Forecasting of Stock Prices Using Multi Layer Perceptron

A. Victor Devadoss¹, T. Antony Alphonse Ligori²

¹Head and Associate Professor, Department of Mathematics, Loyola College, Chennai, India.
²Ph. D Research Scholar, Department of Mathematics, Loyola College, Chennai, India.

Email: hanivictor@ymail.com, antony_ligori2001@yahoo.com

Abstract - Prediction of stock market has been a challenging task and of great interest for researchers as the very fact that stock market is a highly volatile in its behavior. For predicting stock price of Bombay Stock Exchange (BSE), Multilayer Networks with dynamic back propagation has been used. The stock prices are determined and compared with two different architectures NN1 (3-16-1) and NN2 (3-6-1). Neural Network based forecasting of stock prices of selected sectors under Bombay Stock Exchange show that neural networks have the power to predict prices albeit the volatility in the markets. The paper is organized as follows. In Section one the volatile nature of stock market is discussed. Section two reviews the literature on the applications of ANNs in predicting the stock prices. Section three gives an overview of forecasting methods. In Section four the concept of Artificial Neural Network presented. Section five presents the methodology adopted in forecasting the stock price. In the final section results, future direction of the study and conclusion are derived.

Keywords -Artificial Neural Network (ANN); Fundamental Analysis; Stock Market; Technical Analysis; Time Series Analysis.

I. INTRODUCTION

Prediction of stock market is substantial in finance and is gaining more attention, due to the fact that if the direction of the market is predicted successfully the investors may be better guided. Researchers have proposed many models using various fundamental, technical and time series forecasting techniques to give competitive predictions. The existence of the nonlinearity and volatility of the financial market is propounded by many researchers and financial analysts [1]. As the stock market being dynamic, non-linear, and chaotic in nature it is very difficult to understand because of its volatility, hence it is of great importance for the investors to know its behavior which would help for their effective investment in it. Artificial Neural Network (ANN) has the ability to discover the nonlinear relationship in the input data set without a priori assumption of knowledge of relation between the input and the output [2]. Hence Artificial Neural Networks suits well than other models in predicting the stock market returns. Nowadays, stock markets have become an integral part of the global economy. Any fluctuation in the market influences our personal and corporate financial lives and the economic health of a country. Due to its unpredictable behavior there is always some risk to the investment in the stock market [3]. Many scientific attempts have been conducted on stock market to extract some useful patterns and predict their movements. Moreover, many financial corporations have been in trying to model the behavior of stock movements since it can guide their financial investments and yield significant profits. Albeit no method has been successful to accurately predict the stock price movement till now. ANNs ascertain a hope for the investors, an ability to predict the stock prices.

II. LITERATURE REVIEW

Artificial Neural Networks are highly flexible function approximators that can map any nonlinear function [4] and were used initially in the fields of cognitive science and engineering and later applied in financial time series forecasting. ANNs are also being used for a wide variety of tasks in many different fields of business, industry and science. One major application area of ANNs is forecasting [5]. ANNs are well suited for problems whose solutions require knowledge that is difficult to specify but for which there are enough data or observations [6]. The first forecasting using ANNs [6] using Wildrow’s adaptive linear network to weather forecasting. The first study to use the multi-layer feedforward networks for forecasting purposes is seen in the study [7]. A comprehensive study is done by researchers on the common parameters in designing a backpropagation neural network and provided step by step methodology to design a neural network for forecasting economic time series data [8].

III. METHODS USED FOR FORECASTING

Let us enumerate some available forecasting methods in predicting the stock prices.

A. Fundamental analysis

Fundamental analysis is a type of investment analysis adopted by investors for taking investment decisions and the investors who follow this approach are called ‘fundamentalists’. They try to estimate the intrinsic worth of a company’s share, by studying its sales, earnings, profits, dividends, management proficiency, and a host of other economic factors that have a bearing on the company’s profitability and business prospects. The objective is to estimate what the price of a particular company’s share out to be and consider this price to be its intrinsic or true value of the share as it reflects the inherent worth and value. With the help of intrinsic price one can judge whether the shares are currently over-priced or underpriced in the stock market. The fundamentalist makes his money by buying underpriced shares and later selling them when they become over-priced. Fundamental analysis is more useful for long-term investors.

B. Technical analysis

The technical analysis is characterized by a large number of rules and indicators committed to identify and explain the
regularity of historical price dynamics. Technical analysis uses patterns of the price history of a financial instrument in order to provide indications on the future behavior of prices [9]. Technical analysts argue that prices gradually adjust to new information. The Moving Average method (MA) is one of the most used methods of technical analysis. This method involves a comparison of the market prices or index with the long MA. The MA method is easy to use and apply in investment decision-making or empirical tests [10]. The research [11] showed that MA method can generate significant forecast value errors and deviations from real prices and is not successful in price movement trend generation. Technical analysis is commonly used for taking ‘buying’ and ‘selling’ decisions in the stock market. This analysis attempts to predict the future price of a particular share on the basis of a study of its price movements in the past. Technical analysts are also called as ‘chartists’ as they use charts and graphs for keeping a record of share price movements. They believe that an elaborate study of share price charts and graphs will reveal regular and recurrent patterns of price behavior which are likely to be repeated in the future. Technical variables most frequently cited are shown [12]. They usually ignore all fundamental data like sales, earnings, profits, dividends, business prospects of the company, etc. and believe that these factors have already been taken into account by the market and are fully reflected in the current market price of a share. Technical analysis by the very nature of its approach is suitable for speculators and short-term traders in shares.

C. Time series forecasting
Time series forecasting is the analysis of the time series data that tries to predict the near future data based on its past data. This is significant in the field of stock market investment, as investors want to make right decisions at right times to maximize their financial profit. Conventional researches used time series analysis techniques like mixed auto regression moving average (ARMA) and multiple regression models [13]. Time series forecasting usually find a trend in the past data to predict future data. The more past data, the easier it is to find a pattern. However if the history of a stock is short, an accurate analysis and forecast for such little past data is difficult. So, in this case neural networks are described as great tools to use in this scenario.

D. Artificial Neural Networks in stock market prediction
Investment in stock market carries a higher risk due to its uncertainty and volatility and hence forecasting the stock price behavior is very difficult. The difficulty arises due to the nonlinear and complex behavior of stock prices. As the primary application of artificial neural networks is in areas where problems are ill-defined, data is incomplete or noisy in nature and the environment itself is dynamic. As artificial neural networks are able to adapt to noisy data and establish input-output relationship of nonlinear data, the behavior of stock price prediction is possible. In the last two decades extensive researches have been attempted through neural networks to forecast stock prices.

IV. ARTIFICIAL NEURAL NETWORKS
An important application of neural networks is pattern recognition. Pattern recognition can be implemented by using a feed-forward neural network that has been trained accordingly. During training, the network is trained to associate outputs with input patterns. When the network is used, it identifies the input pattern and tries to output the associated output pattern. The power of neural networks comes to life when a pattern that has no output associated with it, is given as an input. In this case, the network gives the output that corresponds to a taught input pattern that is least different from the given pattern. The study of artificial neural networks has been inspired by the biological learning systems which consist of very complex webs of interconnected neurons. ANNs are built out of densely interconnected units (neurons) where each unit takes a number of real-valued inputs which produces a single real-valued output that may in turn be an input to other units. ANNs have the ability to learn and thereby acquire knowledge and make it available for use. ANNs are among the most effective learning methods to learn and interpret complex real-world sensor data [14]. We just recall the notion of neural network called the Weighted Multi Expert Neural Network (Wt.M.E.N.N) constructed using the fuzzy neural networks. This Wt.M.E.N.N., guarantees equal representation of opinion of each expert; hence this method has an advantage over the Fuzzy Neural Networks. Neural Network learning can be either supervised one or an unsupervised one. In a supervised learning algorithm, learning is guided by specifying, for each training input pattern the class to which the pattern is supposed to belong. In an unsupervised one, the network forms its own classification of patterns. The classification is based on commonalities in certain features of input pattern. Since the data is an unsupervised one, we make use of Wt.M.E.N.N. In any supervised learning, a training set of correct input-output pairs is given so as to minimize the error, but in an unsupervised one the output is purely based on the input data. We just recall the definition of Neural Network.

A. Definition
A neural network is a computational structure that is inspired by observed process in natural network of biological neurons in the brain. It consists of simple computational units, called neurons that are highly interconnected. Each interconnection has a strength that is expressed by a number referred as weight.

B. Definition
The bias defines the value of the weighted sum of inputs around which the output of neuron is most sensitive to changes in the sum. Now we proceed on to define the notion of Weighted Multi Expert Neural Network. In Neural Network bias plays an important role. So we take the bias as an input with value -1 and its corresponding weight is the sum of the average of the other input weights. In general, using this newly constructed Weighted Multi Expert Neural Network (Wt. M.E.N.N.), we can extend to ‘n’ number of experts.

The class of sigmoid function $S_{a}$, defined by the formula

$$ S_{a}(x) = \frac{1}{1 + \exp(-ax)} $$

Then, the output of the neuron is defined by

$$ Y = S_{a} \left( \sum_{i} W_{i}X_{i} - \theta \right) $$

where $\beta$ is a positive constant (Steepness parameter), $\theta$ is called the bias of the neuron, since $\theta$ the bias is considered as
an input, \( x_0 = -1 \) and the associated weight \( w_0 = 0 \). The quantities \( X_i \) and \( W_i \) denote the inputs and weights respectively.

C. Neural Network Architectures

An ANN is typically composed of layers of nodes. In the popular MLP, all the input nodes are in one input layer, all the output nodes are distributed into one or more hidden layers in between. An MLP is determined by the following variables:

- The number of input nodes
- The number of hidden layers and hidden nodes
- The number of output nodes.

The selection of these parameters is basically problem-dependent. There exists many different approaches such as the pruning algorithm for finding the optimal architecture of an ANN, these methods are usually quite complex in nature and are difficult to implement. Furthermore, none of these methods can guarantee the optimal solution for all real forecasting problems. To date, there is no simple clear-cut method for determination of these parameters. Guidelines are either heuristic or based on simulations derived from limited experiments. Hence the design of an ANN is more of an art than a science. An artificial neural network is defined as a data processing system consisting of a large number of simple highly interconnected processing artificial neurons in an architecture inspired by the structure of the cerebral cortex of the brain. There are several classes of neural networks. It is classified according to the learning mechanisms. The three broadly classified learning methods are supervised learning, unsupervised learning and reinforced learning. There are three fundamental classes of networks namely, single layer Feedforward network, multilayer Feedforward network and recurrent network.

D. Multilayer feedforward network with back propagation algorithm

MLP is a feedforward neural network with one or more layers between input and output layer. Feedforward means that data flows in one direction from input to output layer. MLP has three layers; an input layer, one more hidden layers and output layer. The input data are fed to the neurons in the input layer and after processing within the individual neurons of the input layer the output values are forwarded to neurons in the hidden layer and finally to the neurons in the output layer. MLPs are widely used for pattern classification, recognition, prediction and approximation.

Connections among the neurons are associated by weights and changing the weights in a specific manner results to learning of the associated network. The procedure by which the weight changes take place in the network is called learning or training algorithm. The backpropagation algorithm is the most commonly used learning technique. The technique consists of a forward pass and a backward pass. In the forward pass, an input vector is applied to the nodes of the network and result of which becomes a set of outputs for the network at the output layer. During this phase the weights are all fixed. In the backward pass, the error term is calculated by finding the difference between actual response of the network and desired response specified to the network and is propagated backward through the network. Here the weights are adjusted so as to make the actual response of the network becomes closer to desired response [15].

The neural network training is an unconstrained nonlinear minimization problem in which synaptic weights of a network are iteratively modified to minimize the overall mean or total squared error between the desired and actual output values. The most popularly used backpropagation algorithm is used for training which follows the gradient steepest descent method. For the gradient descent algorithm, a step size, called learning rate must be specified. The learning rate is a constant of proportionality which determines the size of the weight changes. The weight change of a neuron is proportional to the impact of the weight from that neuron on the error. A very small learning rate requires more training time. One method to increase the learning rate and thereby speed up training time without leading to oscillation is to include a momentum term in the backpropagation learning rule. The momentum term determines how past weight changes affect current weight changes. Most neural network software programs provide default values for learning rate and momentum that typically work well. Initial learning rates in the literature are found to vary widely from 0.1 to 0.9. Common practice is to start training with a higher learning rate such as 0.7 and decrease as training proceeds. Many neural network programs will automatically decrease the learning rate and increase momentum values as convergence is reached.

V. APPLICATION OF MLP IN FORECASTING STOCK PRICE

Assume that \( x_i \) is the data series of stock price, where \( i = 1, 2, 3, ..., N \) and \( N \) is the number of data of selected companies under Bombay Stock Exchange between 1st January 2012 and 7th November 2013.

The following Table 1 display the selected companies and sectors used in the study.

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Sector</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Computers-Software</td>
<td>Tata Consultancy Services Ltd</td>
</tr>
<tr>
<td>2</td>
<td>Computers-Software</td>
<td>Infosys Technologies Ltd</td>
</tr>
<tr>
<td>3</td>
<td>Healthcare and Pharmaceuticals</td>
<td>Dr. Reddy’s Laboratories Ltd</td>
</tr>
<tr>
<td>4</td>
<td>Healthcare and Pharmaceuticals</td>
<td>Sun Pharmaceutical Ltd</td>
</tr>
</tbody>
</table>

In the present study Multilayer feedforward network (MLP) with dynamic backpropagation learning has been used. Two networks are constructed namely NN1 and NN2. Both the network contains an input layer, one hidden layer and one output layer. The number of neurons in the input layer is three which are the three consecutive past prices of the particular stock under study. The number of hidden layers and the number of neurons selected in the study has been done heuristically. The hidden layer consists of sixteen neurons in...
NN1 and six in NN2 which provide the network with its ability to generalize. In the study it was started with a fewer number of neurons, but due to the inaccuracy in the initial predictions the number of neurons were increased in the hidden layer [16]. The number of neurons in the output layer is one as the modeling applied in the study aims to predict one step ahead closing value in the future forecasting. The sigmoid function is used as a transfer function because it is commonly used for time series data as they are nonlinear and continuously differentiable which are desirable properties for network training. Table II and Table III show the parameters for the construction of training sets for the companies. In the following tables LR denotes learning rate and MR denote momentum rate.

Table 2. Training Parameters for NN1

<table>
<thead>
<tr>
<th>Company Name</th>
<th>LR</th>
<th>MR</th>
<th>Total Net Error</th>
<th>Total Mean Squared Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tata Consultancy Services Ltd</td>
<td>0.4</td>
<td>0.5</td>
<td>0.00035</td>
<td>0.00101</td>
</tr>
<tr>
<td>Infosys Technologies Ltd</td>
<td>0.4</td>
<td>0.4</td>
<td>0.00117</td>
<td>0.00382</td>
</tr>
<tr>
<td>Dr. Reddy’s Laboratories Ltd</td>
<td>0.2</td>
<td>0.5</td>
<td>0.00036</td>
<td>0.00069</td>
</tr>
<tr>
<td>Sun Pharmaceutical Ltd</td>
<td>0.2</td>
<td>0.3</td>
<td>0.00030</td>
<td>0.00114</td>
</tr>
</tbody>
</table>

Table 3. Training Parameters For NN2

To measure the performance of the neural network model used, Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD) and Root Mean Squared Error (RMSE) were calculated. Suppose \((x_1, x_2, \ldots, x_n)\) are actual values and \((\hat{x}_1, \hat{x}_2, \ldots, \hat{x}_n)\) are the predicted values then the MAPE, MAD and RMSE can be calculated by using the formula (1), (2) and (3).

\[
\text{MAPE} = 100 \times \frac{1}{n} \sum_{i=1}^{n} \left| \frac{x_i - \hat{x}_i}{x_i} \right| \quad \text{--- (1)}
\]

\[
\text{MAD} = \frac{1}{n} \sum_{i=1}^{n} |x_i - \hat{x}_i| \quad \text{--- (2)}
\]

\[
\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \hat{x}_i)^2}{n}} \quad \text{--- (3)}
\]

In this study NEUROPH has been employed to forecast stock prices of selected companies and sectors listed in the table1.

Step1: Divide the whole data into two teams 60% for training set and 40% for testing set.

Step 2: 60% data has been used to train the network. The normalization for the input is done using the formula

\[
x_{N} = \frac{x - x_{\text{min}}}{x_{\text{max}} - x_{\text{min}}}
\]

should be normalized; \((x)\) denotes the normalized value of \(x\); \(x_{\text{max}}\) represents the maximum value of \(x\); \(x_{\text{min}}\) represents the minimum value of \(x\). After the normalization the data (stock prices) will be in the range of \([0, 1]\).

Step 3: A maximum network error of 0.01, the momentum rate and learning rate range between 0.1 and 0.9 are used in the training.

Step4: The trained network obtained in step 3 has been tested with randomly selected data from the 40% testing sets.

VI. CONCLUSION AND DIRECTION

The following Table IV displays the Actual value Vs. Predicted value against the companies under BSE on randomly selected dates from the 40% testing set. Table V displays the performance of the network adopted in the study. A highly flexible non-linear modeling technique ANN has been implemented to forecast the stock prices of selected sectors under Bombay Stock Exchange. Two different neural networks used in this study namely NN1 (3-16-1) and NN2 (3-6-1) where sigmoid function is considered transfer function. The architectures are tested with the testing data set and the results are predicted. The input data used in the model is the preprocessed historic closing prices of the companies. The model predicts the closing price if three consecutive trading days’ stock prices are supplied to the model. In a highly volatile market like Indian Stock Market, if the prediction of the direction of the market is possible with fairly high accuracy it will guide the investors to reap benefits.

Table IV. Actual value Vs. Predicted Value of Stock Prices

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Date</th>
<th>Actual value (Rs.)</th>
<th>Predicted value</th>
<th>Forecasting Error (%)</th>
<th>Predicted value</th>
<th>Forecasting Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tata Consultancy</td>
<td>29/4/2013</td>
<td>1370.70</td>
<td>1452.00</td>
<td>5.93</td>
<td>1423.96</td>
<td>3.89</td>
</tr>
</tbody>
</table>
Comparing the performance of the two networks, NN1 performs better than NN2 by observing the MAPE results and are shown in Fig. 5, Fig. 6 and Fig. 7.
The predicted results show that artificial neural network has been able to predict stock prices and ensure that it is suitable for forecasting with better accuracies. Limitations and Future Scope of Improvement In this study only the historic prices of stock has been used for the prediction problem with artificial neural network. In order to improve the accuracy of the model, macroeconomic factors and international stock market data can also be used as input variables. Technical analysis indicators can also be used in the input variables and can be checked for improvement in the performance of the network.

REFERENCES

Proceedings of International Conference on Computational Intelligence for Modelling, Control and Automation, Vienna, Austria, pp. 670-673, 2008.