Research Journal of Applied Sciences 9 (12): 1078-1081, 2014
ISSN: 1815-932X

Decision Making Support System in Multi-Objective Issues of Quality Management in the Field of Information Technology

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Abstract: The decision making technique for quality control issue based on fuzzy logic is described. The analysis of alternative choice is considered and the solution allowing reduce the human factor impact is provided. An example of the proposed method use is provided. The possibility of the developed method use for decision-making in other areas is specified.

Key words: Decision making, fuzzy logic, IT quality, multi-objective optimization, IT, outsourcing

INTRODUCTION

One of the most pressing problems in the management of information technology is the problem of decision-making, i.e., the choice of the optimal management choice among several alternatives, realizing certain goals. This class of problems include for example, the decision making concerning the transition to outsourcing (Desai, 2009; Hecker and Kretschmer, 2010) the decision on the choice of an implemented automated system (Calder and Moir, 2009) etc. The selection and comparison of just two options at a sufficiently large number of considered factors is the time-consuming procedure and during the uncertainty when the assessments of options are unclear, the procedure of choice does not have a well-developed methodological framework. In this case, the acquiring of knowledge and expert practical experience are of great importance. It is necessary to simulate the process of decision-making by specialists to select the optimal management option. The most important steps of this process are the determination of the evaluation structure and the criteria of alternative project selection (Steuer, 1988).

The existing models of choice under uncertainty conditions may be divided into fairly independent groups: according to the number of stages (single-stage and multi-stage ones), the number of decision-makers (individual and collective ones), the number of criteria used (one-criterion and multi-criteria). Finally by the nature of preferences description, one may select the model of fuzzy mathematical programming and fuzzy alternative relations (Olivero *et al*., 2013; Semenova, 2003).

In this study a Decision Making Support System (DMSS) is developed in multi-objective issues of information technology management based on fuzzy alternative relations.

MATERIALS AND METHODS

DMSS is a set of procedures for the settlement and logical type, combining strict mathematical methods for solution with the lax heuristic methods based on expert knowledge. At that an expert, heuristic component is the main one and the strict methods are mainly auxiliary ones (Sra *et al*., 2012).

The description of multi-objective problems under the conditions of uncertainty is conveniently carried out by constructing the preference relations between alternatives, followed by the separation of the fuzzy set of non-dominated alternatives. The expression of preferences in decision-making problems is usually implemented in the form of a binary relation on the set of alternatives a more universal method of solution in comparison with the use of an objective function.

In an multi-objective case the purpose function is a vector function $\varphi(a) = (\varphi_1(a))$ that is φ: $A \subset R^m \rightarrow R^n$ where, $A = (a_1,..., a_m)$ is a set of alternatives. At that the strict order on R^n is impossible. Any two alternatives a_1 and a_j are compared with each other if $\varphi_k(a_i) \geq \varphi_k(a_j)$ or $\forall k = 1,..., n$. Thus, the notion of optimality is replaced in vector optimization by the concept of domination absence. While in one-criterion problem the solution is an optimum point in the multi-objective problem it gives many effective (Pareto optimal) alternatives. The additional information from an expert is needed for the further, narrowing of this set and the different procedures

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used at that are limited mostly to the explicit or implicit transition of individual criteria into a single criterion. The examples of such generalized criteria may be the weighted sum of fuzzy criteria:

$$C = \sum_{k=1}^{n} w_k c_k$$

the equation of:

$$C = \prod_{k=1}^{n} c_k^{w_k}$$

type, minimal relations:

$$C = \min_{k=1,\ldots,n} (c_k / w_k)$$

Where:

c_k = Normalized criteria
w_k = Their weight

RESULTS AND DISCUSSION

Main part: The concept of domination structures and non-dominated solutions in multi objective issues may consider common cases in which there is information about the expert preferences. The differences of individual opinions causes fuzzy preference relation at the Cartesian product A×A.

Let $A = (a_1,\ldots, a_m)$ is a lot of alternatives, $C = (c_1,\ldots, c_n)$ is the set of criteria (Semenova and Smirnova, 2007). The fuzzy relation R_k of a lax preference by the criterion k on A is calculated as follows. The following element matrix is taken as a fuzzy relation matrix R_k:

$$\forall i \neq j \;\; r_{ij}^k = \begin{cases} 1, \text{if } a_i \text{ is better then } a_j \text{ by} k, \\ 0\text{-in other cases} \end{cases}$$

$$r_{ii}^k = 1$$

If the ratio R_k is developed in terms of social choice, the following element matrix is taken as a fuzzy relation matrix R_k:

$$\forall i \neq j \; r_{ij}^k = \frac{\sigma_{ij}^k}{N}$$

Where:

σ_{ij}^k = The number of people who believe that
a_i = Preferable than a_j
N = The number of experts $r_{ii}^k = 1$

The fuzzy relation R of lax preferences by all criteria on A is determined as follows:

$$R = \bigcap_{k=1}^{m} R_k$$

To develop a set of non-dominated alternatives R the fuzzy relation of strict preference R^s is used with FP:

$$\mu_{R^s}(a_i, a_j) = \begin{cases} \mu_R(a_i, a_j)\text{-}\mu_R(a_j, a_i), \text{if } \mu_R(a_i, a_j) \geq \mu_R(a_j, a_i), \\ 0\text{-in other cases,} \end{cases}$$

where, $\mu_R(a_i, a_j)$ is the preference function of non-strict preference fuzzy relation to A. Then the fuzzy subset of non-dominated alternatives is described by FP:

$$\mu_R^{ND}(a_j) = 1 - \sup_{a_i \in A} \mu_{R^s}(a_i, a_j) = 1 - \sup_{a_i \in A}(a_i, a_j) - (\mu_{R^s}(a_j, a_i))$$

where, $a_j \in A$. The alternative a^0 is taken from the set of clearly non-dominated alternatives:

$$A^{UND} \subseteq P$$

$$A^{UND} = \left\{ a_j \in A \,\middle|\, \mu_R^{ND}(a_j) = 1 \right\}$$

In the case of C_k criteria unequal importance the fuzzy relation R^* with FP is developed:

$$\mu_{R^*}(a_i, a_j) = \sum w_i \mu_k(a_i, a_j)$$

where, $\mu_k(a_i, a_j)$ is FP corresponding to fuzzy relation R_k.

To determine the degrees of criteria C_k importance w_k the procedure proposed by Saaty (1993) is used for the FP calculation. The degrees of criteria importance are determined based on the pairwise comparisons of the considered criteria. To this end, the matrix of pairwise comparisons $M = \{m_{pq}\}(p, q = 1,\ldots,k)$ is used, the elements of which are the evaluations m_{pq} of C_p criterion compared with the criterion C_q. The following scale of options rating is used to develop the matrix:

- The same significance of criteria
- Weak preference
- Significant preference
- Clear preference
- Absolute preference
- 2, 4, 6, 8 are the intermediate grades between adjacent value. In the case of group evaluation of options m_{pq} as an estimate the average value of C_q criteria individual ratings is taken compared with the criterion C_q

To ensure the consistency of the variant estimates we suggest that $m_{pq} = 1/m_{pq}$. In general, the empirical scale

$w = (w_1,...,w_m)$ should meet the problem of finding its own value where is the largest proper value $Mw = \lambda_{max}w$ where λ_{max} is the largest proper value. The closer λ_{max} to the number n, the more certain is the result. The deviation from n is the measure of the expert judgment inconsistency. After the finding of values the fuzzy subset of non-dominated alternatives is determined taking into account the importance of the following criteria:

$$\mu_{R^*}^{ND}(a_j) = 1 - \sup_{a_i \in A}(\mu_{R^*}(a_i, a_j) - (\mu_{R^*}(a_j, a_i)))$$

Finally, the alternative a^0 is taken from the set of clearly non-dominated alternatives:

$$B^{UND} = \left\{a_j \in A \middle| \mu_R^{ND}(a_j) \wedge \mu_{R^*}^{ND}(a_j) = 1\right\}$$

The selection of a particular solution from the Pareto set may also be performed using the method, the idea of which is to find the solutions, located as close as possible to the vector of simultaneously unattainable goals (to the ideal point).

Suppose we have a set of criteria C by which the decision options about an outsourcer choosing are evaluated and the best option is chosen. The goal is defined as the component of a linguistic variable, the meaning of which is expressed by the set of reference FP (Mikhailov, 2000).

The baseline data of alternative technological routes are presented in the form of a possible solutions matrix (Table 1): its lines contain the alternatives description $a_1 \in A$, I = 1,..., m and the columns correspond to the criteria C_k, k = 1,..., n. The matrix cells are filled with FP, built on the basis of the expert assessments by the Saaty Method.

To compare the estimates by different criteria the criterion scales are normalized according to the following equation:

$$U_j = \frac{t_j - t_{jmin}}{t_{jmax} - t_{jmin}}$$

Where:

t_j = The current estimate of an alternative according to j criterion

$\lfloor t_{jmin} \rfloor$, t_{jmax} = The range of acceptable values for the assessment by j criterion

Table 1: Possible solution matrix

	Criteria			
Alternatives	C_1	C_2	...	C_n
a_1	μ_{11}	μ_{12}	...	μ_{1n}
a_2	μ_{21}	μ_{22}	...	μ_{2n}
...	...	...	...	...
a_m	μ_{m1}	μ_{m2}	...	μ_{mn}
Requirements for an outsourcer	μ_{31}	μ_{32}	...	μ_{3n}

The selection of the best option is performed in accordance with the following rule:

$$D^* = \min_1 \sum_{k=1}^{n} w_k \cdot \rho_k(a_1, a_3)$$

where, $\rho_k(a_1, a_3)$ the indicator of the difference between the current and the reference assessments according to k criterion:

$$\rho_k(a_1, a_?) = 1\text{-}\max_{U_j} \mu_{1k}(u_j) \cap \mu_{эk}(u_j)$$

Summary: The implementation of the proposed approach to the multiple criteria approach of quality management allows to state that:

- An approach to multi-objective quality management in IT is developed during uncertainty
- The proposed solution allows to reduce the subjective assessment factors significantly
- The solution is an effective one and has a practical orientation

CONCLUSION

The developed DMSS implements the fuzzy optimization models of decision-making at multi-objectives under uncertainty and may be used for expert assisting in decision-making at the field of information and communication technologies.

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