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Prediction of the Stock Price Using Fuzzy Cascade Correlation Neural Networks

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***Abstract*—** Prediction of the stock market data is a challenging task to make more profit for investor and customers. The artificial neural network has been applied to predict the stock market data in order to obtain more profit on the right time with efficient manner. The conventional neural network learning algorithm has been producing low prediction performance due to the high level of uncertainty in the stock market data. Hence, the fuzzy cascade correlation neural network has been applied to predict future behavior of the stock market index. The simulation result demonstrates that the proposed method shows high generalization performance and produced higher prediction accuracy.

***Keywords*—**Fuzzy Neural Network, Cascade Correlation Neural Networks, Back Propagation Neural Networks, Stock Index Prediction.

I. INTRODUCTION

Stock market prediction is one of the crucial and demanding tasks in time series analysis. The stock market predictors focused on developing perfect methods to predict with more profit of the investors. The stock market data influenced by many factor, including uncertainty, discontinuities, nonlinearity, non-stationary and movements of stock market data are quite complicated.

The artificial neural network is an information processing system and it is significantly used computational intelligent method ability to handle the nonlinear data in the stock market data [1]. However, a conventional artificial neural network does not handle the problem of uncertainty [2]. Accordingly, many models have been incorporated with the ANN model in order to get superior performance than particular models.

In ANN, The back propagation neural network algorithm is a supervised well-known feed forward neural network. But, the conventional BPNN architecture has fallen into many drawbacks, including slow convergence rate, over fitting or under fitting, fall into local minima due to its decide proper hidden neuron in the hidden layers [3]. Hence, the cascade correlation neural network is a famous constructive neural network algorithm due to their higher degree of learning ability [4].

On the other hands, Stock prediction is a primarily due to the uncertainties implicated in the movement of stock market data[5] and also influenced by various factors including dynamic, multivariate complex systems [2]. Fuzzy set theory was introduced by the Zadeh [6] in order to handle the uncertainty with the help of continuing membership function. The concept of the fuzzy logic is endeavoring to capture the expert knowledge and show rather capable candidate for replicating the stock experts [7].

Many research works have been applied to solve stock price prediction using fuzzy systems [8]. It is not extremely objective due to expert's knowledge. Hence, the artificial neural network learning algorithm has been applied to enhance the performance fuzzy system. Artificial neural networks are combined with fuzzy theory is called fuzzy neural networks. Fuzzy neural network has ability to learning the universal approximation of the neural networks and linguistic interpretability of the fuzzy system.

The main idea of the FNN is to assume that some particular membership function values that have been defined and the number of rules is determined according to either expert knowledge or trial and error method [9]. Hence, it is an efficient system that handles to the stock market data easily to achieve an optimum solution. In this paper, the cascade correlation neural network is an incorporated with fuzzy theory called the fuzzy cascade correlation neural networks (FCCNN) proposed to apply the stock market prediction

The section II discuss about the architecture of cascade correlation, Section II explained about the proposed method, section IV discuss about the result and discussion. Finally, the conclusions about the research work demonstrate in the section IV.

II. CASCADE CORRELATION NEURAL NETWROKS

The cascade correlation neural network algorithm (CCNN) is the well-known constructive supervised learning algorithm [4] and its architecture is shown in Figure 1. The benefit is to create dynamically the size and topology of the architecture of the CCNN instead of creating a static size of the networks. The CCNN is commencing its learning process without hidden unit and then adds one by one based on the specified performance attitude is satisfied [10]. In CCNN algorithm, learning process is an initiates without hidden unit, the connection of the input layer and output layer is directly connected that are trained the whole training data samples to arrive at given criteria is to meet satisfied as possible level [11]. After getting the convergence level, there is no considerable error lessening happened then the current learning process is finished. Consequently, the learning process of the CCNN is two phases, including input phase and output phase and its connection weights adjustment is done with Quickprop.

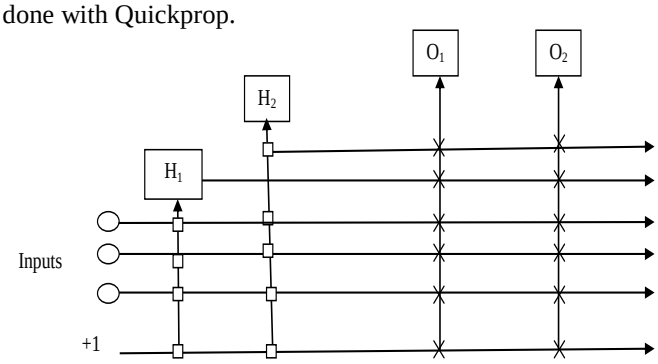

Figure 1 : Architecture of CCNN

First, learning process is progressing to the input phase to acquire a new hidden neuron. To include the latest hidden unit, the learning process of input phase is commenced with a new candidate unit that accepts input signals from all input units and pre-existing hidden neurons. The learning process of input phase is to regulate the weight to maximize the correlation between outputs of the candidate unit and the residual errors. The learning process of input phase is stopped when the correlation value stop not get an improvement. Correlation value is defined as follows

$$C = \sum_{j=1}^{m}\sum_{p=1}^{P}\left(z(p)-(z-av)E_j(p)-(E-av_j)\right) \quad (1)$$

The residual error of the output neurons is

$$E_j(p) = (t_j(p) - y_j(p)) \quad (2)$$

The average residual error is calculated is

$$Z - av = \frac{1}{p}\sum_{p=1}^{P} z(p) \quad (3)$$

Finally, the current best candidate unit is added to the present network and its weights are frozen. Second, process of output phase is beginning with changeable output weight to decrease the error between actual and predicted output. In this stage, the weights of the output phase only adjusted and others weights are frozen.

The network error is calculated at the end of present learning process, it may reach the optimal error, and then learning process terminated otherwise the process swing to the input phases for take on a new hidden unit. The abovementioned two phases of learning process to be continued until to attain the least error or to accomplish maximum iterations

III. PROPOSED FUZZY CASCADE CORRELATIN NEURAL NETWORKS

In the FCCNN, the crisp input values are converted range between 0 and 1 using Gaussian membership function which is called membership function values. Then, the membership values are considered as the inputs to the neural network architecture. The architecture of the proposed fuzzy cascade correlation neural network is shown in Figure 2. The input layer is calculated as follows

$$\mu_i(x) = \exp\left(\frac{x_i - c_{ik}}{2(\sigma_i^2)}\right) \quad (4)$$

Then, the values of the hidden node is calculated for the first hidden neurons as follows,

$$Z_{i1} = V_0 + \sum_{i=1}^{n}\sum_{k=1}^{K} V_{ik}\,\mu_i(x_i) \quad (5)$$

In the second hidden neurons,

$$Z_{i2} = V_0 + \sum_{i=1}^{n}\sum_{k=1}^{K} V_{ik}\,\mu_i(x_i) + Z_{i1}u_{i1} \quad (6)$$

The K hidden neurons is calculated as follows

$$Z_{ik} = V_0 + \sum_{i=1}^{n}\sum_{k=1}^{K}\left(V_{ik}\,\mu_i(x_i)\right) + \sum_{k=1}^{K} Z_{ik}u_{ik} \quad (7)$$

The values of the output layer is calculated as follows,

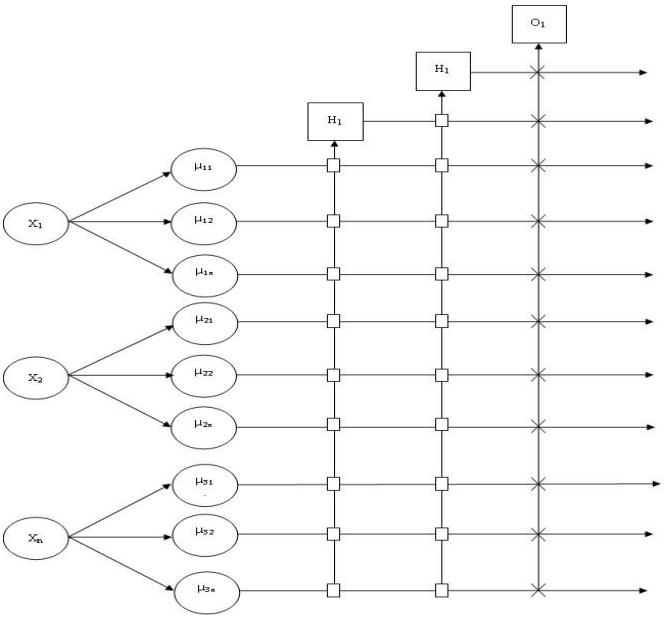

Figure 2 : Proposed Fuzzy CCNN

$$Y = w_0 + \sum_{i=1}^{n}\sum_{k=1}^{K}\left(W_{ik}\, Z_{ik}(x)\right) + \sum_{i=1}^{n} V_{ik}\, \mu_i(x) \quad (8)$$

The objectives of the minimize the error term is calculated as,

$$E_p = (t_p - y_p) \quad (9)$$

The processing of an information is too disturbed of its learning ability and the properties of their universal approximating due to an under situation of uncertainty, nonlinearity [12]. The artificial neural network and fuzzy logic is both universal function estimators to guess any nonlinear function to some degree of accuracy. The goal of the proposed fuzzy cascade correlation neural network is high interpretability and capability of good approximation in order to solve given problem.

IV. RESULTS AND DISCUSSION

The performance of the proposed prediction model is evaluated using two bench mark stock data sets such as Nifty 50 and S & P Sensex indices. The experimental results are conducted using MATLAB 2015.

A. Stock market prediction

Prediction of the stock market data is broadly considered topic in many fields, namely trading, finance, statistics and computer science [13]. In the stock market prediction, even small improvements in predictive performance can be very earned more profitable to the investors [14]. Moreover, leading approach for the prediction stock price in the computer science seems to be using neural networks with fuzzy time series.

B. Data Collections

Two well-known stock indices are used in this research work in order to evaluate the healthiness of the proposed prediction method including Nifty 50 and S&P BSE Sensex that datasets cover the periods from January 3, 2005 to June 30, 2018. The data sets are composed from the National Stock Exchange (NSE) and Bombay Stock Exchange (BSE) official websites.

The datasets contain an open price of the day, the high price of the day, the average price of data, and closing price of the day which is used as an input data and its closing price of the day used for target value of the models. An each data set consists of 3350 working days and it converted into two phases, namely training phase and testing phase. 2850 data points are used for training phase and the remains 500 data points are used for the testing phase for the given whole data samples.

C. Performance indicators

The strength of the proposed FCCNN is assessed using Root Mean Square Error (RMSE) and Directional Symmetry (DS).

$$RMSE = \sqrt{\frac{1}{N}\sum_{p=1}^{P}\left(t_{(p)} - y_{(p)}\right)^2} \quad (10)$$

$$DS = \frac{100}{N}\sum_{p=1}^{P} d_i \;,\; d_i = \begin{cases} 1 & (y_p - y_{p-1})(t_p - t_{p-1}) \\ 0 & otherwise \end{cases} \quad (11)$$

The greatest performance of the neural network architecture is considered a smaller value of RMSE and higher values of the Directional Symmetry.

Table 1 : Performance analysis of the proposed model for S&P BSE Sensex data set

Model	RMSE	DS (%)
FCCNN	**0.0056**	**91.29**
CCNN	0.0058	88.21
BPNN	0.0102	81.42

Table 2 : Performance analysis of the proposed model for Nifty 50 datasets

Model	RMSE	DS (%)
FCCNN	**0.0051**	**93.49**
CCNN	0.0059	89.42
BPNN	0.0107	83.46

D. Performance Comparisons

The performance of the proposed prediction model has been produced higher prediction accuracy with optimum number of hidden neurons in the hidden layer. The experimental result has shown in Table 1 for Nifty fifty datasets and Table 2 for S & P Sensex index. The graphical representation of the proposed model is shown in Figure 1 and Figure 2 for Nifty 50 and S & P Sensex index datasets respectively. From

the experimental results, the proposed that the FCCNN has produced higher performance compared with conventional CCNN and BPNN.

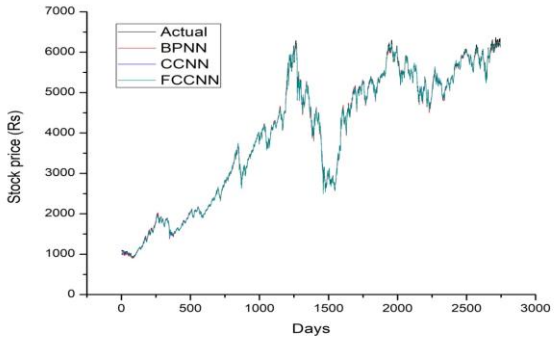

Figure 3 : Performance comparison of proposed fuzzy cascade correlation neural networks for Nifty 50

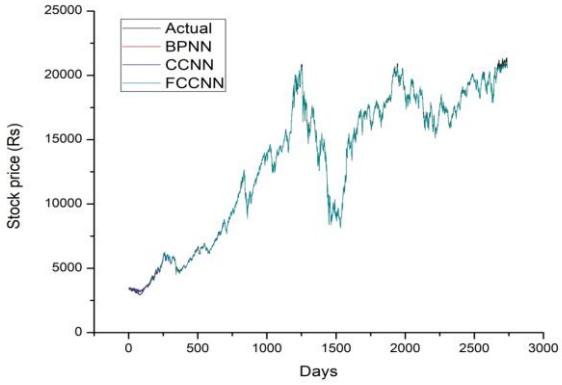

Figure 4: Performance comparison of proposed fuzzy cascade correlation neural networks for S & P Sensex

V. CONCLUSION

In this research, a fuzzy cascade correlation neural network has been applied to predict the stock market indices. The major goal of the proposed method is to enhance the prediction accuracy with prevent under fitting / over fitting during the learning process and in order to handle the uncertainty of the stock market data. The experimental results confirmed that the proposed FCCNN prediction algorithm produced superior performance compared with conventional CCNN and BPNN.

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Appendix – A: Details of the used notations

1) $\mu_i(x_i)$ - Membership function values
2) $z(p)$ - The activation of the candidate unit for the input vectors
3) $z-av$ - The average activation of candidate units
4) $t_{(i)}$ - Target value
5) $y_{(i)}$ - Predicted output of ANN Predictors
6) Z_{ik} - Output of the hidden layer
7) $'N'$ - Total number of data points.
8) x_i is the input values
9) c_i - is the center value of the i^{th} input node.
10) σ - is the width of the i^{th} input node.
11) V_0 - Bias values

Authors Profile

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