

A Three-Dimensional Approach for Stock Prediction Using AI/ML Algorithms: A Review & Comparison

S. Srinivasulu Raju
Assistant Professor,
Dept of EIE
Velagapudi Ramakrishna Siddhartha
Engineering College
Vijayawada, A.P.
srinu85raju@gmail.com

P Pandiyyan
Associate Professor,
Dept of EEE
KPR Institute of Engineering and
Technology,
Coimbatore, Tamil Nadu, India
pandyyan@gmail.com

M. Srikanth
Assistant Professor,
Dept of EIE
Bapatla Engineering College
Bapatla, A.P.
msrikanthjobs.bec@gmail.com

B. Teja
III-B.Tech, Dept of EIE
Velagapudi Ramakrishna Siddhartha
Engineering College
Vijayawada, A.P.
tejabuddepu007@gmail.com

K Guravaiah
Assistant Professor,
Dept of CSE
Indian Institute of Information
Technology Kottayam,
Kottayam, India
kguravaiah@iiitkottayam.ac.in

K. Sai Tarun
III-B.Tech, Dept of EIE
Velagapudi Ramakrishna Siddhartha
Engineering College
Vijayawada, A.P.
saitarunkara@gmail.com

Abstract— For last few years, there has been significant research on application of AI/ML algorithms in stock prediction and stock market. Prediction in stock market is challenging as it is affected by various factors related to global markets, domestic markets, company related and overall sentiments of people. Stock market prediction can be done based on three aspects that is fundamental analysis, technical analysis, and sentimental analysis. In this paper, we have reviewed various AI/ML algorithms that can be used in predicting stock markets. We have covered all the three aspects of prediction and AI/ML algorithms applied in each one of them. After reviewing some research papers, we have implemented a model which has given us 85% accuracy, we have achieved 10.28% return from our model portfolio, in last three months and 175% return in last one year.

Keywords—Stock Prediction, Artificial Intelligence, Machine Learning, Technical Analysis, Fundamental Analysis, Sentimental Analysis

INTRODUCTION

Purchasing and selling shares of corporations with public markets is known as stock trading. It is the fundamental idea at the centre of every financial and commercial activity. With the establishment of joint stock corporations in Europe, stock trading was born and played a crucial part in European imperialism. In India, the first stock exchange was established in 1875 known as Bombay Stock Exchange. It was also the first stock exchange in Asia. India has two main exchanges namely Bombay Stock Exchange (BSE) and National Stock Exchange (NSE).

A. Understanding the mindset of trader/investor

While taking a position in the stock market, a trader must have information and knowledge about that

stock and company. The trader needs to analyze the data and pattern to reap maximum returns.

There are primarily three ways to analyze a stock and its data. The trader can use either of these three ways or combine them before executing the trade.

1. Fundamental Analysis:

Fundamental analysis is about analysing the economic reports like balance sheet, profit and loss report and cash flow report of the company and deriving financial ratios from these reports. Then we need to look at historical financial performances and ratios of the company before investing in it. We also need to do management and promoter analysis. Value investing and growth investing are two types of strategies used in important investigation.

2. Technical Analysis:

In technical analysis, we try to predict future price movement based on past price movements. We need understanding of important price levels, chart patterns and indicators. Data about price and volume plays important role in technical analysis.

3. Sentimental Analysis:

In sentimental analysis, we try to take advantage of market sentiments driven by news, economic factors, or emotions. To analyse sentiments, we must take help of social media platforms, news, websites, prominent investors, and companies.

Algorithm	Datasets	Inference	Accuracy	Limitations
Convolutional neural networks	Korean News Articles and Stock Data	Word vectors created from this neural network, allow sentimental analysis, in different languages	0.3034 correlation value	Nature of Korean Language reduce accuracy
Naïve Bayes	Twitter and news headlines	Stock volume is correlated with trading volume, mood indicators are correlated with extraordinary returns.	0.59 accuracy score with Microsoft	Despite a company's high closing prices, investing in it would not be a wise move given its sentence score.
Sentiment feature vector analysis	A news archive from FINET2	The news-poor stocks can use new-rich stock data	0.38 with Yahoo stocks	The selection approach based on sector categorization is insufficient because commerce contains a variety of enterprises, even though they are all part of the same sector.

Table 1. Comparison of AI/ML algorithms on sentimental analysis

B. Role of AI/ML in stock trading and investing

In past few years, stock prediction using AI/ML algorithms have got lot of popularity. We can apply AI/ML algorithms in all the three aspects of prediction i.e. Fundamental, technical, and sentimental analysis. Researchers have said no to the theory of random walk and agreed that historical data do tend to take importance while predicting stock price. They also concur that mood also tends to play a part in deciding stock price during evaluation[6].

The stock market behaves as a highly complicated non-parametric dynamic system and is non-linear in nature. It is influenced by many factors like interest rates, foreign exchange, politics, policies, psychology, economy, etc. [6]. The Indian stock market is influenced by RBI policies, company related factors, political events, investor's expectations, global markets etc. [4].

The big data strategy, which tries to gain insights from a substantial amount of publicly available data and analyses this data on platforms like Hadoop, is one method for forecasting stock values [3]. Performing calculations based on neural networks is the fundamental idea behind the deep learning approach [4]. Long-term dependencies are a challenge, however the Long Short-Term Memory (LSTM) [5] kind of Recurrent Neural Network (RNN) is employed to solve this issue. Analyzing the sentiments on social media data [6] or news stories that assist in understanding the general trend that a particular company's or sectors' shares may take based on a collective view is another technique to forecast stock prices. Since the value of a stock is sometimes viewed as a time series model, time series analysis [7] is another well-liked method for predicting stock values.

In this research paper, we have discussed and compared different AI/ML algorithms to predict stock price movement based on fundamental, technical, and sentimental analysis.

C. Objectives of study

1. To determine various machine learning algorithms that are currently used to predict stock market movement and price.

2. To understand and determine the factors and data that affect the stock market index and sectors.

3. To understand various machine learning algorithms used for sentimental analysis for stock market news.

4. To analyse literature on AI/ML on stock prediction.

II. LITERATURE REVIEW

A. Sentimental Analysis

A text analysis approach called sentiment analysis, commonly referred to as opinion mining, finds polarity (such as a positive or negative view) in stock news, twitter feeds, and popular websites.

Understanding people's emotions is crucial for investors since, in the age of social media, everyone who invests expresses themselves more honestly than ever before. Brokers and applications can listen carefully to investor input and customise suggestions and services to suit their needs by automatically assessing investor feedback, such as comments in survey replies and social media chats.

Previous studies have shown the need for personalized sentiment dictionary. Students from School of Electrical Engineering at Korea University [1] employed deep learning techniques such Convolutional Neural Networks (CNN) and Long Short-Term Memory, as well as word tagging done by hand and positive indexing (LSTM) [2]. The model was created on the correlation of the positive index and the reoccurrence worth of the stock the next day. Since this was only for a Korean Stock news, we will be creating our own sentiment dictionary for Indian news.

We can also use Artificial Neural Networks for sentiment analysis [8]. Data for the study was gathered from stock-specific websites like Stock Twits. Sentiment analysis was done on every tweet that was taken from Tweepy. The market information came from Yahoo. The neural network was trained on this data to predict a closing price, but this was also correlated with

the sentence score of the stock in question [16], to predict if the price might go down. The training of this network was by the Levenberg-Marquardt algorithm finds error using mean square error. The log sigmoid [8] function was used as the activation function for the neural network. Although for this project, the dataset was only used for 5 important companies and not all sectors. Now since we are including all sectors, we will also be including news-poor stocks [9]. Stocks such as MRF tires and Ramco cements that do not have much movement in stocks. For this we will use the stocks of news-rich in sector to make our model substitute it for the news-poor stocks. Stocks such as Apollo tires and Shree cements can help with the sentiment analysis for the news-poor stocks. This is possible. The words in news stories, for instance, are searched up in the emotion dictionary and associated with other sentimental dimensions if they contain any affective elements with the aid of sentimental transfer learning [9]. Each word can be represented by an emotion feature vector of the same length because the sentimental dimensions are predetermined in the dictionary.

B. Fundamental Analysis

They help in forecasting future stock prices while combining various factors such as industry, economic and company's value to help gain insights about the intrinsic value of the company.

The study of fundamental elements includes looking at everything that can have an impact on a security's stock price, from macroeconomic factors like the nation's economy and market conditions to microeconomic factors like the efficiency of the company's management. A lot of information on the past performance and anticipated future performance of businesses, industries, and the economy as a whole must be evaluated by an investor before making an investment decision if they want to be objective and scientific.

The impact of fundamental analysis using different measures on the success of the index has been examined in earlier studies. These research took into account numerous stock markets and fundamental and technical indicators from different countries.

Prakash K. Aithal et. al. [11] examined how macroeconomic parameters affected India's National Stock Exchange (NSE) and Bombay Stock Exchange (BSE). The suggested approach determines the correlation matrix of each macroeconomic statistic taken into consideration. Using validation methods such as the Kaiser-Meyer-Olkin and Bartlett tests, it is demonstrated that dimensionality reduction is required and multicollinearity exists. These macroeconomic metrics are utilised to forecast stock market movement using an artificial neural network.

Silpa K S et. al. [12] did a study with regards to essential investigation on certain IT companies which were listed at NSE. It took into consideration various factors such as GDP, IIP, Fiscal deficit, inflation.

Company Analysis was also done using indicators such as extra pay-outs ratio, P/E ratio, Debt-Equity ratio. She studied the intrinsic value with market value and analyzed through this company whether stocks of a company were undervalued or overvalued.

Joseph D Piotroski et. al. [14] evaluated whether a basic accounting-based approach could provide significant returns when used on a single firm. He demonstrates how the market's incapacity to perceive these predictable patterns contrasts with strategy's ability to forecast future corporate performance. This study provides new information about the profits made by small, financially struggling businesses and the relationship between those profits and past performance.

Yuxuan Huang et. al. [15] compared artificial neural networks for stock prediction utilizing fundamental financial ratios in comparative research that was presented. The goal of the study was to compare the relative returns of the chosen portfolios to each architecture's performance while also taking the benchmark stock index into account. The findings demonstrate that one can sample winners and losers from a sample universe of stocks separately.

Investors are compelled to heavily rely on basic aspects in their investing decisions due to the significant feature of capital market instruments. The goal of fundamental research is to identify and evaluate the variables that affect the price of securities and various indicators and parameters needs to be taken into consideration while conducting fundamental analysis.

C. Technical Analysis

In this type of analysis, Indicators and historical data play an important part. Predictions are typically solely backed by probability based on past trends and data [3]. Data comprises details regarding the stock's opening price, closing price, high, and low points for a certain time period. Along with that we also look at volatility and volume of the stock. With help of different ML algorithms (Regression, classification), Deep learning algorithm we can derive various information. Out of all parameters, date and closing price are most important. Using the closing value of a stock we calculate two more parameters –Momentum' and 'Volatility' [7]. Apart from this, we can extract important structures grounded on Candlestick Pattern by means of Unsupervised Learning like K-means clustering. The production can be used as input for other machine learning algorithms [10].

Indicators include moving averages, Bollinger bands, VWAP, Stochastics, RSI etc. Let us understand different AI/ML algorithms that can be applied to technical analysis data to predict stock movement [13]. In the table below, lists of algorithms and the datasets used are described that can be used in technical analysis.

Algorithms	Dataset	Inference	Accuracy
Random forest and J48 bagging algorithm [17]	Indicators like MACD, Stochastics, RSI, Bollinger bands	Daily stock prices for various stocks during the previous five years are recorded, and based on price movement, values for the RSI, MACD, Bollinger Bands, and Stochastic (KDJ) are created. These values form the basis of the buy, sell, or hold decisions. The J48 Algorithm can handle qualities that are discrete and continuous. Bagging works because it uses many copies of a same model that have been trained on various datasets to increase accuracy.	68% accuracy was achieved when applied on 1000 stocks with minimum Reward: Risk ratio of 3:1.
Fuzzy logic, Fuzzy inference system [18]	Opening and closing price based on candlestick, Bollinger bands data	Candlestick data and Bollinger bands data was used to determine strength of Buy, Hold and Sell call. Total of 9 functions were created to generate strength and type of the call. The fuzzy inference system provided 48 rules to evaluate these functions.	After 36 evaluations system provided 94.44% of accuracy.
Recurrent Neural Network, Deep Learning, Long short-term memory [20]	Historical data of the stock that includes Open, Low, High, Close and Date	Used MinMaxScaler to apply normalization on the data for feature scaling. RNN computation is done in three steps i.e., from input stage to hidden stage, first hidden to next hidden stage and from last hidden stage to output stage.	For Infosys, 97.64% accuracy was achieved using 60-time steps and RMSprop as optimizer
SVM, Random Forest, K-Nearest Neighbor, and SoftMax [19]	Date Open, High, Close, and Volume. Twelve technical indicators have been used for the model prediction.	For the purpose of predicting stock price, the supervised machine learning algorithms SVM, Random Forest, KNN, and SoftMax have been used. The outcomes demonstrate that the Random Forest method beats all other algorithms in terms of accuracy for huge datasets. When we use fewer technical indicators, each algorithm's ability to forecast stock market developments performs less accurately.	73% accuracy was achieved using SVM algorithm
Naïve Bayes Algorithm [21]	Date Open, High, Close, and Volume and Twelve technical indicators	The Nave Bayes algorithm exhibits the best accuracy results when the size of the dataset is decreased.	81% accuracy achieved with Naïve Bayes.

Table 2. Comparison of AI/ML algorithms on Technical analysis

III. PROPOSED METHODOLOGY

After reviewing different research papers and algorithms, we have discussed few points and present our conclusions for future research. In our discussions, we found following things:

- Stock market prediction is complicated and depends on various factors.
- The AI/ML algorithms can be used to predict stock market fundamentally, technically as well as taking sentiments in consideration.
- In fundamental analysis, we saw about various macroeconomic factors as well as company related factors affecting the price movement. ANN can be used to predict the movement based on macroeconomic indicators.
- In technical analysis, we use price levels and technical indicators to predict the movement. Various algorithms like Random Forest, Naïve Bayes algorithm and fuzzy logic can be used on combination of indicators like Bollinger bands, MACD, RSI and stochastics. Random

forest works best with large dataset, Naïve Bayes works best with smaller dataset. Fuzzy logic can be used for determining the strength of the predicted call.

- Sentimental analysis plays an important role with advent of social media and gives investor extra confidence before executing a trade. Neural Network, LSTM, Levenberg-Marquardt algorithm can be used for sentimental transfer learning and predict the confidence level in the stock.

After our literature review, we have implemented a model to test our theory by applying this three dimensional on the Indian stock market. This would help investors in taking informed decision after analyzing stocks fundamentally, technically, and confidently.

IV. IMPLEMENTATION

A. Fundamental Analysis

With help of different combinations of analysis focusing on macroeconomic factors and financial ratios we were

able to shortlist companies that performed financially well in current financial year and recent quarters.

The main parameters considered were:

- 1) ROE
- 2) ROCE
- 3) Debt/ Equity
- 4) Cash flow generation
- 5) Profit generation QoQ, YoY.

```
0 Dixon Technolog.
1 Alkyl Amines
2 Astrazeneca Phar
3 KSE
4 Rudrabhish. Ent.
5 Diamines & Chem.
6 Jyoti Resins
7 Intense Tech.
8 T & I Global
Name: Name, dtype: object
```

Figure 1. Shortlisted companies on the basis of free cash flow

These companies were shortlisted as they showed a growth greater than industrial growth, with positive free cash flow generation and stronger sector growth than overall economy.

B. Technical analysis:

Once companies are shortlisted, Random forest and J48 bagging algorithms were applied and with help of indicators and oscillators Buy, Sell and Hold signals were generated for that instance of time.

Indicators and oscillators used were:

- 1) 20 Combination of Moving averages
- 2) RSI
- 3) MACD
- 4) Stochastics
- 5) ADI
- 6) William percent range
- 7) Bull Bear power

The signals were classified into following ways:

- 1) Strong Buy
- 2) Buy
- 3) Hold
- 4) Sell
- 5) Strong Sell

```
{'RECOMMENDATION': 'BUY', 'BUY': 15, 'SELL': 1, 'NEUTRAL': 10}
```

Figure 2. Recommendation for Dixon Technologies with the help of oscillators and moving averages.

Bagging works because it uses many copies of a same model that have been trained on various datasets to increase accuracy.

C. Sentimental Analysis

We used web scraping to get news articles for the stocks in question. We also have added a binary feature which sets to 1 if the close value of the stock increased the next day and 0 if the close value of the stock decreased the next day, this allowed us to compare the test and train sets to find out how accurate our sentiment model was, which came out to be 85% with the Dow Jones stock we used for testing. We also calculate the subjectivity and polarity of the score to give a proper score to the stock in comparison to the others. We used the Vader Sentiment Library for the sentiment dictionary.

```
print(classification_report(y_test, prediction))
```

	precision	recall	f1-score	support
0	0.88	0.79	0.83	281
1	0.83	0.91	0.86	316
accuracy			0.85	597
macro avg	0.85	0.85	0.85	597
weighted avg	0.85	0.85	0.85	597

Figure 3. Classification of predicted closing values of Dixon Technologies based on the sentiment analysis.

V. RESULT

The whole model was tested using back test data and following results were derived for last 3 months:

We tracked not only the stock price returns but also dividend returns so as to estimate overall performance of the model.

		Return				
Current Price	Current Value	Capital Gains	Dividends	Total Gain inc Currency	Avg Years	Total Return
4269	7361.98	2900.84	0	2994.61	0.25	68.57%
5327.7	7352.55	2267.78	13.8	2388.47	0.25	47.98%
3245.65	7352.55	-2308.06	0	-2104.98	0.25	-22.26%
2290.95	7352.55	849.37	0	986.07	0.25	15.49%
182.75	7352.55	3019.47	0	3110.56	0.25	73.33%
260.1	7352.55	-1687.61	0	-1497.58	0.25	-16.92%
475.2	7352.55	2321.65	0	2427.41	0.25	49.29%
32.6	7352.55	-2514.75	0	-2307.33	0.25	-23.89%
92.45	7352.55	-23.86	0	131.2	0.25	1.82%
	66182.36	4824.83	13.8	6128.43		10.20%
	Total Return	8.03%	0.02%	10.20%		
	CAGR	48.16%	0.12%	48.29%	0.25	

Table 3. Three months return from model portfolio.

For the same time frame Nifty 50 index fund gained 13.4% slightly outperforming the model portfolio.

For last 1-year returns:

		Return				
Current Price	Current Value	Capital Gains	Dividends	Total Gain inc Currency	Avg Years	Total Return
4269	7361.98	6125.71	1.38	6176.39	1	520.35%
5327.7	7352.55	5626.44	27.6	5722.88	1	345.32%
3245.65	7352.55	2011.41	4.53	2228.95	1	43.46%
2290.95	7352.55	4222.75	112.33	4459.9	1	148.42%
182.75	7352.55	6125.45	10.06	6184.44	1	524.92%
260.1	7352.55	3062.85	113.07	3347.01	1	81.27%
475.2	7352.55	5186.39	38.68	5311.46	1	255.39%
32.6	7352.55	4307.78	45.11	4474.32	1	153.06%
92.45	7352.55	2938.63	0	3114.67	1	73.50%
	66182.36	39607.41	352.76	41020.03		160.77%

	Total Return	155.23%	1.38%	160.77%	
	CAGR	158.71%	1.38%	160.09%	1

Figure 4. One Year return from model portfolio

For the same Time frame Nifty 50 Index fund gained 76.9%. Therefore, the model successfully outran the market returns achieving the desired goal.

VI. CONCLUSION AND FUTURE WORK

Fundamental Analysis allows us to filter out financially strong companies that have generated free cash flow on YoY basis by evaluating net cash flow, ROCE, ROE and Profit Growth Rate. Technical Analysis provides us with proper buy/sell signals with help of combination of moving averages, oscillators and indicators. Sentimental Analysis allows us to analyze the opinions of people for a particular product or for a company and give us a subjectivity and a polarity score to help in comparison. So, instead of investing in a stock based on its closing prices, we would recommend that you analyze the stock on the basis of these three factors, to get better returns. It is required to identify combinations of moving averages, which may give one better accuracy and increase their sentimental model score by using a specific sentiment dictionary for the Indian stock market. One can also apply value investing principles to get better results from fundamental analysis.

REFERENCES

- [1] J. Kim, J. Seo, M. Lee and J. Seok, "Stock Price Prediction Through the Sentimental Analysis of News Articles," 2019 Eleventh International Conference on Ubiquitous and Future Networks (ICUFN), Zagreb, Croatia, 2019, pp. 700-702, doi: 10.1109/ICUFN.2019.8806182.
- [2] M. Cliché, "BB_twr at SemEval-2017 Task 4: Twitter Sentiment Analysis with CNNs and LSTMs", Proceedings of SemEval-2017, 20 April 2017
- [3] S. Lauguico et al., "A Fuzzy Logic-Based Stock Market Trading Algorithm Using Bollinger Bands," 2019 IEEE 11th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM), Laoag, Philippines, 2019, pp. 1-6, doi:10.1109/HNICEM48295.2019.9072734.
- [4] A. Sachdeva, G. Jethwani, C. Manjunath, M. Balamurugan and V. N. Krishna, "An Effective Time Series Analysis for Equity Market Prediction Using Deep Learning Model," 2019 International Conference on Data Science and Communication (IconDSC), Bangalore, India, 2019, pp. 1-5, doi: 10.1109/IconDSC.2019.8817035.
- [5] Kumar, K. Dogra, C. Utreja and P. Yadav, "A Comparative Study of Supervised Machine Learning Algorithms for Stock Market Trend Prediction," 2018 Second International Conference on Inventive Communication and Computational Technologies (ICICCT), Coimbatore, 2018, pp. 1003-1007, doi: 10.1109/ICICCT.2018.8473214.
- [6] M. Usmani, S. H. Adil, K. Raza and S. S. A. Ali, "Stock market prediction using machine learning techniques," 2016 3rd International Conference on Computer and Information Sciences (ICCOINS), Kuala Lumpur, 2016, pp. 322-327, doi: 10.1109/ICCOINS.2016.7783235.
- [7] S. Ravikumar and P. Saraf, "Prediction of Stock Prices using Machine Learning (Regression, Classification) Algorithms," 2020 International Conference for Emerging Technology (INCET), Belgaum, India, 2020, pp. 1-5, doi: 10.1109/INCET49848.2020.9154061.
- [8] S. K. Khatri and A. Srivastava, "Using sentimental analysis in prediction of stock market investment," 2016 5th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO), Noida, 2016, pp. 566-569, doi: 10.1109/ICRITO.2016.7785019.
- [9] X. Li, H. Xie, Tak-Lam Wong and F. L. Wang, "Market impact analysis via sentimental transfer learning," 2017 IEEE International Conference on Big Data and Smart Computing (BigComp), Jeju, 2017, pp. 451-452, doi: 10.1109/BIGCOMP.2017.7881754.
- [10] [S. Sangsawad and C. C. Fung, "Extracting significant features based on candlestick patterns using unsupervised approach," 2017 2nd International Conference on Information Technology (INCIT), Nakhonpathom, 2017, pp. 1-5, doi: 10.1109/INCIT.2017.8257862.
- [11] P. K. Aithal, A. U. Dinesh and M. Geetha, "Identifying Significant Macroeconomic Indicators for Indian Stock Markets," in IEEE Access, vol. 7, pp. 143829-143840, 2019, doi: 10.1109/ACCESS.2019.2945603. P. K. Aithal, A. U. Dinesh and M. Geetha, "Identifying Significant Macroeconomic Indicators for Indian Stock Markets," in IEEE Access, vol. 7, pp. 143829-143840, 2019, doi:10.1109/ACCESS.2019.2945603.
- [12] Silpa, K.S. & Mol, J. & Ambily, A.s. (2017). A study on fundamental analysis of selected IT companies listed at NSE. Journal of Advanced Research in Dynamical and Control Systems. 9. 1-10.
- [13] R. A. Kamble, "Short and long term stock trend prediction using decision tree," 2017 International Conference on Intelligent Computing and Control Systems (ICICCS), Madurai, 2017, pp. 1371-1375, doi: 10.1109/ICCONS.2017.8250694.
- [14] Piotroski, Joseph. (2001). Value Investing: The Use of Historical Financial Statement Information to Separate Winners from Losers. Journal of Accounting Research. 38. 10.2307/2672906.
- [15] Huang, Yuxuan, "Machine Learning for Stock Prediction Based on Fundamental Analysis" (2019). Electronic Thesis and Dissertation Repository. Huang, Yuxuan, "Machine Learning for Stock Prediction Based on Fundamental Analysis" (2019). Electronic Thesis and Dissertation Repository.
- [16] Y. Kara, M. A. Boyacioglu and Ö. K. Baykan, "Predicting direction of stock price index movement using artificial neural networks and support vector machines: The sample of the Istanbul Stock Exchange", Published in Expert Systems with Applications, vol. 38(5), May1, 2011
- [17] Jose, J., Mana, S. and Samhitha, B.K., 2019. An efficient system to predict and analyze stock data using Hadoop techniques. International Journal of Recent Technology and Engineering (IJRTE), 8(2), pp.2277-3878.
- [18] Hu, Z., Zhao, Y. and Khushi, M., 2021. A survey of forex and stock price prediction using deep learning. Applied System Innovation, 4(1), p.9.
- [19] Obthong, M., Tantisantiwong, N., Jeamwatthanachai, W. and Wills, G., 2020. A survey on machine learning for stock price prediction: algorithms and techniques.
- [20] Yadav, A. and Vishwakarma, D.K., 2020. Sentiment analysis using deep learning architectures: a review. Artificial Intelligence Review, 53(6), pp.4335-4385.
- [21] Sulandari, W., Suhartono, Subanar and Rodrigues, P.C., 2021. Exponential Smoothing on Modeling and Forecasting Multiple Seasonal Time Series: An Overview. Fluctuation and Noise Letters, p.2130003.