Parameters and Rules of Fuzzy-based Risk Management Models

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***Abstract**: A solution for the risk management and risk communication modeling is offered by fuzzy-based risk management, as it can calculated using words, manage parameter-related insecurity and imprecision, and incorporate the experiences communicated by experts into a fuzzy rule-based reasoning system. In the paper an overview of the basic characteristics in fuzzy rule-based risk management systems is given.*

***Keywords**:risk management, fuzzy, risk factors*

1 Introduction

In recent years special attention has been paid to risky and dangerous situations in the natural environment as well as in social economic surrounding, within the bounds of one's personal life, concerning health and lifestyle. Thanks to the revolution of information communication one is quickly and realistically informed about all these issues. But the question is, is there really a greater amount of information or is it the ever-improving information process that enables one to know all these? According to analysts, risks and dangers are not more common, but one has the appropriate tools to predict them or at least evaluate their risk-level.

Various risk situations may appear in system operation, which in extreme cases may even lead to disasters. In this sense in system modeling these risk situations and the factors causing them must be evaluated, their interaction and consequences modeled. A general model can be a system where the risk level is determined based on the risk factors and the rule-based system as set up by the experts [1].

The risk level of planned or predicted events can be anticipated and planned, but even so a number of unplanned factors may arise stemming from risk factor interaction, measuring or evaluation error, or the uncertanty and versatility of the premises. Disaster risks are specific in the sense that their occurrence is characterized by an even greater level of insecurity, as the potential loss or risk may be extremely large for the extreme input values. In terms of risk management it can be seen as aggravating circumstances when complex events are not independent of each other, or are in close correlation in territorial, temporal or other terms.

Further insecurity or uncertanty is caused by the fact that different people, groups (laymen or experts) sense and evaluate the same risk differently and assign it with different values, and such situation is also very difficult to model using only traditional devices. People's sense of risk determination is constantly changing during interaction, this makes the process a social and communication process. In terms of system modeling the competence of the participants in the system modeling process is crucial, as the soft computing systems primarily incorporate information gained through experience into the system, and one of the key features of these is subjectivity [2].

Risk-communication includes any communication related to risk determination, prediction, evaluation, management and visualization. A great example for this is the health service, where all of the above are incorporated into the doctor-patient communication process.

A great solution for the given challenge is offered by fuzzy-based risk management, as it can calculated using words [4], manage parameter-related insecurity and imprecision, and incorporate the experiences communicated by experts into a fuzzy rule-based reasoning system. Also it is very effective in communication towards the user, as these solutions are very human-oriented, and since they are based on expert experience, they have a mathematically-based background model. The Mamdani-type model is suitable for such purposes.

Generally the risk management system in the preliminary form contains the identification of the risk factors of the investigated process, the representation of the measured risks, and the decision model.

This article sets out to focus on the significant elements of this approach.

2 The Parameters of the Fuzzy-based Risk Management

The uncertainties and vagueness of the complex risk management system, and the multi-criteria and multi-parametrical environment suppose, that the fuzzy descriptions of the parameters, and fuzzy logic based approximate reasoning seem to be a useful tool for the representation. The models for solving are knowledge based models, where the linguistically communicated modeling is needed.

The fuzzy-based risk management models assume that the risk factors are fuzzified (because of their uncertainties or linguistic representation). Furthermore, depending on the used fuzzy calculation and goal of the risk management, the method is constructed to figure out the final result: decision, risk level, or others.

As the output of the risk management system, the risk or risk level may be defined as the measure of the probability and severity of an unwanted event. An unwanted event is an occurrence that has an associated undesirable outcome. There are usually defined outcomes from any some initial events, and may range in severity from trivial to catastrophic, depending on conditions [3]. Due to this, the outputs of the rule base system can be represented with those words, namely with trapezoidal fuzzy numbers representing those words, scaled on the universe [0,1], the subset of the real number set.

The calculated risk or risk level can be therefore defined as a function defined basically on the universe of input risk factors. The hierarchical or multilevel construction of the decision process assume the grouped structural systematization of the input risk factors, depending on their belongings to the decision subsystems.

Based on the main ideas from [5] a risk management system can be built up as a hierarchical system of the risk scaled on their universe and represented by membership functions covering over all possible qualitative or quantitative values appear in the application [6]. The membership functions can be represented based on the experts' experiences, statistical distribution or others. Input risk factor can be defined usually on the universe, which is the set-product of the frequency with which an event is anticipated to occur and the seriousness of the consequence of the event's outcome: *Risk factor-universe = Frequency-universe X seriousness-universe,* where the frequency depends on the number of occurrence and it is scaled on the interval [0, presumed max. number of the occurrence] with related fuzzy sets like *infrequently, normal, frequently*. The seriousness can be scaled on the interval [0,1], and covered by the fuzzy sets like *low risk*, *normal, dangerous, catastrophic*.

Fuzzy environment is able to represent the ambiguous risk factors and rules in an acceptable form, where the risk factors are grouped based on theirs role in the decision making system. The system parameters' interaction is not on irrelevant moment in the modeling process, that is why the pair wise comparison matrix can be added to the risk management system model. If one builds up a fuzzy based model with the grouped risk factors on the input, a fuzzy AHP (Analytical Hierarchy Process) model for the multilevel, hierarchically structured risk management system can be constructed, with further open problems and possibility to fine tuning in the reasoning process [7].

3 The Rules of the Fuzzy-based Risk Management

The models for solving of the risk management problems are knowledge based models, where the objective and subjective knowledge (definitional, causal, statistical, and heuristic knowledge) is included in the decision process. Based on the human approach where the basic rules and order are known for experts, it is natural to offer the rule-base representation. In those systems the risk management and risk level calculation statements are represented in the form of *if premises then conclusion* rule forms, and the risk factor calculation or output decision (summarized output) is obtained using fuzzy approximate reasoning methods (Mamadani type for example) [8]. Considering the fuzzy logic and fuzzy set theory results, there are further possibilities to extend the fuzzy-based risk management models modeling the risk factors with type-2 fuzzy sets, representing the level of the uncertainties of the membership values, or using special, problem oriented types of operators in the fuzzy decision making process [9].

The hierarchical or multilevel construction of the decision process, the grouped structural systematization of the factors, with the possibility of gaining some subsystems, depending on their importance or other significant environment characteristics or on laying emphasis on risk management actors' is a possible way to manage the complexity of the system. Carr and Tah describe a common hierarchical-risk breakdown structure for developing a knowledge-driven risk management, which is suitable for the fuzzy approach [5]. Based on the ideas from [5] the membership functions which describe the risk factors can be represented based on the experts' experiences, statistical distribution or others. Risk management actions and direction or directions for the next level of risk situation solving algorithm represent the decision making system. Actually, those directions are represented as the intermediate risk factors for the action on the next level of the risk management process. The outputs of the rule based reasoning subsystems are risk factors for the next level of the risk factor calculation. In the applications from the firs level of the risk management and general risk level calculation the subsystem outputs are scaled on the unipolar scale [0,1], where 1 means the big risk, and the values near 0 the low level of risk related to the risk factors included as the inputs in the investigated reasoning subsystem.

It is reasonable to use the scale of unit real interval to this intermediate values, because the weighting of the subsystems can be more controlled by the gaining multiplayer from the interval [0,1], namely the product of the intermediate value and gaining factor still stay on this unit scale, and fire the next level input scales. The trapesoidal fuzzy sets on the borders of the parameters' scales guarantie the trating of the extreme situations (using for example description of the words like *chatastrofic* and others).

The rules are constructed carefully, considering the unipolar character of the intermediate system parameters. The final, general risk level is calculated using all informations related to the input risk factors, and it can be a number from the interval [0,1] and permit the ranking or seriousness of risk situation.

Conclusions

The article has given an overview of the scaling of the universe of the risk management systems' input and output parameters, which can also be well-managed in a fuzzy environment, and the basic knowledges about reasoning system in fuzzy based risk managemet models. From the point of view of scaling several types of scaling can be defined. There are a number of issues to be further developed. One of these tasks is the fine tuning of the hierarchical and other multilayer systems in such a way, so that the scaling between the layers will better follow the operation of the system. In terms on fuzzy ontologies, this would be of utmost importance.

Acknowledgement

This work was supported by the Research Grant of Óbuda University (ÓE-RH 1186/2-2011) and Vojvodina Secretary of the Science and Technological development (title of the project: Mathematical Models for Decision Making under Uncertain Conditions and Their Applications).

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