International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Analysis of Financial Market Forecasting using Long Short-Term Memory (LSTM)

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Abstract: ***One of the most popular applications of machine learning is financial market forecasting. Share markets are dynamic, unpredictable, volatile and chaotic. Because of this, predicting stock prices is anything but simple. Understanding trends is very important to help investors in proper decision-making. In this research, we collected 1 year and 3 years data of National Stock Exchange of India (NSE) from Yahoo Finance and proposed a comprehensive customization of feature engineering. Deep learning-based models are used for predicting price trend of stock markets. The programming language used is Python. In this solution we have included pre-processing of the stock market dataset as well as utilized various feature engineering techniques and with a customized deep learning system is combined for the stock market price trend prediction. Open, High, Low and Close prices of stock are used as inputs to the model. The proposed model is applied on State Bank of India (SBI) and HDFC bank. Both shares are among NIFTY50. The models are evaluated using RMSE & MAPE. The low values of RMSE & MAPE show that the models are efficient in predicting stock price.***

Keywords: Data science, Deep learning, LSTM, RNN, Time series

1. Introduction

Stock market prediction is an act of trying to determine the future value of a stock traded on a financial exchange. Although being a task which seems impossible, stock market price trend prediction has become a hot topic for researchers from economics, mathematics, material science, and computer science backgrounds.

Every country has one or more stock exchanges [3]. Stock exchange is one of the most sophisticated ways to do business. Even though it is very complex, it is also the most efficient way to make profits. Stock Exchange is a place where shares of listed companies can be bought or sold. The shareholder owns a proportion of the company equal to the number of shares the person bought, against the total outstanding shares of the company. In India, the BSE (Bombay Stock Exchange) and the NSE (National Stock Exchange) are the two most active stock exchanges. The BSE is oldest stock exchange in India and has around 5000 listed companies where as NSE has around 1600. Market's opening time, closing time, settlement process, trading mechanism is same for both the exchanges.

In recent years, fixed deposit interest rates are decreasing and inflation rate is increasing. Due to this, investors are more attracted towards share markets. As various studies shows that shares produce greater returns than any other assets and to be able to predict the stock price is one of the key abilities which a trader must have to gain consistent profits.

Traditionally, two main approaches have been proposed for predicting the stock price of an organization: 1) Fundamental analysis and 2) technical analysis. Fundamental analysis includes the study of the fundamentals of the company and technical analysis uses historical parameters of the stocks like closing and opening price, volume traded, adjacent close values etc. for predicting the future price of that stock. It is the study of stock prices to make a profit, or to make better investment decisions. By the momentum, stock prices also create movement trend. The technical analysis uses price charts and a related formula, along with that it observes the patterns for the prediction of future stock prices. Previously stock investing was focused on looking for stocks to buy long term that were likely to appreciate [20]. Nowadays investors employ both long-and short-term strategies in their stock selection.

The objective of this research is to build and analyze a prediction model for price trend prediction with sufficient accuracy and profitability using the resources available to us, free of cost. And main purpose of the prediction is to reduce uncertainty associated with investment decision making.

There are three key contributions of this work (1) a dataset extracted and cleansed (2) a comprehensive feature engineering, and (3) a customized long short-term memory (LSTM) based deep learning model. Machine learning techniques have the potential of discovering patterns we didn't see before, and those can be used to make predictions. Machine learning can be used efficiently to increase stock market prediction as we can see from various research work done recently.

2. Previous Work

There is lot of work that has been done in the field of automated and computer-oriented stock market predictions. For investing or trading, investors normally perform two types of market analysis [21]. First is fundamental analysis where investor looks at the fundamentals of selected company. These fundamentals include economic factors such as P/E, EPS, etc., industry performance, value of the stock, etc. Primary aim of fundamental analysis is to determine whether the share is overvalued or undervalued [22]. Second type of analysis is technical analysis. Technical

analyst tries to find patterns in stock price using charts and formulae to make a profit or to make a better investment decision. It tries to forecast future price movement direction on their historical data. It is mostly used by short term investors. Malkiel and Fama's Efficient market hypothesis (EMH) say that, predicting stock prices is possible with financial information as the prices are informationally efficient [30]. Many unpredictable variables influence stock markets which are reflected into price. By properly pre-processing data, algorithms and appropriate factors it may be possible to predict stock price.

Many trading strategies are based on predictions. Therefore, machine learning is widely used for prediction of future stock prices. Machine learning includes supervised, unsupervised and reinforcement learning methods. ARIMA (Auto Regressive Integrated Moving Average) model also called as Box-Jenkins model was used to predict volatility of Indian market index based on time series data by the authors in [25]. They have also discussed various statistical models such as AR model, MA model, ARMA model and ARIMA model for forecasting. Authors in [27] proposed a machine learning model 'q learning' method of reinforcement learning by using Particle Swarm Optimization (PSO) and Least Square Support Vector machine (LS-SVM).

Deep learning has also shown very promising performance in many applications [28]. Long short-term memory (LSTM) is type of RNN which can be used for time series data. Financial market data is also time series data. Fischer and Krauss [24] have used LSTM to predict price trends of share market. LSTM became very popular after 2010. Nowadays it is very commonly used in many industries. [32] proposed an agent based trading using recurrent reinforcement learning and LSTM to achieve human level profits. [34]

3. LSTM Architecture

In this section we will go through some of the fundamental concepts to understand long short-term memory (LSTM) approach.

I) Recurrent Neural Network (RNN)

Recurrent Neural network are class of artificial neural network (ANN) where output from last step is used as an input for the next step. RNN are adapted to work for sequential data or time series data. Hidden state is most important feature of RNN, which remembers some information about sequences. RNN have 'Memory' that helps them store information. All RNN have chain of repeating modules of neural networks.

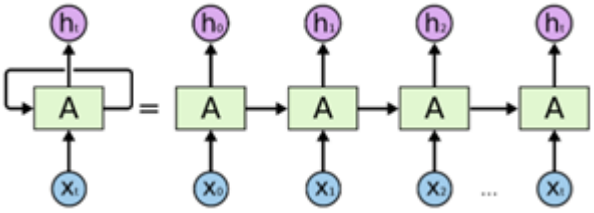

Figure 1: An unrolled recurrent neural network [31].

The figure 1 shows the RNN with a feedback loop and the unrolled version of the same [3]. There are different variations of RNN as Bidirectional recurrent neural networks (BRNN), Gated Recurrent Units (GRU), Long Short-Term Memory (LSTM).

II) LSTM Network and its working

RNN is not suitable for stock market prediction because of its short memory remembering power. There is a popular and special type of RNN which can learn long-term dependencies and is called as Long-Short Term Memory (LSTM). LSTM enables RNN to remember long-term inputs. This feature makes LSTM suitable for stock market price predictions based on time series data.

Just like RNN, LSTM also has hidden state represented by H (t-1) also known as Short Term Memory. It also has cell state represented by C (t-1) for previous timestamp and C (t) for current timestamp. Cell state which is called as Long-Term Memory.

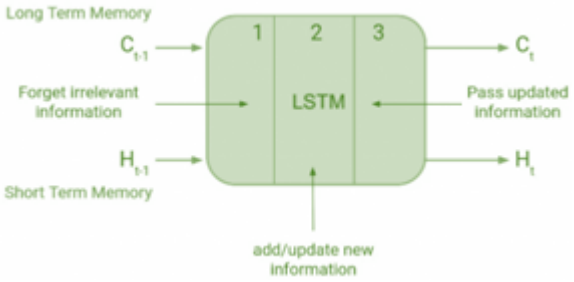

Figure 2: Three parts of LSTM [29]

LSTM has set of repeating memory modules. In below diagram we see that output from one node is provided as input to next node.

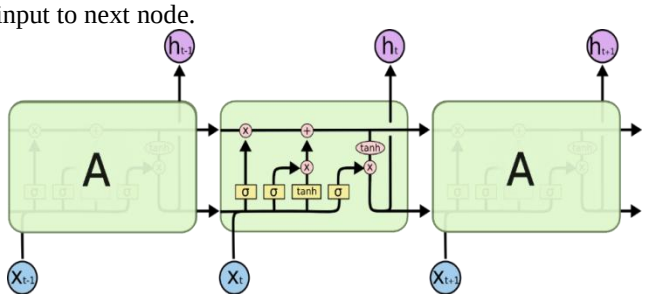

Figure 3: Architecture of LSTM [31]

Figure 4: Notations for above diagram

LSTM consist of three step process. These three processes of LSTM cell are known as Gates [19]. First is forget gate, second called as input gate and third is called as output gate.

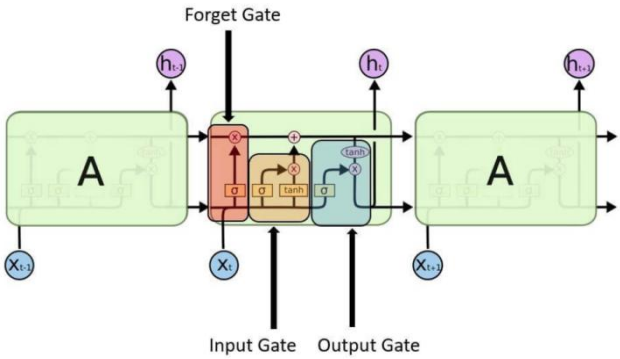

Figure 5: LSTM Unit with its 3 gates [33]

Forget get throw away the information from the memory determined by sigmoid function. Input gate decides what information to be added to cell state from current input. Output gate determines what part of information is going to become the output.

4. Methodology

The flow of data science approach for data visualization and stock prices prediction is shown in Figure 6.

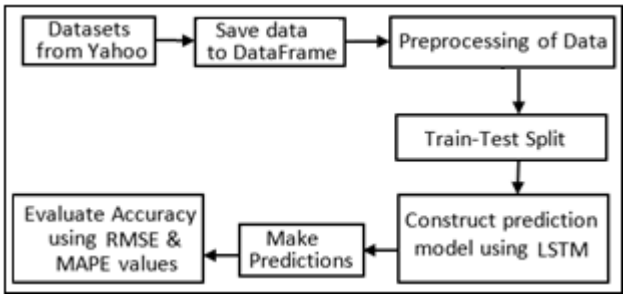

Figure 6: Model for stock prices prediction using data from Yahoo Finance

I) Dataset of Stock Prices

Yahoo finance provides financial news, data and commentary including stock quotes, press releases, financial reports, and original content [17]. State Bank of India datasheet from 1 April 2021 to 30 March 2022.

Date	Open	High	Low	Close	Adj Close	Volume
2021-04-01	367.700012	371.899994	363.100006	370.649994	367.259277	31883453
2021-04-05	367.500000	369.200012	349.049988	353.549988	350.315704	51743981
2021-04-06	355.700012	357.000000	349.299988	350.549988	347.343140	44147709
2021-04-07	351.250000	363.200012	347.600006	358.549988	355.269958	48023602
2021-04-08	361.000000	363.299988	354.299988	355.600006	352.346954	33370259
2021-04-09	354.399994	364.500000	351.200012	353.000000	349.770721	46473100
2021-04-12	344.000000	344.000000	322.549988	328.850006	325.841675	75501713
2021-04-13	332.000000	342.250000	330.500000	341.000000	337.880524	49773360
2021-04-15	342.100006	347.549988	336.100006	342.700012	339.564972	52992349
2021-04-16	343.000000	345.500000	338.649994	339.899994	336.790558	37766793

Figure 7: State Bank of India Datasheet

HDFC Bank datasheet from 1 April 2021 to 30 March 2022

Date	Open	High	Low	Close	Adj Close	Volume
2021-04-01	1499.400024	1499.400024	1465.000000	1486.750000	1480.343018	17881881
2021-04-05	1480.000000	1485.000000	1431.000000	1449.599976	1443.353149	8003293
2021-04-06	1460.000000	1462.650024	1432.650024	1440.250000	1434.043457	7537867
2021-04-07	1439.300049	1456.699951	1421.550049	1447.199951	1440.963501	12544090
2021-04-08	1453.000000	1460.900024	1430.500000	1432.800049	1426.625610	8806796
2021-04-09	1426.000000	1432.800049	1415.099976	1421.750000	1415.623169	14078908
2021-04-12	1393.000000	1399.000000	1353.000000	1367.050049	1361.158936	11274564
2021-04-13	1368.000000	1406.449951	1361.000000	1400.349976	1394.315430	9300341
2021-04-15	1405.000000	1436.699951	1391.000000	1430.099976	1423.937134	17222492
2021-04-16	1434.949951	1445.000000	1423.500000	1428.650024	1422.493408	7803263

Figure 8: HDFC Bank Datasheet

II) Feature Extraction

Feature extraction is process of transforming raw data into new features from the existing ones that can be processed. We will choose our features from date, open, high, low, close, adj close and volume.

III) Dataset visualization

Data visualization is important step in data science. Here OHLC Average is used, which provides better trading signals. The average of the open, high, low, and close (OHLC) for a given time frame is the average value of the opening price, the highest price, the lowest price, and the closing price. Following graphs are plotted for OHLC average values of selected stocks.

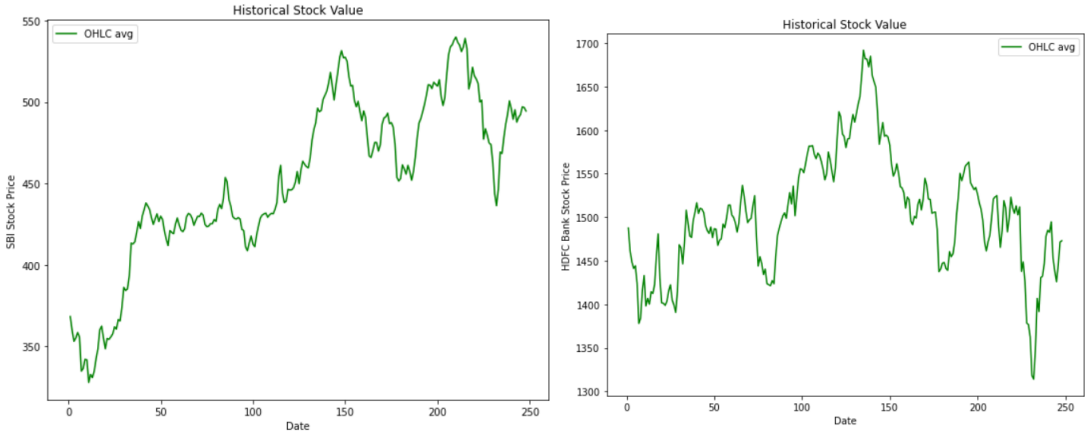

Figure 9: OHLC Average data Visualization for State Bank of India and HDFC Bank

IV) Train-Test Split

Train-test split involves taking a dataset and dividing it into two subsets. First subset also called as Train dataset is used to fit model. And second subset called as Test dataset is used to evaluate the fit model. We have divided of our data into 80% for training and 20% for testing. Objective of train-test spilt is to forecast the performance of our model on new data which is not used to train the model.

V) Model Creation and Training

Proposed LSTM model consist of a sequential input layer followed by 2 LSTM layers and dense layer with activation. The output layer consists of dense layer with linear activation.

VI) Model Validations

For analyzing model performance, we have used RMSE & MAPE. Root mean square error (RMSE) calculates the average difference between the predicted values from the model and the actual values in the dataset. The use of RMSE is very common. The formula to find the RMSE, is as follows [16]:

$$\textbf{RMSE} = \sqrt{\Sigma}(P_i - O_i)^2/n$$

where, Σ is symbol that means "sum", Pi is the predicted value for the i^{th} observation in the dataset, Oi is the observed value for the i^{th} observation in the dataset and n is the sample size.

Mean absolute percentage error (MAPE) is the most common metrics used to measure the forecasting accuracy of a model. It is commonly used because it's easy to interpret and explain. The formula to calculate MAPE is as follows [16]:

$$\textbf{MAPE} = (1/n)* \Sigma(|\text{actual- forecast}|/ |\text{actual}|)* 100$$

Where Σ is symbol that means "sum", n for sample size, actual for the actual data value and forecast for the forecasted/predicted data value

5. Result & Comparison

I) State Bank of India

Here we will see the actual price and predicted price of SBI, a large public sector stock. The model was trained in bulk sizes of 25, 50, 75 and 100 epochs, and the forecasts were made very similar to stock prices, as seen in the graph.

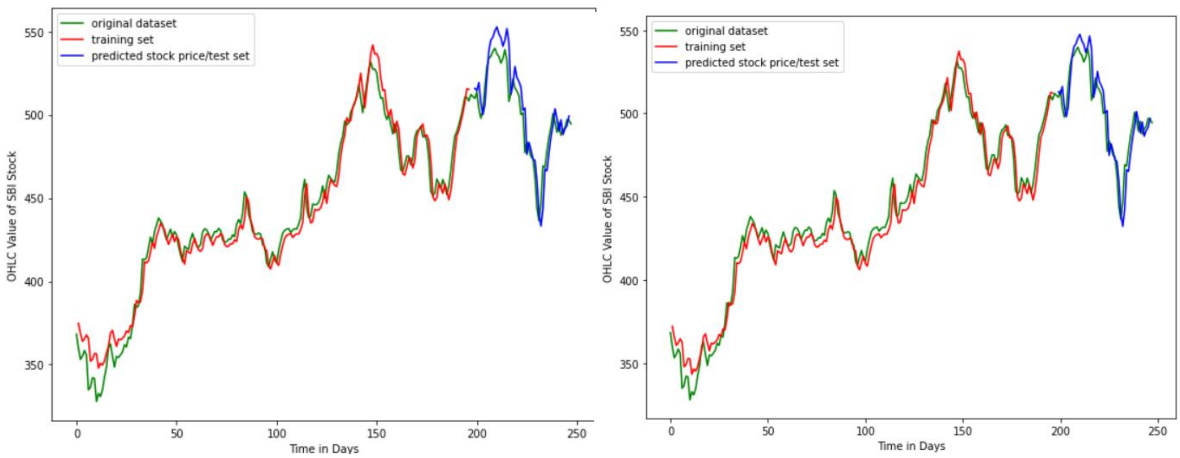

Figure 10: Trained with 25 and 50 epochs

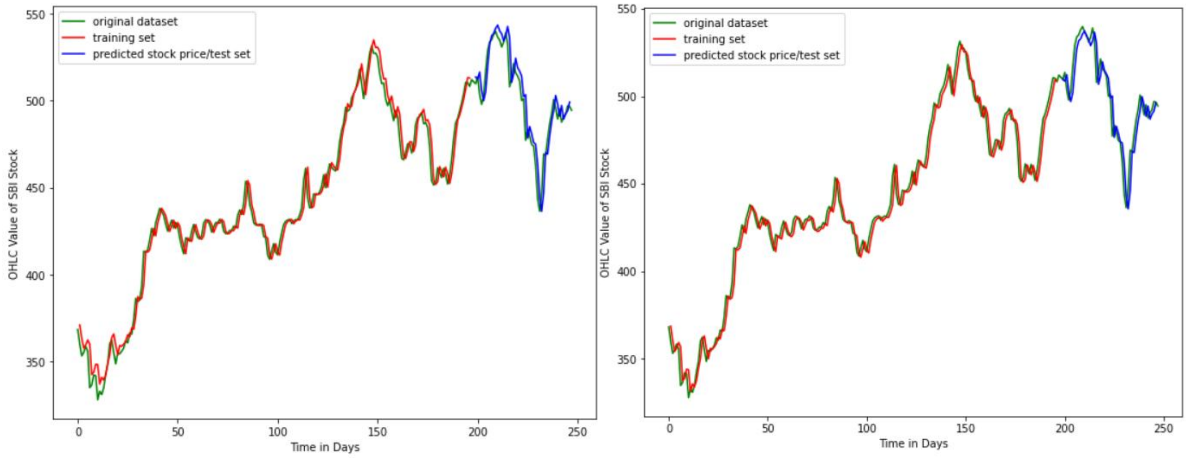

Figure 11: Trained with 75 and 100 epochs

II) HDFC Bank

Here we will see the actual price and predicted price of HDFC Bank, a large private sector stock. The model was trained in bulk sizes of 25, 50, 75 and 100 epochs, and the forecasts were made very similar to stock prices, as seen in the graph.

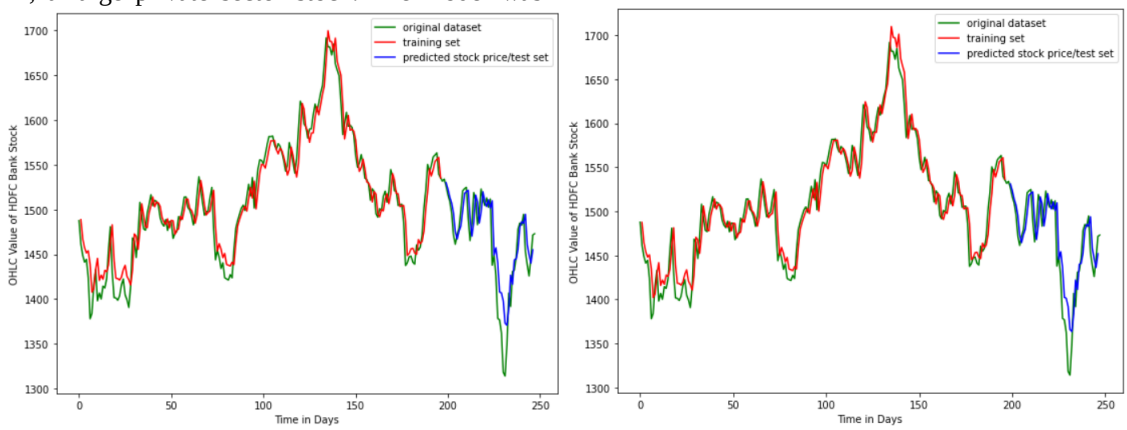

Figure 12: Trained with 25 and 50 epochs

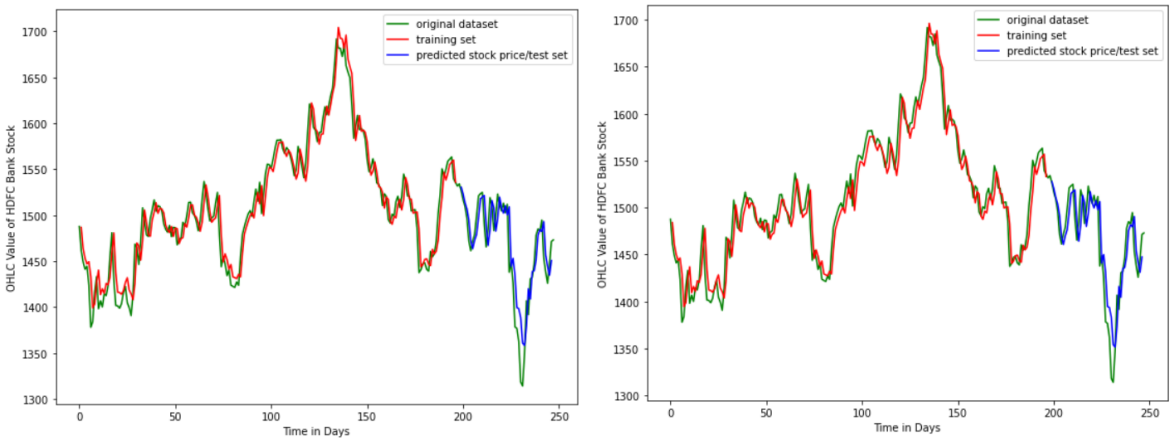

Figure 13: Trained with 75 and 100 epochs

We also experimented on 3 years of State Bank of India and HDFC bank data. The model was trained using 25, 50, 75, 100 epochs. The predictions made were a bit far from actual price of the stock.

6. Conclusion

Stock investing has attracted interest of investors around the globe. Investors are very eager to predict stock markets. These predictions are beneficial for investments to be profitable. Even small improvement in performance can be very big. Predictions are always helpful in decreasing risk factor in any business environment. Risk factor can be analyzed on the basis of historical data. In this paper we compared 1 year and 3 years of publicly available data of NSE of India. We experimented by varying epoch of bulk size 25, 50, 75 and 100. We trained the LSTM model to predict next day price of the stock. We achieved best results at 75, 100 epochs. For evaluating performance of the model, we used Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE). We got the RMSE value as 1.06 and MAPE value as 3.67. Our experimental

result concluded that our LSTM model gives very good accuracy for period of 1 year data. We suggest LSTM as a good option for handling time series data.

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