Financial Time Series Prediction
Master’s Thesis within the Intelligent Information Systems programme
EXTENDED ABSTRACT

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Abstract. Artificial neural networks (NN) can be used to model complex relations between inputs and outputs or to find patterns in data. When dealing with time series, the process of prediction with NN has to be adopted to take into account the temporal characteristics of the data. A variety of different aspects of designing NN based forecasting models were introduced, and the most common way of dealing temporal data is by using sliding window. This master thesis presents a work where NNs are used to forecast stock market prices. It has been analyzed which models are more adequate for different companies from Balkan stock exchanges and determine if there are possible relations among them. Unique aspect of the approach in the master thesis is that experimentally are determined the optimal sliding window parameters and the optimal number of hidden neurons for the appropriate companies. Also are emphasized the main reasons that influents on the forecasting stock market prices.
Master Thesis Preface

Main target of the master thesis is a deep analysis of the techniques for financial time series prediction with a main focus on artificial neural networks as a technique with the best performance in the recent research. Thereby, in the thesis fully detailed are elaborated the main challenges which occur in the process of financial time series prediction, analysis and organization of the recommendations in the literature and the main problems which still are solved via trial and error process.

In the master thesis beside the analysis, also was proposed a procedure for designing a stock price prediction movement model as a typical example of a financial time series. Based on the proposed procedure, several prediction models are designed.

In the proposed procedure for designing a stock price movement prediction model every step is explained in details. For every step are described the main challenges, the recommendations that are proposed in the literature and the recommendations for their optimal determination. The proposed procedure consists of steps which parameters and attributes are empirical, but also of steps which parameters should be determined by experimental process. Exactly those parameters, which determination is part of an experiment are the main contribution of the master thesis. In the same time, in the master thesis are previewed several artificial neural network models and their division according to way they handle with time series. This is very crucial, because artificial neural network initially are developed for pattern recognition, not for task like forecasting time series.

The designed models based on the purposed procedure are tested on stock exchange historical data from different companies which operates on Balkan stock exchanges.

The obtained results leaded us to notable conclusions. Firstly, the prices of Macedonian stock exchange have more static behavior than the stock exchanges previewed in the literature. The second conclusion is that different companies required different models. There is no general model that will give satisfactory results for all companies. With other words, quality forecasting of stock exchange prices for given company requires design and development of separate model. Final conclusion is that in the process of pattern recognition there are many different factors that add a lot of noise in the time series data which makes the whole process of time series prediction very difficult task.
**Master thesis analysis**

Master thesis conceptually is consisting of two main parts. In the first one an overview of the procedures for designing models for forecasting stock exchange prices is given. In the second part is given the main contribution of the master thesis. There are designed and explained few models for forecasting stock exchange prices which are tested on historical data from different companies from Macedonian stock exchange and other Balkan stock exchanges.

In the first part of the master thesis are analyzed few challenges. First of all is the experimental part of defining the neural network optimal topology, in the mean of experimental defining the number of hidden neutrons. Also in this process, experimental defining of the size of the training frame in the moving – window approach is included. With the moving – window approach the artificial neural networks are transformed in a powerful toll for forecasting time series. The experiments were performed using historical data from stock trading from three Macedonian companies from Macedonian stock exchange, one company from Croatian stock exchange and one company from Hungarian stock exchange. The main idea is that the one company from Macedonian stock exchange is in a tiny relation with the companies from Croatian and Hungarian stock exchange. With this effect another important issue is analyzed. And that is the relationship between different stock exchanges.

The master thesis is organized in five headings which short description is given in the continuation:

In the first heading an overview of the most characteristic research papers and short introduction to the thesis is given.

The second heading is more concentrated on the description of the time series and the financial time series. There are described the main components and the types of the time series. Further, the data generated from the stock exchanges, the data types and their main characteristics are elaborated in details.

In the third heading in details is elaborated the full description of the procedure for designing an artificial neural network based model for forecasting financial time series. In the
same time detailed description of the every step of the procedure is given. This heading ends with a proposed model for forecasting stock exchange prices.

In the fourth heading the experimental part of the master thesis is described. In this part in details are elaborated the steps in designing a model for forecasting stock exchange prices which require experimental phases. The heading ends with detailed presentation of the experimental results.

The fifth heading is the master thesis conclusion. In details are explained the results, future forecasting of the proposed models are provided and the best recommendations for future work in this area are given.

Conclusion

In general, the main target of the master thesis is achieved. With the literature overview and with the experimental support was design a referent model which is a basis for further analysis in the area of forecasting stock exchange price movement. From the experimental part were extracted rules which will help in defining the optimal model for certain data. There are deviations from the rules, and for some of them there are explanations and for others there are not. As an additional effect to the experiments was defining the noise factors which have a big influence on the final forecasting results.

Main conclusion is that for successful forecasting of stock exchange price movement there are a couple of conditions that must be met. Firstly, the company must have regular daily trading on the stock exchange and the frequency of the daily trading in a month should be as same as the tested companies in the master thesis. The second factor is that there is a big influence of the noise to the end result and the noise must be foreseen.

With the proposed model, actually we have a referent model for further research in this area. Further research can be navigated in different directions. Firstly, further research can be done in the finding the optimal artificial neural network topology. Secondly, the moving – window approach can be modified in the mean of finding more optimal parameters. These two require additional experiments and research resources.

In this master thesis have been presented design and implementation guidelines details of a NN based model for forecasting Balkan stock exchanges. The work has been motivated by the theoretical properties of NNs in time series prediction and by challenge of
the idea to predict stock prices. The main contribution was to experimentally evaluate the optimal parameters of such a forecasting system like sliding window size and number of neurons in the hidden layer of the neural network.

In the master thesis have been evaluated the proposed model based on the historical data from Balkan stock exchanges in period of four years. Testing process included testing with different NN topologies and different sliding window sizes. The testing has shown interesting results. First of all there were extracted several trends that appeared in the results. Then MSE and MAE values were discussed and were selected main reasons for the obtained results. At the end were discussed possible relationships between related companies trading on different stock markets.

The future work will be focused on several targets. First of all, another more market related input variables will be considered, in order to provide more optimal models in a matter of shorter training sliding window size. For example, current input variables are selected for dynamic stock markets with high daily deviations. Balkan stock markets are more static. Idea is that input variables that represent larger period of time will produce models with smaller training sliding window size. Second idea is to involve semantics in the models, which will provide semantic information to the neural network, and we expect that this will result in better generalization capabilities of the models.

As a part of the master thesis two papers have been published on international ICT conferences. First one, is Forecasting stock market prices, ICT Innovations 2010 (Editor M. Gusev), Web proceedings, ISSN 1857-7288, pp.107-116 and the second one is Neural Network Model for Forecasting Balkan Stock Exchanges. Advanced Intelligent Computing: 7th International Conference, ICIC (1) 2011, Lecture Notes in Computer Science 6838 (Editor D.-S.Huang):ISSN 0302-9743, pp.17-24. Both of them were published under supervision of my master thesis mentor Slobodan Kaladziski Ph.D.

References