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Systematic Literature Review: Stock Price Prediction Using Machine Learning and Deep Learning

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Abstract
In order to determine the type of evaluation with the attributes utilised, the methods employed, the methods most frequently used, and the methods with the greatest performance, this research was carried out using a literature review method to analyse various studies. Based on pre-established criteria, 40 publications were selected from research conducted between 2016 and July 2021 for this study. Four research topics estimation, classification, clustering, and association—were determined by this review. Four research topics fundamentals, technical, sentiment analysis, and even a combination with analyses that make use of their respective qualities and datasets—are the results of this study. Thirty-one different methods have been identified for stock price prediction. The most popular approaches are LSTM, MLP, RF, and SVM. Furthermore, MLP is a technique that yields the best results, with an LSTM of 70% and a performance of 71.63%. For better precision, it is advised to employ deep learning, ensemble approaches, mixed machine learning, and input attribute selection at pre-processing.

Keywords
Systematic literature review; stock price prediction; technical analysis; fundamental analysis; sentiment analysis; machine learning; deep learning.

I. INTRODUCTION

The most difficult problem with financial concerns is predicting and analysing stock prices . This is due to the fact that financial markets are extremely volatile, chaotic, dangerous, and unpredictable. The two primary analyses used to make stock market investment decisions are fundamental and technical . Aside from examining these forms, a variety of factors, including investor attitude, current events, economic policy, and news, affect stock prices. Every type of analysis has unique qualities for analysing or forecasting stock prices. Technical analysis is an analytical approach that uses historical market data to forecast prices. A number of characteristics from past market data, including date, open price, closing price, highest price, lowest price, volume, and other technical data, will be used for technical analysis. To be able to forecast price changes, fundamental analysis examines the state of the economy and the industry as a whole, as well as the financial standing and calibre of management of the company. The company's basic data will be used for the fundamental analysis. Additionally, sentiment analysis can be used to investor sentiment, social media sentiment, and news sentiment. Furthermore, a combination of the two attributes could be used, for example, by integrating sentiment and technical attributes. A combination of fundamental and technical qualities.
The drop in stock prices across all industrial sectors indicates that the COVID-19 epidemic has also had an impact on Indonesia's stock market and economic expansion. Nevertheless, it was discovered that stock investors rose throughout the pandemic. Fomo or simply following the trend of stocks that have significantly increased throughout the epidemic are primarily to blame for this surge. Due to FOMO, many novice stock investors enter the market without properly understanding it, resulting in significant losses. Therefore, stock forecasting will assist investors in turning a profit and aid in the stock market's recovery from the pandemic.

To determine the optimal accuracy, researchers employ a variety of techniques and algorithms. For instance, the Random Forest algorithm is used by [12], [13], and [9] to forecast stock prices or buy, sell, and hold decisions. Additionally, some academics investigate stock movements using Deep Learning tools like Artificial Neural Networks, LSTM, and MLP [14], [15], and [16]. Additionally, a number of additional algorithms will be employed.
To improve accuracy, it is also critical to understand current research trends, the type of analysis being utilised,

and processing input qualities in addition to methodologies and algorithms. Some academics have examined stock predictions, such as one study [17] that solely examines technical analysis without taking sentiment and fundamental analysis into account. The purpose of this study was to examine studies on stock price forecasting that were carried out between 2010 and 2018.
As a result, it is essential to supplement the earlier, unfinished research. For example, an analysis that incorporates different forms of analysis rather than focussing solely on one, as well as earlier studies that haven't thoroughly examined the most recent research.
In order to determine the type of research, the research topic, the methods employed, the most popular approach, and the method with the best work performance, this study focusing on research conducted between 2016 and July 2021. The writing structure of this paper is as follows.
The research techniques employed in this study will be explained in Part 2, the research results will be described in Part 3, and the conclusions and future research will be described in Part 4.

II. RESEARCH METHODS

When examining the literature on stock price forecasting, the Systematic Literature Review will serve as a guide.
The process of finding, evaluating, and interpreting all available research information in order to address research questions is known as systematic literature review [18]. One phase will be carried out in accordance with the guidelines of the systematic literature review, which is to describe the research questions that serve as the goals of the study in order to keep it focused. Next, describe the search approach, mentioning any databases and data sources as well as the search terms.
Next, choose the collected data according to pre-set standards. Studies that are inappropriate will also be eliminated. Figure 1 illustrates the research flow for readers' convenience.

1. Research Questions

Determining the research topics is essential to keeping the study on track. The PICOC [18] framework—Population, Intervention, Comparison, Results, and Context—was used in the design of the research question. The PICOC structure of the research topics is displayed in Table 1.

Structure	Description
Population	Stock, Stock Market
Intervention	Stock Prediction, Stock Forecasting, Technical Analysis, fundamental analysis, sentiment analysis
Comparison	n/a
Outcomes	Prediction accuracy of stock return,
Context	Studies in stock forecast

Based on the PICOC table, research questions are makes of what will expect from this research. For this reason, the following research questions will formulate:

RQ1: Which research issues are currently being explored in the field of stock prediction?

RQ2: Which kind of analysis is most frequently applied to stock prediction?

RQ3: What are the methods used in predicting stocks?

RQ4: What are the most frequently used methods of predicting stocks?

RQ5: What is the best performing method for forecasting stocks?

2. Search Strategy

2.1 Search Term

To make sure the chosen literature would be pertinent to the study, we first specify keywords with possible alternatives before defining a search string. We will only utilise articles with English-language writing in this SLR. The following keywords were used to construct the search query:
1) The stock market, stock index, and stock price
2) Technical analysis, sentiment analysis, and fundamental analysis
3) Prediction and forecasting
Following the definition of these search terms, a search query will be generated using a Boolean operator. The following search terms were used:

("Stock market" or "Stock price" or "Stock Index") AND ("sentimental analysis" or "fundamental analysis" or "technical analysis") AND (forecast* or predict*)

2.2 Literature Resource

The search method in this study selects a digital library or database to review. Using a database or library that is pertinent to the study being done is advised by this step. Finding pertinent articles will be made easier by using the most widely used digital libraries or databases. A list of digital databases where articles can be found is provided below:
1) IEEE Explore (ieeexplore.ieee.org)
2) ScienceDirect (sciencedirect.com)
3) Springer (springerlink.com)
In the search for articles on Literature Source limiting research from 2016-2021.

2.3 Search Procedure

The next step in choosing articles that will fit the criteria is to search using a keyword-based query and then filter the articles by year and type. After that, filtering is carried out by going over the abstract and title to quickly eliminate any unnecessary information. Next, choose all of the literature using the predetermined standards, and then examine the chosen papers to determine the answers to the research questions.

2.4 Selection Criteria

This step serves as a filter to eliminate articles that were initially chosen and that meet the predetermined standards. The following are the exclusion criteria:

a. Research that doesn't advance deep learning or machine learning
b. Research doesn't show its findings.

Table 2 shows the selection of articles from start to finish. A total of 2706 articles were returned based on the query. There were 269 items downloaded at that point. Forty papers were chosen for additional study after the desired and exclusion criteria were reviewed.

Table 2. Search Result

Portal	Result Based on keywords	Download Journal
Science Direct	569	131

IEEE Explore	117	59
Springer	2020	269
Total	2607	269

3. Research Result

3.1 The Most Popular Subjects in the Predictive Stock Market

The purpose of this study is to determine which research subjects are currently popular in the field of stock prediction. 41 chosen articles are categorised according to the research topic as part of the analysis. The four research themes are as follows:

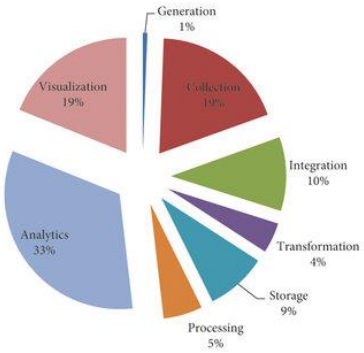
1. Forecasting, prediction, or forecasting.
Research on this subject uses regression or forecasting algorithms to estimate, forecast, or anticipate stock price returns.

2. Grouping In this topic, the research implementation divides the research into two or more classes, such as "UP and Down," "Buy and Hold," or "Buy, Sell, Hold," using a classification method.

3. Clustering In order to arrange stocks according to investment decision-making, the study implementation for this topic employs a clustering method.

4. Association Research on this topic will determine how one factor affects stock price movements, such as how bullish and bearish signal indicators related to stock price movements originate.

Predicting stock prices is done by a variety of algorithms that use artificial neural networks, including backpropagation neural networks [19], [14], MLP, RNN, and other neural network techniques [20, 21]. Furthermore, regression is used, specifically Lasso regression [22].
The output of the stock data grouping will then be displayed, such as "buy," "sell," "hold," [7], [12], or "up" and "down" [24]. A number of algorithms, including LSTM [10] Random Forest utilised in research [9], [13] and Random Forest ensemble in research [12], will be classified in this work. Using additional techniques, like Decision Boosted Tree, MLP, FNN, fuzzy logic, and others [2], [8]. Numerous research have examined the best clustering techniques, such as [31], which indicated that Naive Bayes is superior to SVM.
Blustering is a technique used in clustering to identify purchasing and selling tendencies, according to study [5]. Furthermore, in order to establish forecasting models for businesses that develop for any market scenario, study used K-means to identify markers that influence market sentiment. ANN Backpropagation is also used by the association approach in research [33] to determine the correlation between factors and stock prices the next day.
The overall distribution of research topics related to stock prediction from 2016 to June 2021 is displayed in Figure 2.
With 65% of the overall research, classification is the most researched topic, followed by estimate (28%), clustering (5%), and association (2%), which has the least amount of study.



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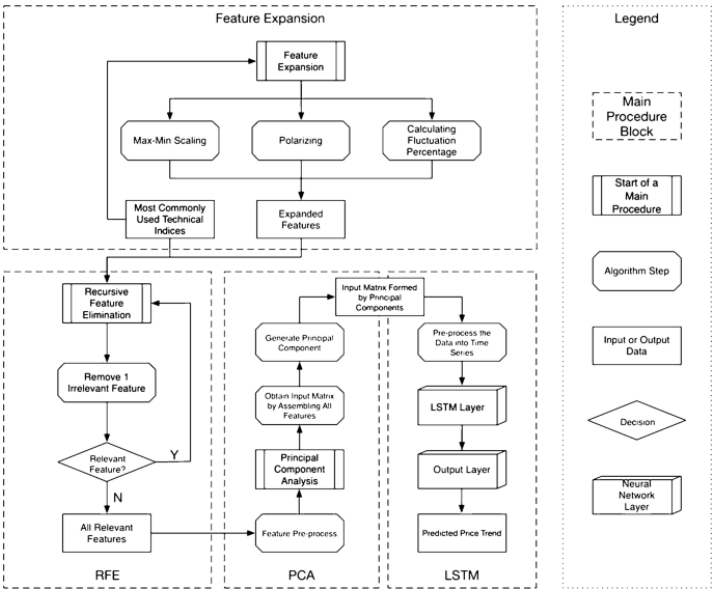
3.2 The Most Type of Analysis Used in Predicting Stocks

To predict stock prices, a variety of analysis techniques are used, each with unique characteristics. Technical analysis, sentiment analysis, and fundamental analysis are the three main categories of analysis used in this study. Technical analysis predicts the stock market by using technical data or past stock market data as features. Different characteristics are employed; some researchers use historical data directly, including volumes, open prices, closing prices, and so on .Furthermore, some employ technical data attributes such Weighted Moving Average (WMA), Bollinger Bands, and Moving Average in addition to sharing other technical data properties [7], [12]. Then, in order to forecast stock values, sentiment analysis is done by examining data or sentiment from an object, such as news and social media.

Using Twitter data with tweet and date indications, sentiment analysis was carried out in research [9]. Additionally, fundamental analysis examines a company's financial health using its financial data; the characteristics that exist also differ. In order to forecast stock prices, this literature study employs fundamental analysis using 21 basic qualities.

Furthermore, more than one type of analysis can be used; that is, two or more of the aforementioned forms of analysis can be used to predict stocks. Sentiment and technical analysis refers to the application of distinct technical and sentimental aspects in stock prediction. As demonstrated by [1], [10] stock price prediction is achieved by combining technical characteristics with analytical sentiment. Then, a number of studies that combine technical and fundamental analysis employed both technical and fundamental characteristics of companies to forecast stock values.

Each researcher has unique technical and fundamental characteristics. Using the third kind of analysis simultaneously also entails the use of basic characteristics and additional attitudes not present in this experiment. To supplement the research done with the technical and sentimental traits, a study by [44] proposed raising the attribute basic.



Additionally, used fundamental analysis to conduct the study. First, choose a business by looking as its liquidity. Fifteen businesses in all submitted applications to train models. Both a training and a test model are created using the financial data. Test data was utilised from 1/10/2019 to 15/12/2019, while training data was used from 18/02/2019 to 01/09/0219. Volume, History, Expiry, Take Profit, Stop Loss, Minimum, RSI, Donchian channel, MACD, MFI, and Moving Average are the basic attributes that the model uses for training. After then, several parameter combinations are checked by adding, deleting, and crossing them to see which ones get the greatest results. After determining which of the three fundamental parameters—history, expiration, and minimum—work well, additional parameters are added and crossed.

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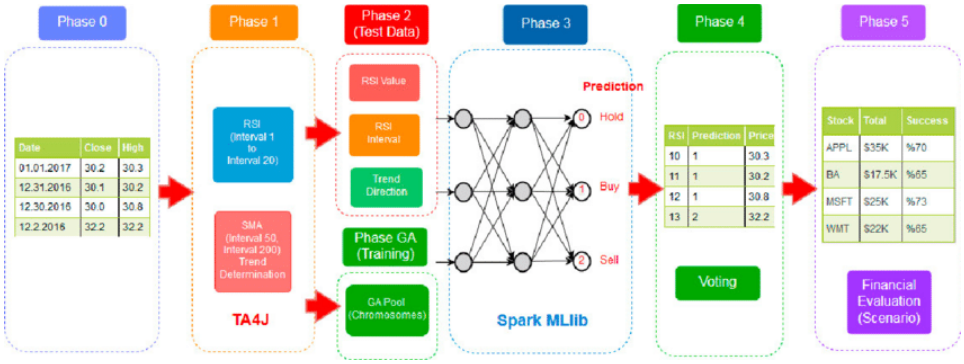

Figure 4. Proposed Method (Genetic Algorithm and MLP) [15].

Research combines technical analysis with sentiment analysis. Following the first use of Twitter and news data as input data for sentiment research, historical data is analysed to identify trends, ongoing up/down, and volume change. Machine learning will be used to integrate some of these inputs into the prediction model. The study's findings will yield an output that is either upward or downward.
Next comes research [2] that combines technical and fundamental analysis methods. The financial ratio that performs feature selection and data discretisation is the attribute employed for fundamental analysis. Technical analysis, on the other hand, uses stock prices that have first undergone discretisation data. The Hybrid Model will use the results of the two earlier assessments as input to the prediction system. Accuracy will be displayed by processing the result of the preceding Hybrid Model utilising MLP and entering data collected from the Nasdaq Stock Market.

3.3 Method Used in Predicting Stock

Several machine learning techniques are being used to study the potential for identifying the most effective stock price prediction system. According to research conducted between 2016 and July 2021, up to 31 algorithms are being used to determine the optimum accuracy.
All of the techniques are shown in Figure 6.

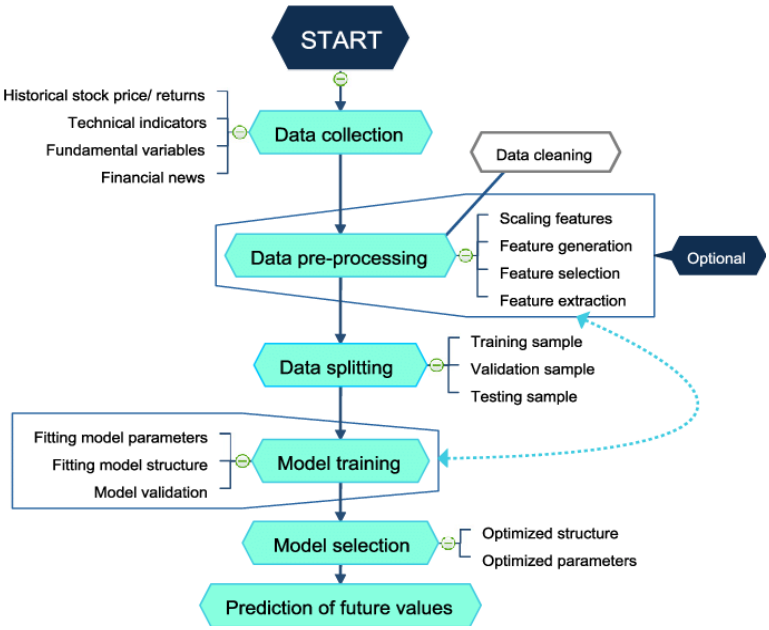

Figure 6. Method used in stock prediction

3.4 The Most Used Method in Stock Prediction

Based on Figure 6, we can see that the most widely used methods are MLP and LSTM, which Random Forest and Support Vector Machine follow. Therefore, this method still has the potential in the future to be used to predict stock prices.

3.5 The Best Performing Methods in Stock Prediction

Several techniques are being used to increase stock prediction accuracy. Even with the same procedure, the outcome of the prediction still varies based on the dataset and attribute type. Only a small number of these studies may be summarised because they frequently present the findings without offering research accuracy. The accuracy value was explained by the study results in Table 3, which showed that the MLP used technical analysis to predict the stock price with an accuracy of 71.63% [15]. According to research [15], trading systems can be used for a variety of stock markets, even for longer periods of time, and produce buy, sell, and hold classification outcomes that are on par with or better than purchase and control.
Then ANN Backpropagation generated RMSE 0.0348 in its research in analysing stock prices using technical analysis [32]
LSTM in predicting stocks using technical analysis and sentiment analysis from Twitter Figure 6. Method used in stock prediction Advances in Economics, Business and Management Research, volume 194 57 data with 70% accuracy and then random forest in fundamental analysis has an accuracy of 66.30%.

Table 3. Method with best performing

Author	Method	Analysis Type	Accuracy	RSME
[15]	MLP	Technical	71.63%	-
[33]	ANN Back Propagation	Technical	-	0.0348
[24]	LSTM	Technical and Sentiment	70%	-
[13]	Random Forest	Fundamental	66.30%	-

Some of these techniques are still very difficult to employ for additional research because the best-performing approach is also a list of the most popular techniques. The LSTM and MLP approaches are suggested for application in further studies. To determine which of these algorithms is the best, more research with the same data is required.
According to studies, some flaws that result in subpar accuracy are: First, do a comprehensive analysis of the market's current status, using a variety of research methods to improve accuracy.
To get the highest accuracy, pre-processing is required, such as attribute selection; therefore, it is preferable to complete feature selection before entering any attributes. Next, experiment with different potential algorithms or hybrids to determine which approach is best for stock prediction.
Combining different kinds of analysis is suggested. In addition, pay more attention to pre-processing processes such as feature selection of input
data to be used. It was discovered in this study that using deep learning also increased accuracy.

4. Conclusion

The trends in research themes, analysis types, methodologies, most popular methods, and best-performing methods are all verified and examined in this study of the literature. The research methodologies used in this literature review are [17]. 40 studies in all, covering the period from 2016 to June 2021, while accounting for anticipated research criteria. Four study areas—estimation, classification, clustering, and association—are covered in this review. According to the findings, category emerged as the most popular research topic in 65% of studies, followed by estimates (28%), clustering (5%), and association (2%).
The kind of analytical methods employed—technical, fundamental, sentiment, or a mix of two or more analyses—were then also investigated.
Data sets from historical stock data are used in technical analysis, data sets from firm fundamentals are used in fundamental analysis, and news or social media can be used to gather public sentiment regarding the stock. Additionally, it is employed in a combination of the two types of analysis. According to the findings of this literature review's overall distribution, 56% of research employs technical analysis together with technical attributes or datasets, followed by 23% that combines technical analysis with sentiment analysis. 15% used both technical and fundamental analysis, 3% used fundamental analysis, 3% used sentiment

analysis, and no research combining all three types of analysis was discovered.
31 algorithmic techniques were utilised in this investigation, according to this review.
The most popular techniques were MPL and LSTM, followed by RF and SVM. Different data sets and qualities make it impossible to select performance approaches; nonetheless, it is known that MPL can offer an accuracy of 71.63% in stock price detection with this kind of technical analysis. Furthermore, LSTM has a 70% accuracy performance in sentiment and technical analysis. With the right preparation and procedures for every data collection, the strategy will yield good performance.
This systematic literature evaluation suggests performing a variety of analyses in the future. Additionally, it is anticipated that employing deep learning techniques in conjunction with ensemble machine learning approaches will yield superior outcomes.
Processing the choice of significant input characteristics is also necessary for further
Research.

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