Using Neuro Fuzzy Methods for Creating Sales Forecasting Web Service

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***Abstract* — This paper presents a new way of implementing the forecasting process using a neural network and a fuzzy controller. At the first stage of the process, the neural network performs the forecasting based on internal parameters, and then the fuzzy controller adapts the results to the changes of the external parameters. The main problem of neural networks in forecasting is the impossibility to foresee the changes in the external parameters. This problem is solved by the fuzzy controller, which reacts to any change in the external parameters and adjusts the forecasted data provided the neural network.**

***Key words* – neural network, fuzzy logic, fuzzy controller, rule base, time series, diagnostication.**

I. Introduction

Forecasting is the process of making statements about the future outcomes of events, processes etc., based on the analysis of the circumstances that determine their occurrence and evolving. The anticipation of future values of certain dimensions is a widely popular challenge due to its importance in multiple fields like medical science, tech, economy etc.

The complexity of the process of discrete sequences forecasting is high due to the fact that, unlike the algorithmically well-organized interpolation procedures, the forecasting needs extrapolation of data from the past towards the future. Moreover, many unfamiliar factors that influence the discrete sequences must be considered. There are many studies dedicated to the elaboration of the mathematical model of forecasting. Most of them are based on probabilistic and statistical tools, and their use requires a considerable amount of experimental data, which is not always available or even possible to accumulate.

In the last years, a growing interest in neural networks in addressing forecasting problems can be observed. These are considered a most close model to reproduce human brain activity, and can be "taught" to identify regularities previously unobserved.

In the fuzzy specialty literature, the forecasting methods are divided in 4 groups:

- based on actual data, presented as temporary strings
- based on heuristic information, obtained from highly-qualified specialists in the field
- based on mathematical, biological or historical analogies
- complex methods - combine multiple approaches [1].

In this paper a model for sales forecasting will be presented, being created based on a neural network and a fuzzy controller connected serially. At the first stage, the neural network will generate the forecasting data based on the data from previous sales (internal parameters). At the second stage, the data generated by the neural network will be automatically adapted to the influence of external factors (parameters).

Thus, forecasting is a continuous adaptive process, which needs its results to be modified in order to have optimal overall results and taking into consideration every change in the external factors.

II. Forecasting Method Description

The determination of objectives is one of the main purposes of forecasting. The objectives selection is performed as a result of the problem analysis. After the selection a tree of objectives classified by index of priority is created (fig. 1).

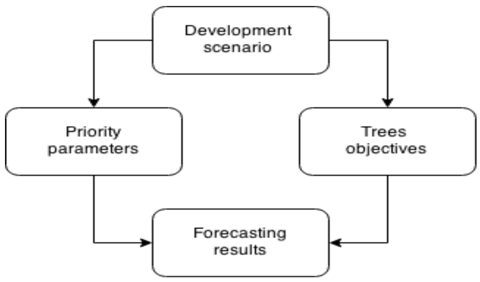

Fig. 1. Obtaining the forecasting results.

Another object of the study is the method of creation of forecasting systems which are based on up-to-date intellectual technologies: fuzzy set theory, neural networks, fuzzy logic methods and genetic algorithms.

The most important issues in the forecasting models creations are the following:

- there are some unclear links between the intern and extern parameters (fuzzy);
- there is no statistical stability in neither the input nor the output parameters [2, 3].

Thus, the use of classical methods like extrapolation and regressive analysis are not useful, because their main disadvantage is the need of a big amount of statistical data for many parameters and for different time spans.

Fuzzy sets offer the possibility to formalize values, to determine cause-and-effect relationships between parameters and the factors that may influence them, and to formulate a prognosis in a state of uncertainty.

In fig.2 there is the diagram of the forecasting method which is based on fuzzy logic methods.

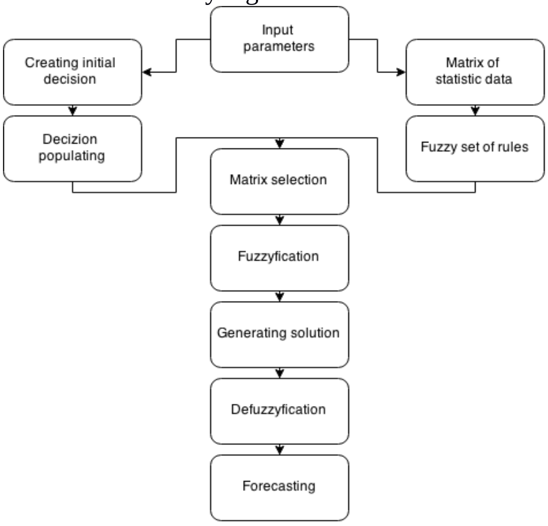

Fig. 2. Forecasting method diagram.

The algorithm used to create the forecasting mathematical model is:

- establish input and output parameters;
- based on an expert system, form fuzzy sets and select the unit of measurement;
- define the set membership functions;
- form the rules base;
- establish the decision making algorithm [4].

While building the mathematical algorithm, the object is investigated as the function:

$$P = FuzzyPrognosis(t_{1,} t_{2, \ldots} t_n), \quad (1)$$

where n – the number of terms (input parameters), P – the final solution.

The working algorithm of the *FuzzyPrognosis* function is:

1. collecting the input parameters set that can influence the final solution;
2. generate linguistic variables for each of the input parameters and of the respective correspondences;
3. create a graph that will reflect the parameter classification;
4. collect statistical data;
5. fuzzify data (transform the precise values of input parameters into linguistic fuzzy values);
6. the membership functions of the linguistic variables are given in the following form (2)

$$fA(X) = \quad (2)$$

where P_i stands for the configuration parameters;

7. get the modelling results; it is done by transforming the fuzzy sets back into exact values (defuzzification).

The configuration of the fuzzy model is made by the completion of the rules base and composing the membership function (2) and is represented by the form in fig. 3.

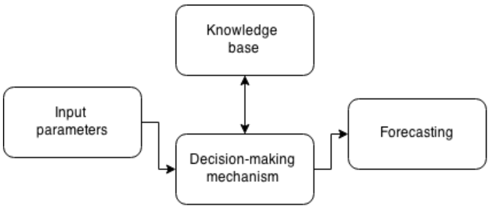

Fig. 3. The fuzzy decision making model.

The rule base consists of data received from experts, in a *cause-effect* format(3).

$$S: \begin{Bmatrix} S_{1,}\ if\ A_1\ then\ B_1 \\ S_{2,}\ if\ A_2\ then\ B_1 \\ \ldots \\ S_{n,}\ if\ A_n\ then\ B_1 \end{Bmatrix} . \quad (3)$$

The matrix generation (3) takes place using genetic algorithms approaches: as a result of a finite number of iterations of the genetic algorithm a solution is chosen (chromosome) having the maximal quality index, based on the initially announced criteria.

Every iteration of the genetic algorithm consists of several consecutive operations:

- forming the set of chromosomes;
- creating the chromosome descendants as a result of combining base chromosomes with certain mutations;
- calculating the quality level for the newly created chromosome.

In order to determine the subject of the prognosis, the analysed and forecasted variables must be specified. It is very important to know the level of particularization, which is influenced by many factors: availability and quality of data, the costs of the analysis of user preferences in the system.

In cases where the best variable combination isn't clear, different alternatives could be tried, selecting the one with the best results.

Another important step in building a neural networks based forecasting system is the definition of the following three parameters: the period, the interval and the horizon of the forecasting.

The forecasting period is the essential time unit for which the prognosis is made.

The forecasting horizon represents the number of periods in future for which the prognosis is made. For example, a forecasting for a period of one week could be necessary, presenting separate data for each day. In this case, the period is one day, while the horizon – one week.

The forecasting interval – the frequency of new prognosis.

The coherent selection during a particular period or horizon is the most difficult part of neural network based forecasting. The accuracy of a prognosis on a particular problem, has a solid impact on the whole forecasting system. Also, of a big influence on the prognosis accuracy is the data set chosen for the network to "learn" [5].

III. The Issue

A specific example must be investigated: forecasting the amount of sales of an enterprise which sells food. The medium is nondeterministic, because the conventional models do not allow to determine with certitude what will happen in the next moment in time and because all factors that could possibly influence the moment are not known.

There are several financial signs [6]:

Enterprise activity

- sales history (amount of products, amount of money);
- storage operations history;
- advertising activity indicators.

External factors

- prices for competitors services;
- market state;
- inflation level;
- currency exchange state;
- stock market index.

There are also secondary factors (table 1), which can also influence sales. These parameters have a different significance, have different values and origins.

TABLE I. Secondary factors

Parameter	Importance
P1 = Products is store	I(P1) = 30
P2 = Advertising intensity	I(P2) = 20
P3 = Raw material price	I(P3) = 60
P4 = Geographical position	I(P4) = 10
P5 = Inflation	I(P5) = 40
P6 = Competitors prices	I(P6) = 30
P7 = Import	I(P7) = 10
P8 = Market share	I(P8) = 30
P9 = Customers concentration	I(P9) = 10
P10 = Monetary exchange	I(P10) = 20

As a consequence of the analysis made, it can be easily observed that some parameters cannot be included in the model because of the impossibility to obtain truthful data for them, while other ones do not have an influence on the model dynamics big enough to be considered and can be excluded from the model without significant loss in precision. It should be mentioned that the sales history can provide about 50-60% of the total amount of information necessary for the neural network.

The issue with the prognosis of sales for a company has some characteristics that make the neural networks an efficient solution to pick:

- the amount of data can be relatively small (data regarding sales of new products);
- there can be blank data in the database;
- data can be distorted;
- an adaptation mechanism of the model to newly incoming data is necessary;
- it is quite difficult to create a linear algebra model for this case;
- the number of products can be big [7, 8].

IV. Forecasting Algorithm Description

Table 2 contains data regarding sales history (in thousands of units) during the time between 01.01.2013 and 31.12.2014, grouped by months. The data should be used as input for the neural network.

TABLE II. Sales history

Month	Sales	Month	Sales
01.2013	2,0	01.2014	2,3
02.2013	2,5	02.2014	3,1
03.2013	2,5	03.2014	3,2
04.2013	2,7	04.2014	3,5
05.2013	3,2	05.2014	4
06.2013	3,7	06.2014	4,3
07.2013	3,8	07.2014	3,5
08.2013	3,9	08.2014	4,3
09.2013	2,8	09.2014	3
10.2013	2,4	10.2014	2,5
11.2013	3,8	11.2014	4
12.2013	4,5	12.2014	4,8

After the neural network "learns" the information and by a statistics comparison, the following data is obtained (fig. 4 time interval 01.2014 – 12.2014).

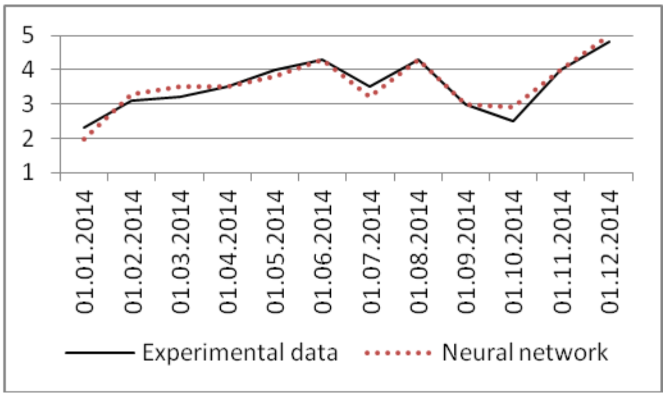

Fig. 4. Verification sample.

The maximum fault value of the network is of 0,3 units (6%), while the medium fault is of 0,04 units (0,8%), which means it can be used in forecasting.

The next step is the generation of the forecasting data for the first 6 months of the year 2015. Using the neural network, the following results are obtained (table 3).

TABLE III. Forecasting results

Month	Sales
01.2015	2,35
02.2015	3,0
03.2015	3,1
04.2015	3,7
05.2015	4,2
06.2015	4,7

V. Adapting Results to External Factors

The data obtained is generated solely based on internal parameters. But in real world, the examined results can be influenced by external factors, too (table 1), which are dynamic and mostly unpredictable.

Thus, there appears the problem of accuracy (the data obtained previously can only be applied to cases that exist in isolation from external factors - exterior has a null impact or should be ignored for other reasons). But, in reality, these factors cannot be ignored, so, the forecasting results (table 3) will be inapplicable.

In order to solve this problem, the present article suggests using a fuzzy logic controller that receives data given by the neural network (table 3) and values of external parameters (table 1) and adapts data for daily use.

At the first stage, the rule base for the controller will be composed (using table 1):

<u>For parameter P1</u> – Products in store

IF products in store = few THEN sales decrease by I(P1) percent

IF products in store = sufficient OR products in store = many THEN sales remain at the prognosed level

<u>For parameter P2</u> – Advertisement intensity

IF advertisement = none THEN sales decrease by I(P2) percent

IF advertisement = few THEN sales decrease by I(P2)/2 percent

IF advertisement = much THEN sales increase by I(P2)/2 percent

<u>For parameter P3</u> – Raw material price

IF raw material price = high THEN sales decrease by I(P3) percent

IF raw material price = low THEN sales increase by I(P3)/2 percent

<u>For parameter P5</u> - Inflation

IF inflation = high THEN sales decrease by I(P5) percent

IF inflation = low THEN sales increase by I(P5)/2 percent

<u>For parameter P6</u> – Competitors prices

IF competitors prices = high THEN sales increase by I(P6)/3 percent

IF competitors prices = low THEN sales decrease by I(P3) percent

<u>For parameter P8</u> – Market share

IF market share = high THEN sales increase by I(P8)/4 percent

IF market share = low THEN sales decrease by I(P8) percent

One can modify the number of the parameters or the rules base in order to increase the controller efficiency.

Due to the fact that the adaptation process is continuous, the application of the fuzzy controller will increase the forecasting precision, because both the predictable and random factors will be taken into account.

VI. Conclusions

Using an intelligent system based on neural networks, a sales-related forecasting can be generated, based on statistical data describing sales in the past. One of the most important advantages of the method is the lack of the need to have a strict specification for the mathematical model.

When forecasting for a period of several months, it is quite difficult (even when using neural networks) to predict external factors of influence.

In order to facilitate this, an innovative method has been suggested – creating intelligent systems that incorporate neural networks together with a fuzzy controller (connected serially), which implies dividing the process into 2 stages:

1. Forecasting – the neural network generates temporary strings based on internal parameters (sales history for the past 2 years);
2. Adaptation to external factors – the fuzzy controller adapts the data produced by the neural network to certain external factors.

As a consequence, the main problem of the neural networks in forecasting is the impossibility to foresee the changes in external parameters, which is resolved by the fuzzy controller, which reacts to every change in the external parameters and adjusts the forecasting data accordingly.

VII. Acknowledgment

This article is carried out as part of the project "Developing of a text processing system with heterogeneous structure" supported by Supreme Council for Science and Technological Development from Republic of Moldova.

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