SOFT DECISION MAKING AND FUZZY LOGIC

MĚKKÉ ROZHODOVÁNÍ A FUZZY LOGIKA

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Anotace:

Měkké rozhodování je postaveno na metodách, v nichž je na úkor preciznosti použitého modelu podporována schopnost vlastního řešení, robustnost a snadná implementovatelnost. Čím je systém složitější, tím jej lze méně podrobně popsat a zároveň klesá naše schopnost vytvářet o systému přesné soudy.
Fuzzy logika představuje přirozené vyústění systémovosti, kdy člověk není schopen se vyjadřovat pouze exaktně. Fuzzy logika naplňuje nepřesné pojmy lidského myšlení matematickým obsahem, který lze zpracovat a vyhodnotit.
Příspěvek se zamýšlí nad touto problematikou z hlediska překonávání problému nekomplexnosti a nejistoty při ekonomickém rozhodování. Fuzzy myšlení představuje metodický přístup moderního řízení a rozhodování.

Annotation

Soft decision-making is built on methods, which are based on solution finding, robustness and easy-implement ability, not precision and quality of used model. How the complexity of the system grows, it is not easy to describe system's characteristics and fall our ability to make reason about the system down.
Fuzzy logic is constitutional opening of systematism, where a man is not able to express himself exactly. Fuzzy logic enlarges inexact terms of human mind by mathematical comprehension, which can be compiled and analyzed.
The paper thinks over this problematic from the view of overrule the incomplexity and the uncertainty in economical decision making. Fuzzy thinking is methodical access to recent management and decision-making.

Key words

Soft methodology, soft systems, soft decision making, fuzzy measure, fuzzy logic, fuzzy modeling, fuzzy management

Klíčová slova

Měkká metodologie, měkký systém, měkké rozhodování, fuzzy míra, fuzzy logika, fuzzy modelování, fuzzy řízení.

1. Introduction

There are typical permanent changes and unexpected failures, which can be hard to forecast in global society. Often, slim unrecognized causation can invoke a disaster and in opposite, slim unrecognized input can invoke big desiderative effect. In these conditions, there are in control/management/leading process more and more important part, which highspeed information provide. It is necessary to have enough objective information available to make right decision, these information are provided by exact methods. In case of deficit of these information, it is necessary to use also subjective information, which has mostly qualitative character.

Steps, which lead to precision growing of classical mathematical model, lead also to that demand of quality and dimension of information, which is often unrealized in practice. Dimness, which goes together with subjective information in unconventional models, arises from subjective understanding in language quantification.

With growing number of elements and relations in complex systems, our ability to make exact judgments about system is falling. Often we cannot describe character of elements of these systems correctly, in the sight of quality and position in the system. In many cases, there is no high exactness of results, which are exact way obtained, required for decision making, for example in agriculture. It shows in some cases, there are better results in soft decision-making based on rough information and intuition, than mathematical optimization.

Approach to modeling, where instead of precision the self-learning ability, robustness and easy implementation is better, this approach we involve into soft methodologies. There are methods based on fuzzy logic also involved.

2. Soft decision-making

Soft decision-making term is used for decision in soft systems, which required special procedures (Získal, 2001). Softness of system is made by practically one factor and a man is mentioned by this factor, or in agriculture it can be biological subject. Soft systems we define by number of their characteristics.

Soft methodologies highlight the need of absolute system and system's environment understanding, the most advantageous problems description, without the formalization aspect. That's the reason why informal notes, panel discussions, and expert teams etc. are successfully used.

Result in soft system problem solving is not usually single-valued and definite solution. It can seem as recommendation. Solution finding in soft systems can be sometimes problematic. There are various reasons, for example there is no possible solution for the specific problem, algorithm of solution is not known, PC doesn't have required capacity etc. For these kinds of problem solution are usually approximate solutions used, because soft methodology uses new elements in classic procedures, e.g. subjective probability usage, fuzzy logic or qualitative simulation. Environments for computer-solved problems are suitable object-oriented and logic-oriented (e. g. Prolog, Smalltalk).

Soft systems methodology is essentially wider than hard systems methodology, which is a part of the soft systems methodology. Hard systems methodology uses tried apparatus, based on modeling and decision theory and on OR/MS methods. Positives are easy algorithmization of procedures, predictability and computation automatization possibility.

Hard methodologies are included in soft methodology in every analogical step; it is described e.g. by Simon (Simon, 1960). There is a difference in soft methodology; it takes human factor influence into account, in/outside the system, in all social, psychics, sociologic and politic aspects.

There is a need to respect a connection between soft and hard methodologies in practical problems solution, because one system can seem hard from one sight and on the other hand it demands a soft methodology usage. That is why making up of interdisciplinal teams to solve problems is supported; it can be said trans-disciplinal teams, which connect knowledge from very far science specializations.

In soft systems analysis there are finding ways how to describe the problem perfectly and how to show it by non-mathematical symbols and vague hypothesis, that means, it uses meta-methodology. The most important is the procedure description, which embodies methodology of methodologies. For example in systems science metamodeling is derived from this.

3. Fuzzy evaluation

Uncertainty, fortuity and possibility in soft system are very closely connected with a system complexity problem. Soft systems are used to be noncomplex, it means, information are missing and it affects uncertainty in reasoning and conclusions making. Uncertainty can be, in fact, described by probability measure or by fuzzy measure.

Fuzzy measure is good for soft systems analysis and description. Presence of uncertain event is taken as possibility, which is nearer to human mind. The Theory of Fuzzy set and fuzzy logic present very strong tool for soft systems analysis. It is relatively good described in literature, e.g. (Klír, 1995), (Ross, 1995) and others, but number of application these principles into practice problems solving is not so high as it should be.

Classic logic is binary and fuzzy logic is multi-valued. The easiest multi-valued logic is three-valued logic (0/1; ½ /½; 1/0). With help of language operators can be fuzzy statements made. Classic statement can be true or untrue. In fuzzy statement is it degree of truth. With the help of language operators can be degree of truth of fuzzy statements measured (e. g. statement: “the tree is high”). Fuzzyfied can be some rules used in classical logic (Havlíček, 2000).

Fuzzy set is typical by non-same limits among elements. Degree of element pertinence to set can be found on interval [0,1]. In formal mathematic is fuzzy set A same as its pertinence function μA: $X \rightarrow [0,1]$, where X is under consideration of possibilities set (universe).

Procedure of fuzzy evaluation of system starts with universe definition, universe is set of all classes of objects. Universe can be, for example set of farms in region. Universe can be divided into any number of fuzzy subsets (e. g. large, medium and small farms). Experts value pertinence on continual interval <0,1>. They transform their knowledge and experience in fuzzy logic into marked point on abscissa (0, 1), which is, in their opinion, the best degree of pertinence to given class for surveyed object. Negative side of this procedure is the problem, that the expert cannot involve his/her own system valuation, which can be non-same with given classes. After the identification of a pertinence degree to classes, solver compiles initially valued data into demand’s base, which means, that all classes definition is finished with the help of language operators and with the help of modification functions and he/she revises quantitative degrees of pertinence. Next criterion is meet of fuzzy sets, it means, which characteristics should be filled together to choose this concrete system.

There can different methods in elements of system evaluation be used, there are hard and soft accesses involved (Získal, 2001). In soft systems qualitative information, mathematical formulas are changed by word formulas and characteristics of soft system are valued vague reasoning.

Soft methods in expert evaluation can be better for some specific problems solution. Its basis is soft evaluative scale; on that scale the expert mark his/her degree of agreement by formal vague way. The results of expert's report are in fact cardinal evaluation from absolute disagreement to absolute agreement with statement. Prof. Havlíček instead points discrete evaluative scale suggested evaluations by continuum on abscissa (Havlíček, 2000). In this method expert marks his/her evaluation of elements on abscissa, where left extreme is „absolute positive" evaluation and right extreme is „absolute negative" evaluation. Inner points mean, by their distance from each extreme, the degree of expert evaluation.

4. Fuzzy approach application

- **Multicriteria decision-making** is one of the most developed and extended applications of fuzzy sets. For example (Ramík, 2001), (Brožová, Houška, 2000). Problematics of multicriteria variant decision making has typical characters, which can be summarized as followed. We have to respect a lot of criterions, which are often in conflict and incommensurable. Solution for those decision-making situations can be "the best" in all criterion variant finding, variant set ordering or exclude non-effective variants.

  There is basic term set of effective solutions in vector optimization problems; this set can be too large and unnoticed for person, who makes decision. Set of effective solutions can be sometimes taken as fuzzy set; it allows involving points "near" to set of effective solutions.

  In problems of complex variant analysis, especially in partial preference aggregation into final preference, there have fuzzy sets different character. Fuzzy set apparatus (relations apparatus) is central instrument of preference aggregation problem solution. It is mostly in effect of corresponding problems connected with pertinence function construction, these problems often resist/obstruct fuzzy sets apparatus practical application.

- **In fuzzy management** are rules formulated in linguistic form. From the point of view of system solution, there are all variable divided into controlled ones and uncontrolled ones. All variables have to give adequate information about controlled object situation and alongside controlled variables have to allow emulous operation to managed object. With help of fuzzyfication are transferred data load by a certain uncertainty into fuzzy sets characterized by concrete pertinence function. Interference can help to find to given fuzzyficate factors assumptions of fuzzy system rules, which are best for these factors. Defuzzyfication deduces concrete values of controlled variable from resultant fuzzy set, these values are usable in next reasoning (Konečný, Pezlar, 2001), they present all fuzzy system phases of control by loans offer to banks. Fuzzy approaches are used for system management/control with help of fuzzy regulators FCL (Fuzzy Logic Control), it is said by (Pokorný, 1996). Regulators are based on language description of control process principles usage and derived compositional principles. FCL are rated into engineering part of management problems.

- **Fuzzy linear programming application**

Fuzzy linear programming can help to solve some kinds of variant selection from set of alternatives, when selection is limited by vague demand (Havlíček, Získal, 1994). If one of the linear programming model input factors is a fuzzy (**A, b, c**) number, than value of criterion function is a fuzzy number too. It means, that certain value of criterion function, after criterion acquittal, can be reached with a certain degree of pertinence, it can be regarded as a risk measure of relevant solution. Procedure is easy because of linearity demand of all used functions. To make it easier, we can suppose, that right side limits of linear programming problem are fuzzy, limit are given as fuzzy number. It shows solution of that kind of problem by model parameterization; in this case is it right side limits of restrictive conditions parameterization. In cases, where values of c_j or a_j are given as fuzzy numbers, there is procedure by analogy.

When linear programming model is given as $max\{cx | Ax \le b, x \ge 0\}$, where at least one of values b_i, i = 1,2, … m is fuzzy number, than right sides of unequation can be written in form of $\widetilde{b} = b_i + \rho p_i$, where p_i is the higher possible tolerance $b_i \ a \ \rho \in \langle 0,1 \rangle$. To restrictive condition $\sum a_{ij} x_j \le b_i$ is given corresponding pertinence function.

$$\mu_i(x) = \begin{cases} 1, & when \sum a_{ij} x_j \le b_i \\ 1 - \dfrac{\sum a_{ij} x_j - b_i}{p_i}, & when\ b_i \le \sum a_{ij} x_j \le b_i + p_i \\ 0, & when \sum a_{ij} x_j \ge b_i + p_i \end{cases}$$

Here μ (x) = l, when limit is certainly filled, μ (x) ∈ (0,1), when maximum tolerance p_i is growing down progressively to zero value μ (x) ∈= 0, when restriction is not certainly filled. If tolerance p_i is given, **linear programming problem** can be described as:

$$\max\left\{ cx \middle| \sum a_{ij} x_j \le b_i + (1-\lambda) p_i, x_j \ge 0, \lambda \in \langle 0,1 \rangle \right\}$$

Problem formulated this way can be taken as right sides linear programming model parameterization problem with parameter $\rho = 1 - \lambda$. Value ρ is risk of solution measure and on the other hand it gives also a degree of pertinence $\mu_A(x)$ into fuzzy set **A** („Solution by risk“). If $\rho = 1, \quad \lambda = 0,$ there are right side limits in solution, with maximum value $b_i + p_i$, it means, there is a solution with the highest risk. If is $\rho = 0, \quad \lambda = 1,$ right side is in solution with value $b_i + 0p_i = b_i$, solution is without risk. Value 100ρ gives relative risk of solution acceptance in percents.

5. Conclusion

Soft management became more and more applied on managed systems. It has more reasons, but mostly it is need of total knowledge of problem, based on the most pregnant description, with no regard to its formalization.

One of basic tool for description and cognition of reality is fuzzy theory. It starts to be a part of various spheres of human activity. For example, many applications show, that fuzzy regulations are more stationary and tolerate mistakes more than common regulation systems. Today's level of fuzzy models methodology is relatively high and this methodology is applied in environmental problems solving, especially in ecological systems modeling. Pragmatic thinking is clear, elegant and tried, in opposite fuzzy thinking is critical to one-way solutions and is open for future solution space.

Higher forms of soft information are knowledge. Information lower degree of uncertainty on receiver side, knowledge arise from number of information into context insertion. Trend leads us to knowledge society.

6. References

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