we

integrated the evaluation results of individual evaluations by reviewers. In this research, we developed and demonstrated a methodology for the decision makers to guide decision support system using its computer programs. These programs transform several individual multi-criteria rank-ordered lists of decision alternatives into one aggregated and prioritized rank-ordered list. Also a literature survey about the majority-rule methods(MRM), a fuzzy set priority method was performed and these methods were known to be applicable to the aggregation of multiple criteria rank-ordered ordinal priorities. Figure 1 shows this two-step approach of decision support system.

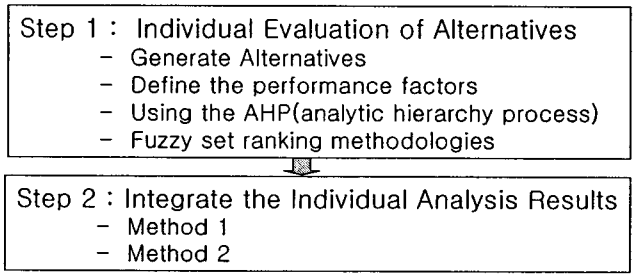

Figure 1. Two-step approach of decision support system

We developed a systematic and practical computer program to solve the problems in the proposed method. Computational experiments are then performed to sample systems and show the effectiveness of the proposed model.

2. INDIVIDUAL EVALUATION OF ALTERNATIVES

1) Construct Decision Structure and Alternatives

Evaluation of alternatives and methods can be determined based on the system attributes and experiences of evaluators. To create the ideas of alternatives and methods for decision support system analysis, we used a brainstorming method and also we developed a GUI-type program for users to use this method in network-based environment without any problems.

Figure 2 shows a sample output of alternative generation and construct the decision structure of an example with 3-echelon structure and 4 alternatives.

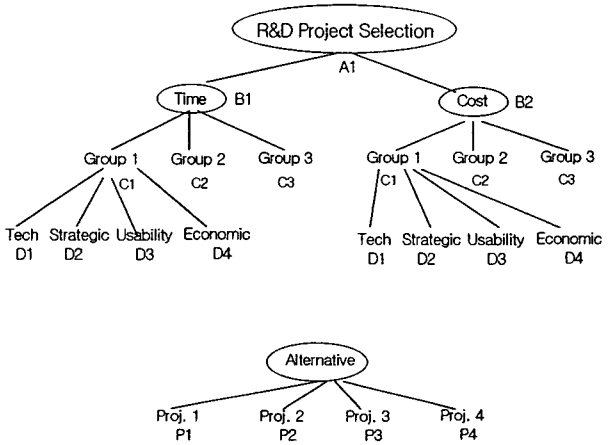

Figure 2. Decision Structure and Alternatives Constructed by Brainstorming

To determine the weighted values of factors, we used AHP and fuzzy set priority method. For the evaluation of total object performance of each alternatives, we construct a multi-echelon structure of decision support system as Figure 3.

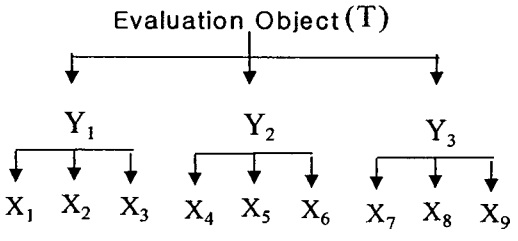

Figure 3. Multi-echelon Structures of Analysis

2) Analytic Hierarchy Process, AHP

For the performance evaluation of decision alternatives we used a multi-echelon and multi-attribute analysis method, AHP(Zahedi 1986). It is performed by 4 steps as following :

① Construct a hierarchical structure,

② Pair wise matrix of decision factors,

③ Compute the weighted value,

④ Consistency analysis.

Hierarchical structure of example factory is shown in Figure 4

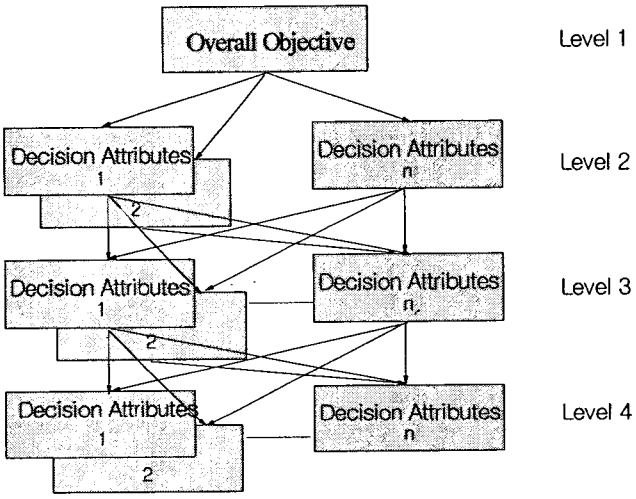

Figure 4. Hierarchical Structure for AHP

3. INTEGRATION OF INDIVIDUAL EVALUATION

For the integration of the results of individual evaluations, prioritized sets, we used two heuristic models Heuristic Model 1, Model 2 and fuzzy set priority method which are a kind of majority-rule methods. These methods were compared to determine the most preferred one for the decision support system purpose.

1) Heuristic Model 1 :

In this method the preference score is given by the sum of the marks received from the evaluators, where for m alternatives, the marks are given, in decreasing order preference, (m-1), (m-2), ..., 0. The ranking was based on the scores of each alternatives. In this case, the highest score will be the first priority. For example of the Heuristic Method 1, a sample result with N = 5 evaluators and M = 4 alternatives is given as :

Evaluator 1 : C > A > B > D

Evaluator 2 : A > D > C > B

Evaluator 3 : D > A > C > B

Evaluator 4 : C > B > A > D

Evaluator 5 : D > A > C > B

Table 1. Example Result of Heuristic Method 1

Alt.	Preference Matrix				Raw Sum	Weighed Value
A	0.0	4.0	3.0	3.0	10.0	0.34
B	2.0	0.0	1.0	2.0	5.0	0.17
C	2.5	3.5	0.0	2.0	8.0	0.28
D	1.5	2.0	2.5	0.0	6.0	0.21
Column Sum	6.0	9.5	6.5	7.0	29.0	1.00
Heuristic Method 1 Rank Order	A > C > D > B					

The value of each cell of basic evaluation score matrix is given by one if the raw alternative wins against the column alternative, otherwise given by 0. In the summed frequency matrix the weighted value of the raw sum is the basis of rank order, thus the Heuristic Method 1 rank order is A > C > D > B.

2) Heuristic Model 2 :

In this method, the evaluator frequency matrices were added to form a summed frequency matrix where a count was made for each alternative of the number of times it was preferred to each of the

other alternatives. Then, the preference matrix was developed by a comparison of the scores in the component cells(A, B versus B, A). If the A, B value equals B, A, then each component cell in the matrix is given by 1/2. On the other hand if the A, B value is greater than the B, A , then A, B is given by one and B, A cell of the preference matrix is given by 0. The alternatives were ranked by the order of their preference matrix row sums. By applying the Heuristic Model 2 to the same example of Heuristic Method 1, the result is given by Table 2, where Heuristic Model 2 priority is given by A > B > D > C

Table 2. Example Result of Heuristic Model 2

Alt.	Summed Frequency Matrix				Raw Sum	Weighted Value
A	0.0	4.0	3.0	3.0	10.0	0.32
B	1.0	0.0	0.0	2.0	3.0	0.10
C	2.0	4.5	0.0	2.0	8.5	0.28
D	2.0	3.5	4.0	0.0	9.5	0.30
Heuristic Model 2 Rank Order	A	> D	> C	> B		

Comparing the above Methods we have chosen Heuristic Model 2 as the most promising one and demonstrated it as the preferred method for this example evaluation with the fuzzy set priority method.

3) Fuzzy Set Priority Method

The theory of fuzzy sets has extended traditional mathematical decision theories so that they can cope with the kind of vagueness which cannot adequately be represented by probability distributions. The model for this study had a limited capability to study the fuzzy set priority that could be obtained from the summed frequency matrix of Heuristic Model 2. The fundamental concept of fuzzy set priority relation R was derived from result by Heuristic Model 2. From the summed frequency matrix for complementary cells, A_{ij} and A_{ji}, an additional fuzzy set matrix was made by considering $A_{ij} = 1 - A_{ji}$ for all cells. The fuzzy matrix complement cell values sum to 1 and fuzzy set difference matrix is defined as follows :

R-RT = U(A, B) - (B, A), if U(A, B) > U(B, A),

= 0 otherwise

where, for U(A, B) quantifies, A is preferable to B. To obtain fuzzy preferences, following five steps are considered :

Step 1 : Find the summed frequency matrix (using Heuristic Method 2)

Step 2 : Find the fuzzy set matrix R which is the summed frequency matrix divided by the total number of evaluators

Step 3 : Find the difference matrix

R - RT = U(A, B) - U(B, A), if U(A, B) > U(B, A),

= 0, otherwise

where, for U(A, B) quantifies, A is preferable to B.

Step 4 : Determine the portion of each part

Step 5 : The priority of the fuzzy set is then the rank order of X^{ND} values in decreasing

4. COMPUTER PROGRAM DEVELOPMENT

The computer program was developed using C-language through the use of the module based tool and applied to a set of example problems of multi-structured decision support system. The computer model for this research emphasized the flexibility of programming options as well as future operational flexibility for the improvement. The schematic flow diagram of the model is shown in Figure 5.

The flexibility of the model encompasses the wide variety of areas to provide the methodology and tools to permit exploration research in such areas as fuzzy set priority, preference scoring constants, and comparative aggregation methodologies. Table 3 presents the comparison of sample runs between two heuristic and fuzzy set priority methods.

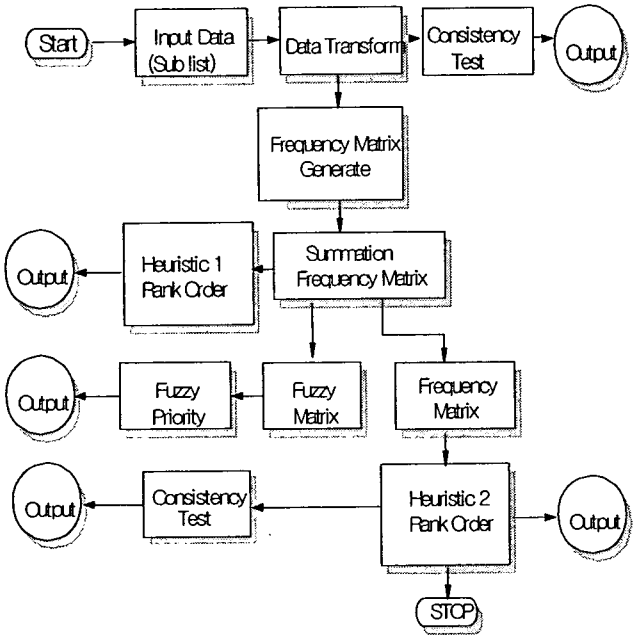

Figure 5. Schematic Flow Diagram of the Proposed Model

We applied this model to a set of examples of multi-structured decision support system as shown in Figure 1. First, we determined the weighted values by eigenvectors of AHP and also by fuzzy set priority method. Table 3 shows the comparison of results of both heuristic and fuzzy set priority method.

Table 3. Comparison of Sample Runs

Methods	Integrated Rank Order (Weighted Values)
- Heuristic Methods	
Heuristic Model 1	A > C > D > B (0.34 0.28 0.21 0.17)
Heuristic Model 2	A > D > C > B (0.32 0.30 0.28 0.10)
- Fuzzy Set Priority Method	A > C > D > B (0.38 0.31 0.30 0.01)

5. SUMMARY AND CONCLUSIONS

We developed a two-step approach of performance evaluation model for multi-structured decision support systems in the view of multi-attribute evaluation. We used AHP, heuristic and fuzzy set reasoning methods and programmed for the user's convenience. Finally, for a simple and efficient computation, we have developed a systematic and practical program to calculate all the algorithms. The model was validated by comparative computations for various multi-structured decision support examples. By the sample results of both AHP and fuzzy set reasoning method, it is known that the proposed model is a good method for the performance evaluation of multi-attribute and multiple goals.

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