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Sustainable Stock Market Prediction Framework Using Machine Learning Models

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ABSTRACT

Prediction of stock prices is a challenging task owing to its volatile and constantly fluctuating nature. Stock price prediction has sparked the interest of various investors, data analysists, and researchers because of high returns on their investments. A sustainable framework for stock price prediction is proposed to quantify the factors affecting the stock price and impact of technology on the ever-changing business world. The proposed framework also helps to understand how technology can be used to predict the future price of stocks by using some historical dataset to produce desirable results using machine learning algorithms. The aim of this research paper is to learn about stock price prediction by using different machine learning algorithms and comparing their performance. The results reveal that Fb-prophet should be preferred for more precise prediction among different ML algorithms.

KEYWORDS

Comparative Analysis, Decision Tree Regression, Fb-Prophet, Holt's Winter Model, Linear Regression, Machine Learning, Stock Price Prediction

1. INTRODUCTION

The stock market is a public market where buying, selling, and issuance of shares and other assets of different companies takes place. There are two main stock exchanges that provide the platform for trading in India named as the Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE).

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All the important firms of India are listed on both exchanges. The two main Indian market indexes are Sensex and Nifty. Sensex and Nifty are the benchmark index values that are used to measure the performance of the stock market as a whole. The Securities and Exchange Board of India (SEBI) monitors the execution, development, regulation, and supervision of the stock market.

Investments in the stock market are done commonly via stock brokerages and electronic trading platforms. Changes in the stock prices occur due to demand and supply for a particular stock. Higher demand than the supply of stock results in rising of the stock prices whereas less demand and high supply results in fall in stock prices. To earn profit, traders need to invest in stocks at low price and when the price is high, sell it to get maximum return on investment. To be able to do so, they should be aware of the trends in the stock market i.e. the opening and closing price of the stocks because they want to sell the stock at a higher price than the price they have bought the stock at. This is the reason why one should analyse the company whose stocks they are going to invest in to ensure profitable returns. When you are looking to invest in stock there are two ways to evaluate it. One is with fundamental analysis and the other is with technical analysis. The former uses the financial statements reported by the business to calculate the intrinsic value of the business. An intrinsic value is what the company is worth today. Intrinsic value has nothing to do with the stock price so it does not consider the stock price in its calculation. Technical analysis looks at the stock chart to analyze the short-term and long-term trend of the stock to determine where the stock price is most likely going to move to. The movement of the stock is based on supply and demand which is driven by the emotion of greed and fear. In technical analysis, we do not look at anything related to financial statements and we just look at stock charts and indicators.

Most of the investors use both financial and technical analysis in their stock investment to buy a stock when it's first undervalued and when it's on an uptrend and in the long term stock price will move towards the intrinsic value of the company that we calculated through fundamental analysis. However, in the short term, price movement is very volatile and driven by emotions and analysed through technical analysis. Technical analysis is done by various data analysts, researchers, and traders to predict the future prices of a stock given the past stock trends and activities. This analysis aims to predict the future stock price values which should be closer to the actual stock price values. Chart patterns and statistical numbers are used extensively by technical analysts and this makes technical analysis strenuous and more complex computation. This is where machine learning comes into play. Machine learning plays a very crucial role in stock price prediction. In simple words, machine learning is the process of adding learning ability to a machine. Machine learning is all about writing an algorithm to pass data and use that data to learn and understand the patterns from the data and use the learned algorithm to make further predictions. Machine learning models are built on sample datasets that are trained to make predictions or decisions to solve problems without specifically being programmed to do so. Various data analysts, researchers use different machine learning algorithms to develop a good decision-making system. The algorithmic method using different algorithmic models helps us to get more accurate results as it eliminates human emotions of fear, greed, etc. A particular machine learning model can be improved by training it again and again if we are not satisfied with the results.

In this research paper, we will be doing algorithmic analysis on stock prices by using machine learning. The predictions of future prices will be made on the datasets NFLX.csv and Stocks. csv taken from the internet. In section 3, work related to the research has been discussed and in section 4 the role of stock market in economy has been discussed. In section 5, we learn about the prediction methodologies using machine learning. In section 6, sustainable framework for predictions has been discussed that include linear and decision tee regression. In section 7, the results and comparison of the two algorithms is discussed on two different datasets. This research paper focuses on the use of Linear Regression and Decision Tree Regression algorithms to predict stock values. The parameters of the datasets taken into consideration are opening price, closing price and the number of trading days.

2. RELATED WORK

With the massive rise in technology, there have been many research experiments and evaluations in the stock market in predicting the future trends in the stock market. Various different methods and techniques have been introduced in the recent years to predict the stock prices.

In (Nayani, 2021) the author has discussed about the role of artificial intelligence in stock price prediction and how it has helped investors in making the right decisions. Two machine learning techniques have been used in the study which are Support vector machine (SVM) and linear regression and compared their performance. SVM model shows various classes in a hyperplane in n-dimensional space. SVM generates the hyperplane in order to minimize the error. The use of SVM is that it divides the data points into classes to find the maximum marginal hyperplane. It is considered to be the best algorithm for time series prediction. Whereas in linear regression, relationships are built between two variables which are dependent and independent variables. relationships are formed by using linear equations on the data. In the end, after comparing their performance on the same dataset, it was concluded that the SVM model works better than linear regression as it gives accurate predictions.

In (Dr. P. K. Sahoo, 2015), the author has studied stock price prediction using the auto-regressive model. In this model, the current output is defined as the linear combination of its past value and the present values of the input variables. To calculate the coefficients of the linear equation, the author has used Moore and Penrose techniques. The regression equation is used to find the coefficients, which are further used to predict the future price of stocks. The study concludes with the visualization of data and comparing the predicted data and actual data of the stocks. The graphs of predicted and actual data overlap a lot which shows the accurate nature of the predictions.

In (Alamir Labib Awad, 2021), the author has explored and analysed different techniques that are used in the prediction of stock prices and performed a comparative study on them. These techniques include various machine learning and deep learning algorithms. Comparisons are done based on their performance, advantages and disadvantages. The algorithms studied are K-NN regression, DRL (Deep Reinforcement Learning) in stock trading, BERT for sentiment analysis, MAS simulator to simulate the stock movements, LSTM for trading, combining LSTM (for prediction) with C-NN(for feature extraction), etc. This paper is very informative if you want to learn about different types of algorithms and it covers both deep learning and machine learning areas. The study concludes by recommending LSTM method over others due to its better performance and learning abilities. Also, we learn that the latest learning method for stock price prediction is DRL because of its efficiency and excellent ability to solve time-series problem. In (Singh, Kaur, & Aggarwal, 2014), the authors have discussed an advanced computing concept called unbiquitous computing, discussing the pervasive concept, characteristics of pervasive concept, applications and requirements, consequences, etc.

3. ROLE OF STOCK MARKET IN ECONOMY

A stock market serves as a platform for investors where they can purchase stocks, commodities, and bonds. It does not have any assets of its own, but acts as a market to investors for buying and selling the stocks. It is quite similar to a telephone that connects the caller and the receiver, whereas the stock market connects buyers and sellers. A stock market is one of the significant parts of a free-market economy. It is the platform where investors can get a small part of the company on investing in the company's stocks. One can purchase stocks of those companies that are listed on the stock exchange.

3.1 Top 10 Stock Markets in the World

All the stock exchanges in the world combined constitute a capital of **$89.5 trillion**. (Trade Brains, n.d.) World's top 10 stock markets along with their market capital in descending order are:

World's Top Ten Stock Markets

SR NO.	NAME OF STOCK EXCHANGE	MARKET CAPITAL
1	New York Stock Exchange (NYSE), US	**$27.69T**
2	NASDAQ, United States	**$24.56T**
3	Shanghai Stock Exchange (SSE), China	**$8.15T**
4	EURONEXT, Europe	**$7.33T**
5	Japan Stock Exchange (JPX)	**$6.54T**
6	Shenzhen Stock Exchange (SZSE), China	**$6.22T**
7	Hong Kong Stock Exchange (SEHK)	**$5.43T**
8	LSE Group, UK and Italy	**$3.8T**
9	National Stock Exchange (NSE), India	**$3.55T**
10	Toronto Stock Exchange, Canada	**$3.26T**

3.2 Factors That Affect Stock Market:

i) **Interest Rates:** There are two major reasons why low interest rates make stock market very attractive to invest. Low interest rates means less risks therefore more investors buy the stock. This in turn leads to economic growth of the company which makes a company more profitable. If given a choice of saving the money in banks and investing at a lower interest in stocks, the investor will invest in stocks as it will give him profitable returns in the future.

ii) **Economic Growth:** Rise in economic growth will help in increasing a company's profits as there will be a higher demand for goods and services of that company. This will increase the company's dividends and therefore stock prices.

iii) **Investor's Emotions:** Humans are emotional beings. An investor's sentiments during investing plays a vital role in the trends in the stock market. Every investor wants maximum return possible on his/her investment. Since investors are human beings with emotions like fear, greed, anger, etc. If they receive some positive news about a particular company's stock, will most likely buy it. Whereas if there is bad news, the fearful and anxious investors will sell it. This panic to sell quickly can start a recession.

iv) **Inflation and Deflation:** Inflation is the rate at which the prices of goods and services increase. When this increase in prices becomes huge, investors and consumers face problems. If a dollar buys less that means it is worth less. Therefore, the value of the stock reduces and the investors do not want to buy the stocks and those who have already bought want to sell. Deflation is a macroeconomic condition in which the prices of goods and services decrease. It is the opposite of inflation. Although, it might seem good at first as everything becomes cheaper but if it continues for too long, the company's profits start decreasing. Since there is a huge supply of goods and services, companies are forced to sell their products for even cheaper prices and reduce the production costs or maybe even stop the production of goods. It might also lead to reduces salaries of employees and firing them which leads to an increase in unemployment. Thus, prices start falling and investors sell the stocks which are no longer profitable to them.

v) **World Events**: There are a lot of other events in the world that can easily affect the stock market including:
   - Natural Disasters (Earthquakes, Tsunami, etc.)
   - Terrorist Attacks
   - Riots/Civil unrest

- Elections
- Major changes in governments

3.3 Impact of Technology on Stock Market

In the earlier days, investors and traders used to yell out their orders to each other creating complete chaos at the trading place. The traders used to gather generally based on news related to a particular stock and start shouting their offers and it seemed like a fish market. Whereas today because of various technical advancements, tech-trading has come into the picture which requires no yelling. It has made investors' work efficient and hassle-free as they can research and buy stocks by using technology.

Technology has helped in various different ways as follows:

i) Electronic Trading

The introduction of technology is such a boon to the traders in the stock market. Fast and efficient trading requires accurate and fast data analysis. This is where technology comes into play as technology is far better at these tasks than an average human This made technology and the stock market a perfect match. The first fully computerized platform for the stock market was offered by NYSE(New York Stock Exchange) in 1966. The digitalization of the stock market changed the entire scenario of the way the market functioned. Investors were able to make deductions based on the statistics using different algorithms to find the probabilities of various events and how they would affect the market.

ii) Readily available data for research

Technology has brought about transparency in the stock market as earlier a lot of information about the stock market was unknown to the traders whereas today there is an ample amount of data on the internet about different companies and their stocks. Investors can research and study this data to decide whether to invest in the stocks of a particular organization or not. The information related to the current stock prices, opening and closing price of each stock, company's revenue, previous dealings of the company, etc. is also available readily on the Internet. Investors can seek the help of financial advisors based on this research to track the performance of a company's stock in real-time. This way the investors can stay informed about the company's status and decide whether to invest or not and if they want to invest when is the best time to do so to ensure profitable returns.

iii) Trading Software Tools

In recent years, apps have become one of the most common mediums of accessing and investing in the stock market. Even a person with zero knowledge of investing and stock prices can start investing as a beginner using such apps. These apps also provide practice accounts for people who are new to stock trading to practice. Earlier, the investors had to travel to reach the company or the broker for trading which would usually lead to reduced profits. Whereas now with the help of these apps, one can trade at one's own convenience and comfort of their homes or offices.

iv) Fast decision making& Time saving

The advancements in technology have helped in making the trading process very quick. In the earlier days, traders had to travel miles to participate in stock trading which use to take a lot of time and energy. Because of technology, traders now have unlimited access to the market through various apps and websites where they can get information about the stocks in real time. They can buy and sell stocks according to their convenience while sitting at their home or office by using these apps and websites. For example, an investor had bought a stock at 10 USD and its price goes up with a margin of 0.5, now it's his choice to decide whether

to sell it or wait until the margin increases further. This has made investor's life easier by saving their time and helping in making quick decisions.

v) Accurate Predictions

Investing in the stock market is very risky as the market is very volatile, the prices vary a lot. So, the traders want to have an idea before investing about the prices of stocks that how high can a particular stocks price rise or fall in the near future. This is where algorithmic prediction comes into the picture. Various data analysts, scientists, and researchers use different techniques and algorithms to predict the future prices of stocks. This is one of the best methods as it gives accurate results as it removes human sentiments like fear, greed, anger, etc. This helps the investors to make decisions that will yield them profits.

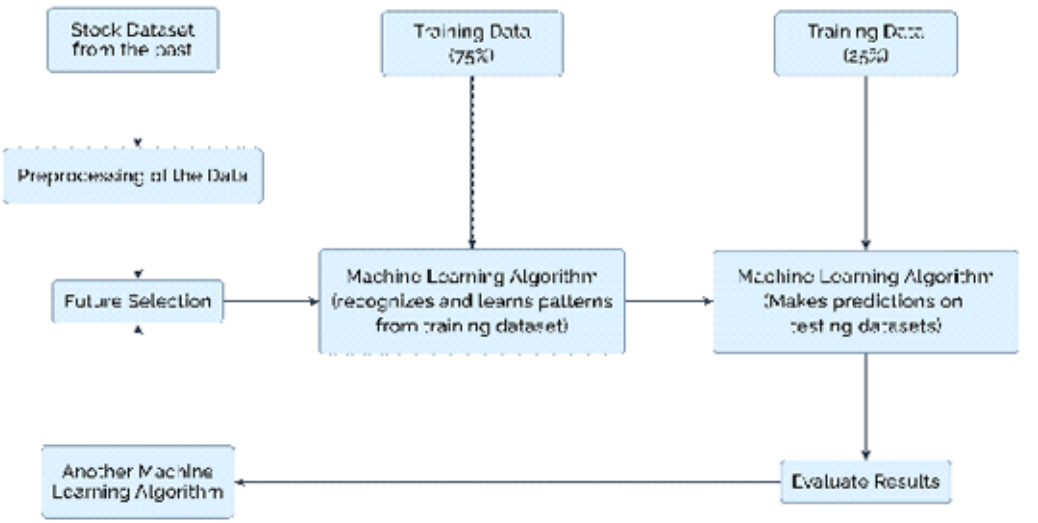
4. PREDICTION METHODOLOGIES USING MACHINE LEARNING

Machine learning algorithms are capable of dealing with huge datasets in a very short period of time. By using various algorithms, machine learning can analyse datasets and find valuable patterns and information from them. This is the reason why machine learning is the best for stock price predictions as it observes and evaluates the historical raw data of stock prices and find patterns to predict future prices.

Machine learning is vastly used today by various scientists, data analysts, researchers to predict the future stock prices of a particular firm. Different machine learning algorithms can be used to predict the prices and compare their results. Raw data is collected from the internet and it is used for the prediction of future stock prices. The main goal is to get maximum profit on your investment.

In this study, I will be using two machine learning models which are the Linear Regression and the Decision Tree Regression model to predict the future stock prices of stocks using two different datasets. My main focus will be on the close price of the stocks like the above-mentioned algorithms will be predicting the future closing prices of the stocks. After that, the data will be visualized according to the values predicted by both the models i.e. graphs corresponding to each model's predicted values will be plotted and the results will be compared. The working of two algorithms in predicting the stock prices prediction process can be summed up into a flowchart as shown in figure 1.

Figure 1. Flowchart representing Stock price prediction using training and testing dataset



5. SUSTAINABLE PREDICTION FRAMEWORK

5.1 Linear Regression

This algorithm is used to build a relationship with two types of variables, one being independent variable and the other being dependent variable. It is statistical model used to build a relation between variables by using a linear equation. It represents the change in the variable on the y-axis with respect to the change in the variable on the x-axis. This analysis involves plotting a set of data points that join to form a line that covers the maximum data. This line is called the line of best fit. Linear Regression is represented by the equation

$$y=mx+b$$

It is the best fit line, where y is the dependent variable, m is gradient, x represents the independent variable and b is the y-intercept.

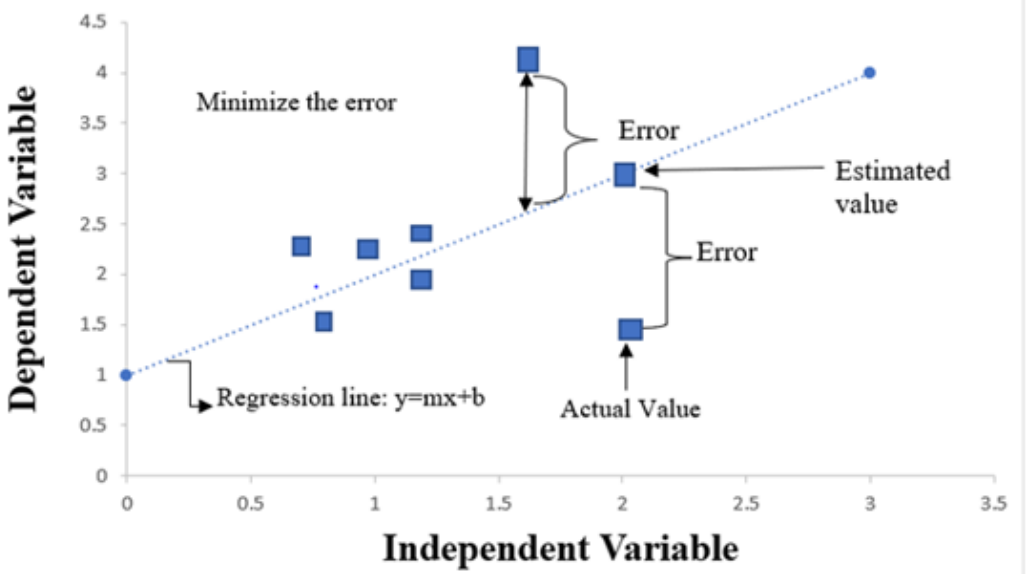
In linear regression, data points are plotted in the form of a line. The datasets are modelled using a linear equation.

As shown in the picture, we have an estimated value and an actual value. We need to reduce the error i.e. the linear distance between the estimated and actual value. The best fit line is one which has the least error. Basically, we have to minimize the error.

Linear Regression is most commonly used methods in statistics. Various researchers, data analysts and scientists use this algorithm to find relationship between different factors. Researchers often use linear regression to understand the relationship between expenditure and revenue. Investors use this algorithm to predict the relationship between various independent variables that can affect the stock price and the dependent variable.

Prediction of future stock prices using linear regression is done by using historical data of a company's stocks. This data can be found in the form of datasets on various different sites on the internet. There are many factors that can affect the prices of stocks like opening price, closing price, volume, etc. In our prediction, the close price is the variable that is dependent on the number of days.

Figure 2. Graphical Representation of Linear Regression



Linear regressor model is imported by using "from sklearn.linear_model import LinearRegressor()". Then we can define and call the corresponding functions. We call the LinearRegressor() function and use the fit function by passing the trained dataset as parameters. Then, after training and testing the dataset and using it to predict future values using linear regression algorithm, data visualization will be done i.e. plotting the original data from the dataset, the predicted future stock price values, and the actual valid values, we will compare the predicted and valid values on the graph and see how close the predicted prices are to the valid prices.

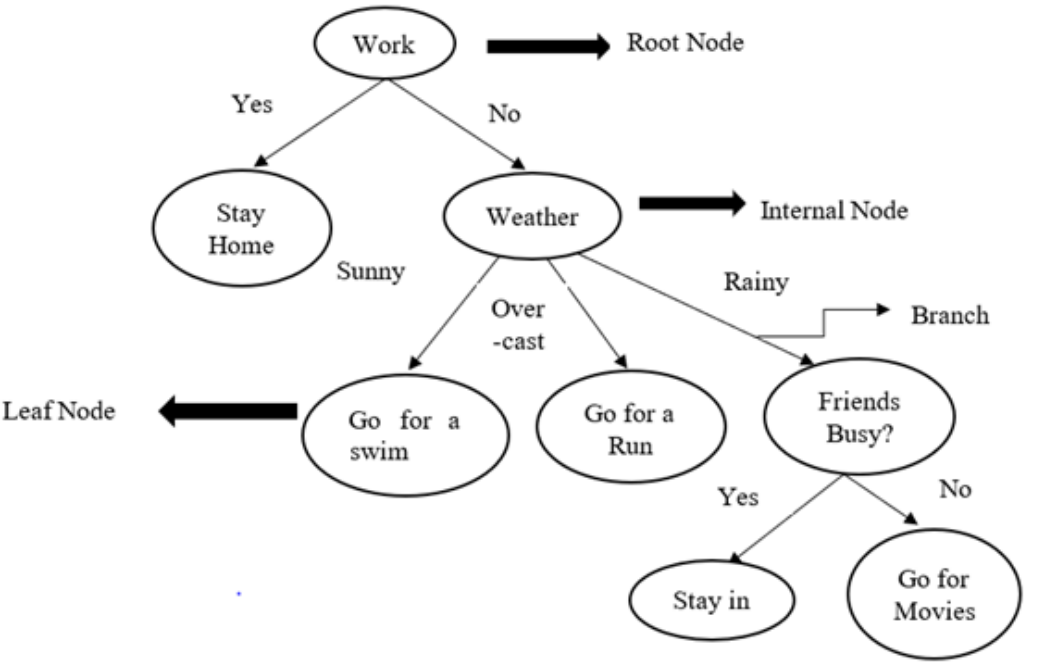
5.2 Decision Tree Regression

A decision tree is a flowchart kind of a structure used to visualize solution of a problem in a step-by-step way. It is based on supervised learning algorithm. Just like a tree, it has a root node and then various branches that represent different decisions and finally their corresponding results. This algorithm makes use of conditional control statements to segregate data.

A decision tree consists of three types of nodes: root node, internal nodes, leaf nodes. The root node is the first node from the top which represents entire dataset which will be split in further nodes (Elgendy et. al). The internal nodes represent characteristics of the dataset and the branches represent decisions or questions which are generally in a true or false form. The leaf nodes represent the final decision. This algorithm is useful where we have to take decisions step by step based on certain conditions.

Decision trees are used in classification and regression techniques. Decision tree regression is a supervised learning algorithm. This type of algorithmic predictions in regression using decision tree is used vastly in machine learning, data science, etc. (Mohd Arshad, 2019) Decision tree regression observes features of a dataset and trains a model in the form of a tree to predict data in the future to produce meaningful continuous output. Continuous output means that the result is not discrete, i.e., it is not represented just by a discrete, known set of numbers or values (Gupta et. al 2015).

Figure 3. Example of a decision tree regression



Decision tree regressor model can be imported in the code just the way we import datasets and python libraries. It is imported by using "from sklearn.tree import DecisionTreeRegressor()". Then we can define and call the corresponding functions. We call the DecisionTreeRegressor() function and use the fit function by passing the trained dataset as parameters. This is how the decision tree regressor model gets created and the next step is to predict the values using the trained dataset by implementing model. After we get the predicted values, we visualize the data by plotting a graph.

6. RESULTS AND COMPARATIVE ANALYSIS

6.1 Visualization of Nflx.csv Dataset

Figure 4 shows the graph of close price of the dataset originally before the implementation of linear and decision tree regression algorithms. To predict the values, we remove the last few days from the dataset and it is done by removing last few rows. In this case, the last 25 rows have been removed. After that the predictions will be done for those removed 25 days and the days after that. This is done as we can compare the predictions of those 25 days with the already existing values that we have from the original dataset using the graph of close price shown in fig 4.The part of graph that represents those removed 25 days becomes our valid data with which we compare the predicted data.

The following graphs are represented with three colours: Blue, Red, and purple. The original data is shown with blue colour, the valid data is shown by the colour red and the predicted data is shown by the colour purple. To know the accuracy of our predictions, we need to observe the valid data and the predicted data, we need to compare the two and find out if the data we predicted is somewhat close to the valid data.

Figure 5 represents the visualization of the predicted values of closing prices of stocks using the Linear regression algorithm on the dataset NFLX.csv. As we can see in the graph, the red graph and the purple graph are way apart. The red graph represents the valid values whereas the purple graph represents the predicted values. The values are not very close as we can see in the graph, the red graph is going upwards whereas the purple graph is going in a downward direction. Thus, the predictions done using the Linear Regression model is not that good (Kaur et. al 2021). The predicted data is not even close to the valid data.

Figure 6 shows the graphical representation of the predicted values of closing prices of stocks using decision tree regressor algorithm. Similarly, in this we can see from the graph that the red and

Figure 4. Visualization of Close price of stocks before training the dataset using algorithms

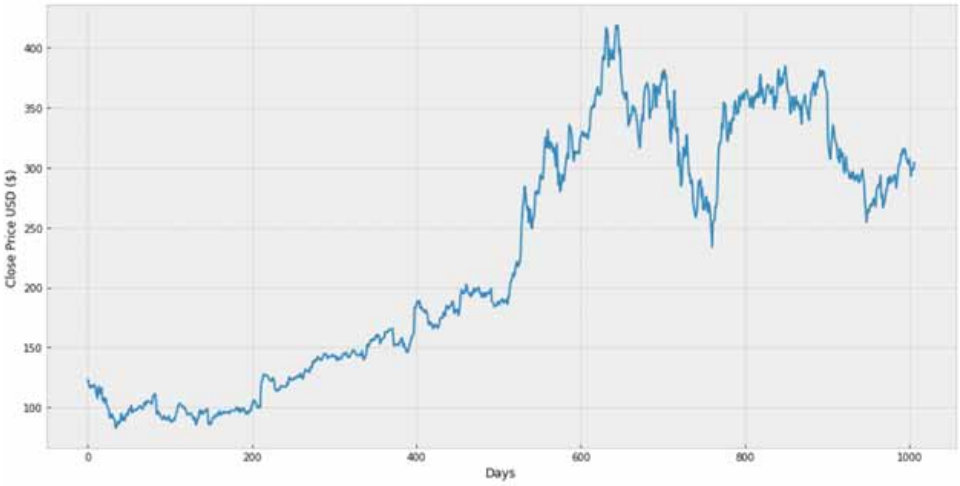


Figure 5. Visualization of stock price predictions using Linear Regression on NFLX.csv dataset

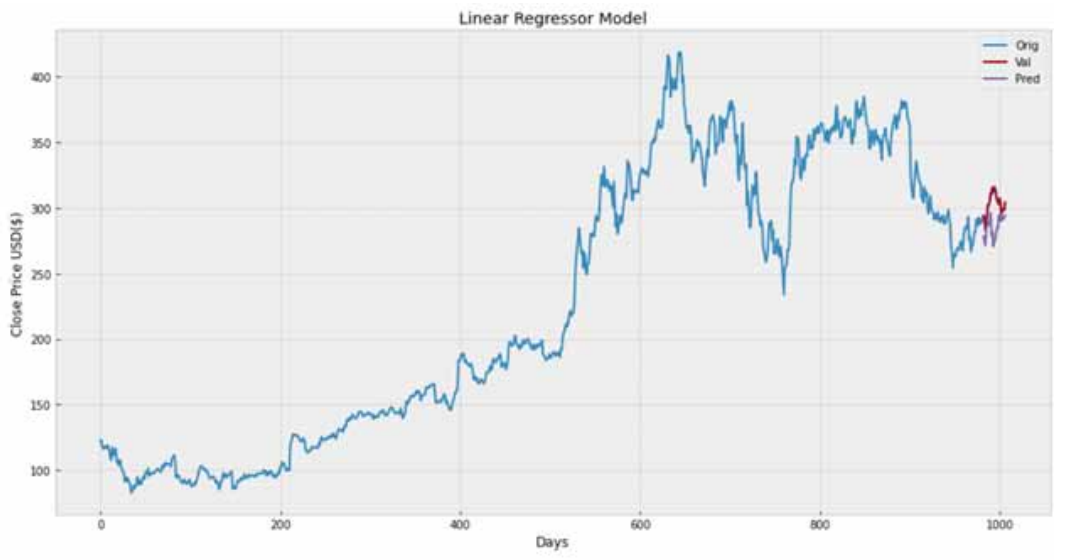
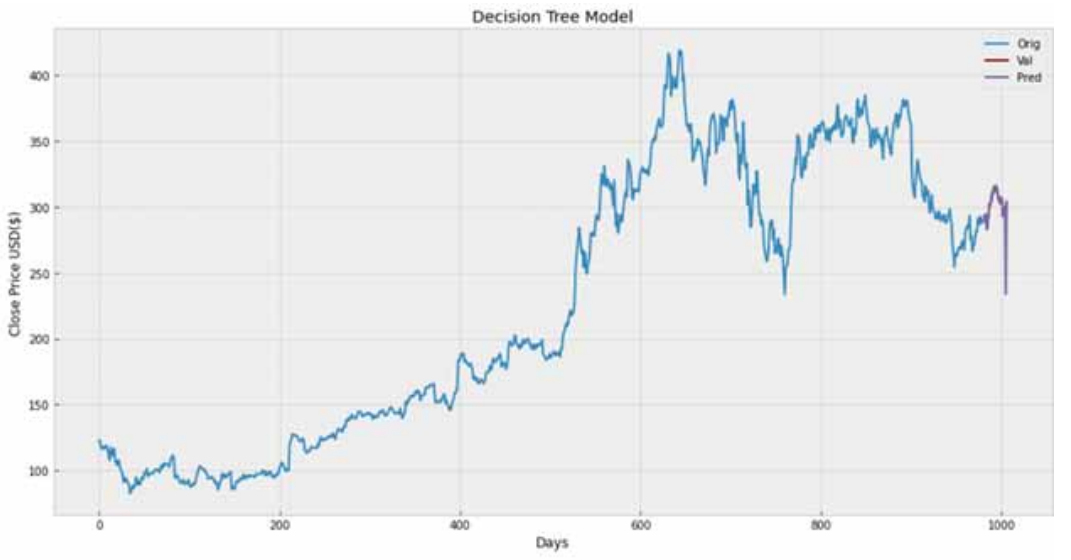


Figure 6. Visualization of stock price predictions using Decision Tree Regressor on NFLX.csv

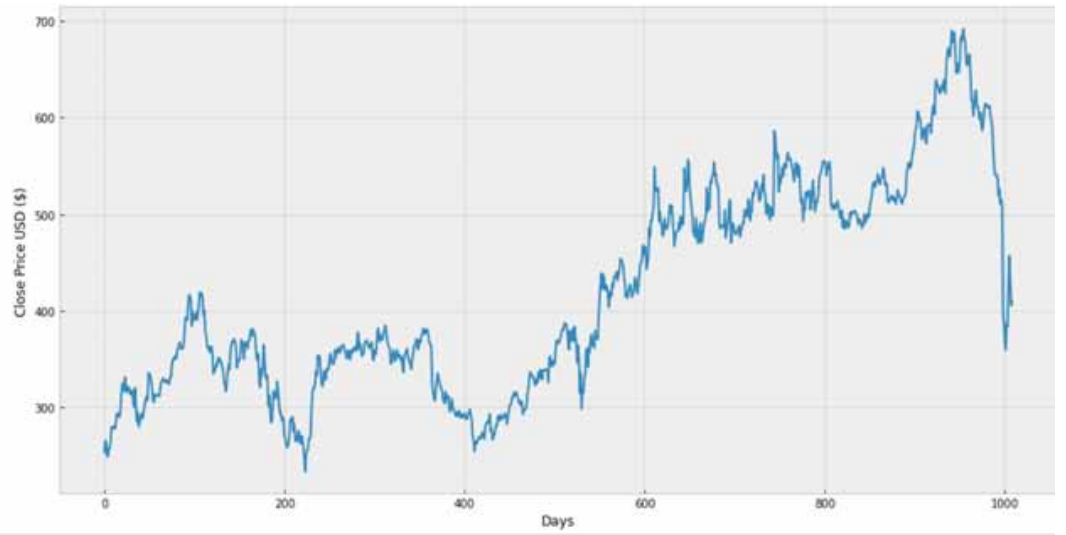


purple graphs are overlapping in the beginning, it shows that the data we predicted is very close to the valid data. So, we can say our predictions made by using decision tree regression model are very accurate.

6.2 Visualization of Stocks.csv Dataset

Figure 7 shows the graph of close price of the dataset originally before the implementation of linear and decision tree regression algorithms on the dataset Stocks.csv (Cvitić et. al, 2021). To predict the values, we remove the last few days from the dataset and it is done by removing last few rows.

Figure 7. Visualization of Close price of stocks before training the dataset using algorithms



In this case, the last 25 rows have been removed. After that the predictions will be done for those removed 25 days and the days after that. This is done as we can compare the predictions of those 25 days with the already existing values that we have from the original dataset using the graph of close prices as shown in fig 7 (Manasrah et. al 2019).The part of graph that represents those removed 25 days becomes our valid data with which we compare the predicted data.

The following graphs are represented with three colours: Blue, Red, and purple. The original data is shown with blue colour, the valid data is shown by the colour red and the predicted data is shown by the purple colour. To know the accuracy of our predictions, we need to observe the valid data and the predicted data, we need to compare the two and find out if the data we predicted is somewhat close to the valid data.

Figure 8 represent the visualization of the predicted values of closing prices of stocks using the Linear regression algorithm on the dataset Stocks.csv. It can be clearly seen in figure 8 that the graph of predicted values is far away from the graph of valid values. The valid values are going downwards whereas the predicted values are moving forward. The two graphs are not overlapping anywhere except their mutual starting point. We can conclude that the predictions made using linear regression model are not good and not even close to the valid values.

Figure 9 shows the graphical representation of the predicted values of closing prices of stocks using decision tree regressor algorithm. On observing the graph, it can be seen that the predicted values in purple are overlapping the valid values that are represented by the red coloured graph. The predictions made using decision tree algorithm are very accurate and better than those made by linear regression algorithm.

6.3 Comparative Analysis

Linear Regression does not give accurate predictions on both the datasets whereas Decision Tree Regression gives very accurate predictions on the given datasets. The main difference between the two algorithms is that the presence of missing values i.e. outliers in the dataset affects the accuracy of predictions in linear regression whereas decision trees function effectively even if there are a few outliers present in the dataset. Linear regression algorithm produces best results when the dataset is linearly separable and the linear nature of this algorithm can be seen in the graphs above. Whereas, decision tree regression gives good results with both linearly separable and non-linearly separable datasets. This can

Figure 8. Visualization of stock price prediction using Linear Regression of Stocks.csv dataset

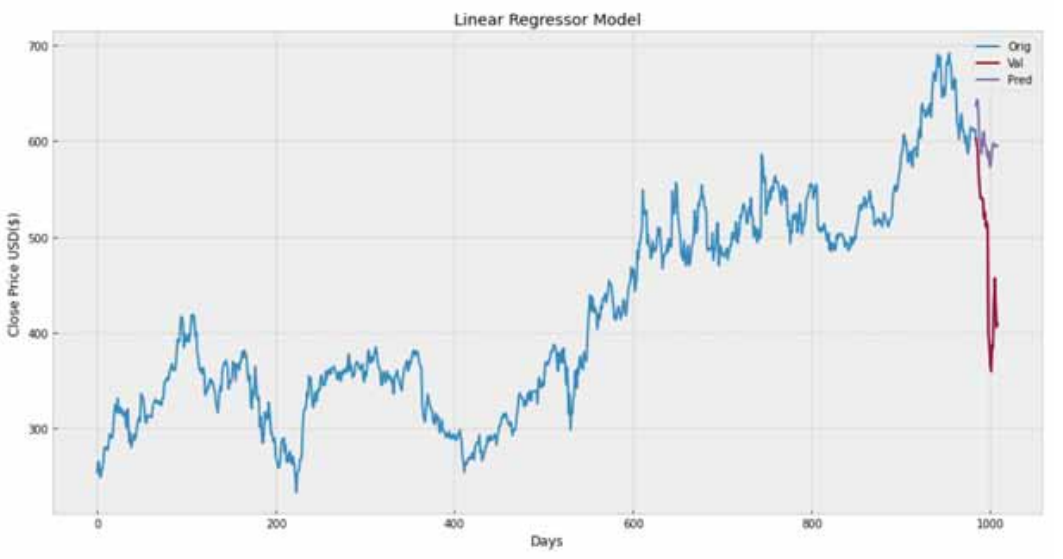
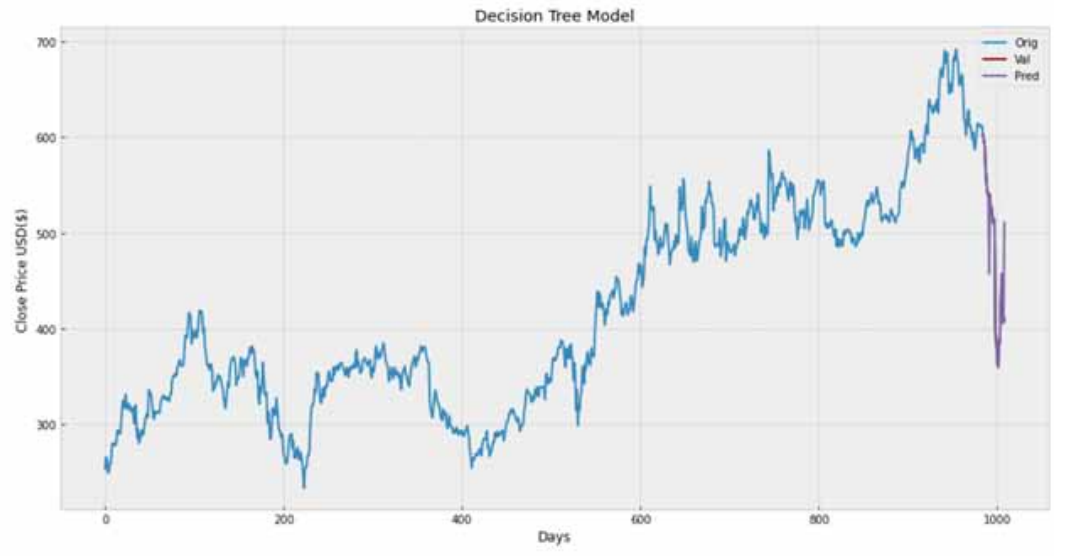


Figure 9. Visualization of stock price predictions using Decision Tree Regressor Model of Stocks.csv



be seen in the graphs above. Only big datasets yield accurate predictions in case of linear regression. On the contrary in decision tree regression, big datasets will give poor predictions because if size of data is very big, one tree will have so many nodes which will make the process complex.

7. CONCLUSION AND OPEN ISSUES

We can conclude that stock price prediction has helped many investors and will continue to do so. Also, it will become more efficient, easy and quicker with the increasing advancements in technology

especially in the fields like artificial intelligence, machine learning, etc. Through this study, it can be concluded that different machine learning algorithms can be very useful to predict the trends of stock market. These predictions help in reducing the risk factor and to ensure profitable returns to the investors. Such predictions help in the decision-making of investors as to when to buy or sell the stocks to ensure gains. The two algorithms have been studied for stock price prediction which are linear regression and decision tree regression. After studying and observing the nature of both the algorithms on two different datasets, it can be concluded that decision tree regression is better than linear regression as it gives pretty accurate results. The predictions are very close to the valid data. Stock price prediction is one such problem that challenges the researchers and analysts as it is not easy to develop models that can take so many factors that the stock prices depend on, into consideration to produce accurate predictions. This has always been a challenge and continues to be so. New methods and solutions are being developed every now and then by data scientists and researchers to overcome these shortcomings.

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