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A Study of Stock Market Prediction(SMP) Using Machine Learning Techniques

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Abstract
The study discovers the application of machine learning techniques for predicting stock market trends, aiming to enhance forecasting accuracy and effectiveness. Traditional approaches like Fundamental Analysis and Technical Analysis are compared to current machine learning algorithms like Artificial Neural Networks (ANN), Support Vector Machine (SVM), and Naïve Bayes (NB) in a comprehensive framework. The paper classifies data into market data and textual data and outlines pre-processing methods involving feature selection, order reduction, and feature representation to extract valuable insights. The challenges of data quality, model interpretability, and market volatility are discussed, emphasizing the need for more study and advancement. This paper aims to transform stock market prediction by using machine learning methods, providing investors and financial institutions with essential tools for making educated decisions in rapidly changing market conditions.

Keywords: *Artificial Neural Networks (ANN), Machine Learning, Market Volatility, Naïve Bayes (NB), Support Vector Machine (SVM)*

1. Introduction
The stock market is a consolidated platform including many marketplaces and exchanges where products and shares are bought and sold publicly, with comparison research conducted in a public setting. The stock market is a trading venue where investors purchase and sell shares depending on their availability. Fluctuations in the stock market impact the earnings of stakeholders. When market prices rise and there is sufficient stock available, stakeholders make a profit on their acquired equities. If the market declines and stock values fall, stakeholders will incur losses. Buyers acquire shares at low prices and trade them at higher prices to generate significant profits. Sellers also offer their items at elevated prices to generate profits [1]. The stock market acts as a consistent forum for sellers and buyers. The shareholder demonstrates attention in earnings by investing funds in the stock market. The stock market has piqued interest of stake holders with new apps that enable predictive analysis for more accurate market forecasts. Forecasting stock market movements accurately relies on advanced knowledge. The stock market must manage various data on industrial stocks that include the whole financial market. These are tailored based on the business's current situation for investors who focus on buying and selling. Various variables influencing market positioning include projected future income, earnings announcements, and changes in management [2]. Machine Learning approaches may help investors increase their earnings by taking on higher risks. Investors seek methods and approaches to enhance profits and minimize risks. Stock Market Prediction (SMP) is a complex challenge for its non-linear, vibrant, stochastic, and unstable characteristics. SMP is a time-series prediction method that quickly analyses historical data to predict future data estimates. Forecasting financial market trends has been a concern for experts across several fields such as mathematics, economics, Computer Science, and Material Science. Generating revenues via stock exchange is a crucial element for

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forecasting the stock market. Forecasting stock movements relies heavily on the investment and trading of stock data. Tools used for stock market prediction can forecast, monitor and manage the market to assist in making informed decisions [3]. The stock market needs to handle diverse industrial stock data that covers the entire financial sector [4]. Found that throughout history, investors have sought methods to get information about firms listed on the market to enhance their investment returns. Previously, investors depended on their own knowledge to recognize market trends, but this is not possible now because of the large size of the markets and the rapid execution of deals. Basic statistical examination of financial data offers some understanding, but investment firms have been turning to different artificial intelligence (AI) systems to analyse large volumes of real-time equities and economic data for trends. According to [5] Stock market movements are very volatile, making predictions more challenging. Researchers drawn to study advanced methods for improved prediction due to this unpredictable characteristic. Accurately predicting stock market developments leads to substantial income. The stock market applies to the random walk principle, which means that the most accurate forecast regarding the price of tomorrow is based on the price of today. Predicting stock indices is undeniably tough due to the unstable characteristics of the market, which necessitates the use of an accurate forecast model. The extreme volatility of stock market indices influences the investor's outlook. Stock prices are notoriously volatile and prone to sudden fluctuations due to the fundamental characteristics of the economic sector and a combination of known and unknown factors (e.g., the earlier day's ending price, price-to-earnings fraction, rumours, etc.) [6]. Sentiment analysis is a technique used to identify stock market trends. Various components are fluctuating due to the unpredictable nature of the stock market. Sequence trends altered by causes and non-linear relationships. The forecast of the stock market is an appealing subject in both academic and real-world business contexts. The forecast is made by collecting customer feedback and categorizing them as good or un favorable. Several statistical and econometric methods were used to anticipate stock market trends using emotional analysis. Stock market projections are prone to inaccuracies when using sentiment analysis tools. Reduced categorization accuracy directly impacts the dependability of stock market indicators [7]. This research analyzed the current issues in stock market prediction to enhance forecast accuracy. Figure 1 shows the Stock Market Prediction Process.

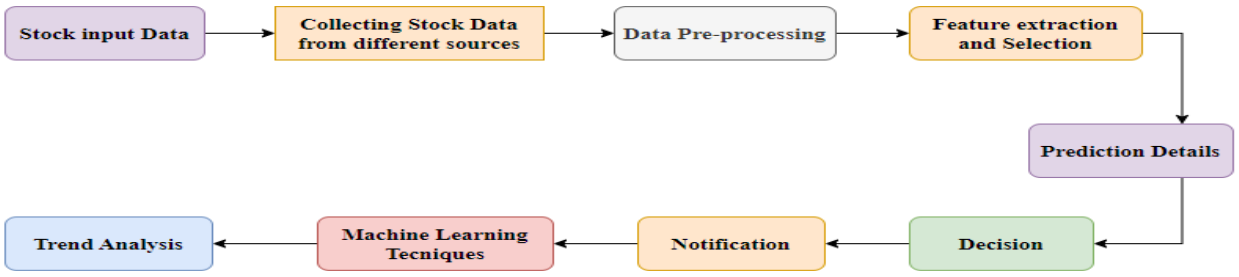

Figure1 Stock Market Prediction Process

2. Stock Market Prediction Approaches

There are two usual approaches for predicting the stock market. These are fundamental and technical analyses [8].

2.1 Fundamental Analysis

A company's performance and profitability may be assessed to determine its intrinsic worth. The intrinsic worth may be assessed by an analysis of staffing

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quality, sales, return on investment and infrastructure. Aspects including future growth, profit margins, sales revenues, and returns on equity are all used in basic analysis. This is the correct strategy for long-term investment and development. This method is beneficial for its methodical nature and its capacity to forecast changes in advance, prior to their manifestation on the charts.

2.2 Technical Analysis

Technical analysis is a path of evaluating stocks by analysing information derived from market movement, historical values, and trading volume. Technical Analysis encompasses important aspects of stock price fluctuations such as patterns, trends, peak price, lowest price etc. Predicting stock prices often relies on analysing the historical performance of the stock and its connected factors. It analyses patterns and indications on stock charts to predict the stock's future performance.

3. An Overview of Machine Learning in Finance

Machine Learning, on the other hand, permits scholars to derive rare perceptions from high-dimensional data. This modern approach offers significant advantages over traditional methods like linear regression in two main kinds of high-dimensional data. Firstly, ML effectively handles high-dimensional numerical data, characterized by many variables in relation to the number of observations. This scenario often arises when numerous economically significant variables are present or when nonlinearities and interaction effects are important. Additionally, ML is inherently connected to the concept of big data, which encompasses a large volume of observations, a high number of variables, or both [10]. In general, having many observations improves the correctness of machine learning predictions. When the data includes numerous variables comparative to the number of observations, machine learning tends to outperform simpler, traditional approaches like linear regression. Utilizing machine learning on datasets with extensive observations and variables leverages both benefits, leading to superior prediction accuracy and better performance compared to conventional methods. Deep learning methods applied to these problems may yield more useful outcomes than conventional methods in finance [11]. Specifically, deep learning has the capability to identify and capitalize on data interactions that are presently imperceptible to any established financial economic theory. As the adage goes, each novel circumstance also presents a prospect; therefore, machine learning methodologies developed as a lifesaver in the realm of business decision-making, which frequently involved enormous and intricate datasets. While machine learning has been prevalent in financial services for over four decades, its influence on investment management and trading has only become apparent in recent years [12]. Advancements in both computational and theoretical aspects of machine learning have contributed to the expanded relevance of machine learning in the domain of finance. Currently, machine learning techniques are more prevalent in finance research compared to when the studies for this thesis began [13]. The OECD in 2021 acknowledged the significance of this developing trend in the financial sector to assist policymakers in facilitating the implementation of this new kind of innovation in the business. [14] outlines many research objectives for machine learning technology in finance. Prior to exploring applications of machine learning in our specific industry, it is crucial to examine its inception as an academic discipline and its fundamental concept. Machine learning involves creating mathematical tools and algorithms that use data to perform a certain activity, aiming to mimic human learning processes.

4. Generic Scheme for SMP

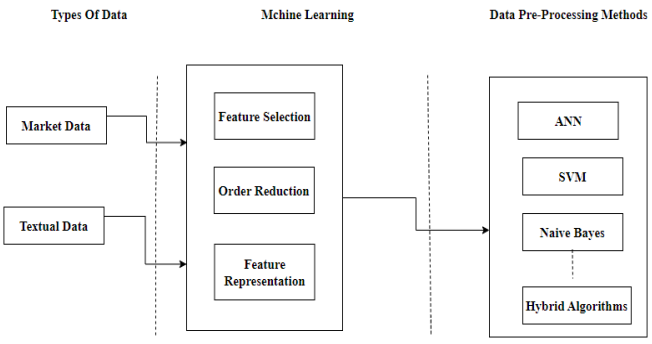

Figure 2 Generic Scheme for SMP (Stock Market Prediction)

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5. Types of Data

Stock market prediction (SMP) systems may categorized based on the kind of data they use as input. The majority of the research utilized market data for their study. Current research has also analysed textual data from internet sources. In this area, the research is categorized according to the sort of data used for predictive purposes. Table 1 at the conclusion of this segment compares the data sources, kind of input, and forecast length employed in the research conducted. Figure 2 shows the Generic Scheme for SMP (Stock Market Prediction)

5.1 Market Data

Market data encompasses past statistical information pertaining to financial market prices. Analysts and traders utilize this data to study historical movements and assess current stock values in the market [15]. Researchers provide the necessary information for comprehending market behaviour. Market data is often available for free and may downloaded straight from market websites. Several academics have used this data to forecast price fluctuations with machine learning systems. Prior research has focused on two sorts of predictions. Additionally, the majority of prior research relies on categorical prediction, where forecasts are classified into distinct categories such as up, down, positive, or negative [16]. Technical indicators are often used for stock market prediction because they provide a concise summary of patterns

in time series data. Moreover, other research has used a combination of diverse technical indicators for stock market prediction.

5.2 Textual Data

Textual data is utilized to analyse the influence of sentiments on the stock market, as public emotions significantly affect market dynamics. The most challenging aspect is transforming the text data into mathematical values that can be employed by a predictive model. The extraction of textual data is a complex job [17]. Textual data may be sourced from several resources such as general news, financial news websites, and social networks [18]. Predicting regardless of how people feel about certain stocks are good or bad is the main goal of most research in textual data analysis. Research on social media processing has not given enough attention to data derived from text found in social media and micro blogging sites in comparison to other textual data sources. One issue in processing textual data is the vast amount of information created on these platforms, leading to increased computing problems.

5.3 Machine Learning

Machine learning is used across several industries. Machine learning algorithms are categorised as either supervised or unsupervised [19]. Supervised learning implies preparing a model using labelled input data and then applying an algorithm. Classification and regression are both forms of supervised learning. It has a more regulated environment. Unsupervised learning uses unlabelled data and operates in a less regulated environment. It analyses patterns, correlations, or clusters.

5.4 Feature Selection

Feature selection is an essential stage in processing textual data. Much research on SMP have used fundamental feature extraction methods like Bag of Words, which involves breaking down the text into words and converting each word into a numerical feature. Feature selection Previous studies, as in references [20], [21] often used feature selection approaches that disregarded the sequence of words, resulting in the loss of context. Another way for selecting features is Word2Vec, as suggested by references. This methodology is a word embedding method that relies on a multi-layer perceptron. This approach considers the sequence and simultaneous appearance of words, thereby preserving the context. Word2Vec has been used in several studies, including those referenced in citations [22]. N-grams are contiguous collections of N words extracted from a given series of text. Additional techniques such as genetic algorithms and particle swarm optimization have been used for feature selection, as shown in references [23] [24]. is contingent on the frequency of a word's occurrences.

5.5 Order Reduction

Feature selection for textual data results in an expansion of the feature set. Processing high-dimensional data poses significant challenges and

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sometimes results in low efficiency of many learning techniques. This is referred to as the curse of dimensionality. Reducing the number of features will simplify the training process of the algorithms The authors used three different versions of Principal Component Analysis (PCA) and found that including PCA not only decreased the total training complexity but also enhanced the accuracy of the predictions. In reference [25], several feature reduction methods such as PCA, Factor Analysis (FA), Genetic Algorithms (GA), and Firefly Optimization (FO) were used to address data complexity.

5.6 Feature Representation

Effective feature representation is crucial for optimizing the training of machine learning algorithms. After establishing the necessary characteristics, the input data is transformed into a numerical format for efficient processing by machine learning algorithms. Boolean representation is a fundamental feature representation approach where the existence of a feature is denoted by 1 and its absence by 0 in Bag of Words. Another method, Term Frequency-Inverse Document Frequency (TF-IDF), has been used in many research projects. The text pre-processing step is often seen as a critical stage that may have a substantial effect on the accuracy of the model.

5.7 Data pre-processing Methods

Stock Market Prediction (SMP)- Machine learning techniques are working for stock market prediction and forecasting. After the data undergoes pre-processing and standardization, it is fed into machine learning models for additional analysis. These techniques include Artificial Neural Networks (ANN), Support Vector Machines (SVM), and Naïve Bayes (NB). In financial research, machine learning algorithms are frequently utilized to deliver accurate predictions. These models derive financially relevant features from various information sources, with structured data such as historical stock prices and technical indicators being of paramount importance. Financial publications, press announcements, and yearly reports are often used in predicting market trends [28]. The sources are unstructured and need pre-processing before being used as inputs for machine learning models. Figure 3 shows the Block diagram of stock market system.

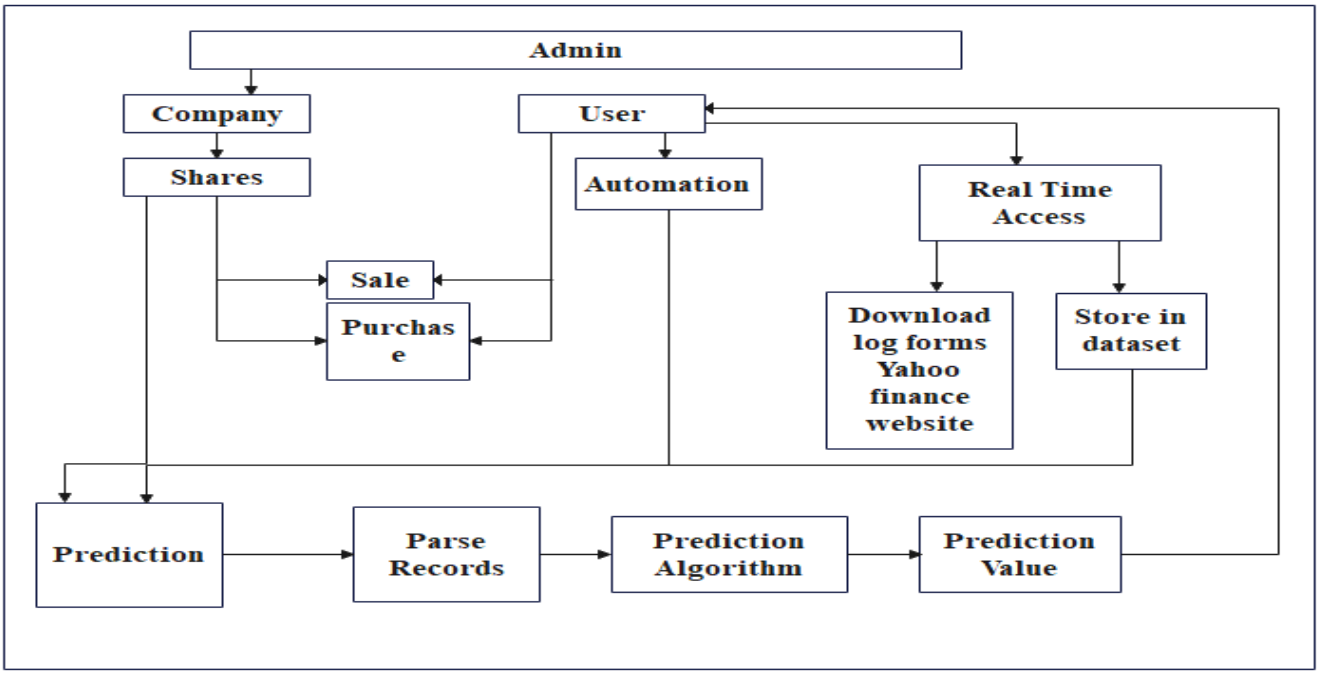

Figure 3 Block Diagram of Stock Market System

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Artificial Neural Networks (ANN)- Artificial Neural Networks (ANNs) are widely accepted for identifying nonlinear relationships in financial markets. Although artificial neural networks (ANNs) may be valuable for forecasting stock market returns, research indicates that they are limited by the presence of significant noise, non-stationary features, and intricate complexity in stock market data [29]. Hence, pre-processing is necessary prior to using artificial neural networks for predicting stock market returns. Their results endorse the use of Artificial Neural Networks (ANNs) for financial prediction. The application has emerged as the most used technique in machine learning, demonstrating superior performance compared to conventional approaches. Their findings support the utilization of Artificial Neural Networks (ANNs) for financial forecasting. This technique has become the most prevalent method in machine learning, showing better performance than traditional approaches.

Support Vector Machine (SVM)- The Support Vector Machine (SVM) learning method is gaining popularity for predicting market prices. The mathematical model is based on a strong theoretical framework and has been extensively advanced in the fields of pattern recognition, function evaluation, and time series forecasting [30]. A precise prediction of stock prices enables you to make more informed investing choices while minimizing risk. SVM is a valuable method for data categorization and regression analysis. It is also an effective technique for identifying patterns and making predictions. It is mostly used for classification jobs, including the categorization of linear and non-linear data. The Support Vector Machine (SVM) establishes a boundary where data points on either side are assigned distinct labels. [31] defined that several research has used various machine learning models to replicate the characteristics of financial markets. SVM is a prominent model in financial prediction jobs because of its capability to manage the non-linear and dynamic characteristics of markets. Figure 3 shows the Block Diagram of Stock Market Prediction using SVM.

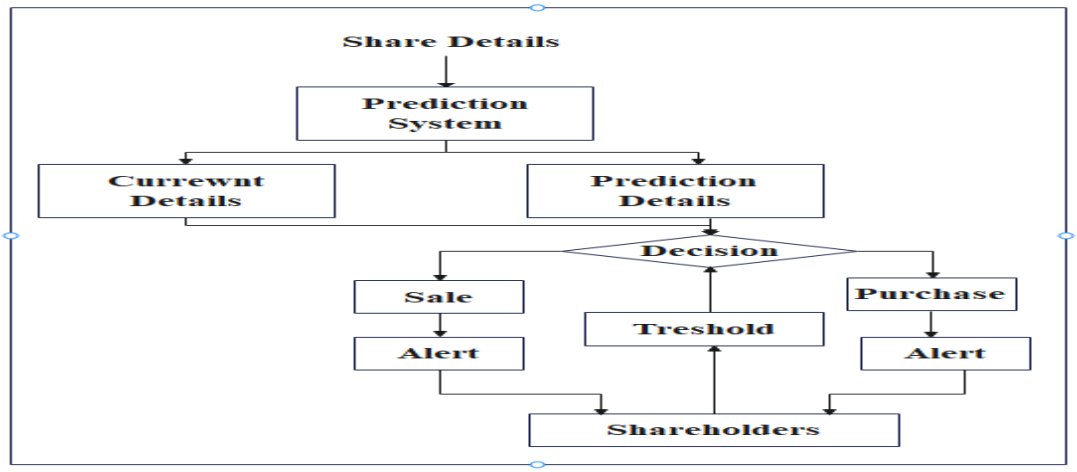

Figure 3 Block Diagram of Stock Market Prediction using SVM

Naïve Bayes (NB) Naive Bayes algorithm is a classification technique that constructs Bayesian networks using Bayes' theorem with a specific dataset. This dataset is intended to include a unique function in a class that is independent of any other functions. For instance, an item is classified as A based on certain characteristics [39]. The existence of these traits may be interdependent or reliant on other features. However, the presence of these features individually influences the probability that this item is A, thus the term "Naive". Naive Bayes is advantageous due to its ease of implementation on large datasets and its ability to outperform sophisticated classification algorithms.

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Hybrid Stock Prediction-Diverse DNN-based methods were considered appropriate for certain application areas, but research demonstrates their relevance to other financial sectors. Utilizing a combination of these strategies may help overcome restrictions and be used for stock market forecasting. Hybrid techniques may include a combination of neural network approaches, transformation methods for denoising or data processing, metaheuristics for parameter optimization, and the use of linear and non-linear models. [43] Comparative study of different neural networks has also been conducted. In addition to the specific uses of RNN-based structures, hybrid methods have been created to address the constraints of current methodologies. A model was created using the Colombo Stock Exchange (CSE) data from three businesses. The model used the close, high, and low price data from the previous two days to forecast the closing price for the next day, as outlined in the reference by [44]. In a research by [45], the movement directions of Google stock price were forecasted using multilayer RNN, LSTM, and GRU models.

6. Challenges

Studying and forecasting the stock market is a fascinating and complex issue. With the increasing availability of data, we encounter new obstacles in obtaining and analysing the data to extract insights and assess the impact on stock prices. [40] The problems include live testing, self-defeating strategies, long-term forecasting, algorithmic trading, and sentiment analysis of business filings. Most stock analysis and prediction literature suggest that the approaches may be used in real-time for profit in the stock market. Claiming that an algorithm works well based on back testing in controlled circumstances is bold, since live testing presents challenges due to variables such as price fluctuations, unexpected news, and market noise. Currently, sentiment analysis using Twitter or news data is receiving more attention due to the growing impact of social media on several parts of our life. Table 1 shows the Comparison of Support of Vector Machine (SVM) Techniques.

Table 1 Comparison of Support of Vector Machine (SVM) Techniques

Authors	Method (Model)	Improvement/ Accuracy	Discussion
[29]	Artificial Neural Networks on tick data.	96.2% for Levenberg-Marquardt 97.0% for Scaled Conjugate Gradients 98.9% for Bayesian regularization.	The authors used three methodologies for prediction and compared them to see which one yielded higher prediction accuracy.
[32]	SVM with volatility and momentum indicators	60.2% average prediction accuracy.	SVM utilizes polynomial functions as kernel functions, which have moderate prediction accuracy.
[33]	SVM and Linear Regression	SVM is better than LR due to improvement over RMSE, MAE, MSE, and R-squared.	Linear regression is used to identify the linear pattern in stock price.
[34]	Support Vector Regression (SVR)	MAPE with RMSE shows marginal improvement.	This strategy is more effective when the stock market has little volatility. Regressive technique is used in SVM to enhance prediction accuracy marginally.

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[35]	SVM with KNN (K-nearest neighbour)	93.33% for K=4 with three indicators.	The authors use the KNN method to get the nearest stock price, then conduct feature selection using SVR.
[36]	SVM and Variable Selection Methods.	89.1667% with the Peeling method + SVM 84.1667% with Cross-correlation based method + SVM 82% with SVM.	The author first predicts the direction of travel using POCID and then applies SVM.
[37]	SVM with ICA (Independent Component Analysis.	Improvement of 0.019191 RMSE using SVM-ICA against 0.12286 RMSE using SVM.	ICA is a technique for selecting features in data, whereas Radial Basis Function is used in SVM.
[38]	Efficient Market Hypotheses based on Financial results with SVM	57.1% using (EPS, BPS, NPGR)	The writers used the company's financial statements. using SVM to enhance predict ability.

Conclusion

This review paper explores stock market prediction (SMP) approaches, focusing on traditional methodologies and the growing field of machine learning in finance. It highlights the importance of data in SMP, distinguishing between market and textual data, and a number of machine learning techniques can be used for predictive analytics. A general plan for stock market prediction is presented, with a focus on feature selection, order reduction, and data preprocessing. Numerous machine learning techniques, including Support Vector Machine (SVM), Naïve Bayes (NB), and Artificial Neural Networks (ANN), are examined and each has specific benefits and uses. However, challenges such as data quality issues, model overfitting, and the unpredictability of financial markets remain. The integration of machine learning holds immense potential for improving predictive accuracy and investment decision-making.

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