Predicting the Closing Value of Amazon Stock using Long Short Term Memory (LSTM)

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Abstract— **The closing price is considered the most accurate evaluation of a stock or other security until trading resumes on the next trading day. Here, we make use of the LSTM model to predict the closing price of Amazon stocks.**

Index Terms—**LSTM, Amazon, Closing value, RNN, ANN, Machine learning**

I. INTRODUCTION

Stock market prediction is an act of trying to get some information on the future outlook of a company's stock or other financial instrument traded on an exchange. Stock market prediction and analysis are difficult because of market volatility and a variety of other dependent and independent variables that influence the value of a certain stock in the market. Closing prices are useful markers for investors to use to assess changes in stock prices over time. The closing figure on one day can be compared to closing figure on the previous day, 30 days earlier, or a year earlier to measure the changes in the market sentiment toward that stock. It is because of the importance of this parameter that many researches have been dedicated towards its forecast. For example, Shen and Shafiq, 2020 [3] collected 2 years data from the Chinese stock market for predicting the stock market price trend. In 2021, Gosh et al [4] compared the effectiveness of both random forests and LSTM in forecasting the out-of-sample directional movements of constituent stocks of the Standard Poor's 500 (SP 500) from January 1993 till December 2018 for intraday trading. [5] used the artificial neural network (ANN) and the random forest techniques for predicting the next day closing prices for five companies belong to different sectors. In order to improve the prediction accuracy, [6] incorporated the investor sentiment information with deep learning to forecast the market stock index. In this work, our focus is to predict the closing price of Amazon stocks using LSTM model.

II. THE LONG SHORT-TERM MEMORY

The Long-short term memory (LSTM) is an artificial recurrent neural network (RNN) architecture used in the field of deep learning. Unlike the standard feedforward neural networks, LSTM has feedback connections. It can process not only single data points (such as images), but also entire sequences of data (such as speech or videos). A common LSTM unit is composed of a cell, an input gate, an output gate and a forget gate. The cell remembers values over arbitrary time intervals and the three gates regulate the flow of information into and out of the cell. LSTM networks are suitable for classifying, processing and making decision based on time series. LSTMs were developed to deal with the vanishing gradient problem that can be encountered when training traditional RNNs.

A. LSTM with a forget gate

$$f_t = \sigma_g(W_f x_t + U_f h_{t-1} + b_f)$$
$$i_t = \sigma_g(W_i x_t + U_i h_{t-1} + b_i)$$
$$o_t = \sigma_g(W_o x_t + U_o h_{t-1} + b_o)$$
$$\tilde{c}_t = \sigma_c(W_c x_t + U_c h_{t-1} + b_c)$$
$$c_t = f_t \circ c_{t-1} + i_t \circ \tilde{c}_t$$
$$h_t = o_t \circ \sigma_h(c_t)$$

where the initial values are $c_o = 0$ and $h_o = 0$ and the operator $\circ$ denotes the Hadamard product (element-wise product). The subscript t indexes the time step.

Variables:

1) $x_t \in \mathbb{R}^d$: input vector to the LSTM unit.
2) $f_t \in (0,1)^h$: forget gate's activation vector.
3) $i_t \in (0,1)^h$: input/update gate's activation vector.
4) $o_t \in (0,1)^h$: output gate's activation vector.
5) $h_t \in (-1,1)^h$: vector of the LSTM unit.
6) $\tilde{c}_t \in (-1,1)^h$: cell input activation vector.
7) $c_t \in \mathbb{R}^h$: cell state vector.
8) $W \in \mathbb{R}^{h \times d}$, $U \in \mathbb{R}^{h \times h}$ and $b \in \mathbb{R}^h$: weight matrices and bias vector parameters which need to be learned during training where the superscripts d and h refer to the number of input features and the number of hidden units, respectively.

Activation functions:

1) σ_g : sigmoid function.
2) σ_c : hyperbolic tangent function.
3) σ_h : hyperbolic tangent function or the identity function.

III. DATA COLLECTION

Amazon's stock is listed on Yahoo finance (https://finance.yahoo.com) and their value is updated every working day of the stock market. The stock market day does not include Saturdays and Sundays. We are going to use
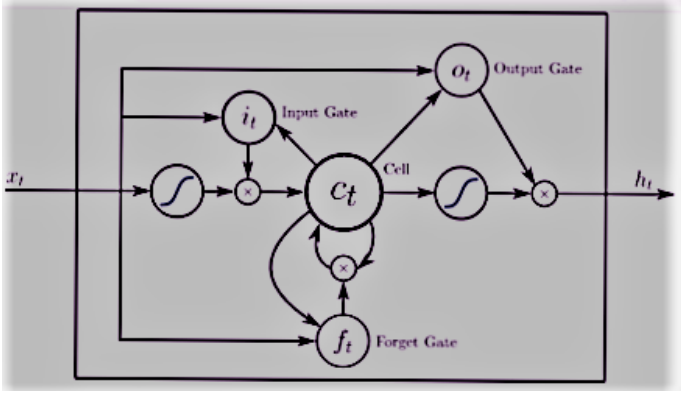
Fig. 1. A typical LSTM model.

these data remotely from January 1st 2010 to January 31st 2022. The data has 6 columns without the date column: The opening value of the stock, the highest and lowest values as well as the closing values are listed at the end of each day. The adjusted close value reflects the stock's value after the dividends have been declared. Furthermore, the total volume of the stocks in the market is provided.

Date	Open	High	Low	Close	Adj Close	Volume
2010-01-04	136.250000	136.610001	133.139999	133.899994	133.899994	7599900
2010-01-05	133.429993	135.479996	131.809998	134.690002	134.690002	8851900
2010-01-06	134.600006	134.729996	131.649994	132.250000	132.250000	7178800
2010-01-07	132.009995	132.320007	128.800003	130.000000	130.000000	11030200
2010-01-08	130.559998	133.679993	129.029999	133.520004	133.520004	9830500
...	...	...	...	...	...	...
2022-01-24	2780.000000	2898.899902	2707.040039	2890.879883	2890.879883	7781200
2022-01-25	2844.850098	2872.000000	2762.899902	2799.719971	2799.719971	4541200
2022-01-26	2895.000000	2903.699951	2746.370117	2777.449951	2777.449951	4780100
2022-01-27	2816.000000	2884.870117	2787.000000	2792.750000	2792.750000	3875800
2022-01-28	2817.209961	2879.959961	2758.590088	2879.560059	2879.560059	3719600

3040 rows × 6 columns

Fig. 2. Stock Preview.

A. *Target Variable and Features*

The variable to be predicted is the adjusted closing price of amazon stock. We choose "Open," "High," "Low" and "Volume" as the features to serve as the independent variable for the target variable "Adj Close."

B. *Training and Testing data*

We would divide the entire dataset into the training and the testing data. The LSTM model will be trained on the data in the training set and tested for accuracy on the testing set. We are going to use 90% and 10% of the data as the training and testing data, respectively.

C. *Building LSTM Model for Amazon Closing Price Prediction*

We build a Sequential Keras model with one LSTM layer. The LSTM layer has 32 units and is followed by one dense layer of one neuron. We compile the model using Adam optimizer and mean squared error as the lost function.
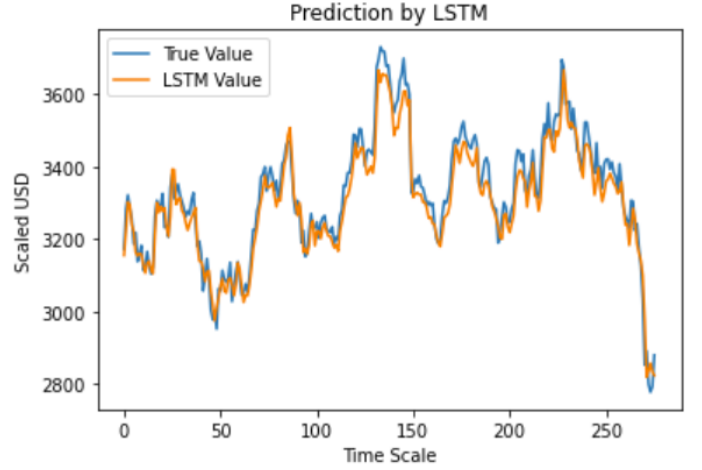
IV. RESULTS

Fig. 3. Actual versus Prediction.

The graph in Figure 3 shows the true adjusted closing price of Amazon stock in blue and the LSTM-predicted closing value in orange. From the graph, it is clear that the LSTM-predicted values not only follow the pattern of true values but they are very close to the actual value. This demonstrates the power of LSTM model. Given, any Amazon features, one can input them into the LSTM-predicted model to get insights into what the adjusted closing value might look like. This model could help potential investors in Amazon's stock to make informed decision in evaluating the changes in the stock values over time.

In conclusion, stock market predictions are difficult due a number of factors. However, with the advent of machine learning and its algorithms, we can get more and more accurate predictions by adjusting the parameters and perhaps increasing the number of layers in the design of the machine.

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