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Stock price prediction using a fusion model of wavelet, fuzzy logic and ANN

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Abstract. Stock price prediction is vital for making informed investment decisions and is receiving increasing attention especially because of its practical applications. Predicting the stock market is very difficult since it depends on several unknown factors. The traditional prediction models are not able to achieve a satisfying prediction effect in the problem of a non-linear system and non stationary financial signal. On the other hand data preparation is an important step for complex data analysis and it has a huge impact on the success of prediction. In this paper we propose a fusion model of forecasting by combining wavelet as a data preparation tool, fuzzy logic and neural network. We have used Tehran stock market prices as a sample dataset to compare simulation error of stock market returns between the proposed models. The experimental results show that this fusion model achieves better forecasting accuracy than either of the models used separately.

Keywords: ANN, ANFIS, Wavelet, Stock prices, Prediction.

1. Introduction

In recent years, with the introduction of online trading, the stock market has become one of the avenues where even small investors can earn good profits [13]. It would therefore be quite appealing if we can predict the market behavior accurately, so that investors can decide when and where to invest their money. Prediction of stock price return is a highly complicated and very difficult task because there are too many factors such as political events, economic conditions, traders' expectation and other environmental factors that may influence stock prices. In addition, stock price series are generally quite noisy, dynamic, nonlinear, complicated, nonparametric, and chaotic by nature.

Preparing data is an important and critical step in neural network modeling for complex data analysis and it has an immense impact on the success of a wide variety of complex data analysis, such as data mining and knowledge discovery. The main reason is that the quality of the input data into neural network models may strongly influence the results of the data analysis [6].

Fuzzy systems and neural networks are considered as two most widely used techniques in intelligent systems. Automatic control, pattern recognition, human-machine interaction, expert systems, modeling, medical diagnosis, economics, etc. are some of these systems' application areas. Obviously, each technique has its own advantages and drawbacks. Fuzzy systems have the ability to represent comprehensive linguistic knowledge and perform reasoning through fuzzy rules. However, fuzzy systems do not provide a mechanism to tune those rules. On the other hand, NN are adaptive systems that can be trained and tuned from a set of input-output data set. Nevertheless, it is very difficult to understand and represent the obtained knowledge.

The remainder of the study is organized as follows: In Section 2, we review the literature. In section 3, a data preparation scheme using wavelet is proposed and the structure of the fusion models is discussed. In

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section 4, to verify the effects of data preparation on data analysis, and to compare the proposed models, an example dataset is used. Finally, the paper ends with concluding remarks and future directions in Section 5.

2. Literature Review

Ademola Olayemi (2007) mentioned that forecast performance improves when pre-processed data is used. He has used a general pre-processing method, based on multi scale wavelet decomposition to provide a local representation of time series data prior to the application of fuzzy models [5]. Jovita Nenortaite (2007) introduces an intelligent decision-making model which is based on the application of artificial neural networks (ANN) and swarm intelligence technologies. The proposed model is used to generate one-step forward investment decisions for stock markets [4]. Chong Tan (2009) proposed an exchange rate forecasting model based on neural network, stationary wavelet transform and statistical time series analysis techniques. His experimental results demonstrate that the proposed method substantially outperforms classical approaches [3]. AK Dhamija (2010) compares the predictive accuracy of neural networks and conditional models like ARCH, GARCH, GARCH-M, TGARCH, EGARCH and IGARCH, for forecasting the exchange rate series. His results show that Neural networks' performance is better than that of conditional models in forecasting exchange rate [1]. And finally K.S.Vaisla (2010) used Neural Networks and Statistical techniques to forecast the stock market prices and then compared the results of these two models. All these results show that Neural Networks, when trained with sufficient data and proper inputs, can predict the stock market prices very well [2].

3. Methodology

The two models presented in this paper are categorized as fusion models. The first model consists of ANN and wavelet and the second model consists of ANFIS and wavelet with necessary modifications. Fig.1 shows the structure of models. First we normalize the data and then we pass it to fusion models. At last the effect of data preparation using wavelet and the accuracy of forecasting models are compared.

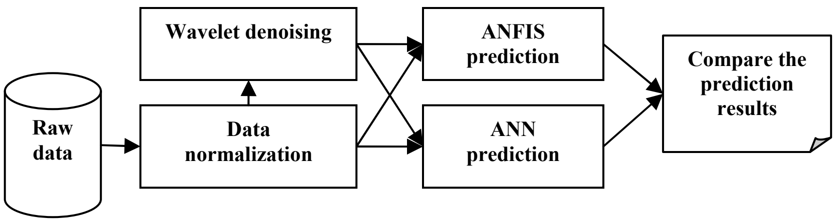


Fig.1: structure of the models.

3.1. Wavelet

Wavelet analysis is used to process information effectively at different scales. It is very useful for feature detection from complex and chaotic time series. In particular, the specific local properties of wavelets can be useful in describing the signals with discontinuous or fractal structures in the financial market. It also allows the removal of noise dependent high frequencies, while conserving the signal bearing high frequency terms. However, one of the most critical issues in the application of the wavelet analysis is to choose the correct wavelet thresholding parameters. In this study, we have used one dimensional discrete db3 wavelet. Also we choosed level 3 because it showed better results than the other levels.

3.2. Neural network

The foundation of the artificial neural networks paradigm was laid in the 1950s. Since then, ANNs have earned significant attention because of the development of more powerful hardware and neural algorithms [6]. Artificial Neural Network is an artificial representation of the human brain that tries to simulate its learning process. Neural network modeling for complex data analysis has three main processes: problem identification, neural network modeling and data analysis. Fig.2 shows the neural network model.

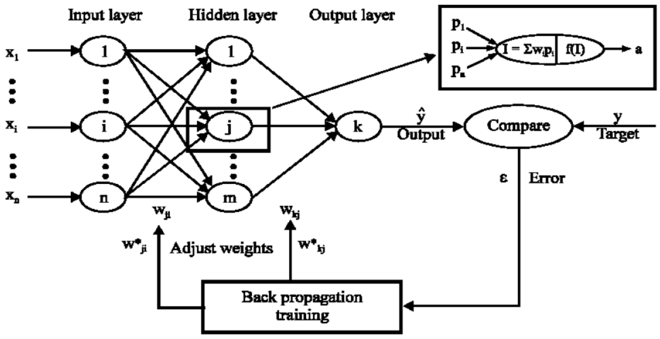


Fig. 2: Neural network model.

In this study we have illustrated a network with one hidden layer consisting of four neurons. It also has one output and four input nodes. To train the network we have used feed forward back propagation algorithm. The output layer function is taken Sigmoid for the forecasting.

3.3. ANFIS

Adaptive neuro-fuzzy inference systems (ANFIS) represent a neural network approach to the design of fuzzy inference systems. ANFIS is a fuzzy inference system that can be trained to model the collection of input-output data. There are two approaches used by ANFIS: Artificial neural network and fuzzy modeling. In ANFIS, fuzzy logic is used to determine decision surfaces rather than the uncertainty associated with particular linguistic terms [7]. For educational purposes, one can imagine a fuzzy inference system with two inputs x and y and one output z. Figure.3 shows the equivalent ANFIS architecture. The first layer implements a fuzzification, the second layer executes the T-norm of the antecedent part of the fuzzy rules, the third layer normalizes the membership functions, the fourth layer calculates the consequent parameters, and finally the last layer computes the overall output as the summation of all incoming signals.

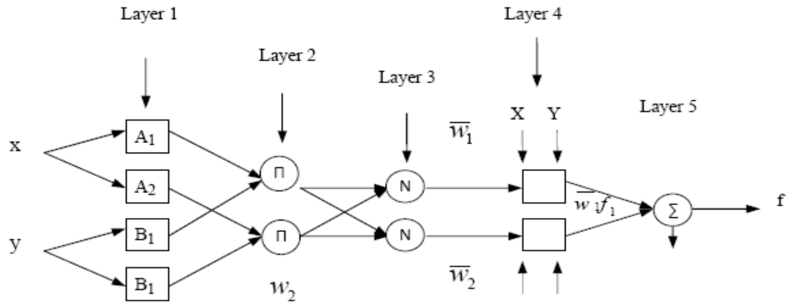


Fig. 3: The equivalent ANFIS structure.

We have used bell membership functions on each of the four inputs. The generated FIS structure contains 16 fuzzy rules.

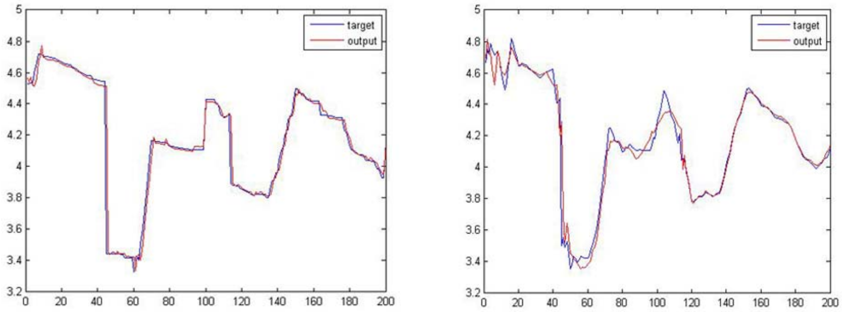
4. Experiments and results

We have used daily stock price of ISC[1] from January 2005 to January 2010 as a sample dataset to compare simulation error of stock market returns between the proposed models. The data is obtained from tsetmc website[2]. In this study the four attributes: open, high, low and close price from the daily stock market are used to form the observation vector. The forecast variable is the next day's closing price.

Fig.4(a) shows the output of ANFIS without using wavelet and Fig.4(b) shows the output when we use the wavelet as an data preparation tool. Fig.5 shows the output of ANN with and without using wavelet. Output and target data are compared in these figures.

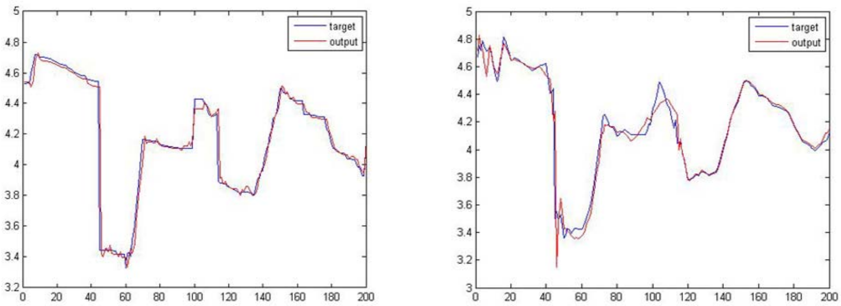
[1] Information Services Corporation

[2] www.tsetmc.com



(a) (b)

Fig.4: ANFIS outputs.



(a) (b)

Fig.5: ANN outputs.

We employ five measures to evaluate the performance of different forecasting models. Here they are:

Mean Absolute Error (MAE) = $\frac{1}{n}\sum_{t=1}^{n}|y_t - \hat{y}_t|$ (1)

Mean Absolute Percentage Error (MAPE) = $\frac{1}{n}\sum_{t=1}^{n}\frac{|y_t - \hat{y}_t|}{y_t}$ (2)

Mean Squared Error (MSE) = $\frac{1}{n}\sum_{t=1}^{n}(y_t - \hat{y}_t)^2$ (3)

Root Mean Squared Error (RMSE) = $\sqrt{\frac{\sum_{t=1}^{n}(y_t - \hat{y}_t)^2}{n}}$ (4)

Normalized Mean Square Error (NMSE) = $\frac{\sum_{t=1}^{n}(y_t - \hat{y}_t)^2}{\sum_{t=1}^{n}(y_t - \bar{y}_t)^2}$ (5)

Where y_t and $\hat{y}_t$ are the actual and predicted values, $\bar{y}_t$ is the mean value of y_t. The smaller values of error, the closer are the predicted values to the actual values. Fig.6 and table.1 show the results of the experiment.

Table1. Comparison of models.

	MAE	MSE	MAPE	RMSE	NMSE
ANN	0.0316	0.008	0.008	0.0893	0.0609
ANN + Wavelet	0.0359	0.0057	0.0088	0.0756	0.0438
ANFIS	0.0281	0.0076	0.0071	0.0874	0.0583
ANFIS + Wavelet	0.036	0.0057	0.0089	0.0754	0.0436

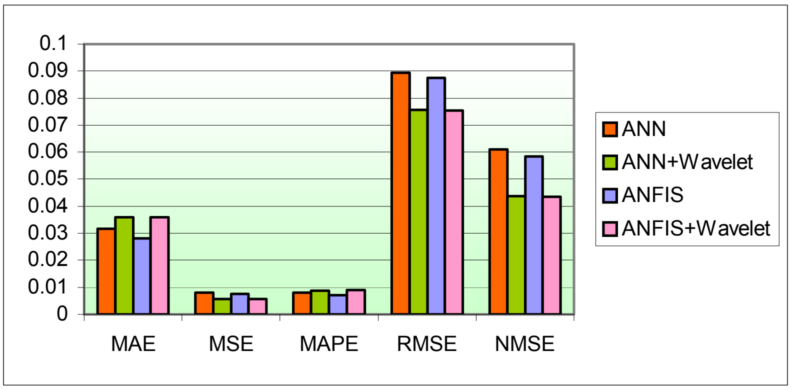


Fig. 6: Comparison of models diagram.

The above comparison clearly show that the hybrid model of ANFIS and wavelet in MSE, RMSE and NMSE measures outperforms the other model which uses ANN in prediction phase. In MAE and MAPE measures using ANFIS alone, outperforms all others.

5. Conclusion

In this paper we proposed a fusion model of forecasting by combining wavelet, fuzzy logic and neural network. We used Tehran stock market prices as a sample dataset to compare simulation error between the proposed models. The forecasting ability of models accessed on the basis of MSE, MAE, RMSE, MAPE and NMSE. The experimental results show that this fusion model achieves better forecasting accuracy than either of the models used separately. The logical next step for the research is to improve the accuracy of prediction using NNs, through better training methods, better input variable selection and better data preparation tools for chaotic time series.

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