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# Predictive Analytics for Financial Forecasting – Past and Present

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## Abstract.

Predicting prices of shares is an intractable problem and has drawn the attention of investors and computer scientists. This review paper explores machine learning techniques that have been used for the purpose of building effective share price prediction model, in the last decade or so. Various linear and non-linear machine learning algorithms, neural network structures, data sources and commonly used metrics for evaluation of results in the research papers have been categorized. The implementation methods and reproducibility have been studied. A summary of the technical papers is prepared as well as a brief description of each paper is included. The study has been carried out to investigate possibility of making profit through day trading on the stock market using relatively low computational power available to retail investors.

**Keywords.** Stock price prediction, LSTM, Neural Network

## 1. INTRODUCTION

The term stock market is used for exchanges where publicly held company shares are bought and sold. There are defined set of regulations which govern the operation of stock exchanges. The stock market allows buyers and sellers to meet, interact and transact. Stock market allows price discovery of shares and serve as a bell weather of overall economy. It ensures fair price, liquidity and transparency to participants' competing in open market. In olden days stocks were issued in physical form but nowadays the operations are done electronically with shares in dematerialized form.

Prediction of share prices lies in the interdisciplinary domains of finance and computer science. Although Efficient Market Hypothesis (EMH) states that price movement of share happens randomly and technical, fundamental or any other analysis will not yield consistent above average profit to investors. Any new information in the market is

immediately reflected in stock price and it is not possible to generate excess returns. However many researchers and investment houses disagree with the hypothesis and have beaten the market average consistently and made profit for their investors.

Satish et al. proposed a system for predicting intraday trading volume using VWAP (Volume Weighted Average Price) with expected alpha trajectories of stock prices at 5 to 30 minute intervals [2]. In intraday trading an investor is allowed to transact in stocks during the day and square off his position at the end of the day. Vella and Ng used a hybrid method utilizing London Stock Exchange data at 1 min interval [3]. Chang and Lee combined Genetic Algorithm (GA) and Markov Decision Process and proposed a new framework for stock price prediction and developed a decision support system for devising stock trading strategies to yield better results than benchmark [6]. Nelson et al. applied LSTM networks for analyzing and predicting stock market price movements using data from Brazilian Stock Exchange [7].

Intrinsic value of a company is evaluated in Fundamental analysis i.e. prospects, profits, long term plans and potential of the company, with a view to investing in the company in the long term. Technical analysis only evaluates charts and trends of current prices of the stock, with a view to short-term opportunity of making profit.

Today even a retail investor has access to a host of facilities available at affordable cost. The objective of retail investor is to invest in the stock market and get a return on his investment, which would be better than his chosen benchmark like return on bank fixed deposit rates. There are online brokers which allow an individual investor to trade in margin, allow usage of proprietary or bought-out software packages [25] for algorithmic trading enabling him/her to deal with large amount of data and learning relationships between input features and prediction target. They use models for prediction and algorithms for taking trading decision in the stock market. When a retail investor wants to invest in stock market, he has to interact with the stock exchange through a broker. The brokers have the approval of the stock exchange and the systems to allow online transactions directly with the exchange. There are brokers who allow investors to participate in multiple markets simultaneously, thereby spreading out risks and opportunities. Also market sentiment can be factored into decision making based on a collection of online news and twitter data.

Normally, a retail investor does stock trading manually by selecting and buying a particular stock and remains invested for a long period waiting for the value of the stock to appreciate and then sell it at a profit. Investment banks and portfolio management companies use algorithms to do stock trading. The potential of profit by stock trading through algorithms have attracted many asset management companies and investment banks. They are investing in artificial intelligence research and deep learning models to make their trading decisions more profitable. However, despite the continuous new technical developments and participation of big players there is still a space more an ordinary retail investor to make enough profit to justify investing in stocks.

Although our focus is on trading application in stock exchanges, Machine Learning (ML) and Deep Learning techniques have been widely in many real life domains [21] [22]. The insights gained from this review will also apply for other time series prediction problems, for example, in Foreign Exchange, Cryptocurrency trading.

## 2. RELATED WORK

The price movements of stocks are dynamic, volatile and non-linear. Multiple factors e.g. global economic conditions, unexpected events, politics, affect local markets and a company's performance. This makes price prediction very challenging. A lot of data have to be analysed to find patterns in the data. Data Scientists, researchers, financial analysts continue to explore analytical techniques to detect trends in the stock market and / or individual stock. Algorithmic trading uses automated, pre-programmed trading strategies to execute orders.

Gandhmaland Kumar have done a systematic review and study of techniques for price prediction in stock market. It is a review of 50 research papers and various research methods such as Bayesian Model, Fuzzy Classifier, ANN, SVM classifier, NN, ML methods used for prediction of share prices [23].

Hu et al. conducted a survey of selected papers for prediction of Foreign Exchange prices and Stock prices using Deep Learning (DL) methods [24]. In this survey, papers are selected and classified according to different DL methods e.g. CNN, LSTM, DNN, RNN, RL and others. Results are presented through most used performance metrics e.g. Root Mean Square Error, Mean Absolute Percentage Error, Mean Average Error, Mean Square Error, Accuracy, Sharpe Ratio and Return Rate. Currency and Stocks exhibit similar behavior in many respects, both are affected by market sentiments and traders use technical indicators and charts to predict their behavior.

Sharma et al., conducted a survey of well-known efficient regression approaches such as Radial Basis Function (RBF) regression, Sigmoid Regression, Linear Regression for predicting the stock market prices which will increase their profits, while minimize their risks [27].

Kumar et al. surveyed various Core Computational Intelligence approaches (ANN, GA etc.) prediction of prices in major stock exchanges [26].

## 3. CHRONOLOGICAL ROADMAP OF CONDUCTED SURVEY

This survey has been done with 20 research papers during the year 2013 to 2021 from prominent databases like IEEE, Elsevier, Springer and others.

Based on the techniques used in the selected papers a chart has been prepared to get an idea of techniques used by researches, at a glance (Fig. 1).

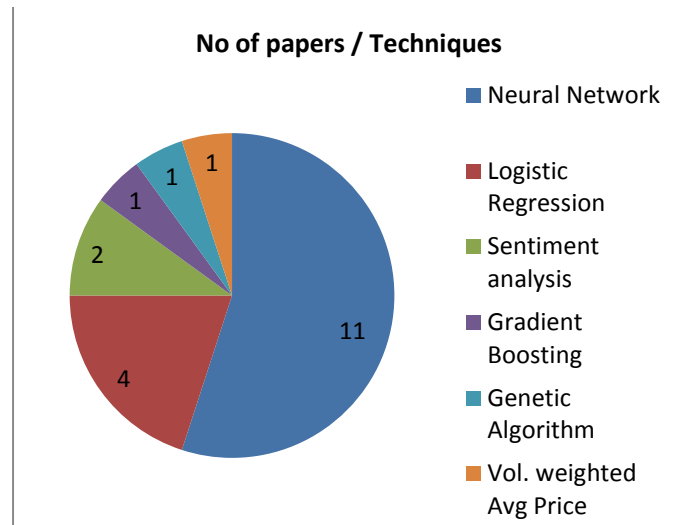


Fig 1: Methods/ techniques used vs.Number of research papers

The following chart shows the year-wise selection of papers, at a glance (Fig. 2).

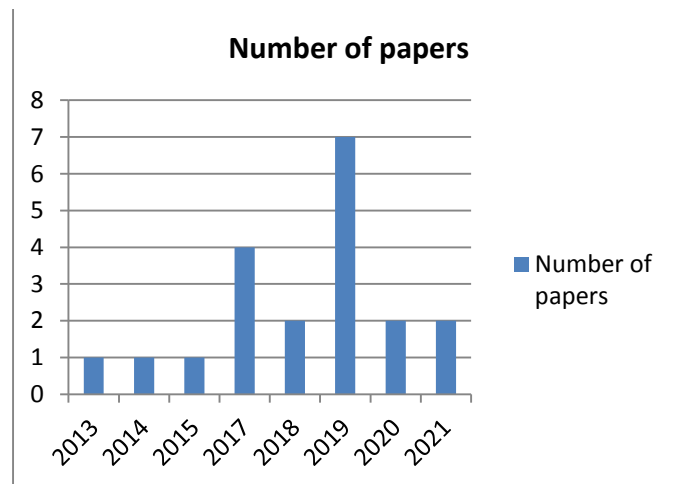


Fig 2 : Year-wise number of selected papers

Table 1 presented below, shows a chronologically arranged list of relevant technical papers that have been reviewed in the area of Predictive Analytics for financial forecasting with emphasis on stock price prediction.

Table 1: Summary of reviewed papers on financial forecasting

<b>Year</b>	<b>Author</b>	<b>Technique</b>	<b>Data Source</b>
2013	Ticknor	Bayesian ANN	Microsoft & Goldman Sachs stock price [1]
2014	Satish et al.	Modified VWAP	DJIA and Russell 3000 stocks [2]
2015	Vella and Ng	Hybrid Fuzzy Logic with NN	London Stock Exchange [3]
2017	Ananthkumar et al.	Logistic Regression	BSE SENSEX data [4]
2017	Krauss et al.	Deep NN, GBT, RAF	S&P 500 data [5]
2017	Chang and Lee	MDP and GA	Taiwan Stock Exchange [6]
2017	Nelson et al	LSTM	Brazilian Stock Market [7]
2018	Selvin et al.	Deep Learning	NSE data [8]
2018	Hiranshahet al.	MLP, RNN, LSTM CNN	NSE data [9]
2019	Zhang et al.	Predictive Regression analysis, Recursive estimation window	Chinese Stock Exchange [10]
2019	Wei	LSTM with attention layer	Chinese Stock Market [11]
2019	Berradi and Lazaar	PCA and RNN	Casablanca Stock Exchange [12]
2019	Sun et al.	ARMA-GARCH-NN	US Stock Exchange [13]
2019	Karhunen	Algorithmic sign prediction using LR	Data from 11 stock markets [14]
2019	Long et al.	S&S kernel	Medical Industry data [15]
2019	Brzeszczyński and Ibrahim	modelled by stochastic parameter regressions	American, European and Australasian stock markets [16]
2020	Nevasalmi	Gradient Boosting	S&P 500 data used [17]
2020	Istiake et al.	Bidirectional LSTM	Google Stock Market data [18]
2021	Kumar	PSO-BPNN	Stock data from NSE [19]
2021	Kim and Suh	MOM and SWMOM	Stock data from US stocks [20]

#### 4. SURVEY DETAILING WITH INSIGHTS

In this section, we have detailed the findings of each research papers and found out the techniques, pros and cons faced by each researcher for their forecasting.

Various Neural Network based methodologies have been used for forecasting. Ticknor proposes Bayesian artificial neural network to forecast behavior of financial market [1]. Vella and Ng built a system adopting a hybrid method in conjunction with a popular neural network (NN) trend prediction model [3]. Krauss et al. analyzed Deep Neural Networks (DNN), Gradient-Boosted-Trees (GBT), Random Forests (RAF) and their effectiveness [5].

Nelson et al. studied the use of LSTM networks, on the problem of prediction of movements of share price, using data from Brazilian Stock Exchange[7]. Selvin et al. employed a sliding window for predicting future value of shares in the short term [8]. Hiranshah et al. used historical prices of stocks of a company and used various types of Deep Learning architectures for predicting stock price[9].Wei proposes a LSTM Neural Network with Attention layer, to overcome time-lag limitations of LSTM NN using three representative stocks of Chinese Stock Market[11]. Berradi and Lazaar integrated Principal Component Analysis (PCA) and Recurrent Neural Network (RNN) to predict stock price using data from Casablanca Stock Exchange [12].Sun et al. used a machine learning approach to capture intraday patterns for stock market shock forecasting using data from US stock market [13]. Istiake et al. suggested that Bi-directional LSTM performs better than LSTM when properly tuned model parameters are used[18]. The results obtained by the study of Kumar proved the PSO-BPNN (Particle Swarm Optimization-Back Propagation NN) showed highest prediction accuracy in intraday stock price [19]

Some researchers of the selected papers used Logistic Regression in their study. Ananthkumar et al. proposed Logistic Regression and certain macro financial variables to analyze which ratios are affecting stock prices [4]. Zhang et al. used Predictive Regression Analysis and Recursive estimation window[10]and Karhunen used logistic regressions, logistic regressions with regularization and classification for algorithmic sign prediction[14]. Brzeszczyński and Ibrahim investigated if magnitude and direction of returns can be modeled with stochastic parameter regressions to generate stock market trading signals[16].

Some researchers have used news contents and sentiments of the market in their strategies. Long et al.used a kernel of semantics and structures [15].Kim and Suh suggested sentiment-weighted trading for better performance in momentum and short term reversal situations[20].

Other strategies seen in the selected research papers are proposed by Satish et al. for predicting intraday trading volume using VWAP (Volume Weighted Average Price) with expected alpha trajectories of stock prices at 5 to 30 minute intervals[2].Chang and Lee combined Markov Decision Process (MDP) and Genetic Algorithms (GA) in a novel analytical framework to develop a decision support system stock trading strategies to yield better results than benchmark[6]. Nevasalmi proposed a new multinomial classification approach to forecast stock prices. He showed that in a real time trading simulation, machine

leaning method outperformed the benchmark buy and hold strategy. The gradient boosting algorithm performed best in both economic and statistical criteria used [17].

## 5. CONCLUSION

In some of the papers it can be seen that sophisticated AI/ML techniques have been used on historical data in order to predict future data. In intraday trading of stocks, it is important if the closing price of the day can be predicted one day in advance. In other words, from historical data up to the previous day, it is possible to predict the closing price of next day. Data of share prices is available from NSE which gives Opening price, Closing price, High, Low and Traded Volume. From this data various methods of predicting closing price of next day and accuracy thereof, have been studied.

For intraday trading, not only choosing the right stocks but also it is important to enter and exit at the correct time and the stakes can be high in margin trading. To achieve accuracy, technical analysis is the answer. A correct combination of technical indicators and Closing Price, predicted with AI methods, if used in a suitable trading algorithm to make BUY/SELL/HOLD decisions every 5 or 10 minutes, has the potential of beating a benchmark like Fixed Deposit interest or chosen Market Indices in the short to medium term.

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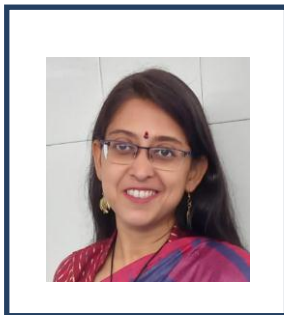


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