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Stock Market Behavior Prediction Using NN Based Model

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Method Article

Abstract

Stock market collects huge amount of data which is uncertain, insufficient or fuzzy in nature. To make predictions for such data is very complicated task and one of the biggest challenges to the AI community. Various traditional and statistical indicators have been proposed for this. However, combination of these tools and techniques requires highly human expertise and so much justification in the area. Stock market behavior is highly suspecible. To increase performance of prediction there is a need of method which can accurately predict stock price and can train multiple records simultaneously. Neural Network is very important tool for stock market prediction. This paper mainly highlights the Neural Network based approach to predict stock market behavior and also helps the stock brokers and investors to invest money in stock market business at the right time.

Keywords: Stock Market, prediction, artificial neural network, back propagation, multilayer perceptron, feed-forward.

1 Introduction

1.1 Stock Market

The dictionary meaning of market is a place for selling and buying goods or services. Thus a securities market is a place where buying and selling of securities takes place. It depends upon the demand and supplies that prices are vary. The prices will high when the demand is high, when the share is heavy to sell that decreases the price. A good security market is a market where trading is conducted in a fair, open, and orderly manner. A securities market can be broadly divided into primary market and secondary market [1].

A primary market is a market in which securities are sold to investors (buyers) for the first time i.e. new securities are traded. Selling of new securities for the first time is referred to as Initial Public Offerings (IPO) [2].

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A Secondary market is a market where existing securities are traded among investors. Here the securities are bought and sold after their initial sale in the primary market [1,3].

1.2 Artificial Neural Network

Artificial Neural Networks has a wide range of applicability in all branches of real life because of its easy formulation and mathematical structure. This method is most widely used in various fields in last two decades. Stock market is also one of the most important areas where Artificial Neural Network can play very important role. Stock market behavior is non linear and chaotic which make them hard to model and predict. Various researchers have proposed statistical and time series methods like Linear Regression (LR), Auto Regressive (AR), Moving Average (MA), and Auto Regressive Integrated Moving Average (ARIMA). These methods are too much complicated and failed to take non linear relationship into account. Classical time series models inferred future relationships based on past observation and analysis. Neural network is also important tool for time series models. The idea of formulation prediction models using NN is to find appropriate mapping between input and output data through training [4]. The rest of this paper is organized as follows: section 2 discusses review of literature for stock market prediction using artificial neural network. The section 3 focuses data preprocessing task, section 4 discusses about the proposed methodology (Back Propagation Multilayer Perceptron), section 5 focuses experimental results and at last section 6 draw the conclusion and future scopes of this study.

2 Literature Review

Prediction of stock prices is very challenging and complicated process because price movement just behaves like a random walk and time varying in nature. In recent years various researchers have proposed intelligent methods and techniques for stock market study. Here, we are presenting a brief review of some significant researchers.

Minsky and Papert [5] presented first significant study of perceptrons network, which mathematically proved the limitations of perceptrons network. They suggested that neural network cannot be used to represent even some simple systems. Their article was so influential that neural network research was brought to a stand-still for over a decade.

Kaastra and Boyd [6] developed neural network model for forecasting financial and economic time series. In the study they selected a large number of parameters for neural network forecasting model. They described eight-step procedure to design a neural network forecasting model in which they include some common pitfalls, parameters for their study, and also focused some points of disagreement among practitioners.

Hadavandi et al. [7] proposed an integrated approach based on Genetic Fuzzy Systems (GFS) and Artificial Neural Networks (ANNs) for developing a stock price forecasting expert system. At the first step, they used Stepwise Regression Analysis (SRA) to determine the factors which have most influenced on stock prices. At the next stage, they divided their raw data into k clusters by means of Self-Organizing Map (SOM) neural networks. Finally, all clusters were fed into independent GFS models with the ability of rule base extraction and data base tuning. Also they evaluated the performance of the proposed approach by applying it on stock price data organized from IT and Airlines sectors, and compared the performance with previous stock price forecasting methods using Mean Absolute Percentage Error (MAPE). Results showed that the proposed approach performs better than all previous methods, so it can be considered as a appropriate tool for stock price forecasting problems.

White [8] presented the first significant study on the application of the neural network models for stock market forecasting. In his study, several research efforts were carried out to examine the forecasting effectiveness of the neural network models in stock markets.

K.K. Sureshkumar et al. [9] have proposed an ANN method for stock market price prediction. They selected consecutive 1000 days of NSE stock data of Infosys Company and the actual stock price of Infosys company have compared with the predicted value of the Gaussian, Isotonic regression, Least Mean Square, Multilayer Perceptron Functions Pace Regression, Simple Linear Regression and SMO regression values. In their study evaluate the net performance of the stock value four different indicators have been calculated. The indicators are Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), Relative Absolute Error (RAE) and Root Relative Squared Error (RRSE). These indicators are used to evaluate the error rate of the stock prices.

Chan et al. [10] proposed a neural network model using the technical analysis variables for listed companies in Shanghai Stock Market (SSM). In their research study performance of two learning algorithm and two weight initialization methods are compared. The results showed that prediction of stock market is quite possible with both the algorithm and initialization methods but the performance of the efficiency of the back propagation can be increased by conjugate gradient learning with multiple linear regression weight initializations.

Bai Li [11] proposed integrated Wavelet Neural Network (WNN) algorithm with Artificial Bee Colony (ABC) algorithm for gold price forecasting issue. In this algorithm instead of convergence roulette selection strategy in previous cycle it utilized the feedback messages to manipulate the searching strategy in subsequent cycle. The experimental results shows that this algorithm is very efficient than conventional ABC and seems to be very effective for gold price forecasting issue.

The present work in this research study is inspired by Neural Network approach which is appropriate technique to predict stock market behavior, which is discussed in next sections.

3 Data Preprocessing

Stock market collects a large amount of data which is incomplete, or inconsistent in nature. Data preprocessing is used to fill missing values, removing noise and inconsistency from data set. For the purpose of this study we have considered last 10 years of data (i.e. Aug 2004 to Nov 2013) from Bombay Stock Exchange of India [12]. The data employed in this study contain attributes like open price, high price, low price and close price. Stock prices are so much large and not feasible for computation, so data cleaning and normalization steps are applied on data. We have used the following formula to scale price values within the range of [0, 1].

$$\frac{(NP - MINSP)}{(MAXSP - MINSP)} * (1 - 0) + 0 \quad (1)$$

Where *NP, MINSP* and *MAXSP* denotes New Price, Minimum Stock Price, and Maximum Stock Price.

Stock data contains large amount of variability, before getting predictions on stock data we have applied some statistical measurements on data which is shown by Table 1.

Table 1. Statistical results of stock data

Min	Max	Mean	Standard Deviation	Correlation	Skewness	Kurtosis
366.2	2218.15	1131.63	364.79	97.2	0.32	0.094

Here Min shows the minimum stock price, Max shows the maximum stock price, Mean shows the mean of stock prices. Higher standard deviation value shows there is higher risk is present in the market. Correlation is calculated among stock variables like open price, high price, low price and close price which is very high and also shows that very strong relationships are present among variables. The ideal values of skewness and kurtosis show that data is symmetric and placed around normal distribution w.r.t. mean values (i.e. Shape close to normal curve).

4 Proposed Methodology: Backpropagation Multilayer Perceptron

Back propagation is a systematic method of training multilayer artificial neural networks. It is a type of supervised learning algorithm that calculates an error at output layer and propagates in the "backwards" direction in hidden layers so it is named as back propagation. In this study we used BPMLP learning algorithm with three input variables like open price, high price and low price, one hidden layer and one output variable like close price. The following algorithm shows step by step procedure of back propagation learning algorithm [4,13,14].

Step1: Select the variable and prepare dataset.
Setp2: Decide Number of Nodes Initialize Weights and Thresholds.
Step 3: Present Input and Desired Output.
Step 4: Propagate Feed Forward (Input and Hidden Layer).
Step 5: Calculate Actual Output.
Step 6: If there is an error in calculation then adjusts the weights and thresholds for input layer and hidden layer as well as output layer and hidden layer.
Step 7: Finally get the desired output.

In this study we have considered 7 hidden neurons at hidden layer and for output computation choose a binary sigmoidal activation function (also called logistic function) which is shown below [18,27].

$$f(x) = \frac{1}{1 + \exp(-\sigma x)} \tag{2}$$

Where, σ is called the steepness parameter.

5 Experimental Results

In this paper a prediction model proposes uses back propagation multilayer perceptron method of neural network and stock data set of TCS Company from Aug-2004 to Nov-2013 is used for training and testing purpose [12]. The artificial neural network is used to predict closing price of day from open price, high price and low price of day. For calculating purpose MATLAB R2008a is used.

In MATLAB environment firstly input and target data from workspace is selected where input data consists of 2302 samples (i.e. 3 elements) and output data consists of 2302 samples (i.e. 1 elements).

After selecting data divided into training, validation and test dataset. Here we used 60% of data for training (1382 samples), 20% for validation (460 samples) and 20% for testing (460 samples). For hidden layer 7 hidden neurons are considered for study.

We have used multi-layer feed-forward back propagation network for prediction of closing price of a day, and "TRAINLM" is used as training function i.e. Levenberg-Marquardt algorithm. "TRAINGD" is used as learning function while "MSE" is used as performance function.

After choosing training and testing functions network training is performed which is shown by Fig. 1.

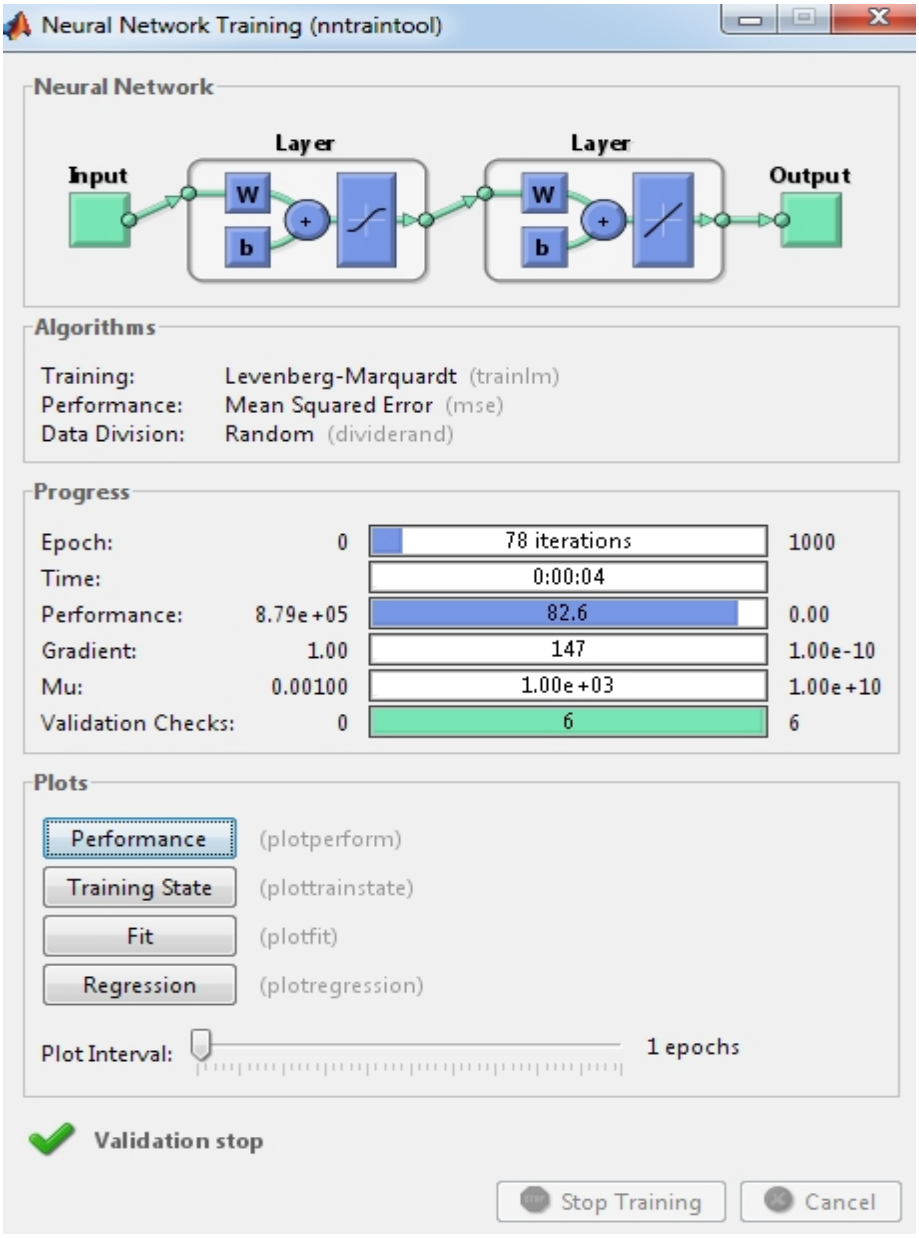

Fig. 1. Training of network

The Fig. 2 shows the performance measure in the form of mean squared error (MSE) against number of epochs. The numbers of epochs are set to 1000 and got the best validation performance at epoch number 72 which is 97.8021.

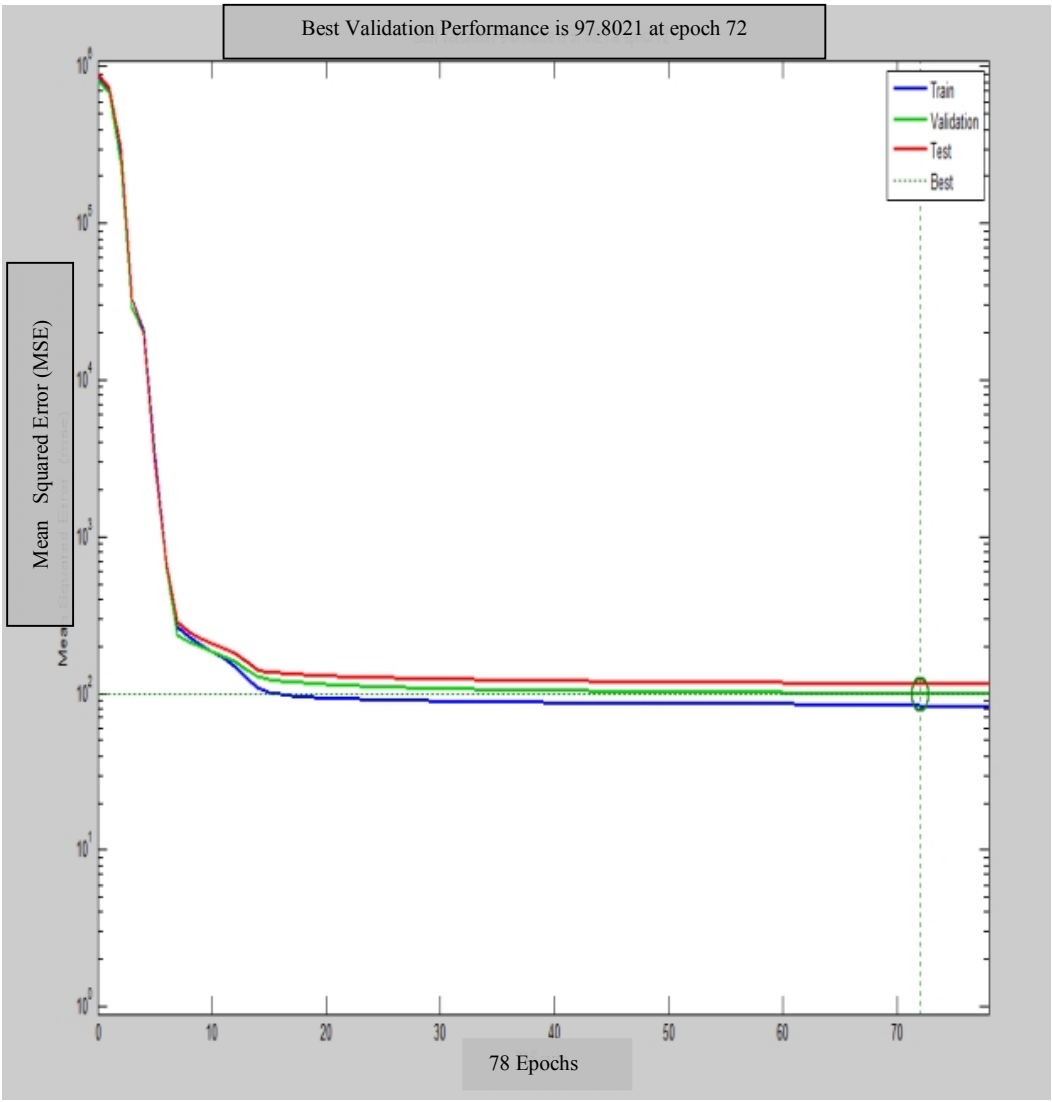

Fig. 2. Performance Plot of Network

The training state of network is shown in Fig. 3.

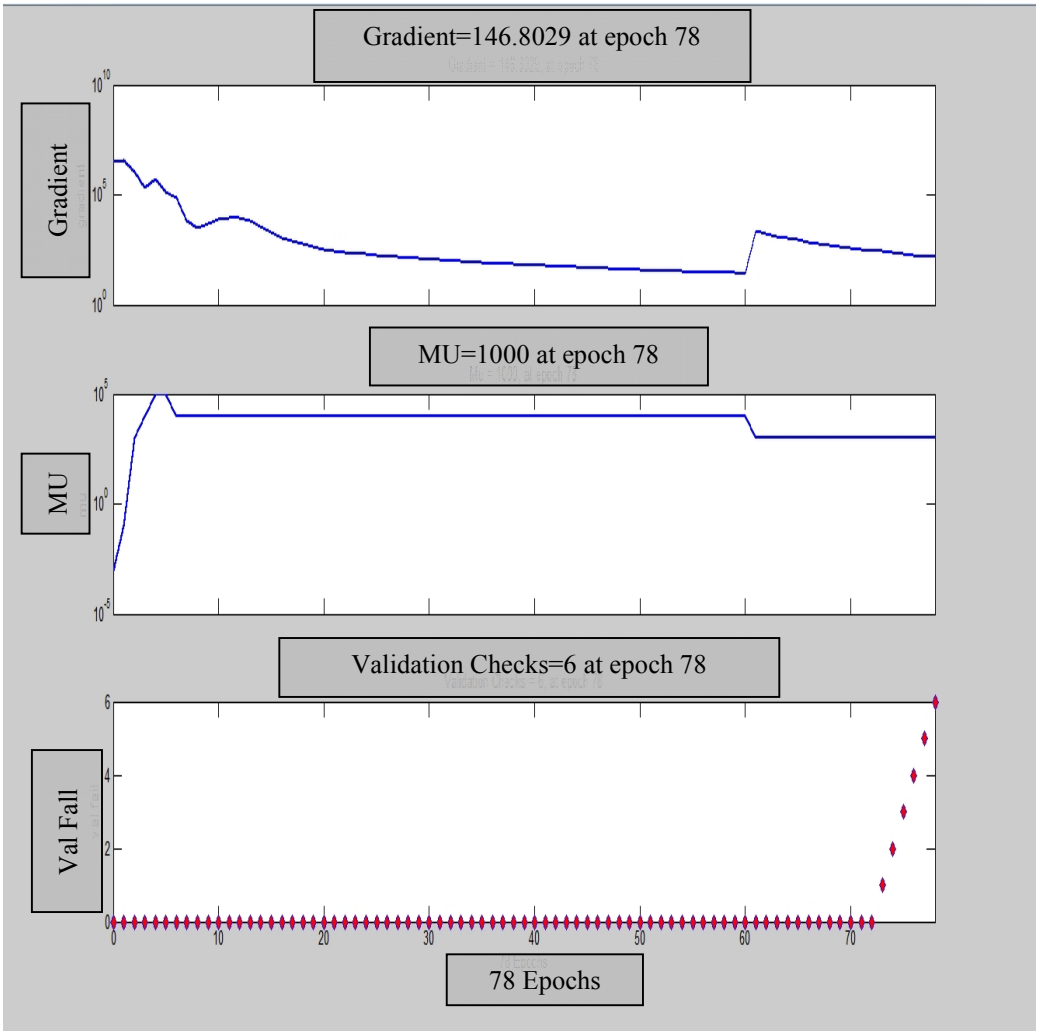

Fig. 3. Training state of network

The Fig. 4 shows the regression plot of network performance based on training, testing and validation which depend linearly on their unknown parameters are easier to fit than models which are non-linearly related to their parameters and because the statistical properties of the resulting estimators are easier to determine.

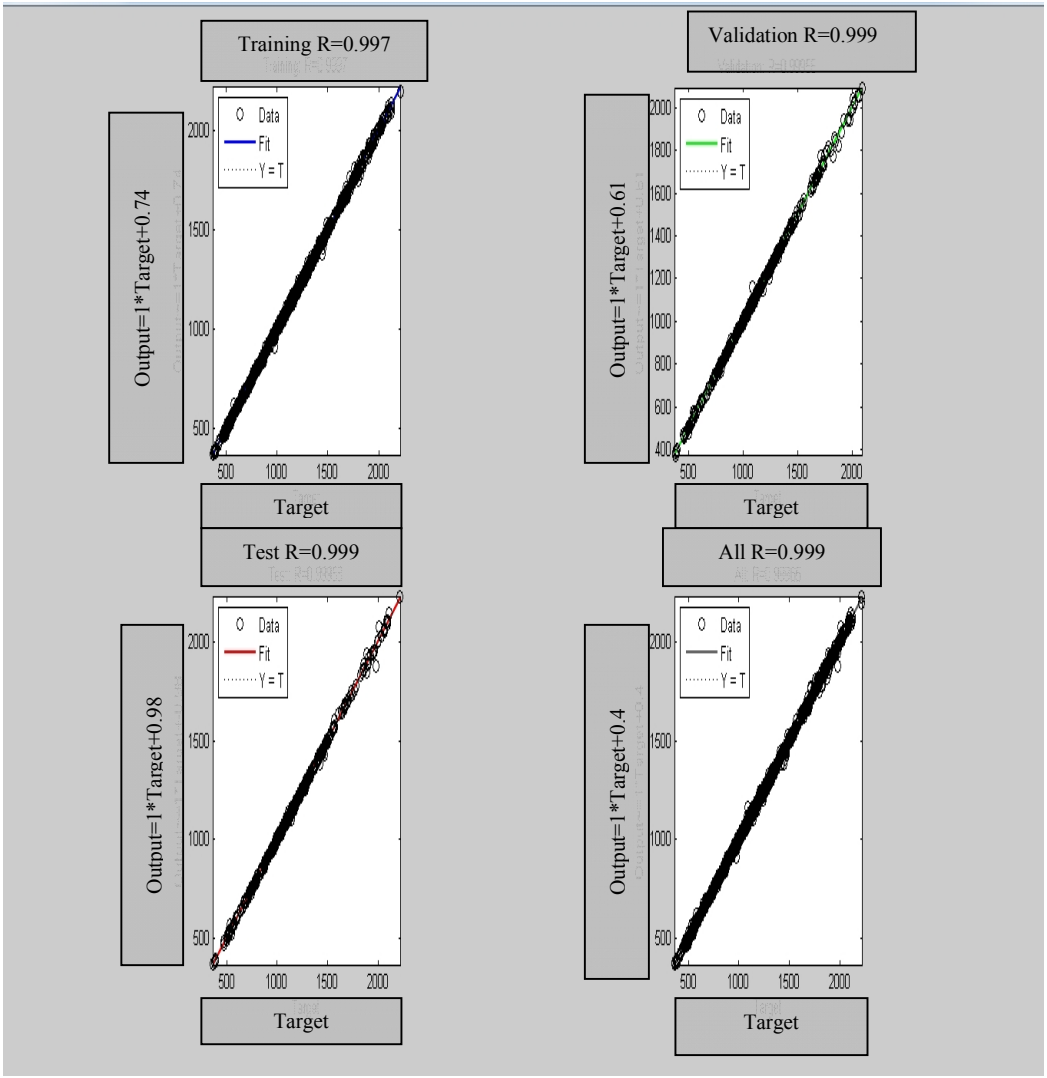

Fig. 4. Regression plot of network

Here final value of R is 0.999 that shows the very strong relationship exist between output and Target price.

The Fig. 5 plots graph of error i.e. the difference between target (actual) close price and predicted close price.

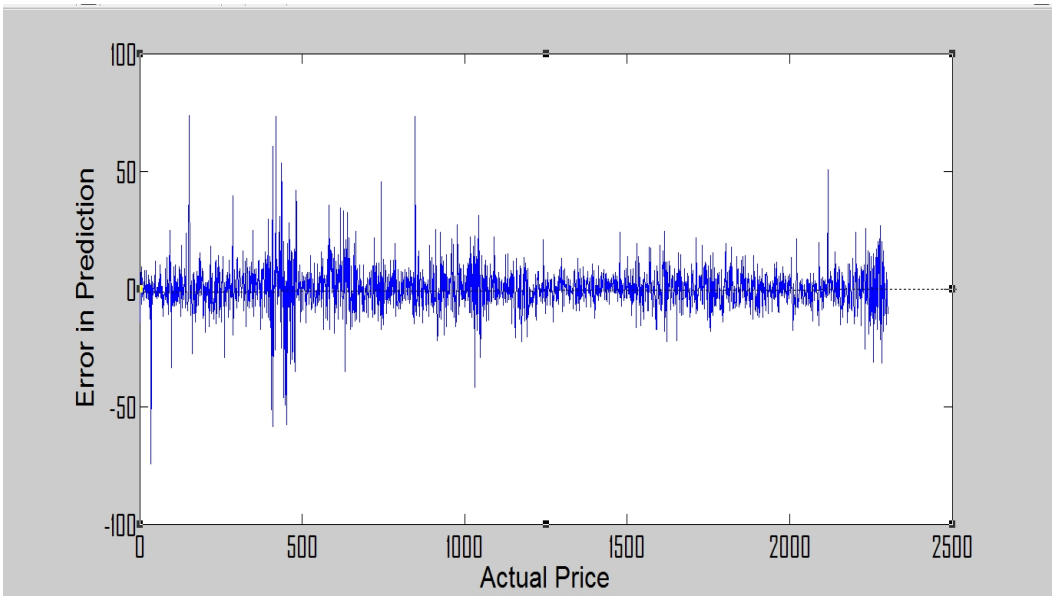

Fig. 5. Error Plot for stock dataset

The Table 2 gives the target close price, predicted close price and error in prediction i.e. the difference between original close price and predicted close price.

Table 2. Close price, predicted close price and error in prediction

Close price	Predicted close price	Error in prediction
987.5	1008.425	-20.9247
978.55	982.535	-3.98505
1230.95	1226.208	4.74207
1215.8	1217.971	-2.17067
1220.6	1210.126	10.47429
1235.9	1235.977	-0.07683
1233.95	1236.854	-2.9044
1216.05	1220.339	-4.28895
1243.55	1236.769	6.781022
1275	1278.536	-3.53615
1263.55	1264.17	-0.62011
1235.35	1234.593	0.757287
1213.75	1221.762	-8.01218
1216.95	1225.416	-8.466
1210.5	1212.509	-2.00886
1382.35	1378.056	4.293686
1400.5	1398.258	2.242165
1319	1333.475	-14.475
1320.2	1328.888	-8.68802
1209.75	1253.552	-43.8018

Table 2 Continued……

1115.65	1118.226	-2.57636
1142.2	1136.72	5.479689
1166.35	1159.271	7.079439
1157.95	1156.875	1.074703
1140.65	1151.132	-10.4823
1118.4	1115.478	2.922315
1162.4	1165.233	-2.83268
1168.25	1153.115	15.13478
1224.3	1223.587	0.712688
1229.35	1217.825	11.52537
1259.1	1259.076	0.023999
1284.5	1279.119	5.381084
1270.3	1273.753	-3.45281
1319.5	1311.587	7.91321
1335.2	1326.64	8.55953
1304.1	1307.025	-2.92471

After getting predictions on stock data the next task is to perform statistical measurements on stock forecasted prices. The Table 3 shows statistical measurements on forecasted prices.

Table 3. Statistical results on stock forecasted prices

Min	Max	Mean	Root mean square error (RMSE)	Standard deviation (SDV)	Skewness	Kurtosis
369.24	2268.18	1129.14	8.95	363.92	0.32	0.096

The results of Table 3 can be analyzed as: RMSE (%) Is very low (8.95) that means stock users can get more accurate prediction. The value of SDV shows that substantial risk is reduced in the market as compared to previous value. In the same way the value of skewness and kurtosis show that the symmetric of data and data is placed under normal distribution w.r.t. mean values.

After getting the statistical measurements we classified the price values within the range of above mean and below mean. The prices values below the mean are called stock cost price because people always purchase stock on low cost price. The price values above mean are called stock sell price because people always sell stock on high price. The Table 4 shows this classification.

Table 4. Data classification of price values

Mean	Stock cost price	Stock sell price
1224.22	Lies between (982.535-1223.587)	Lies between (1225.416-1398.258)

After classification of price values the next task is to find the profit or profit % on individual stock because people invest on stock market based on some observation and analysis. The Table 5 shows the profit & profit % on individual stock. For calculation of profit and profit (%) following formula is used.

$$profit = sell\ price\ of\ stock - cost\ price\ of\ stock \quad (3)$$

$$profit(\%) = \frac{(Error)}{(Actual\ Stock\ Price - Error)} * 100 \quad (4)$$

Table 5. Profit computation of stock dataset

ID	Stock Cost Price	Stock Sell Price	Profit	Profit (%)
1	982.535	1225.416	242.881	-0.4
2	1008.425	1226.208	217.783	-2.03
3	1115.478	1234.593	119.115	0.26
4	1118.226	1235.977	117.751	-0.22
5	1136.72	1236.769	100.049	0.48
6	1151.132	1236.854	85.722	-0.9
7	1153.115	1251.617	98.502	1.32
8	1156.875	1253.552	96.677	0.09
9	1159.271	1259.076	99.805	0.61
10	1165.233	1264.17	98.937	-0.24
11	1209.827	1273.753	63.926	-0.93
12	1210.126	1278.536	68.41	0.87
13	1212.509	1279.119	66.61	-0.16
14	1217.825	1307.025	89.2	0.95
15	1217.971	1311.587	93.61	-0.17
16	1220.339	1326.64	106.301	-0.34
17	1221.762	1328.888	107.126	-0.65
18	1223.587	1313.475	89.888	0.05

The results of Table 5 can be analyzed in following manner. Here ID-1 shows when person purchase/sell a stock then profit (%) in negative so investing on particular date would not be beneficial. In the same manner when person purchase/sell a stock on particular date (ID-3) then there would be a profit on earning a share. In the similar way (ID-17) shows that there would be a loss on earning a share. This research study will also help the stock brokers and investors to invest money in stock market and also shows the best time of purchasing and selling of stocks.

6 Conclusion and Future Scopes

Stock market behavior is dynamic. To accurately predict the stock price, a new model is proposed which can rigorously train the network and take in account multiple variables as well as multiple records simultaneously. In this paper a Neural Network (NN) based model is used with 4 variables. In this research study we observed the NN method has great prediction accuracy than other methods like linear regression and multiple regression. But drawback of NN method is that sometimes it takes a lot of time for training and testing the results. The design process of NN method i.e. architecture of NN (number of layers) is very complicated. As growing number of investor, the stock data is growing fast. To study this incremented data there is need to design a good predictor model that can predict correct trends. In future, the integrated Neural Networks and other techniques such as genetic techniques, wavelet analysis, fuzzy inference and time series models can be used for finance and economic forecasting.

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Competing Interests

Authors have declared that no competing interests exist.

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