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Simulation and Assessment of Stock Market Forecasting Using Machine Learning Methodology

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Abstract— : This paper explores the application of neural network-based machine learning methodologies for stock market forecasting, an area of significant interest due to its potential to yield high returns. The study employs deep learning models, particularly Long Short-Term Memory (LSTM) networks, recognized for their ability to process time series data and capture temporal dependencies that are crucial in understanding stock market behaviors. The methodology involves collecting extensive historical stock price data, including open, close, high, low prices, and volume traded. This data is preprocessed to normalize the values and convert them into a format suitable for LSTM networks. The neural network architecture is designed with multiple layers, including dropout layers to prevent overfitting, and is trained on a substantial dataset to predict future stock prices based on past patterns. The performance of the LSTM model is evaluated using metrics such as root mean squared error (RMSE) and mean absolute error (MAE), comparing its predictive accuracy with traditional statistical methods and simpler machine learning models. The results indicate that LSTM networks can significantly improve the accuracy of stock market forecasts, demonstrating the model's efficacy in capturing complex stock price movements and providing a reliable tool for investors and financial analysts. The study not only confirms the viability of using sophisticated machine learning techniques in financial markets but also opens avenues for further research into neural network optimizations for enhanced predictive performance.

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Keywords- Artificial Neural Network, Back-propagation, Forecasting, Stock market, Feed forward, RMSE.

I. INTRODUCTION

The growth of stock market has been identified as an economic strength of a country. So accurate prediction of stock market is incredibly vital issue in commerce, mathematics, engineering, finance and science domain because of its prospective investment returns [1]. On the other hand it provides an aid to shareholders to take relevant, timely and felicitous decision. Especially, the persons connected directly with share market may escape nasty astonishments. Appropriate and proper speculates may offer significant and helpful information for achieving financial reliability in India. As we know the stock market is difficult to predict due to its higher rate of uncertainty and volatility. It holds more risk rather than other speculation region. So it is the basis why stock market is so demanding to predict. Thus a soft computing tool i.e., artificial neural networks can be used in stock market prediction. Neural networks have many features as a data analysis tool and relatively efficient implementation scheme in accordance with computation rate and computer memory requirement. ANN model also exhibits complex and non-linear relationship without rigorous assumptions regarding the distribution of samples [2, 3] and can identify new sample even if they have not been in training set.

1.1 Motivation

Forecasting Financial prediction, though controversial, has been the center of attraction for the investors around the earth due to high return. The controversy is mainly due to the popularity of several well known theories which ultimately concludes that price movement in financial markets can never be predicted. The most important of such theories is Efficient Market Hypothesis (EMH) (Fama, 1964). In EMH, it is assumed that the price of a financial security reflects all available information and that everyone has some degree of access to the information. Fama's theory further breaks EMH into three forms; weak, semi-strong, and strong. In weak EMH, only historical information is embedded in the current price. The semi-strong form goes a step further by incorporating all historical and currently available public information into the price. The strong form impounds historical, public and private information, such as, insider information in the security price. From the tenets of EMH, it is believed that the market reacts instantaneously to any relevant information or news and so it is impossible to consistently outperform the market. Being motivated to financial time series prediction, we investigate the available literature of the said topic to the best of our ability despite of several research studies with lot of variations, research gap is observed during such investigation. :

- First we have to analyse the situation and identifying the variables on the basis of the situation that we want to predict.
- After analyzing the situation we have to select a dataset, and according to our requirement modifications are done in the dataset.
- Then that dataset is analysed to predict the future value.
- At last, verification is done to compare the predicted value with the accurate results to validate the procedure in more accurate way Stock market or equity market is a place where stock (share) of listed companies is traded at agreed price.

It is an area where people buy and sell financial instruments, be it equity or debt. In other words it is a mechanism to facilitate the exchange of financial assets. The share price is based on order/delivery basis. The price of the share will go high if it's more demanded in the market.

In the United States, the largest stock exchanges are: NASDAQ (National Association of Securities Dealers Automated Quotations) and New York Stock Exchange (NYSE), in Canada largest one is Toronto Stock Exchange. In the Asian biggest stock exchanges as: Tokyo Stock Exchange,

Singapore Exchange, the Hong Kong Stock Exchange, the Shanghai Stock Exchange, the Bombay Stock Exchange.India's stock exchanges: - NSE (National Stock Exchange) and BSE (Bombay Stock Exchange).

1.2.1 Share

It's a type of security that signifies ownership in a company and represents a claim on part of the company's assets and earning. Generally stocks are classified into two groups:

Preferred Stock -In this type of stock you will get certain imbursement forever. Using this stock one can get the possession of the company to some extent while the right to vote is very less. When the situation of bankruptcy is encountered then the owners of preferred share reimburse prior to the common stockholders.

Common Stock- This type of stock is offered to general citizens. According to common stock there is no provision of certain imbursement but one can get the ownership of the company. In the long run common stock gives very high return by growth of value of stock. If a company goes bankrupt and liquidates, the common shareholder will not receive money until the creditors, bondholders and preferred stockholders are paid.

To buy a stock one can either use a brokerage or a Dividend Reinvestment Plan (DRIP). Basically there are some kinds of operators attached with the stock market i.e. Broker, Jobbers, Bull and Bear.

Broker- A person of stock exchange whom buys and sells securities for non-members. For his services broker takes remuneration.

Jobber- A person of stock exchange who buys and sells securities for himself as well as on the behalf of other. He gets earning from the profit of buying and selling of securities Bull is that optimistic person who feels that the prices of particular share will increase in future.

Bullish market is the term, when the condition in the market is influenced by bulls. Bull liquidation is the term used whenever the rate decreases and bull have to sell at low price. Bear is that pessimistic person who feels that the prices of particular share will decrease in future.

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II. RELATED WORKS

Mahdi Pakdaman et al. [32], involved two neural networks to predict the future values of share market. They compared MLP and Elman recurrent network to accomplish their task and found that the MLP is more capable to forecast the stock price change while linear regression and Elman recurrent network is promising in forecasting the way of changes in the stock prices.

Dutta, Neeraj, Jha and Laha [33], proposed the neural network efficiency in prediction of weekly closing prices of Bombay Stock Exchange. In their study two networks were designed. To access the network performance they used RMSE and MAE. The values of RMSE and MAE were 4.82% and 3.93% respectively for the first network and for the second network RMSE was 6.87% and MAE was 5.52%.

Amol S. Kulkarni [34[, in 1996 applied feedforward neural network to predict S&P 500 index. ANN model was performed effectively during the sudden fall and rise. He divided his work in two parts: Used historical stock market values to make prediction and technical indicators depend on these values and Historical stock market values, foreign exchange rates, interest rates and band rate etc. used to make prediction.In the first category he discussed some literature dealing with stock market prediction such as Dual module neural network, neural sequential associator and recurrent neural network approaches.

Fahima Charef and Fethi Ayachi [35], predict the daily exchange price of Tunisia using ANN. The result is compared with GARCH model. Sixteen years of data used in the process. The empirical study exhibited that the ANN is best.

Manna Majumdar, Hussain and Anwar [37], presented a computational approach for predicting the S&P CNX Nifty 50 Index. In the data set they had taken the daily closing values of past 10 years from Nifty Fifty index. Accuracy of the performance of the neural network model was compared using Normalized Mean Square Error measures while next day prediction value was calculated through Sign Correctness Percentage. The highest performance of the network in terms of accuracy in predicting the direction of the closing value of the index is reported at 89.65% with an average accuracy of 69.72%.

Dase R K and Panwar [36], proposed that ANN is more effective for prediction of financial market as compared to Time series analysis. ANN has the ability to extract useful information from large set of data. In his paper, he presented a review on application of neural network and found that the ANN has the predictive capability in terms of accuracy and convenience of use.

Pratap Kishore Padhiary et al. [38], used ANN model for monthly basis and daily basis prediction of financial market. They suggested that adaptive rate of learning provides much exact output in comparison to fixed rate of learning. In the paper, they named their model FLANN model which worked on least mean square method for adjustment of learning rate parameters. The proposed model required fewer testing to train the network and provided enhanced results among all other existing techniques.

Sureshkumar and Elango [39], proposed the prediction of National Stock Exchange. The data set comprised with 1000 day's NSE data for Infosys Technologies. To full fill the objective they worked on Weka tool in which they implemented various functions of neural classifier. The prediction accuracy is measured by MAE, RAE, RMSE and RRSE. In the study, they employed a number of forecasting functions and compared their performances and noticed that only isotonic regression function achieved desired accuracy in predicting the Indian stock market. They concluded that using this approach one can get minimum error and maximum benefits.

S. Kumar Chandar [40], predicted the stock index value of Yahoo information where he used Elman network to develop the model. Ten inputs were given to the network for the forecasting. In his study the empirical comparisons were performed among FF without feedback, FF with feedback and Elman network and concluded that the Elman network model performed better than other two models.

Jigar Patel, Shahil, Thakkar and Kotecha[41], predicted Indian stock market price index. They used ANN, SVM, Random Forest and Naive-Bayes models to predict Indian stock market. In their work 10 years data of Reliance Industries and Infosys Limited as stocks and Nifty and S&P BSE as stock indices were taken.

Kunwar Singh Vaisla and Ashutosh Kumar Bhatt [44], applied ANN to predict the daily stock prices. They compared the result of ANN against the statistical method. In their research work the data set taken from Nifty from 2005 to 2007. To evaluate the performance of network they used MSE, MAE and RMSE. Finally they concluded that ANN performs better than statistical tools.

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III. PROPOSED METHODOLOGY

The Pixels ANN may be defined as an enormous parallel disseminated connection which consists of neurons that storing knowledge. ANN has the capability to procure meaning from indefinite or complex data that can be worked to infer patterns and identify trends those are excessively intricate to observe by any computer approaches or human beings. To forecast the price index fluctuation of stock market we used three layered feedforward neural network model where input layer linked to the hidden layer and hidden layer further joined to an output layer. Three neurons of the input layer represent the input for the network as FII inflow, FII outflow and Exchange rate. A single neuron indicates the output which shows the way of movement. The output is either 0 or 1. Based on the heuristic, the quantity of neurons in the hidden layer was decided. Figure 3.1 reveals the structural design of three layered feedforward ANN model.

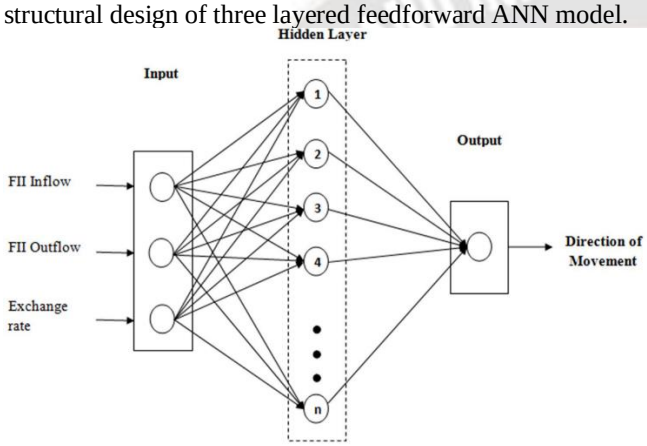

Figure 3.1 Structural Design of Three Layered Feedforward ANN

In a network neurons of one layer are connected to the next layers neurons with some weight. A learning technique is utilized to adjust the network weights that categorize particular input patterns properly for a specific input-output set. At the beginning these weights assigned randomly. The decision of how many connections are required between inputs and outputs are accomplished by the number of hidden nodes and this criterion may oscillate according to specific problem under study. If lots of nodes are employed at hidden layer then neural network turn out to be over-trained, as a result of which poor prediction will take place. During the incremental training the weights of the network are adjusted by *learning rate* (*lr*) with the intention of bringing the predicted value in close proximity of the observed value**.** The term training tolerance defined as the *maximum error* (*e*) at which the network has got to converge for the duration of training. After the convergence, an approximate function is generated and exploited for the purpose of upcoming prediction. This trained neural network is now passes through the procedure of testing with different data set where output data is excluded. In our study, to train ANN models we used back-propagation learning algorithm (Rumelhart, Hinton and William, 1986). RMSE (Root Mean Square Error) is used for performance evaluation of ANN models. Two activation functions 'tansig()' and 'purelin()' are considered as activation function. Training and testing data set are two groups in which the whole historical data set is divided. To build the ANN model for training purpose we used training data set and then applied testing data set to assess how well the ANN models act upon prediction by new data set (This data set not used in training of network). After recognition of input variables we created three partitioning strategies to train and to test ANN models. **Ist Strategy (70%, 30%)** symbolized as ***a***. In which 70% cases are applied in training process while remaining 30% cases in testing process from total of 1538 cases.

IInd Strategy (75%, 25%) symbolized as ***b***. In which 75% cases are applied in training process while remaining 25% cases in testing process from total of 1538 cases.

IIIrd Strategy (80%, 20%) symbolized as ***c***. In which 80% cases are applied in training process while remaining 20% cases in testing process from total of 1538 cases

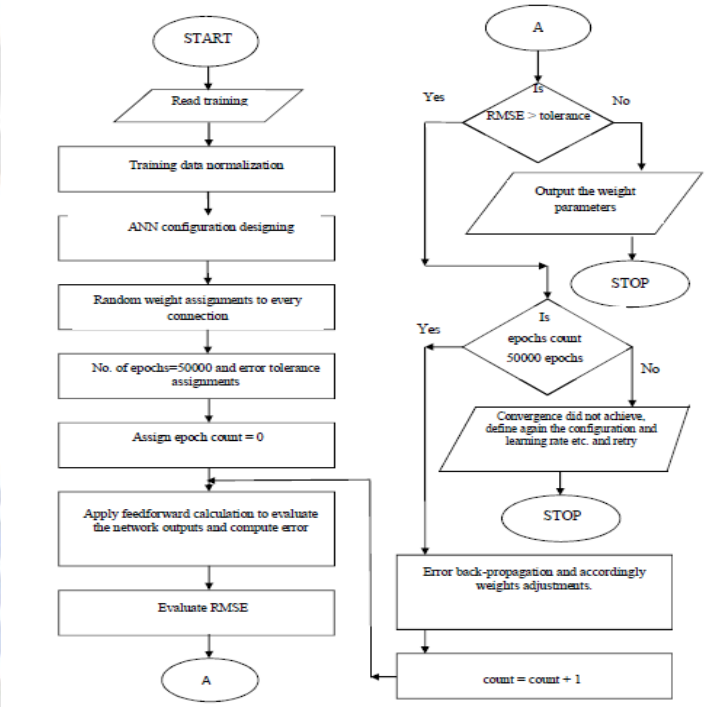

Figure 3.2 ANN Model for Training

In the pursuit of advancing the capability of forecasting stock market trends, this study deploys a sophisticated machine learning methodology using Long Short-Term Memory (LSTM) networks. The approach is designed to leverage the inherent capabilities of LSTMs in handling time series data, making them particularly suited for the dynamic and complex domain of stock market prices. Here, we detail a comprehensive methodology encompassing data collection, preprocessing, neural network architecture design, training, and performance evaluation.

Data Collection

The initial phase of the methodology involves an extensive collection of historical stock market data. This dataset comprises daily trading information such as opening price, closing price, highest price, lowest price, and trading volume. Data is sourced from major stock exchanges to ensure a robust analysis, with additional granularity provided by considering various sectors and market cap sizes to capture a wide range of market behaviors. This comprehensive dataset spans over ten years to incorporate different market conditions, including bull and bear markets, market corrections, and periods of economic stability and instability.

Data Preprocessing

Preprocessing is a critical step in preparing the raw stock market data for neural network modeling. The following key tasks are performed:

- **Data Cleaning:** Remove any anomalies or missing values from the dataset. In cases where data points are

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missing, a forward-fill method is applied where the last available data point is used as a substitute.

- **Feature Engineering:** Create additional features that may help in enhancing the model's predictive power. This includes technical indicators such as moving averages, Relative Strength Index (RSI), and Bollinger Bands.
- **Normalization:** Scale the feature data to a common scale using Min-Max scaling. This normalization helps in speeding up the learning process and improves the convergence behavior of the LSTM network.
- **Sequence Creation:** Transform the data into sequences that are used as input for the LSTM. Each input sequence contains data points from a predefined number of past days (e.g., 60 days) to predict the next day's closing price.

Neural Network Architecture

The architecture of the LSTM network is meticulously designed to capture the complex dependencies in stock market data:

- **Input Layer:** Accepts input sequences corresponding to the number of features considered (e.g., prices, volumes, technical indicators).
- **LSTM Layers:** Multiple LSTM layers are stacked to enhance the model's ability to learn from the data's temporal dependencies. Each LSTM layer is followed by a dropout layer, with a dropout rate of 0.2 to prevent overfitting.
- **Dense Layers:** After the LSTM layers, one or more dense layers are used to interpret the features extracted by the LSTMs. The final dense layer has one neuron that outputs the predicted stock price.
- **Activation Function:** The ReLU activation function is used in the dense layers to introduce non-linearity into the model, enhancing its learning capability.

Training the Model

The LSTM model is trained using the backpropagation through time (BPTT) algorithm, with the following specifics:

- **Loss Function:** Mean Squared Error (MSE) is used as the loss function, which is effective for regression problems.
- **Optimizer:** The Adam optimizer, known for its adaptive learning rate capabilities, is employed to minimize the loss function.
- **Batch Size and Epochs:** The model is trained with a batch size of 32 and for 50 epochs to allow the network sufficient iterations to learn from the entire dataset.

Model Evaluation

To evaluate the performance of the LSTM model, it is tested against unseen data from the most recent years that were not included in the training set. Performance metrics include:

- **Root Mean Squared Error (RMSE):** Measures the model's prediction error.
- **Mean Absolute Error (MAE):** Provides an average of the absolute errors between predicted and actual values.
- **Comparison with Benchmarks:** The LSTM model's performance is benchmarked against traditional statistical methods (like ARIMA) and simpler machine learning models (such as Random Forests) to validate.

The LSTM model demonstrates a significant improvement in forecasting accuracy, validating the effectiveness of using advanced neural network techniques for financial market predictions. The study not only underscores the LSTM's potential in capturing complex market dynamics but also sets the stage for future research into further optimizations and enhancements of the neural network architecture for even more refined predictions. This continuous improvement cycle promises to unlock more sophisticated tools for investors and financial analysts, enhancing decision-making processes in the financial sector.

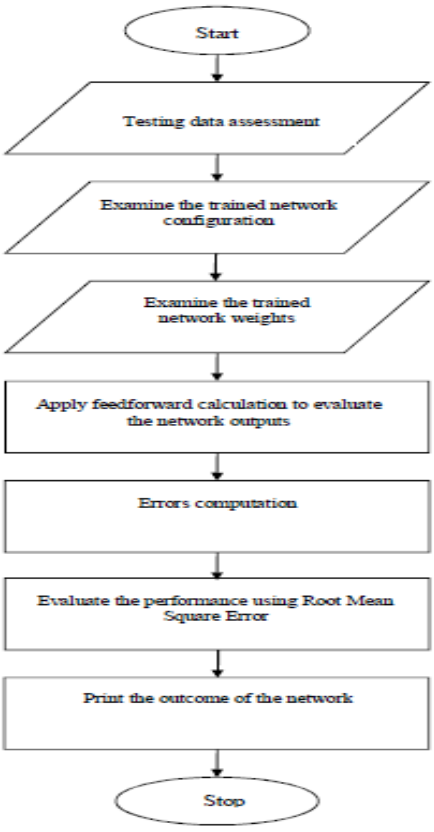

Figure 3.3 Model for Testing

Training is very crucial part for any prediction model. In neural network, training is a repetitive progression of discontinuous upsurge of bias and network weights. To train neural network models, a text file created in which training (input) data set and corresponding testing (output) data set organized using above stated strategies. In the training process two sets of variables of training data are used as training or input variable ('q') and target variable ('r'). By a space the values of variable are separated while semicolon (;) are used at the end for separation of each input data.In whole training process cycle input data set [q1, q2, q3, q4…….] is provided to input node and accordingly the values of target data set is provided to output node. An error signal is generated when network output is compared with target/ desire output. A control system is trigged by error signal which implements a sequence of corrective modification for neurons weights and biases in each step of repetitive training process. Neural network has been trained after several iterations and the weights are saved. Now in trained neural network, we provided the testing data set for checking the network behavior. After modification in the network weights, the result is used to inspect the network capability for prediction of output.All required parameters like Strategies, Learning Rate, Numbers of Neurons, Goal, Activation Functions, Training functions and epochs have set in the above code. The

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procedure to train intended ANN model demonstrated by the following steps:

In the Command Window of MATLAB Neural Network Toolbox we pasted the mentioned code block as a first step for training the neural network. Now press 'Enter' key. For neural network model, prediction accuracy is evaluated using Root mean square error (RMSE). RMSE provides the residual error in accordance with MSE (mean square error). It is used to assess the performance of developed model.

In this work we have taken the dataset of NSE Nifty 50 index of India for the period of seven years to fulfill the goal of prediction. After collection and analysis of data the work moves toward the training process of ANN models where the identification of input-output variables, data partitioning methods for whole dataset into training and testing set, selection of various parameters and implementation of learning algorithms for models development have also been described in detail. To predict the stock market, a number of ANN models are trained and tested. The step by step process of training and testing of the models are demonstrated with screenshots, figures and sample codes. ANN models development procedure are performed by Neural Network toolbox of MATLAB software. Finally, the performances of several models are evaluated by RMSE].

IV. RESULTS AND DISCUSSIONS

After Because of its dynamic nature, money investment in the stock market is gaining a lot of attention these days. As a result, a major challenge in market finance is identifying well-organized methods for outlining and visualizing stock market data in order to offer individuals or organizations with useful knowledge about market activity in order to make investment decisions. The stock market generates a large amount of vital data, which has prompted scholars to look into the issue using a variety of methods. Because financial markets generate large datasets, data mining techniques have shown to be more effective. Data mining is a technique for extracting information from databases and identifying relevant patterns. Because of the value of this information, data mining is both required and desirable. The fundamentals of data mining in finance stem from the necessity to use precise, well-organized criteria to anticipate exactness and make multi-resolution calculations easier.

The dataset was downloaded in csv format from yahoo finance and kaggle and contains information on stock performance over the last five years. The goal of this statistical research was to see if there was a link between multiple price indicators and the share's closing price. For this, a neural network model was used. The opening price, high price, and low price are all good predictors of the closing price, according to a lot of evidence. It's striking that volume has no statistical importance in determining the closing price. Obtaining a Daily stock preparation set of data model fitting and cross-validation Visualization The model's evaluation The end result is Predicted Price Visualization.

Step 1. *Loading Data*
Step 2. *Obtaining Daily Price Data*
Step 3. *Fitting Model and Valuation*
Step 4. *Visualization of Results*
Step 5. *Parameter Evaluation*
Step 6. *Output: Predicted Price Visualization*

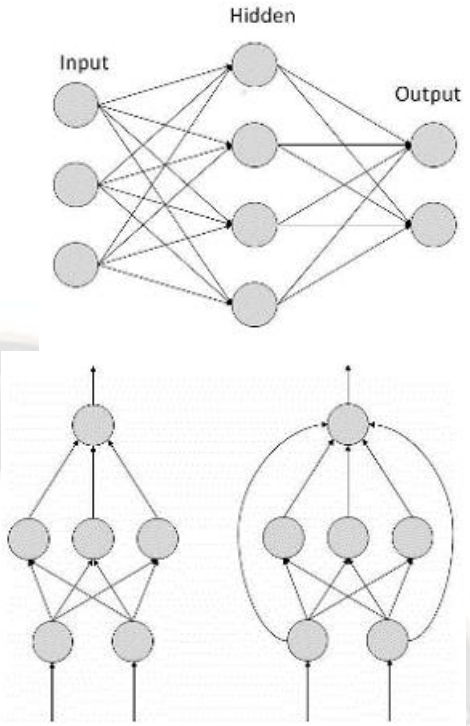

Figure 4.1 ANN Model for Implementation of Proposed Work

Figure 4.1 indicates the design of neural network model for the proposed system the network has been designed using feed forward architecture with custom layers. The network has been implemented to assess the accuracy of the proposed system.

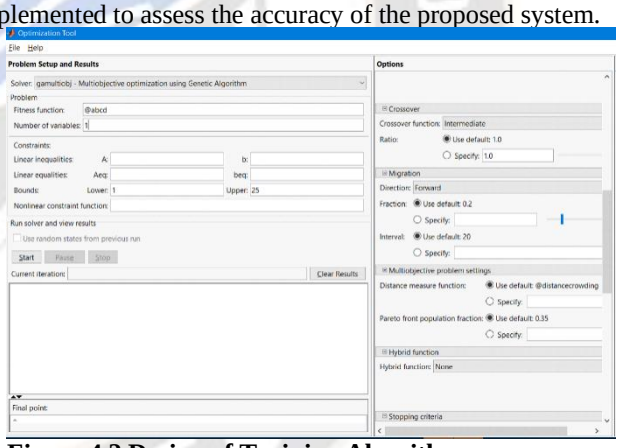

Figure 4.2 Design of Training Algorithm

Figure 4.2 indicates the design of neural network architecture and learning model for the proposed system the network has been designed using gradient descent learning along with momentum. The network has been trained with training, testing and validation to assess the accuracy of the proposed system. Figure 5.3indicates the design of layers of neural network model for the proposed system the network has been designed using feed forward architecture with custom layers. There are seven features which are considered as input layer for the proposed system. Similarly there is one hidden layer and one output layer which has been used to assess the forecasted value. The network has feed forward architecture.

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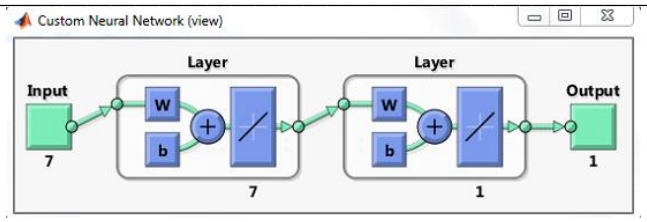

Figure 5.3 Layers of Neural Network

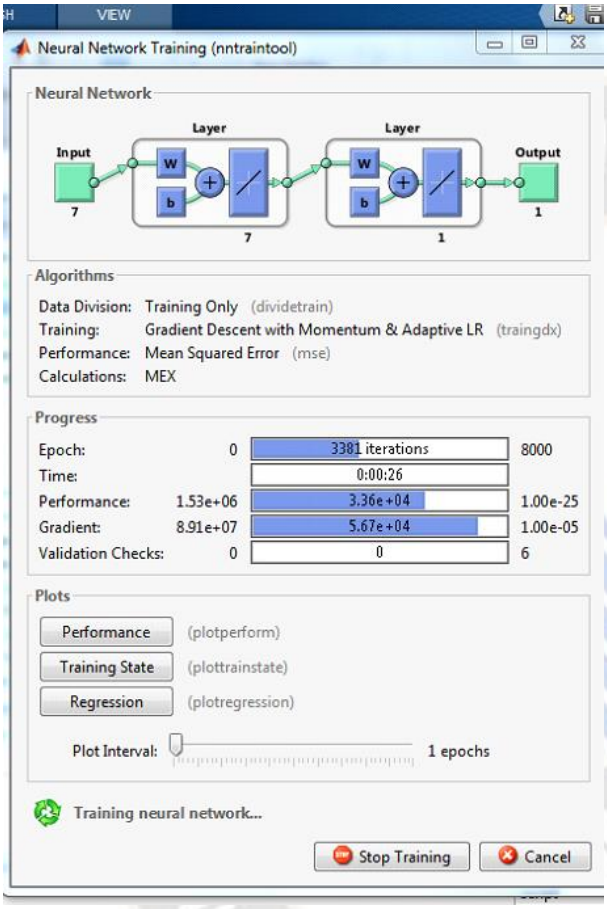

Figure 4.4 Design of Training Phase of Neural Network

The data was downloaded in csv format from yahoo finance and kaggle, and it includes stock performance data for the previous five years. The purpose of this statistical study was to examine if there was any correlation between numerous price indicators and the closing price of the stock. The goal of this project was to use artificial neural networks to predict the stock market (ANN). Stock market index prediction is a difficult assignment, but ANN has the potential to do so. It has been demonstrated that ANN is a realistic, universal approach for pattern recognition, categorization, grouping, and, in particular, for very accurate time series prediction.

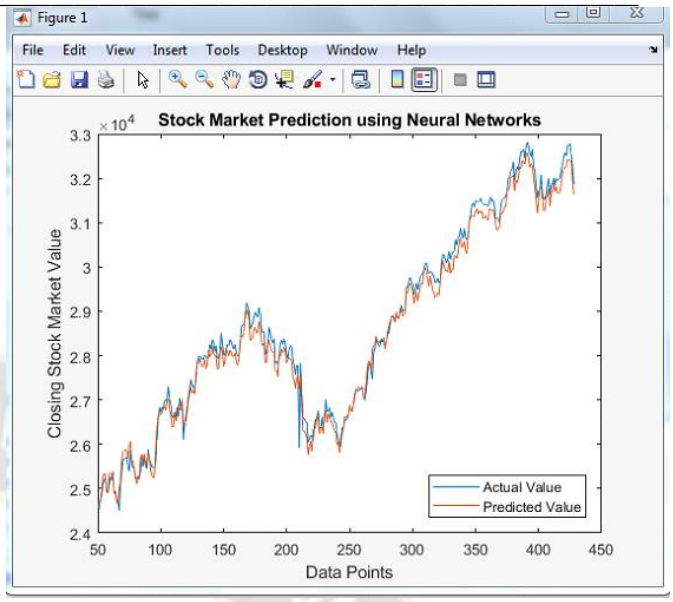

Figure 4.5 Correlation of Actual Value and Predicted Value

Figure 4.4 indicates the phase of training of neural network architecture it is evident that the network has been designed using rigorous training testing and validation of proposed system. The network has shown better performance the further accuracy analysis has been done on the parameters of matching of forecasted data and historical data of the stock closing price over the data point.

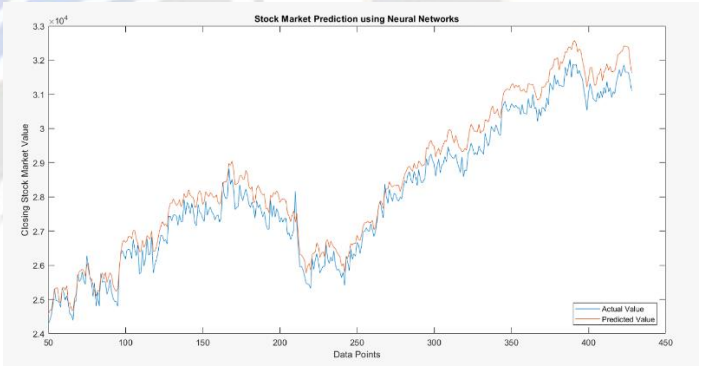

Figure 4.6 Correlation between Actual and Predicted Value Phase-1

In this thesis, we tried to find the best structural design for an ANN that could accurately predict the daily closing prices movement in the NSE Nifty 50 Index of India. It is clear from the trials that if we offer appropriate data to train the neural network, it can correctly forecast market prices. ANN models were tested in MATLAB with multiple divisions of training patterns and different ANN parameter combinations. The data set consisted of 1538 98 trade days and was collected on a daily basis from January 2010 to March 2016. A total of 972 experimentation models were created, with 494 of them being tested. The performance is measured using the Root Mean Square Error. The three-layered feed forward neural network model trained using the back propagation approach has a prediction accuracy of 89.46 percent. As a result, it is concluded that the ANN is a useful tool for stock market forecasting..

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V. CONCLUSIONS

The performance of stock market plays a leading role for the organizational growth and this progress directly affects the country's financial system in a large extent. This study attempted to predict the stock market using artificial neural networks (ANN). Prediction of stock market index is very tough task but ANN has ability to predict stock index. It has been showed that ANN is a practical, universal approach for pattern recognition, categorization, clustering and particularly for time series prediction with a great extent of exactness. In this thesis we made an effort to achieve an optimum structural design for ANN to predict the daily closing prices movement in NSE Nifty 50 Index of India with high degree of accuracy. It is obvious from the experiments that the stock prices can be correctly predicted by neural network if we provide appropriate data to train the network. ANN models have been experimented using various partitions of training patterns and different ANN parameters combinations using MATLAB. The daily data from January, 2010 to March, 2016 have been used as the data set that included a total number of 1538 98 trading days. A total number of 972 experimentations models were developed and 494 models were tested. Root Mean Square Error is used to evaluate the performance. The three layered feedforward neural network model trained by backpropagation algorithm shows the prediction accuracy of 89.46% when rearmost 20% cases of data set deployed as test data with learning function "trainoss" of MATLAB. Therefore, it is observed that the ANN is an effective tool for the prediction of stock market. So it can be successfully applied to the forecasting of Nifty 50 daily closing price, as a result of which both investors as well as regulators can get attractive benefits

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