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Price Prediction of Stock Market- An Empirical Research

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Abstract*: Stock market price prediction is an inspiring problem domain of financial sector as it involves several factors and drives people towards a complex problem solving approach. Financial markets are one of the key points of any country economy. Researchers have been working over several years on stock market prediction which is an interesting problem in itself since a number of variables are involved for prediction. In this study, an extensive review of existing techniques dedicated to stock market forecasting is carried out. A comparative analysis of the existing techniques, mentioning methodologies along with the future direction also provided.

***Keywords* : Stock Exchanges, Stock Market Analysis; Prediction; Statistics; Sentiment Analysis**

I. INTRODUCTION

As a part of economic progress, stock market has been the most popular field in the domain of financing. The stock market provides platform to the entrepreneurs and governments so that resources can be mobilized by the investors. Stock Market is the most appropriate investment for the common man as their investments are diversified across multiple entities, provides a platform to gain in professionally managed portfolio at comparatively low cost investment. The stock market is highly perturbed by Real Gross Domestic Product (RGDP), Inflation Rate (INF) and Interest Rate (INT) [1]. The capital market prediction has drawn enormous attention from last few years. This field is quite interesting due to its dynamic, non-linear, complicated, time-varying, and chaotic nature and often affected by economic, political factors [2].

Many investors aim to achieve forecasting technique that could ensure stress-free gaining and eliminate risks from the stock market which drives researches to develop new predictive models [3]. By analysing stock market behaviour through techniques and various methods, forecasting tool is necessary to obtain. This tool will assist investors to buy and sell with comfortable price. Prior indication to volatility estimation may aware investors for taking risks. In recent years, several researches have been made for forecasting stock market price. Analysing and forecasting stock market price can be implemented by applying machine learning and other relevant algorithms. The stock market prediction can be short term or long term. However, short term prediction is challenging to obt than long term prediction. Many Governments in the globe participate in stock market by investing a part of their healthcare, employment, or retirement funds for achieving healthier returns for everyone. Online trading services revolutionised the way people buy and sell stocks. The financial markets have progressed rapidly into an interconnected global marketplace. Based on the technique used, the researches regarding stock market prediction may be categorized into broad sections- Statistical Approach, Artificial Intelligence Approach and Hybrid Approach.

This paper provides a critical analysis of the various existing techniques for predicting stock market. The next section briefly discusses the existing research methodologies for forecasting tools. Section 3 provides a comparative study of the techniques discussed, including mentioning the datasets on which the experiments were performed and the objective of the experiments. The paper concludes by discussing the future research scope of the problem examined.

II. EXISTING METHOLOGIES

In recent ages, many researches have drawn attention to estimate stock market price in advance. The leading objective of forecasting tool is to guide an investor to take wise decision while trading. In order to perceive that, researchers employed several techniques like Statistical Approach, Artificial Intelligence based Approach, Hybrid Approach. This paper carries a comprehensive review of the various researches done pertaining to each domain mentioned above.

1. Statistical Approach

A wide number of linear statistical models were suggested as predictive models. Approaches employed by several researchers are described as follows.

In order to address some real life problems in stock market such as seasonal trend and flow are considered as the emphasis of stock market investors in [4]. The future forecasts of each index, new investment decisions are also considered in this paper. Past data from four Indian midcap companies are collected, pre-processed and utilised as input for Autoregressive integrated moving average (ARIMA) model.

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The Akaike Information Criterion Bayesian Information Criterion (AICBIC) test was applied to measure the accuracy of the model[4].

In [5],autoregressive integrated moving average (ARIMA) models are used as predictive model for guiding investors in case of short-term prediction. Among several ARIMA models, the best predictive model is identified based on the parameters, such as, Bayesian or Schwarz Information Criterion, adjusted R^2, standard error of regression.

This model is applied on data acquired from New York Stock Exchange (NYSE) and Nigeria Stock Exchange (NSE). For forecasting in short-term prediction, ARIMA model gave quite good result with the emerging forecasting techniques.

Cheng-Ming Lee et. al. in [6] provide an innovative idea embeds lifting scheme with ARIMA model to increase short-term forecasting accuracy. The lifting scheme is a four-stage procedure that splits the original data loads into several sub loads at different resolution levels. These sub loads are fitted using several ARIMA models and the forecasting results are obtained. Applying inverse lifting scheme, original forecasting result is retrieved. Experimental results indicate that the proposed scheme outperforms well over back-propagation network (BPN) algorithm and traditional ARIMA models in terms of forecasting accuracy.

Bhuriya et. al. in [7] provides a mechanism to estimate Tata Consultancy Services stock price using variants of regression models incorporating five features i.e., open, high, low, close price, and volume. Collected data are divided into two parts- one for defining the model and the other one for testing the model. This training and testing data has the division ratio as 8:2. The paper has drawn a comparative analysis among the performances of the linear, polynomial, and Radial Basis Function (RBF) regression models based on the confidence values of the predicted results. Experimental results convey that the linear regression model outperformed the other techniques.

2. Artificial Intelligence based Approaches

Instead of using regression models or smoothing models for stock market price prediction, from 1980 onwards use of Artificial Intelligence is used in an enormous scale [8]. This section provides idea regarding several researches made using artificial intelligence based techniques.

Concept of textual financial news into the prediction model is used in [9]. The model counts keyword tuples and transforms tuple counts into weights employing couple of learning techniques such as rule-based, nearest neighbour and neural net for forecasting purposes. Experimental results have shown that Rule based techniques obtains potential results. In brief, this application behaves like a decision support tool for portfolio managers for their investments. However, incorporating other interfering factors such as acquiring more information from web, assimilating other conventional time series forecasting tools with this prediction model may achieve higher accuracy.

Kamijo and Tanigawa in [8] establish a pattern recognition technique that is used to estimate the stock prices on the Tokyo Stock Exchange. Recurrent neural networks are utilised to recognise stock price based triangle patterns. This method is also applied for extracting temporal contextual transition. The objective of this paper is to minimize patterns that mismatch.

Phetchanchai et. al. in [10] consider zigzag pattern movements in financial time series indexing. For this purpose, Zigzag-Perceptually Important Points (ZIPs) method is used to identify significant points and Zigzag based M-ary tree (ZM-tree) is used for organizing these significant points. The proposed method performs well over techniques like Specialized Binary Trees (SB-Tree) in terms of dimensionality reduction by applying the tree-pruning approach.

A comparative analysis between two very promising artificial neural network models between a Long Short-Term Memory recurrent neural network (LSTM-RNN) and a deep neural network (DNN) are drawn in [11]. This will yield forecast results for daily and weekly activities of the Indian BSE Sensex index. The problem of overfitting is handled in both the cases. Only closing price data are considered for these models. However, inclusion of other interfering factors such as trending news, political affairs, and daily volumes, past histories may enhance the performance of the forecasting procedures.

Chun et. al. in [12] combines the concept of Dynamic Adaptive Ensemble (DAE) and Case Based Reasoning (CBR) for obtaining the prediction of a stock market index. The CBR system is beneficial because without having a strong knowledge base it can fill out the gaps in weak domain. While retrieving past experiences to form cases, Case reasoning may face two problems- *matching problem* which denotes the task of search prior cases in order to solve current problem and *indexing problem* which refers to organization of cases for retrieving all relevant prior solutions. DAE incorporates multiple CBR predictors dynamically and chooses the optimal model. In order to identify an optimal model from the test phase, this technique assimilates series of feature vectors by considering all possible classifiers and evaluates the outcomes according to criteria such as hit rate, Mean absolute percentage error (MAPE), RMSE. Next, after evaluation process, multiple classifiers are adapted and applied for the next prediction. Experimental results indicate that DAE CBR technique performs significantly better than other existing models. However, incorporating other classifiers to this technique may improve performance.

In [13], researchers focus on forecasting stock price short term (next day) and long term (15 days) by implementing the concepts of Back Propagation (BP) Neural Network along with an improved version of bacterial chemotaxis optimization (IBCO). BP is a supervised learning technique that attempts to meet the small approximation that involves steepest gradient descent method. The weights in BP are adjusted using IBCO which is capable of identifying relationships between unknown stock values and stock indices. The final evaluation showed significantly better result than traditional BP in terms of prediction accuracy, training time, and computational complexity.

In [14], 'topic-sentiment' feature such as products; service, dividend etc. are employed in order to predict stock market. The social media contents are analysed and relevant topics along with sentiments are extracted as well as utilised for stock market prediction.

The feature extraction process follows two ways- One is implementing existing topic model called the joint sentiment/topic model (JST) and the other one is Aspect based sentiment method which is proposed here and the latter method performs better than JST. This model is built on historical prices and sentiments on the social media; however, incorporating other interfering factors may increase efficiency of stock prediction task.

In [15], researchers used NASDAQ stock market data for implementing correlation tests, likelihood tests, and hypothesis tests for the purpose of identifying exact characteristics of data set and relation among those data points. Use of pre-estimation as well as post-estimation analysis identifies fitness of data set. Next, an optimized subtractive clustering method is applied to that dataset for the purpose of making fuzzy rules. However, modifying default parameters along with type of membership functions supports in obtaining Fuzzy Interface Structure during the simulation phase. Further neural network method is employed to obtain Adaptive Neural-Fuzzy Interface System. This proposed system reached an accuracy of 74% and can be further improved by varying other factors such as changing the clustering methods, parameters, statistical and econometrical analysis etc.

WASP (Wave Analysis Stock Prediction) proposed in [3] is a neuro-fuzzy system that focuses on forecasting time-series data. This WASP system is inspired from the concept of "Elliot Wave Theory"[3]. This system is accompanied by Elliott wave oscillator (EWO) which formulates the input data (price). The input price is also used to find out returns into the values [-1, 0, +1] as the output value. The previous formulated input data is divided into two parts where the first part is fed as a new data set for forecasting and the other part is combined with the resultant data constitutes the total data set. This total data set is used for training as well as testing purposes. Several subsystems are evaluated based different membership functions and among those subsystems nine are selected and used for final prediction. The WASP system gives output in terms of hit rate, returns and prediction. The Elliot Wave Theory consists of nine cycles which is simulated by selecting and combining nine different ANFIS sub-models for forecasting final results. This proposed system achieved hit rate above 75% which is quite significant in terms of forecasting.

In order to remove random walk dilemma in stock market prediction, [16] focused on obtaining Translation Invariant Morphological Time-lag Added Evolutionary Forecasting (TIMTAEF) method. This method is an intelligent integrated model that combines the concept of a Modular Morphological Neural Network (MMNN) and Modified Genetic Algorithm (MGA). Back Propagation (BP) algorithm is employed for training of each population of MGA and the MMNN parameters are adjusted accordingly. Once the training is done, the TIMTAEF method selects the predictive model for representing time series. Since time phase distortions are often perceived in financial time series, a behavioral statistical test is performed where phase-matching and adjustment is done. This approach is evaluated against five performance metrics, such as, Mean Squared Error (MSE), Mean Absolute Percentage Error (MAPE), Normalized Mean Squared Error (NMSE), Theil Statistic (THEIL), Prediction of Change in Direction (POCID), Average Relative Variance (ARV) which are responsible while obtaining a fitness function. The experimental results indicated that the proposed system has outperformed well over the TAEF and MRLTAEF models.

An integrated model named as Genetic Complementary Learning Fuzzy Neural Network (GCL) is proposed in [2]. It is a combination of Genetic Algorithm (GA) and fuzzy neural network. Along with stock market prediction, bank failure is also focused as a problem solving area of this paper. GCL is designed using complementary learning and GA. The complementary learning is based on positive and negative knowledge acquisition which leads to pattern recognition like human brain. The GA is an approach that identifies optimal solution of a dynamic and chaotic problem. The GCL method is superior over other methods since it is capable of inferring rule base as well as explaining reasoning process. However, other price interfering factors like current political issues; economic condition etc. may be incorporated to improve the performance of this model.

Particle Swarm Optimization (PSO) and Fuzzy logic is extensively used tool in complex problem solving approach. But PSO suffers from convergence problem and fuzzy logic suffers from effective learning capability. In [17], an improved version of Particle Swarm Optimization (IPSO) is proposed first and further it is assimilated with fuzzy logic and neural network. Using this model network training process is optimized. This IPSO-FNN model [17] contributes significantly better result than Neural Network.

For stock market analysis, [18] proposed an intelligent cohesive system which starts with data pre-processing and using Principal Component Analysis (PCA) features are extracted. These extracted features are fed into Artificial Neural Network (ANN) and for training purpose Scaled Conjugate Gradient Algorithm (SCGA) is used, which assimilates Levenberg-Marquardt algorithm and Conjugate Gradient Algorithm (CGA). The output from the ANN is again fed into neuro-fuzzy system that is a combination of ANN and Fuzzy Inference System (FIS). An Evolving Fuzzy Neural Network (EFuNN) [18] is implemented here that is a five-layer structure and incorporates Mamdani type FIS. The output from EFuNN indicates detailed and promising trend analysis of stock market.

III. HYBRID APPROACH

For perceiving higher accuracy in terms of forecasting, two or more models are assimilated. These models may be homogeneous or heterogeneous in nature. This section contributes to hybrid approaches those were employed while forecasting stock market.

Tang et. al. in [19] proposed a framework that associates text mining techniques with time series analysis (TSA) algorithms for forecasting stock price and other economic indices. Using text mining techniques information related to stock market are extracted. TSA algorithm is applied to stock market data to obtain forecasting outcomes. A regression-function is applied to the information mined during news mining and those are represented using feature vectors and weighted. Later these features are combined to TSA forecasting results which outperforms over regular TSA.

For capturing linear as well as non-linear features of stock market time series, an integrated model is proposed in [20]. This combines Exponential Smoothing Model (ESM), autoregressive integrated moving average model (ARIMA), and back propagation neural network (BPNN). ESM, ARIMA is capable of identifying linear characteristics and non-linear characteristics are captured by BPNN. Genetic Algorithm (GA) determines the weights of these models. Closing index of the Shenzhen Integrated Index (SZII-China) and opening index of the Dow Jones Industrial Average Index (DJIAI-USA) are used for performance evaluation of this model.

Along with autoregressive integrated moving average (ARIMA) model, Support Vector Machine (SVM) is collaborated in [21] for capturing linear as well as non-linear characteristics of time series for forecasting stock market price. Four parameters, MAE (mean absolute error), MSE (mean square error), MAPE (mean absolute percentage error), and RMSE (root mean square error), are used for measuring forecasting accuracy of this model. Experimental results prove that assimilating two dissimilar models help in reducing the forecasting errors.

IV. COMPARATIVE ANALYSIS

Table I, II, III present a comparative analysis of the existing stock market forecasting algorithms with respect to the approaches used. Each paper is described using its employed dataset, objective and technique implemented.

Table I. Comparative Analysis of Stock forecasting techniques using Statistical Approaches

Reference	Objective	Dataset Used	Techniques Used
[4]	Considered seasonal trend and flow for prediction	Data from NSE India for the period from January 2007 to December 2011	ARIMA model with different parameters.
[5]	short-term prediction	New York Stock Exchange (NYSE) and Nigeria Stock Exchange (NSE)	ARIMA considering parameters- Bayesian or Schwarz Information Criterion, standard error of regression, adjusted R^2.
[6]	short-term forecasting	Taipower Company 2007	Combines the lifting scheme with autoregressive integrated moving average (ARIMA) models.
[7]	Stock price prediction	Tata Consultancy Services	linear regression

Table II. Comparative Analysis of Stock forecasting techniques using Artificial Intelligence Approaches

Reference	Objective	Dataset Used	Techniques Used
[9]	Predict stock markets periodically using data contained in published articles on the Web.	Data from 6th Dec 97 to 5th March 98	Used news mining techniques and keyword tuple counting and transformation.
[8]	Recognition of stock price patterns	Tokyo Stock Exchange	Recurrent neural networks
[10]	Pattern recognition: Zigzag-Perceptually Important Points	Index Financial Time Series	Zigzag based M-ary Tree (ZM-Tree)
[11]	Daily and Weekly Movements prediction	BSE Sensex, Tech Mahindra	Neural Network-LSTM-RNN, DNN
[12]	forecasting a stock market index	Korean Stock Price Index (KOSPI) for the period from 4 January 2000 to 30 June 2004	Dynamic adaptive ensemble case-based reasoning

[13]	Short-term as well as long-term prediction	Data from 23rd October 1998 to 27th February 2008 of Standard' s & Poor's 500 (S&P 500), USA	Integrated bacterial chemotaxis optimization (IBCO) and the back propagation (BP) artificial neural network
[14]	Predict stock price movement using social media sentiment.	18 stocks such as AAPL, AMZN, YHOO and many more.	Used topic-sentiment and predicted stock market prices using SVM with linear kernel.
[15]	Predict stock price considering statistical and econometrical analysis	NASDAQ stock market data	Used Adaptive Neural-Fuzzy Interface
[3]	forecasting time-series data	Stock of the National Bank of Greece	Neuro-fuzzy system that incorporates Elliot Wave Theory
[16]	Removes random-walk problem for stock market prediction	West america Bancorp Stock, First Citizens Bancshare s Inc. Stock Prices, BancFirst Corporati on Stock Prices, Alliance Financial Corporati on Stock Prices	Combines the concept of a Modular Morphological Neural Network (MMNN) and Modified Genetic Algorithm (MGA).
[2]	stock market and bank failure predictions	Stock-The Developm ent Bank of Singapore (DBS), Neptune Orient Lines (NOL), and Singapore Airline (SIA) stock indices listed on the Stock Exchange of Singapore (SES), Bank-Fin ancial statement s observed for a period of 21 years from January 1980 to December 2000 are acquired from the Call report Federal Bank of Chicago 2001.	Integrated approach using Genetic Algorithm (GA), fuzzy neural network. Method is known as Genetic complementary learning (GCL).
[17]	Considered non-structured and nonlinear characteristics of stock market prediction	Shanghai Stock Exchange	Combined approach using Improved particle swarm optimization algorithm (IPSO) and fuzzy neural network that optimizes the network training process.

[18]	forecasting and trend prediction	stock data from Nasdaq-100 for 24 months as main index and data of the companies listed in the Nasdaq100 index	Combination of ANN and Fuzzy Inference System (FIS).
	cs of stock market time series	2002 for 10 stocks	
[22]	Forecast stock market considering linear as well non-linear parameters	Closing price of 25 stocks from 14-05-2013 to 30-12-2013	Hybrid approach using ARIMA,ESM, and Recurrent Neural Network

Table III. Comparative Analysis of Stock forecasting techniques using Hybrid Approaches

Reference	Objective	Dataset Used	Techniques Used
[19]	forecasting stock price and other economic indices	Chinese Shanghai stock market collected for the period from January 2008 to November 2008	Associates News mining techniques with time series analysis
[20]	Captures linear as well as non-linear characteristics of stock market time series	Closing and opening of the Shenzhen Integrated Index (SZII) and the Dow Jones Industrial Average Index (DJIAI) respectively.	Combines Exponential Smoothing Model (ESM), autoregressive integrated moving average model (ARIMA), along with back propagation neural network (BPNN)
[21]	Captures linear as well as non-linear characteristi	Closing price from Oct. 21, 2002 to Dec. 31,	Combines ARIMA model and the SVMs model

V. CONCLUSION AND FUTURE WORK

This paper provided an exhaustive discourse on the existing stock market price prediction methodologies. The existing techniques were roughly divided into three categories –Statistical Approach, Artificial Intelligence Approach, and Hybrid Approach. The statistical approaches basically capture linear characteristics whereas non-linear characteristics are captured by artificial intelligence approaches. In order to accommodating both of these characteristics hybrid models were imposed. These combined approaches often achieve better performance while forecasting.

Based on our understanding of researches pursued in this field, the following areas can be earmarked for future work:

1) Incorporating impactful factors such as past histories of each companies- reason of uptrends and downtrends, price-earnings ratio, bonus declarations, and dividend declarations may enhance the performance of forecasting tools.

2) More analysis and emphasis on attributes like volume, volatility can yield high-performance foresting mechanism. Global economic trends often generate momentum to stock market. Investigating the momentum, volatility in stock market can be estimated. However, other interfering factors such as current socio-economic structure, currency risk, political issues, and natural disaster can also be taken into consideration.

3) As stock market yields an enormous amount of data, a big data based distributed approach may be considered for better and faster processing. In fact, big data based approach can be assimilated with machine learning and statistical approaches can guide for an informed decision making tool.

4) Hybrid approach based predictions that consider both linear as well as non-linear contexts can be still explored while designing an effective stock market prediction tools. Though neural network based framework yields significant result, implementing it further with more complex problem solving approach like Fuzzy logic as in [17] [18] [2] [3] will obtain better predictions.

A forecasting model should focus on both short as well as long-term predictions. However, implementing all the above mentioned schemes into one single framework can achieve a very high accuracy forecasting tool. This future tool can outperform well over the state-of-art.

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