

Event-Triggered Share Price Prediction



Jay Pareshkumar Patel, Nikunj Dilipkumar Gondha, Jai Prakash Verma , and Zdzislaw Polkowski

Abstract The stock market price analysis or the prediction of the stock prices has always been a classical problem because of the fluctuating prices of the stocks for a particular company based on the economy. This stock market price analysis/prediction problem has attracted researchers from various fields like statistics, machine learning (ML), deep learning (DL), etc. The analysis or prediction of the stock prices will help the individuals/customers to buy/sell shares of a particular company in order to incur profit. The aim of the proposed paper is to accurately predict the future prices of shares of a company. The prediction on prices can be done through various techniques or methods of machine learning and deep learning. In this paper, we are proposing a hybrid approach of deep learning neural network long short-term memory (LSTM) with sentiment analysis to predict the variations in share prices. First, we apply sentiment analysis on the various company news, market sentiments and get the values. Then, the sentiment results are combined with the LSTM features and observed the results. We predicted the variations in the prices of the stocks for one day and for 30 days long-time period. The observation that we got is very helpful to get the idea of a particular company's future variations in share prices.

Keywords Share price prediction · Deep learning · Sentiment analysis · Machine learning · Long short-term memory (LSTM)

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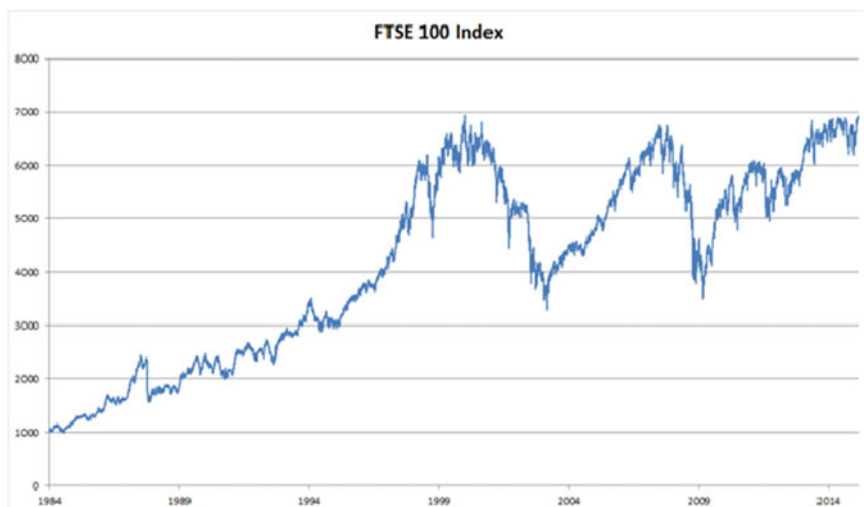
1 Introduction

The stock market is a market designated for an activities like selling and buying of stocks of publicly-held firms takes place. In stock market, stock exchanges takes place among hundreds and thousands of participants by ensuring fair pricing and under a set of rules which are predefined. The values of the stocks for an individual firm/company depends on the selling and buying of its stock. If more number of customers buy a particular firm/company's stocks, the values of that stock increases; and if more number of participants sell stocks, the value of the stock decreases, and also the stock price variation depends on various other economic factors. The stock market prediction is a very interesting and classical problem, which has never failed to attract researchers from various multidisciplinary fields like statistics, economics, machine learning, deep learning, etc. [1]. The stock market prediction system is a system which does the prediction of future values of stocks of a firm for a given interval of time. The analysis or prediction of the stock prices will help the individuals/customers to buy/sell shares of a particular company in order to incur profit. Although a great amount of effort is given for this in previous decades, the accurate prediction of the values, and their movement is still a challenging problem. Various models and strategies have been used for the prediction of share values.

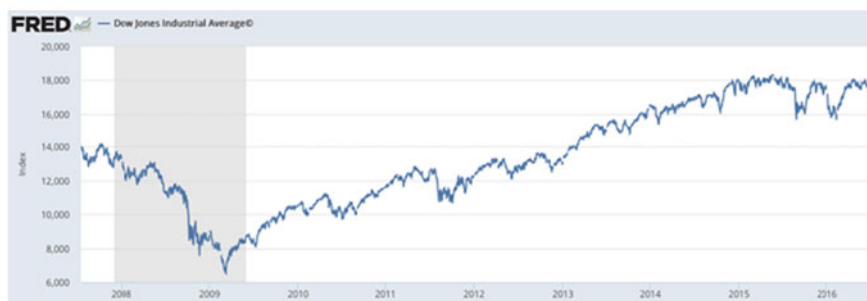
The machine learning-based methodologies include support vector machine (SVM), forest algorithm, fuzzy system, etc. Neural network-based approaches like recurrent neural network (RNN), long short-term memory (LSTM) [2] are used for the prediction of future values of stocks [3, 4]. The accuracy achieved through machine learning-based techniques is better than that achieved from statistical techniques. For example, the accuracy achieved through support vector machine in daily stock value movement is approximately 56%.

Other than these, hybrid models are also used for the prediction. Tsai and Wang et al. [5] combined decision tree and neural networks for achieving a 70% accuracy in predicting the stock values. Though machine learning-based methods have shown good accuracy, but they still have limitations. The machine learning-based approaches cannot handle the non-stationarity of the values of stocks, in which the deep learning-based methods have shown considerable amount of accuracy [6]. The methodology used in this proposed paper is based on a hybrid model. This hybrid model consists of neural network-based technique LSTM along with sentiment analysis from the data obtained from news and market. Many researchers have given a lot of efforts in previous decades [7].

As per paper [8], the proposed work is based on the prediction of stock market which predicts the future values of the stocks of various companies. In this proposed paper, we have done the prediction of the prices of stocks using DL approach of long shot-term memory (LSTM) along with the news data sentiment analysis and also with market indexes. The paper predicts the variation of the stock prices which helps for the buying/selling of stocks. Stock market help the entrepreneurs for raising the funds for their businesses. Companies can also gain funds through stock market for various operational and strategic reasons, establishing new markets and building



(a) Impact of stock market on the Indian economy



(b) The effect of the stock market crash in 2009

Fig. 1 Some facts of stock market analysis

infrastructures. Through this work, successful prediction of stocks can be done which helps various individuals and companies to yield financial profit [9, 10].

The stock market has a profound and a huge impact on a country's economy. The stock market affects the wealth prosperity of the individual customers. The share market affects the gross domestic product (GDP) of the country to a great extent. If the share market is in bull mode, people tend to have more money which increases the GDP and in bear mode, due to lack or loss of money, people tend to spend less money which has a negative effect on the GDP. The daily stock movements do not affect the economy to a great extent but a crash in the stock market can have a large effect on the economy [11, 12].

Figure 1a shows the increasing impact of the stock market on the Indian economy over the years. Figure 1b also shows the effect of the stock market crash in 2009 which led to the recession.

2 Related Work

Number of people involved in trading /investing in stocks have increased significantly, in last few decades, which includes both professionals and non-professionals. The financial market is a complex, evolutionary, and nonlinear dynamical system [13]. It has become crucial to be accurately predict the stock prices to avoid risks. Lijuan Cao et al. [14] studying and have introduced stock market forecasting methods based on machine learning techniques, where ANN and SVM models been the most widely discussed, compared, and used. Tay et al. [15] state that the SVM gives the best performance for financial time series data. It is observed that the implemented support vector machine algorithm performs very well in predicting the stock price downwards, irrespective of market trend but performance reduces significantly in predicting the stock price upwards [16].

In general, these methodologies can be broadly classified into two categories: statistical techniques and machine learning-based strategies [17]. The statistical-based techniques includes auto-regressive integrated moving average approach (ARIMA) [18], linear regression-based approach, smooth transition auto-regressive (STAR), etc. [13]. These methodologies are based on the linearity among the distributed variables, but in real stock market, these linearity assumptions are not satisfied.

Table 1 shows some legacy case studies done in the area of share price prediction and analysis.

3 Proposed Research Work

The proposed model predicts the value of the stocks for a firm/company from the data sources like news Website, market indexes and from the past values of the stock trends available from Google Finance or Yahoo Finance (Please refer Fig. 2). The prediction of the model is based on two parameters, i.e., sentiment analysis of the news information and past value analysis through long short-term memory (LSTM)-based on neural networks. In the sentiment analysis module, data is collected from news displayed on the general news Websites and also from companies Website. The data collected is preprocessed, and a binary polarity is assigned to each word. At the end of the day, overall sentiment is calculated by average of all the sentiments. The value prediction for the stock is carried out through LSTM deep learning algorithm. Along with that, the prediction of the value from sentiment analysis of the data collected from news Websites and market indexes is taken into consideration. The cumulative effect of both the modules is taken, and the final value of the stocks is predicted. Thus, the proposed hybrid model minimizes the error which occurred in the single long short-term memory (LSTM) model without considering sentiment analysis.

Table 1 Different case study analysis in the area of stock market analysis

Case study	Year	Objective	Accomplishment	Highlights	Challenges
Moving average By R.H. Hooker and published as “instantaneous averages” in Journal of the Royal Statistical Society	1901	Predict the stock movement by moving average of past stock value	The predicted closing value for each day will be the average of a set of previously observed values. For each subsequent step, the predicted values are taken into consideration while removing the oldest observed value from the set	It is the easiest method for stock movement prediction. The graph is the average of closing values of the firm/company in past years	The result of this technique is not very promising. The result can not show the effect of crest and troughs in the stock values
Linear regression from a lecture presented by Sir Francis Galton	1877	Predicting the values of the stocks by basic linear regression method on the previous years values of the stock	In this method, we create the features such as month, year, week, date, quarter start, quarter end, etc. And then, perform linear regression by splitting the data into training and validation sets	This method is the most basic and easy method of machine learning. This method can perform well where the independent features are useful. Like, in big market sales	In this method, the model is overfitting the date and month column. It will consider the value from the same date a month ago. It will not consider all the characteristics of the previous values
K-nearest neighbors By, Fix and Hodges in an unpublished US Air Force School of Aviation Medicine report	1951	Predict the stock values by KNN algorithm by finding the similarity between new data points and old data points	In this method, we find exact k no. of nearest neighbors of a particular point in the graph and then take the average value from that neighboring points	In this method, the plot for the predicted and actual values should provide a more clear understanding than above others	It shows somewhat same results as linear regression model
Auto ARIMA By, Box, George; Jenkins, Gwilym	1970	Predicting the time series predictioning of stock values with Auto (Automatic parameter tuning) ARIMA	ARIMA is auto-regressive integrated moving average. These all terms are showing the various components of the method	It uses the past data to understand the pattern in time series. This technique is far better than any above. The reason is a capacity to capture a trend	This model can capture a trend in the series, but does not focus on the seasonal part
Prophet By, Facebook	Open Source	prediction of time series on stock data by Prophet, the method provided by Facebook	Prophet is the library which requires no data preprocessing. The input is a dataframe with date and target columns	It can capture a trend of the graph and also seasonality from past data	As, stock values cannot depend upon particular trend or seasonality. Prophet is somewhat unusable in stock prediction

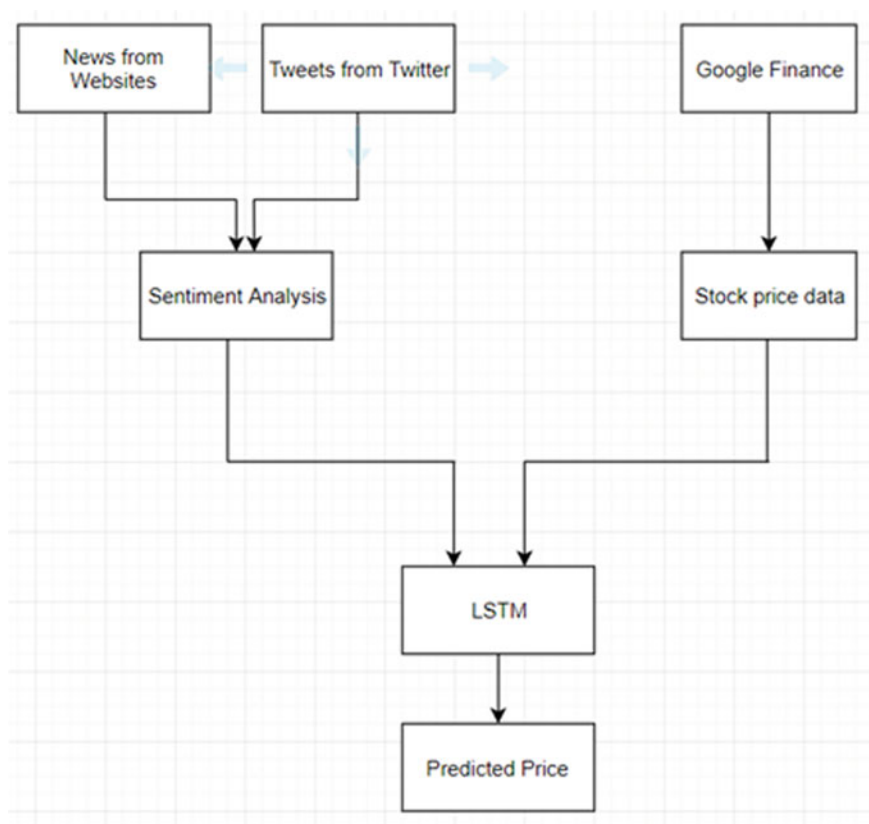


Fig. 2 System architecture

4 Methodology

4.1 Long Short-Term Memory (LSTM)

Long short-term memory (LSTM), in the field of deep learning, is an architecture which is basically based on recurrent neural networks (RNN) [19]. The recurrent neural networks are efficient, but this architecture has long-term dependencies problem. It can only remember data from small duration of time in the sequence of data. LSTM approach was introduced to overcome the problem of long-term dependencies [20]. As shown in Fig. 3, LSTM can not only process single data points, but it can process data from entire sequence; remembering information for long time is their natural behavior. Another problem with RNN was that, if a single information has to be updated or removed, it changes the entire information by applying the function to the entire sequence of data. In the case of LSTM, this problem is taken care of.

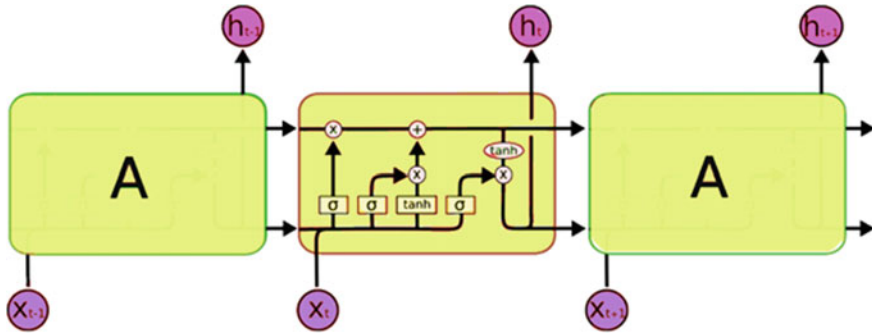


Fig. 3 Execution steps long short-term memory (LSTM)

LSTM approach uses a conveyor belt mechanism, which updates or removes only the desired information or data. The following diagram shows the basic architecture of the LSTM cell.

Figure 3 displays the different memory blocks called “cells” which are present in the LSTM network. There are two states from each cell that are transferred to the next cell, the present cell state, and the hidden state. These memory blocks are solely responsible for the updation and removal of the information which is done through gates mechanism. Each LSTM cell has in particular three gates which are discussed below:

Input Gate: The input gate is responsible for the updation of the information in the cell. It specifies whether the cell is updated or not.

Forget Gate: The forget gate specifies the memory which is set to 0 or not. It is responsible for the removal of the information or data in the cell.

Output Gate: The job of the output gate is to select only the useful information or data from the cell which is to be displayed as an output. As LSTM can process the entire sequence of data, it is applicable to tasks like speech recognition or handwriting recognition, etc. In our proposed work, we use the LSTM-based deep learning approach for the prediction of stock’s values.

5 Execution and Implementation

5.1 Dataset Selection

As per Fig. 4, data for the model is taken from three different places. For the LSTM model, the opening and the closing values of stocks for a particular firm/company is taken from Google Finance. Other than that, the data for the sentiment analysis of the data from news information and information obtained from market indexes is

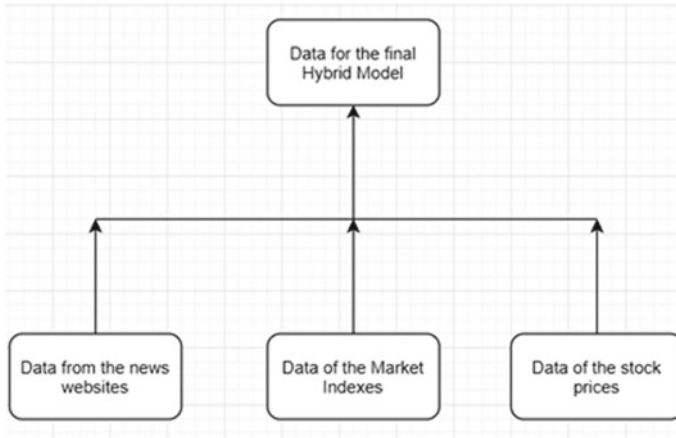


Fig. 4 Dataset selection and extraction

also taken into consideration. The news sentiments by people is taken from Reddit Website, and other news related to the particular firm/company is taken from that firm/company's Website. The data collected from the Websites is analyzed, and a polarity is assigned to the data of the stocks for a particular day. These news data along with the data of the market indexes (economic indicators) is directly considered as a feature in the hybrid model including LSTM output.

5.2 Pre-processing of the Data and Polarity Assignment

The data for the prediction of a firm/company's future stocks are taken from the news Website Reddit and news of the economic indicators regarding the market health. Now, the data which is collected from news Website for a firm/company has to be processed, and a polarity is assigned to the data. A starting date is defined from which the news data is to be considered. In our case, the starting date is from year 2011 to year 2017.

5.3 Methodology Used for Polarity Assignment

The news headlines which are shown on the Website are split into each word, and a polarity is assigned to each word and stored in a data structure. The polarity which is to be assigned is of three types: positive polarity, negative polarity, and a neutral polarity. Those words which indicate the falling values for a stock are assigned a negative polarity, and those words which indicates the rising values for a stock

are assigned a positive polarity. Other than this, those words which are unable to indicate the falling or rising value of a stock are assigned a neutral polarity. Now, the mean positive polarity and the negative polarity are calculated by taking the average of each polarity, respectively. Now, an average polarity for a particular day is calculated by taken into consideration the mean positive, negative, and neutral polarities for that day. Thus, average polarity of each day is calculated in this way from the news Website. In the proposed work, we have taken data for five companies: Apple, Amazon, Facebook, Google, and Tesla.

Now, the data of the economic indicators is selected for the given period of time. The economic indicators show the stats about any economic activity. The economic indicators are generally used by economists and analysts to predict future economic performance.

6 Results

Figure 5 shows the polarity assignment of the data obtained from the news analysis. If the average polarity for the particular day is positive, it shows that the price will increase as per the prediction, or if the average polarity for the day is negative, it shows that the price of the stock will decrease as per the prediction. The fourth column in the table shows the actual scenario where 0 represents that the price of the decreased that day and 1 represents that the price of the increased that particular day. The data about the stock's values for a particular firm/company is taken from Google or Yahoo finance (depending on availability). Now, all these data about the

Date	Polarity	Prediction	Actual
01-07-2011	-0.049007937	0	1
7/15/11	0.038047138	1	1
7/29/11	0.031026171	1	1
8/26/11	0.104386457	1	1
9/23/11	0.040737564	1	1
10/21/11	0.0675	1	0
11/18/11	0.021616161	1	0
12/16/11	-0.043576	0	1
12/30/11	0.096296296	1	1
1/13/12	0.033333333	1	1

Fig. 5 Polarity assignment

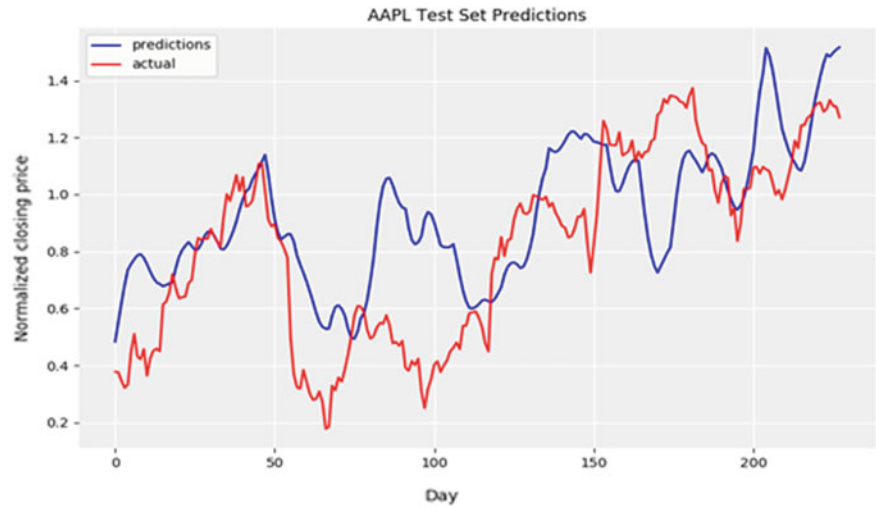
values, data of the news sentiment analysis, and data of market sentiment are merged and taken as an input in the long short-term memory (LSTM) algorithm. The LSTM neural networks is used for the prediction of the stocks based on these combined data. In our case, we have done the analysis for Apple company stock value. The prediction is divided into two parts: (1) One day prediction of stocks and (2) 30 days prediction of the stocks. Now, for both the predictions, the LSTM methodology gives different outputs.

Figure 6a shows the prediction of stock's values of Apple firm/company for one day only. The prediction is done through LSTM based on the combined data, i.e., data from sentiment analysis of news and market and the past data values of the stocks. From Fig. 6b, we can see the prediction of future stock's values of Apple firm/company for one day only. This prediction is also done through LSTM approach, but the data input to the LSTM include only the past data of the stocks and not the data from sentiment analysis of the news and market.

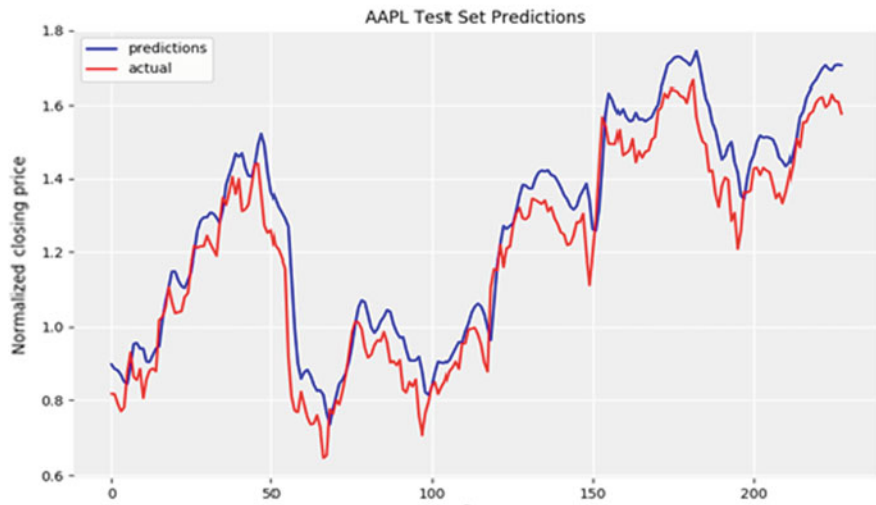
Figure 7a displays the prediction done through LSTM which includes the combined data input of data of the stocks as well as the data of sentiment analysis. From Fig. 7b, we see the prediction done through LSTM, but the data input given to the LSTM includes only the past data of the stock values of APPLE firm/company and does not include the data from sentiment analysis of news and market.

7 Discussion

In the proposed work, we have done the prediction of stock values for a particular firm/company based on the data obtained from the past stock values of the firm/company and from the sentiment analysis of the data obtained from the news Website and data obtained from the market. The results of the experimental analysis show that the prediction of future stocks for one day prediction using the combined data has less accuracy than the one day prediction using only the past stock values. On the other hand, the prediction of the future stocks for 30 days time period has more accuracy when the LSTM approach uses the combined data, and the accuracy is comparatively less when the LSTM approach uses only the stock value data. The reason behind such observation is because, for one day curve prediction, the sentiment analysis cannot work properly due to the less time period. The news sentiments prove to be a disadvantage here. On the other side, the prediction for 30 days time period has enough time for the news sentiment. So, the sentiment analysis used is found to be a disadvantage here. Although, the accuracy for 30 days prediction with sentiment analysis is not highly satisfying, but it can correctly measure the increments or decrements or even the consistency in future stock prices with perfect accuracy. However, the long prediction without sentiment analysis can not measure the change in the stock prices.

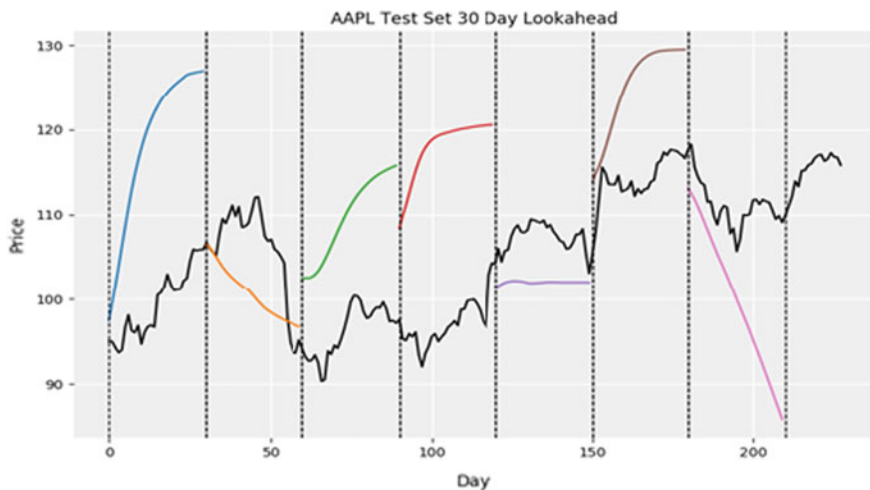


(a) Prediction of stocks with sentiment

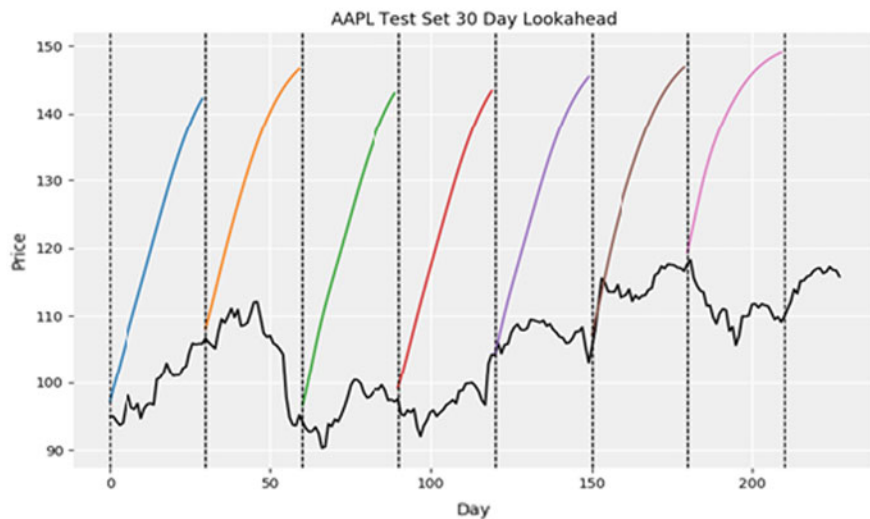


(b) Prediction of the share price without sentiment

Fig. 6 AAPL test set prediction for one day



(a) Prediction of stocks with sentiment



(b) Prediction of stocks without sentiment

Fig. 7 AAPL test set 30 days prediction

8 Conclusion and Future Work

The proposed work includes the prediction of future stock's values of a firm based on the long short-term memory (LSTM) methodology. In this, we first done the sentiment analysis on the news for the company and then include the output of this as the features in LSTM module with other features like past stock values and market indices. The accuracy shown by this model is comparatively much more than the accuracy obtained by other methodologies used for the prediction. From the experimental analysis, we conclude that the LSTM approach which uses combined data including the data of stock values and the sentiment analysis output data of news shows very high accuracy when we predict the price for long duration. For small data, or for a small period of time like one day prediction, the LSTM approach without the sentiment analysis of the news proves to be more efficient. So, by this, we can predict the stock values for very long duration by using the news sentiment analysis with nice accuracy. It is very beneficial to estimate the long duration stock prices for the investors for preventing them to invest in wrong companies.

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