BUSINESS FORECASTING VIA SOFT COMPUTING METHODS

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Abstract

Forecasting methods have had successful applications in business. Nowadays the new theories of soft computing are used in this field because it helps to lead to higher profits. There are especially the methods such as fuzzy logic, neural networks and genetic algorithms. The fields of applications of forecasting methods in business cover a wide area of applications

Keywords: Forecasting, soft computing, fuzzy logic, neural networks, genetic algorithms

1. INTRODUCTION

There are various ways of using the methods for forecasting such as fuzzy logic, neural networks, genetic algorithms and others. The soft computing methods are used for forecasting the future. The program MATLAB® with Fuzzy Logic Toolbox, Neural Network, and Global Optimization is used [19, 20, 21, 22]. The fields of applications of forecasting methods in business cover a wide area of applications [1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 15, 16].

2. FUZZY LOGIC PREDICTION

In classical logic, a theory defines a set as a collection having certain definite properties. Any element belongs to the set or not according to clear-cut rules; membership in the set has only the two values 0 or 1. Later, the theory of fuzzy logic was created by Zadeh in 1965. Fuzzy logic defines a variable degree to which an element x belongs to the set. The degree of membership in the set is denoted μ (x); it can take on any value in the range from 1 to 0, where 0 means absolute non-membership and 1 full membership. The use of degrees of membership corresponds better to what happens in the world of our experience. Fuzzy logic measures the certainty or uncertainty of how much the element belongs to the set. People make analogous decisions in the fields of mental and physical behaviour. By means of fuzzy logic, it is possible to find the solution of a given task better than by classical methods.

A fuzzy set A is defined as (U, μA), where U is the relevant universal set and μA: $U \rightarrow \langle 0,1 \rangle$ is a membership function, which assigns each elements from U to fuzzy set A. The membership of the element $x \in U$ of a fuzzy set A is indicated $\mu A(x)$. We call $F(U)$ the set of all fuzzy set. Then the “classical“ set A is the fuzzy set where: μA: $U \rightarrow \{0, 1\}$. Thus $x \in A \Leftrightarrow \mu A(x) = 0$ and $x \in A \Leftrightarrow \mu A(x) = 1$. Let Ui, $i = 1, 2, ..., n$, be universals. Then the fuzzy relation R on $U = U1 \times U2 \times ... \times Un$ is a fuzzy set R on the universal U.

Let us mention an example that solves the problem of decision making whether to order the product from supplier or not. The wrong decision can influence the situation of the firm in future. The model for the MATLAB program and its Fuzzy Logic Toolbox is presented in Figure 1. The inputs and output use vague terms.

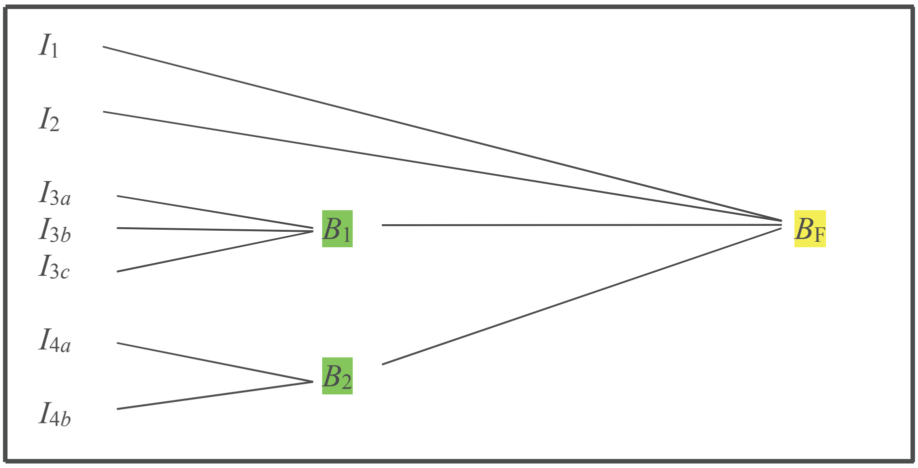

Fig. 1 The diagram of model - Stock Trading

The variables I_1 and I_2 are inputs to the final rule box B_F together with output from rule box B_1 with inputs I_{3a}, I_{3b}, I_{3c} and output from rule box B_2 with inputs I_{4a}, I_{4b}.

The rules and terms are as follows: the box B_F (No, Yes) determines whether to order the product from supplier or not; the block B_1 (bad, good, excellent) evaluates the business conditions represented by input I_{3a} package (bad, good, excellent), input I_{3b} discount (no, low, high) and input I_{3c} guarantee (no, one year, more years) of product; the block B_2 (bad, good, excellent) evaluates additional conditions represented by input I_{4a} reliability of supplier (bad, good, excellent) and input I_{4b} helpfulness of supplier (bad, good, excellent). The input I_1 represents the price of goods (low, medium, high) and input I_2 represent the quality of goods (low, medium, excellent). The output variable B_F evaluates whether to order the product from supplier or not. The membership functions were used in the shapes of Λ, Π, S and Z (see Figure 2).

When more rule boxes are necessary for using the decision-making process it must be connected. The connection can be done by creation of an M-file that enables reading the input data, but also the transfer of results to other blocks.

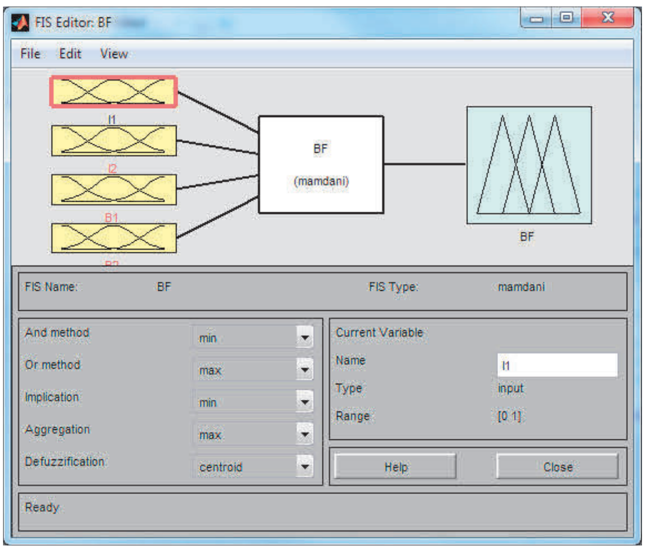

Fig. 2 Rule box B_F

The program for calculation was created. The results of the calculation are presented by inputs I_1, I_2, I_{3a}, I_{3b}, I_{3c}, I_{4a}, I_{4b}. The results of two examples lead to No and Yes in case of order the product from supplier (see Figure 3).

Inputs I_1; I_2: [high; low]	Inputs I_1; I_2: [low; excellent]
Inputs I_{3a}; I_{3b}; I_{3c}: [bad; no; no]	Inputs I_{3a}; I_{3b}; I_{3c}: [excellent; high; more years]
Inputs I_{4a}; I_{4b}: [bad; bad]	Inputs I_{4a}; I_{4b}: [excellent; excellent]
Result of delivery = No	Result of delivery = Yes

Fig. 3 Results of calculation

3. NEURAL NETWORK PREDICTION

Cells, large neurons with many branching dendrites were discovered in the eighteen century by Purkinje. The history of the development of artificial neural networks started in the first half of the twentieth century. The first publications were by McCulloch. Later Pitts worked on the simplest model of a neuron, and after that Rosenblatt created a functional perception that solves only problems involving areas that are linearly separable. When the multilayer network was discovered by Rumelhart, then Hinton and Williams created back-propagation methods for multi-layer networks. A great boom of neural network applications has been ongoing since the mid-1970s.

The neural network model represents the thinking of the human brains. The model is described as a "black box." It is not possible to know the inside structure of the system in detail. We make only a few suppositions about the inner structure of the system. It is simulated by a "black box" that enables us to describe the behaviour of the system by the function that performs transformation of input and output. It is suitable to use neural networks in cases where the influences on searched phenomena are random and deterministic relations are very complicated. In these cases we are not able to separate and analytically identify them.

Artificial neural networks are essentially simple mathematical models defining a function $f : X \rightarrow Y$. Mathematically, a neuron's network function $f(x)$ is defined as a composition of other functions $g_i(x)$, which can further be defined as a composition of other functions. This can be conveniently represented as a network structure, with arrows depicting the dependencies between variables. A widely used type of composition is the nonlinear weighted sum, where $f(x) = K(\sum_i w_i g_i(x))$, is some predefined function. It is convenient to refer to a collection of functions g_i as simply a vector $g = (g_1, g_2, \dots , g_n)$.

It is possible to predict any time series. The quality of forecasting can be influenced by the choice of a start of the time series (a short time series can be as unsuitable for forecasting as a long one), the choice of transfer function and parameters of neural network (number of layers), the range of data for testing and learning, the method of learning and testing etc.

Let us mention example of the use of neural networks for forecasting of values of time series. The time series is created from the history of sold products recorded in defined file. The program was created. The results are presented in graph in Figure 4. The graph presents history of 120 days of selling products and it's forecasting for next 30 days to help to set up a plan of production.

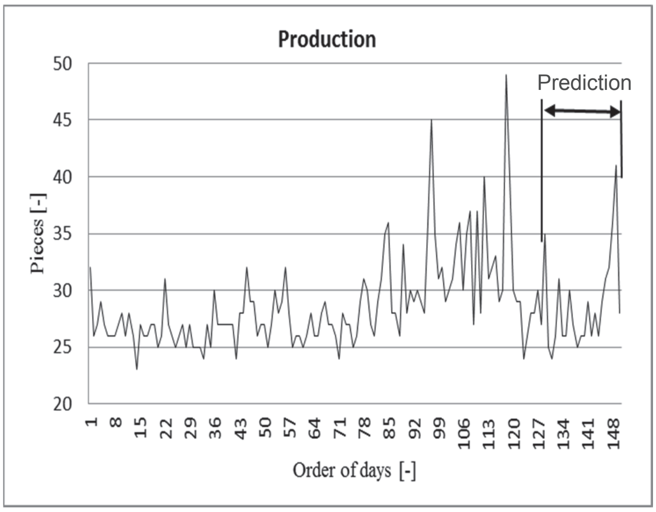

Fig. 4 Historical and forecasted data of time series

4. GENETIC ALGORITHM PREDICTION

Genetic algorithms are used in studies where exact solution by systematic searching would be extremely slow. Genetic processes in nature were discovered in the nineteenth century by Mendel and developed by Darwin. The computer realization of genetic algorithms discovered in the 1970s is connected with the names of Holland and Goldberg. Recently there has been considerable expansion of genetic and evolutionary algorithms in the spheres of economic applications and the decision making of firms and companies.

The genetic algorithm can be used for forecasting. The aim of a genetic algorithm as an optimization task is to divide a set of *N* existing objects into *M* groups. Each object is characterized by the values of *K* variables of a *K*-dimensional vector. The aim is to divide the objects into groups so that the variability inside groups is minimized. The sequence of steps is as follows:

The software MATLAB and its Global Optimization Toolbox are used for the software applications that can be used to solve these types of problems. The input data are represented by coordinates $x_1, x_2, \ldots, x_K$ that characterize the objects. It is possible to define any number of groups. The fitness function is the sum of squares of distances between the objects and centroids. The coordinates of centroids $c_{j1}, c_{j2}, \ldots, c_{jK}$ ($j = 1, 2, \ldots, M$) are changed. The calculation assigns the objects to their centroids. The whole process is repeated until the condition of optimum (minimum) fitness function is reached. The process of optimization ensures that the defined coordinates $x_{i1}, x_{i2}, \ldots, x_{iK}$ ($i = 1, 2, \ldots, N$) of objects and assigned coordinates $c_{j1}, c_{j2}, \ldots, c_{jK}$ of groups have the minimum distances. The fitness function is expressed by following formula

$$f_{\min} = \sum_{i=1}^{N} \min_{j \in (1,2,\ldots,M)} \left(\sqrt{\sum_{l=1}^{K} (x_{il} - c_{jl})^2} \right), \quad (1)$$

where *N* is the number of objects, *M* the number of groups, and *K* the dimension.

Let us mention an example of the use of genetic algorithm for the prediction of business risk where clustering method was used. Input data are represented by 48 objects with *Quality of Product* and *Reliability of Delivery*. The output is *Business Risk*.

The program was created. When the calculation is terminated, the input parameters and results of calculation are displayed on the screen. The results are presented by coordinates of centroids and assignment of risk of clients to groups (see Figure 5).

Number of groups: 3; Population size: 1000

assign =	*1*	*3*	*3*	*1*	*1*	*1*	*3*	*3*	*1*	*1*	*3*	*2*
	1	*3*	*2*	*2*	*2*	*1*	*2*	*3*	*2*	*1*	*3*	*3*
	1	*2*	*3*	*2*	*3*	*1*	*2*	*1*	*2*	*1*	*3*	*1*
	1	*3*	*2*	*1*	*3*	*3*	*1*	*2*	*3*	*1*	*1*	*2*
fval =	*629.1939*											
xyz =	*82.6359*		*93.1444*		*12.7026*							
	14.5173		*20.0677*		*80.5966*							
	44.8121		*52.4713*		*51.8326*							

Fig. 5 Coordinates of centroids and location of places to clusters

A three-dimensional stem graph is drawn where values are in per cents (0% - the worst case, 100% - the best case), see Figure 6. The results presents the case where the cluster C_1 means low business risk represented by the group of supplier with high quality of product and reliability of delivery of supplier, the cluster C_2 means medium business risk represented by the group of suppliers with medium quality of product and medium reliability of delivery of supplier and the cluster C_3 means high business risk represented by the group of suppliers with low quality of product and reliability of delivery of supplier.

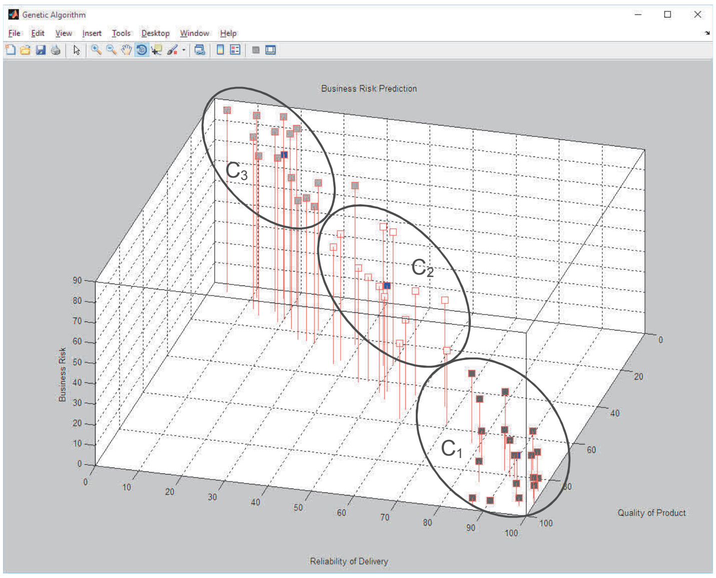

Fig. 6 Three-dimensional graph - 3 clusters

The presented example illustrates how to solve various problems. The tasks from practice lead to multi-dimensional ones, where their graphical presentation is impossible: the image of the solution is in a hyper sphere (the inputs could be also the package, discount, guaranty etc.).

5. CONCLUSION

The prediction methods have specific features in comparison with others. The processes are focused on obtaining profit. Therefore, such applications, both successful and unsuccessful, are not published very often because of secrecy in the highly competitive environments in business. The forecasting methods play very important roles because they help to lead to higher profit. The forecasting processes in business are very complicated because they include political, social, psychological, economic, financial, and other factors. Some variables are difficult to measure; they may be characterized by imprecision, uncertainty, vagueness, semi-truth, approximations and so forth.

The use of soft computing methods can lead to higher quality of forecasting that can be used for decision-making.

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