SOFT COMPUTING AND ITS USE IN RISK MANAGEMENT

doc. Ing. Petr Dostál, CSc.

Brno University of Technology, Kolejní 4, 612 00 Brno, Czech Republic, Institute of Informatics, Faculty of Business and Management, Tel. +420 541 143 714, Fax. +420 541 142 692, e-mail: dostal@fbm.vutbr.cz, dostal@iqnet.cz, http://www.iqnet.cz/dostal

ABSTRACT

New analytical methods have begun to be used in risk management. The methods such as fuzzy logic, neural network and genetic algorithms rank among them. The article shortly describes these methods and represents their possible applications in the risk management. These methods can contribute to decreasing of the risk and thus the human and material losses.

KEY WORDS

Risk management, soft computing, fuzzy logic, genetic algorithms, neural networks

1 INTRODUCTION

The new decision-making methods that include the findings from the theory of fuzzy logic, neural networks and genetic algorithm are dynamically developing. The scientific problem is how to use these findings in the field of risk management. The subject of the research is the construction of models using these theories. The scientific aim is to find the applicable models. The used methods are based on the theoretical findings and they include the system approach in the process of the build-up of the models, their testing and evaluation of results.

2 THE BASIC ELEMENTS OF SOFT COMPUTING

Among significant elements of soft computing it is possible to rank fuzzy logic, neural networks and genetic algorithms (Aliev,2002; Ribeiro,1999). Further it is possible to mention the parallel genetic, swarm particles, ant colonies, hill climbing algorithms, tabu search, simulated annealing, methods based on artificial immune systems, multi-agent systems that use agents or holons etc. A lot of methods were used or they are successfully applied in technical systems. Their applications start also in the areas of social systems. Risk management belongs to them.

2.1 Fuzzy logic

The theory of fuzzy logic is described in literature (Altrock,1996; Klir and Yuan,1995). Fuzzy logic uses the fuzzy sets that measure the certainty and uncertainty of the pertinence of element to the set. Likewise people make a decision during the mental and physical activities that is not easy to describe by algorithm. It determines "how much" the element belongs to the set or not. For example, the risk of investment can be described instead of numbers by scale: very high risk, high risk, medium risk, low risk, very low risk, no risk. In such a way it is possible to describe the inputs (fuzzification). The so called membership functions of attributes are expressed by mathematical functions. The further step (fuzzy inference) defines the behavior by means of the rules of the type <If>, <Then>, <With>. The conditional clauses creates these algorithms which evaluate the state of relevant input variables with set up of weight x of rules in the form

<If> $Input_a$ <And> $Input_b$ …<And> $Input_x$ <Or> $Input_y$ …<Or> $Input_z$ <Then> $Output_1$ <With> x.

The last step (defuzzification) converts the results to outputs (defuzzification), for example very profitable, profitable, non profitable investment etc (fig.1).

Figure 1. Fuzzy logic

2.2 Neural networks

The theory of neural network is described in literature (Bose and Liang,1996; Hagan and Demuth,1996; Kazabov and Kozma,1998; Novák,1998). Neural network rises from the findings of biology and it uses the principles which are controlled by human brain. In a simplified version the biological neuron consists of more inputs (dendrites), body cell and one output (axon). The inputs are processed by neuron and its output information is spread by axon to their endings (synapses). These synapses influence the dendrites of other neurons. The activity of the human brain is enabled by means of huge quantity of connections of neurons that create the life of man and include the process of learning. By means of simplified model of activities of the human brain it is possible to set up a neural network. Such a built-up computer program allows us to solve various problems that we find in economy. Similarly a man defines the process of learning, testing and realization.

The neural networks represent the thinking of human brain. The activity of neural network consists of three stages - learning, testing and implementation (fig.2).

Figure 2. Neural network

The weights of nodes are set up during the process of learning, the process of testing search how is the network learnt. The network has become an "expert" when it is learned and it produces outputs on the basis of knowledge obtained during the process of learning.

2.3 Genetic algorithms

The theory of genetic algorithms is described in literature (Davis,1991). The genetic algorithms simulate the evolution of human population. At operation with genetic algorithms the most often used operators are selection, crossover and mutation. The selection means the choice of best population. The crossover means the exchange of so called chromosomes among single individuals of population. The mutation means the modification of part of chromosome when a random change happened. These operations are presented at table 1.

Selection			Crossover		Mutation	
01111010	>	00100010	Parents	Offspring	Before	After
122	>	34	011|**0010**	011*1001*	0110010	0010110
			011|*1001*	011**0010**		

Table 1. Genetic algorithm

The genetic algorithms operate in such a way that the initial population of chromosomes is created first; this population is changed by means of genetic operators so long until the process has no been finished. The reproduction process that is repeated is called the epoch of evaluation of population (one generation) and it is presented by three mentioned steps. Similarly the build-up programs work that does the optimization of economic problem.

3 Risk management

Risk management is a branch that covers a wide range of methods used in many branches. The risk is connected with the hope of achievement of the best economic results, that is the decrease of danger of failures or losses that can affect the stability of the firm or to evoke the bankruptcy. The risk rises from the reasons of lack of information and insufficient understanding of phenomena, the use of unsuitable and unreliable data, and the use of unsuitable methods or by the influence of random processes. This branch has become inevitable to keep the competitiveness. The aim of the firm is to achieve the best economic results that means to decrease failures and/or loses (Smejkal and Rais,2006). This aim can be achieved with the help of methods such as use of fuzzy logic, neural networks and genetic algorithms. Always it is important to have good knowledge about the used method.

3.1 Risk management - case study

The case study includes the evaluation of risk of payment of debt by customer. Here is an example of part of the table 2 of searched data.

Gender	Age	Status	Child	Income	Account	Debt	Employ	Contact	Order	Payment	Risk
0	65	1	0	11000	50000	0	45	5	15	0	35
0	25	0	1	10300	0	0	5	2	8	1	60
1	78	0	0	8300	0	0	60	2	20	0	42
1	19	0	0	4900	0	520000	0	0	4	0	75
0	48	1	2	42000	850000	0	28	8	40	0	15
1	79	0	0	7400	0	0	45	0	1	1	85
1	26	0	0	12600	100000	88000	8	2	10	0	55
…	…	…	…	…	…	…	…	…	…	…	…

Table 2. Part of searched data

3.1.1 Fuzzy logic

The application of the fuzzy logic model can be demonstrated on the case of evaluation of rate of risk of payment of active debt. The application is solved with eleven input variables, three rule blocks and one output variable with three attributes. The inputs and their attributes are: Sex (man, woman), Age (young, middle, old), Marital status (married, single, other), Children (none, one, more), Income (low, medium, high), Account (none, medium, high), Debt (none, medium, high), Employment (short, medium, long term), Contact with client (short, medium, long term), Order (first, few, more), Delayed payment (none, few, more). It presents eleven inputs where from two to three attributes are selected according to the demand of realization of project. The output from the rule box Personal data evaluates the personality of the client (excellent, good, bad), the rule box Financial data evaluates the financial situation of client (excellent, good, bad), the rule box Quality of a client evaluates the client from the point of view of the relation consumer - supplier (excellent, good, bad). The output variables is the Risk of payment of active debt with three attributes (low, medium, high). It is necessary to set up the membership function for all inputs and outputs. We can use the functions in the shape of Λ, Π, Z, S. The rule box must be set up with rules and their weigh (DoS = Degree of Support) among inputs and outputs. The weight of rules can be changed during the process of optimization. The build-up model can be used for the evaluation of the rate of risk of payment of active debt. On the basis of input values we obtain the information whether the risk of payment of active debt is low, medium or high. The course of membership function and the weight of rules DoS can be set up by means of neural network in case we have data at disposal.

The fuzzy logic model was built-up (fig.3) and tested, that performed evaluation of risk of client with the result of low risk (fig.4). It was tested tens of cases that lead to the conclusion, that the model is usable in practice. The FuzzyTech program of Inform GmbH was used.

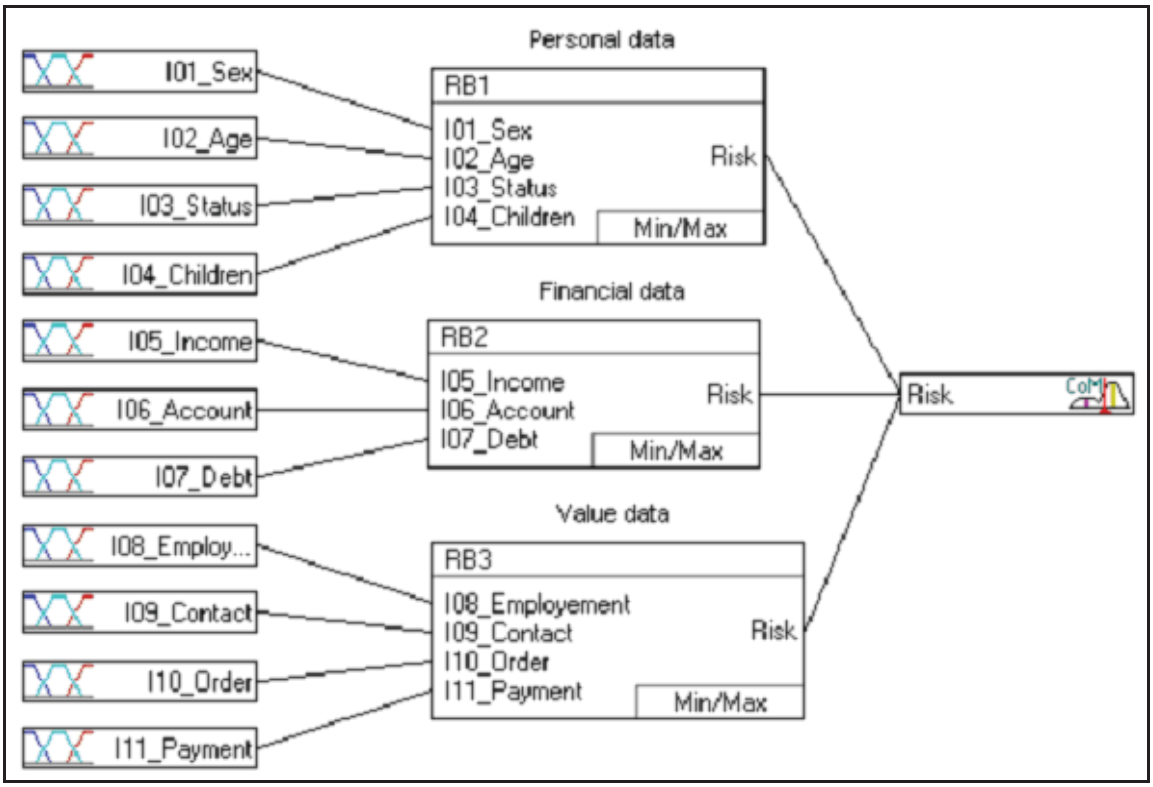

Figure 3. Fuzzy logic - model

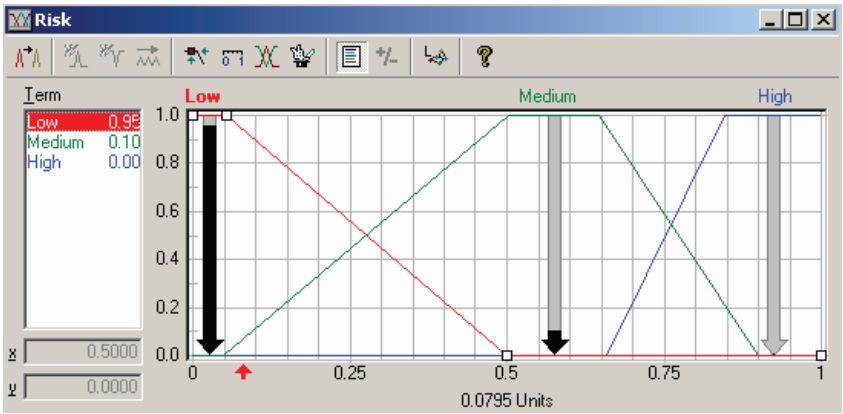

Figure 4. Fuzzy logic – output

3.4.2 Neural network

The application of neural network can be demonstrated on the case of evaluation of the risk of payment of active debt. The input of neural network is a matrix of values which characterize single parameters. The inputs and output variables are Sex (man = 1, woman = 0), Age (years), Marital status (free = 0, married = 1, other = 2), Children (number), Income (USD), Account (USD), Debt USD), Employment (years), Contact with client (months), Order (number), Delayed payment (number) and Risk (from 0 to 100%), The single rows present single cases of the clients. If we do not know and we want to know the risk of payment of active debts we mark it with symbol ?. If we determine the input matrix we set up the inputs and

outputs, the type of transfer function, the number of layers of neural network, the range of data for learning and testing. During the process of testing and learning it is possible to trace the error of testing and learning. If the error is small the process is terminated. The result is the suggested value of risk of payment of debt by client for new searched case.

The neural network model was built-up (fig.5) and tested, that performed evaluation of risk of client with the result of medium 35% risk (fig.6). It was tested tens of cases that lead to the conclusion, that the model is usable in practice. The NeuroForcaster of NIBS Pte. Ltd. was used.

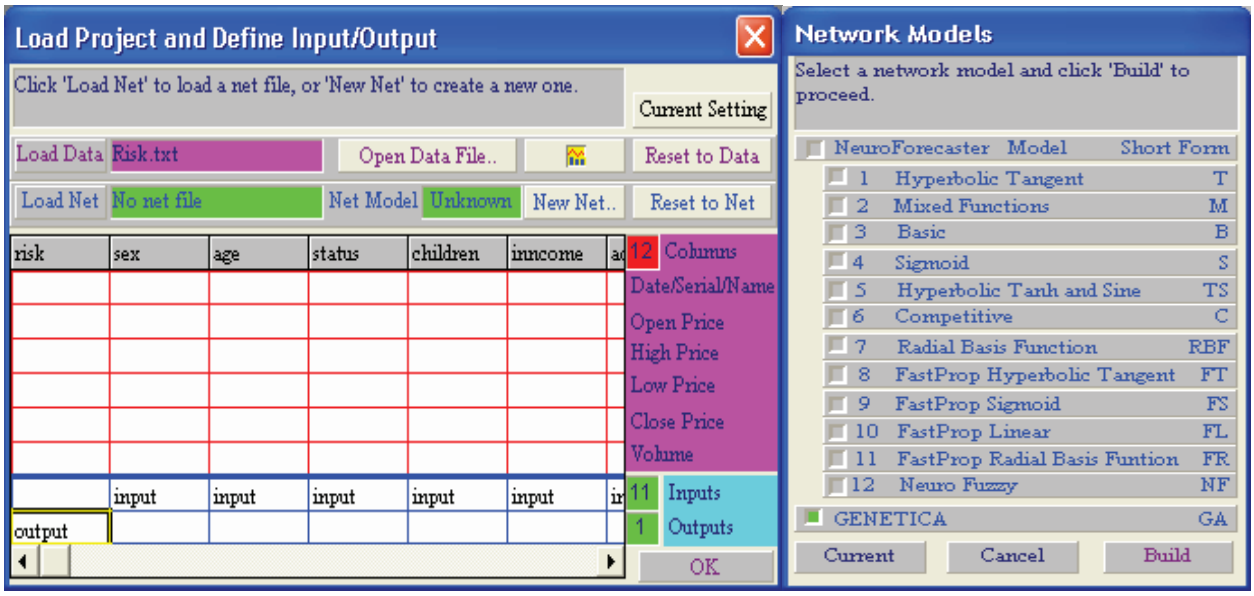

Figure 5. Neural network - model

Risk	Sex	Age	Status	Children	Inncome	Account	Debt	Duration	Time	Purchase	Number
35	0	65	1	0	11000	50000	0	45	5	15	0

Figure 6. Neural network – output

3.4.3 Genetic algorithms

The use of genetic algorithms can be presented in the area of risk of payment of active debt. It is possible to use the genetic algorithms in the process called cluster analyses. It is the way when we try to divide the data into clusters and find their centers. The inputs can be any number of variables and many numbers of values and it is possible to choose any number of areas of division. The mentioned case is multidimensional. It is presented by twelve vectors that express dependences of risk (from 0 to 1) on the input variables such as Sex (man = 1, woman = 0), Age (years), Marital status (free = 0, married = 1, other = 2), Children (number), Income (USD), Account (USD), Debt USD), Employment (years), Contact with client (months), Number of orders (number), Delayed payment (number). It is possible to run the calculation after the determination of number of clusters, set up of table and parameters of calculation.

During the process of calculation the program set up randomly the centers of clusters and it assigns the points to the nearest centers. The whole process is repeated as long as the position of centers fulfils the condition of optimum of fitness function. The fitness function presents the sum of distances among points and centers of corresponding clusters. This function is optimized. After the calculation it is possible to obtain the clusters that present for example customers with high income and low risk of payment of active debt etc.

The genetic algorithm model was built-up (fig.7) and tested, that performed evaluation of risk of client with the result the result of high risk HR (fig.8). It was tested tens of cases that lead to the conclusion, that the method is usable in practice. It was tested tens of cases that lead to the conclusion, that the method is usable in practice. The GeneHunter of Ward System Group Inc. was used.

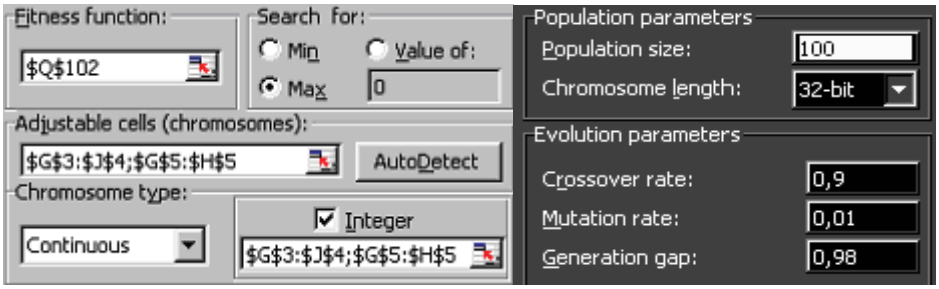

Figure 7. Genetic algorithms – model

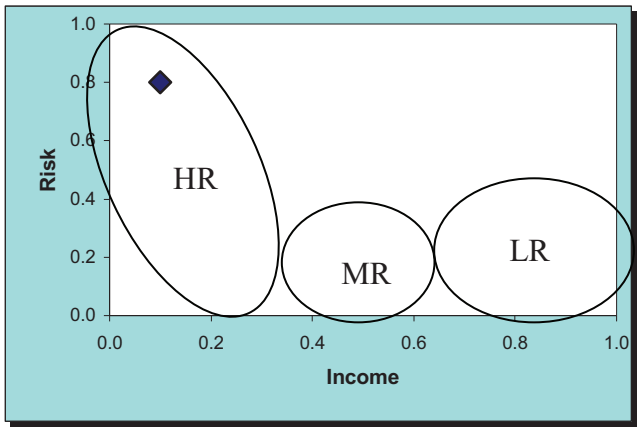

Figure 8 Genetic algorithms - results

4 Discussion

The research was focused on the use of the soft computing in risk management. The problem of evaluation of risk clients was tested on the tens of cases and hundreds of data by means of fuzzy logic, neural network and genetic algorithm. The methods defer slightly in inputs data (fuzzy logic and genetic algorithm do not work with vague terms and neural network needs output data for build-up of a model). The outputs give us slightly different results (fuzzy logic vague terms, neural network the numerical value and genetic algorithm the assign to the cluster). Each of the methods represented by the models in the article gets good results. Some knowledge and results are presented in literature (Dostál and Rais,2001; Dostál,2002; Dostál,2005; Dostál and Rais,2005; Dostál,2006; Dostál and Rais and Sojka,2006).

5 Conclusions

The risk management processes can be ranked among the most complicated processes because the society creates the phenomena with significant rate of chaotic behaviour. In cases when it is necessary to make a decision it is appropriate to use the methods of soft computing that give promising results. These methods to which fuzzy logic, neural network and genetic algorithms belong, can be used separately but also in their combination. These methods have wide range of utilization. The results of analyses and calculations serve us as a support of decision making processes. The correct decision making is an important step for the firm or organization to be successful and competitive.

6 Literature

Conference

DOSTÁL, P., RAIS K. Methods of Large Investment Unit Modeling, *In Transformation of CEEC Economies to EU Standards*, University of Trento, Italy, 2001, pp. 84-89, ISBN 80-86510-27-1.

DOSTÁL P., RAIS, K. Risk Management and Artificial Neural Network, *In Word of Information Systems*, Zlín, 2005, pp. 292-297, ISBN 80-7318-276-9, ISSN 1214-9489.

DOSTÁL, P. The Use of Fuzzy Logic at Support of Manager Decision Making, *In Management, Economics and Business Development in the New European Conditions*, Brno, 2005, p.44, 5p., ISBN 80-214-2953-4.

DOSTÁL P. Risk Management and Fuzzy Logic, *In Word of Information Systems*, Zlín, 2006, pp. 115-120, ISBN 80-7318-400-1, ISSN 1214-9489.

Book

ALTROCK, C. *Fuzzy Logic & Neurofuzzy – Applications in Business & Finance,* Prentice Hall, USA, 1996, 375p., ISBN 0-13-591512-0.

DAVIS, L. *Handbook of Genetic Algorithms,* Int. Thomson Com. Press, USA, 1991, 385p., ISBN 1-850-32825-0.

DOSTÁL, P. *Modern Economic Analyses – Financial Cybernetic*, (In Czech), UTB Zlín, 2002, 110p., ISBN 80-7318-075-8.

DOSTÁL, P. *Advanced Methods of Analyses and Simulation in Economy*, (In Czech), VUT Brno, 2006, 61p., ISBN 80-214-3324-8.

NOVÁK, N. *Artificial Neural Network – theory and practice,* (In Czech), C.H.BECK, Praha, 1998, 382p., ISBN 80-7179-132-6.

Book (more authors)

ALIEV, A., ALIEV, R. *Soft Computing and Its Applications,* World Scientific Publishing Ltd, UK2002, 444p., ISBN 981-02-4700-1.

BOSE, K., LIANG, P. *Neural Network, Fundamental with Graphs, Algorithm and Applications,* Mc Graw-Hill, USA, 1996, 478p., ISBN 0-07-114064-6.

DOSTÁL, P., RAIS, K., SOJKA, Z. *The Advanced Methods of Manager Decision Making,* (In Czech), Grada, 2005, 168p., ISBN 80-247-1338-1.

HAGAN, T., DEMUTH, B. *Neural Network Design,* PWS Publishing Comp., USA, 1996, 702p., ISBN 0-534-94332-2.

KAZABOV, K., KOZMA, R. *Neuro - Fuzzy – Techniques for Intelligent Information System,* Physica-Verlag, Germany, 1998, 427p., ISBN 3-7908-1187-4.

KLIR, G.J., YUAN, B. *Fuzzy Sets and Fuzzy Logic, Theory and Application,* Prentice Hall,New Jersey, USA, 1995, 279p., ISBN 0-13-101171-5.

RIBEIRO, R., YAGER, R. *Soft Computing in Financial Engineering,* A Springer Verlag Company, 1999, 590p., ISBN 3-7908-1173-4.

SMEJKAL V.,, RAIS K*., Risk Management in Firms and Other Companies*, (In Czech), Grada, 2006, 296p., ISBN 80-247-1667-4.

Petr Dostál

SOFT COMPUTING AND ITS USE IN RISK MANAGEMENT

Summary

The risk management processes can be ranked among the most complicated processes because the society creates the phenomena with significant rate of chaotic behaviour. The problem is how to use the findings from the theory of fuzzy logic, neural networks and genetic algorithm in the field of risk management. The subject of the research is the construction of models using these theories. The aim is to find the applicable models.

The fuzzy logic uses the fuzzy sets that measure the certainty and uncertainty of the pertinence of element to the set. The neural network rises from the findings of biology and it uses the principles which are controlled by human brain. The genetic algorithms simulate the evolution of human population.

The application of the fuzzy logic model, neural network and genetic algorithms are demonstrated on the case of evaluation of rate of risk of payment of active debt. The problem of evaluation of risk clients was tested on the tens of cases and hundreds of data by means of fuzzy logic, neural network and genetic algorithm. The methods defer slightly in inputs data and the outputs give us slightly different results. Each of the methods represented by the models gets good results.

The results of analyses and calculations serve us as a support of decision making processes. The correct decision making is an important step for the firm or organization to be successful and competitive.

Recenzent/Reviewer:
doc. Ing. Vladimír Chalupský, CSc.
Brno University of Technology
Faculty of Business and Management
Kolejní 4
612 00 Brno, Czech Republic
E-Mail: chalupsky@fbm.vutbr.cz