Applications of ANNs in Stock Market Prediction: A Survey

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***Abstract*— This paper surveys recent literature in the domain of machine learning techniques and artificial intelligence used to predict stock market movements. Artificial Neural Networks (ANNs) are identified to be the dominant machine learning technique in stock market prediction area.**

Keywords— Artificial Neural Networks (ANNs); Stock Market; Prediction

I. INTRODUCTION

Prediction stock price or financial markets has been one of the biggest challenges to the AI community. Various technical, fundamental, and statistical indicators have been proposed and used with varying results. However, none of these techniques or combination of techniques has been successful enough. 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. By its nature the stock market is mostly complex (non-linear) and volatile. With the development of artificial neural networks investors are hoping that the market mysteries can be unraveled because networks have great capability in pattern recognition and machine learning problems such as classification and prediction. These days' artificial neural networks are considered as a common data mining method in different fields like economy, business, industry, and science [6].

The application of artificial neural networks in prediction problems is very promising due to some of their special characteristics.

First, artificial neural networks can find the relationship between the input and output of the system even if this relationship might be very complicated because they are general function approximations. Consequently, artificial neural networks are well applied to the problems in which extracting the relationships among data is really difficult but on the other hand there exists a large enough training data sets.

Second, artificial neural networks have generalization ability meaning that after training they can recognize the new patterns even if they haven't been in training set. Since in most of the pattern recognition problems predicting future events (unseen data) is based on previous data (training set), the application of artificial neural networks would be very beneficial.

Third, artificial neural networks have been claimed to be general function approximations. It is proved that an MLP neural network can approximate any complex continuous function that enables us to learn any complicated relationship between the input and the output of the system.

II. BRIEF HISTORY OF ARTIFICIAL NEURAL NETWORKS

"Neural" is an adjective for neuron, and "networks" denotes a graph-like structure. Artificial neural networks refer to computing systems whose central theme is borrowed from the analogy of biological neural networks. The basic structure in the human brain is called neuron. A neuron contains dendrites (small branched extensions of nerve cells that receive signals from other cells) for receiving input and axons that carry output to the other neurons. A neuron carries a potential that is collected as signals from dendrites. When the signal strength exceeds a certain threshold value, the neuron sends out an impulse (a transformation of the original input signal) which is called an action potential as stated by Blakemore and Frith (2005).

Artificial neural networks also referred to as "neural nets". The roots of all work on artificial neural networks are in neurobiological studies that date back to about a century ago.

Like the biological structure defined above, artificial neurons receive inputs and produce an output but they do not accurately model their biological counterparts.

Biological neuron stores knowledge in a memory bank, while in an artificial neuron the data or information is distributed through the network and stored in the form of weighted interconnections. The simulation of transformational behaviour of biological neurons is done by a nonlinear function. The interconnections between artificial neurons are called weights. Artificial neurons reside in layers. Fig 1 shows a graphical representation of an artificial neuron, where xi represents the inputs to the neuron and wi represents the weights of the neuron.

The overall input to the neuron is calculated by a = $\sum_{i=0}^{n} w_i x_i$. To normalize this sum into a standard range, functions called threshold functions, (sigmoid functions being the most widely preferred one) are used. A sigmoid function is defined as$f(a) = \frac{1}{1+ e^{-a}}$. The output of this function is guaranteed to be in (0, 1).

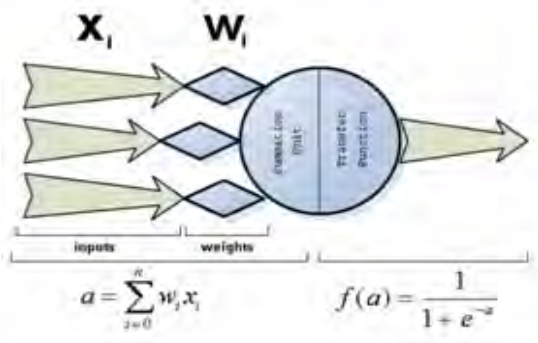

Fig. 1 Graphical representation of artificial neuron

ANNs generally have at least three layers containing the artificial neurons: input, hidden (or middle), and output. Artificial neurons are arranged in these layers. The input layer takes the inputs and passes to the middle layer. Even though it depends on the implementation, generally there occurs no data processing at the input layer. The middle (hidden) layer is where all the complexity resides and the computation is done.

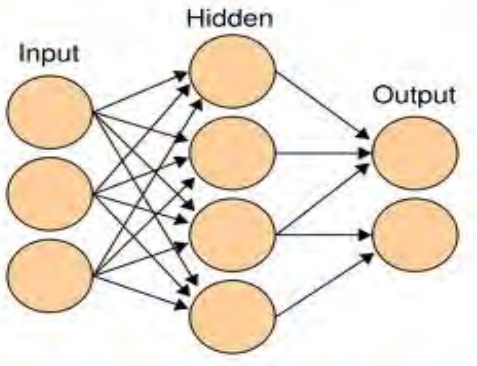

Fig 2. Layers of artificial neural network

III. WHY NEURAL NETWORK IS BEST FOR PREDICTION

There are several distinguished features that propound the use of neural network as a preferred tool over other traditional models of prediction [5]. Artificial neural networks are nonlinear in nature and where most of the natural real world systems are non linear in nature, artificial neural networks are preferred over the traditional linear models. This is because the linear models generally fail to understand the data pattern and analyse when the underlying system is a non linear one. However, some parametric nonlinear model such as Autoregressive Conditional Heteroskedasticity (Engle, 1982) and General Autoregressive Conditional Heteroskedasticity have been in use for stock prediction. But most of the non linear statistical techniques require that the non linear model must be specified before the estimation of the parameters is done and generally it happens that pre specified nonlinear models may fail to observe the critical features of the complex system under study.

Artificial neural networks are data driven models. The novelty of the neural network lies in their ability to discover nonlinear relationship in the input data set without a priori assumption of the knowledge of relation between the input and the output (Hagen et al., 1996) the input variables are mapped to the output variables by squashing or transforming by a special function known as activation function. They independently learn the relationship inherent in the variables from a set of labelled training example and therefore involves in modification of the network parameters.

Artificial neural networks have a built in capability to adapt the network parameters to the changes in the studied system. A neural network trained to a particular input data set corresponding to a particular environment; can be easily retrained to a new environment to predict at the same level of environment.

Moreover, when the system under study is non stationary and dynamic in nature, the neural network can change its network parameters (synaptic weights) in real time. So, neural network suits better than other models in predicting the stock market returns.

IV. BRIEF INTRODUCTION TO STOCK MARKETING

In this section we are going to discuss some of the basics of stock market i.e. what is stock market, market index, stock exchange and many other concepts of the stock market. There are many different kinds of customers with different kinds of needs and preferences. The market segmentation means divide the total market, choose the best segments and design strategies for profitability serving the chosen segments better than the company's competitors do. In order to make superior value and customer satisfaction, the data needs information at every level.

A. What is stock market

A stock market is a public market for the trading of company stock and derivatives at an agreed price; these are securities listed on a stock exchange as well as those only traded privately. It is an organized set-up with a regulatory body and the members who trade in shares are registered with the stock market and regulatory body SEBI. The stock market is also called the secondary market as it involves trading between two investors. Stock market gets investors together to buy and sell shares in companies. Share market sets prices according to supply and demand. A stock that is highly in demand will increase in price, whereas as a stock that is being heavily sold will decrease in price. Companies that are permitted to be traded in this market place are called "listed companies" [37].

B. Importance of stock market

The stock market is one of the most important sources for companies to raise money. This allows businesses to be publicly traded, or raise additional capital for expansion by selling shares of ownership of the company in a public market. History has shown that the price of shares and other assets is an important part of the dynamics of economic activity, and can influence or be an indicator of social mood. In fact, the stock market is often considered the primary indicator of a country's economic strength and development. Rising share prices tends to be associated with increased business investment and vice versa. Share prices also affect the wealth of households and their consumption. Therefore, central banks tend to keep an eye on the control and behaviour of the stock market. Exchanges also act as the clearing house for each transaction, meaning that they collect and deliver the shares, and guarantee payment to the seller of a security. This eliminates the risk to an individual buyer or seller that the counterparty could default on the transaction. The smooth functioning of all these activities facilitates economic growth, lower costs; promote the production of goods and services as well as employment. In this way the financial system contributes to increased prosperity [37].

Primary market deals with the new issues of securities. In the primary markets, securities are bought by way of the public issue directly from the company. An official prospectus is published under the Corporations Law and contains all the information that is reasonably required to allow you to make an informed investment decision about the company. Secondary market: it is where existing securities are bought and sold. Secondary market deals with outstanding securities. In the secondary market shares are traded among investors. This market is made of organized exchanges and may have a trading floor, where orders are transmitted for execution. This is where all the trading of stocks are maintained and guided by the rules set down by the exchange [37].

C. Stock market basics

Stock market basics include shares and stocks. A share or stock is a document issued by a company, which entitles its holder to be one of the owners of the company.

Share: it is directly issued by a company through IPO or can be purchased from the stock market. By owning a share one can earn a portion of the company's profit called dividend. Also, by buying and selling the shares gets capital gain. So, return is the dividend plus the capital gain. However there is a risk of making a capital loss, if selling price of the share is below than the buying price. Stock: it is nothing but a collection or a group of shares. The stock may be common stock or preferred stock. Common Stock: it represents the majority of stock. It represents ownership in a company and a claim on a portion of profits, or dividends. The dividend amount fluctuates and is not guaranteed. Shareholders are entitled to one vote per share to select board members, who oversee the major decisions made by the company's management. In the long run, common stock yields higher returns than most other investments. Preferred Stock: it represents a degree of ownership in a company but usually does not include voting rights. The stock holders of this type have the right to get a guaranteed fixed rate of dividend before the payment of dividend to the equity holders. They also have right to get back their capital before the equity holders in case of winding up of the company [37].

A stock exchange formerly a securities exchange is a corporation or mutual organization which provides "trading" facilities for stock brokers and traders, to trade stocks and other securities, thus providing a marketplace (virtual or real). Stock exchanges also provide facilities for the issue and redemption of securities as well as other financial instruments and capital events including the payment of income and dividends. The securities traded on a stock exchange include: shares issued by companies, unit trusts, derivatives, pooled investment products and bonds. To be able to trade a security on a certain stock exchange, it has to be listed there. Trade on an exchange is by members only. The initial offering of stocks and bonds to investors is by

definition done in the primary market and subsequent trading is done in the secondary market. A stock exchange is often the most important component of a stock market. There is usually no compulsion to issue stock via the stock exchange itself, nor must stock be subsequently traded on the exchange. Such trading is said to be off exchange or over-the-counter. This is the usual way that derivatives and bonds are traded. Increasingly, stock exchanges are part of a global market for securities. There are 20 major Stock Exchanges in the world [37].

Stock exchanges have multiple roles in the economy; this may includes raising capital for businesses, mobilizing savings for investment, Facilitating company growth, profit sharing, corporate governance, creating investment opportunities for small investors, government capital-raising for development projects, barometer of the economy. Listing requirements are the set of conditions imposed by a given stock exchange on companies that want to be listed on that exchange. Conditions sometimes include minimum number of shares outstanding, minimum market capitalization and minimum annual income. Companies have to meet the requirements of the exchange in order to have their stocks and shares listed and traded there, but requirements vary by stock exchange [37]. Bombay Stock Exchange (Asia-Pacific Region): Bombay Stock Exchange (BSE) has requirements for a minimum market capitalization of Rs.250 Million and minimum public float equivalent to Rs.100 Million [37]. NASDAQ Stock Exchange (America Region): To be listed on the NASDAQ a company must have issued at least 1.25 million shares of stock worth at least $70 million and must have earned more than $11 million over the last three years [37].

D. What is market index

An index is a statistical composite measure of the movement in the overall market or industry. Basically, indexes allow measuring the performance of a group of companies over a period of time. Companies are organized in an index according to two main methods or weighting as it is commonly termed. The movements of the prices in a market or section of a market are captured in price indices called stock market indices, e.g., the S&P, the FTSE and the Euro next indices. Such indices are usually market capitalization weighted, with the weights reflecting the contribution of the stock to the index. The constituents of the index are reviewed frequently to include/exclude stocks in order to reflect the changing business environment. There are two major classes of indexes in use: Equally weighted price index: The index is calculated by taking the average of the prices of a set of companies.

Equally weighted price Index = Sum (Prices of N companies) / divisor.

Market capitalization weighted index: In this index, each of the N companies' prices is weighted by the market capitalization of the company.

Market capitalization weighted index = Sum (Company market capitalization * Price) over N companies / Market capitalization for these N companies [37].

A few decades ago, worldwide, buyers and sellers were individual investors, such as wealthy businessmen with long family histories and emotional ties to particular corporations. Over time, markets have become more "institutionalized" buyers and sellers. The market participants includes; investors, large institutions, issuers of securities, intermediaries.

Stock broker is person who is licensed to trade in shares. They also have direct access to the share market and can act as agent in share transactions. For this service, they charge a fee. Stock brokers can also offer additional services such as portfolio management or advice. The type of broker will depend on own confidence in trading shares. Often investors, who know exactly what they want to buy, will go to a discount broker to enact the trade.

Stock broker may be full service broker or discount broker. Full-service broker will provide you with advice on which stocks to trade. They can often operate as financial planners and help with other aspects of your investment portfolio. Because they offer advice, a full service broker usually charges between 2 and 2.5 per cent fees, depending on the size of the transaction. Discount broker will execute trades, but will not provide any advice. As a result brokerage charges are low. Discount brokers generally operate via the telephone, Internet or both. Trader: In finance, a trader is someone who buys and sells financial instruments such as stocks, bonds and derivatives. Traders are either professionals working in a financial institution or a corporation, or individual investors.

They buy and sell financial instruments traded in the stock markets, derivatives markets and commodity markets. Several categories and designations for diverse kinds of traders are found in finance, these include: stock trader, day trader, pattern day trader, swing trader, floor trader and rogue trader. Trading: Participants in the stock market range from small individual stock investors to large hedge fund traders, who can be based anywhere. Exchange is physical locations, where transactions are carried out on a trading floor, by a method known as open outcry. This type of auction is used in stock exchanges and commodity exchanges where traders may enter "verbal" bids and offers simultaneously. The other type of stock exchange (derivative exchanges) is a virtual kind, composed of a network of computers, where trades are made electronically via traders. Buying or selling at market means accepting any asked price or bid price for the stock, respectively. When the bid and ask prices match, a sale takes place on a first come first served basis [37].

E. Theories of Stock Market classification and prediction

Stock market has been studied over and over again to extract useful patterns and predict their movements. Stock market prediction has always had a certain appeal for researchers. While numerous scientific attempts have been made, no method has been discovered to accurately predict the price movement. There are various approaches in predicting the movement of stock market and a variety of prediction techniques has been used by stock market analysts. In the following section we briefly explain the two most important theories in stock market prediction. Based on these theories two conventional approaches to financial market prediction have emerged technical and fundamental analysis. When predicting the future prices of the stock market securities, there are two important theories available. The first one is efficient market hypothesis (EMH) introduced by fama in 1964 and the second one is random walk theory [38].

1. Efficient Market Hypothesis (EMH)

The EMH states that no form of information can be used for generating extraordinary profits from the stock market, as stock prices always "fully reflect" all available information. Any new information which arises will be quickly and efficiently absorbed into the price of the stock. From the way that the EMH is defined, it is obvious that the result obtained in this work has a direct implication on the validity of the EMH. Fama contribution in efficient market hypothesis is significant. The EMH hypothesizes that the future stock price is completely unpredictable given the past trading history of the stock The efficient market hypothesis (EMH) states that the current market price reflects the assimilation of all the information available. This means that given the information, no prediction of future change in the price can be made. As new information enters the system the unbalanced stock is immediately discovered and quickly eliminated by the correct change in the price [38].

The EMH exists in three forms, depending on the information which is used for making predictions weak EMH, semi-Strong EMH, strong EMH

In weak EMH, any information acquired from examining the stock's history is immediately reflected in the price of the stock .The "weak" form of EMH states that past stock prices cannot be used to predict future stock prices. Only past price and historical information is embedded in the current price. This kind of EMH rules out any form of prediction based on the price data only, since the prices follow a random walk in which successive change has zero correlation [38]. The semi strong form goes a step further by incorporating all historical and currently public information into the price.

This includes additional trading information such as volume data and fundamental data such as profit prognosis and sales forecast [59]. The strong form includes historical, public and private information such as insider information, in the share price. According to fama in his article "efficient capital market" states that the efficient market hypothesis surely must be false the strong form, due to the shortage in data, has been difficult to be tested. The "strong" form of EMH states that nothing can be used to predict future stock prices as all information is already reflected in the current price of the stock. By investigating the performance of mutual fund managers in [4], empirical evidence showed that the fund managers could not make use of any privileged information to achieve higher profits. The weak and semi-strong form of EMH has been fairly supported into a number of research studies [38].

2. Random walk theory

The random walk hypothesis claims that stock prices do not depend on past stock. Prices, so patterns cannot be exploited since trends to not exist. With the advent of more powerful computing infrastructure (hardware and software) trading companies now build very efficient algorithmic trading systems that can exploit the underlying pricing patterns when a huge amount of data-points are made available to them. Clearly with huge datasets available on hand, machine learning techniques can seriously challenge the EMH [38]. It is a different perspective on prediction stock market prediction is believed to be impossible where prices are determined randomly and outperforming the market is infeasible. Random walk theory has similar theoretical to semi-strong EMH where all public information is assumed to be available to everyone. However, random walk theory declares that even with such information, future prediction is ineffective [38].From EMH and random walk theories, two distinct trading philosophies have been emerged.

These two conventional approaches to financial market prediction are technical analysis and fundamental analysis [38].

(i) Technical trading rule

The term technical analysis denotes a basic approach to stock investing where the past price are studied, using charts as the primary tool. It is based on mining rules and patterns from the past prices of stocks which are called mining of financial time series. The basic principles include concepts such as the trending nature of prices, confirmation and divergence, and the effect of traded volume. Many hundreds of methods for prediction of stock prices have been developed and are still being developed on the ground of these basic principles. Technical analysis is based on numeric time series data and tries to forecast stock market using indicators of technical analysis. It is based on the widely accepted hypothesis which says that all reactions of the market to all news are contained in real time prices of stocks. Because of this, technical analysis ignores news. Its main

concern is to identify the existing trends and anticipate the future trends of the stock market from chart. But charts or numeric data contain only the vents and not the cause why it happened. It is believed that market timing is critical and opportunity can be found through the careful averaging of historical price and volume movements and comparing them against current price. Technicians utilize charts and modelling techniques to identify trends in price and volume. They rely on historical data in order to predict future outcomes. There are many promising prediction methods developed to predict stock market movement from numeric time series [59]. Auto regression and moving average are some of the famous stock trends prediction technique which has dominated the time series prediction for several decays. It is performed by the technical analysts that this method deals with the determination of the stock price based on the past patterns of the stock using time-series analysis [38].

(ii) Fundamental trading rule

Fundamental analysis investigates the factors that affect supply and demand. The goal is to gather and interpret this information and act before the information is incorporated in the stock price. The lag time between an event and its resulting market response presents a trading opportunity. Fundamental analysis is based on economic data of companies and tries to forecast markets using economic data that companies have to publish regularly for example annual and quarterly reports, auditor's reports balance sheet, income statements [38]. It is performed by the fundamental analysts. This method is concerned more with the company rather than the actual stock. The analysts make their decisions based on the past performance of the company, the earnings forecast etc [38]. In fundamental trading philosophy, the price of a security can be determined through the nuts and bolts of financial numbers. These numbers are derived from the overall economy, the particular industry's sector, or most typically, from the company itself. Figure such as industry return on equity, debt levels can all play a part in determining the price of a stock [38]. When applying machine learning and data mining to stock market data, we are more interested in doing a technical analysis to see if our algorithm can accurately learn the underlying patterns in the stock time series. This said machine learning can also play a major role in evaluating and prediction the performance of the company and other similar parameters helpful in fundamental analysis. In fact, the most successful automated stock prediction and recommendation systems use some sort of a hybrid analysis model involving both Fundamental and Technical Analysis [38].

V. STOCK MARKET PREDICTION WITH NEURAL NETWORK

There are many real life problems in which future events must be predicted on the basis of past history. An example of that task is that of predicting the behaviour of stock market indices. Weigend and huberman in 1990 observe that prediction hinges on two types of knowledge underlying laws, a very powerful and accurate means of prediction and the discovery of strong empirical regularities in observations of a given system. Through perfect prediction is hardly ever possible, artificial neural networks can be used to obtain reasonably good prediction in a number of cases. In prediction problems, it is important to consider both short-term ("one leg") and long term ("multi lag") predictions. In one leg prediction, we forecast the next value based only on actual past values. In multi lag prediction, on the other hand, some predicted values are also used to predict futures values.

From a very broad perspective, artificial neural networks can be used for financial prediction in one of the three ways.

i. It can be provided with inputs, which enable it to find rules relating the current state of the system being predicted to future states.

ii. It can have a window of inputs describing a fixed set of recent past states and relate those to future states.

iii. It can be designed with an internal state to enable it to learn the relationship of an indefinitely large set of past inputs to future states, which can be accomplished via recurrent connections.

Prediction on stock price by neural network consists of two steps training or fitting of neural network and prediction. In the training step, network generates a group of connecting weights, getting an output result through positive spread, and then compares this with expected value. If the error has not reached expected minimum, it turns into negative spreading process, modifies connecting weights of network to reduce errors. Output calculation of positive spread and connecting weight calibration of negative spread are doing in turn. This process lasts till the error between practical output and expected value meets the requirements, so that the satisfactory connecting weights and threshold can be achieved. Network prediction process is to input testing sample to predict, through stable trained network (including training parameters), connecting weights and threshold. It is nowadays a common notion that vast amounts of capital are traded through the stock markets all around the world. National economies are strongly linked and heavily influenced by the performance of their stock markets. Moreover, recently the markets have become a more accessible investment tool, not only for strategic investors but for common people as well. Consequently they are not only related to macroeconomic parameters, but they influence everyday life in a more direct way. Therefore they constitute a mechanism which has important and direct social impacts. The characteristic that all stock markets have in common is the

uncertainty, which is related to their short and long term future state. This feature is undesirable for the investor but it is also unavoidable whenever the stock market is selected as the investment tool. The best that one can do is to try to reduce this uncertainty. Stock market prediction is one of the instruments in this process. The main advantage of artificial neural networks is that they can approximate any nonlinear function to an arbitrary degree of accuracy with a suitable number of hidden units [12].

Halbert white in [1] reported some results of an on-going project using neural network modelling and learning techniques to search for and decode nonlinear regularities in asset price movements. Author, focus on case of IBM common stock daily returns. Having to deal with the salient features of economic data highlights the role to be played by statistical inference and requires modifications to standard learning techniques which may prove useful in other contexts.

Dase R.K. and Pawar D.D. in [2] predicated stock rate because it is a challenging and daunting task to find out which is more effective and accurate method so that a buy or sell signal can be generated for given stocks. Predicting stock index with traditional time series analysis has proven to be difficult an artificial neural network may be suitable for the task. Neural network has the ability to extract useful information from large set of data. In this paper author also presented a review on application of artificial neural network in stock market prediction.

Phaisarn sutheebanjard et al. in [3] predicted the stock exchange of Thailand index movement. Currently, there are two stock markets in Thailand; the stock exchange of Thailand (SET) and the market for alternative investment (MAI). This paper focuses on the movement of the stock exchange of Thailand index (SET Index). The back propagation neural network (BPNN) technology was employed in prediction the SET index. An experiment was conducted by using data of 124 trading days from 2 July 2004 to 30 December 2004. The data were divided into two groups: 53 days for BPNN training and 71 days for testing. The experimental results show that the BPNN successfully predicts the SET Index with less than 2% error. The BPNN also achieves a lower prediction error when compared with the adaptive evolution strategy, but a higher prediction error when compared with the (1+1) evolution strategy.

Tong-Seng Quah in [4] presented methodologies to select equities based on soft-computing models which focus on applying fundamental analysis for equities screening. This paper compares the performance of three soft-computing models, namely multilayer perceptrons (MLP), adaptive neuro-fuzzy inference systems (ANFIS) and general growing and pruning radial basis function (GGAP-RBF). It studies their computational time complexity; applies several benchmark matrices to compare their performance, such as generalize rate, recall rate, confusion matrices, and correlation to appreciation. Author also suggests how equities can be picked systematically by using relative operating characteristics (ROC) curve.

Manna majumder and MD anwar hussian in [5] presented a computational approach for predicting the S&P CNX Nifty 50 Index. A neural network based model has been used in predicting the direction of the movement of the closing value of the index. The model presented in the paper also confirms that it can be used to predict price index value of the stock market. After studying the various features of the network model, an optimal model is proposed for the purpose of forecasting. The model has used the pre-processed data set of closing value of S&P CNX Nifty 50 Index. The data set encompassed the trading days from 1st January, 2000 to 31st december, 2009. In the paper, the model has been validated across 4 years of the trading days. Accuracy of the performance of the neural network is compared using various out of sample performance measures. 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% and with an average accuracy of 69.72% over a period of 4 years.

Jing tao yao and chew lim tan in [6] used artificial neural networks for classification, prediction and recognition. Neural network training is an art. Trading based on neural network outputs, or trading strategy is also an art. Authors discuss a seven-step neural network prediction model building approach in this article. Pre and post data processing/analysis skills, data sampling, training criteria and model recommendation will also be covered in this article.

Jibendu kumar mantri et al. in [7] presented study aims at applying different methods i.e GARCH, EGARCH, GJR- GARCH, IGARCH & ANN models for calculating the volatilities of Indian stock markets. Fourteen years of data of BSE sensex & NSE nifty are used to calculate the volatilities. The performance of data exhibits that, there is no difference in the volatilities of sensex, & nifty estimated under the GARCH, EGARCH, GJR GARCH, IGARCH & ANN models.

Mohsen mehrara et al in [8] simulated the non-linear models with the help of MLFF neural network with back-propagation learning algorithm and GMDH neural network with genetic algorithm (GA) learning to predict TEPIX based on the TSE database. Moving average crossover inputs has used on technical analysis rules and the results show the exponential moving average has better result than simple moving average and also the GMDH has better result in the forecasting, power tracking and profitability relative to MLFF neural network.

Dogac senol in [9] also predicated stock market that always been an attractive area for researchers since no method has been found yet to predict the stock price behaviour precisely. Artificial neural networks (ANNs) are mathematical models simulating the learning and decision making processes of the human brain. Because of

their nature of easy adaptation to noisy data, and solving complex and nonlinear problems, they fit into the area of stock price behaviour prediction. The Istanbul stock exchange (ISE) is the only stock market in Turkey, which has an emerging economy. The market situations and economic fluctuations in Turkey create more uncertainty and volatility in the stock market when compared to emerge markets. This study tries to reduce the effect of this uncertainty and volatility by modelling the change in stock price direction of stocks, identifying the theory and steps involved in applying ANN in financial markets and developing a software package to be used for predicting directional daily stock price behaviour. It also discusses the appropriate ways to use this process in developing trading systems, further discussing the superiority of ANN over traditional methodologies.

M. thenmozhi et al in [10] presented studies on artificial neural networks that have the capacity to learn the underlying mechanics of stock markets. In fact, artificial neural networks have been widely used for prediction financial markets. However, such applications to Indian stock markets are scarce. This paper applies neural network models to predict the daily returns of the BSE (Bombay Stock Exchange) Sensex. Multilayer perceptron network is used to build the daily returns model and the network is trained using error back propagation algorithm. It is found that the predictive power of the network model is influenced by the previous day. Return than the first three day inputs. The study shows that satisfactory results can be achieved when applying artificial neural networks to predict the BSE sensex.

Karsten Schierholt et al. in [11] made to predict the behaviour of bonds, currencies, stocks, or stock markets. In this paper, the Standard and Poors 500 Index is modelled using different neural network classification architectures. Most previous experiments used multilayer perceptrons for stock market forecasting. In this paper, a multilayer perceptron architecture and ZL probabilistic neural network are used to predict the incline, decline, or steadiness of the index. The results of trading with the advice given by the network are then compared with the maximum possible performance and the performance of the index. Results in this paper show that both networks can be trained to perform better than the index, with the probabilistic neural network performing slightly better than the multi layer perceptron.

Emad W. Saad et al. in [16] compared three networks for low false alarm stock trend predictions. Short-term trends, particularly attractive for neural network analysis, can be used profitably in scenarios such as option trading, but only with significant risk. Therefore authors focus on limiting false alarms, which improves the risk/reward ratio by preventing losses. To predict stock trends, authors exploit time delay, recurrent, and probabilistic artificial neural networks (TDNN, RNN, and PNN, respectively), utilizing conjugate gradient and multi stream extended kalman filter training for TDNN and RNN. Different predictability analysis techniques and history of daily closing price is also analysed by authors.

Mahdi pakdaman nae in [17] used two kinds of neural networks, a feed forward multi layer perceptron (MLP) and an elman recurrent network, are used to predict a company's stock value based on its stock share value history. The experimental results show that the application of MLP neural network is more promising in predicting stock value changes rather than elman recurrent network and linear regression method.

Kyoung-jae kim [18] suggested a genetic algorithms (GA) approach to change point group detection in artificial neural networks (ANN) for the prediction of the Korean stock price index (KOSPI). The basic concept of this proposed model is to obtain intervals divided by change points, to identify them as optimal or near-optimal change-point groups, and to use them in the prediction of the stock price index. This study suggests a new concept named for the change-point group which is built up of intervals obtained by change-point detection. The proposed model consists of three stages. The first stage is to detect successive change points. The second stage is to detect the change-point groups with GA. The final stage is to forecast the output with ANN. This study then examines the predictability of the proposed model for the prediction of stock price index.

John S. Chandler in [19] intended to mine reasonable trading rules by classifying the up/down fluctuant direction of the price for Korea stock price index 200 (KOSPI 200) futures. It consists of two stages. The first stage is classifying the fluctuant direction of the price for KOSPI 200 futures with several technical indicators using artificial intelligence techniques and the second stage is mining the trading rules to resolute conflict among the outputs of the first stage using the inductive learning. To verify the effectiveness of proposed approach, this study composes four comparable models and performs statistical test. Experimental results show that the classification performance of the proposed model outperforms that of other comparable models. In addition, the proposed model yields higher profit than other comparable models and buy-and-hold strategy.

C. D. tilakaratne in [20] predicted trading signals of the Australian all ordinary index (AORD), one day ahead. These predictions were based on the current day's relative return of the close price of the US S&P 500 index, the UK FTSE 100 index, French CAC 40 index and German DAX index as well as the AORD. The prediction techniques examined were feed forward and probabilistic neural networks. Performance of the networks was evaluated by using classification/misclassification rate and trading simulations. For both evaluation criteria, feed forward artificial neural networks performed better. Trading simulations suggested that the predicted trading signals are useful for short term traders.

In one of the study in [21] presented the use of artificial neural networks as a prediction tool for predicting the direction of the stock market. The neural network is employed to use the homogeneous input data set which

in this case is the daily returns of S&P CNX Nifty 50 Index. The data set encompassed the trading days from 6th November, 1991 to 31st March, 2007. The daily return of the index is calculated from the daily closing prices of Nifty 50 index. The data is collected from the historical data available on the website of national stock market. The study also seeks to document the self similarity characteristic of the stock market. Accuracy of the performance of the neural network is compared using various out of sample performance measures. Modelling techniques and the architecture of the ANN will also report in the paper.

Mr. pritam in [22] analysed feed forward network using back propagation learning method with early stopping and radial basis neural network to predict the trend of stock price (i.e. Classification) and to predict the stock price (i.e. value prediction). Fundamental or technical indicators were not used in this research as basic objective of this research was to determine the usability of artificial neural networks in predicting the future prices based on past prices alone.

Jacek in [23] presented neuro-evolutionary method for a short-term stock index prediction is presented. The data is gathered from the German stock exchange (the target market) and two other markets (Tokyo Stock Exchange and New York Stock Exchange) together with EUR/USD and USD/JPY exchange rates. Artificial neural networks supported by genetic algorithm (GA) are used as the prediction engine. The GA is used to find suboptimal set of input variables for a one day prediction. Due to high volatility of mutual relations between input variables, a particular choice of input variables found by the GA is valid only for a short period of time and a new set of inputs is generated every 5 days. The method of selecting input variables works efficiently. Variables which are no longer useful are exchanged with the new ones. On the other hand some particularly useful variables are consequently utilized by the GA in subsequent independent steps. Simulation results of the proposed neuro-evolutionary system applied to prediction of the percentage change of closing value of DAX index are very promising and competitive to the ones obtained by the three other heuristically models implemented and tested for comparison.

Abdullah in [24] examined Saudi stock market (SSM) to predict the direction of daily price changes. Back propagation neural network has been applied to predict the direction of price changes for the listed stocks in SSM. The price change in SSM ranges between -10% and 10%. The target has a representation of three classes 1, -1 and 0 that respectively represent the increase, decrease or insignificant change in the stock prices. The dynamic target is a novel enhancement to the traditional objective function mean-squared-error (MSE) for better classification. Our preliminary results show that the classifier's performance improved using dynamic targets in terms of quantitative performance and qualitative performance.

Qui-yong Zhao in [25] predicted accuracy of price date by the traditional BP network by considering a single closing price as the time series vector. But, in this paper author also add other factors vector to the BP network input vector so that low training accuracy caused by the a large number of factor can be recovered. In order to solve the issues the author sets up a two-step forecast approach with the combination between SOFM network and BP network. First, use the Gray correlation analysis to choose the set of variable which can describe the characteristics of the state of the stock market from a number of technical indicators. Then classify the state of stock market by the SOFM network which has the capacity of self organizing classification. And base on the classification, BP network is used to accurately predict. The results of experiment showed that the predictive accuracy of SOFM-BP model is more improved than that of traditional BP neural network model. And it is feasible and effective to forecast China’s stock market by SOFM-BP model, which has a prospective future.

Karsten schierholt et al. in [26] predicted the behaviour of bonds, currencies, stocks, or stock markets. In this paper, the Standard and Poor 500 index is modelled using different neural network classification architectures. Most previous experiments used multilayer perceptrons for stock market forecasting. In this paper, a multilayer perceptron architecture and ZL probabilistic neural network are used to predict the incline, decline, or steadiness of the index. The results of trading with the advice given by the network are then compared with the maximum possible performance and the performance of the index. Results show that both networks can be trained to perform better than the index, with the probabilistic neural network performing slightly better than the multi layer perceptron.

Feng Li et al. in [27] analysed complexity of interior and variety of exterior structure of stock price system based on BP neural network to provide prediction model for stock market by utilizing three-layered feed forward neural networks, presents topology of network, principles of determining the number of hidden layers, selection and pre-treatment of sample data and determination of preliminary parameters. In order to avoid local extreme and promote convergence speed, levenberg marquardt BP algorithm has been adopted. Simulation experiment based on representative index from Shanghai stock exchange market, through training on selecting samples and prediction model, indicates that this algorithm can make efficient short-term prediction.

In one of the paper in [28] the Standard and Poor 500 index is modelled using different neural network classification architectures. Most previous experiments used multilayer perceptrons for stock market forecasting. In this paper, a multilayer perceptron architecture and ZL probabilistic neural network are used to predict the incline, decline, or steadiness of the index. The results of trading with the advice given by the network compared

with the maximum possible performance and the performance of the index. Results show that both networks can be trained to perform better than the index, with the probabilistic neural network performing slightly better than the multi layer perceptron.

Takashi Yamashita et al. in [29] utilized artificial neural networks (ANNs) for financial market applications. Author also shown that multi-branch artificial neural networks (MBNNs) could have higher representation and generalization ability than conventional NNs. Author also investigate the accuracy of prediction of TOPIX (Tokyo Stock Exchange Prices Indexes) using MBNNs. Using the TOPIX related values in time series and other information, MBNNs can learn the characteristics of time series and predict the TOPIX values of the next day. Several simulations were carried out in order to compare the proposed predictor using MBNNs with those using conventional NNs. The results show that the proposed method can have higher accuracy of the prediction.

Rong-Jun Li et al in [30] used neural network to forecast indices and prices of stock market due to the significant properties of treating non-linear data with self-learning capability. However, artificial neural networks suffer from the difficulty to deal with qualitative information and the "black box" syndrome that more or less limited their applications in practice. To overcome the drawbacks of neural networks, in this study we proposed a fuzzy neural network that is a class of adaptive networks and functionally equivalent to a fuzzy inference system. The experiment results based on the comprehensive index of Shanghai stock market indicate that the suggested fuzzy neural network could be an efficient system to forecast financial time series. To make this clearer, an empirical analysis is given for illustration.

Yuhong Li in [32] reviewed on the application of artificial neural networks in prediction financial market prices. The objective of this paper is to appraise the potential of using artificial neural networks to predict the financial system, as it is reflected in many relevant articles. It will provide some guidelines and references for the research and implementation. This paper begins with an introduction to the theory of artificial neural networks. Subsequently it focuses on the forecast of stock prices and option pricing based on a nonlinear ANN model. It proceeded with a presentation of the application of ANN in predicting exchange rates. The paper then reviewed the theoretical literature on the prediction of banking and financial crisis based on artificial neural networks. In general artificial neural network is a valuable forecast tool in financial economics due to the learning, generalization and nonlinear behaviour properties. Finally it identifies a number of important opportunities for future research on the application of artificial neural networks in financial economics.

Jason E. Kusturelis in [33] examined the use of artificial neural networks to predict the future trend of stock market indices. The accuracy of prediction is compared with traditional multiple linear regression analysis. Besides, the probability of the correctness of the model forecasted is calculated using conditional probabilities. The back propagation algorithm is used in order to minimize the error term between the output of the neural network and the actual desired output value. The error term is calculated by comparing the network's output to the desired output and is then fed back through the network causing the weights to be changed in an effort to minimize error. This process is repeated till the error reaches a minimum value. The study concludes by registering a 93.3% probability in predicting a market rise and 88.07% probability in predicting a market drop in the S&P 500. The author also affirms that linearity assumption in multiple regression analysis may not be true in all cases while neural network can model both linear and curvilinear systems. Besides, neural network models are significantly more accurate than multiple linear regression analysis. The author also cautions not to blindly follow the networks advice but recommends to double check the network using multiple networks incorporating different inputs to predict the same output. The four input variables correspond to macro-economic variables such as foreign exchange rate, price/earnings (P/E) ratio, U.S. market performance index and liquidity. These indicators have been chosen deliberately to account for globalization phenomenon of financial markets. The inputs were used to predict the TOPIX monthly returns using back propagation neural networks. While the influence of input variable P/E ratio is decreasing the influence of liquidity is increasing. These findings are associated with increased volatility of Japanese market in the period 1982. 1990. This study reveals that neural network with four inputs and one lag of output variable as input achieves the best result.

An attempt is made by Tan Sen Suan et al. construct an ANN model to predict share price movements in the Singapore Stock Exchange (SES) using the Singapore Airlines (SIA) stock as an example. The data for 569 trading days are used in the example from 19th January 1993 to 21st April 1995. The network model was constructed to predict the closing price of SIA for one week into the future, based on the knowledge of the current and historical (in this case, each of the past two days) high, low and closing prices, as well as volume traded. The input vector consists of 12 values (4 data variables per day times 3 days), requiring 12 nodes for the input layer. The output layer has just one node holding the value of the predicted closing share price a week from today. The networks performance is enhanced during training by following rule of thumb with trial and error adjustments. The network is trained using supervised learning via the generalized delta rule. It is seen that the predicted closing prices are pretty close to the actual ones. Out of the 50 test cases, 47 (94%) record absolute errors of less than 5% and 35 predictions (70%) record errors by less than 1%.

A.N. Refenes et.al in [34] developed a model to predict the 30-day stock returns of the Paris Stock Exchange. The stock returns are estimated as a function of long and short-term interest rates, earnings per share,

price earnings ratio and exchange rate of Franc against the U.S. dollar. The network chosen is the feed-forward, multi-layered and fully connected networks and is trained using the standard back propagation algorithm. The work concludes by reinforcing the fact that the back propagation networks are more efficient for non-linear data.

Peter C. Mc Cluskey et al. used neural network training algorithms to predict the Standard & Poor 500 Index and then compared the results with the genetic programming and hand coding approaches. Feed forward networks are used to predict the index returns and the network is trained using the back propagation algorithm. The networks are trained to predict the change in S&P 500 closing prices for the next 1, 2 and 4 weeks. The data used is divided into two parts: prior to November 16, 1979 and November 19, 1979 to April 2, 1993. Though the model has worked well based on the historical data set taken as input, the author mentions that the future performance of the model is not warranted as the results are not likely to match the ideal of the historical closing prices.

A.N. Burgess describes a study of Eurodollar futures. The data consists of daily, high, low, open and close prices for Eurodollar futures over the time period August 1987 to July 1994, giving 1760 daily observations in all. The futures contract ranged from less than three months at the short end to three years at the long end. The standard multi-layer perceptron network was used with two hidden layers. The out of the sample test showed that the neural network could generate consistent profits resulting in an average return of 47% per year which is sufficient enough to conclude that the Eurodollar yield appears to be predictable by non-linear techniques.

James M. Hutchinson et.al in [35] proposed a non-parametric method for estimating the pricing formula of a derivative using learning networks. The inputs to the network are the primary economic variables that influence the derivatives price namely, current fundamental asset price, strike price, time to maturity, etc. The derivative price is defined to be the output into which the learning network maps the inputs. Once the network is trained, the network becomes the derivative pricing formula. The data used here is the daily closing prices of S&P 500 futures and options for the 5-year period from January 1987 to December 1991. On comparing the results with the parametric derivative pricing formula, the authors have been cautiously optimistic about their general approach with a number of promising directions for future research. The stock price movements have been basically analysed on the assumption of linearity of the time series in the Indian scenario. The trends in stock prices are estimated using moving averages, regression and other linear methods when the time series seldom moves in a linear fashion.

Thenmozhi (2001) has examined the nonlinear nature of the Bombay stock exchange time series using chaos theory. The study examines the sensex returns time series from 16/01/1980 to 26/09/1997 and shows that the daily returns and weekly returns series of BSE sensex is characterised by nonlinearity and the time series is weakly chaotic. The study recommends the use of nonlinear methods to predict the time series rather than using linear methods for prediction.

Dutta and shekbar in [40] applied ANNs to bond rating using bond prices. They conclude that artificial neural networks outperform classical statistical methods like linear regression models. This study helps to understand that linear models do not provide enough explanation to bond rating models. Also they conclude that even though it provides a better output for the error function (total square error in this case), increasing number of hidden layers in the ANN topology does not improve prediction significantly. More layers improve fit to the training data (also may cause an undesired situation called over-fitting) without changing the power of prediction.

Research of Kimoto et al in [41] seems to be the first research where a system based on artificial neural networks has been tried in a real environment (Tokyo Stock Exchange Prices Indexes) and has succeeded in beating the market. They use five inputs vector curve, turnover, interest rate, foreign exchange rate and dow jones average index. The approach followed is the modular network approach, in which different networks learn for different data items. Each expert module has its own input domain and pre-processing unit. A final post-processing unit has combined the results to an overall output. The research has been further funded by an investment firm. Each modular network has one hidden layer, uses standard sigmoid as an output function and is trained using back propagation algorithm.

Phua et al in [42] used ANNs with genetic algorithms to do predictions on the Stock Exchange of Singapore. 360 samples (between August 1998 and January 31, 2000), with daily opening, daily high, daily low and closing prices with the trading volume of the index, have been examined in this approach. The result is promising: a rate of 81% in predicting market direction.

Fernandez-Rodriguez et al in [43] built an ANN that takes nine inputs as difference of Nikkei index values between consecutive days corresponding to the returns in the previous nine days.

Yao et al in [44] used moving average (MA), momentum (M), relative strength index (RSI), stochastic (%K), and moving average of stochastic (%D) to predict the Malaysian stock index using an ANN model for 303 trading days in 1990-1991. Significant profits are obtained compared to interest rates and other investment techniques.

Yumlu et al in [39] have studied 12 years of financial data (a set of ISE index close value, USD value and two interest rates) using a modular ANN model and have concluded that the model outperforms the

conventional autoregressive model used for comparison. The authors state that the model introduces a powerful way to predict the volatility of financial time series data, contradicting EMH.

VI. CONCLUSIONS

This paper surveyed the application of artificial neural networks (ANNs) in stock market prediction. After survey following conclusion can be drawn about ANNs:

i. ANNs has ability to extract useful information from large set of data therefore ANNs play very important role in stock market prediction.
ii. Artificial neural networks approach is a relatively new, active and promising field on the prediction of stock price behaviour.
iii. ANNs are significantly more accurate than other competitive models and algorithm i.e. genetic algorithm [8], multiple linear regression analysis [33] models for stock market prediction.
iv. Mostly foreign stock market dataset [3, 9, 11, 18, 19, 20, 23, 29, 34, 41 and 42] are used by researchers as compared to Indian stock market dataset [7].
v. Different stock market parameter are used i.e. movement of SET index[3] , fundamental analysis [4] , closing value of the index [5] , moving average crossover inputs [8] , stock share value , daily returns of stock and many others for analyse stock market prediction.

In future work ANNs can also be explore for other applications and comparative study with other models.

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