Predicting Closing Price of Stock Using Artificial Neural Network

Muztoba Ahmad Khan[1,*], and Tanzim Ahmed Rusho[2]
[1] Department of IMSE, West Virginia University, USA
[2] Department of CSE, Bangladesh University of Engineering & Technology
[*] E-mail: mdkhan@mix.wvu.edu

Abstract— **Stock Market prediction using data mining techniques is an important issue in finance that has attracted researchers' attention for many years. Data mining techniques can be used extensively in the financial markets to help investors make qualitative decision. One of the data mining techniques is artificial neural network (ANN). This paper investigates the application of ANNs for predicting closing price of stocks. Many studies have shown that ANNs have the capability to learn the underlying mechanics of Stock Markets. As a matter of fact, ANNs have been widely used for forecasting financial markets. However, such application of ANN has not been applied to Bangladesh Stock Markets. This paper applies ANN model to predict the closing price of stocks. Stock Market data of Grameenphone has been used for validating the usefulness of the ANN model. In this analysis back-propagation algorithm is applied. Opening price, closing price, highest price, lowest price and number of shares traded were used as input data, while the one-day ahead closing price of stock was the only output of the ANN. The database consists of 1,113 daily measured data, between November 2009 and July 2014, in term of opening price, closing price, highest price, lowest price and number of shares traded. The data has been collected from Dhaka Stock Exchange (DSE). The 975 daily measured data between November 2009 and December 2013 are used to train the neural networks while the data of 138 days from January 2014 to July 2014 are used to test the neural network. MATLAB neural network toolbox is used to train and test the network. Both estimated and actual values of closing price were compared during testing phase statistically using two methods: Root Mean Square Error (RMSE) and Regression R Value (R). The results show that the closing price of stock can be predicted with reasonable accuracy by using this ANN model.**

Keywords— Grameenphone; DSE; predicting; Stock Market; closing price; back-propagation algorithm.

I. INTRODUCTION

National economies are strongly linked and heavily influenced of the performance of their Stock Markets. Recently the Markets have become a more accessible investment tool, not only for strategic investors but for common people as well. Moreover, the Stock Market has always been an attractive area for researchers since no method has been found yet to predict the stock price behavior precisely [1]. Before the age of computers, people traded stocks and commodities primarily on intuition. As the level of investing and trading grew, people searched for tools and methods that would increase their gains while minimizing their risk. But Stock Market, due to its high rate of uncertainty and volatility, carries a higher risk than any other investment area, making the stock price behavior difficult to forecast [2-6].

Predictions in financial engineering have been based on traditional statistical forecasting methods for many decades. Statistics, technical analysis, fundamental analysis, time series analysis, chaos theory and linear regression are all used to attempt to predict and benefit from the market's direction. But these conventional methods have succeeded partially or have completely failed to deal with the nonlinear and complex behavior of stock prices. This uncertainty in the Stock Market has forced the researchers to find a way to estimate the effect of this uncertainty to the flow of stock prices.

The successful application of non-linear methods in other areas of research has kindled the hopes of financial researchers. Nonlinear dynamics proposes a new way of viewing financial asset prices, and it suggests new techniques for empirically measuring their nature. This new discipline proposes that past prices help determine future prices, but not in a straightforward way. To begin with, the relation of past prices to future prices will not be linear, but nonlinear. This non-linearity implies that past price change can have wide ranging effects on future prices [7].

Artificial Neural Networks (ANN) have been shown to be an efficient tool for data modeling in a variety of different contexts where the output is a non-linear function of the inputs. These include business forecasting, credit scoring, bond rating, business failure prediction, pattern recognition and image processing. The very power of neural network modeling lies in its ability to adjust itself according to the information given in order to optimize some pre-determined objective. This is particularly useful in financial engineering applications where much is assumed and little is known about the nature of the processes determining asset prices. Due to ANN's ability to mine valuable information from a mass history of data; its applications to financial forecasting have been very popular over the last few years [8-11].

This paper investigates the application of ANNs for predicting closing price of stocks. The objective of this paper is to select the optimal parameters for designing of an ANN based model for forecasting closing price of stock. The ANN model is developed and tested with Stock Market data of Grameenphone. Data are collected from Dhaka Stock Exchange (DSE) located in Motijheel.

II. Related Works

Although the concept of artificial neural networks (ANN) has been around for almost half a century, only in the late 1980s could one ascertain that it gained significant use in scientific and technical presentations. There are quite a lot of research works on the application of ANNs in economics and finance [12]. ANNs are very widely used for predicting Stock Market predictions. ANNs have proved to be more effective in solving business problems as compared to other statistical methods that do not include Artificial Intelligence (AI). In the past two decades, a large body of research for predicting Stock Market returns has been developed. This body of knowledge contains many AI approaches, namely ANN, Fuzzy Logic and Genetic Algorithms [13-20].

Prediction is a difficult task, especially when the relationship between input and output is nonlinear, stock price prediction is one such an item. Ramani, Prakash, and P. D. Murarka, in the paper "Stock Market Prediction Using Artificial Neural Network", proposed a method for stock price prediction. The method makes use of ANN and back propagation algorithm. Historical stock prices are used for training the network [21].

K. Abhishek, in his paper "Stock Prediction using Artificial Neural Networks", presented an Artificial Neural Network approach to predict Stock Market indices. He outlined the design of the Neural Network model with its salient features and customizable parameters. A number of activation functions are implemented along with options for cross validation sets. He finally tested his algorithm on the Nifty stock index dataset where he predicted the values on the basis of values from the past n days. He achieved a best case accuracy of 96% on the dataset [22].

K. Ryota, and N. Tomoharu, in the paper titled "Stock Market Prediction Based on Interrelated Time Series Data", proposed a method based on interrelated time series data for predicting Stock Market. Although there are many methods proposed for Stock Market price but only a few of them consider other time series data for the same. In the proposed method the interrelationship between the predicted stock and various time series data such as other stocks, world Stock Market indices, foreign exchanges and oil prices are derived. These interrelationships are used for predicting the daily up and down changes in the closing value. The experimental results proved to be good especially in the manufacturing industry [23].

M. Thenmozhi, in his paper "Forecasting Stock Index Returns Using Neural Networks", applied neural network models to predict the daily returns of the BSE (Bombay Stock Exchange) Sensex. Multilayer perceptron network is used to build the daily return's model and the network is trained using Error Back Propagation algorithm. It is found that the predictive power of the network model is influenced by the previous day's return than the first three-day's inputs. The study shows that satisfactory results can be achieved when applying neural networks to predict the BSE Sensex [7].

In the paper titled "Stock Market Prediction Using Artificial Neural Networks", B. Egeli, proposed a method for predicting the Istanbul Stock Exchange (ISE) market index value using the Artificial Neural Network. The inputs to the system includes previous days index value, previous days TL/US exchange rate, previous day's overnight interest rate and 5 dummy variables each representing the working day of the week. The Network Architecture includes Multi-Layer Perceptron and Generalized Feed forward Networks. Training and Testing is performed with these two Network Architectures. Results are compared to moving averages where ANN prove to be better in performance [24].

Abhishek, Kumar, A. Khairwa, T. Pratap, and S. Prakash, in the paper "A Stock Market Prediction Model Using Artificial Neural Network", predicted the market share price using Neural Networks with the given input parameters of the share market. Artificial Neural Network can remember data of any number of years, which can be used for training the network and thus predicting the future based on the past data. The proposed method makes use of feed forward architecture for prediction. The network was trained for one year data [25].

III. Artificial Neural Network

Artificial neural network models employ artificial intelligence techniques and are data driven; they learn and memorize a data structure and subsequently simulate the structure. They are able to learn key information patterns within a multidimensional information domain [26]. In a way, artificial neural network mimic the learning process of a human brain and therefore do not need characteristic information about the system; instead, they learn the relationship between input parameters and the output variables by studying previously recorded data. This makes artificial neural network ideal for modeling non-linear, dynamic, noisy data and complex systems [27]. Further, artificial neural networks are good for tasks involving incomplete data sets [28]. Fig. 1 shows a typical neural network, which consists of an input layer, a hidden layer and an output layer. An input x_j is transmitted through a connection, which multiplies its strength by a weight w_{ij} to give a product $x_j w_{ij}$. This product is an argument to a transfer function *f*, which yields an output y_i represented as:

$$y_i = f\left(\sum_{j=1}^{n} x_j w_{ij}\right)$$

Where *i* is an index of neurons in the hidden layer and *j* is an index of an input to the neural network.

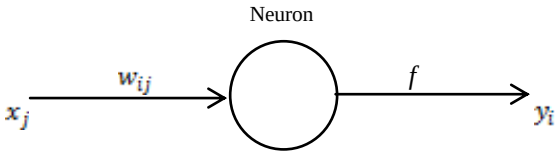

Figure 1. Typical neuron in a neural network system.

There are three steps in solving an ANN problem which are 1) training, 2) generalization and 3) implementation. Training is a process that network learns to recognize present pattern from input data set. We present the network with training examples, which consist of a pattern of activities for the input units together with the desired pattern of activities for the output units. For this reason each ANN uses a set of training rules that define training method. Generalization or testing evaluates network ability in order to extract a feasible solution when the inputs are unknown to network and are not trained to network. We determine how closely the actual output of the network matches the desired output in new situations. In the learning process the values of interconnection weights are adjusted so that the network produces a better approximation of the desired output. ANNs learn by example. They cannot be programmed to perform a specific task. The examples must be selected carefully otherwise useful time is wasted or even worse the network might be functioning incorrectly. The disadvantage is that because the network finds out how to solve the problem by itself and its operation can be unpredictable. In this paper the effort is made to identify the best fitted network for the desired model according to the characteristics of the problem and ANN features.

IV. METHODOLOGY

Opening price (BDT), closing price (BDT), highest price (BDT), lowest price (BDT) and number of shares traded (no.) of Grameenphone stock between November 2009 and July 2014 are collected from Dhaka Stock Exchange (DSE). The database is consists of 1,113 data sets.

The data set was split into two sets. The training data set: the group of data by which the network adjusts, in order to reach the best fitting of the nonlinear function representing the phenomenon. Training data was consisted of 975 data sets. The testing data set: a set of new data used to evaluate the developed artificial neural network model generalization. Testing data was consisted of 138 data sets. The training data set was between November 2009 and December 2013. The testing data set was between January 2014 and July 2014.

The ANN model was developed using neural network tool of MATLAB version R2011b. For the training process of the ANN, a Bayesian regulation back propagation algorithm was used. This algorithm is a supervised iterative training method that updates the weights and bias values according to Levenberge Marquardt optimization [29]. It minimizes a linear combination of squared errors and weights, and then uses Bayesian regularization to determine the correct combination that results in a network that generalizes satisfactorily. The number of hidden neurons in an ANN is a function of the problem's complexity, the number of input and output parameters, and the number of training cases available. A trial and error process was used to determine the number of hidden neurons. After trying a number of different configurations, and repeating each training process ten times to avoid random errors, it was found that 7 neurons in the hidden layer yielded the best results with a reasonable computational effort. Two transfer functions were investigated, including the tangent sigmoid and log sigmoid functions. Linear transfer function was used for both input layer and output layer. Tangent sigmoid function was used for the hidden layer.

MATLAB representation of the final neural network model is presented in Fig. 2. The characteristics of the developed artificial neural network model used in the present study are presented in Table I.

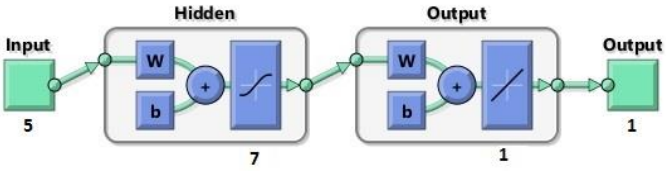

Figure 2. Final neural network architecture.

TABLE I. CHARACTERISTICS OF THE ANN MODEL

Item	Value
Number of Layers	3
Input Layer Nodes	5
Transfer Function	Linear
Hidden Layer Nodes	7
Transfer Function	Sigmoid
Output Layer Nodes	1
Transfer Function	Linear

Fig. 3 shows the flowchart of back propagation algorithm. Since supervised learning is involved, the system will attempt to match the input with a known target, such as the closing stock price. The process begins by assigning random weights to the connection between each set of neurons in the network. These weights represent the intensity of the connection between any two neurons. Given the weights, the intermediate values (in the hidden layer) and then the output of the system are computed. If the output is optimal, in the sense that it is sufficiently close to the target, the process is halted; if not, the weights are adjusted and the process is continued until an optimal solution is obtained or an alternate stopping rule is reached.

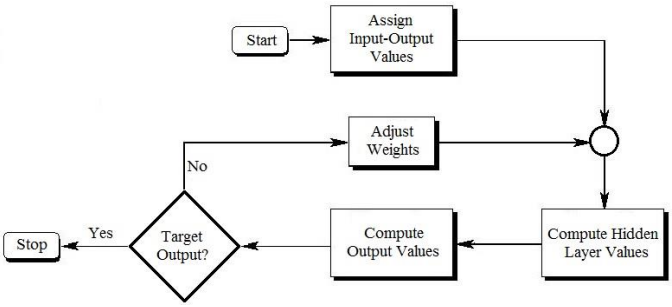

Figure 3. Flowchart of back propagation algorithm.

V. Results and Discussion

Although the tested period seems short but it has appeared that the developed artificial neural network model with one hidden layer based on the standard back propagation algorithm, using tangent sigmoid transfer function in hidden layer and linear transfer function in output and input layers, resulted as an efficient model to forecast one-day ahead stock closing price of Grameenphone in Dhaka Stock Exchange. The comparison between estimated and actual closing price during training and the comparison between predicted and actual closing price during testing is depicted in Fig. 4 and Fig. 5 respectively for one-day ahead stock closing price of Grameenphone.

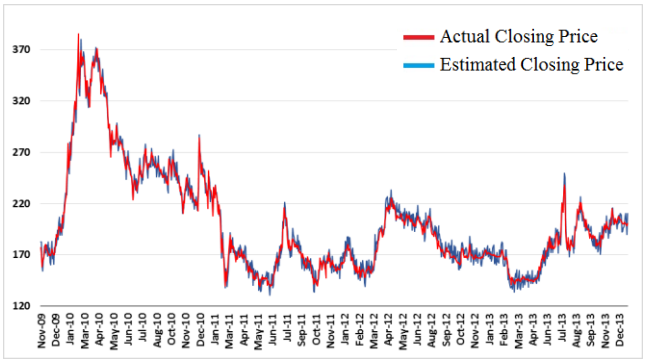

Figure 4. Comparison between estimated and actual closing price

The performance of the neural network model is measured using RMSE (Root Mean Squared Error) and Regression R Value. Regression R Values measure the correlation between outputs and targets. An R value of 1 means a close relationship and 0 means a random relationship. Mean Squared Error is the average squared difference between outputs and targets. Lower values are better. Zero means no error.

The value of R was 0.9725 and 0.9663 in training and testing phases, respectively. The proposed artificial neural network model, which accepts 5 input variables, predicts with a RMSE of 6.58 BDT. These lower values of errors demonstrate that, the proposed artificial neural network model can forecast one-day ahead closing price of Grameenphone stock for the testing data set with reasonable accuracy.

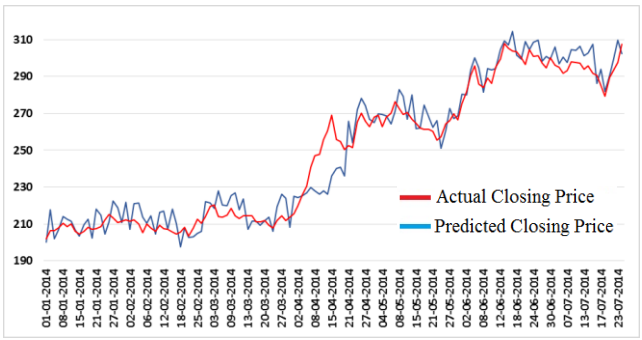

Figure 5. Comparison between predicted and actual closing price.

Conclusion

The use of ANN technique in predicting closing price of stock in DSE has been reported. It is evident from Fig. 4 and Fig. 5 that the prediction is fairly accurate unless there is a huge and sudden variation in the actual data, where it becomes impossible to exactly predict the changes. Thus we can see that ANNs are an effective tool for stock market prediction and can be used on real world datasets like the DSE dataset.

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