A Critical Analysis of Artificial Intelligence in Stock Market Prediction: A Literature Review

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Abstract: Stock market prediction, a vital responsibility for investors and financial institutions, enables them to make knowledge-driven investment decisions. Artificial Intelligence (AI) techniques, such as deep learning (DL) and machine learning (ML), have exhibited impressive outcomes in the field of stock market prediction due to their ability to decode complicated and nonlinear correlations in financial data. This research paper offers an exhaustive examination of the literature related to AI methodologies for stock market prediction, including machine learning, deep learning, and hybrid models. It also discusses the diverse types of data utilized for stock market prediction, namely historical price data, news articles, social media inputs, and financial statements. Moreover, it includes various evaluation metrics critical for assessing the effectiveness of AI models in stock market prediction. In addition, the paper draws attention to the existing limitations and challenges in the field while highlighting potential avenues for future research. Providing an insightful understanding of the cutting-edge AI techniques for stock market prediction, this paper is a useful resource for researchers and practitioners in the finance industry to make well-informed decisions.

Key Words: Stock market prediction, Artificial Intelligence, Machine Learning, Deep Learning.

I. INTRODUCTION

The stock market is a critical part of the global economy, serving as a platform for companies to raise capital and investors to buy and sell shares. The ability to predict the stock market's future direction has long been a challenge, given the numerous factors that can impact its performance. Researchers have tried to predict stock market since 1990s [1]. However, recent advancements in artificial intelligence (AI), including machine learning (ML) and deep learning (DL), have enabled the development of techniques that hold promise in stock market prediction. According to a report by Grand View Research, the global AI in finance market is projected to grow at a compound annual growth rate (CAGR) of 16.5% from 2022 to 2030, reaching $41.16 billion by 2030 (Grand View Research, 2020) [2]. The increasing availability of big data fuels this growth, the development of advanced machine learning algorithms, and the growing demand for automation in the financial industry. As Sundar Pichai, CEO of Alphabet and Google, noted, “AI is one of the most important things that humanity is working on. It’s more profound than, I don’t know, electricity or fire" [3]. The use of AI in stock market prediction has the potential to help investors make better-informed decisions by providing accurate and timely predictions of future stock prices. By analyzing large volumes of data from various sources, AI techniques can identify patterns and relationships that human analysts do not discern easily, leading to more accurate and timely predictions of stock prices. However, the use of AI for stock market prediction also poses significant challenges and limitations. One of the primary challenges is the lack of transparency in AI models [4], which can make it difficult to understand how the predictions are generated. Additionally, the accuracy of AI predictions can be affected by various factors such as data quality, model selection, and market volatility. Despite these challenges, the field of stock market prediction using AI has made significant progress in recent years. This review paper will provide a comprehensive overview of the current state of research in this field. Specifically, we will review the different types of AI techniques used for stock market prediction, the types of data used for training and evaluating these techniques, the accuracy and reliability of the predictions, the limitations and challenges associated with using AI for stock market prediction, the potential applications of this technology in finance and other fields, and the ethical considerations associated with using AI for stock market prediction. By addressing these topics, we hope to provide insights into the current trends and future directions in the field of stock market prediction using AI.

II. METHODOLOGY

This review paper aims to investigate the use of artificial intelligence (AI) techniques for stock market prediction, with a focus on providing a comprehensive overview of the current state of research in this field. To achieve this goal, we have employed a methodology consisting of three main steps: literature review, analysis, and discussion, as shown in Fig. 1.

Literature Review: In this step, we conduct a comprehensive search of various academic databases, such as Google Scholar, ACM Digital Library, IEEE Xplore, and ScienceDirect, as well as other relevant sources, such as books, reports, and news articles. Our goal is to identify relevant studies that focus on the use of AI techniques for stock market prediction. We use a range of search terms to identify studies related to machine learning, deep learning, neural networks, natural language processing, and other AI techniques used in stock market prediction. We assess each study's quality and relevance based on predefined criteria, such as the study's research question, methods, results, and implications. We exclude studies that do not meet our criteria or are not related to our research question.

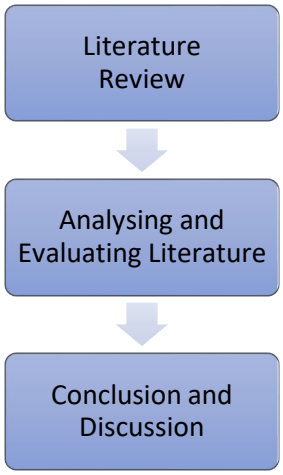

Fig. 1. Overview of Methodology.

The remaining studies are thoroughly analysed and synthesized to provide a comprehensive overview of the use of AI techniques in stock market prediction. Analysis: In this step, we select and evaluate appropriate AI techniques that are relevant to our research question and data. We explain each technique's basic concepts and assumptions and compare their advantages and disadvantages. We also assess the sensitivity of our results to different assumptions and hyperparameter settings. We carefully consider the strengths and limitations of each technique to ensure that our analysis is robust and reliable. In the discussion and conclusion step, we synthesize and summarize our main findings and contributions from applying AI techniques to stock market prediction. We discuss the implications of our results for theory, policy, and practice, and acknowledge the limitations of our study. We suggest possible extensions or improvements for future work and highlight the potential benefits of using AI techniques in stock market analysis and financial planning. Overall, the methodology for this review paper involves conducting a thorough literature review, selecting, and evaluating appropriate AI techniques, and synthesizing and discussing the findings to provide a comprehensive overview of the use of AI techniques for stock market prediction. Our methodology is designed to ensure that our findings are based on a rigorous and systematic analysis of the existing literature and that our results are robust and reliable.

III. LITERATURE REVIEW

In [5], I. Parmar et al. investigated stock market prediction using machine learning techniques, focusing on a dataset obtained from Yahoo Finance, consisting of approximately 900,000 records of stock prices and other relevant values. The data was transformed into a data-frame using the Pandas library in Python and normalized using the sklearn library in Python. The dataset was then divided into training and testing sets, with the test set comprising 20% of the available dataset. Their study employed two machine learning models: a Regression-Based Model and a Long Short-Term Memory (LSTM) Network-Based Model. The Regression-Based Model utilized the gradient descent linear regression algorithm to predict correct values by minimizing the error function. Factors considered for the regression included low, open, high, close, and volume. The R-square confidence test was employed to determine the confidence score, and the predictions were plotted to show the results of the stock market prices versus time, resulting in a confidence score of 0.86625. The LSTM Network-Based Model, an advanced version of Recurrent Neural Networks (RNN), is capable of handling long-term dependencies, making it suitable for stock market prediction tasks that rely on large amounts of data and are dependent on the market's long-term history. The authors addressed the problem of vanishing gradient by implementing an LSTM with a remembering cell, input gate, output gate, and a forget gate. The model comprised two stacked LSTM layers, each

with an output value of 256. A dropout value of 0.3 was fixed to avoid overfitting and increase training speed. Finally, the model was compiled with a mean square cost function to maintain the error throughout the process, and accuracy was chosen as the metric for prediction. The LSTM model resulted in a Train Score of 0.00106 MSE (0.03 RMSE) and a Test Score of 0.00875 MSE (0.09 RMSE), offering more accuracy than the Regression-Based Model.

Parmar et al.'s paper contributes to the growing body of literature on stock market prediction using machine learning techniques by exploring the application of both Regression-Based and LSTM Network-Based Models. Their findings highlight the potential of these techniques in predicting stock market prices and offer insights into their relative strengths and limitations. The results are promising and indicate the possibility of predicting stock market trends with greater accuracy and efficiency using machine learning techniques. In [6], Hiransha M et al. explore the use of deep learning models, including Multilayer Perceptron (MLP), Recurrent Neural Networks (RNN), Long Short-Term Memory (LSTM), and Convolutional Neural Network (CNN), to predict stock prices in the National Stock Exchange (NSE) of India and New York Stock Exchange (NYSE). The researchers selected highly traded stocks from three sectors—automobile, banking, and IT—for NSE and two active stocks for NYSE. The deep learning models were trained on the historical closing prices of Tata Motors from the NSE and tested on data from both stock exchanges. The study employed a dataset from January 1, 1996, to June 30, 2015, containing 4,861 days of closing prices for Tata Motors. Data was normalized to fit a range between 0 and 1, and a window size of 200 was used to predict 10 days into the future. The network was trained for 1,000 epochs. The models were tested on stocks from the NSE and NYSE using the same methodology, and the Mean Absolute Percentage Error (MAPE) was used to calculate the error in the predicted output.

The results demonstrated that CNN outperformed other models, and the neural networks were more accurate than the linear ARIMA model. This finding is attributed to neural networks' ability to identify non-linear trends in the data, which ARIMA fails to do. The study also showed that the network could predict NYSE prices despite being trained on NSE data, suggesting that the two stock markets share common inner dynamics. In conclusion, this research highlights the effectiveness of deep learning models, particularly CNN, in predicting stock prices in different stock exchanges. These findings have significant implications for improving stock market prediction and analysis, which play a crucial role in today's economy. In [7], M. Rout et al. proposed a stock market prediction model utilizing the Artificial Bee Colony (ABC) algorithm combined with an adaptive linear combiner (ALC). The ABC algorithm was developed by Dervis Karaboga in 2005 [8] it was inspired by the intelligent behavior of honey bees, is a population-based search method that balances exploration and exploitation processes to find the optimal solution. In the proposed model, ALC-ABC, the weights of the hybrid model are updated by the ABC algorithm to minimize the mean square error (MSE).

The authors applied the ALC-ABC model to predict two stock market indices, DJIA and S&P500, for 1 day, 1 week, and 1 month ahead using technical indicators. The data was split into training and testing sets, and the weights of the ALC-ABC model were updated using the ABC algorithm. The performance of the proposed model was evaluated by calculating the mean absolute percentage error (MAPE). The prediction results of the ALC-ABC model were compared with those obtained using particle swarm optimization (PSO) and genetic algorithms (GA) combined with the adaptive linear combiner. The comparison showed that the ALC-ABC model had better prediction accuracy compared to the ALC-PSO and ALC-GA models. The MAPE values for next day prediction were less than 1%, and the maximum percentage of errors for 1 month ahead prediction was 2.30% and 2.45% for DJIA and S&P500 stock indices, respectively. In conclusion, the ALC-ABC based prediction model showed improved prediction accuracy for stock market indices using technical indicators when compared to other adaptive parameter learning algorithms, such as PSO and GA. In [9], Kalra et al. proposed a novel stock market prediction model that integrates news sentiment, historical stock price data, and the variance of closing prices of adjacent days to enhance the accuracy of stock market movement predictions. This approach aims to assist investors in making better-informed decisions and reducing financial risks when investing in the stock market. The model forecasts daily price movements by considering all available news and numeric historical data, employing supervised machine learning techniques for training purposes.

News sentiment is extracted and combined with numeric historical prices to create the prediction model. The authors perform text analysis on news data to determine text polarity. For future price movement prediction, the study incorporates stock historical prices, such as open, low, high, and the variance of adjacent days' closing prices.

The numeric dataset for the model is sourced from Yahoo Finance, while news data is collected from online financial websites like Moneycontrol, Livemint, Financial Express, Business Today, and NDTV. Using the Naive Bayes algorithm, the authors employ sentiment analysis to categorize news data into positive and negative sentiments [9]. The proposed prediction model merges numeric news sentiment values, variance, and numerical stock prices to examine the impact of released news, variance, and historical data on stock movements. The integrated dataset is divided into training and testing datasets for predicting future price movements. The prediction model demonstrates that the incorporation of numeric sentiment values and variance with open, high, and low values improves prediction accuracy up to 91.2% using the KNN algorithm. The results also suggest that the variance attribute significantly influences stock price movements. Four machine learning techniques, namely KNN, SVM, Naive Bayes, and Neural Network, are employed for prediction purposes. The study reveals that the proposed model, which combines numeric sentiment values and variance with historical data, offers higher prediction accuracy compared to previous studies, which achieved accuracy ranging from 65% to 86.12%.

In conclusion, the model proposed by Kalra and Prasad [9] effectively investigates the impact of analyzing various types of stock-related news combined with numeric historical data on the stock market. The model's highest prediction accuracy, achieved with KNN, is 91.2%. This suggests a strong correlation between stock-related news and changes in stock prices. Future work may involve incorporating social media data, reviews, and blogs over an extended period that may influence the stock market and considering a higher number of news data instances. In [10], Kusuma et al. proposed a novel method for stock market prediction that employed deep learning neural networks and candlestick chart representation. They used two stock market datasets, including 50 company stock markets for Taiwan50 datasets and 10 company stock markets for Indonesian datasets. The study involved generating period data using a sliding window technique and creating candlestick chart images with computer graphic techniques. The prediction model was built using a Convolutional Neural Network (CNN) learning algorithm. In [10], the authors found that their model achieved the highest performance in sensitivity, specificity, accuracy, and MCC when using long-term trading days period with a CNN learning algorithm. The results demonstrated that the CNN could effectively identify hidden patterns within the candlestick chart images, which aided in forecasting future movements of specific stock markets. Interestingly, adding volume indicators to the candlestick charts did not significantly improve the algorithm's ability to find hidden patterns.

In the same study [10], comparisons were made between the proposed method and existing methods used by Khaidem et al. [11] , J. Patel [12] , and Zhang [13] . The results indicated that the proposed method provided a more accurate forecast for other datasets compared to other methods. For instance, Patel's [12] method achieved an accuracy range of 89% - 92% with trading data from Reliance Industries, Infosys Ltd., CNX Nifty, and S & P Bombay Stock Exchange BSE Sensex, while the proposed method achieved an accuracy range of 93% - 97%. Similarly, Khaidem's [11] method achieved an accuracy range of 86% - 94% using trading data from Samsung, GE, and Apple, whereas the proposed method reached an 87% - 97% accuracy range. Lastly, Zhang's [13] method, which used data from 13 different companies in the Hong Kong stock exchange, achieved an accuracy of 61%, while the proposed method achieved 92% accuracy. In summary, the method proposed by Kusuma et al. in [10] demonstrated its superiority over existing methods in predicting stock market movements, providing better accuracy across various datasets. In [14] Ren et al. proposed an innovative method to forecast stock market movement direction by combining sentiment analysis and the Support Vector Machine (SVM) model. Using sentiment analysis techniques, they collected textual data from Sina Finance and Eastmoney, two major Chinese financial websites, and transformed the unstructured text into daily sentiment indexes. The sentiment indexes were then adjusted for the day-of-week effect and holidays. Applying the SVM model to predict the movement direction of the SSE 50 Index, an important index in China, the authors used a combination of fivefold cross-validation and a realistic rolling window approach. The results showed a significant improvement in prediction accuracy, reaching 89.93% when sentiment features were incorporated with stock market data—an 18.6% increase compared to using only stock market data. Additionally, the authors demonstrated that when their approach was combined with a stop-loss order strategy, it could help investors reduce risks and make more informed decisions. The study also suggested that sentiment analysis could provide valuable insights into asset fundamental values, potentially serving as a leading indicator for stock market movements.

IV. RESULT AND OBSERVATIONS

TABLE 1

Authors	Dataset	Country / Index	Algorithms

I. Parmar et al. [5]	Yahoo Finance (900,000 records)	N/A	Regression-Based Model, LSTM Network-Based Model
Hiransha M et al. [6]	Tata Motors stock prices (4,861 days)	NSE (India), NYSE (USA)	MLP, RNN, LSTM, CNN
M. Rout et al. [7]	DJIA and S&P500 stock indices	USA	ALC-ABC, ALC-PSO, ALC-GA
Kalra et al. [9]	Yahoo Finance, news data from financial websites	N/A	KNN, SVM, Naive Bayes, Neural Network
Kusuma et al. [10]	50 company stock markets (Taiwan50 datasets), 10 company stock markets (Indonesian datasets)	Taiwan, Indonesia	CNN
Ren et al. [14]	Textual data from Sina Finance and Eastmoney, SSE 50 Index	China	SVM

TABLE 2

Authors	Objective	Limitations
I. Parmar et al. [5]	To compare LSTM and regression-based models for stock market prediction	Limited to the dataset; not tested on other stock markets or data sources
Hiransha M et al. [6]	To evaluate various deep-learning models for stock market prediction	Single stock (Tata Motors); not tested on other stocks or indices
M. Rout et al. [7]	To develop an ALC-ABC model for stock market index prediction	Limited to DJIA and S&P500; not tested on other stock market indices
Kalra et al. [9]	To study the efficacy of news sentiment in stock market prediction	Limited to select algorithms; not tested on other data sources or sentiment analysis techniques
Kusuma et al. [10]	To predict stock market trends using deep learning neural networks and candlestick chart representation	Limited to Taiwan and Indonesian datasets; not tested on other countries or indices
Ren et al. [14]	To forecast stock market movement direction using sentiment analysis and SVM	Limited to the SSE 50 Index; not tested on other stock market indices or data sources

This research paper investigated the application of machine learning and deep learning techniques for stock market prediction, focusing on methods proposed by various authors in the literature. The techniques explored included Regression-Based Models, LSTM Network-Based Models, Artificial Bee Colony algorithms, Convolutional Neural Networks, and a combination of sentiment analysis and SVM models. The results across different studies show promising potential in predicting stock market trends with increased accuracy and efficiency. Notably, the LSTM Network-Based Model offered better accuracy than the Regression-Based Model in predicting stock market prices [5]. In another study, the Convolutional Neural Network outperformed other deep learning models in predicting stock prices in the NSE and NYSE [6]. The ALC-ABC model demonstrated improved prediction accuracy for stock market indices compared to other adaptive parameter learning algorithms such as PSO and GA [7]. Furthermore, the model that Kalra and Prasad proposed combined news sentiment, historical stock price data, and the variance of closing prices of adjacent days, achieved a prediction accuracy of up to 91.2% using the KNN algorithm [9]. Kusuma et al.'s method, which employed deep learning neural networks and candlestick chart representation, demonstrated superior accuracy compared to existing methods in predicting stock market movements [10]. Ren et al.'s approach, which combined sentiment analysis and SVM models, significantly improved prediction accuracy, reaching 89.93% when sentiment features were incorporated with stock market data [14].

V. Conclusion

In conclusion, the findings from the literature review suggest that machine learning and deep learning techniques can effectively predict stock market trends and provide valuable insights for investors. Further research can be conducted to explore additional methods, incorporate more diverse data sources, and refine the models to enhance prediction accuracy and applicability in real-world scenarios.

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