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Improvement of Stock Price Prediction by Synthesizing Recurrent ANN Back Track Solver

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Abstract--- *Stock market is always multi-dimensional in nature. Artificial neural network techniques are used to form the prediction of different training set of variables. In our previous paper knowledge set is applied for selecting the resultant training set. ANN Back propagation method is one of the best techniques used for analysing the historical data set. We used back propagation as the prediction analyser, which is best for reducing noisy in the data set. In this paper, we propose a Back propagation based multi-layer neural networks with back track solver (BTS) to expedite the training set. This paper focuses on BTS united with the Back propagation multi-layered neural networks for stock prediction method to show how the interaction of training set will improve the forecasting of stock market closing price.*

Keywords--- *ANN (Artificial Neural Networks), Back Propagation, Multi-layer, Back Track Solver, Stock Market.*

I. INTRODUCTION

1.1 Stock market

Stock market data set is formed as surfs by computers using previous historical data. Stock market data system inherits variation with time. Stock price prediction was one of the tough challenges for researchers to solve. ANN has lots of algorithms, which are best to detect the stock market. The predicted value may be up or down according to the actual predictability result. Stock market has all the information about the price movement in response to events. It is difficult to predict the price movements of stock. Recent advances in computing trends in ANN, power and multi-layer technology facilitate more precise models of events in stock prediction. Many historical data source inputs are analysed to get the prediction set. Stock market prediction set is formed by using previous history of stock market. Grouping of proper and necessary data is one of the most important steps of forming predictive model. Stock market allows one to buy or sell the ownership of the company. If the stock of the company goes up then one who invest in the stock also get profited. If the stock of the company goes down then the investors also gain loss, so everyone needs some future predictions for a given dataset. The stock market is random and unpredictable. No one share the future stock value with any one. The only way to predict the future stock is to invent the future predictive model.

1.1.1 Stock Selection

Stock selection needs prediction analysis for accessing the domain of knowledge in terms of when to buy or sell or hold the stock. Stock selection is done by using two analysis methods known as fundamental analysis and technical analysis. Fundamental analysis is analysing a stock based on the sector and individual company. It

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includes analysing the Balance Sheet and Profit and Loss statement of the company using various ratios. The ratios are EPS (earnings per share), PE (price-earnings), and P/BV (present share price/book value).

P/E Ratio = Price per Share/Annual earnings per share

P/B Ratio = Market capitalization/Tangible assets-liabilities → (1)

The above equation (1) used to find the forecasting the future direction of the price by analysing the study of historical market data, primary price and volume is knows as technical analysis. Technical analysis is used to build feature extraction.

1.1.2 Stock Exchange

Stock exchange is a market where shares and securities are bought and sold by members/brokers on behalf of their clients and also on their accounts. There are more than 20 stock exchanges in India, but the two largest stock exchanges are NSE (National Stock Exchange) with Indices name S & P Nifty and BSE (Bombay Stock Exchange) with indices name Sensex. NSE is a stock exchange located in Mumbai, Maharashtra, India. It is one of the largest stock exchanges in the world by marketing capitalization and daily turnover. NSE is mutually owned by a set of leading financial institutions, banks, insurance companies, and financial intermediaries in India, but its ownership and management operate as a separate entry. BSE is a stock exchanged located on Dalal Street, Mumbai. It is the oldest stock exchange in Asia. It is also the largest stock exchange in the world. It includes largest number of listed companies in the world. The following diagram 1 is used to describe the various terms of stock market.

1.1.3 Stock Market Terms

Open: It is the beginning stock price of a day.

High: It is the highest value reached in a day.

Low: It is the lowest value reached in a day.

Close: It is the stock price which remains after the end of the market timing or the final price of the stock when the market closes for a day.

Volume: It is the quantity of stock.

Bid: It is the buying price of the stock.

Offer: It is the selling price of the stock.

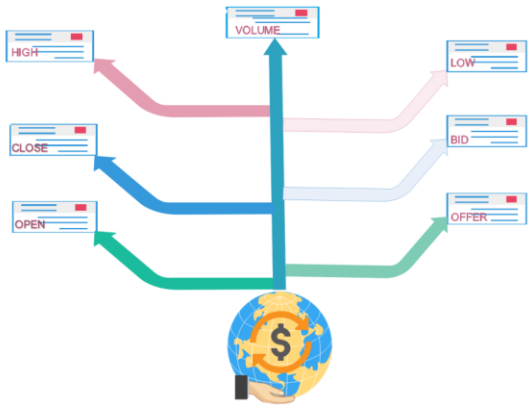

Diagram 1: Stock market terms used in forecasting

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II. ARTIFICIAL NEURAL NETWORK (ANN)

The ANN development involves 3 major concerns such as topology of the network, proper training algorithm, and an activation function. An ANN network learns by adjusting the interconnections between the layers. The nodes are connected by weights and output signals, which are thefunction of sum of the inputs to the node modified by simple nonlinear transfer or activation function. It is superposition of many simple nonlinear transfer functions that enables the multilayer perceptron to approximate extremely nonlinear functions. Due to its easily computed derivative a commonly used transfer function is sigmoid function.

An artificial neural network is an iterative process in which the values are presented to the network one at a time, and the weights associated with the input values are adjusted each time. After all values are presented the process is repeated again. During this the network trains by adjusting the weights to predict the correct label of input. Neural network has high tolerance in noisy data and it has the ability to classify the patterns. Once a network is structured for a particular application it is ready for training. The training begins by choosing the initial weights by random. By using the weights and the functions in the hidden layer the network processes the records in the training set at a time. Then the resulting outputs are compared against the desired output. The errors are propagated back to the system to adjust the weights. This process occurs repeatedly as the weights are adjusted.

ANN is a mathematical model that imitates the human brain to solve problems. Because ANN has the ability to train itself under various circumstances, various fields such as finance and marketing make use of this method. ANN is well-suited for the training data of comparative decision making. The target function is defined by predefined features. For noisy data analysis ANN is the best learning method. The ability of weight learning by the neuron for the interpretation is very important for the target function creation. ANNs are best statistical perspective neural networks used in the prediction and classification of the problem. ANNs are non-linear data driven self-adaptive approach. ANNs replicates the learning process of the human brain and can process problems relating non-linear and complex data even if the data are indefinite and noisy.

ANN uses previous history from computers and learning algorithms to pick stocks. Market moves in waves and algorithms are designed to detect and predict these waves. The algorithm forecast many inputs from many different sources with each input affecting the outcome. The output of the stock is up or down along with its predictability.

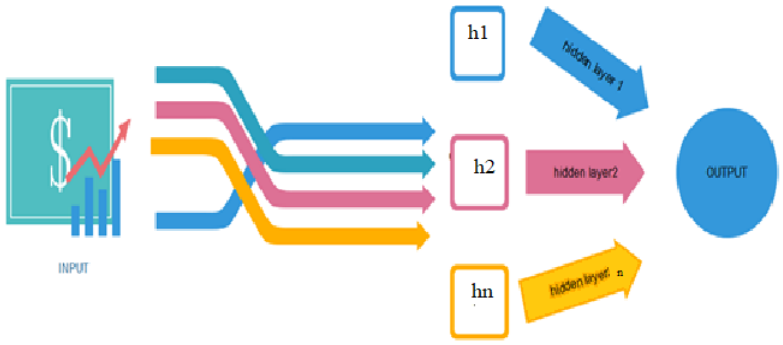

Diagram 2: Stock market prediction with ANN

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The above Diagram 2 illustrates the general multi-layer formation of the stock market prediction using the Artificial Neural Network techniques. This method needs some improvement to get some accurate result of price prediction. This causes the necessity of the recurrent network in the prediction model.

III. RECURRENT ARTIFICIAL NEURAL NETWORK

Neural networks have been good for all application where we can merge traditional methods with statistical work. Mainly this is applied in classification work like predictions, identifications and reorganization. In ANN, there are lots of time analysis network for statistical data analysis. ANN can be well known trained for their presumption capability on unknown assumptions of the problem. Recurrent Neural Network is a neural network that operates in time. At each step it accepts an input. Vector updates its hidden state via non-linear activation functions, and uses it to make a prediction of its output. Neural network is used for the customization of the hidden layers used in the neuron identification. Recurrent means the repetition of network. RANN is best for multi-layered networks.

3.1 Necessity of recurrent in ANN

This network is very useful in the case of sequence of independent data is used in the sequences. In the stock data, the historical data are in time series basis. Therefore, recurrent ANN is very much necessity to combine with the ANN technique. The recurrent network is useful in the basis of multi-layered feed forward networks. Recurrent networks are used to merge the hidden layer by storing all the previous step input with the current step. This type of merging is necessary in the combining of the current value with the past history to make prediction of the future. In diagram 3, the hidden layer block applied to the current input as well as the previous state.

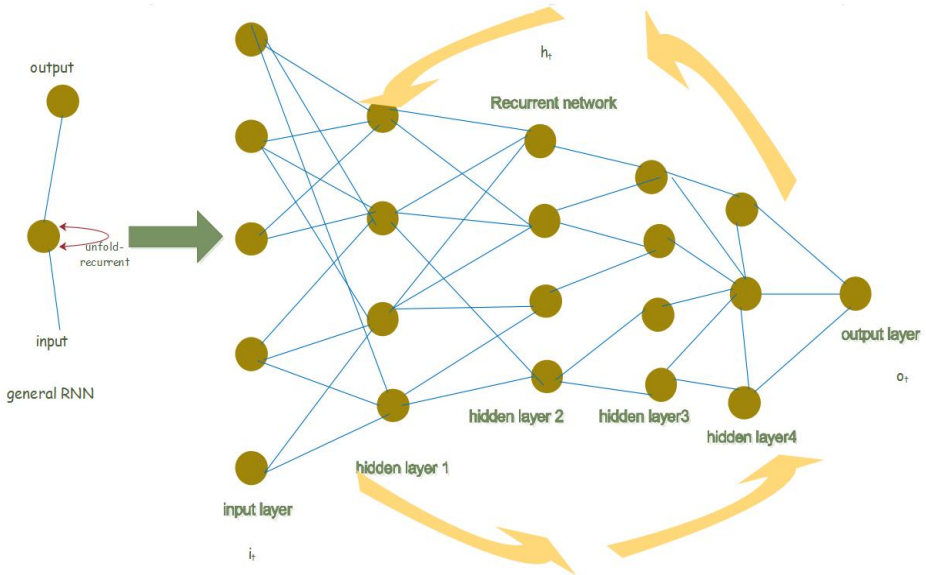

Diagram 3: Recurrent multi-layered ANN network

The above diagram 3 demonstrates the general and unfolded Recurrent Artificial Neural Network for prediction results. This RANN technology is used to perform the same task for each and every element available in the set of

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sequences depending on the previous state of computations for the outputs. RANN is used as the techniques to recollect the calculated results together to capture the outcome of the problem considered.

3.2 Formal definition of Recurrent Neural Network

First pick the closing price of the actual from the previous historical data list. With the use of a language model, one can pick the predicted closing price. Given the existing closing price we can predict the future closing price depending upon the probability of the closing price from the preceding data set. This type of model formation is known as generative model of recurrent neural network. This is expressed in the given equation (2).

For a given sequence of actual closing price inputs $(p_1, p_2, \ldots p_n)$ the probability of the predicted closing price is defined as

$$P(p_1, p_2, \ldots p_n) = \prod_{i=1}^{m} P(p_i \mid p_1, p_2, \ldots p_{i-1}) \rightarrow (2)$$

In the above equation $P(p_1, p_2, \ldots p_n)$ is the predicted closing price to be calculated from the RANN back track solver techniques. p_i is the final predicted value among the set of all previous actual closing price.

Training sets are formed like same as normal ANN. The back propagation is used for parameter sharing to the steps in the multi-layered networks. This is used in stock market prediction because RANN based result to the given values are depend on the elements in the sequences of the future. To predict the future cost in the sequence of date one has to look the previous historical data in multidirectional way. The output is then computed based on the hidden state of the RANN.

For a given input layer ' x_t 'the following equation (2) to (4) is used to get the recurrent network for the multi layers of artificial neural network.

The general formulas of hidden layer h_t at recurrent network

$$h_t = f_W (h_{t-1}, x_t) \rightarrow (3)$$

where h_t is the new state.

f_W is some function with parameters W.

h_{t-1} is the old state.

x_t is the input vector at some time step.

The hidden layer h_t values at time 't' to the recurrent network is obtained by considering 'tan h' at equation 1.

$$h_t = \tan h (W_{hh} h_{t-1} + W_{xh} x_t) \rightarrow (4)$$

The final output layer equation at recurrent network '' is

$$y_t = W_{hy} h_t \rightarrow (5)$$

Synthesizing back propagation with recurrent neural network means connecting the neurons in the same layer are not connected to each other, but the neurons in each layer were fully connected to all neurons in the next layer. The neuron weights were adjusted using the activation function called sigmoid function.

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For the given inputs $a_1(p)$, $a_2(p) \ldots a_n(p)$ and $d_1(p)$,..$d_2(p) \ldots d_n(p)$ are the estimated output. Then the sigmoid back propagation recurrent neural network equation is

$$d_j(p) = \frac{1}{1 + e^{-a_j(p)}} \rightarrow (6)$$

By inserting the weights w_{ij} between the input layers with that of the hidden layers and output layer with threshold θ_j. The output from the output layer is calculated as

$$d_j(p) = \text{sigmoid}\left[\sum_{i=1}^{n} a_i(p) \times w_{ij}(p) - \theta_j\right] \rightarrow (7)$$

The error from the output layer $\delta_k(p)$ is defined as

$$\delta_k(p) = d_j(p) \times [1 - d_j(p)] \times d_{j,k}(p) - d_k(p) \rightarrow (8)$$

The error from the hidden layer $\delta_k(p)$ is defined as

$$\delta_k(p) = d_j(p) \times [1 - d_j(p)] \times \left[\sum_{i=1}^{n} \delta_k(p) \times w_{ij}(p)\right] \rightarrow (9)$$

The weights of gain $w_{ij}(p)$ is defined as

$$w_{ij}(p) = \alpha \times a_i(p) + \delta_j(p) \rightarrow (10)$$

Finally, the back track solver rule is a network rule that applies to all the neurons and specifies how the outputs from the cells are combined into an overall net input to neuron 'n'. The term $BT_{NET}(i)$ (11) used to represents this combination. The most common back tracking rule is the weighted sum is adding the products of the inputs and their corresponding weights forms the sum. In this the term 'j' takes on the appropriate indices corresponding to the numbers of the neurons that send the information to the neurons a_i the term b_i is bias associated with the neurons.

The recurrent back propagation is calculated as

$$BTS_{BP_{NET}}(i) = b_i + \sum w_{ij}(p) \times a_{ij}(p) \rightarrow (11)$$

Now, applying back tracker rule to find out the percentage of error difference between the actual and estimated values. It is able to perform the task properly by propagating the error each time reaching to the minimum error difference between the actual and the estimated values. It is formed by calculating mean square error (12).

$$MSE = \frac{1}{N}\sum_{i=1}^{N}(p_i - a_i)^2 \rightarrow (12)$$

Where N is the number of data points, p_i is the value returned by prediction and a_i is the actual value.

IV. RANNBACK TRACK SOLVER

This solver is used a simple function to solve the problem by using the backtrack technique if any necessity of the change in the previous values.

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Neural networks' back propagation algorithm is typically optimised using gradient descent method. Stock market predictions need some reinforcement learning technique tasks to solve them.

ANN techniques are best for event driven stock market prediction. The events are extracted from the dense of stock information news, which are trained using novel artificial neural networks. ANN is also used to model the events on the basis of stock market price movements.

In RANN back track solver one has to learn the historical data to form the training set. Neural network models are mostly used to develop a model in mathematical optimization. It is one of the parts of the applied mathematics which is useful in the stock prediction industry to improve the economics. Optimization means selecting the best from the collections.

Algorithmic steps for the RANN back track propagation are obtained from considering the following steps like,

1. Forming the objective function f(x): The maximized or minimized output of the function which we call it as the objective function.
2. Collecting the variables: These are the collection of the input and output controlling variables. These are one or many depending on the use cases.
3. Forming the constraints: These provide the limits how large or small the variables can get.
4. Start with randomly chosen weights and compute MSE (mean square error).
5. If MSE is not in satisfied range then repeat the above steps for the input range $a_1(p)$, $a_2(p) \ldots a_n(p)$.

The prediction model is formed by uniting the Back-Track solver within the RANN. The flow structure of RANN algorithm is illustrated in the diagram 4. This diagram graphically shows all the 5 steps of RANN.

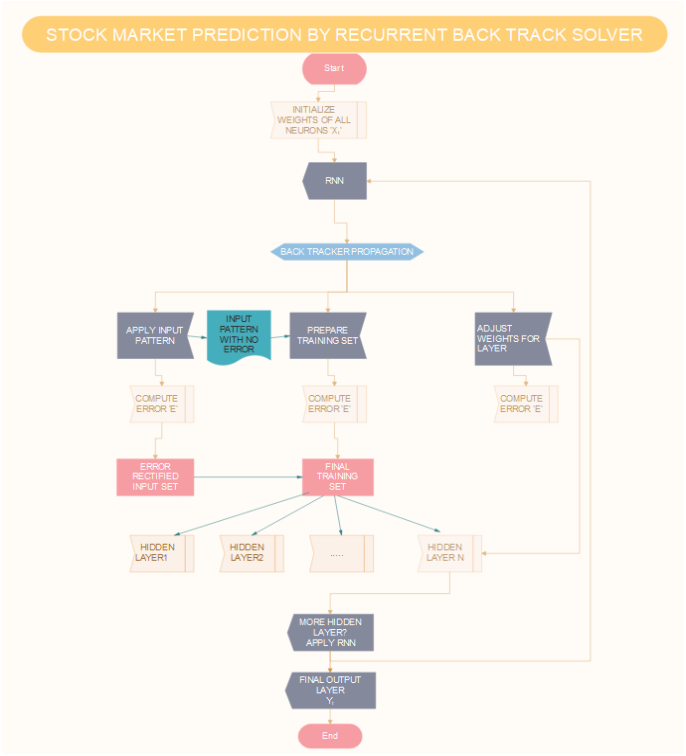

Diagram 4: Stock market prediction flow approach by RANN Back Track Solver

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A study of past performance is necessary to establish a general behaviour of the system forecasting. Careful data screening is necessary for the future assessment of forecasting. An accurate forecast depends on the judgement of the forecaster and it is impossible to rely strictly on the analytical methods to obtain an accurate forecast. Forecasting model is developed using a multilayer neural network with an appropriate back propagation-learning algorithm. The model is created to produce forecasting in a day back propagation-learning algorithm.

This network works on the principle of saving the output of the layer and feeding this back to the input to help in preceding the outcome of the layer. Here the first layer is formed similar to Feed Forward Network with the product of sum of the weights and the features. The Recurrent Neural Network process starts once this is computed and it step into the next one. Then each neuron will remember some information it had in the previous time step. This makes each neuron act like a memory cell in performing computations. In this process, we need to let the Neural Network to work on the front propagation and remember what information it needs for later use. In this, if the prediction is wrong, we use the learning rate or error correction to make small changes so that it will gradually work towards making the right prediction during the back propagation. The following diagram 3 will describe the recurrent neural network.

In the recurrent network the input is a sequence of values at a given time and the hidden layers are of the output from the historical result is looped back in to the future output of next predicting activity to get final result.

V. RANNBACK TRACK SOLVER IMPLEMENTATION

The various RANN stock prediction process is:

1. Dataset collection
2. Data Scaling
3. Evaluation of RANN
4. The result analysis of RANN

5.1 Dataset Collection

We use finance.yahoo.com to examine the historical data for stock market in BSE- SENSEX. We have taken 7 years of historical data for stock price prediction. In the previous paper, we conclude multi-layer of ANN plays vital role in price prediction, but we have some prediction error. To make it more predictable there is a need for some additional technique to be hybrid with the ANN multi-layer feed forward. After finding error one has to propagate back to adjust weights by training. This is known as Recurrent Neural Networking. In this, the error in result is then communicated back to previous layers to identify how it affects the answer being wrong. Then the weights are re-adjusted for the improvement.

5.2 Data Scaling

In the case of stock prediction, the objective function is to form the function so that the closing price of the stock market predicted is nearer to the actual closing price value. This can be done by choosing the variables like,

- Date
- Open price

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- Low price
- High price
- Closing price
- Volume

All these variables are chosen in certain limit from the total time of training time taken. The possibility of the stock price prediction scenario was limited and unlimited data variables, which has one variable and many variables depending on the conditions taken. These variables could be limited values which are considered to be discrete and unlimited values, which are considered as continuous taking on any values. The stock market problem is dynamic in nature. Dynamic means continuous when changes made all times and taking on any values. The dynamic values taking values like deterministic or noisy randomness to the data resultant set.

It is the beginning stage of the prediction model preparation. This neural network method can be start from anywhere by random initialisation. Model of analogies are developed by taking the random instances. This method of neural networks is used to initialize the random dataset in feed-forward linear layers. This propagation of feed forward is a natural step to verify the performance of the prediction method.

This method of implementation is started from the input, which is collected from the historical data of the Google finance. Then this neural network layer used for calculates the actual output of the model in straightforward way. The feed forward method of propagation is hybrid with the prediction method to calculate the flow of the direction from the input towards the output.

Back track solver is introduced in the target function to reach the goal of generating outputs as close as possible to reach the desired outputs to be learned in the network. The problem is generalised as by considering the target function. The performance of the neural network is to reach the actual outputs as close as possible to the desired value generated.

5.3 Evaluation of RANN

Backtrack solver is an important tool for finding all the solution to some computational problems, which incrementally builds candidates to the solutions

In this implementation, we use backtracking solver in recurrent multi-layered back propagation technique to predict the next day stock closing price sequence. The recurrent model used in this paper able to generate the sequential time-based prediction.

The training set is prepared first. The RMBP technique is used. Back track solver is applied in it. The model designed using the RMBP is trained. After training is done, the loss is checked in the data trained. Again, loss of the validation data is done. Actual training is started by forward passing and back propagation with back track solver is used for error calculation. The weights are updated by stages to do predictions.

This paper explored the effect of five input variables date, high, low, open, and close price. Training is the process of making the system able to learn. It consists of randomly selected data that includes a variety of facts and

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details including irrelevant data. It is characterized as a hypothesis. Algorithms are used to consume the training set to infer relation between input vectors which optimizes for known output labels.

Forecasting the future events is a great, important and risky task that attracted many researchers in different fields. This type of problems contains many variables that should be studied, highlighted, and considered to build the suitable models. The world events and processes should be clearly explained and obviously stated to be processed. ANN was largely used in solving different problems in numerous fields of forecasting. ANN also proved its efficiency and strength in different number of applications such as sales prediction, shift failures, estimating prices and stock returns.

Recurrent multi-layer hidden units are repeated every time. To optimize it, the weights in the hidden layer of recurrent neural network the weights in the hidden layers are passed to the lower layer by using the Back-propagation algorithm. By doing so each outcome of each layer now maintains the weights of optimality. The errors rate is also calculated. This will help to have the single layer structure in all time steps to maintain the same weights.

5.4 The result analysis of RANN

A stock market forecasting is used for providing big probability domain. The enormous historical data sometimes provide competitiveness. The adjustment in the price provides the consistent way of profit. The various parameter process noticed by using the input as closing price and the data is collected has 4500 training set and 300 testing set. The learning rate identified as 0.01. The number of times the process is repeated. The iteration on the error is found by using MSE function.

The result is analysed as if the predicted value is greater than the desired output. After applying the feed forward method as the initial stage of the prediction one has the actual output of the randomly initialised neural network like below **Table** 1.

Table 1: The Actual/Predicted Closing Price with MSE

Actual Closing Price	Predicted Closing Price	MSE
210.52	210.38	0.14
210.52	210.08	0.44
210.52	210.08	0.44
210.52	210.24	0.28
210.52	209.5	1.02
210.52	210.83	0.31
210.52	208.22	2.3
210.52	210.64	0.12
210.52	201.1	9.42
210.52	200.6	9.92
213.66	213.72	0.06
214.96	213.73	1.23
215.96	215.21	0.75

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216.8	216.92	0.12
217.54	219.79	2.25
218.21	218.76	0.55
218.82	217.82	1
219.4	218.94	0.46
219.94	218.12	1.82
220.44	219.34	1.1
215.32	216.97	1.65
217.31	217.7	0.39
208.83	208.22	0.61
218.12	218.79	0.67
221.25	223.19	1.94
222.28	223.65	1.37
211.22	209.98	1.24
214.1	210.35	3.75
224.92	224.63	0.29
211.7	210.93	0.77
206.41	207.53	1.12
207.43	208.97	1.54
216.19	210.24	5.95
213.99	211.58	2.41
211.6	212.79	1.19
215.27	214.02	1.25
214.82	215.14	0.32
214.42	216.28	1.86
217.93	217.32	0.61
218.49	218.37	0.12
206.12	207.83	1.71
215.76	215.64	0.12
205.11	211.32	6.21
214.51	213.06	1.45
214.7	214.69	0.01
216.96	216.34	0.62
217.08	217.88	0.8
219.27	219.42	0.15
220.39	220.87	0.48
222.56	222.3	0.26

The above table shows the actual and predicted results obtained using RANN back track propagation techniques using R Studio. The table also shows about the MSE, the mean square error. From the error it is clearly displayed that there is only small difference occurred in the predicted and actual real closing price value.

Experiments are conducted to predict the stock trend of the major stock index BSE. It is shown in the below diagram 5 with result by using R tool.

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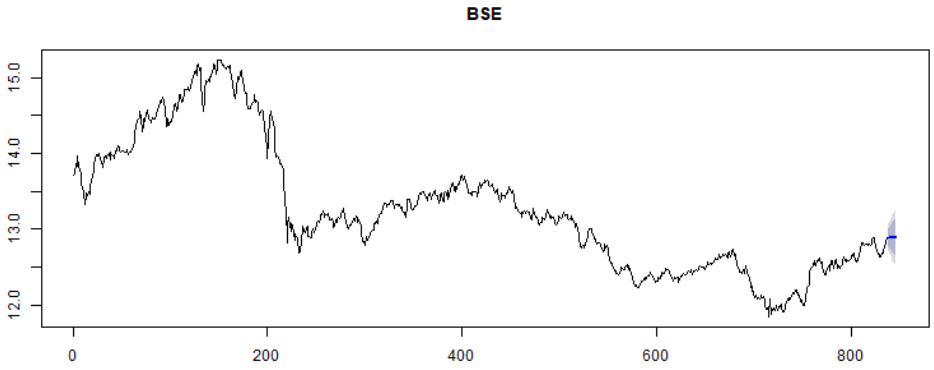

Diagram 5: Stock trend of BSE using R tool

RANN-back track solver is used in making trend prediction based on classification approach. A trading system is used to find out the annualized profit generated based on the given prediction. The result shows better performance of recurrent artificial neural network with back track solver techniques when compared to only multilayer perceptron network classifier. RANN with back track solver shows the overall better performance on average than normal MLP network. All these are described in the below set of results shown in diagram 6. This result shows the value obtained from 01/01/2018 to 25/03/2019. This result represents the predicted price with that of the interval for 3 months.The yellow lines represent the predicted price and the blue area represents the predicted interval.

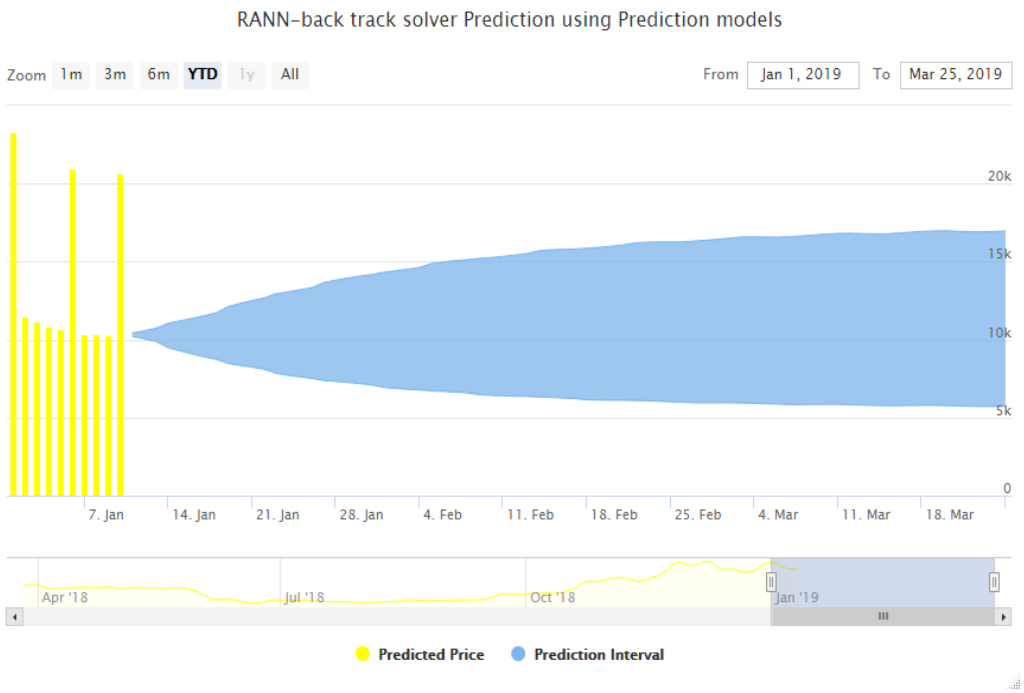

Diagram 6: RANN – back track solver prediction using prediction models with predicted price and interval from 01/01/2018 to 25/03/2019

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The performance result of RANN- back track solver for actual and predicted price is described in the diagram 7 from 01/01/2018 to 25/03/2019. The red dots represent the predicted value and the blue area represents the predicted price.

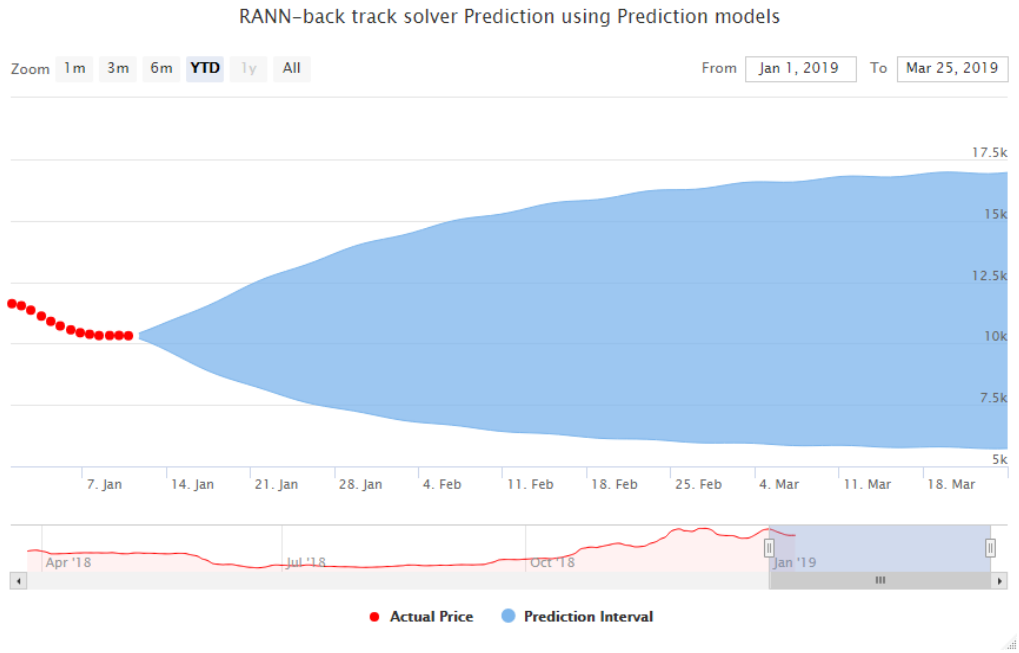

Diagram 7: RANN– back track solver prediction using prediction models with actual price and predicted price interval from 01/01/2018 to 25/03/2019

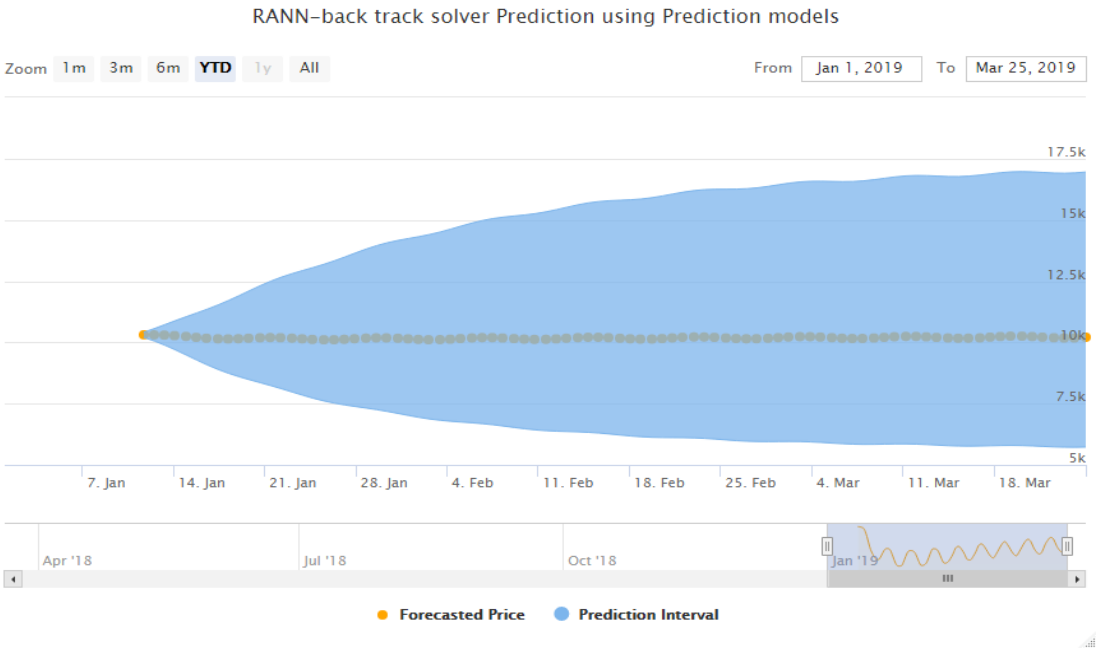

Diagram 8: RANN– back track solver prediction using prediction models with forecasted price and predicted price interval from 01/01/2018 to 25/03/2019

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The diagram 8 shows the robustness of the real actual stock price considered with that of the predicted value. This graph shows that real and predicted stock values are very in RANN-back track propagation solver while compared to MLP network model. The yellow dots represent the forecasted price value and the blue area represents the prediction interval. This resultant diagram shows that all the forecasted value is closed to that of the actual stock price.

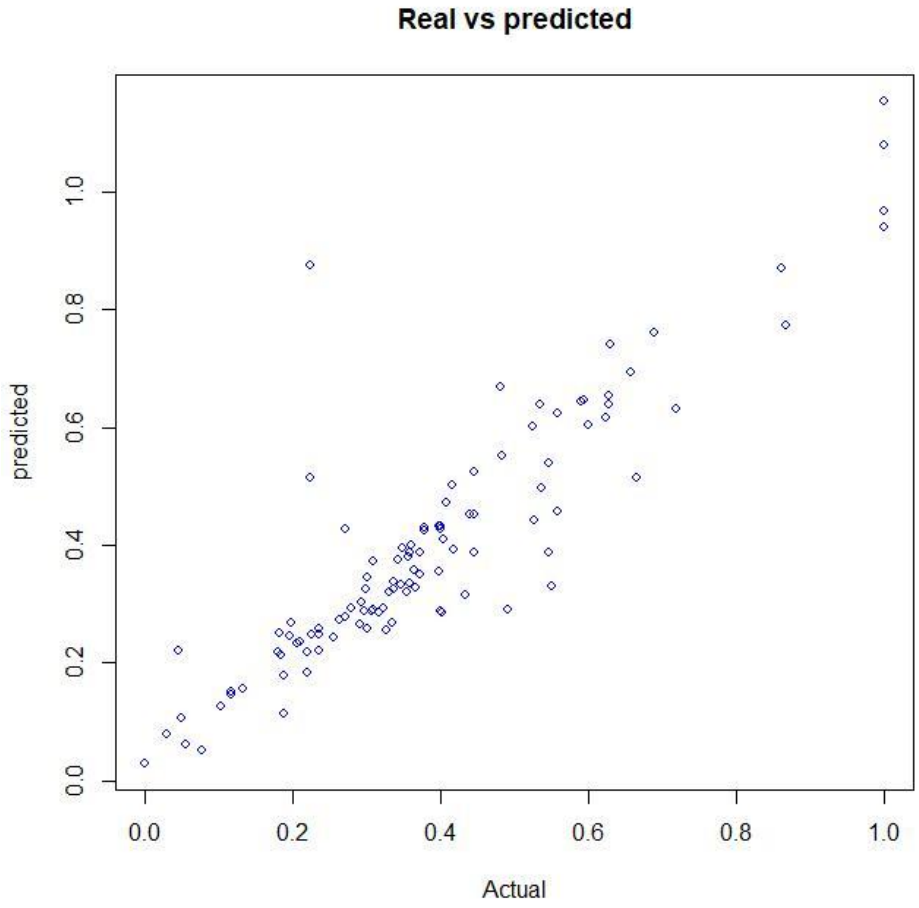

Diagram 9: Performance measurement of actual and predicted stock closing price

The above diagram 9 represents the predicted and actual stock closing price. From this diagram, we analyse that RANN back track solver predicts the closing price accurately with less MSE.

VI. CONCLUSION

In this study, we proposed a Recurrent ANN back track solver model to predict the stock market closing price. The proposed model result shows that Recurrent back propagation network model with that of synthesized back track solver was enough of producing high prediction. This is clearly noticed from the obtained results. The relationships are also shown in table 1. Adding back track solver, using the Recurrent ANN back track solver we proved that its ability in solving time series problem like stock prediction.

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In this study, multi-layered back propagation is used as a training algorithm. Back propagation modifies the connection strength between the output nodes and the inner nodes. There are several advantages to this method. It is easy to use, and it can model any type of data. In short, networks with one hidden layer are capable of approximating any continuous functional mapping, if the number of hidden units is sufficiently large.

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