Algorithms for multiple criteria decision making in fuzzy environment: programming support

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The problems of Multiple criteria decision making (MCDM) refer to making decisions in the presence of multiple usually conflicting criteria. Problems involving multiple criteria decision making are of common occurrence in everyday life.

One may state that there exist two different sets of MCDM problems due to the problem setting: one set contains problems involving finite number of elements (alternatives) and the other consists of problems with infinite number of potential alternatives. The MCDM problems can be therefore broadly classified into two categories in this respect:

- Complex evaluations of alternatives.
- Vector optimization.

In multiple criteria problems of any type some of the data may be vaguely defined.

The vagueness may concern the values of the criteria given, the values of weights of the criteria as well as the definition of the set of feasible alternatives. Among the mathematical means of expressing such vagueness the theory of fuzzy sets seems to be the most appropriate. To handle the decision situations under fuzziness two special cases of fuzzy sets are of particular importance, namely the fuzzy binary

relations and fuzzy numbers. The former are used to express the vaguely formulated DM's preferences; the latter to express both indefinitely given values of characteristics and indefinitely given mutual importance of them.

The nature of the MCDM problems requires the possibility of flexible interaction among decision maker, analyst and computer in the whole process of solving the problem. Recently there became available various computing systems which make such interactions possible. Screen terminals and graphical displays connected to the computer are well-known examples of such devices. Even better contact with the user give small computers of the desk type, which are now well--spread. In our institute we have at our disposal such a computer Wang 2200 VP, which has proved very useful for solving small and medium sized problems of MCDM.

The procedures for solving MCDM problems which we have developped on our computer form three different groups according to the nature of the problems solved:

- procedures supporting vector optimization problems,
- procedures for complex evaluation of alternatives,
- procedures used for the formalized analysis of the set of criteria.

The first group of procedures consists of various methods for evaluating the finite set of alternatives with respect to several criteria not necessarily of cardinal nature. This group was gradually extended so that they take into account the case of incomplete input data, which means that it is not necessary to evaluate every alternative with respect to all

criteria. Moreover some methods newly included into that group handle the situations when the alternatives are evaluated by means of intervals instead of single values. For this purpose the concept of fuzzy semipreference relation is considered. With the help of such a relation the fuzzy subset of nondominated alternatives can be selected.

Another method dealing with interval evaluations of alternatives uses the principle of stochastic simulation (Monte Carlo method). This group of procedures contains also some methode for solving the problem of collective choice, which are suitable e.g. to aggregate experts opinions.

The group of procedures solving vector optimization problems is oriented towards interactive approaches, in witch the preferences among various vectors of criteria values are established gradually in the course of a dialogue between the decision-maker and the algorithm. Perhaps the most widely used interactive algorithm is a STEM method due to Benayoun and further modified by a number of authors.

In some situations it may be difficult for the decision-maker to give exact answers to the questions put by the algorithm. This is true particularly in the case when there is a collective body (committee) of decision-makers whose preferences may differ. Therefore modification of the STEM method was developped which allows fuzzy answers by the decision-maker. Further the method of fuzzy goal programming for solving the optimization problems with indetermined and/or inconsistent set of constraints was included.

The methods for the formalized analysis of the set of criteria are based on the assumption that the values of criteria on a finite set of alternatives are given.

Consequently their programming support is built in much the same way as the procedures for the complex evaluation of alternatives, i.e. on the common data basis. The programs make it possible to compute the coefficients of similarity or distance, the Kendall's and Spearman's rank correlation coefficients of consistency. The set contains also the program for determining the weights of criteria by the Saaty's method. This group of procedures was extended to handle the situations where the input to the Saaty's method (i.e. the matrix of pairwise comparisons of criteria) is incomplete. The approach used is based on the logarithmic regression and can be applied also in the case where there are several estimations of pairwise comparisons given (e.g. by several experts).

The Saaty's approach was also extended by Narasimhan's approach to handle the inconsistencies in the matrix of comparisons.

Most of the algorithms included into our MCDM programming support were tested in handling complex decision-making situations encountered in some problems in applied research and practice, such as evaluating different strategies of radiological protection in nuclear power-plants, analyzing the consumer's demand for motor-cars etc. The experience has

shown that even the small computers of Wang type can be successfully used to solve small and medium - sized decision-making problems occuring in practice and research.

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