System Model for the Risk Level Calculation of the Leisure Activity

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Abstract: - The model of the risk level calculation for the sport and physical exercises is a complex risk management model, where a great number of coherent and also independent risk factors should be taking into the consideration as the statically description of the problem. The dynamism of the system is represented by the rules of the risk level calculation and decision about the possible activities of the subjects (patients). In the paper the general system model description for the mentioned problem is given, and summarizing to what extent the here-investigated subsystems' further possible solutions are forecasted considering the interference of the risk factors.

Key-Words: - Fuzzy decision making, Risk management, Leisure activity

1 Introduction

In a complex, multilayer, and multi-criteria system, such as the risk management system is, the question arises how to manage a huge number of coherent and also independent risk factors and the reasoning system, and how to incorporate them into the well structured environment. The risk factor structure can be handled by different architectures, i.e. hierarchical system [1], cognitive map [2] ontology [3] or others. The mutual effects of the system parameters can be represented with the help of the AHP (Analytic Hierarchy Process) methods [4]. The timely relevant general system theory summary can help as to recognize the behavior of the investigated risk management system: model of the risk level calculation for the sport and physical exercises as a complex risk management model.

1.1 System and system model

Systemizing and system research has always been present in science, however the last century has seen a huge leap thanks to the development of informatics and technical-scientific development leading to the establishment of system theory.

The system is a collection of elements and parts, working together towards a common goal. The characteristics of both living, social, and technical systems state that the processes, activities within the system have to be examined in context in order to be able to make valid deductions. The aim of system theory is to understand and examine the system and its reality, possibly with the help of isomorphic or similar models.

The model is understood to be a system representing another (the modeled) system and the connections of their elements, and/or the processes within the modeled system. The creation of system models is usually an interdisciplinary task, since in order to make an isomorphic system, identical to the original, one needs to know the original thoroughly. However, it is also necessary to know the methods by which a formalized model can be created and the original system's behavior modeled.

The system models usually consist of static and dynamic components. The static constituent models the relationship system of the system elements and subsystems, while the dynamic constituent models the rule of system functioning, and the system conditions changing over time. The static model is often given in a visualized form, a graph, with the expected mathematical description, whereas the dynamic behavior is represented with a mathematical model.

These are the basics of the so-called *formal systems*. The aim of the formal systems is to provide such mathematically based system models, system descriptions, which can be transferred into an IT environment, using software and hardware to simulate the system model behavior on the computer.

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Generally the models have always been created by man, either as simple sketches or equations, however, systems have always been complex. The great challenge of the 21st century is to provide the systems' formal models that are as true to reality as possible, with the technological background provided by the head-spinning rate of IT development .

1.2 Mathematical thinking – the mathematics of thinking

Since the mid-20th century the created system models have been of a technical, possibly economic character. This period was also the origin of the algorithms and formal representations connected to paradigms of various generations of computer programming languages: the system structure diagrams, analyzing graphs, flowcharts or unified modeling language, which is capable of multi-component and multi-layer representation to depict the static and dynamic behavior, in sync with object-oriented and web-based computer realization.

When creating the static relationship system the basics of graph theory have to be taken into consideration and the system limits acknowledged. Mathematical thinking may be a great help with this, as it highlights relationships between system components, recognizing hierarchical and mutual relationships and formalizing them. It takes widespread knowledge and often interdisciplinary team work to obtain selected data that can be recognized, modeled in IT environment, and formalized in a system model. It must be understood that the established connection and relationship system can be adaptive, as well, by including past and current experiences to make future estimates in order to use in the analysis of environmental analysis. This, though, means that one needs the description of system behavior rules.

When modeling dynamic behavior of the system or system model it is vital to use basics of mathematical logic, i.e. the mathematics of thinking. Intelligent understanding and reasoning, design and decision making are all basic human cognitive skills. Thinking is also the 'language of the brain,' i.e. even without thinking about it, it is a more or less formalizing process. Logical human thinking has to be the basis for formalized, modeled, machined reasoning and decision making in IT environment. Correct syntax and semantics of the applied mathematical logical model are key issues for the modeling process.

Human thinking and reasoning rarely fits into strictly two-valued logic, i.e. strictly true or false statements. Man's thinking is more nuanced, there is possibility, dependence on the passing of time, or the handling of uncertainty in these models. The previously mentioned problems already have their widespread mathematical logical theories (possibilistic, temporal, fuzzy logic and others), what's more, in an IT environment it is not only possible to represent data quantitatively, but qualitative representation and computation - computation with words is also possible [5].

One of the challenges of the current times is to create a mathematical logical model capable of modeling full-scale human thinking and cognitive skills. The following need to be considered: using a language that can be computed in its form and syntax and keeping the correct reasoning rules, i.e. semantics should mirror how man thinks and reasons. The artificial intelligence (AI) is a synthesis of numerous fields of science: mathematics, computer science, system theory combined to perform the reasoning process about the system's actors and system characteristics so as to teach and develop the system. It is clear that there is no artificial intelligence system capable of such complex thinking, reasoning as a human being, since man does not only take into consideration logical factors, but also the factors of emotion, habit, human difference, and others, but the 21st century models will be models that do not only take rationality into consideration, but also emotionality and other human manifestations.

When analyzing a system, then the agent approach seems to be the obvious one. The organizational forms and behavior of agents follow the architecture and manner of human and natural communities, since these have been successfully functioning for several millennia, and there is no need to invent new ones, rather model their counterparts in IT computational environment with transparent mathematical model. In this way one finds in models hierarchy, oligarchy, coalition, team, congregation, community, federation, market, matrix and other structures of agents.

It must be stated, though, that creating a model that describes all characteristics of the agents, and their overall role in the structure is an extreme difficult task. It ought to be enough, however, to systemize and important elements, as the current IT and computational technologies are stressed as it is by all the verification and validation methods needed to ensure the systems consistency and seamless operation, even if these are already working in the cloud system.

The mental or cognitive map is a representation of visual and later computation modeling, which enables one to gather special and interactive

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information, store, categorize, recall and compute these. All this naturally involves further expansion for generalization possibilities of the past decades' modeling techniques, though the following must be regarded: a consistent system model, correct rule of reasoning, and the computer-based realization.

Consistency and reasoning method within a system are always controlled and verified by the tools of mathematical logic. Apart from the traditional binary zero-order and binary first-order logics, the Lukasiewitz logic and fuzzy logic have a history of more than half a century. After suitable interpretation the extended logic models are referred back to binary logical methods which can be handled in IT environment, or to such function descriptions, whose mathematical models can be handled by software. Novel methods include fuzzy as well as other soft computing methods: genetic algorithms, neural networks, and cognitive methods.

The most significant questions regarding the cognitive models are still the following:

- What is more desirable, qualitative or quantitative data processing?
- Can data collection be standardized?
- Can it be made more efficient if used together with other research methods?
- In the case of hybrid systems, or with diverse types of (maps of analytical) data, how can they be connected and a suitable interface created?

Can ethical questions be modeled?

2 Physical exercises - the risk management model

Considering the previous survey of the system modeling conception one can apply the general determinations for the risk management problem, which is a complex, multi-criteria and multi-parametrical system full of uncertainties and vagueness. In its preliminary form contains the identification of the risk factors of the investigated process (statically model), and can be enlarged by monitoring and review in order to improve the risk measure description and decision system (the dynamic model). The models for solving are knowledge-based models, where very often linguistically communicated modeling is needed, and objective and subjective knowledge (definitional, causal, statistical, and heuristic knowledge) is included in the decision process. Considering all these conditions, fuzzy approach helps manage complexity and uncertainties. The input factors can mostly be grouped, the groups can be weighted, and the mutual effects of the factors can be given in a matrix form. Considering the complexity of the risk management systems and the hierarchical or multilevel construction of the decision process, the grouped structural systematization of the factors can be introduced. This approach allows 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.

Especially the investigated model of the risk level calculation is the sport and physical exercises risk management model, where a great number of coherent and also independent risk factors should be taken into consideration as the statically description of the problem. The dynamism of the system is represented by the rules of the risk level calculation and decision about the possible activities of the subjects (patients).

Physical exercises in human life can make one healthier and the lack of sport can lead to our health deteriorating. It is however important to be aware that improper movement can be harmful, if it is not the right movements for our capability or not the proper duration, frequency, intensity was chosen. The basic physical information, actual physical status of the subject, age and many other sub-factors should be considered, in order for the sport to be safe and healthy rather than making the situation worse.

The first approach to the problem modeling constructed by the authors was based on the Analytic Hierarchy Process with Fuzzy Comprehensive Evaluation (AHP-FCE) model [6], and the authors' model constructed in Matlab Fuzzy Toolbox environment try to find the way to calculate the risk of physical exercise using a hierarchical decision structure with a multilevel decision tree. The input parameters are the measured risk factors. The alignment based on the event is analyzed using multi-criteria rules and hierarchical system structure where at the intermediate levels the specified risk factor groups are analyzed. The final step is the calculation of the total risk for the problem, where the evaluation is executed through the hierarchy from the bottom levels to the highest.

The groups of risk factors are Medical condition, Activity load and Environmental condition. The Medical condition is a basic risk group, and includes such persistent diseases as hypertension, diabetes or cardiac diseases and others. In all cases the personalized medical recommendations of these sub-factors should be considered. Possible values are very bad, bad, medium, healthy and very

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healthy. Current physical status is used to assess the actual physical condition. Parameters such as pulse or blood pressure can be measured online, other are a priory quoted and asked from the subject. Basic physical information is about age, sex and the living conditions such as occupation (stress and activity). The Activity load refers to the current activity with sub-factors: intensity, duration and frequency. The third main group is Environmental condition., related first of all to the outdoor sports activity, but humidity and temperature together can influence the risk level of the activities indoor, too.

It is important to mention that AHP-FCE is a weighted fuzzy model, but the introduced model does not use those type of weights to represent the priority and the importance of the risk factors and groups of the risk factors. The novel introduced fuzzy based model was an effective way for health promotion for every group that was tested. At special groups of the subjects the model was more careful than the AHP-FCE, but the conclusion was that the input parameter set should be extended and precisely defined [7].

The neuro-fuzzy model is based on the author's former validated fuzzy logic-based model [8]. Due to the easily expandable hierarchical multilevel decision structure of the fuzzy model, one of the risk groups was effortlessly substituted with a neuro-fuzzy subsystem. Neuro-fuzzy systems combine the advantages of both approaches. Fuzzy approach in risk management is also very advantageous, because it can handle the uncertainty, imprecision and subjectivity in data and in evaluation process. The studied model is used for risk calculation for physical exercise and in this kind of applications there are many interactions between the input factors and there is a need to tune the membership functions and rules according to the patient characteristics. This is not feasible with a fuzzy approach, but it can be handle by a neural network. The neural network regards the evaluation process as a black box, but with the fuzzy rule layer it can be handled. The two approaches are complementary and in this way the evaluation will be more efficient than the fuzzy or the neural network approach itself. Risk management systems are very complex with a high number of input factors and rules, furthermore the interactions between the input factors should also be handled. The size of the rule base is particularly important, because the increase in the number of the rules increases the number of the nodes exponentially. This study aims to simplify the structure of the neuro-fuzzy subsystem without rule-base reduction, but with decreases in the number of the nodes. To achieve this goal an OR layer was incorporated into the system to connect the rules which has the same consequent part. In this layer the disjunction operator was used. Since the three basic operations of crisp sets (negation, conjunction, and disjunction) can be generalized for fuzzy sets in an infinite number of ways, different functions can be efficient for different problem implementations [9]. The neuro-fuzzy model has a hierarchical multilevel clustered structure, which makes it easy to expand the model structure and also simplifies the evaluation process. The risk level evaluation of the "Medical condition" group performs with a neuro-fuzzy subsystem, which is based on the ANFIS model structure the with Mamdani-type inference system. There are some rules in the system which rule-premise belongs to the same consequent part. This is the basis of the structure simplification, because these rule-premises can be connected together with a novel layer incorporated into the system. This layer is a disjunction operator layer and it builds in the system between the normalization layer and the consequent layer. In this way the number of the nodes in the consequent layer can be significantly decreased. In the basic neuro-fuzzy subsystem there are one hundred and twenty-five nodes, because each rule has a node in the consequent layer. In the simplified structure the output membership functions can be represented sufficiently with five nodes.

The simplification with using the maximum operator as a conjunction method trivially can be performed, because of the Mamdani type inference system rule evaluation method. In this process the overall rule output is obtained as union of each rule output. Consequently the rules with the same consequent part have the same output membership function and as a result of the union these trapezoids overlap. Therefore among the rules which have the same consequent part the output will be applied which has the higher supremum, this includes

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the others. The maximum method is equivalent with this, therefore this disjunction operator can be used in the OR layer. In this case only the output with higher supremum will be considered.

During the study the model was tested with several possible disjunction (OR) operators. It can be concluded that the author's basic neuro-fuzzy model structure can be simplified without rule-base reduction, but only the maximum and product operators give acceptable results comparing with the other studied t-conorms. They are more effective in the connection layer, than the others.

The previously presented solutions give answers for some of the questions from the introduction:

What is more desirable, qualitative or quantitative data processing? Can it be made more efficient if used hybrid systems?

The presented fuzzy and neuro-fuzzy, as a hybrid model handle both of qualitative and quantitative data processing. The grouping of the input factors and hierarchically constructed decision tree a priori uses the natural human cognitive scheme.

4 Conclusion

Besides the investigation of different decision structures, which represent the dynamic behaviors of the risk level calculation model for the sport and physical exercises, henceforward is an open problem the broaden set of input factors, coherent and also independent risk factors.

The preliminary idea was, as it was presented, the grouping of the factors based on the role and other characteristics of the them in the model: Medical condition, Activity load and Environmental condition. Consulting the experts it is clear that the interaction of the factors inside the groups and between the groups is very important, and one of the possible solutions it is the construction of the cognitive map. The further works will be related to the integration of this method in the existing one.

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