

Stock Market Behavior Prediction Using NN based Model

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 susceptible. To increase performance of prediction there is a need of method which can accurately predict stock price and can train multiple records simultaneously. A Neural Network is very important tool for stock market prediction. This paper mainly highlights the Neural Network based approach to predict stock market behavior. The proposed design of Neural Network architecture consist the structure (number of layers and number of neurons in the layer), the input and output functions and the learning parameters.

Keywords: Stock Market, Prediction, Artificial Neural Network, Back propagation, Multilayer Perceptron, Feed-Forward.

1. INTRODUCTION

1.1 Neural Network

Artificial Neural Networks, one of the most interesting research area over the last few years and have been successfully applied diversified range of problem domains such as Medical, Finance, Engineering, Geology and Physics [2].

Artificial Neural Networks (ANNs) model consist of many nodes, i.e. processing units as similar to neurons in the brain. Each node has its own node function, associated with it along with a set of local parameters determines the output of the node, given an input. Modifying the local parameters may alter the node function. Artificial Neural Network thus is an information processing system. In this information processing system, the elements called neurons, process the information [3]. The human brain consists of a large number of neural cells (more than billion) that process information contained by cell. Each cell

works as like a simple processor and only the massive interaction between all cells and their parallel processing makes the brain's abilities possible. Figure 1 shows the structure of neural cell in the human brain [17].

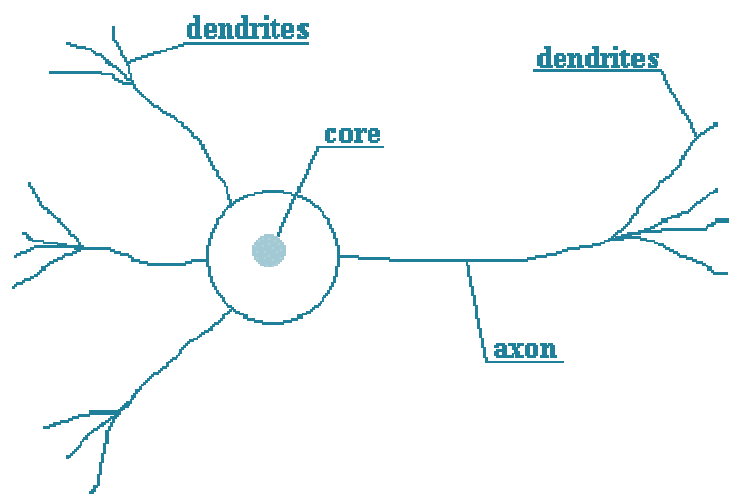


Figure 1: The Biological Model of Human Brain

As the Figure 1 shows the neurons consists of a core, dendrites for incoming information and axon with dendrites for outgoing information that is passed from one neuron to another neuron in the form of electrical stimulations along the dendrites. The information is incoming from the neuron's dendrites is added up and then delivered along the neuron's axon to the other dendrites end, where the information is passed to other neurons if the stimulation has been exceeded a certain predefine threshold. In this case, the neuron is said to be activated. On the other hand, if the incoming stimulation had been too low, then information will not be transported to any further neuron, in this case, the neuron is said to be inhibited. The connection structures, between the neurons are changing dynamically i.e. adaptive in nature. It is indicated that the learning ability of the human brain is based on this adaptation [3][17]. The following Figure shows simple structure of neuron in a neural net.

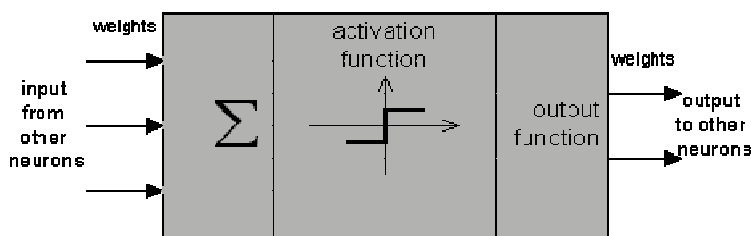


Figure 2: Structure of a Neuron in a Neural Network

The Figure 2 [18] shows an artificial neuron looks similar to a biological neural cell. And it works in the same way. The input (information) is sent to the neuron with incoming weights and this input is processed by a propagation function that adds up the values of all incoming weights. The resulting value is compared with a certain threshold value by the neuron's activation function. If the input exceeding the certain threshold value, then neurons will be activated, otherwise it will be inhibited. If activated, the neuron sends an output on its outgoing weights to all connected neurons and so on [18].

67

68 **1.2 Stock Market**

69 The dictionary meaning of market is a place for selling and buying goods or services. Thus a securities
 70 market is a place where buying and selling of securities takes place. It depends upon the demand and
 71 supplies the prices are vary. The price will high when the demand is high, when the share is heavy to sell
 72 the decrease the price. A good security market is a market where trading is conducted in a fair, open, and
 73 orderly manner. A securities market can be broadly divided into primary market and secondary market [7].

74

75 A primary market is a market in which securities are sold to investors (buyers) for the first time i.e. new
 76 securities are traded. Selling of new securities for the first time is referred to as Initial Public Offerings
 77 (IPO) [1][4].

78 A Secondary market is a market where existing securities are traded among investors. Here the securities
 79 are bought and sold after their initial sale in the primary market. For stock market study two most
 80 important types of analyses are in tradition [1][4][7].

81

82 There are two prominent Indian market indexes are Sensex and Nifty. Sensex is the oldest market index
 83 for equities; it includes shares of 30 firms listed on the BSE, which represent about 45% of the index's
 84 free-float market capitalization. It was created in 1986 and provides time series data from April 1979,
 85 onward. Another index is the S&P CNX Nifty; it includes 50 shares listed on the NSE, which represent
 86 about 62% of its free-float market capitalization. It was created in 1996 and provides time series data from
 87 July 1990, onward [1][4][7][10].

88

89

90 **2. LITERATURE REVIEW**

91

92 Prediction of stock prices is very challenging and complicated process because price movement just
 93 behaves like a random walk and time varying. In recent years various researchers have used intelligent
 94 methods and techniques in stock market for trading decisions. Here, we present a brief review of some of
 95 the significant researchers.

96

97 Minsky and Papert (1988) [15] published perceptrons, which mathematically proved the limitations of
 98 perceptrons. They suggested that neural network cannot be used to represent even some simple
 99 systems. Their article was so influential that neural network research was brought to a stand-still for
 100 over a decade.

101

102 Kaastra and Boyd (1996) [13] developed neural network model for forecasting financial and economic
 103 time series. They selected a large number of parameters for neural network forecasting model. and they
 104 described eight-step procedure to design a neural network forecasting model including a discussion of
 105 tradeoffs in parameter selection, some common pitfalls, and points of disagreement among
 106 practitioners.

107

108 Hadavandi et al. (2010) [11] have presented an integrated approach based on genetic fuzzy systems
 109 (GFS) and artificial neural networks (ANN) for constructing a stock price forecasting expert system. At
 110 first, they used stepwise regression analysis (SRA) to determine factors which have most influence on
 111 stock prices. At the next stage, they divided their raw data into k clusters by means of self-organizing
 112 map (SOM) neural networks. Finally, all clusters were fed into independent GFS models with the ability
 113 of rule base extraction and data base tuning. They evaluated capability of the proposed approach by
 114 applying it on stock price data gathered from IT and Airlines sectors, and compared the outcomes with
 115 previous stock price forecasting methods using mean absolute percentage error (MAPE). Results have
 116 shown that the proposed approach outperformed all previous methods, so it can be considered as a
 117 suitable tool for stock price forecasting problems.

118

White (1988) [25] presented the first significant study on the application of the neural network models for stock market forecasting. Following White's 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. (2011) [12] have proposed ANN method for stock market price prediction. They choosed consecutive 1000 days of NSE stock data of Infosys Technologies Company and the actual stock price of Infosys technology have compared with the predicted value of the Gaussian, Isotonic regression, Least mean square, Linear regression, Multilayer Perceptron functions Pace regression, Simple linear regression and SMO regression values. In order to 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 price.

Chan.et al. (2004) [5] implemented a neural network model using the technical analysis variables for listed companies in Shanghai Stock Market. In this work performance of two learning algorithm and two weight initialization methods are compared. The results reported 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 and with multiple linear regression weight initializations.

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. PROPOSED NN DESIGN STEP

Neural network architecture defining its structure including number of input nodes, hidden layers, number of hidden nodes in the hidden layer and number of output nodes etc. There are 8 steps on designing a neural net which are discussed below [3][17][18].

3.1 Variable Selection

It is very important to choose the input data and to calibrate the Neural Net. In this research study we have selected variable open price, high price, and low price for input data. For output variable close price is selected.

3.2 Data Collection

The continuous stock market trend data is collected from Bombay Stock Exchange site [19].

3.3 Data Preprocessing

First, we have found the maximum and minimum number of the index and then the data is normalized in range [0, 1], which is shown by Figure 5.

3.4 Training, Testing and Validation set

The input data set is divided into training, testing and validation set. In applications, the size of testing set is from 10% to 30% of the training set and the size of the training set must be at least 5 times the amount of total weights. Validation set is the final check on the performance of the trained network.

3.5 NN Paradigms

3.5.1 Number of Hidden Layers

The neural network ability can be generalized with number of hidden layer(s). In general theory, a neural network with one hidden layer with a sufficient number of hidden neurons is capable of performing any continuous function. Generally, neural network with one and occasionally two hidden layers are most widely used [17][18]. In this study 2 hidden layers are considered for design required NN model.

3.5.2 Number of Hidden Nodes

There is no magic formula available for selecting the optimum number of hidden neurons. However, some heuristics are available for calculating number of hidden neurons. For a three layer network with n input and m output neurons, the hidden layer would have $\sqrt{n * m}$ neurons [18]. In this study we have considered the value of $n = 3$ and $m = 1$ (input and output variable). So number of neurons is calculated 2. For better performance, proposed NN design the value of hidden neurons is considered as 7.

3.5.3 Number of Output nodes

Neural networks with multiple outputs, especially if these outputs are widely spaced, will produce inferior results as compared to a network with a single output. In this study, we have considered one output node.

3.5.4 Activation Function

The activation function is used to calculate the output response of a neuron. The sum of the weighted input signal is applied with an activation to obtain the response. For neurons in same layer, same activation functions are used. There may be linear as well as nonlinear activation functions. The nonlinear activation functions are used in a multilayer net [17]. The some names of activation function which are used in linear and nonlinear network are identity function, binary step function, sigmoidal function, bipolar sigmoidal function. In this study, we have considered binary sigmoidal function which is shown below [18].

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

Where, σ is called the steepness parameter.

3.6 Evaluation Criteria

To evaluate the performance of neural network prediction system, the mean square error of prediction and the actual number of iterations are used.

3.7 Network training

The Number of training iterations: is determined in several ways,
 1. The training process will stop until a defined number.
 2. The training process will stop until the error is smaller than the defined value.
 3. We can also early terminate training, when the error on validation set is a minimum.

Break the training set into 2 parts. Use part 1 to compute the weight changes every m cycles and apply the partially trained network to part 2 (the validation set) and save the weights. In principle, we will raise a number of iteration until convergence to the requirement level [17][18].

3.7.1 Learning rate (η)

Determined to some extent, the convergence speed of the network and a low value of learning rate (0.01, 0.6) is equivalent with a small step size of training and this means learning process is steady. Otherwise, the higher learning (0.6-0.9) rate means an unstable learning process and cannot reach the range of the error. In empirical application, the lower learning rate is commonly used [17].

3.7.2 Momentum (α)

Determines how much of the previous corrective term should be remembered and carried on in the current training. Accelerate convergence and increase the stability [17].

3.8 Implementation

The back propagation network is simply implemented by MATLAB tool.

2354. PROPOSED METHODOLOGY:MULTILAYER FEED-FORWARD NETWORK

A neural network can be used to represent a nonlinear mapping between input and output vectors. Neural networks are among the popular signal-processing technologies. In engineering, neural networks serve two important functions: as pattern classifiers and as nonlinear adaptive filters. A general network consists of a layered architecture, an input layer, one or more hidden layers and an output layer. A feed-forward artificial neural network consists of layers of processing units; each layer feeding input to the next layer in a feed-forward manner through a set of connecting weights [18][22]. To set the stage for a description of the multilayer perceptron in its general form, the network shown in Figure 3 is fully connected. This means that a neuron in any layer of the network is connected to all the nodes/neurons in the previous layer. Signal flows through the network progresses in a forward direction, from left to right and on a layer-by-layer basis. By choosing suitable architecture for feed-forward neural network several pattern recognition tasks can be perform [18][22][26].

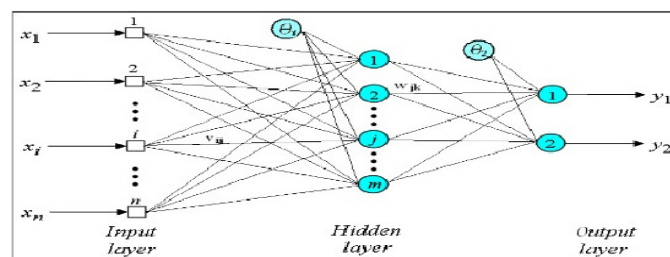


Figure 3: Simple Artificial Feed Forward Neural Network

The back-propagation neural network is supervised method for training artificial neural network. It is multi-layer feed-forward neural network with no backward loop but it back propagates the error so that it is

named as “Back propagation neural network” [14][17][18]. Back propagation calculates the gradient of the error of the network regarding the network’s modifiable weights. Each layer in this multi-layer neural network has activation functions associated with it. The back propagation algorithm has two parts which are training algorithm and application algorithm. Training algorithm is used to create the best neural network model. This algorithm is divided into three main parts which are feed forward, error calculation and the last part is updating the weight. The following algorithm shows step by step procedure of back propagation learning algorithm [9][17].

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).

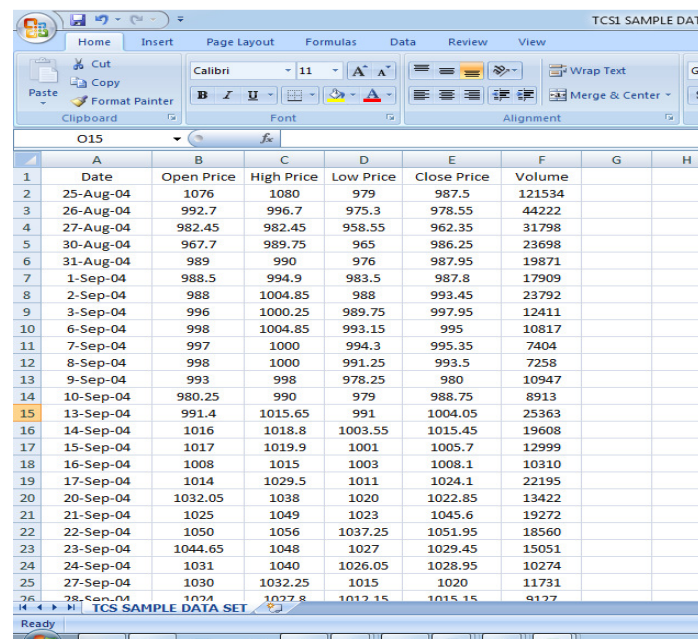
Step 5: Calculate Actual Output.

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.

5. EXPERIMENTAL RESULTS

In this paper a prediction model proposed uses 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 [19]. 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. Stock market dataset from Jan-2004 to Nov-2013 [19] is shown in Figure 4.



	A	B	C	D	E	F	G	H
	Date	Open Price	High Price	Low Price	Close Price	Volume		
1	25-Aug-04	1076	1080	979	987.5	121534		
2	26-Aug-04	992.7	996.7	975.3	978.55	44222		
3	27-Aug-04	982.45	982.45	958.55	962.35	31798		
4	30-Aug-04	967.7	989.75	965	986.25	23698		
5	31-Aug-04	989	990	976	987.95	19871		
6	1-Sep-04	988.5	994.9	983.5	987.8	17909		
7	2-Sep-04	988	1004.85	988	993.45	23792		
8	3-Sep-04	996	1000.25	989.75	997.95	12411		
9	6-Sep-04	998	1004.85	993.15	995	10817		
10	7-Sep-04	997	1000	994.3	995.35	7404		
11	8-Sep-04	998	1000	991.25	993.5	7258		
12	9-Sep-04	993	998	978.25	980	10947		
13	10-Sep-04	980.25	990	979	988.75	8913		
14	13-Sep-04	991.4	1015.65	991	1004.05	25363		
15	14-Sep-04	1016	1018.8	1003.55	1015.45	19608		
16	15-Sep-04	1017	1019.9	1001	1005.7	12999		
17	16-Sep-04	1008	1015	1003	1008.1	10310		
18	17-Sep-04	1014	1029.5	1011	1024.1	22195		
19	20-Sep-04	1032.05	1038	1020	1022.85	13422		
20	21-Sep-04	1025	1049	1023	1045.6	19272		
21	22-Sep-04	1050	1056	1037.25	1051.95	18560		
22	23-Sep-04	1044.65	1048	1027	1029.45	15051		
23	24-Sep-04	1031	1040	1026.05	1028.95	10274		
24	27-Sep-04	1030	1032.25	1015	1020	11731		
25	28-Sep-04	1029	1027.8	1012.15	1015.15	9127		

Figure 4: Preview of Stock Dataset of TCS

The data is normalized because data required for processing using neural network must be in the range of (0, 1) or (-1, +1), which is shown by Figure 5.

No.	Open Price	High Price	Low Price	Close Price
	Numeric	Numeric	Numeric	Numeric
1	1.0	1.0	0.25984...	987.5
2	0.230840...	0.14607...	0.21283...	978.55
3	0.136195...	0.0	0.0	962.35
4	0.0	0.07483...	0.08195...	986.25
5	0.196675...	0.07739...	0.22172...	987.95
6	0.192059...	0.12762...	0.31702...	987.8
7	0.187442...	0.22962...	0.37420...	993.45
8	0.261311...	0.18247...	0.39644...	997.95
9	0.279778...	0.22962...	0.43964...	995.0
10	0.270544...	0.17990...	0.45425...	995.35
11	0.279778...	0.17990...	0.41550...	993.5
12	0.233610...	0.15940...	0.25031...	980.0
13	0.115881...	0.07739...	0.25984...	988.75
14	0.218836...	0.34033...	0.41232...	1004.05
15	0.445983...	0.37263...	0.57179...	1015.45
16	0.455216...	0.38390...	0.53939...	1005.7
17	0.372114...	0.33367...	0.56480...	1008.1
18	0.427516...	0.48231...	0.66645...	1024.1
19	0.594182...	0.56945...	0.78081...	1022.85
20	0.529085...	0.68221...	0.81893...	1045.6
21	0.759926...	0.75397...	1.0	1051.95
22	0.710526...	0.67196...	0.86975...	1029.45
23	0.584487...	0.58995...	0.85768...	1028.95
24	0.575253...	0.51050...	0.71728...	1020.0

Figure 5: Normalized Data

The Figure 6 shows selection of input and target data from workspace and how they are oriented i.e. column-wise or row-wise.

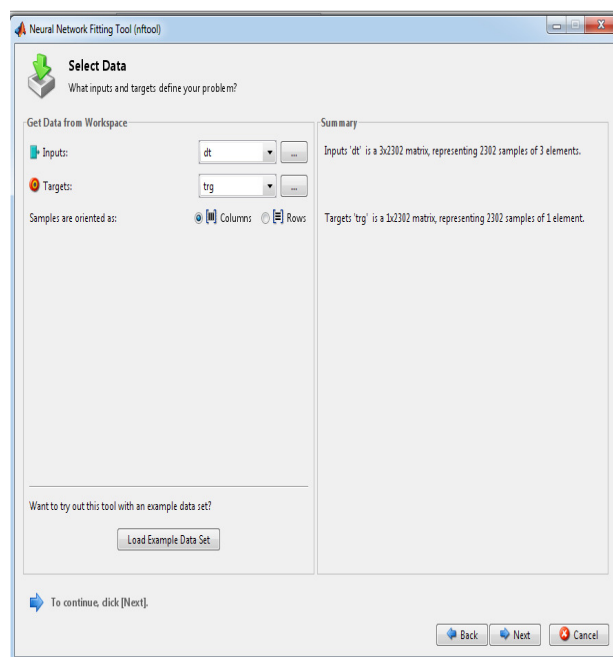


Figure 6: Data Manager for Taking Input and Target Data

After selecting data it divided into training, validation and test dataset as shown in Figure 7. Here we used 60% of data for training, 20% for validation and 20% for testing.

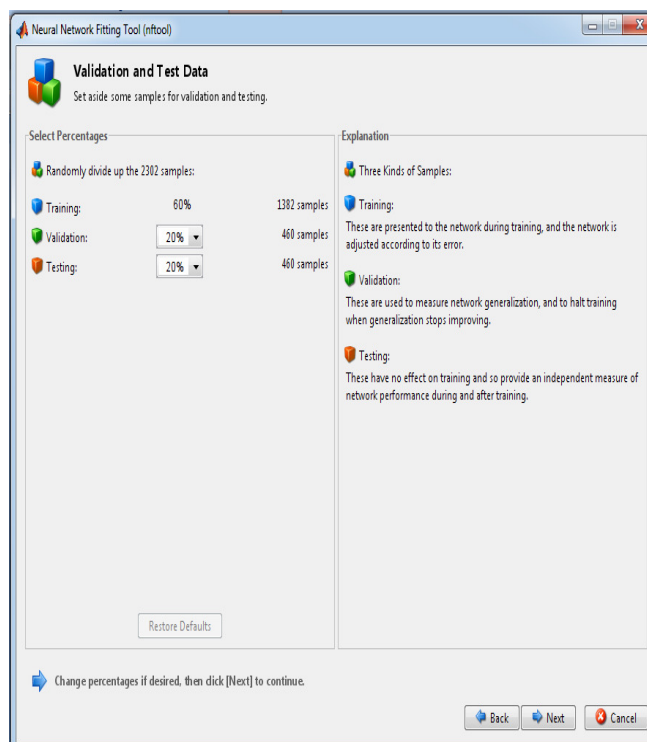


Figure 7: Division of Stock Data into Training, Validation and Testing Dataset
Further need to set the size of network by setting number neurons in hidden layer as shown in Figure 8, which is set on 7.

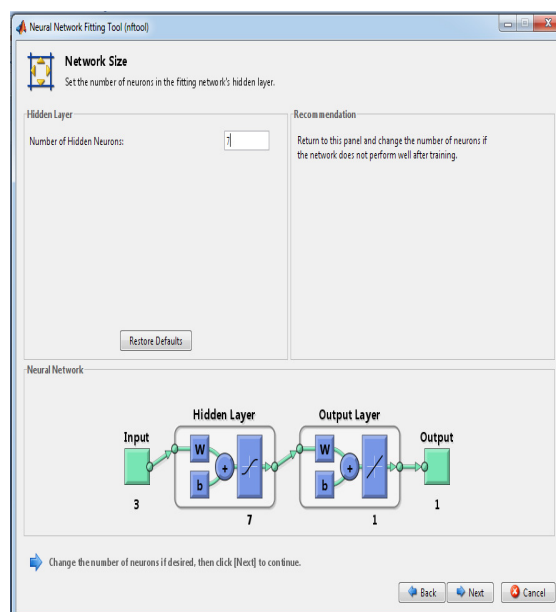


Figure 8: Numbers of Neurons in Hidden Layer and View of Network

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 Figure 9.

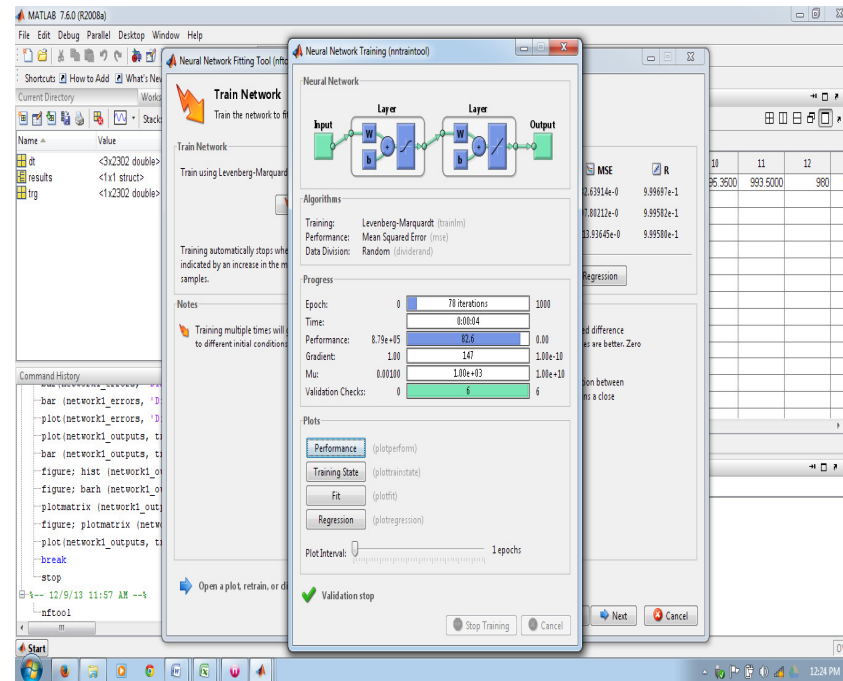


Figure 9: Training of Network

The Graph 10 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. The training state of network is shown in Figure 11.

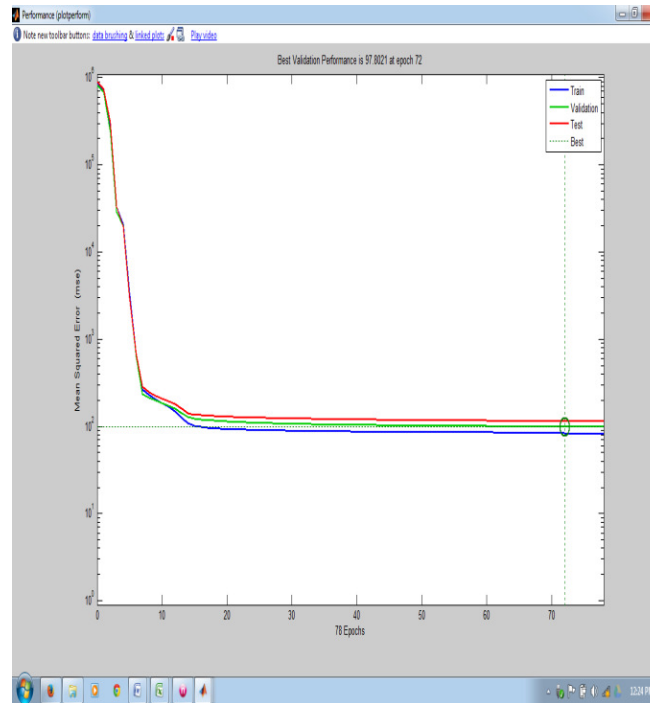


Figure10: Performance Plot of Network

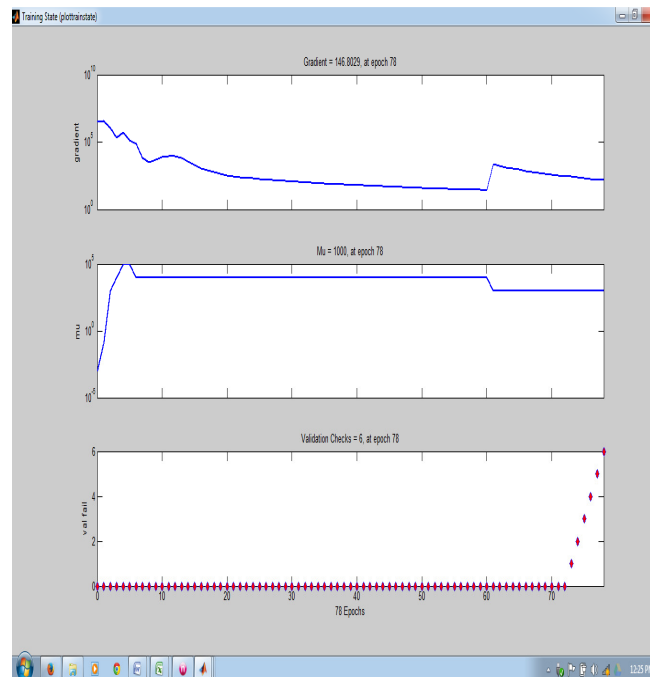


Figure 11: Training State of Network

The Figure 12 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.

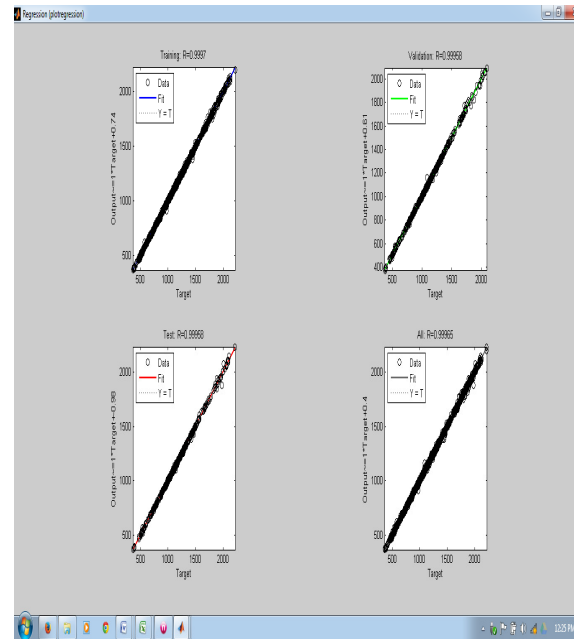


Figure 12: Regression Plot of Network

The Figure 13 shows the line graph between actual price and predicted price.

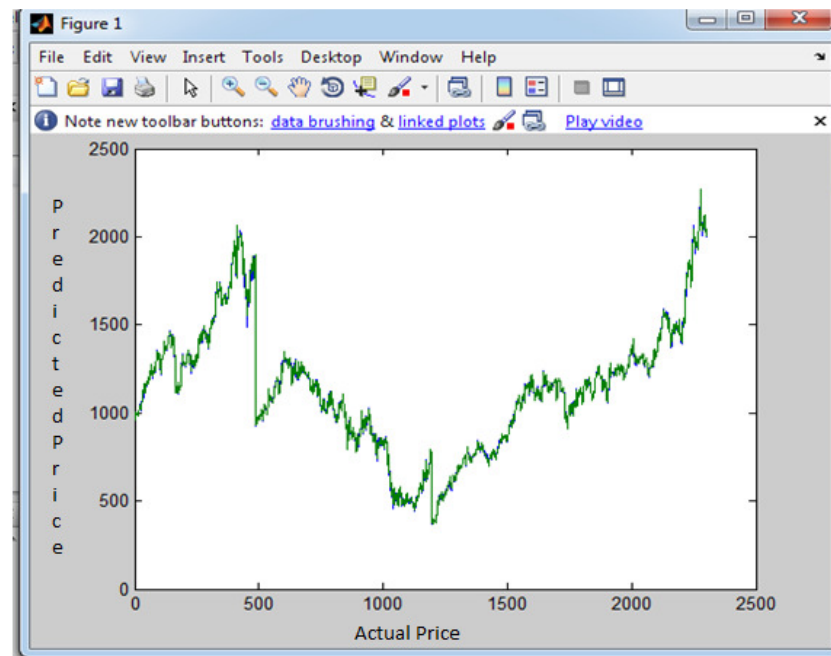


Figure 13: Line Graph between Target Close Price and Predicted Close Price

Table 1 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 1: 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
1242.45	1251.617	-9.16736
1235.35	1234.593	0.757287
1213.75	1221.762	-8.01218
1216.95	1225.416	-8.466
1198.45	1209.827	-11.3767
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
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

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, 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. Each method has its own advantages and disadvantages. In this research study we observed the NN method has great prediction accuracy. 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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