Computer Science Journal of Moldova, vol.1, no.2(2), 1993

An interactive decision support system for selection of scientific and technical projects

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Working out experience of decision system in financing of long-term scientific and technical projects in the framework of programs having a paramount importance for development of economy is considered in the article.

Suppose a program which must determine the development of an economic unit to perspective and the money means for the program are defined. Suppose also that the set of scientific and technological projects proposed for this program is given. The proposed projects are sent for analysis where every program project is estimated by the group of experts on beforehand stated criteria and scales. After receiving expert's estimation one has to work out one or more variants of a plan of projects financing using the decision making system.

The process of plan's working out consists of two stages:

- the primary processing of introduced data and receiving of generalized indexes of quality for each project;
- the choice of projects set from the totality of suggested ones which optimizes the total index of quality.

The system is built in such a way in order to have a possibility to use optimization modules and different procedures for generalized quality evaluation of projects.

In connection with this the system's structure is worked out in such a way, in order to have a possibility to introduce the necessary changes only to separate blocks without breaking the whole system. An extended structure of four blocks has been chosen:

- block for information input;

- block of the quality indexes evaluating and the construction of a global weak order on the whole set of projects;
- block for selection of a set of projects (plan of projects financing);
- block for data output.

Each of this blocks is built from separate modules agreed on input/output so that the introduction of changes in one module allows to have a hard-working system.

Data characterizing each project suggested for including into the program consist of three parts:

a) data about the program:

   - the number N of scientific and technological projects proposed within the given program;
   - the total money fund C intended for financing of the given program;
   - the number M and the names of criteria on the basis of which the projects were evaluated.

b) initial data for each project corresponding to the given program:

   - name of the project;
   - executor;
   - required sum of money c_i for fulfillment of the project i;
   - the term t_i required for realization of project i.

c) data of the expert evaluation of all the projects within the program:

   - estimation e_{ij} of the project i on the criterion j in accordance with a given scale ($i = 1, 2, \ldots, N;\ j = 1, 2, \ldots, M$).

The information from the points a) and b) is necessary for the work of the system. As for the information from the point c) it allows to take into account the opinions of experts in the given field suggested for the plan elaborating.

If only the information from the points *a*) and *b*) is introduced then the system can give a plan of financing only on the basis of the quantitative appreciation of each project in assumption that all the projects are equivalent on all the evaluation criteria. But for adequate evaluation of projects a qualified expert analysis is needed of course and the usage of the obtained estimates in the process of working out of decisions is necessary.

Besides it is necessary to consider a preference structure on the set of criteria defined as a weak order. Each criterion is given a rank k_j related to its position in the weak order among the criteria. If such a preference structure is not defined then all the criteria are considered to be equivalent.

Working out of the generalized indexes of quality for a project consists of following steps.

1. Definition of distances

$$d_{ij} = [\lambda e_{ij}^2 + (1-\lambda)k_j^2]^{1/2}, \quad (i = 1, 2, \ldots, N;\ j = 1, 2, \ldots, M)$$

with $0 \leq \lambda \leq 1$.

2. All the distances d_{ij} are located into a vector $D = (D_1, D_2, \ldots, D_{MN})$ with ordered components $D_1 \geq D_2 \geq \ldots \geq D_{MN}$,

$$D_1 = \max_{i,j} d_{ij}, \quad D_{MN} = \min_{i,j} d_{ij}.$$

3. We use the mean ranks r_l $(l = 1, 2, \ldots, MN)$ discussed in [1]. They are defined such that if m components $D_k, D_{k+1}, \ldots, D_{k+m-1}$ $(1 \leq k \leq MN - m + 1)$ of the vector D are found to be equal, then

$$r_l = \frac{k + (k+1) + \ldots + (k+m-1)}{m}, \quad (l = k, k+1, \ldots, k+m-1).$$

It is obvious that $1 \leq r_l \leq MN$. If I_i denote a set that includes all the indexes l_p $(p = 1, 2, \ldots, M)$ such that rank r_{l_p} corresponds to the project i then one can see that for $i = 1, 2, \dots, N$

$$\frac{M(1+M)}{2} \leq \sum_{l \in I_i} r_l \leq \frac{2M^2N - M^2 + M}{2}.$$

4. Define the generalized indexes of quality for each project:

$$v_i = \frac{2M^2N - M^2 + M}{2} - \sum_{l \in I_i} r_l,$$

Thus, project i is preferred to project j iff $v_i > v_j$.

5. Find a variant of plan of financing by solving the boolean programming problem:

$$maximize \quad V = \sum_{i=1}^{N} \alpha_i v_i x_i,$$

$$subject \quad to \quad \sum_{i=1}^{N} c_i x_i \leq C, \quad x_i \in \{0, 1\}.$$

The solution of this problem is the vector $x^* = (x_1^*, x_2^*, \dots, x_N^*)$, where $x_i^* = 1$ if the project i is included into the plan and $x_i^* = 0$ otherwise.

The term of fulfillment of the whole plan (program) is defined as

$$t^* = \max_{i: x_i = 1} t_i.$$

Coefficients α_i are defined on the basis of the variant of the problem. If one has to find a plan maximizing the specific effect corresponding to an unit of expenditure on a time unit then $\alpha_i = 1/(c_i t_i)$, otherwise $\alpha_i = 1,\ i = 1, 2, \dots, N$.

Note, that the optimization problem may be stated in a "continuous form", when $x_i \in [a, b]$ with $0 \leq a < b \leq 1$.

Two methods was worked up to solve this optimization problem. The first one is based on the concept of branch and bound technique [2] and the second method uses the concept of dynamic programming [3].

We do not consider here a very important stage of the expert analysis when the estimations e_{ij} are determined. We would like to mention only that every such estimation e_{ij} is the result of processing of a set of fuzzy estimations corresponding to a group of experts.

During a work session with the system Decision Maker is allowed to redefine the preference structure on the set of criteria, to review some of indexes, to include into a final plan any subset of project which he considers to be necessary for the program or to exclude some of them, to save the suitable variants of a plan of financing for a post-operating analysis.

References

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Received September 15, 1992