Using Adaptive Neuro-Fuzzy Inference System and Deep Learning to Predict and Estimate the Current Stock Prices

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Abstract: To correctly and accurately predict and estimate the stock prices to get the maximum profit is a challenging task, and it is critical important to all financial institutions under the current fluctuation situation. In this study, we try to use different AI methods and algorithms, such as Adaptive Neuro Fuzzy Inference System (ANFIS) and Deep Learning (DL), to easily and correctly predict and estimate the current and future possible stock prices. Combining with some appropriate pre-data-processing techniques, the current stock prices could be accurately and quickly estimated via those models. In this research, both algorithms are designed and built to help decision makers working in the financial institutions to easily and conveniently predict the current stock prices. The minimum training and checking RMSE values for ANFIS model can be 0.0009828 and 0.001713. The minimum MSE value for DL model is 0.0000047 with a regression value of 0.9958.

1 INTRODUCTION

As the fast development of AI technologies, such as fuzzy inference systems, machine learning and deep learning, today various AI related algorithms have been widely implemented in financial fields to estimate and predict the stock values, currency exchanging rates, bonus analyses and all other related applications (Chen et al, 2019).

Most of research are concentrated on stock predictions or estimations based on neural networks, machine learning, and deep learning studies. Different and various machine learning algorithms accompanied with some sophisticated additions are applied on stock analyses and predications to improve the accuracy of prediction on stock markets. Chong et al. reported to use Ensemble of Deep Neural Networks to performance prediction for stock markets (Chong et al, 2020). L. Yu developed an algorithm based on deep learning and neural networks to improve the analyses for economic and financial data (Yu, 2022). Polepally et al. and Pardeshi and Kale reported to use machine learning and deep learning algorithms to improve the prediction accuracy for current stock prices (Pardeshi and Kale, 2021). H. J. Singh, et al. (Singh, et al., 2022) and Y. Lin et al. (Lin et al., 2021) developed a novel multivariate recurrent neural network and a new convolutional neural network with long short term memory combined model to estimate the current stock prices and their tendency (Lin et al, 2021). Singh et al. performed a comparative studies and analysis for different stock price prediction techniques developed in recent years (Singh *et al*, 2022). S. Roy and S. Tanveer, 2023 (Roy and Tanveer, 2023) developed an algorithm to forecast stock price by using DeepNet method. Instead of using any traditional machine learning model, Tarsi et al. (Tarsi et al., 2023) utilized a Long Short Term Memory (LSTM), which is a variation of machine learning model, to predict the stock price. (Mandee, A. et al. (Mandee et al., 2022) utilized an explainable artificial intelligence XAI to predict stock market trends.

Chinprasatsak et al. (Chinprasatsak et al., 2020) reported to use neural network for forecasting high and low price on foreign exchange market. A. Alamsyah and W. H. Aprillia and P. Aggarwal and A. K. Sahani (Alamsyah et al., 2020) performed some studies in comparisons of the foreign currency prediction performance with neural network algorithms. T. A. Bui et al (Bui et al., 2022) reported to use neural networks and CNN-RNN based hybrid

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machine learning model to predict the currency exchange rate. E. Sarmas et al (Sarmas et al., 2022) performed a comparison study among different machine learning classification methods used for currency exchange rate trends. A. L. C. Tak and R. Logeswaran (Tak and Logeswaran, 2022) also developed a foreign currency prediction method based on machine learning techniques.

To correctly and accurately predict and estimate the current stock prices to get the maximum profit via different AI methods, some correct AI models are necessary with popular algorithms, such as Adaptive Neuro Fuzzy Inference System (ANFIS) and Deep Learning (DL). Combining with some appropriate pre-data-processing techniques, the current stock prices could be accurately and quickly estimated via those models. In this research, both algorithms are designed and built to help decision makers working in the financial institutions to easily and conveniently predict the current stock prices.

Stock prices are changed at any moment, and they may be varied significantly day by day, month by month and year by year. Due to the heavy complicity and unforeseen variations on the current market, to correctly and accurately predict the stock prices needs the following factors and operational steps to be taken:

1) The changing or variation of the stock prices can be considered as a periodic function, and this period could be 3 months, 6 months or longer, which depends on the target period on each research. In our case, we used 3 months as a period.
2) Based on assumptions above, we utilized the Google Stock dataset to train and check our target ANFIS and DL models.

This study is divided into 6 sections; after this Introduction, an introduction to two Google Stock datasets used to train and check AI models is given in section 2. The ANFIS and its implementations is discussed in section 3. A discussion about DL is given in section 4. The experiment studies and results are given in section 5. The conclusion and future works are provided in section 6.

2 GOOGLE STOCK DATASET

Two Google Stock datasets (Kaggle, 2012), one contained 5-year stock transaction records from Jan. 3, 2012 to December 30, 2016, and the other included1-month stock transaction records from January 3, 2017 to January 31, 2017, are utilized in this study. The first one is used as the training and checking data for ANFIS and DL models, and the second works as the testing and validation purpose for those models.

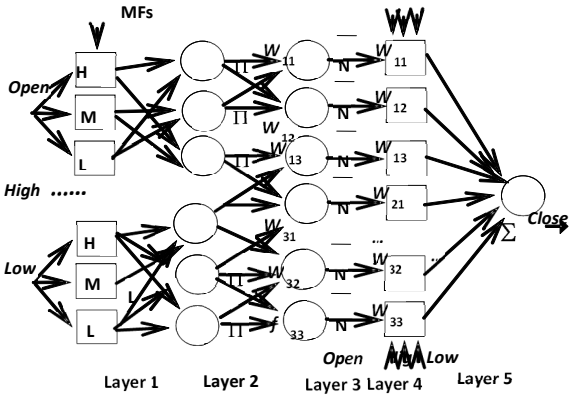


Figure 1: A typical structure of the ANFIS.

Each dataset contained six columns, Date, Open, High, Low, Volume and Close, with both 5-year and 1-month stock price records. Each related column can be mapped to the Opening price, Highest price, Lowest price, transaction Volume and Closing price. For our study, we only need four of them; Open, High, Low and Close. In fact, we use the first three columns, Open, High, Low as inputs and the Close column as the output.

A critical key issue in using those data to train, check and test our ANFIS or DL models is the data preprocessing. As everybody knows, the stock prices are changed or varied in every moment at a time, not each day, and the amounts they changed are significant with a relatively wider range, or even dynamically, for a period of time. This provided a challenging issue when using ANFIS, especially using the fuzzy rules, to estimate the output or the closing price due to the significant variations in the price values. In the worst case, the ANFIS could not perform its normal or correct FIS function due to the out-of-bound of the input values with significant large or big different price values for different time period.

To effectively correct or solve this important and key issue, we need to preprocess those data, exactly to perform a normalization job for those data to enable them to be used in our model training and checking processes. In summary or in a short word, we only take care of those relative changing values on the prices, but not for the absolute changing values, which is good enough for us since we only pay our attention to the changing values in trends or tendency on the stock prices.

3 INTRODUCTION TO ANFIS

The so-called ANFIS is exactly a combination of two soft-computing techniques: Artificial Neural Network (ANN) and Fuzzy Inference System (FIS), which was first introduced by (Jyh-Shing Roger Jang, 1992). The FIS used a Sugeno fuzzy inference system and its structure is similar to a multilayer feed forward neural network structure, but the difference is that the links between nodes in ANFIS define the signals' flow direction and there are no associated weight factors with the links. It consists of a network of neurons that communicate between the input and hidden layers, as well as the hidden and output layers.

Each layer consists of neurons constructed according to the principles of fuzzy control. Figure 1 shows a Sugeno fuzzy model with 27 rules along with a corresponding ANFIS architecture. In our case, total 27 rules in the method of "If-Then" for the Sugeno model are considered with x and y as inputs and f as output (Imran et al., 2019). 27 rules are defined as below (three input columns – *Open*, *High*, *Low*, L: value low, M: value mid, H: value high):

R_1: If *Open* is L and *High* is L, and *Low* is L,
then $f_{111} = p_{111}Open + q_{111}High + r_{111}Low + c_{111}$
R_2: If *Open* is L and *High* is L, and *Low* is M,
then $f_{112} = p_{112}Open + q_{112}\,High + r_{112}Low + c_{112}$
R_3: If *Open* is L and *High* is M, and *Low* is L,
then $f_{21} = p_{113}\,Open + q_{113}\,High + r_{113}Low + c_{113}$
R_4: If *Open* is L and *High* is M, and *Low* is M,
then $f_{22} = p_{211}\,Open + q_{211}\,High + r_{211}Low + c_{211}$

4 ANN AND DEEP LEARNING

An artificial neural network (ANN) has multiple nodes with multiple layers, including input layer, output layer and hidden layers. Figure 2 shows a model of multiple layers feed forward ANN or DL. The dash lines means that multilayer are included in this ANN and these layers cannot be observable. In Figure 2, on each feed forward arrow branch from one node to another, a weight factor w_{ij} should be multiplied to obtain a complete transfer signal.

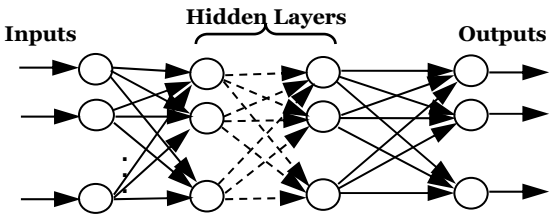


Figure 2: A multilayer feed-forward ANN or DL model.

A neural network can be adjusted or trained, so that a particular input leads to a corresponding target output. The network is adjusted, based on a comparison between the output and the target, until the network output matches the target. Typically, many such input-target pairs are needed to train a network, which is called a supervised learning model.

As we did for the ANFIS, the Google Stock dataset is utilized to train, check and test this DL model. Three columns, *Open*, *High* and *Low*, work asinputs and the *Close* as the output. Totally 1200 sets of data are used with 70% as training data, 15% as checking data and 15% as testing data. The Levenberg-Marquard training algorithm and MATLAB Deeping Learning Toolbox are used to perform these tasks to generate our desired ANN/DL model with 15 hidden layers. The ANN/DL structure is shown in Figure 3.

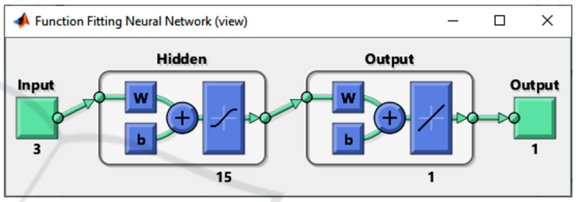


Figure 3: The structure used in our ANN/DL model.

5 EXPERIMENTAL RESULTS

By using the Google Stock 5-year dataset as the training and checking data to train and check our ANFIS model, the model structure and the training result is shown in Figure 4.

Figure 4: The ANFIS model training results.

The testing and performance results for the ANN/DL model are shown in Figure 5.

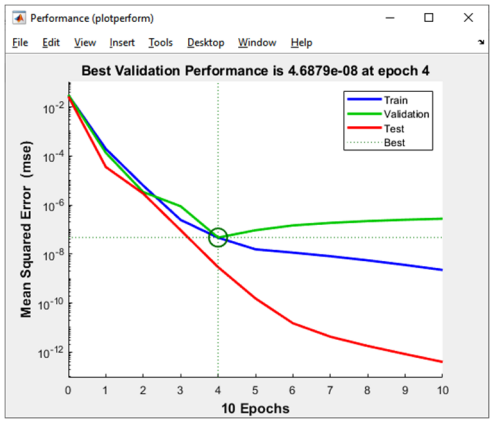
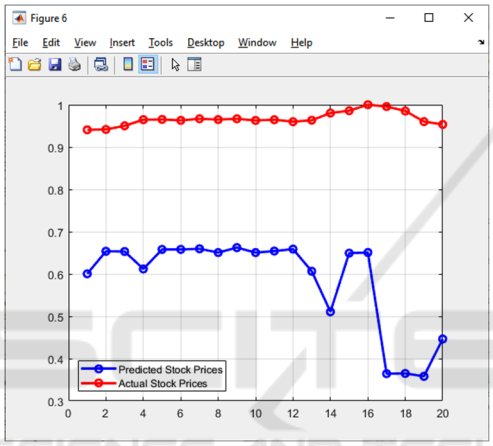
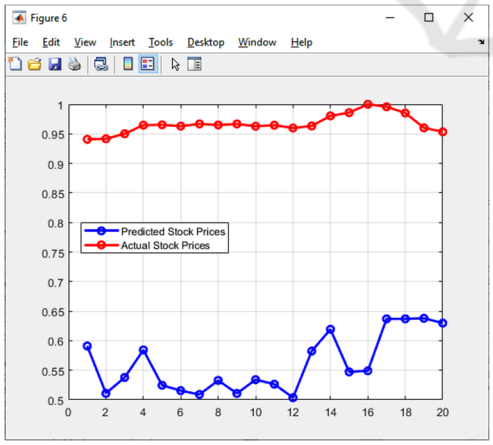


Figure 5: The validation and performance results.



(a)



(b)

Figure 6: Comparison ANFIS and ANN/DL algorithms.

A comparison study is performed for the validation errors between the ANFIS and ANN/DL model, and this comparison result is shown in Figure 6. Both validation errors are RMS values by comparing the actual output and the checking data inputs for ANFIS and ANN/DL systems used in this study.

It can be found that the RMSE value for the ANFIS method is about 0.0016, and the RMSE value for ANN/DL model is 0.0044 with a regression value of 0.9954. The ANFIS algorithm result is better compared with the ANN/DL algorithm for our study, exactly the ANFIS algorithm is about 64% better than that of ANN/DL algorithm by checking the validation RMSE error values in Figure 6 for our study.

6 CONCLUSIONS

With the help of MATLAB Fuzzy Logic and Deep Learning Toolboxes as well as Google Stock dataset, we develop two AI models with two related algorithms, ANFIS and ANN/DL, to perform prediction for stock prices. First we utilized Google Stock 5-year dataset to train ANFIS and ANN models. To confirm and check the effectiveness and accuracy, we utilized another Google Stock 1-month dataset to validate both models. A comparison result shows that the ANFIS model overtakes the ANN/DL model for our study.

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