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Stock Price Prediction of AAPL Stock by Using Machine Learning Techniques: A Comparative Study

Vikas Deswal[1] and Dharminder Kumar[2]
[1]*Research Scholar, PhD (CSE), Department of Computer Science & Engineering, GJUS&T, Hisar, Haryana, India*
[2]*Professor, Department of Computer Science & Engineering, GJUS&T, Hisar, Haryana, India*

***Abstract*—In today's world, everyone is looking for smart way of investing his/her hard earned money. There are several ways of investment, such as purchasing land, investing in real estate, fixed deposit in banks and investing in the stock market. In all other investment options except for the stock market, require a lot of initial funds. This is one of the reasons why many people are motivated to invest in the stock market. But stock market is very volatile, dynamic and uncertain. So its prediction is a very challenging and tough task in today's competitive and open environment. Earlier this prediction work was done by expert stock brokers and traders. This prediction by human being was possible because data was limited, simple, restricted to local area and powerful computing machines were not available. Now a day data is unlimited, complex and its generating speed is very fast that's why data prediction is done by machine learning algorithms. Selection of appropriate machine learning model is again a difficult task. This paper evaluates the performance of five different ML algorithms: linear regression, support vector machines (SVM), random forest, neural networks, and long short-term memory (LSTM) for predicting the stock price of Apple Inc. (AAPL). Accuracy of all five machine learning models is evaluated using values of performance metrics like root mean square error (RMSE), mean square error (MSE), mean absolute error (MAE), and mean absolute percentage error (MAPE). Goodness of fit of all five machine learning models is also checked by using values of coefficient of determination (R^2). This paper predicts AAPL stock value by using five different algorithms and then graph is plotted between actual & predicted prices for all models. Plot between actual & predicted AAPL stock value, measurement metrics (RMSE, MSE, MAE, MAPE) value demonstrate that regression algorithms, especially linear regression, neural networks, and LSTM achieve good accuracy on the AAPL stock price data. Value of coefficient of determination (R^2) proves that LSTM model is fit for stock price prediction of AAPL stock.**

Keywords: stock market prediction, machine learning (ML), LSTM, RMSE, MSE, MAE, MAPE, R^2, adjusted R^2, Apple (AAPL).

I. Introduction

Stock market is a place where buyer and seller willing to buy or sell stock of company at a price interact with each other. It plays crucial role in the growth and development of growing economy like India. There is direct relationship between stock market and economic development of any nation. Only 10% people are involved in stock market investment, because of its dynamic, volatile and unpredictable nature. Stock market prediction is finding future stock price in advance by studying past trend and pattern. There is wide scope of stock market prediction in India. At present only 10% of entire population is associated with stock market. This is one of the most popular, cheap but risky way of investment [1].

Majority of stock market experts wants something (expert advice, software, and AI chat bot) which can predict stock trend in advance and give reliable and trustworthy advice. Earlier this kind of prediction was done by stock market experts because data was limited, its scope was restricted to few areas and less awareness among general public. But now because of easy and cheap availability of internet technology, unlimited, high pace, volume data is managed by machine learning algorithms. One of popular and well known method to design and develop prediction model is through application of machine learning algorithms. Machine learning is a technique where computer learn or predict things on the basis of past trend and pattern. Stock market is fully dependent on time where price changes after every second. Such time dependent dynamic things are solved by time series analysis. ARIMA is suitable only for linear time series problems. Non-linear, high volatile problems are easily tackled by machine learning algorithm [2].

Machine learning algorithms are mainly of three types. Supervised, unsupervised and reinforced machine learning algorithms. In supervised machine learning algorithm data is labelled, means for every input there is output. Model is trained for every input. Supervised learning has mainly two main types of problems: classification and regression. Classification problem forecast category of data, whereas regression problem involves forecasting continuous value. Unsupervised machine learning algorithms are trained on unlabelled data. Task of unsupervised machine learning

algorithm is to find trends and pattern in data without any previous knowledge. Reinforced learning algorithms are trained on trial and error basis. Stock price forecasting problem falls under regression because future stock price is a continuous value. Apart from predicted price there are other data like opening and closing price. This data can be used to train the model. Now a day's stock data is huge and nonlinear. For dealing with such data efficient model is highly needed which can identify hidden trends, pattern and complex relation in data set. Selection of proper machine learning algorithm is again a big challenge. There is a myth about stock market i.e. stock market is another form of gambling. By using proper machine learning algorithm, we can prove that prediction of stock is not gambling but it is a pure science which depends upon proper facts and figure. Now a days, advanced machine learning algorithms based on fundamental or technical analysis are used for forecasting stock price [3].

A. Research Questions

The aim is to compare accuracy of five machines learning algorithms for finding future stock price of AAPL stock. For this purpose there is requirement of finding answer of below mentioned questions:

- Which is the main decision variable in the data set?
- What are the values of performance metrics like RMSE, MSE, MAE, MAPE of various machine learning algorithms?
- What is the value of coefficient of determination (R^2) of various machine learning algorithms?
- What is the impact of increase in number of epochs on loss?

B. Research Objectives

1) Main Objective

- To do comparative analysis of various machine learning algorithms used in AAPL stock price prediction.
  Five machine learning algorithms of stock price prediction: linear regression, SVM, Random forest, neural network, and LSTM are compared to find best suited model for prediction of AAPL stock price.

2) Sub Objectives

- To compare and plot actual and forecasting prices of different models discussed in the paper.
- To find accuracy of all five machine learning algorithms used in the paper by comparing measurement metrics like RMSE, MSE, MAE, and MAPE.
- To compare R^2 value of all five machine learning algorithms used in paper for finding model fitness.

C. Organisation of Research Paper

Section-1 introduces the stock market and discusses the need for machine learning algorithms for stock price prediction. It also discusses the research questions that the paper will address and the objectives that it will seek to achieve. Section 2 Literature Review provides an overview of the work that has been done in the past on stock price prediction using machine learning algorithms. It discusses the different algorithms that have been used and the results that have been obtained. Section 3 Machine Learning Algorithms describes the algorithms that are used in the paper. It discusses the advantages and disadvantages of each algorithm and the reasons why they were chosen for this study.

Section 4 Research Methodology describes the steps that were used to conduct the study. It discusses the data that was used, the methods that were used to train and test the models, and the evaluation metrics that were used. Section 5 discusses the results of the study. It presents the tables, figures, and diagrams that support the findings. Section 6 discusses the future scope of the paper. Section 7 lists the references that were used in the paper.

II. Literature Review

Stock price forecasting is basically defined as finding the stock value and provides a basic idea to the investors to know and forecast the market and stock price. In this part work done by various other researchers on the stock price predictions have been reviewed and discussed.

Prasad A et al. (2021) propose a paper in which comparative analysis of 3 machine learning algorithm LSTM, Linear regression and Logistic regression is done. Deep learning based LSTM beats both regression and classification model. This comparison is done on the basis of measuring accurate value with predicted value of three models. This is verified by value obtained by measurement metrics [4]. Hemkar G et. al. (2021) propose a paper in which comparison of 4 machine learning models is done. Data set used is Tesla. 4 different machine learning model are LSTM, Linear Regression, Prophet and Decision tree. On the basis of RMSE value researcher proves that LSTM is best suited model for this data set because RMSE value for LSTM model is lowest as compare to other three models [3]. Lakshminarayanan et al. (2022) proposed a paper in which comparative study of LSTM, neural network, svm take place. Performance of model is measured by performance metrices like RMSE, MSE, MAE, MAPE and R^2 values. Measurement metrics proves that LSTM model perform better than other model [5]. Sathyaraj et. al. (2017) has analysed the performance of 3 machine learning algorithm on nine different stocks to determine next day price. RMSE, measurement metrics is used for evaluation

of model. R^2 is used as goodness of fit for the algorithm. From charts and predicted values we can find that SVM is best than other algorithm. Same thing can be verified by RMSE and R^2 values [6]. Sheta Et. al. (2015) has analysed the efficiency and effectiveness of ANN, SVR algorithm on stock data of S&P 500 index. The major reason for variable selection depends on their effect on S&P 500 index. Data is collected on weekly basis. Hybrid model of SVM and RBF kernel provide better forecasting efficiency as compared to regression and KNN model. The result were approved by measurement metrics like MSE, RMSE [7]. Nunno Lucas (2022) described a price prediction system using different regression models. Predicted stock values, diagram proves that SVR outperformed all other model. Measurement metrics like RMSE, MSE justified this result [8]. Sreeraksha et. al. (2022) compared different techniques of machine learning algorithm (ARIMA time series forecasting, SVM, LSTM) using 5 years of NYSE. Accuracy values of all three models are calculated. From this table one can easily tell that LSTM model has highest accuracy as compare to other models. But if we take training time into consideration along with accuracy then SVR is more fit for current situation [9]. Orsel et. al. (2022) has done comparative analysis of machine learning algorithm (kalman filter, LSTM). Data set used in this study is MSFT, AAPL and TSLA. TSLA is categorizing as volatile stock. MSFT is an example of non-volatile stock [10].

Hu et. al. (2019) compares the up or down classification performance on a series of prediction window of lightGBM, RF, Logistic regression. Some technical indicator (RSI, SMA) are used to train our model. Main recommendation of paper is that RF is best for short term share price prediction. LightGBM is suitable for medium and long term investment [11]. Vargas et al. (2018) uses deep learning algorithm for stock trend prediction. Result shows that RNN is superior to CNN on picking information from news. There was no improvement in performance when technical indicators are included [12]. Inthachot et. al. (2016) uses ANN on technical indicators to predict the future stock price. T-test determine prediction accuracy of model and proves that prediction accuracy of the model is highly significant [13]. Mittal et al. (2022) proposed model which uses technical indicators and varying window size during feeding the model. Researchers believe that if quality of input data is good then definitely there will be increase in model accuracy. For this purpose technical indicators are used along with varying window size. It was found that with the increase in window size and technical indicators there was improvement in stock price prediction. LSTM algorithm is used for this prediction [14]. Dey et al. (2020) proposed model which uses machine learning with 11 technical indicators for stock price prediction. Random forest, Ada Boost, KNeighbour, logistic regression, MLP and SVM are used as machine learning algorithm. System predicts the stock price for consecutive three days. System performs better for today. If there is no fast change in the direction of stock market then technical indicator cannot recognize the pattern. When stock market suddenly changes previous testing become useless. So fundamental, technical indicator together gives better accuracy then alone [15].

III. ML Algorithms Used

This section describes the machine learning models used to train and test collected data. There are various types of regression models for machine learning. The main focus is on Linear Regression, SVM, Random forest, Neural Network and LSTM algorithm.

A. Linear Regression

It is a good option for regression problems where response and predictor variable have linear relation. It is a relatively simple model, so it is easy to use. It is very simple and fast to train and test, so it is generally used where quick predictions are required. If relationship between the predictor and response variable is not linear then this regression is not fit for prediction. This model has linear equation that explains the association of two variables. The independent variable is used to find value of dependent variable. Response variable is the variable whose value is predicted [2].

Y=MX+C, where Y=Response variable, X=Predictor variable, C=Intercept, M=Slope of the line

Some advantages of Linear Regression:-

- It is simple to build, train and test;
- It is relatively fast to train;
- It is used to predict both continuous and categorical values.

Disadvantages of Linear Regression:-

- It is useful where predictor and response variable have linear relation.
- It is very much sensitive to outlier.

B. Support Vector Machine

SVM is given by Cortes and Vapnik. It is a more complex model that works by finding the hyper plane that divide the data into two classes. This hyper plane is a plane which acts as a boundary between two regions, so that data points of one region belongs to one class and other region data points belongs to other class. SVM algorithm finds the hyper plane that increases the margin between the two classes. Margin is the distance between the boundary and

closest data points on both side of boundary. Higher the margin betters the SVM model. This algorithm is highly suited for problem where data is linearly separable. This problem is well suited in case where data is not properly cleaned [16].

Some advantages of SVM:

- It is more complex and versatile model;
- It is used to find answers of classification and regression kind of problem;
- It is more suited to problem where data is not properly cleaned.

Disadvantages of SVM:

- Difficult to build, train and test;
- Difficult to interpret;
- Not perform well if data is not properly separable.

C. Random Forest

This algorithm is given by Ho in 1995. It is a combination of many decision trees. In this algorithm prediction of various decision trees are combined in order to improve overall accuracy. This method gives more accurate result for problems come under classification task as compare to regression. As already discussed prediction of many decision trees are combined for getting prediction of random forest. Most popular technique for combining prediction of many decision trees is majority voting. Class having most votes comes under classification task. Average prediction of all decision trees come under regression task [17].

Advantages of Random Forest:

- Random forest is accurate for classification task;
- It is a robust algorithm;
- It is more helpful in feature selection from dataset.

Disadvantages:

- This algorithm is complex and sensitive to create, model and train;
- It leads to over fitting problem.

D. Neural Networks

ANN is branch of machine learning where desired model is built using lot of layers. Each layer transforms the input data. Every layer is made of set of node called neurons. Some input is given to each layer and linear transformation take place on the input. After this some nonlinear transformation take place on transformed value. This process takes place for all neurons with different weight presented in a layer. Later during processing time weight of all layers are adjusted so that desired output can be provided to the training phase of neural network [9].

Different types of neural networks are feed forward, recurrent neural and deep neural network.

Neural network are applied in various areas like image recognition, natural language processing, speech recognition, medical diagnosis.

Various limitation of neural network:

- Require lot of data for training. Data is very difficult and costly to collect.
- Inner working of neural network is very complex, not easy to understand.

E. LSTM

It is a type of RNN that can take care of sequential data such as time series, speech and text and also remember long term dependency. They come into existence for avoiding the long term dependency. Every RNN is made up of series of repeatable modules. Similar chain like structure is used but repeatable module is different. LSTM has four repeatable modules instead of single. LSTM control the information flow through a network. This information flow across the network is controlled by three gates. Input, forget and output gate [18].

Input gate: This gate controls information flow across the cell.

Forgot gate: This gate control how much old information is allowed to forget.

Output gate: This gate control how much information in the cell is declared as output.

IV. Research Methodology

For any research project, methodology is the main way of getting accurate result. Methodology mainly opted for this research paper is cautiously checked and designed so that authentic, reliable conclusion can be drawn from the implementation. Methodology used in this research paper is described in Fig-4.1. In Step-1 AAPL stock data is collected from yahoo finance. This raw, unprocessed data contains several missing, incorrect and duplicate entries. Step-2 is data pre-processing which includes scaling, standardization and cleaning the raw data. After this pre-processing, we split processed data into training and testing set. The third step is to create the machine learning model. In this paper five machine learning models are created. In the fourth step, the training data is fed into the machine learning model. This is called training of machine learning model. In next step testing of model take place. In this step testing data is feed into the model and we check the output. During this step five ML models were tested and evaluated using efficient performance metrics like, RMSE, MSE, MAE, MAPE. Value provided by these performance metrics help in rating and grading the model performance. Finally graph of the actual and predicted values for five machine learning models used in the paper are plotted and all models are evaluated using the coefficient of determination (R^2).

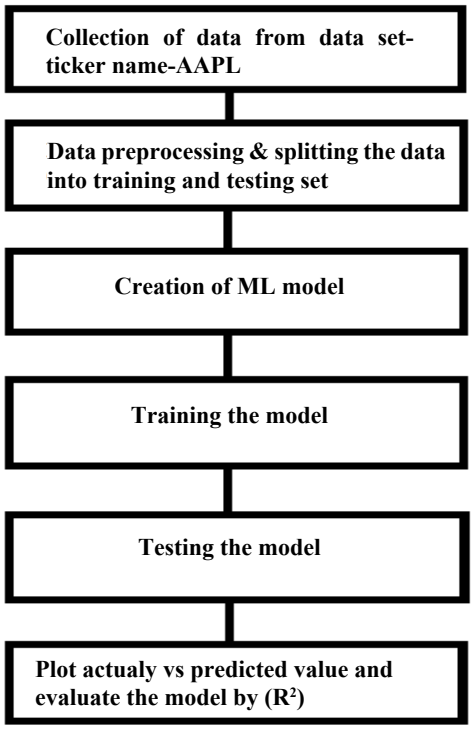

Fig. 4.1: Research Methodology

A. Data Set

In this research paper data of AAPL stock from yahoo finance has been opted and considered (Table-4.1). Dataset contains datewise price of stock with Open, High, Low, Close, Adj Close price along with Volume traded. Close price value for prediction has been used. Every model predicted some value. At last comparision of actual value(Closing price) with predicted value by all five models take place.

Table 4.1: AAPL Stock Dataset

Date	Open	High	Low	Close	Adj Close	Volume
28-07-2023	194.67	196.63	194.14	195.83	195.83	48291400
31-07-2023	196.06	196.49	195.26	196.45	196.45	38824100
01-08-2023	196.24	196.73	195.28	195.51	195.61	35175100
02-08-2023	195.04	195.18	191.85	192.58	192.58	50241600

B. Training the Model

In training model is given a set of labelled data, and it learns to associate the label with features of data. This allows the model to make predictions about new data that it never seen before.

C. Testing the Model

In testing model performance is evaluated by some efficient beneficial parameters or metrics value. There are some metrics like root mean square error (RMSE), mean square error (MSE), mean absolute error (MAE), and mean absolute performance error (MAPE), coefficient of determination (R^2) for comparing and optimization of our model. Values of these metrics indicate the forecasting error of our built model.

3) Root Mean Square Error (RMSE)

It is most common performance metrics for regression kind of problem. It is the calculation of average error between predicted and actual value and is performed by square root of mean square error. RMSE value and model accuracy are inversely related to each other [19].

$$RMSE = \sqrt{\frac{SUM\left(\left(actual - predicted\right)\text{^}2\right)}{n}}$$

4) Mean Square Error (MSE)

It is mean square of errors. Error here means gap between estimated and actual values. MSE value and model accuracy are inversely related to each other [20].

$$MSE = \sum \frac{\left(actual - predicted\right)\text{^}2}{n}$$

It is simple, scale invariant metric to understand. It gives quick response to odd one out data. It does not consider distribution of errors.

5) Mean Absolute Error (MAE)

It is average of difference between errors. Error here means difference between estimated and actual values. It provides us the measure of how far is predicted value from the actual value. This tells us the idea how predicted value is deviated from the actual value. This metric is described as follows:

$$MAE = \sum \frac{\left|actual - predicted\right|}{n}$$

It is easy to understand and interpret. It is not so much responsive to odd one out data. It is more helpful when distribution of errors take into account. MAE value and model accuracy are inversely related to each other [21].

6) Mean Absolute Percentage Error (MAPE)

It is a measure of average percentage error. Error here means difference between estimated and actual values. It is calculated by taking average of absolute percentage errors. MAPE value is inversely related to model accuracy [22].

$$MAPE = 100 * \sum \frac{\frac{\left|actual - predicted\right|}{actual}}{n}$$

It is easy to understand and interpret. It is not so much responsive to odd one out data. It is more helpful when distribution of errors take into account.

7) Coefficient of Determination (R^2)

This coefficient measures how well a regression model fit the data. It is calculated as square of R between forecasted and real values. R^2 value lies between 0 and 1, where 0 indicates that model does not fit into the data set whereas 1 indicates that model is fully fit into the data set.

This metrics is good to use when goal is to explain variance in the dependent variable. R^2 value is directly related to model prediction [23].

V. Results and Findings

In this section, after successful implementation of model results, they are stored in the form of tables and graphs. Table-5.1 contains the actual and predicted values by machine learning model (Linear regression, support vector machine, random forest, neural networks, LSTM). After looking into the table one can easily predict that value predicted by linear regression, neural networks and LSTM are just equivalent to actual value.

Table 5.1: Actual *vs.* Predicted AAPL Stock Price

SNO	Actual	Linear Regression	SVR	Random Forest	NN	LSTM
1	189.16	187.95	26.48	57.33	188.01	188.15
2	189.67	189.64	26.48	57.33	188.69	188.83
3	190.5	190.41	26.48	57.33	189.46	189.99
4	190.22	190.56	26.48	57.33	190.61	190.74
5	191.89	193.86	26.48	57.33	193.91	193.02
6	193.35	193.6	26.48	57.33	193.65	192.76
7	193.1	194.97	26.48	57.33	195.02	194.12
8	195.08	193	26.48	57.33	193.05	194.17
9	194.1	191.81	26.48	57.33	191.86	192.99
10	193.41	192.62	26.48	57.33	192.67	192.79

Values of Table-5.1 shows that values predicted by LSTM model is more close to the actual values. When we compare actual stock value with value predicted by model (Linear regression, SVR, random forest, NN, LSTM) used in this research paper, we can see that LSTM has the best performance. Figures 5.1 to 5.7 shows the graphs of the actual and predicted values for five machine learning models used in paper. The models are evaluated using the coefficient of determination (R2). Figures 5.1, 5.2 and 5.3 show graphs of the actual and predicted values for linear regression, neural networks, and LSTM, respectively. The graphs show that the predicted values are very close to the actual values for all the three models, indicating that they are all good models for this data. However, figures 5.4 and 5.5 show graphs of the actual and predicted values for random forest and SVM respectively. The graphs show that predicted values are far away from actual values for both random forest and SVM models, indicating that random forest and SVM models are not good for this data.

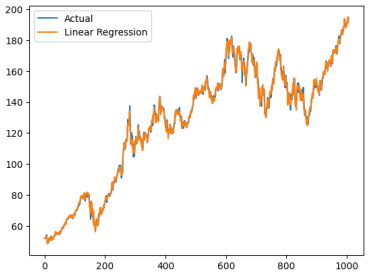

Fig. 5.1: Actual *vs.* Linear Regression

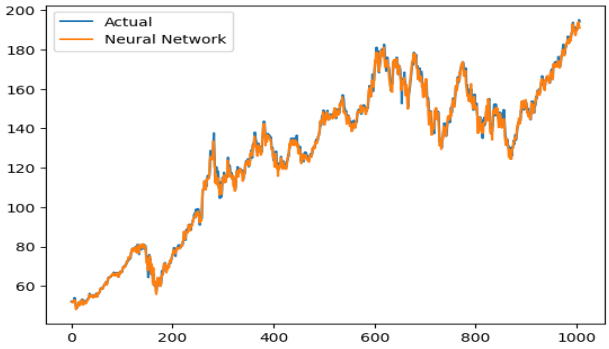

Fig. 5.2: Actual *vs.* Neural Networks

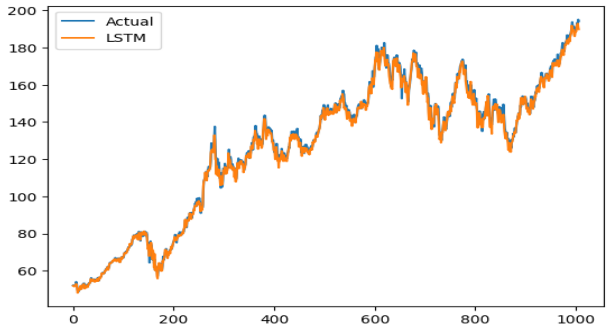

Fig. 5.3: Actual *vs.* LSTM

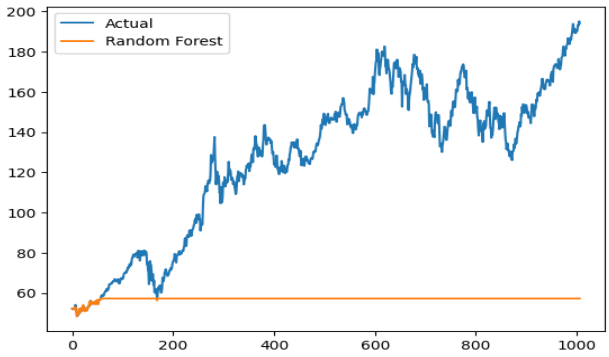

Fig. 5.4: Actual *vs.* Random Forest

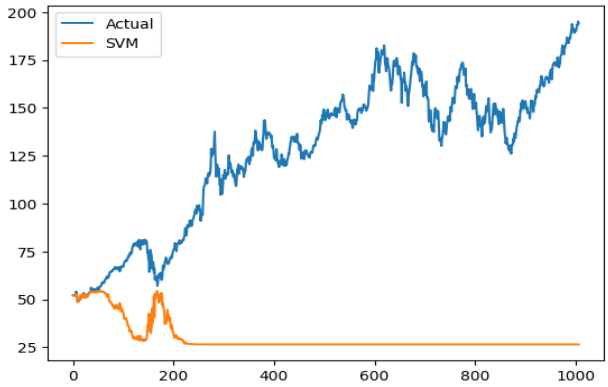

Fig. 5.5: Actual *vs.* SVM

Predicted value graph shows that linear regression, neural networks, and LSTM are good models.

Table 5.2: Value of Measurement Metrics for all Models

Sno	Measurement Metrics	Linear Regression	SVM	Random Forest	NN	LSTM
1	RMSE	2.0795	106.6943	79.4036	2.0812	2.0694
2	MSE	4.3244	11383.677	6304.937	4.3315	4.3119
3	MAE	1.5367	96.8783	69.8942	1.5395	1.5234
4	MAPE	0.0122	0.7027	0.4914	0.0122	0.0121
5	R2	0.997	-6.8134	-3.3275	0.997	0.9971

Table 5.3: Accuracy Value of all Models

Measurement Metrics	Linear Regression	SVM	Random Forest	NN	LSTM
Accuracy Value	0.997	-6.813	-3.3275	0.997	0.9971

But forecasted value is not the only parameter which will help in selection of appropriate model. The coefficient of determination (R^2) and other performance metrics such as RMSE, MSE, MAE, and MAPE should also be considered. Table-5.2 shows that LSTM has the lowest values for all of these metrics, which indicates that it is the best model for this data. The coefficient of determination (R^2) is also known as the accuracy of the model. It measures how well the model fits the data set. Values in table 5.3 show that R^2 value for LSTM model is higher than other four models. This value is also close to 1. This is graphically shown in Fig-5.6.

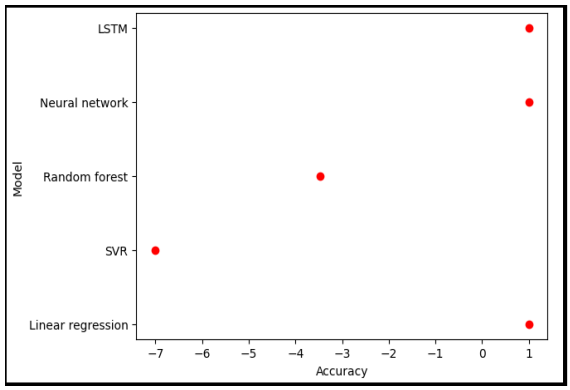

Fig. 5.6: Accuracy of Various Models

This proves that LSTM is best model in all five machine learning model discussed in this paper.

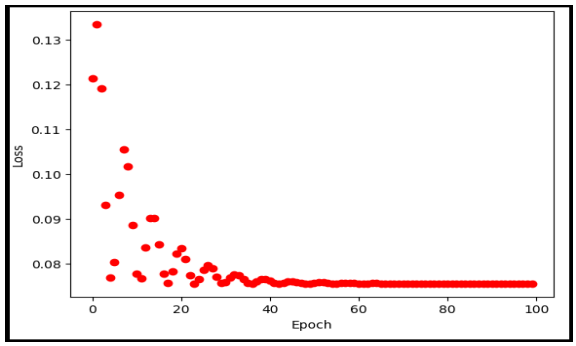

Fig. 5.7: Impact of Increase in Epoch on Loss Function of LSTM Model

Figure 5.7 shows that the loss value for the LSTM model decreases with the increase in epoch. This indicates that the model is learning to fit the training data more closely, which is a good sign for forecasting. As the model learns, it is able to predict the output more accurately, which results in a decrease in the loss value.

VI. Future Scope

This paper concludes that LSTM (based on basic parameters) is a good algorithm for stock price prediction. In future work, the LSTM model can be tuned by giving different parameters to the model and selection of the best combination of parameters. This will improve the accuracy of LSTM model, which will lead to better stock price predictions. Technical indicators and sentiment analysis can also be applied to the refined LSTM model to improve its performance further.

VII. Declarations

A. Ethical Approval

This research did not involve human participants or sensitive data, and therefore did not require ethical approval. However, the research was done with relevant ethical guidelines.

B. Funding

No funding received.

C. Availability of Data and Materials

Data used in this study is publicly available from Yahoo Finance. The data was collected using the python library yfinance. The code used to collect data is

```
# Load the stock price data
data = yf.download('AAPL', period='20y', interval='1d')
```

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