A New Approach to Predict Selective Critical Stock Indices through Artificial Neural Networks and Chaos Theory

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Abstract - *Financial markets are generally considered as dynamic entities behaving in a random and chaotic manner posing a challenging problem to equity, commodity and currency forecasters. Adoption ofartificial neural network techniques to forecast such financial marketshas been resorted to by many, howeverwith many shortcomings. The present paper proposes a new model to address the above via a synthesis of integration of a live trading system, marketcrash factors and liquidity parameters with the help of chaos theory of physics and financial, technical analysis.*

Keywords - *ANN, Chaos theory, Stock Prediction, Integrated model.*

I. INTRODUCTION

A. Stock market fundamentals

Stock market forecasting is based on fundamental and technical analysis. Fundamental analysis is a stock valuation method which uses economic and financial analysis to predict stock price movements. Fundamental analyst examines the current and future health of the whole economy by analysing data like money supply, interest rate, inflation and the financial data of the company like Price/Earnings ratio, book to the market ratio, dividend yield. Generally fundamental analysis is suitable for long term investors who have a buy and hold strategy. Technical analysis is based on the premise that patterns repeat regularly and makeuse of past patterns to predict the future. Technical analysis is specifically important for traders with very short time horizon (could be intra-day, couple of days or few weeks). In both the methods neural networks have been effectively used to forecast. Anyone who is trading in the market will have a strong opinion that the market is chaotic and random and the market is affected by a number of factors. Statistical tools like multiple regression techniques [1] and time series analysis used for forecasting the series, they fail when the series becomes complex [2]. The stock market is non-linear and chaotic.

B. Artificial Neural Network (ANN)

Artificial neural network techniques have become popular for forecasting because of their non-parametric approach and for their ability to learn when properly trained. Neural net- works have the ability to find patterns and irregularities as well as detecting multidimensional non-linear connections in data [3]. Artificial Neural networks outperform the statisticaltechniques in forecasting stock prices [4]. It is extremely useful for modelling dynamical systems like the stock market, futures market, commodity market and the currency market. The strengths of Artificial neural networks are its ability to solve data-intensive problems, rapid prototyping, adaptation, learning and scalability. Artificial neural networks have been applied to diverse areas like Bankruptcy forecasting, Image processing, Signal processing, Healthcare, Drug development, Intrusion detection and in Communication.

The most popular architecture applying for financial market is the multilayer feed-forward neural networks. (Fig. 1) A standard Neural Network has at least three layers. The first layer is called the input layer. The last layer is called the output layer. An intermediary layer of nodes, the hidden layer, separates the input from the output layer. The number of nodes defines the amount of complexity the model is capable of fitting. Each node of one layer has connections to all the other nodes of the next layer. The term “back propagation” is a form of supervised learning which trainsthe neural network. Weights of various layers are adjusted backwards from the output layer back to the input layer.

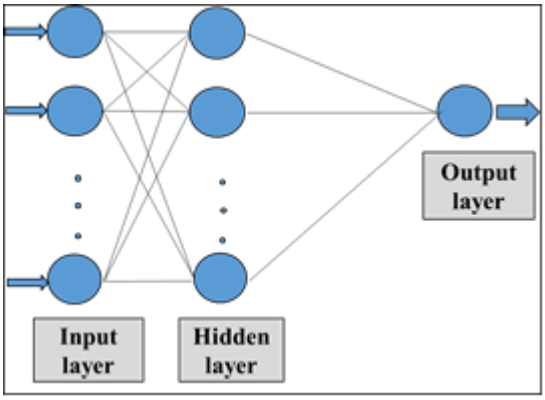

Figure 1. Multilayer Feed Forward Neural network

II. REVIEW OF LITERATURE

Youngohc Yoon and George Swales in 1991 [5] developed a neural network which is capable of learning and concluded that neural network approach can significantly better thepredictability of stock price performance. Qing Cao, Karyl B Leggio, Marc J Schniderjans in 2005 [6] used Artificial Neural Networks to predict stock price movement (price return) for firms traded on the Shanghai Stock Exchange and compared the predictive power of univariate and multivariate neural network models and result shows that neural network outperforms the linear models. GouttamDatta, Pankaj Jha, Arnab Kumar Laha&Neeraj Mohan in 2006 [7] discuss the modeling of the Indian stock market data using Artificial Neural Network and studied the efficiency of Artificial Neural network in Bombay Stock exchange. Chakaradhara panda and V Narasimhan in2006 [8] used the Artificial Neural Network for forecasting of daily Bombay Stock Exchange (BSE) sensitive index (sensex) returns and compare the performance of random walk and lin- ear auto regressive models by using six performance measures. Dase R K and Pawar D D [9] made a comprehensive review of neural network literature during the period 1991-2010 and tried to sum up that artificial neural network has the ability to predict stock market index.

Serge Hayward in 2006 [10] proposed an Agent based modeling with wavelets and an evolutionary artificial neural network and applied to CAC 40 forecasting and the results demonstrate improved abilities of EANN to learn information from signals decomposed on different frequencies. Sorin Vlad, Paul Pascu and NicolaeMorariu in 2010 [11] discuss nonlinear models andapply chaos in forecasting exchange rates and conclude that short term prediction can be made. Prakash Ramani and P D Mururka in 2013 [12] proposed use of method for stock price prediction using ANN and back propagation algorithm. Historical stock prices are used for training. In [13] a computational approach using neural network model to predict S & P Nifty 50 index was proposed. Based on various studies of the network model, an optimal model is proposed for forecasting. The model has been validated across4 years of the trading days. The highest performance predicted is 89.65% with the average accuracy of 69.72% over a period of 4 years. H.B.Kekre, Hitesh MakhijaPallavi H Halarnkar in 2014 [14] proposed a system which predicts the next day closing price of the stock where the learning algorithm used error back propagation learning algorithm. The artificial neural network used is the feed forward artificial network.

III. EXISTING ANN MODELS

A. ANN Model Development

In the review of current literature, it is amply clear that artificial neural network can predict the stock market in short term wherein many models support that.

1) Selvan Simon and Arun Rout [15] analyzed competitive ANN model and in improving ANN accuracy in Stock Market forecasting. The factors considered in improving the accuracy of relevant ANN model is by comparing various ANN models, its learning algorithm most suitable for the given application, prediction target and problem situation to get the best result. It is also possible to combine special algorithms like genetic algorithms heuristic algorithms with ANN for de noising, selecting and optimizing parameters to improve accuracy of ANN model.

2) Thenmozhi [16] applied neural networks to predict daily returns of the Bombay Stock exchange. The author did a sensitivity analysis to find out the relative importance of each input and output. It was found that the predictive power was influenced by previous day price as a primary parameter to influence the prediction

3) In [17] the study of BIST-100 index predictability during July 2007 - December 2009 crisis has been investigated using ANN. According to the results, ANN is quite successfully in predicting Index direction. The results obtained also suggest that ANN can foresee next day and next week values with an accuracy margin error of less than 5% even for unknown samples. The outcome is very important for investors, especially in period's huge economic fragility like financial crises.

B. Proposed New Model

Training ANN with stock market data involves Pre and post data processing issues such as selecting, sampling, cleaning, filtering, de noising, normalizing, deseasonalising, validating, optimizing data for training ANN, for stock market data. The selection of appropriate number of hidden layers, number of neurons in each layer, size of the training set, initial values for weights, inputs to be included, activation function arethe key design issues of a ANN model. Parameter setting should be done by hit and trial method. Targets in ANN stock market models should be considered along with the target application. For example, stock market trend prediction and stock market prediction may require different ANN models and data. Targets in the stock market may be predicting market indices, market trend, market volatility, buy-hold-sell, high- low risk-return classification, best to worst stock for trading strategy and so on. The forecasting may be for long term, short term, given period, or instant. It may be for a stock or a sector. Identifying the most suitable ANN model and data for a specific prediction target will enhance the accuracy. Further one can divide the complex stock market prediction tasks into simpler subtasks, perform the task and integrate the results to get better performance

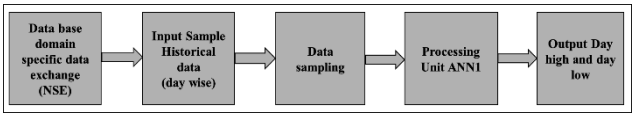

Figure 2. Block Diagram for ANN1

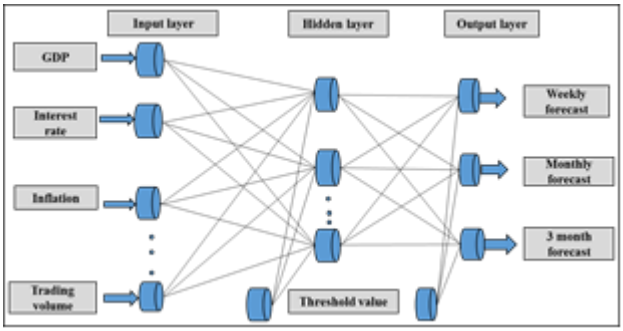

Figure 3. Block Diagram for ANN2

By applying more than one data mining techniques, say genetic algorithm and neural networks on two different subtasks, we can take the advantages of their strengths. The empirical results obtained shows high level of accuracy for daily stock price prediction with hybridized approach performing better than technical analysis approach [15]. The hybridized approach has the potential to enhance the quality of decision making of investors in the stock market by offering more accurate stock prediction compared to existing technical analysis based approach. The strategies for improving accuracy are hybrid analysis, choice of inputs, training ANN with stock market data and ANN component optimization. Although ANN are popular their use in real world scenarios for making trading profits is still under studied. One feature to assess the quality of ANN model development is to integrate the ANN to a live trading system. An automated trading system is required where the predictions are converted into buy and sell decisions for both day-trade, weekly and long term trade. One of the problems associated with classical ANN stock forecasting models are that they are not able to forecast crashes which could be great profit making opportunities for investors. It is necessary that the ANN have that capability. Liquidity factor also plays an important role in the markets because the market has got integrated. Any boom or crisis in any part of the globe has wide ramifications across global markets. Moreover, hedge fund activity, foreign institutional investors (FII's) are an important factor, so we have considered variables like FII inflow short term currency movements.

In these direction the proposed new hybrid model forpredictions is done through integrating three ANN blocks

1) Technical analysis block - ANN12) Fundamental analysis block – ANN23) Liquidity condition – ANN3

ANN1 is based on the premise that future price depends on the previous price.ANN1 Technical analyst network will give an output forecast for the index Min and Max price targets for the day for NIFTY. ANN2 is the fundamental analysis block which will have macroeconomic variables like GDP, inflation, interest rate, gold and oil prices, money supply and other variables which can be given by the user. The network is represented in Fig 3.

ANN2 will generate output for weekly, monthly, 3 monthforecast. It gives a maximum and minimum for the time duration selected. ANN3 is based on the liquidity factor available for the day. Integrating the results obtained by ANN1, ANN2 and ANN3 we employ chaos modelling Over a period of time under supervised learning the neural network will learn when it is deterministic or random dominates and makes a forecast of future index which can be integrated to live trading. Asper the literatureand findingsthis approachof integrationof technical, fundamental and liquidity based models are not found in any literature. In this proposed neural network architecture, we have considered to integrate

predictions of ANN to a live trading system as majority of ANNs system proposed and implemented are evaluated using classical model prediction metrics like mean absolute error (MAE) or the mean squared errors (MSE). Metrics like MAE or MSE gives an idea of model generalization, but do not give direction in the behaviourof the system in the real market. Integrating various analysis techniques like technical, fundamental and liquidity into prediction process is supposed to give excellent forecasting results.

IV. METHODOLOGY

A.Chaos theory

Chaos theory approach can be applied to model non-linear dynamic systems. We assume part of the process to bedeter- ministic and part random. It is an attempt to show that order exists in apparent randomness. Chaos theory contradicts EMH but implying stock market is chaotic and not simply random. A chaotic system is a combination of deterministic and a random process. The deterministic process can be characterized by regression fitting, and the random process can be characterized by statistical parameters of a distribution function. The future share price depends both on the past price (technical analyst view) and can be written as [11].

$$p(t+1) = f(p(t-n)) \quad (1)$$

Where f is a non-linear function, and on a series offundamental economic variables (fundamentalist view).

$$p(t+1) = g(Z) \quad (2)$$

Where Z= (Y, MP. . .) being macroeconomic variables likeGDP, inflation and interest rate. The exact form of f (p (t-n)) is unknown and the neural network by learning will capture the form. Under certain conditions the equation becomes logistic equation, which is known to have chaotic behaviour and during periods of stability it becomes linear. Over a period of time under supervised learning the neural network will learn which one is deterministic or random dominates the equation and makes a forecast of future price.

Data related to the market.

1) Technical data include

- The NIFTY opening and closing at the end of the day
- The highest and the lowest NIFTY of a trading day

2) Fundamental data include

- Inflation
- Interest rate
- Gold price
- Oil price

Other data as defined by the user.

3) Derived data: By transforming and combining technical and or/fundamental data

Algorithm for ANN1

Step1: Acquiring the Historical NIFTY data (from www.nseindia.com in csv format) Collect the historical data and other values needed as input parameters.

Step2: Selection of features like Open price, close, high, low etc.,

Step3: Artificial neural network model to predict.

Step4: Prediction of Next day High and low for Nifty. The input for ANN2 are Gold price, Oil price, inflation, trading volume and other macroeconomic data as specified by the user.

The output will be weekly forecast, Monthly forecast and 3month forecast for NIFTY index.

ANN3 will have FII inflow (historical) and Currency rates, other stock indices like (Dow jones index, FTSE, CAC, etc). More weightage will be for the previous day data.

V. CONCLUSIONS

It is extremely challenging to predict the stock market. In the review of literature, it is clear Artificial Neural networks have the ability to predict stock market index and they are superior to statistical techniques. Emphasis should be on an empirical approach where one first seeks to uncover features of the complex economy. Short term prediction is possible as demonstrated by various ANN models. Hybrid ANN integrating fundamental, technical and liquidity combined with Chaos theory may be the right architecture for forecasting and trading in the real market. We will implement the proposed model for the NIFTY index in the next paper.

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