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Stock Market Prediction using Artificial Neural Networks

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Abstract*— The prediction of stock market prices and conditions has always been a most researched topic amongst the data scientists, investment bankers, and stock brokers. It is a challenging task because of highly non-linear nature of the market flow. In this project, we apply an Artificial Neural Network (ANN) that can be used to map any non-linear function without a prior assumption to try and predict the nature of stock values. We researched some new input variables and implemented them in our project to improve the effectiveness of the prediction algorithm. Back propagation algorithm can be used to verify the prediction ability of the system. This study highlights the use of Artificial neural networks and other possible methods of predicting the stock prices and the improvements that have been implemented overtime. We have designed our system based on ANN after studying the results.

Index Terms*—- Non-linear, Back Propagation, Artificial neural networks, Forecasting

I. INTRODUCTION

Stock market is the place where investors can legally gamble on the values of stocks to gain some kind of benefit or sometimes can lose to the plummeting wave of the highly volatile market. It gives investors the chance to make more money if they know how to play smart in this game of stock market prediction. It has always been a popular field of study in financial data-mining. The objective of prediction research has been largely beyond the capability of traditional AI research which has mainly focused on developing intelligent systems that are supposed to emulate human intelligence. Stock market is highly volatile and is unarguably very difficult to predict accurately based on certain parameters.

People have used several methods to predict the volatility of the rapidly changing stock market such as Moving average convergence-divergence, Point data diagram, even coin tossing and fortune telling to get the desired results. But these are all very non-legitimate and unreliable methods to bet your money on. Some modern prediction techniques like Support Vector Machines (SVM) [8], Hidden Markov Model (HMM) [11], Natural Language Processing (NLP) [9] are in use for currently used financial prediction systems.

Artificial Neural Networks (ANN) are one of the most widely used technique for stock prediction. We have tried to consider some crucial input variables which have been neglected by much of the systems out there. By using the back propagation algorithm, it is possible to train the network by error correction and adjusting the weights based on these corrections. Neural Networks has the ability for arbitrary non-linear function approximation and information processing which other methods do not have. Artificial Neural Networks are well applied to the problems in which reproducing the relationships among data is really difficult provided that on the other hand there exists a large enough training data sets.

II. ECONOMIC PERSPECTIVE

From the economical perspective, the stock brokers, broking firms, and the traders view the stock market as a highly volatile market [6]. Analysing everything and figuring out the time to buy/sell the shares and commodities is a critical task. Broker's decisions can be to gain some commission on the stock or can be wrong. Because of the high number of traders, mathematical models have risen and have been helping their decision making are called technical indicators and they are used to generate decisions, trends, volatility bands, risk changes. The models are generated from the following prices of the stock market goods. Some important parameters:

- Trading price: - The price at which a stock is currently being bought or sold.
- Day's high: - Highest price the stock reached on that day.
- Day's Low: - Lowest price the stock on that day.
- Prev. Closure: - Price of the stock at the end of the trading day.
- % change: - Percent change with respect to previous closure.
- 52 Week High: - Highest trading price in past one year.
- 52 Week Low: - Lowest trading price in past one year.

III. LITERATURE SURVEY

Some of the remarkable works in this field helped us to gain better insight on the problems that might be addressed methodically. Ni, Ni and Gao (2011) [12] used a mixed method to predict prices of stock, which was composed of fractal method and support vector machine (SVM) method.

The study unveiled that fractal method was exceptional for solving the problem of non-linearity of the model, and improving the prediction accuracy. Ling [13] (2013) used the fractal theory to study Taiwan's stock price trend of traditional industry and technology industry. Calculating some related parameters in fractal analysis, he compared the accuracy of prediction of the random stock price in the two industries. In this case, Yang and Chen [14] (2014) considered that the artificial intelligent technology represented by BP neural network generally became the mainstream of the stock price prediction. B. Chauhan, U. Bidave, A. Gangathade, and S. Kale have dealt with the working of Back Propagation algorithm to train an ANN by outlining its control-flow intricacies with the help of a mathematical model [16]. Akinwale adio T, Arogundade O.T and Adekoya Adebayo F in [17] examined the use of error back propagation and regression analysis to predict the untranslated and translated Nigeria Stock Market Price (NSMP). Schierholt and Dagli in [18] focused mainly on maximising the performance of portfolios rather than maximising the percentage of correct decisions. The dataset used was 400 patterns of Standard and Poor's (SNP) 500 index. Only the Closing values were considered. One of three outputs namely buy, sell or keep the current status was given. The two models used were MLP with back propagation and probabilistic NN. MLP worked in static environment with separate training and testing phases whereas probabilistic NN performed better in all the cases.

IV. Motivation

The motivation of creating our system was to learn to use the approach of Neural Network Analysis for predicting the next day's price of a particular stock, based on back propagation algorithm. There is tremendous scope for improvement in this sector. Nowadays, people want exact analysis which will help them to take accurate investment decisions. A human financial analyst can make errors and his predictions can involve an emotional based approach. With our system, it is possible to predict the future stock prices by studying and analysing these variation patterns on historical data of stocks.

V. Basic Theory of ANN

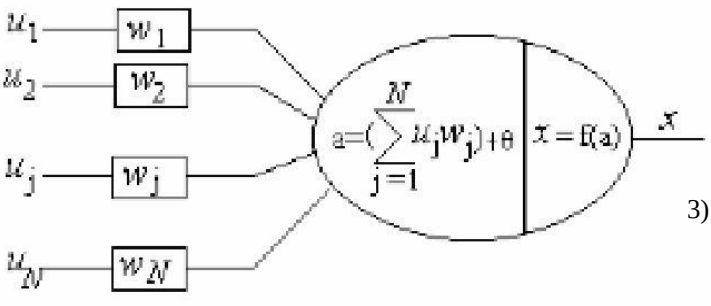


Fig. 1. Artificial Neuron Structure

[7] The artificial neuron given in this figure has N input, denoted as u1, u2, ...uj,...uN. A weight is assigned to every line connecting these inputs to the neurons, which are denoted as w1, w2,..wj,..., wN respectively. Weights in the artificial neuron model resemble to the synaptic connections in biological neurons. The threshold in artificial neuron is usually denoted by and the activation corresponding to the graded potential is given by the formula:

$$a = \sum_{j=1}^{N} w_j u_j + \theta$$

The inputs and the weights are real values. A negative value for a weight indicates an inhibitory connection while a positive value indicates an excitatory one. Although in biological neurons, has a negative value, it may be assigned a positive value in artificial neuron models. Sometimes, the threshold is combined for simplicity into the summation part by assuming an imaginary input u0 = +1 and a connection weight w0 = θ. Hence the activation formula becomes:

$$a = \sum_{j=0}^{N} w_j u_j$$

The output value of the neuron is a function of its activation in an analogy to the firing frequency of the biological neurons:

$$x = f(a)$$

VI. Techniques Used

1) Hidden Markov Model:

A HMM is a statistical Markov model in which the system being modelled is assumed to be a Markov process with unobserved (hidden) states. A HMM can be presented as the simplest dynamic Bayesian network [11].

2) *Natural Language Processing:*

NLP is a field of computer science, artificial intelligence, and computational linguistics concerned with the interactions between computers and human (natural) languages. As such, NLP is related to the area of human computer interaction [9].

3) *Support Vector Machine:*

A Support Vector Machine (SVM) is a discriminative classifier formally defined by a separating hyperplane. In other words, given labelled training data (supervised learning), the algorithm outputs an optimal hyperplane which categorizes new examples [8].

4) *Artificial Neural Networks (ANN):* Artificial Neural Networks is a complex network. It is a system widely interconnected by a large number of simple processing units which is analogous to a neuron. It is an artificial construction of network which is capable of achieving some kind of function based on humans understanding of their brains neural networks [7]. It is a sort of a theoretical mathematical model of human biological neural networks and a kind of information processing system created by implementation and imitation of the biological neural networks structure. It is designed to do a lot of complex logic operations such as finding out patterns in nonlinear relationship by the help of numerous interconnected processing units.

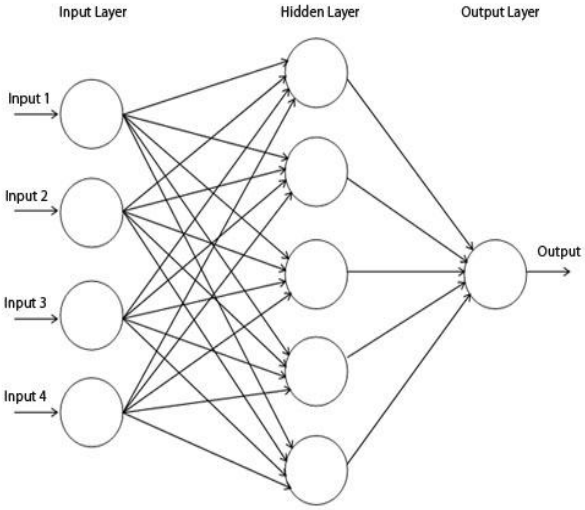


Fig. 2. Artificial Neural Network

5) *Back Propagation Algorithm*:

Back Propagation Neural Network, which can alternatively be called Multilayer Feed-forward Neural Network, is composed of one input layer, one or more hidden layer and one output layer [10]. It can be used to simulate nonlinear mapping model, solve some real world problems, such as classification, valuation, prediction, and so on. Three-layer Feed-forward Neural Network is a single hidden layer network generally used in the complex problem solving. The backpropagation algorithm falls into the general category of

gradient descent algorithms, which intend to find the minima/maxima of a function by iteratively moving in the direction of the negative of the slope of the function to be minimized/maximized. The main goal is to minimize the error function. The mean error function to be minimized (error density) can be given by:

$$\epsilon_{av} = \frac{1}{N}\sum_{n=1}^{N}\epsilon(n)$$

The final rule for updating weights is:

$$\triangle W_{ji}(n) = \eta\delta_j(n)y_i(n)$$

Where,

$$\delta_j(n) = -\frac{d\epsilon(n)}{dv_j(n)}$$

Batch learning scheme for weight updating can be used in which all the training samples are fed into the network and the change in all weights is computed from each input sample. Then at the end the weights are updated according to the sum of all updates. One iteration of inputting all the training samples is called one epoch.

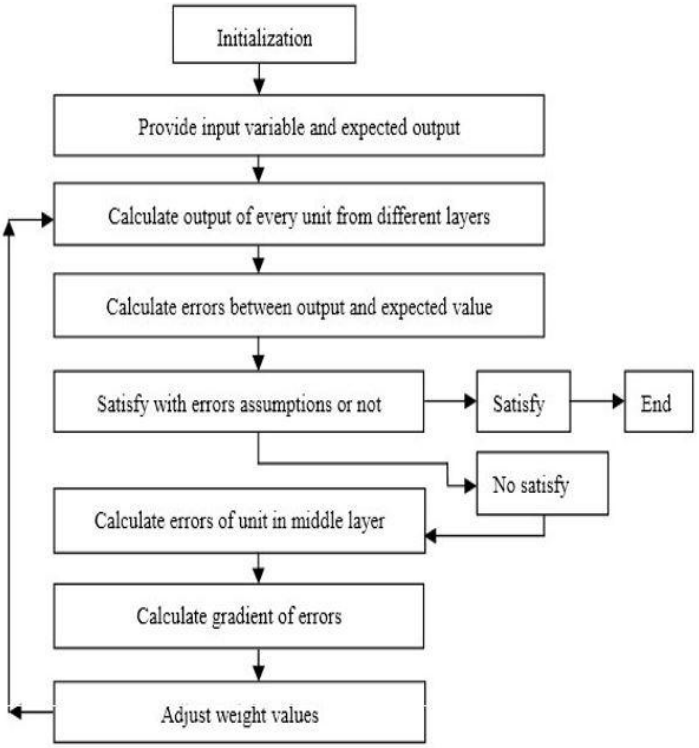


Fig. 3. Back Propagation workflow diagram

For practical reasons, ANNs implementing the backpropagation algorithm do not have too many layers, since the time for training the networks grows exponentially. Also, there are refinements to the backpropagation algorithm which allow a faster learning [15].

VII. Evaluation Components and Properties

1) *Activation Function:* The user also has an option of three activation functions for the neurons:

- Unipolar sigmoid:

$$f(x) = \frac{1}{1+e^{-\lambda x}}$$

- Bipolar sigmoid:

$$f(x) = \frac{2}{1+e^{-\lambda x}} - 1$$

- Tan Hyperbolic:

$$f(x) = \frac{e^{\lambda x} - e^{-\lambda x}}{e^{\lambda x} + e^{-\lambda x}}$$

- Radial basis function

$$f(x) = \frac{1}{\sqrt{2\pi\sigma}} e^{-(x-\mu)^2/2\sigma^2}$$

2) *Hidden Layers and Nodes:* The artificial neural network trained for the prediction of image and stock data has an arbitrary number of hidden layers, and arbitrary number of hidden nodes in each layer, both of which the user decides during run-time.

3) Data Normalization: The data is normalized before being input to the ANN. The input vectors of the training data are normalized such that all the features are zero-mean and unit variance. The target values are normalized such that if the activation function is Unipolar sigmoid, they are normalized to a value between 0 and 1 (since these are the minimum and maximum values of the activation function, and hence the output of the ANN), and if the activation function is Bipolar sigmoid or Tan hyperbolic, they are normalized to a value between -1 and 1 and 0 and $1/\sqrt{2\pi\sigma}$ when the activation function is RBF. The test data vector is again scaled by the same factors with which the training data was normalized. The output value from the ANN for this test vector is also scaled back with the same factor as the target values for the training data.

4) *Error calculation:* The error for convergence is calculated as the RMS error between the target values and the actual outputs. The calculated error value can be used to update the weights for minimizing error in future.

5) *Cross-validation set:* - The cross validation set is independent of the training set and helps in a more general measure of the error and gives better results.

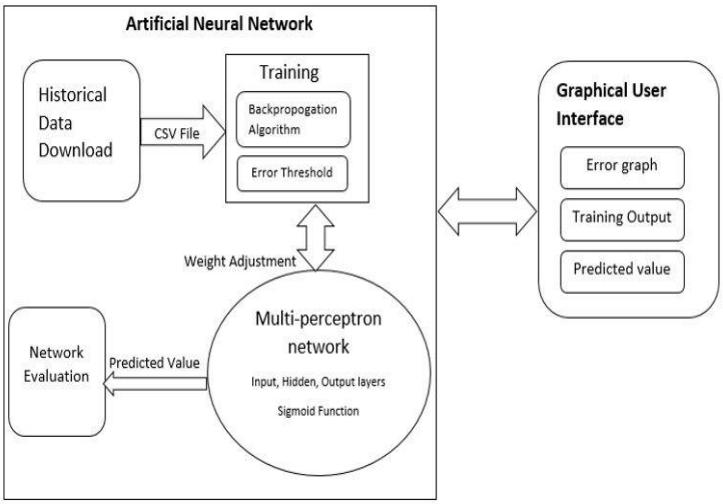


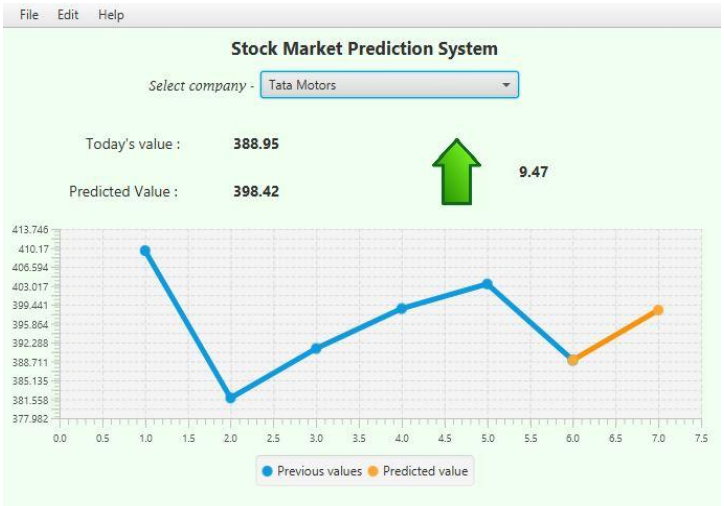
Fig. 4. Architecture diagram

VII. FUTURE SCOPE

Stock Market Prediction is one of the most researched topics in financial sectors. Potential investors are always in a need of better stocks for investing their money for future gains. It also plays a vital role in Investment Banking institutions as they create CDOs for potential investors. Artificial Neural Networks have a dynamic approach and can be easily modified to work on different platforms. It has been realized that these systems are multidimensional enough to work in different environments given different parameters to train the network. With the upcoming of new softwares, prediction is going to be more accurate day by day. Computers have abilities that a normal analyst cannot possess and use of such people oriented technologies can be used towards the betterment of people.

VIII. RESULTS AND OUTPUTS

This is the output window of our system.



IX. Conclusion

By studying different stock predicting technologies, we came to the conclusion that Artificial Neural Networks are best suited for predicting nearest stock prices. With the help of ANN with Back-Propagation algorithm we have made possible to approximately predict the future values of stocks based upon their past values and variations. And this is just a stepping stone in future prediction technologies. Thus we can see that Neural Networks are an effective tool for stock market prediction and can be used on real world datasets.

Appendix

Appendixes, if needed, appear before the acknowledgment.

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