Leveraging Machine Learning Techniques for Accurate Stock Market Price Prediction

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Abstract - ***Stock market price prediction is a technique to predict future values of stocks based on technical and fundamental analysis. The ability to anticipate the price of the stock market is a crucial field of study that has recently drawn a lot of interest from traders and investors. A number of variables, including the global economy, politics, and investor expectations, have made it difficult for investors to anticipate the price of stocks . Currently, several prediction methods are available. These include the hybrid model of LSTM and RF, sentiment and relevance scores to make decisions, the Kalman filter, the hybrid model of LSTM, RF, SVM, and ANN, the morphological and HTM models and the hybrid model of ARFIMA-LSTM. The goal of this survey paper is to provide an analysis of stock market price prediction.***

Index Terms - ***fundamental analysis, technical analysis, sentimental analysis, stock market Long short term memory (LSTM), Random Forest (RF), Support Vector Machine (SVM), Artificial Neural Network (ANN), Hierarchical Temporal Memory (HTM), Auto-Regressive Fractional Integrated Moving Average (ARFIMA).***

I. INTRODUCTION

The stock market has grown in popularity as an investment possibility in recent years. The stock market has certain similarities despite its differences. It presents chances for investors to profit from capital growth, and both are influenced by broader political and economic factors. To sum up, investors have a variety of ways to profit from the stock market. While the stock market provides a wide variety of investment returns, they differ greatly in terms of their guiding principles and risk elements. Publicly traded corporations issue and exchange their stocks with investors on the stock market. It offers a wide variety of investment opportunities, from blue-chip equities to small-cap stocks, and from value to growth-oriented businesses. Investing returns can come from dividends, capital growth, or a combination of the two. Yet, there are dangers associated with investing in the stock market because stock values can change owing to a number of variables, including the economy, corporate performance, and geopolitical events.

II. LITERATURE SURVEY

LSTM, RF, SVM, KALMAN FILTER AND BACKPROPAGATION

In order to forecast the directional movement of stock prices for intraday trading, this study [1] suggests a hybrid model that combines the strengths of the long Short-Term memory (LSTM) and random forest (RF) algorithms. Technical indicators, including moving averages, relative strength indexes, and stochastic oscillators, are used to produce the feature vector for each trading interval, which is then given to an LSTM neural network to predict the direction of price movement in the following interval. A Random Forest classifier, which accepts the output of the LSTM and extra technical indicators as inputs, is used to further refine the LSTM's output alternatives, Bitcoin is a relatively new and extremely volatile asset class. Before choosing one of the two options, investors should carefully assess their investment objectives, risk tolerance, and market expertise.

In 2017, the problem addressed in this [1] was to create a machine learning model that could forecast the direction of stock price changes that occurred during the intraday period. This project aims to offer guidance to help traders make educated decisions on whether to purchase or sell stocks. The model's performance is assessed after it has been constructed using technical indicators and historical stock price data as input characteristics. The ultimate goal is to develop a model that is capable of correctly predicting the direction of stock price fluctuations in real time which would be very beneficial for intraday trading. The goal of the study [2] is to identify the best algorithm or set of algorithms for forecasting stock market trends, while taking into account various aspects, including accuracy.

The evaluation metrics used, including accuracy and F1-score, demonstrate the effectiveness of combining the strengths of both models and the average of daily mean returns is calculated (refer to Figure 1). This study provides insights into the application of machine learning and deep learning techniques in intraday trading and may have practical implications for traders and investors in the financial market. LSTM and backpropagation are suited for sequential data and can capture long-term dependencies, while SVM and the Kalman filter are suited for handling noisy and incomplete data. The LSTM algorithm was found to be the most effective in terms of accuracy and reliability for predicting stock prices, followed by SVM, backpropagation, and the Kalman filter.

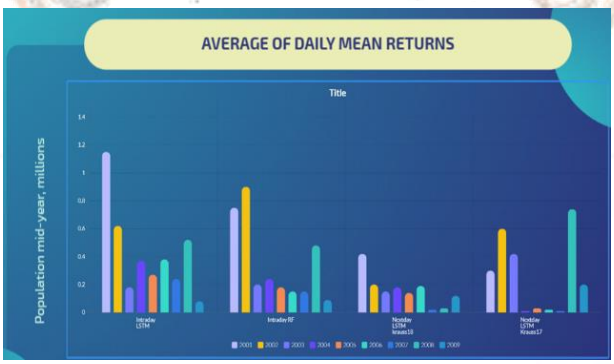

Figure 1: Average of daily mean returns

The neural network is trained to reduce the difference between expected and actual outputs using backpropagation. Also utilized for classification and regression analysis are support vector machines (SVM). Long-term dependencies can be captured by LSTM networks, which are specifically made for processing sequential data, including time series data, and are capable of producing precise predictions. The Kalman Filter is a statistical method frequently used in engineering, control systems, and finance that estimates the state of dynamic systems.

Apple Inc. (AAPL), Amazon.com Inc. (AMZN), Facebook Inc. (FB), Alphabet Inc., the parent company of Google (GOOGL), and Microsoft Corp. are the five equities included in the dataset (MSFT).

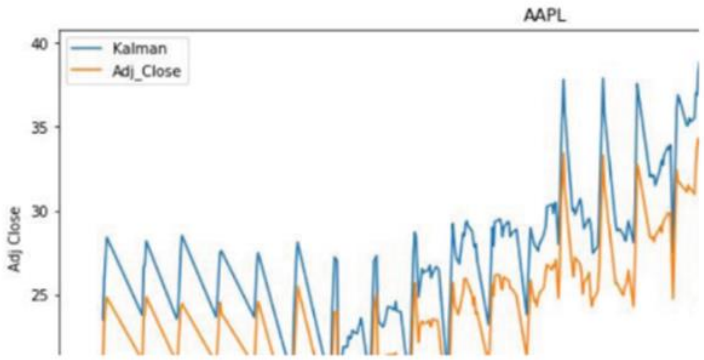

Figure 2: AAPL Stock prediction

In this, the author [2] has concluded that LSTM outperformed the rest of the algorithms, hence the hybrid model [1] achieves an accuracy of 71.17%, compared to 64.29% for the RF model and 55.36% for the LSTM model.

HYBRID MODEL OF LSTM

The research tries to address two challenges: properly projecting financial market trends using time series data. In order to capture the complex dynamics of financial markets and offer more precise forecasts, the authors [3] suggest a novel strategy that blends fractional ARFIMA and LSTM models. With the purpose of supplying more precise and reliable tools for traders and investors in the cryptocurrency and financial markets, the objective is to assess the effectiveness of these proposed models and compare their performance to other conventional and cutting-edge models.

The proposed hybrid model, which combines LSTM and random forest models, was found to outperform the individual models in predicting the directional movement of stock prices for intraday trading. Bitcoin, Ethereum, and Ripple. Another dataset [3] is the S&P 500 stock market index, which consists of daily closing prices from January 1, 1990, to December 31, 2017, totalling 7,971 observations. The EUR/USD exchange rate dataset consists of daily closing prices from January 1, 1999, to December 31, 2017, totalling 4,745 observations. The gold price index dataset consists of daily closing prices from January 1, 1979, to December 31, 2017, totalling 10,958 observations.

The datasets were pre-processed by removing missing values and outliers, and then split into training and testing sets. The training set was used to train the models, and the testing set was used to evaluate their forecasting accuracy.

The fractional ARFIMA model's residuals are supplied as input to the LSTM model, and the model is trained to forecast future values based on the input sequence's historical data. The two system parts are coupled in a "neuro-sequential" architecture, where the output of the fractional ARFIMA model is used to condition the LSTM model. This enables the system to capture both the long-term and short-term dynamics of the financial time series data.

The three financial time series datasets were used to evaluate the proposed system, its performance, and automated trading, he system has the potential to improve the profitability and risk management of trading systems.

By looking for terms associated with cryptocurrencies like Bitcoin, Ethereum, and Ripple in a dataset of 10,000 tweets collected over a six-month period, the authors were able to find their subject.

The authors [3] propose a method for financial market forecasting that is made up of two key parts: an LSTM model that captures the short-term dynamics of tweets collected over a period of six months, using the Twitter API to search for keywords related to the data, and a fractional ARFIMA model that captures the long-term memory and non-stationarity of the financial time series data.

To evaluate the performance of the proposed system, the authors conducted experiments on a dataset of 500 individual stocks listed on the S&P 500 index. The results showed that the proposed system outperformed other state-of-the-art models in terms of prediction accuracy and profitability. The authors also conducted a sensitivity analysis to demonstrate the robustness of the proposed system under different market conditions.

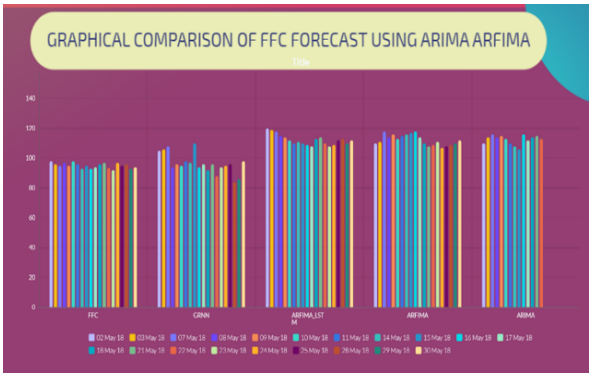

Figure 3: Graphical comparison of FFC Forecast using ARIMA ARFIMA

Overall, the proposed system offers a promising solution to the challenges of stock market prediction, from figure 3, the outcomes demonstrated that the suggested method performed better in terms of forecasting accuracy than the other models, especially over longer forecast horizons.

The long-term memory and non-stationarity of the financial time series data, as well as the short-term dynamics that may influence financial market movements, were all captured by the suggested model. Three financial time series datasets—the S&P 500 stock market index, the EUR/USD exchange rate, and the gold price index—were used to assess the performance of the suggested model. The findings demonstrated that, especially for longer forecast horizons, the suggested model outperformed other conventional and cutting-edge forecasting models in terms of forecasting accuracy. Overall, the suggested model offers a more reliable and accurate instrument for predicting the financial market

SENTIMENTAL ANALYSIS ON THE STOCK MARKET

The authors [6] also use a news sentiment analysis model to generate sentiment scores for news articles related to each stock. The sentiment scores are then combined with the stock price data and fed into the HTM model to improve its prediction accuracy.

Word2Vec and Doc2Vec generate word and document embeddings, respectively, to represent the meaning of words and news articles. They also employed Support Vector Machines (SVMs) to classify news articles into sentiment categories and Latent Dirichlet Allocation (LDA) to identify relevant topics in news articles for individual stocks.

The authors [4] describe this paper as an investigation of the use of sentiment analysis in predicting stock forecasts using machine learning techniques. The authors [4] aim to explore how sentiment analysis, which involves analysing text data to determine the emotional tone of the text, can be used as a predictive tool for forecasting stock prices. The paper aims to determine whether sentiment analysis can provide valuable insights and improve the accuracy of stock price predictions and to contribute to the existing body of knowledge on the use of machine learning techniques in stock market forecasting.

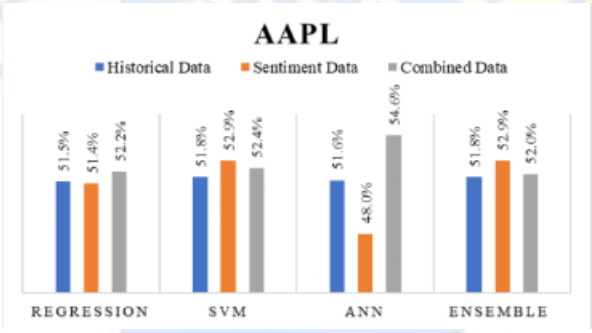

Figure 4: AAPL classification accuracy

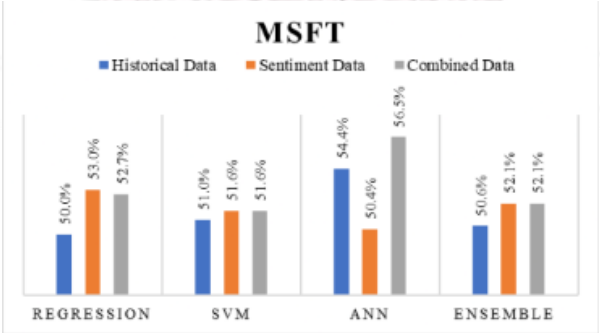

Figure 5: MSFT classification accuracy

The authors [4] conclude that sentiment analysis can be a useful tool for predicting stock prices, especially when combined with machine learning techniques. From Figures 4 and 5, the authors found that a machine learning model trained on sentiment analysis data was able to achieve an accuracy of 60% in predicting the direction of the stock market. However, the authors [4] note that this is a preliminary investigation and more research is needed to further validate the effectiveness of sentiment analysis in stock market

prediction. Overall, the paper suggests that sentiment analysis can provide valuable insights for investors and traders in making informed decisions in the stock market.

In the ML component, the system undergoes three stages: pre-processing, training, and prediction. In the pre-processing stage, the raw stock price data is pre-processed to remove noise and outliers. The authors [6] then used morphological similarity clustering to group similar stock price curves together based on their shape and pattern. In the training stage, the authors [6] utilized hierarchical temporal memory (HTM) to model the patterns and trends in stock prices over time. The HTM model is trained using the pre-processed and clustered data from the pre-processing stage. In the prediction stage, the trained HTM model is used to predict future stock prices based on the input data. Finally, the predicted stock prices are compared to the actual stock prices to evaluate the accuracy of the predictions.

The authors [5] compare both technical analysis and fundamental analysis as two gold standards. Technical analysis is the process of forecasting future market movements by looking at historical market data, primarily price and volume. In order to forecast a company's future stock price, fundamental analysis entails examining its financial and economic statistics, such as revenue, earnings, and assets. These two techniques are frequently employed in the sector and serve as a foundation for comparison with the suggested system.

Three technical indicators, including the Stochastic Oscillator, Moving Average Convergence Divergence (MACD), and Relative Strength Index (RSI), are used in the analysis. These indicators are frequently employed in technical analysis to identify overbought or oversold positions as well as market trend reversals and momentum shifts. The authors [5] utilized several algorithms and models in their automated trading system that combines natural language processing (NLP) and machine learning (ML) with historical data. For NLP, they used

The suggested model obtains an MAE of 207.07, an MSE of 114,434.82, and a DA of 51.55% on the Shanghai Composite Index. The top-performing rival models, such as LSTM, ESN, and ARIMA, contrasted with this, obtain an MAE of 223.24, an MSE of 126,617.88, and a DA of 49.82%.

The suggested model also performs admirably on the CSI 300 index, earning an MAE of 204.16, an MSE of 115,118.61, and a DA of 52.97%.

The research article demonstrates how incorporating news data that is particular to equities can improve trading decisions in the stock market using natural language processing and machine learning approaches. It highlights how crucial it is to analyse news articles' moods and relevancy precisely in order to boost these systems' efficiency.

According to the results, the system achieves a Sharpe ratio of 0.96, which indicates that it generates higher returns for a given level of risk compared to the benchmark methods. The news analysis model attains an average accuracy of 86.5% for sentiment classification and 81.6% for relevance classification.

The Standard & Poor's 500 index responds favourably to the suggested model, with an MAE of 7.14, an MSE of 107.41, and a DA of 56.19%. The best competitor model (LSTM) displays an MAE of 7.89, an MSE of 121.13, and a DA of 53.97% in contrast.

COMPARATIVE ANALYSIS OF CONTINUOUS & BINARY DATA USING ML & DL

The goal of the presented paper [7] is to examine how various machine learning and deep learning algorithms perform when used to forecast stock market movements using both continuous and binary data. The author's goal is to determine which algorithms are most effective at the given task as well as whether the introduction of binary data, such as economic indicators and news sentiment, can increase forecast accuracy. The ultimate objective is to offer insights into how machine learning and deep learning algorithms can be used to forecast stock market movements and to aid financial professionals and investors in making wise decisions.

The research study at hand approaches the problem of predicting stock market trends using machine learning and deep learning techniques through a comparative assessment of multiple algorithms. The researchers use two datasets—one with continuous data (stock prices and volume) and the other with continuous and binary data (news sentiment and economic indicators)—to train and test their algorithms.

The random forest, support vector machine, long short-term memory (LSTM), and convolutional neural network (CNN) algorithms are all evaluated in the study. Accuracy, precision, recall, and F1-score are some of the metrics that are used to evaluate the performance of these algorithms.

To determine if the addition of binary data improves prediction accuracy, the effectiveness of forecasts is analyzed together with the top-performing algorithms. They go over each algorithm's advantages and disadvantages as well as their implications for forecasting stock market developments.

Overall, the study tackles the issue of stock market trend prediction by comparing and testing various machine learning and deep learning algorithms utilizing various datasets and indicators. With this strategy, the researchers may offer a thorough evaluation of the merits of various techniques and offer suggestions for further study and application.

A comparative comparison of various machine learning and deep learning algorithms for forecasting stock market trends utilizing both continuous and binary data is the methodology employed in the paper.

In order to conduct this analysis, the researchers first collect two datasets: one with continuous data (stock prices and volume) and another with both continuous and binary data (news sentiment and economic indicators). The next train and test models on each dataset using four different algorithms: random forest, support vector machine (SVM), Long Short-Term memory (LSTM) neural network, and convolutional neural network (CNN).

These algorithms' effectiveness is assessed using a variety of metrics, including accuracy, precision, recall, and F1-score. The researchers then compare the outcomes to discover which algorithms work best and whether adding binary data increases prediction accuracy.

Figure 6: Statistical analysis of diversified financial indicator

The above figure 6 gives an overview of which financial indicator is well-suited for financial analysis. Finally, the researchers explore the implications for forecasting stock market trends after analysing the advantages and disadvantages of each algorithm. Using both continuous and binary data, this technique enables the researchers to provide a thorough review of how well various machine learning and deep learning algorithms forecast stock market patterns.

The performance of four various machine learning and deep learning algorithms for forecasting stock market trends using both continuous and binary data is compared in the presented work. The dataset and the particular criteria employed for evaluation affect the accuracy of each algorithm differently.

Overall, the findings demonstrate that using binary data instead of solely continuous data greatly increases prediction accuracy. Overall performance was greatest for the long short-term memory (LSTM) neural network, followed by the convolutional neural network (CNN), and support vector machine (SVM) algorithms. The Random Forest algorithm performed the least well out of the four.

The dataset and the evaluation measures have an impact on the model's precision. For instance, the CNN algorithm's accuracy on the dataset containing continuous data was 54.16% compared to the LSTM neural network's accuracy of 57.83%. The accuracy of the LSTM neural network was 68.08% on the dataset with both continuous and binary data, while the accuracy of the CNN algorithm was 65.33%.

The given paper concludes that machine learning and deep learning algorithms can be effective in predicting stock market trends, especially when combined with binary data such as news sentiment and economic indicators. The study found that the inclusion of binary data significantly improved the accuracy of predictions compared to using only continuous data. Among the four algorithms tested, the long Short-Term memory (LSTM) neural network performed the best overall, followed by the convolutional neural network (CNN) and support vector machine (SVM) algorithms.

The study also identified some limitations and challenges in predicting stock market trends using machine learning and deep learning algorithms, such as the difficulty in selecting relevant features and dealing with data imbalance. The researchers suggest that future research should address these challenges and explore new approaches to improving the accuracy and interpretability of predictions.

CANDLESTICKS AND ENSEMBLE MACHINE LEARNING

The author's [8] problem statement for this paper is to develop a more accurate and effective method for predicting stock trends using candlestick charting and ensemble machine-learning techniques. The authors [8] aim to address the limitations of existing stock prediction methods by proposing a novel feature engineering scheme that incorporates both technical and fundamental indicators. Specifically, they propose using a combination of candlestick charting, which involves analysing historical price and volume data to identify patterns, and machine learning algorithms to predict future stock trends. The research is supported by the National Natural Science Foundation of China, highlighting the importance of this problem in the field of finance and economics.

The paper proposes an ensemble machine learning-based approach for stock trend prediction that incorporates a novel feature engineering scheme using candlestick chart patterns. The authors use several machines learning models, including decision trees, random forests, and support vector machines, to predict the stock trend direction. They also develop a feature engineering scheme to extract relevant features from candlestick charts, such as the pattern type, length, and shape.

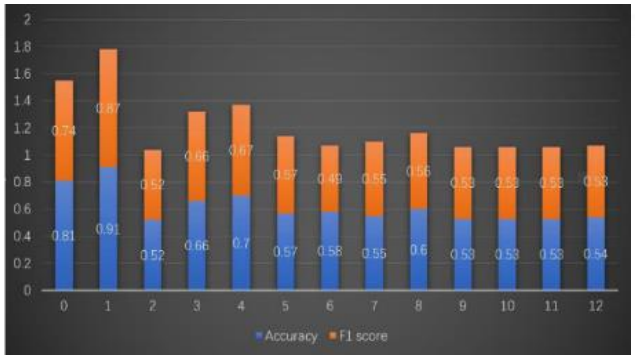

Figure 7: Robustness Test

The proposed method is evaluated on a dataset of Chinese stock market data, and the performance of the models is compared based on accuracy, precision, recall, and F1 score. Overall, as shown in above figure 7, the results suggest that the proposed approach is effective in predicting the stock trend direction, outperforming several baseline models.

They evaluated the performance of their proposed method on the Shanghai Stock Exchange, composite index and achieved an accuracy of 58.94%, outperforming several baseline models. The authors [8] also conducted a sensitivity analysis to demonstrate the robustness of their proposed method.

PREDICTING THE DIRECTION USING EFFECTIVE TRANSFER ENTROPY AND MACHINE LEARNING TECHNIQUES

The authors [9] describe this paper as "developing a more effective method for predicting the direction of US stock prices using transfer entropy and machine learning techniques." The authors [9] aim to address the limitations of existing stock prediction models by proposing a novel approach that combines transfer entropy, a measure of the directional influence between time series data, with machine learning algorithms. Specifically, they aim to investigate the effectiveness of transfer entropy in capturing the causal relationships between stock prices and other relevant variables, such as news sentiment and market volatility, and to evaluate the performance of their proposed method against existing models.

The research is supported by the National Research Foundation of Korea, highlighting the importance of this problem in the field of finance and economics.The model used in this paper [9] is a combination of transfer entropy and machine learning techniques. Specifically, the authors used transfer entropy to capture the directional influence between time series data, such as stock prices, news sentiment, and market volatility, and then used various machine learning algorithms, including logistic regression, random forest, and support vector machines, to predict the direction of US stock prices.

Unfortunately, the paper does not provide specific information about the prediction accuracy of their proposed model. However, they do report that their model outperformed traditional machine learning models such as SVM, random forest, and logistic regression in predicting the direction of stock price movements. They also conducted statistical tests to show that their proposed model incorporating transfer entropy outperformed models that did not incorporate transfer entropy, indicating the effectiveness of their approach.

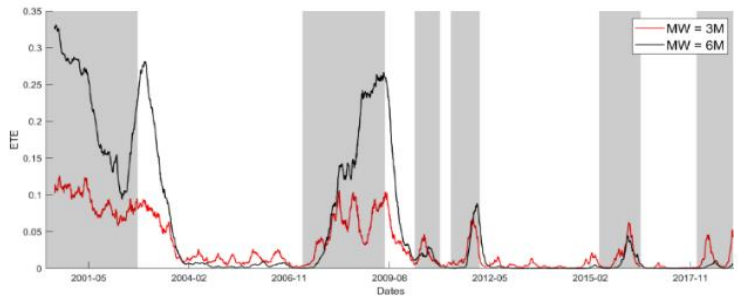

Figure 8: Evolution of average ETE in 3M and 6M moving windows

The authors [9] concluded that their proposed method, which combines transfer entropy and machine learning techniques, is effective in predicting the direction of US stock prices. From the above Figure 8, they found that incorporating transfer entropy into the model improved the prediction accuracy compared to existing models, especially in capturing the directional relationships between stock prices and other relevant variables. Additionally, they demonstrated that their proposed method is robust to changes in the training and testing datasets, indicating its potential for practical application in real-world settings.

The authors suggest that their work contributes to the growing body of literature on the application of machine learning techniques in stock market forecasting and highlights the potential of transfer entropy as a useful tool for capturing causal relationships between time series data.

STOCK MARKET PREDICTION: A COMPREHENSIVE REVIEW AND FUTURE DIRECTION

The proposed study's objectives are to synthesize the literature on the application of machine learning techniques to stock market forecasting and to suggest new lines of investigation. By studying a range of ML approaches that have been applied for stock market prediction, the authors hope to solve the difficulties of stock price forecasting as well as the limits of conventional econometric models.

Additionally, they summarize the results of earlier research that applied the same methodologies, draw attention to noteworthy trends, and draw attention to their shortcomings. To increase the precision and clarity of ML models for stock market prediction, the authors provide potential research fields.

The authors [10] of the cited research article first explore the difficulties in forecasting stock prices and the limits of conventional econometric models before addressing the issue of applying machine learning techniques for stock market prediction. Then they give an overview of several machine learning algorithms, such as decision trees, artificial neural networks, support vector machines, and ensemble methods, that have been employed for stock market prediction.

The results of several studies that employed these methods for stock market forecasting are compiled by the authors, who also note certain recurring themes, including the significance of feature selection and the requirement for non-financial data inclusion. They also go through the study's shortcomings, such as the risk of overfitting and the difficulty in interpreting some machine learning models.

The authors provide prospective research topics based on their analysis of the literature in order to solve the shortcomings and enhance the precision and interpretability of machine learning models for stock market prediction. Incorporating data from social media or news sources, creating hybrid models that include several machine learning approaches, and investigating the interpretability of machine learning models for stock market prediction are some of these study topics.

The presented study is a survey of the literature on utilizing machine learning methods to forecast stock market movements. As a result, the technique employed in the study is a qualitative way of information analysis and synthesis from previously published studies.

The authors of the study do a methodical evaluation of the literature on applying machine learning techniques for stock market prediction, which entails searching for and analysing pertinent publications, summarizing the main conclusions, and suggesting future research avenues. They review the results of earlier studies and critically assess the benefits and drawbacks of various machine learning methods used in stock market forecasting.

The literature on the subject is organized and presented in this study using a descriptive and analytical method. Common themes and limits are noted, and prospective directions for further research are suggested. As a result, the paper's methodology is qualitative and is based on an examination of previous material.

The prediction and accuracy of a particular model are not discussed in the provided paper. Instead, it offers a thorough analysis of numerous machine-learning methods that have been employed in earlier research for stock market prediction. The research results are summarized by the authors, who also note recurring themes and methodological flaws. Additionally, they make suggestions for future lines of inquiry that can enhance the precision and understandability of machine learning models for stock market forecasting. As a result, the article does not offer any particular accuracy or prediction findings.

The paper's conclusion shows the promise of machine learning approaches for stock market forecasting as well as their difficulties and restrictions. In comparison to conventional econometric models, the authors emphasize that machine learning methods have the potential to increase the accuracy and interpretability of stock market forecasts. They do warn that these models are not perfect and that they are susceptible to overfitting, data quality issues, and the inherent volatility of the stock market.

To overcome these issues and enhance the efficacy of machine learning models for stock market prediction, the authors provide a number of prospective research avenues. To help financial professionals and investors make better decisions, they include creating new models that incorporate various methodologies, improving the interpretability of machine learning models, and upgrading data quality and processing procedures.

The conclusion emphasizes the significance of ongoing research into machine learning methods for stock market forecasting since these models have the ability to produce insightful information and facilitate decision-making in the financial markets.

III. CONCLUSION

In conclusion, this literature review has provided a thorough overview of the numerous approaches used to forecast stock market values. Investors and traders looking to make educated judgments in these markets have access to a wide range of tools, from conventional econometric models to more modern machine learning approaches.

Although no one strategy can provide accurate forecasts, it is evident that integrating several strategies and taking many elements into account may increase forecast accuracy. Particularly useful insights into market patterns and assistance in identifying possible dangers and opportunities may be gained by using sentiment analysis, technical analysis, and fundamental analysis.

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