

Analysis and Survey of Stock Market Prediction Techniques over the last decade

Charanjeet Dadiyala, *Department of Information Technology, RCERT, Chandrapur, Chandrapur, India.*

Dr. Asha Ambhaikar, *Department of Computer Science & Engineering, Kalinga University, Raipur, Raipur, India.*

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Abstract:

Data Analysis and Machine Learning algorithms play very vital role in various fields and application including forecasting and investment in stock markets. Forecasting stock market patterns is very useful because correctly forecasting stock prices may contribute to moneymaking returns by making the right decisions. Several analysts and researchers have always been mindful of stock market predictions. In the current domain of framework, various techniques are developed to predict stock market trends. But, due to non-stationary, blasting, and volatile results, stock market forecasting is a major challenge, and thus making it quite difficult to take decisions regarding investment for spinning the big money, and hence stock price analysis and prediction is a promising and exciting challenge. Academic researchers have upgraded many predictive models to predict stock prices. Nonetheless, there are several negative aspects in the previous methods after analyzing the past research, namely, strict quantitative assumptions are essential, human interactions are essential in the forecasting process and an acceptable scope is difficult to be identified. Due to the problems identified, proposing a hybrid and integrated method to predict the stock market prices seems to be promising at present as this approach can blend many different approaches to improve the overall performance of the model. After studying many research papers over the last decade, it may seem that hybrid method framework looks more promising to provide more desirable results as compared to the individual methods.

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1. INTRODUCTION

Stock Market affects many sections including trading, firms, businesses, education, real-estate etc. which eventually affects economy. Hence, researching the stock market looks promising. But, financial markets are very challenging to research, as it is very uncertain, dynamic, non-linear and non-stationary in its nature. Hence, stock market forecasting has become one of traders and stakeholders' serious concern [6][7][24] because correct and accurate stock price forecasts has desirable benefits and productive advantages, and unreliable and inaccurate forecasts can have catastrophic ramifications.

One of the most important, famous and debated theories related to stock market is EMH which stands for Efficient Market Hypothesis, and it states

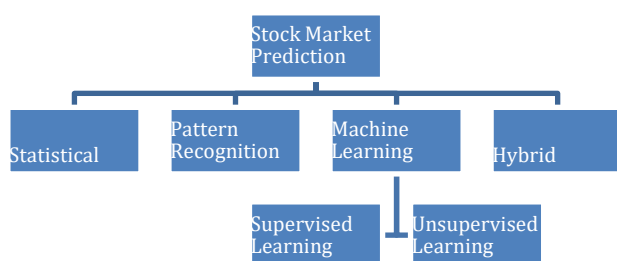
that price movements are volatile & uncertain and it is a futile attempt to forecast financial market. But with time, EMH and its reliability has been cross-examined as many researchers found the quite opposite when they applied new analysis techniques including tools of data mining, artificial intelligence, for prediction. [33][24]

Due to the daunting, complex and ever-changing stock market environment, numerous strategies came into the big picture in attempt to forecast stock prices. Here, in this paper, stock analysis and stock predictions are explored and studied. Incorporating the research over the last decade, this paper focuses primarily on modern techniques, addressing the major challenges they face, and recent accomplishments in stock market analysis and forecasting. [3][30][31]

The rest of this paper covers 5 sections as mentioned: Classification of various popular stock market prediction approaches and its background review have been covered in Section 2, whereas a detailed survey on the methodologies covered in previous section have been described in section 3, followed by section 4 with a brief discussion about the overall literature survey of section 3 and section 5 having a conclusion after the overall discussion over previous sections.

II.. CLASSIFICATION OF STOCK MARKET PREDICTION APPROACHES

Approaches for stock price analysis and forecasting are divided into three broad categories that could overlap namely, fundamental analysis, technical analysis, and technological approaches. Fundamental analysis analyzes and intends to quantify economic, monetary and financial factors using financial reports and statements. [25][27] Technical analysis is an analytical approach for forecasting market trends which shows that prices change in patterns that are influenced and governed by the ever changing consumer preferences against different economic, industrial, monetary, political and psychological factors. The technical indicators are undoubtedly one of the major stock market investing criteria and they play an important role in buying / selling stock signals. [3]



Classification of Stock Prediction Techniques

However, due to the boom in technological approaches and methodologies, the categorization of stock prediction approaches can be identified in much refined way and are further narrowed into four

categories with respect to the recent advancements, as shown in figure 1.

During the initial times of research in Financial Market, before the new popular techniques, it was **statistical techniques** that gave the platform for analyzing, evaluating and forecasting stocks. Few popular techniques of statistical financial forecasting are Exponential Smoothing, The combination of two models namely, AR stands for Auto-Regressive and MA stands for Moving Average is identified as ARMA and ARIMA stands for Auto-Regressive Integrated Moving Average. [7] [26]. These techniques are identified as the simplest form of statistical techniques i.e. univariate analysis, as it considers only one variable in the process. On the other hand, there are other techniques which use multiple variables such as regression analysis, Discriminant analysis and conjoint analysis.

Pattern Recognition centres on frequent data patterns and variations which have typically been used by investors to decide whether to invest or not. Stock price patterns are capable of assuring a shareholder of the future growth of that share. TM stands for Template Matching and PIP stands for Perceptually Important Points are two popular and universally acknowledged techniques for pattern recognition in stock market prediction. [29] [34] Where TM approach facilitates the feature of matching pictographic image for object identification with a given stock pattern, PIP approach comprise the method for reducing the data points i.e. reducing time-series dimensions.

Soon after the technological boom of **Machine learning**, it has been identified as one of the worthy tools for analysis and forecasting of financial markets. Machine learning has two types: Supervised and Unsupervised Learning. [25] For training the algorithm, a set of input data which is already classified along with the observed output data are available in supervised learning, which map the former with the latter and eventually the model can predict the expected output, when trained. [27] Whereas, for training the algorithm, in the case of unsupervised learning, only the output data is

available, which is neither classified nor observed. The main task of unsupervised learning is to train the model in the given dataset for finding a trend, association, or cluster. [33] Many Basic Preliminary techniques were earlier popularly used, but eventually with time got replaced and outperformed by more efficient and better-performance algorithms. [4] [28]

Eventually, the newest addition being deep nonlinear neural network topologies which proving its significance in time series prediction is Deep Artificial Neural Networks which supports multiple variables as input. [6][14]

Sentiment analysis is the method of forecasting stock prices by automated textual repository analysis such as stock market-specific news feeds or tweets and public corporations. It has the enormous capacity at using sentiment inputs from an unstructured text to maximize system output to forecast stock market price patterns. [18] [32] [35]

The **hybrid** approach incorporates many different techniques to enhance the performance of the overall model. For example, a hybrid of many statistical methods, a hybrid combination of many techniques that uses technical indicators, a hybrid combination of few machine learning techniques with few statistical methods, or a hybrid of few pattern recognition techniques with few sentiment analysis methods. [15] Hybrid method gives freedom

to incorporate multi-source data to be analyzed, used and processed with other prediction techniques. This hybrid method gives the possibility for numerous combinations of almost all the techniques available with us. [3] [11] [12] Hybrid approach needs an added overhead for the amalgamation of the output data from various individual methods to generate the final result & output and lastly, to make the final conclusion.[1] Figure 1 depicts the various popular stock prediction techniques.

III. LITERATURE REVIEW

A. Machine Learning

1)Supervised Learning:

This [20] compared a Kalman filter with recurrent neural networks and found that LSM outperformed ESM to predict stock prices, where LSM stands for liquid state machine and ESM stands for echo state machine.

They [14] focused on several ensemble methods such as KF, AB and RF which were very less explored at that time, where KF stands for kernel factory, AB stands for adaboost, RF stands for random forest and their work emphasized on how important is to incorporate these methods for prediction

TABLE I: LITERATURE REVIEW OF MACHINE LEARNING BASED RESEARCH PAPERS

Year of Study	2012	2014	2016	2018
Description	Movements of stock market for short term	frequent patterns in charts by exploring and predicting the trend	selection of technical indicators	Movements of stock market
Approaches	HRK & R K-means clustering	Sequential chart pattern	DT, RF, Naïve Bayesian Classifier	SVM, ANN
Methods	Unsupervised ML	Unsupervised ML	Supervised ML	Supervised ML
Accuracy	71%	56%	79%	70.33%
Reference	[20]	[20]	[9]	[5]

This [10] was mainly focused on the long term prediction with designing a method that enabled them to forecast check if the valuation of any company is higher or not by 10% for the time period of one year or so.

This [9] study emphasized how the process of selection of technical indicators for the prediction plays a vital role. They used 10 microeconomic variables and 3 macroeconomic variables as the input using DT, RF, and Naïve Bayesian Classifier model and acquired high accuracy (78-80%).

This [5] implemented a long term prediction model enabled them to find out how exponentially the prices are inclining towards up or down as well as to observe the movement of price, using ML training algorithms like back propagation and Adam.

2)Unsupervised learning:

They [20] based their work on the movements of price, for shorter term, using clustering techniques such as HRK and R K-means, which uses the capital statements of the company. They showed in their comparison that SVM outperforms for calculating better results and accuracy including the average profits.

They [17] planned their work of prediction, in finding the frequent patterns in the financial charts, followed by exploring and predicting the trend, resulting in the profit on real market. Table I summarizes the significant work based on machine learning approaches

B. Sentiment Analysis

They [21] emphasized on the potential of twitter datasets to be used in forecasting. They studied the correlation with prediction of closing prices, they used neural network, and trained it, with a dataset of more than ten million tweets with company's financial data and got the results with around 87.6% accuracy but the model was time-consuming and

expensive. This model didn't acknowledge the significance of the factors to be considered during the prediction.

They [22] extended the study of [21] by adding the method to generate the average values from values available to be replaced with missing values in the dataset. They further used Tweet Filtering, Daily Score Computation and Score Mapping. They studied, applied and compared the model with 4 algorithms. Their results observed in capturing the public mood and indicated a decent profit over a range of 40 days with an approximate accuracy of 75.56%.

They [17] published their work emphasizing the use of company reports and their text analysis and text classification, and then adding the feature of sentiment analysis. They used companies' published 8-K reports; feature extracted only the considered unigrams/parameters (recent movements, NMF Index, Volatile index, etc). Multilayer perceptron, Regression and RF were tested, and eventually results showed RF outperformed the rest of the techniques. Table II summarizes the significant work based on Sentiment Analysis approach.

Their results surprising was positive only when the prediction was performed using the textual extraction method, and negative results were generated when appended with sentiment analysis method. They finally made a conclusion that stated as the model stays fruitful only when it is used for short term analysis and prediction with approximately 8-10% more accuracy.

They [16] researched on prediction using News Articles where the sentiments (positive/negative) are analyzed, using two ML (Supervised) algorithms, MLR which works on regression of linear with support of multiple variables as input with GD and NE. They first created a sentiment dictionary with data clustering of two classes, positive and negative, using Bing API. Their results concluded that MLR-

GD: Gradient Descent (approx 81.82% accuracy) was more efficient than MLR: NE, Normal Equation (approx 54.54% accuracy).

They [13] extended the research on sentiment analysis on Stock Prediction further by their prediction model where five different algorithms were studied, implemented and their results were compared, namely, SVM, Naive Bayes, RF, DT and NN. They used two datasets, one of Tweets and one of Stock Prices. These datasets were extracted for two weeks duration. The features for classification in

sentiment analysis were Words and its weight, POS Tagging and sentiment shifters.

The results had the accuracy ranging 56% to 67.65% with future scope of extending the period of prediction to a month, using a non linear method and to use other feature extraction classification sentiment analysis methods aiming for better accuracy and efficient model.

They [8] have developed and modeled two self-defined textual representations, which is used to detect the public.

Table II: LITERATURE REVIEW OF SENTIMENT ANALYSIS BASED RESEARCH PAPERS

Year of Study	2011	2011	2014	2014	2018
Description	changes in public mood on Twitter	changes in public mood on Twitter + missing values generation in dataset	text analysis and text classification on company reports + sentiment analysis	Created a sentiment dictionary with data clustering of two classes, positive and negative, using Bing API	tweet data from Twitter & price data from Yahoo Finance
Approaches	Neural Network	Regression, Regression, SVM and SOFN	Multilayer perceptron, Linear Regression and RF	MLR with GD & NE	Implemented two self-defined textual representations
Accuracy	87.6%	75.56%.	83.56%	81.82% , 54.54%	70-71.2%
Reference	[21]	[22]	[17]	[16]	[4]

mood in the tweets. They collected tweets for 1 year using Twitter API and price datasets were fetched from Yahoo Finance and were pre-processed. Instead of two, here they implemented three classifiers during feature extraction, namely, positive, negative and neutral, using Word2vec and N-gram. Results proved a strong correlation between sentiments over social media and prediction methods with good accuracy (70-71.2%) leaving the future

work using much more number of tweets along with more accuracy too.

They [4] further elaborated the research environment with two-year price movements of 88 stocks are selected to targets. They used two datasets, tweet data from Twitter and price data from Yahoo Finance. Their experimental results were ranged between 50-59% accuracy implying room for improvement in the accuracy of the model.

A. Hybrid

They [23] have combined two different approaches, one statistical method and one machine (supervised) learning method which result in a hybrid system, capable of better prediction with accuracy of 92.1%. The model simply worked on Feature extraction using statistical and Feature selection using decision tree and finally making the predictions.

They [19] emphasized in the data to be gathered from various capital markets all around the globe which can be used to forecast in a better fashion in hybrid approach using the ML techniques. They focused their study on Single Feature Prediction (70.8% accuracy), Long Term Prediction (85% accuracy for longer than 30 days) and Multi-Feature Prediction (74% accuracy) using SVM and MART (a decision tree based boosting algorithm).

They [15] have adopted deep learning to predict the trend of stock prices and after comparing the results with SVM they have narrowed the betterment of deep learning tools in hybrid mode for better results. Here [12] they have emphasized on combining the short and long term movements of prices, using neural network with around 6% improvement with accuracy of 65%.

In this study [11], they came up with the idea of developing a hybrid model for prediction by combining linear and non-linear methods that not only outperforms NN but also captures the change in prices at lightning speed.

They compared Long Short-Term Memory (LSTM) recurrent neural network (RNN) and deep neural networks (DNN) to conclude that both are suitable for making daily predictions whereas the LSTM RNN outperformed the DNN [3] in making weekly predictions. This study is important they have taken non-stationarity into account unlike most of the research

They proposed to develop a multi-source multiple instance model spans over multiple sources having consistencies over the data unlike the previous that commonly use only one data source. They considered SVM for basic prediction method in combination with tensor-based learning approach and nested Multi-Instance Learning [1] model. **Table III** summarizes the significant work based on hybrid approach.

IV. DISCUSSION

One of the most important aspects for stock prediction is what kind of data can be effective and useful, even though the discussion and debate has been happening since almost five decades in the field of economic analysis, engineering and finance. Even though, there are many studies and researches have published on the same, we can say stock prediction is still can be termed as a challenging task at hand. Although over time and with the evolution of web and its data.

The modern web has the feature of interconnected format of data, embedding many hidden properties, sentiments, connections and relationships among many data points which may be exploited to extract a pattern of interest. These kinds of patterns and its recognition can eventually prove to be useful in the successful task of prediction.

So, in fact, it can never be termed as complete data, without the Internet Data available around us. Having the historical data is not enough information to be used for prediction. Hence, it can be concluded that the information required for better prediction must have more social media, modern web data than just the technical historical data which can be used to map connections between people's emotions and how are they going to decide to invest or not. Another important observation can be seen that the room for improving the accuracy is very much visible and available with the previous researches.

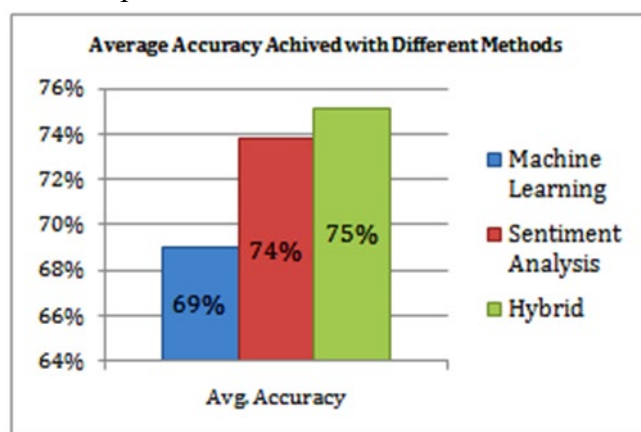
TABLE III: LITERATURE REVIEW OF HYBRID METHOD BASED RESEARCH PAPERS

Year of Study	2010	2012	2014	2015
Description	Feature extraction, Feature selection	Single Feature Prediction, Long Term Prediction, Multi-Feature Prediction	Trend Extraction	long-term events & short-term events combined
Approaches	Hierarchical Hidden Markov model, DT	Correlation, SVM, Decision tree	Neural Networks	Neural Network
Methods	Statistical, ML	Statistical, ML	Deep Learning	ML
Accuracy	92.1%	70.8%, 85%, 74%	59%	65%
Reference	[23]	[19]	[15]	[12]

V. CONCLUSION

After a detailed walk-through of various stock prediction methods over the last decade, the evolution showed that with time, many techniques proved to be effective at different times, but amid the existence and availability of voluminous amount of interconnected web data, it is not enough to consider only single source or single technique in the process of prediction.

It can clearly be observed from the above discussion and literature survey, that value-based analysis is generally not sufficient in order to predict the stock correctly. In order to develop a much better and accurate system for prediction of stock market, one needs to take into consideration multiple parameters like company's performance, its feedback on social media, its previous stock trends etc.



As the nature of interconnected format of data (Historic Data & Internet Data) and the above discussion, it looks promising enough to use data as input from multiple sources to achieve the task of prediction by designing a model which processes inputs from multiple sources independently using different Machine Learning, Natural Language Processing and Sentiment Analysis (various methods among prediction techniques). Various algorithms can be used for each of the component, which were discussed in literature review, and then applied to the prediction system individually. All the components can be combined using a machine learning layer, which can perform semi-supervised training using pre-existing datasets of all the individual components. (Multiple sources)

So, proposing an integrated hybrid system which will take into consideration multiple kinds of data streams including twitter feeds, real-time company feedbacks, recent stock prices and social media handles of the company, and then finally train an artificial intelligence based prediction model in order to find out the next trends in the company's stock price. The model must have higher accuracy in comparison with the other hybrid models summarized in table III. Along with this, it also should work in real-time for on-the-fly detection and price prediction.

After the discussion, it's very much evident that with time, and based on the figure 2, hybrid method is proving to be one of the most effective, efficient and promising methods for achieving better results.[1][2] It seems like the start of an era for the path breaking study and exploration of hybrid methods and hybrid models.

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