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Stock Market Price Prediction Using LSTM

Yash Gaur[1], Yash Singh[2], Utkarsh Singh[3], Mr. Pramit Kumar Samant[4]
Department of Computer Science and Engineering, Galgotias College of Engineering and Technology, Gautam Buddh Nagar, India

Abstract: This research proposes an innovative approach involving the implementation of an LSTM (Long Short-Term Memory) model for forecasting stock prices. The predictive analysis relies on historical data to anticipate future stock movements. The utilization of a Stacked LSTM is advocated for this prediction task, as it effectively incorporates past information, enhancing the accuracy of predictions. The Stacked LSTM model proves advantageous in capturing long-term dependencies within the data, rendering it well-suited for the dynamic and intricate nature of stock market prediction. Following the model's training phase, its efficacy will be evaluated using test data, and subsequently, the model will be applied to forecast stock prices for the upcoming 30 days.

I. INTRODUCTION

Stock market prediction involves forecasting the future value of individual stocks through fundamental analysis of a company's economic health and historical stock performance. The inherently volatile stock market is influenced by global economic conditions, unforeseen events, and a company's financial track record, posing challenges for accurate predictions. Rational and irrational behavior, shaped by physical and psychological factors, adds complexity. Despite these challenges, stock market prediction is crucial for investors to identify optimal times to buy or sell equities. The potential for data analysis to revolutionize this field is significant. The efficient market hypothesis posits that stock prices already incorporate all available information, reacting swiftly to developments. Analyzing historical spot prices influenced by market events enables forecasting future behavior. In predictive analysis, Machine Learning (ML) techniques on historical stock prices play a pivotal role. ML, particularly recurrent neural networks like Long Short-Term Memory (LSTM) networks, excels in uncovering hidden patterns, enhancing forecast accuracy. LSTMs, with long-term memory capabilities, prove effective in modeling sequential data and understanding the intricate dynamics of human behavior, making them suitable for accurate stock price prediction.

II. LITERATURE SURVEY

1) In this paper written by Authors: Ashish Sharma et al Presented at the 2017 in (ICECA) [1] states that, the stock market is primarily nonlinear in nature, and exploration of the stock market is one of the most important issues in recent times. People invest in the stock market based on predictions. For prediction, investors search for methods and tools to increase gains while minimizing losses or risks. Prediction plays a crucial role in stock market business, which is a complicated and challenging process. Traditional styles like fundamental and technical analysis may not ensure the reliability of predictions. To make predictions, regression analysis is substantially used. In this paper, we survey a well-known effective regression approach to forecast stock market prices from stock market-based data. In the future, the results of the multiple regression approach could be improved using a greater number of variables.

2) In the paper authored by Ze Zhang, Yongjun Shen, Guidong Zhang, Yongqiang Song, and Yan Zhu [2] explores the intricate dynamics of the stock market as a non-linear system. Focusing on the Elman neural network, acknowledged for its efficacy in addressing time series challenges, the paper utilizes this network to predict stock market opening prices. Acknowledging the Elman network's limitations, the paper integrates a self-adapting variant PSO algorithm to optimize network weights and thresholds. The resultant model, a self-adapting variant PSO-Elman network, demonstrates superior performance, surpassing traditional neural networks like the BP network and standard Elman network in terms of accuracy and robustness, as confirmed through empirical validation using stock prices.

3) In this paper written by Authors: Yaojun Wang, Yaoqing Wang, Presented at the 2016 IEEE International Conference on Big Data Analysis (ICBDA)[3], the Price prediction in the stock market is considered one of the most problematic tasks due to price dynamics. Former studies established that stock price volatility in the short term is closely related to market sentiment, especially for small-cap stocks. This paper uses social media mining technology for quantitative evaluation of market sentiment, combined with other factors, to forecast stock price trends in the short term. Results of the experiments performed show that, by using social media mining combined with other information, the stock price prediction model can perform predictions with higher levels of accuracy.

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4) In this paper written by Authors: Pramod B S, Mallikarjuna Shastry P. M. [4] states that, the prediction of stock value is a complex task that requires a sturdy algorithmic background to compute long-term share prices. Stock prices are closely correlated with the nature of the market, making it difficult to predict costs. The algorithm proposed in this paper, named Long Short-Term Memory, uses market data to predict share prices using machine learning techniques like recurrent neural networks. In this process, weights are corrected for each data point using stochastic gradient descent. Therefore, such a system will give more accurate results compared to presently available stock price predictor algorithms. The neural network is trained and evaluated with varied sizes of input data to prompt graphical outcomes.

5) In the 2020 IEEE paper [5] written by Md. Arif Istiake Sunny, Mirza Mohd Shahriar Maswood, and their colleagues, the authors introduce a novel framework for stock price prediction. Employing Recurrent Neural Network (RNN) models, specifically the Long Short-Term Memory (LSTM) and Bi-Directional LSTM (BI-LSTM) models, the study emphasizes the significance of hyper-parameter tuning. Through meticulous variations in epochs, hidden layers, and units within layers, the proposed scheme demonstrates high accuracy in predicting future stock trends, as evidenced by Root Mean Square Error (RMSE) measurements. The paper conducts assessments using an openly accessible stock market dataset encompassing open, high, low, and closing prices.

6) In this paper written [6] by Authors: Sreelekshmy Selvin, R Vinayakumar, and colleagues. The forecasting methods that currently exist make use of both linear (AR, MA, ARIMA) and non-linear algorithms (ARCH, GARCH, Neural Networks), but they concentrate on predicting the stock index movement or price prediction for a particular (single) company by analyzing the daily closing price for that company. The proposed system is a model-independent approach. Here, we aren't fitting the data to a specific model; instead, we're identifying the latent dynamics existing in the data using deep learning architectures. In this work, we use three different deep learning architectures for the price forecasting of NSE-listed companies and compare their performance. This paper applies a sliding window approach for forecasting future values on a short-term basis. The performance of models was quantified using the percentage error.

7) In the paper presented by Sneh Kalra and Jay Shankar Prasad [7] at the International Conference [COMITCON 2019], the authors tackle the inherent challenges of forecasting stock market trends, given its stochastic nature. Recognizing the value in diverse data sources like news, blogs, reviews, financial reports, and social media, the study focuses on analyzing fluctuations in stock prices linked to relevant news articles. The paper introduces a daily prediction model that incorporates historical data and news articles to forecast movements in the Indian stock market. Leveraging the Naïve Bayes classifier, sentiment analysis of news text contributes to the prediction model, achieving accuracies ranging from 65.30% to 91.2% through various machine learning techniques.

8) The paper written by Muhammad Firdaus [8], it conducts a content analysis literature review on the application of Artificial Neural Network (ANN) techniques in stock market prediction. Utilizing ProQuest electronic databases, the review spans 2013-2018, employing key terms related to ANN Stock Market Prediction. Out of 129 journals, four met inclusion criteria, utilizing six ANN derivative techniques. Results consistently show high accuracy rates in ANN stock market prediction, with two studies surpassing 90% accuracy and two exceeding 50%. The study concludes that ANN consistently achieves high accuracy, with the Signal Processing/Gaussian Zero-Phase Filter reaching 98.7% accuracy at the Third International Conference on Informatics and Computing (ICIC) in 2018.

9) In the 2018 19th IEEE International Conference paper [9], written by Tanapon Tantisripreecha and Nuanwan Soonthomphisaj present the LDA-Online algorithm, an online learning approach for predicting stock movements. The feature set, including opening, closing, highest, and lowest prices, trains the Linear Discriminant Analysis (LDA). Experimental results on NASDAQ stocks (APPLE, FACEBOOK, GOOGLE, and AMAZON) reveal the model's superior performance in stock prediction. Comparative analysis against ANN, KNN, and Decision Tree in both batch and online scenarios highlights LDA-Online's outperformance, achieving the highest accuracies on GOOGLE, AMAZON, APPLE, and FACEBOOK stocks at 97.81%, 97.64%, 95.58%, and 95.18%, respectively.

10) In the paper [10] authored by Zhaoxia Wang, Seng-Beng Ho, and Zhiping Lin emphasizes the critical role of stock values as indicators for companies, influenced by various factors. Recognizing the dynamic and noisy nature of stock prices as nonlinear time series data, the paper explores the application of machine learning in addressing these complexities. Despite widespread use, predicting stock market trends remains challenging. The paper introduces an innovative learning-based for stock price prediction, considering the impact of news sentiments. Comparative analysis with existing methods highlights the proposed approach's efficacy in reducing Mean Square Error (MSE) using real stock price datasets, providing valuable insights for future research in this domain.

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11) In this paper by Vijayvergia and David C. Anastasiu [11], underscores the enduring interest in predicting stock market prices. The complexity of stock price volatility, influenced by diverse factors, including political, economic dynamics, and investor sentiment, poses challenges for accurate predictions. Prior attempts based solely on historical or textual data have fallen short. Recognizing the correlation between stock movements and news articles, the paper improves prediction accuracy by combining an extensive time series dataset of S&P500 companies' daily stock prices with over 265,000 relevant financial news articles. Leveraging deep learning models and cloud computing resources, the study advances stock price prediction, emphasizing the significance of big data and machine learning in this domain.

12) In the paper authored by Nonita Sharma and Akanksha Juneja, presented at the 2017 2nd International Conference for Convergence in Technology [12], the focus is on predicting future stock market index values based on historical data. Utilizing a decade's worth of historical data from the Indian stock markets, specifically CNX Nifty and S&P Bombay Stock Exchange (BSE) Sensex, predictions are made for various time frames, ranging from 1 to 10, 15, 30, and 40 days ahead. The proposed approach advocates combining predictions from an ensemble of trees within a Random Forest framework using LSboost, denoted as LS-RF. Systematic comparison with the well-established Support Vector Regression reveals that the LS-RF model outperforms, showcasing promise in constructing effective predictive models for stock price forecasting.

13) The paper written by Authors: Sayavong Lounnapha and colleagues [13], endeavors to introduce a predictive model for stock prices anchored in convolutional neural networks, known for their remarkable autonomous learning capabilities. Through training and testing on a dataset that explores the dynamics of Convolutional Neural Networks and the Thai stock market, the study reveals that the model, based on Convolutional Neural Networks, adeptly identifies shifting trends in stock market prices and anticipates them. This capability serves as a noteworthy reference for enhancing stock price forecasts. The observed high accuracy of predictions not only underscores the model's effectiveness but also hints at its potential contributions to advancing financial applications.

14) In the paper by Soheila Abrishami and colleagues [14], the challenges of predicting economic time series are addressed, drawing interest from scholars and proving crucial for investors. The paper introduces a deep learning system dedicated to forecasting stock values on the NASDAQ exchange, utilizing diverse data. Trained on minimal data for specific stocks, the model demonstrates high accuracy in predicting concluding stock values for multi-step-ahead forecasts. It incorporates an autoencoder to eliminate noise, employs time series data engineering for advanced feature integration, and utilizes a Stacked LSTM Autoencoder for multi-step-ahead estimation. Applying a profit maximization approach to guide optimal timings for stock transactions, the results highlight the framework's superiority over prevailing time series forecasting methodologies in terms of analytical accuracy and effectiveness.

15) In the paper written by Achyut Ghosh, Soumik Bose, and their colleagues [15], this paper underscores the exceptional challenge of predicting the stock market within the computational domain. The intricate prediction process involves myriad factors, encompassing physical, physiological, rational, and irrational elements, investor sentiment, market rumors, and more. The study explores the transformative role of data analysis in this complex landscape. It aligns with the efficient market theory, positing that the historical spot price, as the cumulative manifestation of all influencing factors, can predict future movements. Leveraging Machine Learning (ML) techniques on historical stock price data, the paper introduces a framework utilizing the Long Short-Term Memory (LSTM) model and a net growth calculation algorithm, aiming to analyze and predict future growth with precision.

16) In the paper [16] written by Authors Gunduz, H., Yaslan, Y., Cataltepe demonstrate the challenges of forecasting financial market trends due to noise and nonlinear behavior in prices. They propose a more effective approach, designing the Stock Sequence Array Convolution LSTM (SACLSTM) model. This model incorporates various news collections, historical data, and futures, utilizing a Convolutional LSTM algorithm for stock prediction. SACLSTM, combining convolution and LSTM units, surpasses statistical methods, traditional Convolutional Neural Network (CNN), and LSTM in prediction tasks. The framework integrates data into a matrix, employs convolution for feature extraction, and includes leading indicators to enhance stock trend prediction. Overall, SACLSTM significantly improves the accuracy of stock price prediction.

17) In the paper written by Fama E. F, Fisher L, Jensen M, Roll R [17], this study assesses how the GNB algorithm performs with different feature scaling techniques (i.e., standardization scaling and Min-Max scaling) and feature extraction techniques (i.e., PCA, LDA, and FA) in predicting the direction of stock price movement. Stock data were randomly collected from various stock markets. The performance of the various GNB models was evaluated using accuracy, F1-Score, specificity, and AUC evaluation metrics. Kendall’s W test of concordance was employed to generate ranks for the GNB models using the evaluation metrics.

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18) 1The paper written by Nti, I. K., Adekoya, A. F., and Weyori [18], this study introduces a novel "homogeneous" ensemble classifier (GASVM) based on Genetic Algorithm (GA) for feature selection and optimization of SVM parameters for predicting the 10-day-ahead price movement on the Ghana Stock Exchange (GSE). Accuracy metrics such as RMSE, MAE, AUC, Accuracy, and Recall were compared between the proposed model (GASVM) and other state-of-the-art predictive models (DT, RF, and NN). The GASVM demonstrated higher prediction accuracy of the GSE stock price movement compared to DT, RF, and NN. The primary focus of this study is the introduction of GA as a feature selection mechanism to simultaneously optimize various design factors of the SVM.

19) Written by Sharanya Banerjee, this paper [19] attempts to predict stock market trends using regression algorithms. As illustrated in there model it utilizes current stock values from gathered datasets. The collected data is segmented into various subsets, which are then used to train and test the algorithm. Subsequently, regression models in Python or R are employed to model the data. This model executes a comprehensive search algorithm on the datasets and generates a summary table based on the output. The values are plotted on a chart, and regression and clustering techniques are applied to identify the increase or decrease in the price of the stock. Based on these calculations, the model extrapolates current stock prices to generate predictions for a future time. The models are built and trained using supervised machine learning algorithms.

20) In this paper written by Ganapati Panda [20], this paper demonstrates a strong correlation between the rise/fall in stock prices of a company and the public opinions or emotions expressed about that company on Twitter through tweets. The main contribution of our work is the development of a sentiment analyzer capable of judging the type of sentiment present in the tweet. The tweets are classified into three categories: positive, negative, and neutral. Initially, we posited that positive emotions or sentiment expressed by the public on Twitter about a company would be reflected in its stock price. Our speculation is well supported by the achieved results and appears to have a promising future in research.

21) This research paper [21] explores the application of Artificial Neural Network (ANN) and Convolutional Neural Network (CNN) models to predict stock market prices. The study focuses on the Indian stock market, using machine learning and deep learning algorithms to achieve accurate predictions amid dynamic market conditions, including the impact of the COVID-19 pandemic. The ANN model attains a 97.66% accuracy, while the CNN model, employing 2-D histograms from quantized datasets, achieves a higher accuracy of 98.92%. The research emphasizes the significance of efficient stock market predictions for aiding analysts in developing solutions to navigate economic challenges and market fluctuations. Both models offer valuable insights, with the CNN approach proving particularly efficient in terms of training time and prediction accuracy.

22) This research paper [22] proposes a novel approach for stock market prediction using a hybrid Recurrent Neural Network (HyRNN) architecture, combining Bidirectional Long Short-Term Memory (Bi-LSTM), Gated Recurrent Unit (GRU), and stacked LSTM models. The study emphasizes the importance of incorporating sentiments from financial news alongside stock features for improved prediction accuracy. The authors compare the performance of HyRNN with traditional models and demonstrate its superiority in forecasting stock prices. Utilizing sentiment lexicons based on VADER, the model effectively classifies news articles. The research concludes that the hybrid model, integrating news sentiments and stock data, outperforms other deep learning techniques, providing a valuable tool for investors in making informed trading decisions.

23) This research employs Machine Learning (ML) and Sentiment Analysis (SA) on microblogging data from Twitter and Stock Twits for stock market prediction, [23] focusing on Microsoft stock. The study integrates SA using TextBlob and Valence Aware Dictionary and sentiment Reasoner (VADER) with seven ML models. The novel aspect lies in combining multiple SA and ML methods, emphasizing social media's role in enhancing prediction accuracy. Results show the highest accuracy when using VADER on Twitter data with Support Vector Machine (SVM), achieving an F-score of 76.3% and an AUC of 67%. The study acknowledges limitations related to sentiment misinterpretation and suggests future improvements, such as data filtering and exploring additional ML techniques.

24) This study conducts a systematic literature review of 30 research papers on machine learning (ML) approaches in stock market prediction [24]. The primary focus is on understanding the trends and frequently used models in this domain. Neural networks (NN) emerge as the most commonly employed ML approach, with a notable prevalence in 2015 and 2016. Long Short-Term Memory (LSTM) is the second-highest utilized method, gaining traction since 2015, while the use of Support Vector Machines (SVM) diminishes. Overall, ML, particularly NN, proves effective in predicting stock market indices, showcasing advancements over traditional methods. The paper concludes that these findings provide valuable insights for researchers aiming to develop improved ML approaches for stock market prediction.

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25) This groundbreaking research introduces a novel approach to stock market prediction [25] by integrating artificial neural networks (ANN), long short-term memory (LSTM), natural language processing (NLP), and deep reinforcement learning (DRL) with the deep Q network (DQN). Focused on gold datasets, the study leverages historical stock data and social media insights from platforms like S&P, Yahoo, and NASDAQ. By combining sentiment analysis, LSTM for historical data analysis, and DRL for decision-making, the model demonstrates exceptional accuracy in forecasting opening stock values. Comparative analysis against benchmark algorithms highlights the superior performance of the proposed architecture, setting new standards in stock market prediction. Future applications in dynamic environments and diverse sectors are envisioned.

Table 1: Literature Survey Overview

S. NO	Paper Name	Author Name	Year	Key Points
1	Survey of stock market prediction using machine learning approach	Ashish Sharma et al.	2017	Improving stock market prediction, the paper advocates a multiple regression method using diverse market data to boost accuracy with additional variables.
2	Short-term prediction for opening price of stock market based on self-adapting variant PSO-Elman neural network	Ze Zhang et al.	2017	Examining stock market dynamics as non-linear, they employ Elman neural network, augmented by self-adapting PSO algorithm, demonstrating superior empirical validation against traditional models.
3	Using social media mining technology to assist in price prediction of stock market.	Yaojun Wang and Yaoqing Wang	2016	They emphasize on sentiment analysis through social media mining. Their model, integrating multiple factors, enhances accuracy in short-term stock price predictions.
4	Stock Price Prediction Using LSTM	Pramod B S and Mallikarjuna Shastry P. M.	2021	It address stock value prediction complexities using the LSTM algorithm, incorporating market data and recurrent neural networks and Stochastic gradient descent algorithm improves accuracy.
5	Deep Learning-Based Stock Price Prediction Using LSTM and Bi-Directional LSTM Model	Md. Arif Istiake Sunny et al.	2020	Sunny, Maswood and team unveil a stock price prediction framework with LSTM and BI-LSTM RNN models, emphasizing hyper-parameter tuning for heightened accuracy and validation through RMSE measurement.
6	Stock price prediction using LSTM, RNN and CNN-sliding window model	R Vinaya-kumar et al.	2017	They suggest a model-independent stock price forecasting using deep learning for NSE-listed firms, comparing three models with sliding window evaluation via percentage error.
7	Efficacy of News Sentiment for Stock Market Prediction	Jay Shankar Prasad et al.	2019	Kalra and Prasad tackle stochastic stock market forecasting, integrating historical data and news articles. Achieving 65.30% to 91.2% accuracy, they use Naïve Bayes classifier and sentiment analysis.
8	Literature review on Artificial Neural Networks Techniques Application for Stock Market Prediction and as Decision Support Tools	Dionysia Kowanda et al.	2018	It reviews ANN applications in stock market prediction finding high accuracy in four studies, with the Signal Processing / Gaussian Zero-Phase Filter achieving 98.7% accuracy.
9	Stock Market Movement Prediction using LDA-Online Learning Model.	Nuanwan Soonthomphisaj et al.	2018	Introducing LDA-Online for stock prediction, it outperforms ANN, KNN, and Decision Tree on NASDAQ stocks, achieving the highest accuracies for GOOGLE, AMAZON, APPLE, and FACEBOOK stocks.

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10	Stock Market Prediction Analysis by Incorporating Social and News Opinion and Sentiment	Zhiping Lin et al.	2018	Their method, incorporating news sentiments, surpasses existing methods in minimizing Mean Square Error with actual stock price datasets.
11	Stock Price Prediction Using News Sentiment Analysis.	Vijayvergia et al.	2019	They improve stock price prediction by merging S&P500 prices with 265,000 news articles, leveraging deep learning and cloud computing for enhanced accuracy.
12	Combining of random forest estimates using LSboost for stock market index prediction.	Akanksha Juneja et al.	2017	They forecast stock market indices with a decade of Indian stock market data. Their LS-RF model, incorporating LSboost in a Random Forest, outperforms Support Vector Regression, showing promise in stock price forecasting.
13	Research on Stock Price Prediction Method Based on Convolutional Neural Network	Sayavong Lounnapha et al	2019	They introduces a stock price prediction model using CNNs, excelling in trend identification and accuracy
14	Enhancing Profit by Predicting Stock Prices using Deep Neural Networks	Soheila Abrishami, et al.	2019	It present a deep learning system for NASDAQ stock value forecasting, excelling in multi-step-ahead predictions with an autoencoder and Stacked LSTM Autoencoder, outperform-ing existing methodolog-ies.
15	Stock Price Prediction Using LSTM on Indian Share Market	Soumik Bose et al.	2019	Addressing stock market prediction challenges, they employ machine learning, particularly the LSTM model, aligned with efficient market theory. Their framework analyzes and predicts future growth using historical stock price data.
16	A graph-based CNN-LSTM stock price prediction algorithm with leading indicators.	Jimmy Ming-Tai Wu et al.	2021	SACLSTM addresses challenges in financial market trend forecasting by combining convolution and LSTM. Outperforming statistical methods, traditional CNN, and LSTM, it enhances accuracy through data integration and leading indicators.

III. PROPOSED WORK

1) *Data Collection:* Gather historical stock price data, including features like opening price, closing price, volume, etc.
2) *Data Preprocessing:* Clean and preprocess the data by handling missing values, normalizing the features, and creating input sequences for the LSTM model.
3) *Feature Selection:* Choose relevant features that might impact stock prices, such as technical indicators, economic indicators, or sentiment analysis scores.
4) *Sequence Generation:* Create input sequences and corresponding output labels. For instance, use past stock prices to predict the future price.
5) *Model Architecture:* Design an LSTM model architecture. Experiment with the number of layers, units, and activation functions.
6) *Training:* Split the dataset into training and validation sets. Train the LSTM model using the training data and tune hyperparameters based on performance on the validation set.
7) *Evaluation:* Evaluate the model using metrics like Mean Squared Error (MSE) or Mean Absolute Error (MAE) on a test dataset. Ensure the model is not overfitting and performs well on unseen data.
8) *Back-testing:* Simulate the model on historical data to assess its performance over time. This step helps validate the model's effectiveness in a real-world scenario.
9) *Deployment:* Once satisfied with the model's performance, deploy it for real-time predictions. Implement a mechanism to continuously update and retrain the model with new data.

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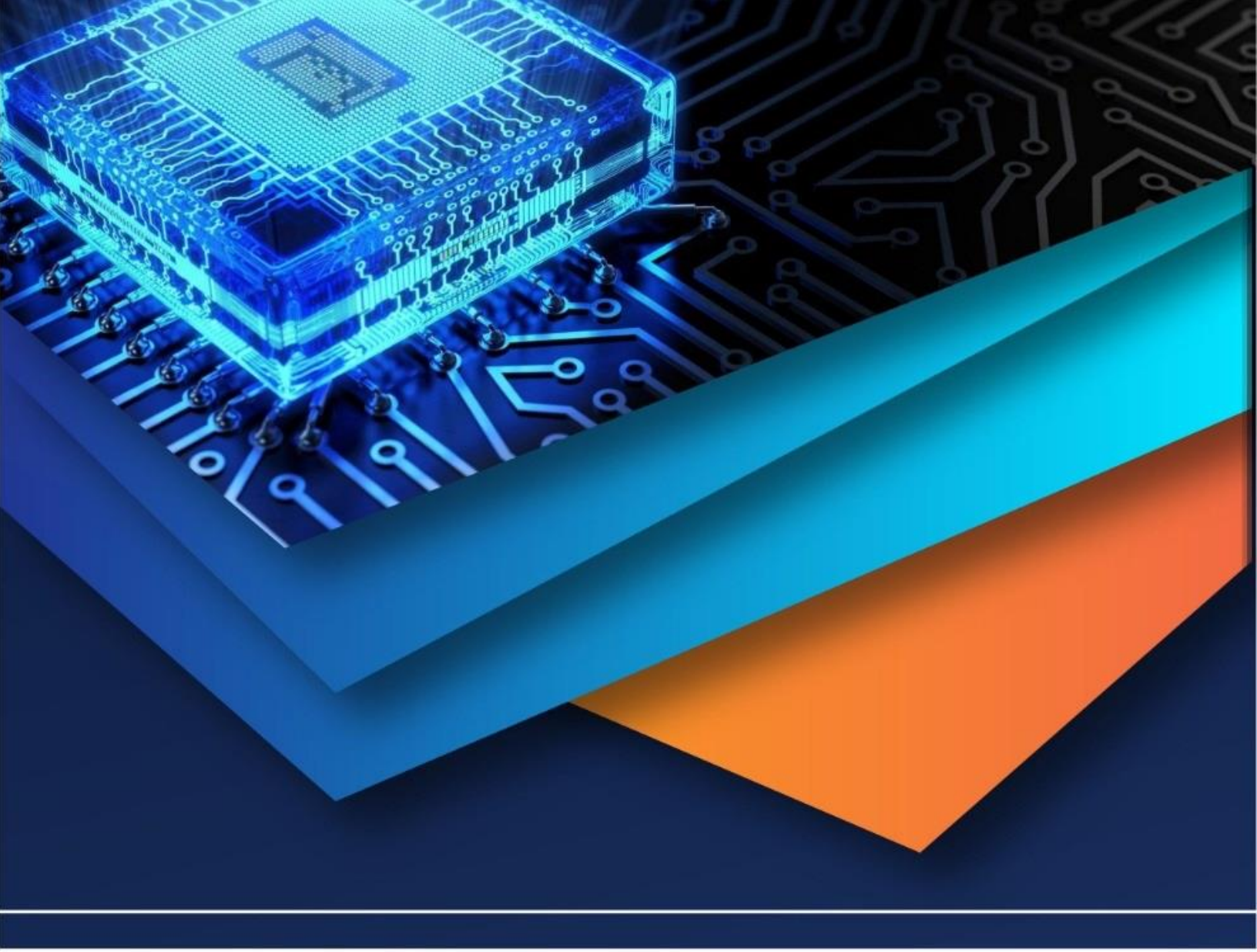
IV. CONCLUSION

In the pursuit of accurate stock market predictions, this project leveraged the advanced Long Short-Term Memory (LSTM) model—a sophisticated Recurrent Neural Network (RNN) variant designed to overcome the challenges associated with handling long-term dependencies and information retention. The LSTM model, featuring Forget, Input, and Output gates, excels in remembering crucial information over extended periods, a limitation faced by traditional RNNs due to vanishing gradients. The Forget gate assesses the relevance of previous data, the Input gate learns from current input, and the Output gate passes updated information to subsequent timestamps. Acknowledging the necessity of a model capable of leveraging historical data while retaining memory, the LSTM model emerged as a fitting choice for stock price prediction. Amidst alternative methods like Regression and Support Vector Regression (SVR), LSTM proved advantageous. The constructed LSTM model demonstrated its efficacy in predicting stock prices, evaluated through a thorough train-test assessment. This model was then deployed to forecast stock values for the upcoming 30 days, showcasing its practical applicability in the dynamic realm of stock market forecasting.

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