Predicting Stock Market Movements Using Long Short-Term Memory (LSTM)

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***Abstract*—This paper explores using artificial intelligence (AI) to predict stock market movements and build optimal portfolios. The research methodology involves using LSTM networks to predict stock performance. The study aims to combine AI with human expertise to develop an intelligent trading system. The findings emphasize the importance of selecting appropriate AI approaches for accurate predictions and optimal portfolio management. The results of this study state that with LSTM, we can predict stock prices that are very close to their real prices. The average LSTM method in predicting stock prices is about 97.2938%. Average error obtained when using LSTM was 2.3223%.**

Keywords— Stock Market, Predicting, Movements, Portfolio, Artificial Intelligence, Optimization.

I. INTRODUCTION

Predicting stock market movements to build an optimal portfolio using artificial intelligence is one of the most challenging problems in time series data analysis. How to accurately predict stock market movements to build an optimal portfolio is an open question in finance and academia. That is a difficult task due to the complexity and dynamics of the market and the many obscure and interrelated factors involved. Economic analysts and stock traders were the early pioneers who made stock performance predictions. In recent decades, thousands of books on stock trading have been published.

Many economic analysts and stock traders have studied the historical patterns of financial time series data and have proposed various methods for Predicting Stock Market Movements. In order to achieve a promising performance, most of these methods require careful selection of index variables and finding the sharing features among the distinguished stocks. Additionally, these methods often involve complex statistical and machine learning techniques, such as neural networks, decision trees, and regression analysis, to identify patterns and trends in the data. They also require continuous monitoring and updating to account for market and economic changes.

The initial contribution of this study is the creation of an intelligent trading system by combining AI with the experience of human stock traders. Important index factors given by economic experts and stock traders are employed in this study to train an artificial neural network to predict future stock performance. The second contribution of this research is the validation of the efficacy of human stock traders' expertise and diverse investment techniques in developing a successful smart trading system. What index characteristics are most relevant and how to make stock performance predictions to maximize income while minimizing investment risk are studied in this study. This study focuses on stock data from the Yahoo Finance website. Yahoo Finance provides financial market data and tools to find interesting investments. Furthermore, it can use to investigate viable investment algorithms for the other stock market.

II. LITERATURE REVIEW

In order to create the optimum portfolio for the stock market, there has recently been much interest in applying artificial intelligence (AI) and machine learning (ML) algorithms to anticipate stock market moves [1]–[3]. Patalay and Bandlamudi proposed an AI and ML-based decision support system for stock portfolio selection [4]. How To predict stock prices and optimize the portfolio, the system employs multiple techniques such as decision trees, random forest, and gradient boosting [5]. Chung and Shin suggested a long short-term memory (LSTM) network optimized by a genetic algorithm for stock market prediction [6]. The approach optimizes the hyperparameters of the LSTM network, which is used to forecast future stock values using a genetic algorithm.

Other research has concentrated on specific AI and ML techniques for stock market forecasting. For example, proposed using deep neural networks (DNN) to forecast stock performance [7]. The suggested method extracts characteristics from the input data using a stacked autoencoder and then trains a DNN to forecast stock performance. Similarly, Lanbouri and Achchab employed high-frequency data to anticipate stock values using a long-short term memory (LSTM) network [8]. The research shows that LSTM networks can handle complex temporal correlations in financial data, and long short-term memory (LSTM) is an improved subset of the RNN method that is used in the deep learning area [9]–[12]. These findings emphasize the significance of AI and ML approaches for specific tasks like stock market prediction and portfolio management. Gupta, Bhatia, Dave, and Jain proposed an AI and ML-based data mining system for stock market prediction [13]. There are two approaches to predicting stock market behavior to predict stock prices and optimize the portfolio. The first one is based on the prediction of the future price values of the stock. The

second is based on predicting the future price direction of a stock, i.e., guessing whether the price will rise or fall the next day or in a couple of days (trend forecasting). A journal by Vishal Dineshkumar Soni states that the prediction results of AI are very good [14]. In a 2019 journal by Bharne and Prabhune, they used Machine Learning and the KNN Method in their research [15]. In conclusion, employing AI and machine learning algorithms in stock market prediction and portfolio management has yielded encouraging outcomes [16]. To anticipate stock prices and improve portfolios, researchers have proposed numerous strategies such as decision trees, random forests, gradient boosting, LSTM networks, and DNNs [17]–[19]. Selecting appropriate strategies for certain activities is critical to achieving accurate predictions and optimal portfolio management[20].

III. METHODOLOGY

The method that will be used in this research to predict the best stocks is Long Short Term Memory (LSTM). LSTM networks are extensions of Recurrent Neural Networks (RNNs) introduced primarily to deal with situations where RNNs fail. A fundamental difference between RNN and LSTM architectures is that the hidden layer of LSTM is the gate unit or gate cell. It consists of four layers that interact in such a way as to produce the state of the cell as well as the output of that cell. The LSTM network operates by first receiving the input data and then deciding how much of the prior state to forget using the forget gate. The input gate then chooses how much fresh data to store in the memory cell. After that, the output gate determines how much information to output from the memory cell.

A. Receiving the input data

The first step is to get the data and load it into memory. Our stock data will come from the Yahoo Finance website. Yahoo Finance provides financial market data and tools to find interesting investments. The data we take consists of many company stocks, such as Apple, Amazon, Google, and Microsoft. In this data, the stock price movement starts from 2013 - 2022. We will download the market data from Yahoo Finance using the finance module, which provides a threaded and Python way. Here is a general outline of how you might go about obtaining historical stock price data using Python, assuming that the finance module you mentioned provides the required functionality.

B. Get the Moving Average (MA)

The moving average (MA) is a simple technical analysis technique that smooths out price data by calculating an average price that is continually updated. The average is calculated over a given period, such as 10 days, 20 minutes, 30 weeks, or any period the trader selects. Figure 1, Figure 2, Figure 3, and Figure 4 show the moving averages for 10, 20, and 50 days and the adjusted close.

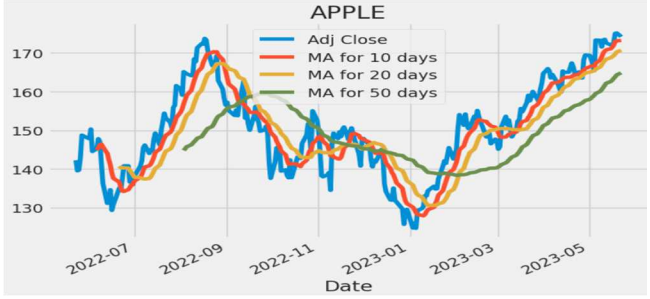

Fig. 1. Apple share price movement over one year

Fig. 2. Google share price movement over one year

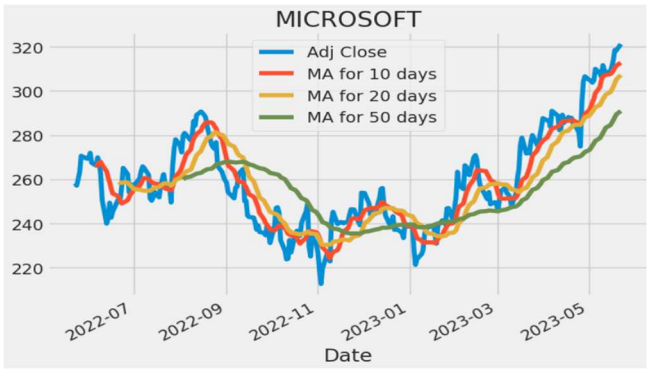

Fig. 3. Microsoft share price movement over one year

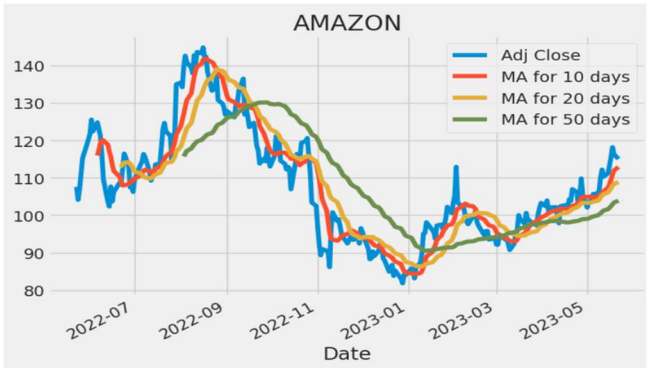

Fig. 4. Amazon share price movement over one year

C. Analyze the daily return of the stock on average

Now that we have completed some preliminary research let us delve further. We are now going to look at the stock's risk. To do so, we must look at the stock's daily movements rather than its absolute value. Let us use pandas to get the daily returns for Apple, Amazon, Google, and Microsoft stock. In Figure 5, Figure 6, Figure 7, and Figure 8, the average daily return using a histogram is shown.

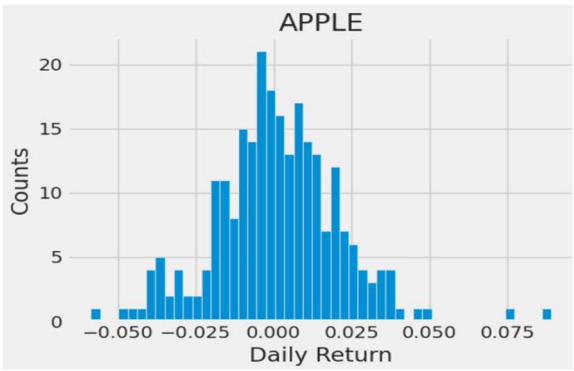

Fig. 5. Stock price risk on Apple

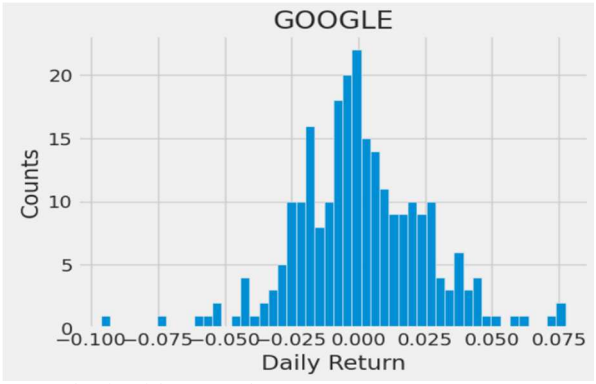

Fig. 6. Stock price risk on Google

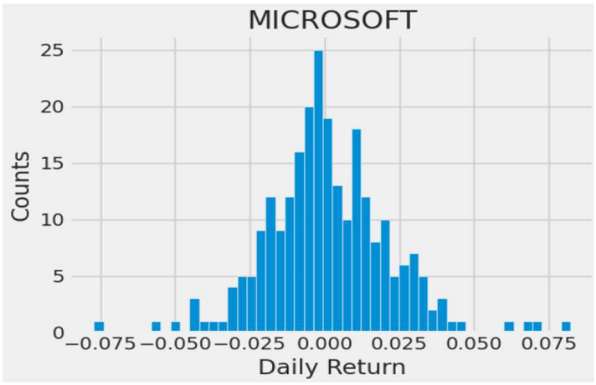

Fig. 7. Stock price risk on Microsoft

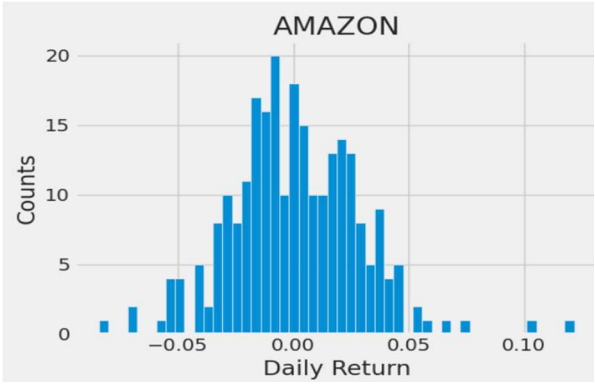

Fig. 8. Stock price risk on Amazon

D. Get the risk value of a particular stockThe word "data" is plural, not singular.

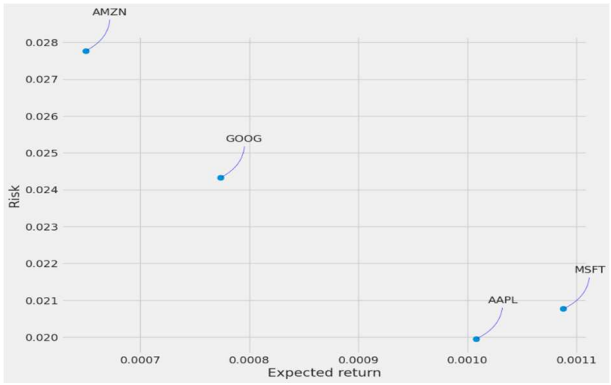

Fig. 9. Return risks when investing in Amazon, Google, Apple, and Microsoft.

Based on Figure 9, AMZN has the highest risk and lowest expected return. Something is interesting because MSFT and AAPL have adjacent positions. MSFT has a higher expected return than AAPL but has a higher risk than AAPL, so AI will prefer AAPL because it has the lowest risk.

IV. RESULT

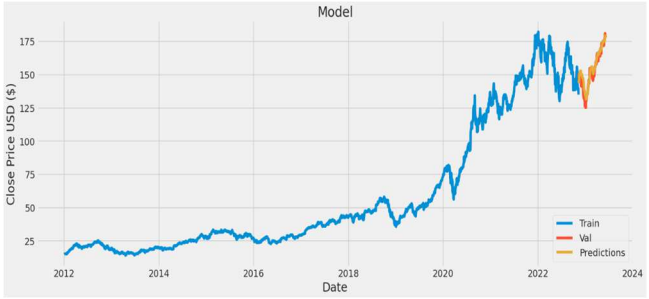

Fig. 10. Prediction Apple stock results using LSTM

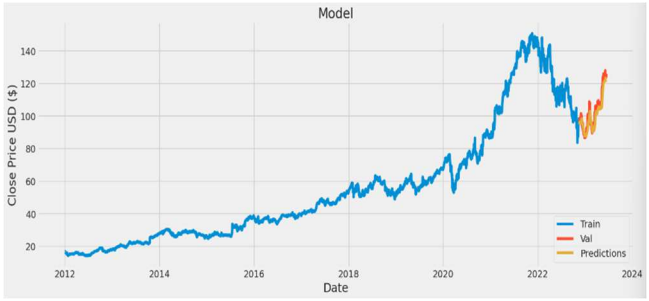

Fig. 11. Prediction Google stock results using LSTM

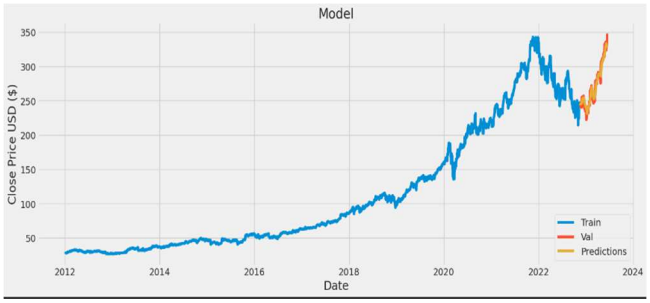

Fig. 12. Prediction Microsoft stock results using LSTM

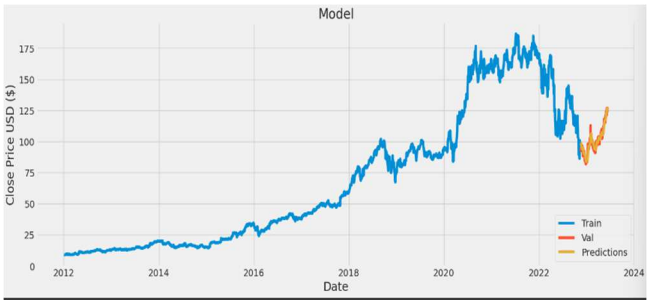

Fig. 13. Prediction Amazon stock results using LSTM.

Figure 10, 11, 12, 13 shows the graph of LSTM prediction results with closing stock prices. The Long Short Term Memory (LSTM) implementation uses Python to predict the stock market in the dataset. Figure 10 shows the results of predicting the stock market using LSTM. Our research uses stock data to predict stock prices at a certain time. In the graph we plotted, we used 87 units of LSTM to determine the accurate stock price. In our graph, the x-axis defines the stock price movement each year, while the y-axis defines the selling price development.

TABLE I. COMPARISON OF THE CLOSE STOCK PRICE WITH THE LSTM QUOTATION

Company	Date	Close	Predictions	Calculation	
				Accuracy	Error
Apple	2022-11-10	146.8699	143.5350	97.73%	2.27%
	2023-06-02	180.9499	177.6458	98.176%	1.824%
Amazon	2022-11-11	149.6999	144.0239	96.21%	3.79%
	2023-06-15	127.1100	133.8545	94.639%	5.307%
Microsoft	2022-11-18	97.8000	99.5942	98.165%	1.835%
	2023-06-15	125.7900	126.8816	99.133%	0.867%
Google	2022-11-18	97.8000	99.5942	98.165%	1.835%
	2023-06-15	125.7900	126.8816	99.133%	0.867%

Table I includes 4 predictions from all tested stock markets: Apple, Amazon, Microsoft, and Google. Where in the first column presents the prediction data of Apple, the second column Amazon, the third Microsoft, and the last column Google. Table 1 compares the close stock price and the LSTM prediction result. For the difference in numbers predicted by LSTM, it is only about 3 numbers different from the actual stock price. The average LSTM method in predicting stock prices is about 97.2938%. The average error obtained when using LSTM was 2.3223%. The Long Short-Term Memory (LSTM) method is very suitable in predicting stock prices because it has a relatively low difference from the real price.

V. CONCLUSION

In conclusion, this research utilized the Long Short-Term Memory (LSTM) method to predict stock market movements and build an optimal portfolio. The study demonstrated the potential of developing an intelligent trading system by combining AI techniques with human expertise. The methodology involved gathering and analyzing stock market data, calculating moving averages, and assessing risk. The findings highlight the importance of selecting appropriate AI approaches for accurate predictions and optimal portfolio management. LSTM networks proved effective in handling complex temporal correlations in financial data it means financial data, such as stock prices or market indices, often involves intricate relationships and patterns that change over time. Continuous model updating and adaptation to market changes are crucial for successful stock market prediction and portfolio optimization outcomes. Overall, this research contributes insights into the effective utilization of AI in finance and emphasizes the role of intelligent trading systems in enhancing decision-making processes.

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