Forecasting Stock Market predictions using Artificial Neural Network Models: A Survey

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ABSTRACT

This paper surveys recent literature in the area of Artificial Neural Networking which is used to predict the stock market price fluctuations and return. Stock market price prediction is one of the most recent phenomenon in the field of finance. Many models have been developed and studies have been made by numerous researchers. Artificial Neural network (ANN) is a technique that is widely used and perused in stock market prediction [38, 62]. This study also seeks to explain the various models and applications of Artificial Neural Networks that predict the stock market returns and price.

Keywords: Artificial Neural Network, Stock market predictions, Genetic Algorithm, ARIMA, GARCH

1. INTRODUCTION

In recent years, stock markets have become more volatile. The prediction of stock price movement is a difficult task for any financial analyst. The fundamental analysis works best for longer period of time, whereas technical analysis is more appropriate for a shorter period. Many researchers claim that the stock market is a chaotic system, and a non-linear deterministic system which only appears random because of its asymmetrical fluctuations. The researchers and academic practitioners have also projected many models using various fundamental, technical and analytical aspects to give a more or less exact prediction on financial information particularly stock market behaviour. Fundamental analysis involves the in-detail analysis of the changes of the stock prices in terms of macroeconomic variables, whereas technical analysis
centers on using price, volume, and statistical charts to predict future stock movements [56]. Some traditional time series forecasting tools are also used for the prediction of stock market. The two approaches of time series analysis and forecasting are linear approach [7], and the nonlinear approach. The linear methods includes moving average, exponential smoothing, time series, regression and Autoregressive integrated moving average (ARIMA) model. The nonlinearity of the financial and stock market is propounded by many researchers and financial analysts [1, 2]. The parametric nonlinear model includes Autoregressive Conditional Heteroskedasticity (ARCH) [20], and General Autoregressive Conditional Heteroskedasticity (GARCH) [6] has been in use for financial forecasting.

Many analytical models have formulated by different researchers to study the prediction of stock price movements. The Artificial Neural Network (ANN) is the one technical tool to forecast the stock market behavior, trends and its characteristics. A stock market is a public market for trading the company’s shares at approved stock price. These are called Securities, listed on stock exchanges. The price of the scripts depends upon the demand and supply gap. Companies may issue shares to raise capital in stock market is called Primary Capital Market and shares of respective companies listed, will allow to trade in the stock market is called secondary capital market.

ANN is the powerful forecasting tool that predicts the stock markets. It is the non-linear model used to map past and future value of time series data [13, 22, 37, 91]. Lapedes and Farber [51] was studied the nonlinear time series model with artificial neural networks. The originality of the ANN lies in their ability to determine nonlinear relationship in the input data set without a prior assumption of the knowledge of relation between the input and the output [26]. Artificial neural networks are applied in the fields of Computer science, Medical, Engineering, Biology and Economic research. ANN is used for analyzing relating of economic and financial related forecasting [10, 25, 31, 40]. Neural networks are best in discovering non-linear relationships [9, 28, 78, 80, 87].

There are numerous studies discussed about the predictions of stock market. This paper, focuses on various reviews in the field of ANNs used in predicting the stock market. Various applications and models of ANN are also discussed in this paper. Avci [4]; Egeli, Ozturan, & Badur [18]; Karaatli, Gungor, Demir, & Kalayci [44]; Olson & Mossman [65]; White [89]
; Leung et al., [53] have studied the stock price return based on ANN model. They examined various prediction models based on multivariate classification techniques.

2. ARTIFICIAL NEURAL NETWORK

Artificial neural networks (ANNs) approach has been suggested as an alternative technique to time series forecasting and it gained immense popularity in last few years.

W.S.McCulloch and W.Pitts [61] established neural network and its mathematical model, known as McCulloch-Pitts (MP) model. This model is used for neuron’s formalization, mathematical description and network construction. During past 70 years, the neural network was widely used in different fields and has developed several hundred models.

The basic objective of ANNs was to construct a model for mimicking the intelligence of human brain into machine [36, 39]. Similar to the work of a human brain, ANNs try to recognize regularities and patterns in the input data, learn from experience and then provide generalized results based on their known previous knowledge.

Artificial Neural Network (ANN) is a set of interconnected links that have weights associated with them. The concept of ANN was originally arrived from biological neural networks. All the ANN can be the deliberation of as a set of interconnected units broadly categorized into input layer, the hidden layer and the output layer. Inputs are fed into the input layer, and its weighted outputs are passed onto the hidden layer. The neurons in the hidden layer (hidden neurons) are essentially concealed from view. Using additional levels of hidden neurons provides increased flexibility and more accurate processing.

In recent periods some research works has been reported on the use of ANNs for analysis of economy and financial markets. Stern[83] provide a introduction of ANNs as follows, the three essential features of ANN are basic computing elements referred to as neurons, the network architecture describing the connections between the neurons and the training algorithm used to find values of the network parameters for performing a particular task. Each neuron performs a simple calculation, a scalar function of a scalar input. Assuming that we make the neurons with positive figures and designate the input to the \( k \)th neuron as \( i_k \) and the output from the \( k \)th neuron as \( o_k \) then \( o_k = f_k(i_k) \) where \( f(.) \) is a definite function that is characteristically done but otherwise subjective. The neurons are connected to each other in the sense that the output from one component can serve as part of the input to another. The weight is associated with each construction; the weight from component \( j \) to component \( k \) is denoted as \( w_{jk} \). Let \( N(k) \) denote the
set of components that are connected to component \( k \). The input to component \( k \) is then 
\[
i_k = \sum_{j \in N(k)} w_{jk} o_j.
\]

**Figure 1**: Single neuron with R inputs

A neuron is a processing unit that takes numerous inputs and gives a distinctive output. The Figure 1 illustrates a single neuron with \( R \) inputs \( S_1, S_2, ..., S_R \), each input is weighted with a value \( W_{11}, W_{12}, ..., W_{1R} \) and the output of the neuron is equal to \( f(W_{11} \cdot S_1 + W_{12} \cdot S_2 + \cdots + W_{1R} \cdot S_R) \).

Artificial Neural Network (ANN) in the Stock Market is depicted in Figure 2. This ANN model consists of three layers namely an input layer, a hidden layer and an output layer, every one of which is connected to the other. At least one neuron should be engaged in each layer of the ANN model. Inputs for the network were four different analysis (Variables/Factors) which were represented by four neurons in the input layer. Output of the system has two patterns (0 or 1) of stock price direction. The output layer of the network consisted of only one neuron that represents the direction of movement (Buy, Hold, and Sell of Shares). The number of neurons in the hidden layer was determined empirically by Feed forward Artificial Neural Network (ANN) model in order to predict Stock Market which has been illustrated in Figure 2. This model has been developed by making some suitable modifications to the existing feed forward ANN model [43].
Figure 2: Feed forward Artificial Neural Network (ANN) Model to predict Stock Market.

3. VARIOUS MODELS OF NEURAL NETWORK

Various Neural network models have been discussed in this paper referring to various existing literature in the field. The various neural network model used in time series are, Recurrent [73, 86], Probabilistic [85, 97], Radial Basis Functions [88], Cascade Correlation [21], General Regression Neural Net [12], Group Method of Data Handling [73], Modular ANNs [47], Neuro Fuzzy [90]. Here we discuss some of these neural network models.

3.1. Modular Neural Network

Kimoto, Asakawa, Yoda, and Takeoka [47] have studied buying and selling time prediction system for stocks in the Tokyo Stock Exchange based on modular neural networks. The authors used a number of learning algorithms and prediction methods for the TOPIX (Tokyo Stock Exchange Prices Indexes) prediction system. Further the authors applied modular neural network model to measure the relationships among various market factors. Ramon Lawrence [52] studied Neural Networks to Forecast Stock Market Prices. He has implemented genetic algorithms, recurrent networks, and modular networks to predict the stock market. The Modular neural network was used for predicting corporate bankruptcy [64]. He also discusses about financial, as well as, political and economic data from the London Stock Exchange, and used domain expert knowledge to select, and organise data in the modular neural network architecture constructed for this study. The Modification and acceleration of MNN (Modular Neural Network) operating principles was described by Schmidt and Bandar [77].
3.2. ARIMA and GARCH based neural network

Jung-Hua Wang and Jia-Yann Leu [41], Ahmed Ismail El-Hammady, Dr. Mohamed Abo-Rizka [19] developed a prediction system in forecasting trend in Taiwanese stock market and Egyptian stock market respectively based on a recurrent neural network trained by using features extracted from ARIMA analyses. ANNs are known to provide competitive results to the traditional time series model such as ARIMA model [13, 22, 37, 45]. The forecasting performance of ARIMA and ANN models in forecasting Korean Stock Price Index also compared by C. K. Lee, Y. Sehwan, and J. Jongdae [8].

Merh et al., [63] studied a comparison between hybrid approaches of ANN and ARIMA for Indian stock trend forecasting with many instances of the ARIMA predicted values shown to be better than those of the ANNs predicted values in relation to the actual stock value. Sterba and Hilovska [35] argued that ARIMA model and ANN model achieved superior forecast performance in many real-world applications.

Manish Kumar and M. Thenmozhi [50] studied the application and development of hybrid methodology that combines both ARIMA and Artificial Neural Network Model to predict the stock market index returns. The stock data obtained from New York Stock Exchange was studied using ARIMA and artificial neural networks [3].

Donaldson and Kamstra [16] proposes a Neural Network modification of a GARCH model. He used multilayer perception and density estimating neural network is used to forecast the returns and volatility of the German Stock Index- DAX stock index. R.Glen Donaldson and Mark Kamstra [23] constructed a semi nonparametric nonlinear GARCH model, based on the Artificial Neural Network (ANN) literature and evaluated its ability to forecast stock return volatility in London, New York, Tokyo and Toronto stock exchanges. The use of GARCH-neural network model for forecasting the volatility of bid-ask spread of the Chinese stock market [82].

Hossain, A; Nasser, M [29, 20] compare the GARCH and neural network methods in financial time series prediction and applied GARCH model instead of autoregressive (AR) model or autoregressive moving average (ARMA) model to compare with Standard Back Propagation (BP) in forecasting of the four international including two Asian stock markets indices.
**Jingtao Yao, Chew Lim Tan and Hean-Lee Poh** [93] developed a neural network compared with ARIMA model that was used to predict the stock index of Kuala Lumpur Stock Exchange, the neural network model have better returns compared with conventional ARIMA models.

### 3.3. Genetic Algorithm

In financial market field, the genetic algorithms are very frequently used to discover the best combination values of parameters in a trading rule, and they can be built into ANN models designed to select stocks. Several studies have conducted, and these methods are proved effective for forecasting the financial trends [42, 55]. **Kim and Han** [46] used neural network tailored by Genetic Algorithm; the genetic algorithm was used to reduce the density of the feature space. The other authors also used genetic algorithms in predicting of Stock prices indexes [14, 59, 84] and exchange market [79]. **Hassan et al.,** [27] projected and implemented the fusion model by combining the HMM (Hidden Markov Model) and Genetic Algorithm to forecast financial market behaviour. Wavelet transform to extract the short-term feature of stock trends was used by **Kishikawa and Tokinaga** [48].

### 3.4. Recurrent Network

The finest neural networks tool for non-linear prediction is recurrent neural network [98]. The development of RNN (Recurrent Neural Network) based on genetic learning algorithm has a statistically significant and successful predictions [58]. **A. Graves, et al.,** [24] introduced a universal framework of sequence learning algorithm, evolution of recurrent systems with Linear Outputs.

### 3.5. Branch Network

**T. Yamashita, K. Hirasawa and Jinglu Hu** [92] says that multi-branch neural networks (MBNNs) could have higher representation and generalization ability than conventional Neural Networks. **Kotaro Hirasawa and Jinglu Hu** [92] developed Multi-branch neural networks (MBNNs) for prediction of stock prices and model were carried out in order to examine the correctness of prediction.

### 3.6. Functional Link ANN

 FLANN is a single layer, single neuron architecture, which has the exceptional capability, to form complex decision regions by creating non-linear decision boundaries [12, 57].
The functional link ANN is a innovative single neuron based architecture first proposed by Pao [70]. The original architecture of functional link artificial neural network with working attitude of different models are provided to accomplish best forecasting and cataloging with increase in accurateness of prediction and decrease in training time [5]. Functional link single layer artificial neural network (FLANN) was used for long term as well as short term stock market prediction [66].

3.7. Fuzzy Neural Network

Fuzzy theory was formulated by Zadeh [94, 95, 96]; Zimmermann [99]. Huarng and Yu [33] used neural networks to extract fuzzy logical relationships from fuzzy time-series to forecast the Taiwan Stock Exchange and their model outperformed Chen’s [11] model.

Renato De C.T. and Adriano J.De O [74] presents the results of the application of Fuzzy Neural Networks to predict the evolution of stock prices of Brazilian companies traded in the São Paulo Stock Exchange. Pantazopoulos et al., [69] presented a neuro fuzzy approach for predicting the prices of IBM company stock. Siekmann et al., [81] implemented a network structure that contains the adaptable fuzzy parameters in the weights of the connections between the first and second hidden layers. Rong-Jun Li and Zhi Bin Xiong [54] developed a fuzzy neural network that is a set of adaptive networks and functionally equal to a fuzzy inference system based on the comprehensive index of Shanghai stock market, designate that the recommended fuzzy neural network could be an competent system to forecast financial information.

3.8. Back Propagation ANN

The performance of back propagation network and regression models to predict the stock market returns was compared [75].

Huang et al., [32] has made comparative study of application of Support Vector Machines (SVM) and Back propagation Neural Networks (BNN) for an analysis of corporate credit ratings. The Back Propagation algorithm designed by Rumelhart, Hinton and Williams [76] is the best appropriate method is being intensively tested in Finance domain. Furthermore, this method is renowned as a good algorithm for generality purposes.

4. APPLICATION OF VARIOUS ANN TO PREDICT INDIAN STOCK MARKET

Neural networks to estimate stock market actions will be a continuing area of researchers and shareholders try hard to outstrip the market conditions. The table discusses about the existing
studies which explored on predicting Indian Stock market. The objectives, models used, data set and major findings are depicted in Table.1.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Authors</th>
<th>Objective</th>
<th>Models Used</th>
<th>Data set</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Manish and Thenmozhi [49]</td>
<td>To forecast India’s S&amp;P CNX Nifty Index returns using Support vector machines (SVM)</td>
<td>ARIMA, Artificial neural network, Support vector machines,</td>
<td>Daily returns on the S&amp;P 500 and HSI Indices</td>
<td>SVM model achieves greater forecasting accuracy and improves prediction quality compared to other models experimented in the study.</td>
</tr>
<tr>
<td>2</td>
<td>Mayankkumar B Patel, Sunil R Yalamalle [71]</td>
<td>To study the current stock market trend and collect trend data.</td>
<td>Multi Layer perceptron (MLP), ANN</td>
<td>The data of companies listed under LIX15 index of NSE, for the duration of 36 months (1-1-2011 to 1-1-2014) have been collected.</td>
<td>The results from the model will be used for comparison with the real data to ascertain the accuracy of the model.</td>
</tr>
<tr>
<td>3</td>
<td>Manna Majumder, MD Anwar Hussian [60]</td>
<td>Predicting the S&amp;P CNX Nifty 50 Index</td>
<td>Artificial Neural Network, Feed forward network, SCP, NMSE</td>
<td>The trading days from 1st January, 2000 to 31st December, 2009</td>
<td>Accuracy of the performance of the neural network is compared using various out of sample performance measures.</td>
</tr>
<tr>
<td>5</td>
<td>Goutam Dutta, et al., [17]</td>
<td>Efficacy of ANN in modelling the Bombay Stock Exchange (BSE) SENSEX</td>
<td>ANN, root mean square error (RMSE) and mean absolute error (MAE)</td>
<td>Weekly closing SENSEX values for the two-year period beginning January 2002.</td>
<td>ANN1 achieved an RMSE of 4.82 per cent and MAE of 3.93 per cent while ANN2 achieved an RMSE of 6.87 per cent and MAE of 5.52 per cent.</td>
</tr>
<tr>
<td>7</td>
<td>Yusuf Perwej, Asif Perwej [72]</td>
<td>To predict the daily excess returns of Bombay Stock Exchange (BSE) indices over the respective Treasury bill rate returns.</td>
<td>Autoregressive feed forward Artificial Neural Networks (ANN), Artificial Neural Networks model using a Genetic Algorithm</td>
<td>Bombay Stock Exchange Market excess returns on a daily basis</td>
<td>Feasibility of the prediction task and provides evidence that the markets are not fluctuating randomly and finally, to apply the most suitable prediction model and measure their efficiency.</td>
</tr>
<tr>
<td>8</td>
<td>Jay Desai, ArtiTrivedi Nisarg A Joshi [15]</td>
<td>Computational approach for predicting the S&amp;P CNX Nifty 50 Index</td>
<td>Neural network based model</td>
<td>Trading days from 1st January, 2010 to 30th November, 2011.</td>
<td>The model generated returns of 59.84% against buy and hold return of -26.08%. The average accuracy of target forecasting is found to be 82%.</td>
</tr>
</tbody>
</table>

Table 1: ANN Models used in Indian Stock Market
5. CONCLUSION AND FUTUREWORK

The Artificial Neural Network used in domain and it is computer based simulation model that predicting more accurate stock price along with the movement and decision of buy or hold or sell shares in the stock market. This paper surveyed the application of neural networks of financial markets with particular reference to stock market prediction. This paper presents how neural networks have been used to test the forecasting share prices. In this review of literature, different applications of Artificial Neural Network models for predicting stock market has been summed up. This field of research is new and emerging and there is significant enormous future scope.

The neural network models for forecasting stock market are at a initial phase and there are potential improvements in the prediction of accuracy and reliability of stocks. The study can help analyst or investors to understand how the market would behave if the Stock price increases or decreases. The future study can also focus on using macroeconomic variables to forecast the interest rate, GDP, etc. In addition, the study should be extended to predict another kind of financial time series like interest rate, derivative (option and future) and foreign exchange prices. More authors put emphasis on the obligation for including more data in the models to predict the exact share price. The researchers also emphasize the integration of neural networks with other methods. The method of ANN is new, many possibilities for combining with other models including linear and non-linear.

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