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Intelligence approach in improving business processes

Ljubinka Sandjakoska [1, 3], Daniela Koteska Lozanoska [2]

[1] Faculty of Computer Science and Engineering, University for Information Science and Technology "St. Paul the Apostle" Ohrid Partizanska bb, 6000 Ohrid, Macedonia
[2] Faculty of Information Systems, Visualization, Multimedia and Animation, University for Information Science and Technology "St. Paul the Apostle" Ohrid, Partizanska bb, 6000 Ohrid, Macedonia
[3] Faculty of Computer Science and Engineering, University Ss. Cyril and Methodius, Republic of Macedonia, Rugjer Boshkovikj 16, 1000 Skopje, Macedonia
{ljubinka.gjergjeska, daniela.k.lozanoska}@uist.edu.mk

Abstract. Nowadays, business intelligence (BI) has the top-most priority for the contemporary enterprises. The aim of this paper is to emphasize the advantages of this computer based approach in improving business processes. Data analytics and modeling of sales prediction system for enterprise is realized with artificial neural networks (ANNs). For the purpose of this research are created over 100 artificial neural networks. Three types of artificial neural networks are designed and evaluated: Function fitting neural networks, Focused Time-delay neural networks and NARX (Non-linear autoregressive) neural networks. Also were performed simulations with different architectures that differ to the number of delays and the number of neurons in the hidden layer. The network prediction performance was evaluated with Average Percentage Error (APE) and Root Mean Square Error (RMSE). The obtained results show big accuracy in prediction of the product sale. The precise prediction has influence to optimization of most of the business processes such as: supply of raw materials, organization of production process, staff scheduling, plan the electricity demand, cost reduction etc.

Keywords: business intelligence, artificial neural networks, forecasting, business process

1. Introduction

Nowadays, business intelligence (BI) has the top-most priority for the contemporary enterprises. The market dynamics force the use of information and communications technologies (ICT) in the daily operations of enterprises. Here it should be noted that the use of ICT is not only related to the daily operation or short-term business strategies but also with long-term strategies, on which the success of a company rely on.

The term BI is broad and covers many aspects of the functioning of an enterprise.

In general, BI is related to data warehouse, data mining, data analytics, etc. The authors of [1] give overview of typical architecture for support BI within an enterprise. This architecture is organized in five layers. The first layer is consisted of the data sources (external and operational datasets). The second includes data movements and streaming engines. The following two layers are for the servers: data warehouse servers and mid-tier servers. The last layer for the front-end applications such as: ad-hoc query, dashboard, spreadsheets etc. In this paper we focus on artificial neural networks (ANNs) as data mining tool. Data mining tools usually are included in the fourth layer – mid-tier server. These engines allow analysis that is the basis of predictive modeling. Building predictive models is key for developing support system for decision making. The process of decision making is crucial for profitable working of the company. Many factors have influence on the business processes or units. Predictive models use this factors or its distributions for providing solutions. Since that, its accuracy is usually high and the need of using them is obvious. In the past a lot of statistical techniques, which are well-defined, fairly predictable and computable in reasonable time, is been utilized for prediction. Now arise the question - why do we need new computing techniques? Or more precise - why we need business intelligence? The author of [2] give explicate answer of this questions. Business intelligence is used to understand the capabilities available in the firm; the state of the art, trends, and future directions in the markets, the technologies, and the regulatory environment in which the firm competes; and the actions of competitors and the implications of these actions.

Also here have to mention that predictive modeling based on ANN is data driven approach. Companies have tendency to provide, manipulate and store big amount of data. Since that, data as a basic resource, are not always fully utilized. The authors of [3] conclude that a critical component for the success of the modern enterprise is its ability to take the advantages of all available data. Business intelligence approach based on ANN can deal with all available data, extracting knowledge for the business process.

ANN are widely used for solving many business issues, such that: prediction of stock price index, prediction of thrift failures, investment management and risk control, developing stock trading decision support system [4], market segmentation [5-8], forecasting stock returns [9], forecasting market response [10] etc. Since the wide range of application

financial service organizations have become the second largest sponsor of research on the application of this tool [11].

2. Methods and Materials

ANNs are one of sophisticated tools of the intelligence approaches. Key question is what makes them so sophisticated. Or, why to use ANN? The basic feature of ANNs is its ability to learn, and therefore does not need reprogramming. Also, adaptability and self-organization contribute in effectiveness and efficiency of solving complex problems. Processing time and error tolerance are other advantages that influence to its sophistication. ANNs can deal with the problem of missing data because of the ability of generalization. All of this advantages provide solid framework for its utilization in business processes.

We would like to stress that the dynamics present in the economic systems make their modeling challenging process. In this research ANNs have proved as appropriate tool for business process implementation.

2.1. What are ANN?

Artificial Neural Networks (ANNs) are mathematical concepts that are computer realized. These models are based on principle of structural organization and function of biological neural systems. Its architecture is consisted of set of related units, known as neurons. (Fig.1)

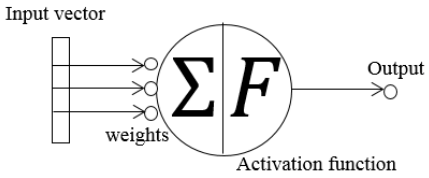

Fig.1. Artificial neuron

According to the DARPA Neural Network Study [12]: a neural network is a system composed of many simple processing elements operating in parallel, whose function is determined by network structure, connection strengths, and the processing performed at computing elements or nodes. According to Haykin [13]: a neural network is a massively parallel distributed processor that has a natural propensity for storing experiential knowledge and making it available for use. It resembles the brain processor

in two aspects: i) knowledge is acquired by the network through a learning process; ii) interneuron connection strengths known as synaptic weights are used to store the knowledge. ANNs are intelligent tools since they are characterized by: representation of experiential knowledge, application of the knowledge for problem solving (making conclusion) and gathering new knowledge (learning). Learning is crucial for ANN. This process includes several events. First event is - environment stimulates neural network. After that the neural network is changing as a result of stimulation and due to the different change network responds to new events. The design of ANN should be viewed from several aspects. Here will be discussed only two of them. The first aspect is *network structures*: a recurrent or nonrecurrent structure. A recurrent structure of the network is realized by feedback. This type of network calculates its outputs based on the inputs and feeds them back to modify the inputs. [14] Second aspect is learning method. The mathematical and software realization depends on a learning method which could be supervised, unsupervised and reinforcement. The authors of [15] claim that most business applications of ANNs today use supervised learning method.

2.2. ANNs architecture development

- **Designing aspects**

The aspects that have most influence in the design of artificial neural networks for prediction can be organized into three groups: data preprocessing, training and topology. Data preprocessing, as a basis or starting point, plays an important role in achieving good network performance. Key parameters that have to be adjust in the data preprocessing are: frequency of data (daily, weekly, monthly, quarterly), data type, method of data sampling, method of scaling of the mean and/or standard deviation. Also data preprocessing includes: noise reduction, dealing with the problem of missing values, inconsistent data, redundancy etc. The second group of parameters that refer to learning or to network training are: rate of learning layer, momentum / dynamics, training tolerance, size of the epoch, maximum number of simulations, random values for weights, data dividing on training, testing and validation sets. The last aspect that is called topology refers to: number of input neurons, number of hidden layers, number of neurons in hidden layers, transfer function, error function.

The main goal is - to design a precise neural network with appropriate architecture that corresponds to the actual processing of segment for orders in the production system. The aim of designing network is to be capable to provide information for requirements in future periods and therefore to be made with a very high accuracy. The goal of using intelligence approach is to be minimized the prediction error. The most important question that has to be answered by ANN is: what will be the order of product X for next month? The order will be forecasted from the business factors that influence on it and historical data of already realized orders in previous months and years. (Fig.2)

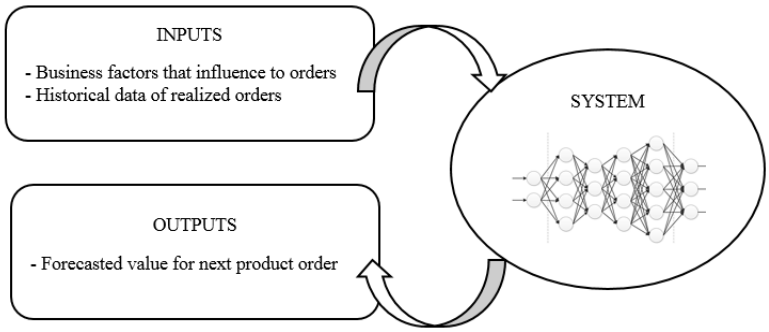

Figure 2: General view of the predictive model

- **Software modeling**

The ANNs created for the purpose of this research are MATLAB realized and can be classified into two categories: static and dynamic. Static neural networks have no feedback elements and do not contain delays. Output is calculated directly from the input, through connections that process forward the signal (feed-forward connections). In dynamic networks the output depends not only on the current input but also by the previous inputs and previous outputs variables that describe the state of the network. The entrance of the network consists of two different input canals: conditions (parameters) and past inputs in the network. Dynamic networks can be divided into two categories. The first category includes those which have connections that only process forward signal (feed-forward connections). The second category includes those which have feedback connections, or connections carrying the output signal back to the input, to assist in generating future output. To create a network that solves relevant and complex problems, we need to make distinguish between static feed-

forward neural network, the dynamic feed-forward network and recurrent - dynamic networks. Signal processing in static feed-forward and dynamic feed-forward network has the same principle, the difference is that dynamic networks have memory and can be trained to teach sequential, or time variable data templates. It makes them more powerful as opposed to static, but greatly affects the field of application. Most used dynamic networks are: Focused Time - Delay Neural Network, Distributed Time - Delay Neural Network, NARX Network - Non-liner Auto Regressive neural network with Exogenous Input, Layer - Recurrent Network.

The nature of the task predicting the orders and system behavior determine the type of the network. Predicting future order is characterized by dynamics because events (the order) and variables (factors that determine the order) are time dependent and are described by time series. From the theoretical studies of ANN, and the study of the order as an event and / or subsystem can be concluded that - compatible neural networks that will provide forecasts for the following orders are: Focused Time - Delay Neural Network and NARX Neural Network.

The scenarios for simulations also differ from the data organizations. In this research work two different data arrangements were provided. The first group of simulations are done with matrix data organizations, and the second one with vector data organizations.

2.3. Business factors included in predictive modeling

The aim of forecasting model from the proposed intelligent approach is to provide information for decision making in the development of a short-term strategy for optimization of the production process. The precise prediction of the orders has influence to optimization of most of the business processes such as: supply of raw materials, organization of production process, staff scheduling, plan the electricity demand, cost reduction etc. The ANNs discussed in this paper are for one product. For complete support of decision process should be created predictive models for all products.

As factors that have influence on the order are: profit per unit product, production costs, quality, promotion, market trend, pricing and logistical availability for customers, as well as: market size, number of population, the preferences of the buyers, attractiveness of the product etc. These are considered as general factors that are relevant to the order of any of the

products. Here is given short explanation of the relation of this factors with the prediction of the order.

Profit per unit of product that is realized from the sale of confectionary product - if varies, variations will occur in order for its cardboard packaging.

Production costs - if they are acceptable, then is acceptable the realization of a particular order or its scope.

Quality of the product determines the demand and order, because the demand for better market products goes in proportion to their quality.

Promotion affect the order from the aspect of unfamiliarity. The demand for unfamiliar product is lower, but for promoted product it is bigger.

Market trend shows the tendency of purchasing the product, which express the need of the product that actually determine the size of the order.

Price is one of the most influential factors of the demand of any product, and if accepted by customers, increased consumption will affect the order of the packaging.

Logistic availability conditions widely represented, more accessible products to be more demanded and therefore the need for packaging will be greater.

Market size or size of the place where the product is offered, largely determines the demand for the product and the need for packaging, which will used for transporting the product to the national and international area.

The population with its size influence of potentially increasing consumption of the product, and therefore on the size of the order for packaging.

The preferences of the buyers, refers to the affections of buyers to a certain product instead of its substitutes, because the greater preferences of buyers influence on the increasing of the demand for the product, which causes a higher order of packaging.

The attractiveness of the product, among other things is conditioned by its packaging, and therefore its order depends on it.

3. Results and Discussion

For the purpose of this research are designed 142 artificial neural networks. The types of the networks are: Function fitting neural networks, Focused Time-delay neural networks and NARX (Non-linear

autoregressive) neural networks. The number of delays and the number of neurons in hidden layer are variables that depend on organization of input data (vector or matrix) and also depend on the size of the dataset. The criteria for performance measurement is the root mean square error (RMSE). As a comparison variable, which indicates the accuracy of the network, is considered Average of Percentage Error (APE).

Table 1. Summarized results for all scenarios and variants of ANNs

Type / designing principle	Function fitting ANN	Focused time-delay ANN	NARX ANN		
	Variant 1	Variant 1	Var. 1	Var. 2	Var. 3
Optimal architecture	1-50-1	1-45-1 delay=49	12-45-12 delay=3	1-45-1 delay=36	1-20-1 delay=48
Number of simulations	1	44	15	12	70
APE	7.1080%	3.2403%	0.0078%	16.0530%	1.4410%
RMSE	1.25e-19	4.38e-20	3.71e-06	3.35e-01	9.03e-21

In Tab. 1 are given summarized results for all scenarios and variants of ANNs. The results show that the function fitting ANN variant has 7.1% error. Although the error is not great, in practice acceptable are the predictive models that have error less than or equal to 5%. So this is ANN is excluded from the optimal solution set. The focus-time delay ANN variant give good results and has error in acceptable ranking. This could be one of the solution. For this research the best results are obtained with NARX ANN. Since that the predictive model for this purpose has to be based on this variant.

Here will be discussed only the ANNs that follow NARX principle because with that type are obtained the best and the worst results for the prediction.

The variant with architecture 12 - 45 – 12 (inputs – hidden neurons – outputs), where we use 12 neurons for every month order. The training algorithm is Bayesian regulation back-propagation. The number of delays is 3 and the number of iterations is 26 for all epochs in all simulations. The data are organized in matrices. With this variant the best value for prediction is obtained. The average percentage error is 0.0078. The second variant from this type has different data organization. In this case the data are vector organized. The number of delays is 36 and this is the same as in the previous variant where we have 3 delays, because here we have vector data organization and the delays are 12 x 3 (from one row). Is expected to get similar results, because it is used the same code, which is means the same training algorithm, performance function, number of epochs, data

division and other characteristics of network. It is important to be emphasized that – in modeling of NARX neural network for prediction the data organization is very important and have big influence. The number of hidden neurons should not be bigger than 45 for this variant because with trials and errors we show that with increasing of the number of neurons increase and the probability for over-fitting. In order to avoid an occurrence of this phenomenon in ANNs we make limitation for the number of delays. For example, with 60 neurons in the hidden layer in the network we have over-fitting and the network is not able to make good forecasting. The third variant is specific because in the coding we have two different configurations: open loop and close loop. The combination of those configurations creates the possibility of predicting of the network one step ahead. Unlike previous approaches, where the last field is filled with Not a Number (NaN), this variant works with the data without having to "reserve" place for the next order. This ability separates the ANNs of other tools for predicting. Also here we have vector data organization and the optimal network architecture is 1-20-1 with 56 delays. The training algorithm is Levenberg – Marquardt. The performance function is MSE (Mean Squared Error).

Also have to be noted that, for good profitable strategy should be developed predictive models not only for the sale but for more processes and/or functions of the enterprise, such as predictive model for electricity demand, electricity price, taxes, prices of raw materials and so on. This include complete data mining and analyzing that could improve decision making process in the business.

4. Conclusion

Improving business processes is the most challenging task that have to be solved in order to increase the profit of the enterprise. Business intelligence, as a key concept for success, may be considered from many aspects. One of the aspects data mining and analytics, realized by artificial neural networks, allows reducing the unpredictability of system behavior. Since the obtained results show big accuracy in prediction of the product sale, the proposed intelligent approach give good framework for optimization of the processes in the production systems. We can conclude that ANNs have proven to be excellent tools in developing solid predictive models.

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