Stock prices forecasting in USA during Covid-19 using Long Short-Term Memory (LSTM)

Project Report

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1 Introduction

One year ago, the U.S. stock market hit rock bottom after the coronavirus outbreak resulting in 30+ percent drops for each of the three major stock market indices from their previous peaks. But, a year later the world is still in crisis, but stock prices are near all-time highs.Investment firms, hedge funds and even individuals have been using financial models to better understand market behavior and make profitable investments and trades. In the midst of the COVID-19 pandemic and the dynamics of the global financial market during the year 2020, majority of global stock index reference indexes have experienced a significant decline. Forecasting stock prices has always been considered a challenging task due to the fact that the stock market tends to be non-stationary, nonlinear, and highly noisy. Artificial intelligence (AI) algorithms have been proven successful in solving problems such as predicting stock prices. Numerous factors influence financial market performance, and even financial experts find it complicated to make accurate predictions. This project seeks to utilize Deep Learning models, Long-Short Term Memory (LSTM) Neural Network algorithm, to predict stock prices.

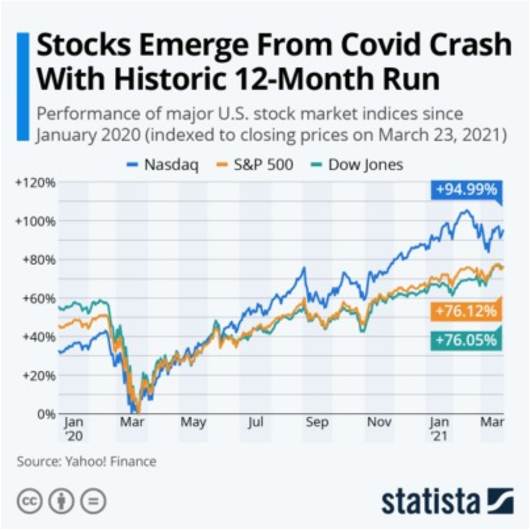


Figure 1: Stock market performance before and during COVID-19

2 Problem Statement and Goal

Problem statement:- Stock market process is full of uncertainty; hence stock prices forecasting is very important in finance and business. COVID-19 have had a significant influence on the global economy, as well as an impact on the financial markets. The challenge of this project is to accurately predict the future stock price of the given stock across a given period of time in the future considering the impact of COVID- 19 on the economy

Goal:- In this project, we are trying to investigate the impact of COVID-19(Confirmed cases data) on the stock prices of companies like Amazon, Netflix, Delta airlines, and United airlines on NASDAQ index. We will be making use of a Long Short Term Memory networks, Regression models to predict the future stock price of these companies on the NASDAQ using a data-set of past prices with and without COVID-19 data.

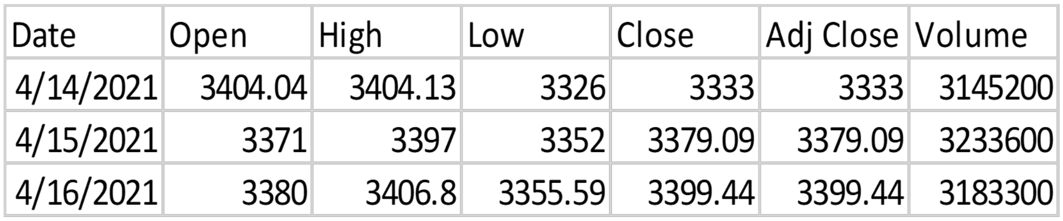
3 Datasets

1) Yahoo Finance:- Historical data of the stock prices. Yahoo Finance is the largest business and financial news site in the world, with unrivaled access to data, insights, and content.

2) NASDAQ Website:- Historical data of the stock prices.

3) Data of COVID19 confirmed cases are publicly available and operated by the Johns Hopkins University Center for Systems Science and Engineering (JHU CSSE).

4 Sample Dataset



Date	Open	High	Low	Close	Adj Close	Volume
4/14/2021	3404.04	3404.13	3326	3333	3333	3145200
4/15/2021	3371	3397	3352	3379.09	3379.09	3233600
4/16/2021	3380	3406.8	3355.59	3399.44	3399.44	3183300

Figure 2: Amazon stock price

Date:- Day on which the stock is traded.

High:- Highest price at which a stock is traded during the course of the day.

Open:- Price of the first trade for any listed stock is its daily opening price.

Low:- Lowest price at which a stock trades over the course of a trading day.

Volume:- The number of shares or contracts traded in a security or an entire market during a given period of time.

5 Algorithms and Techniques

Use different machine learning and deep learning models available and compare them in terms of graphical analysis.

5.1 Linear Regression

Linear Regression algorithm is a supervised machine learning algorithm to model between dependent variable and one or more independent variables to produce a best fit linear line.

Two types of Linear Regression

1) Simple Linear Regression

Simple Linear Regression is used for finding the relationship between the independent variable and the dependent variable. The goal of Simple Linear Regression algorithm is to obtain a line that best fits the data which is achieved by minimizing the loss function.

2) Multiple Linear Regression

In real-life scenarios, there will never be a single variable that predicts a target.

Multiple Linear Regression is used for finding the relationship between dependent variables and one or more independent.

Linear Regression Model (Initial Findings)

Linear regression is an approach for predictive modeling to showcase the relationship between a scalar dependent variable 'Y', (in our case, we have 'Close' attribute) and one or more independent variables 'X' ('Date' attribute).

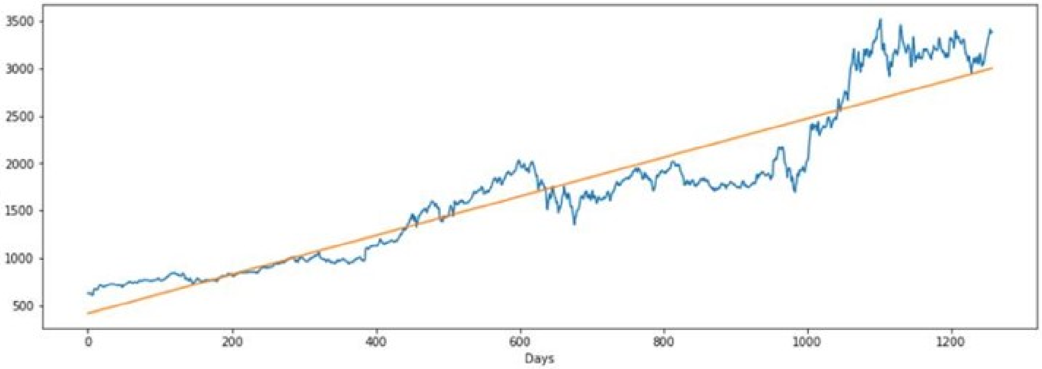
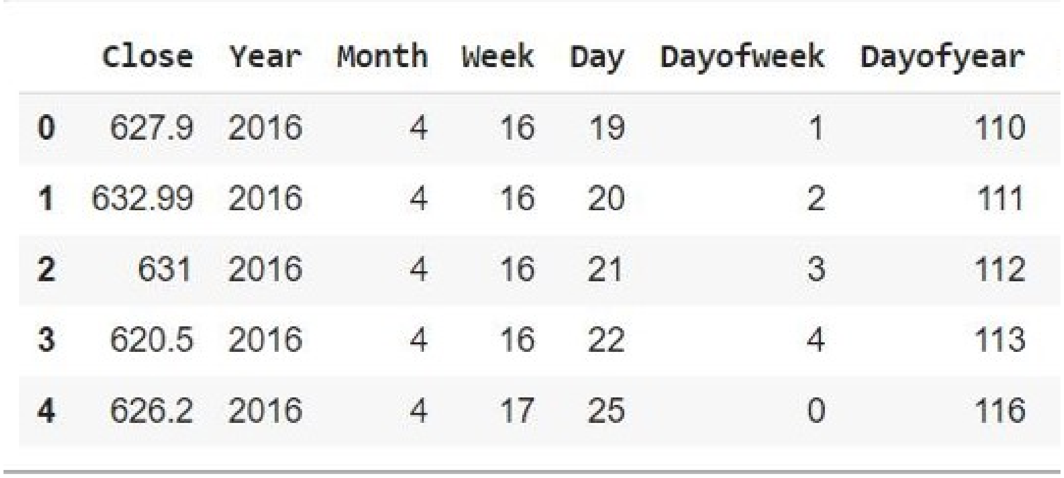


Figure 3: Linear Regression for Amazon dataset

Dataset Used



	Close	Year	Month	Week	Day	Dayofweek	Dayofyear
0	627.9	2016	4	16	19	1	110
1	632.99	2016	4	16	20	2	111
2	631	2016	4	16	21	3	112
3	620.5	2016	4	16	22	4	113
4	626.2	2016	4	17	25	0	116

Figure 4: Dataset For Linear Regression Model

Evaluation Metric Used:- RMSE (Root Mean Square Error)

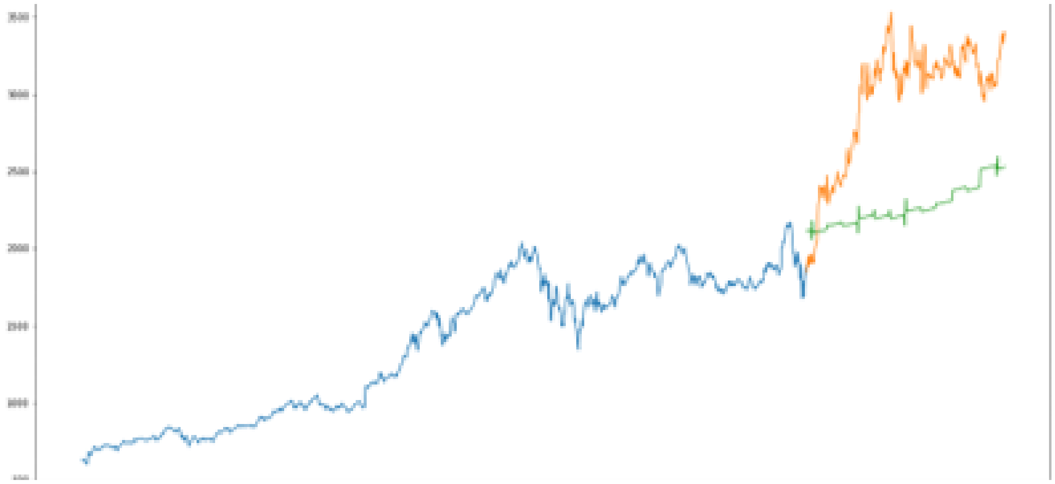


Figure 5: Visualization between the actual value and the predicted value.

Blue curve:- Training Data, Orange Curve:- Test Data, Green Curve:- Predicted Data by the model

5.2 Long Short-Term Memory

According to my research, best possible model to use for solution is LSTM Neural Net Model.

LSTMs are explicitly designed to avoid the long-term dependency problem. Remembering information for long periods of time is practically their default behavior, not something they struggle to learn.

Recurrent Neural Network + LSTM (How it works?)

The key to LSTM is the Memory cell state which stores the information. It runs straight down the entire chain.LSTM has the ability to remove or add information to these cell state, regulated by structures called gates. Gates are composed of Sigmoid neural net layer and a multiplication operation.

There are three gates to protect and control the cell states.

1) Input Gate:- The input gate adds information to the cell state.

2) Forget Gate:- The forget gate removes the information that is no longer required by the model

3) Output Gate:- The output gate at LSTM selects the information to be shown as output.

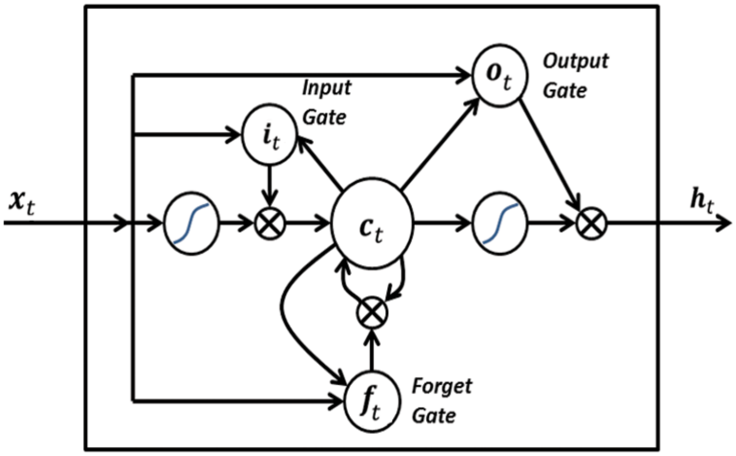


Figure 6: The inner working of LSTM

Initial LSTM Architecture and Initial Findings

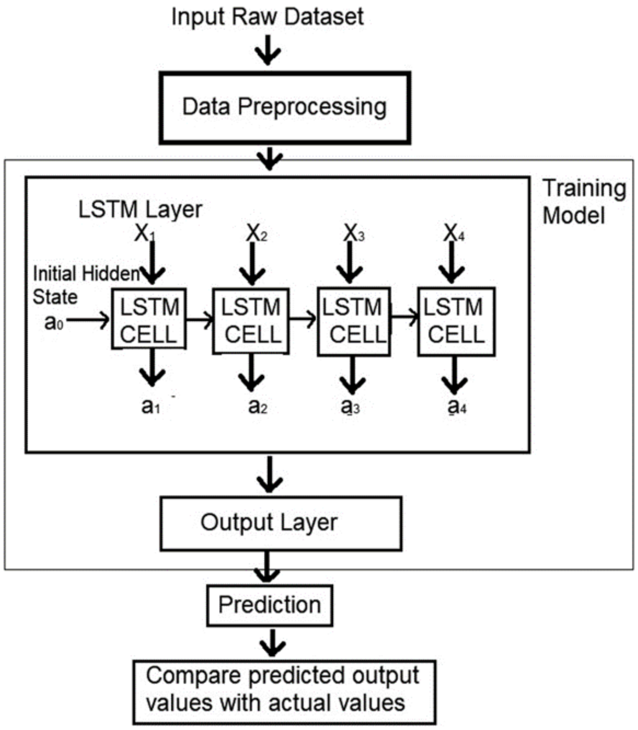


Figure 7: Current LSTM architecture

Model Parameters

Stacked LSTMs

1) Loss function:- Mean Squared Error

2) Optimizer:- Adam

3) Epochs:- 100

4) Batch Size:- 64

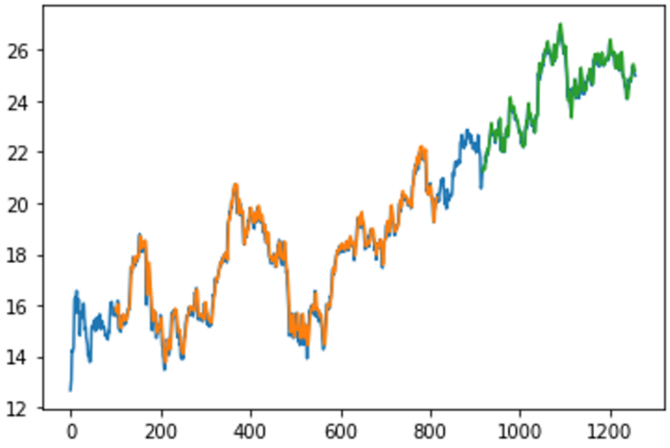


Figure 8: Averaging (High + Low) / 2

Blue curve - Original data, Orange curve - Training model prediction, Green curve - Testing model prediction

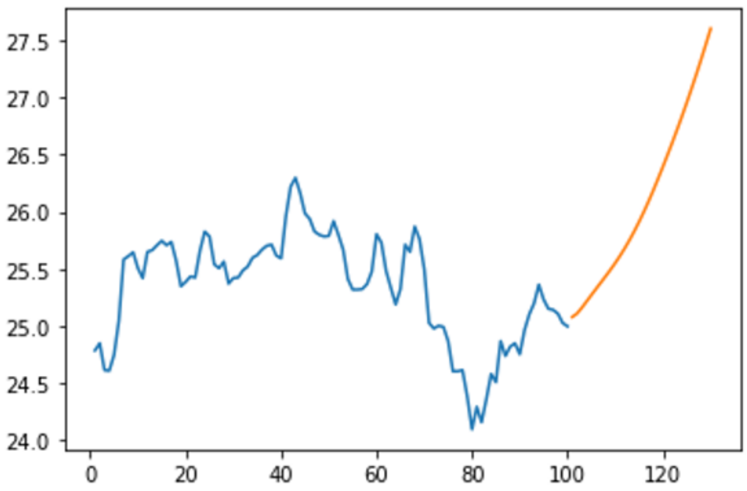
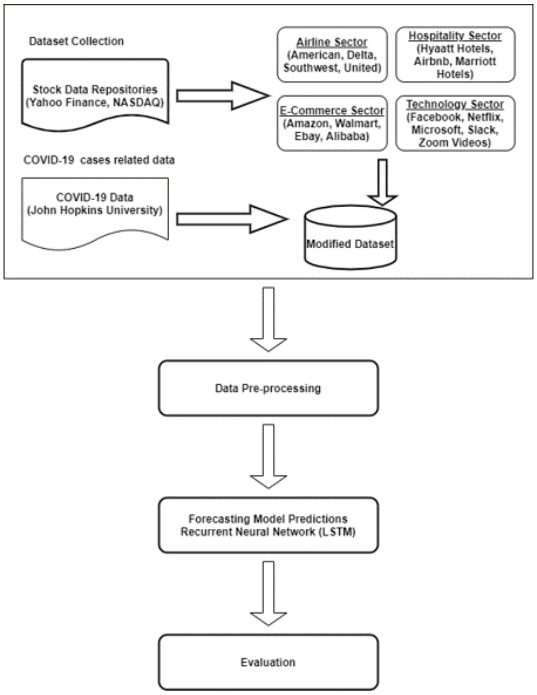
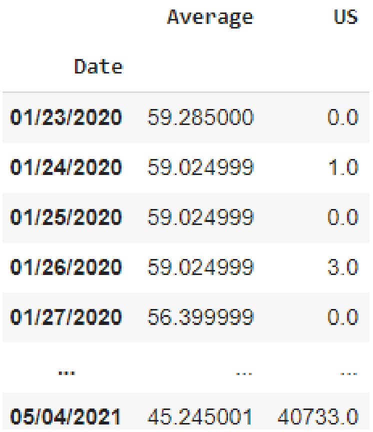


Figure 9: **Blue curve - last 100 days data, Orange curve - next 30 days prediction**

6 Final architecture of LSTM used


Dataset Collection
Stock Data Repositories (Yahoo Finance, NASDAQ)
Airline Sector (American, Delta, Southwest, United)
Hospitality Sector (Hyaatt Hotels, Airbnb, Marriott Hotels)
E-Commerce Sector (Amazon, Walmart, Ebay, Alibaba)
Technology Sector (Facebook, Netflix, Microsoft, Slack, Zoom Videos)
COVID-19 cases related data
COVID-19 Data (John Hopkins University)
Modified Dataset
Data Pre-processing
Forecasting Model Predictions Recurrent Neural Network (LSTM)
Evaluation



	Average	US
Date		
01/23/2020	59.285000	0.0
01/24/2020	59.024999	1.0
01/25/2020	59.024999	0.0
01/26/2020	59.024999	3.0
01/27/2020	56.399999	0.0
...	...	...
05/04/2021	45.245001	40733.0

Left Img:- Final LSTM architecture

Right Img:- Sample final csv file used for this LSTM model

Steps for preparing the data for LSTM model

1) Reading Confirmed Covid-19 cases in the US file in csv and converting it into dataframe.

2) Reading the stock prices data file in csv and converting it into dataframe.

3) Merging the Covid-19 dataset and stock dataset to get the dataset needed to train the LSTM model.

4) Taking the Average of low and high values from the merged dataset.

5) Filling the NaN values with the previous days average value.

6) Making the date column as index of the merged dataset

7) Re arranging the columns and saving it to a csv file.

Model Parameters

Stacked LSTMs

1) Loss function:- Mean Squared Error

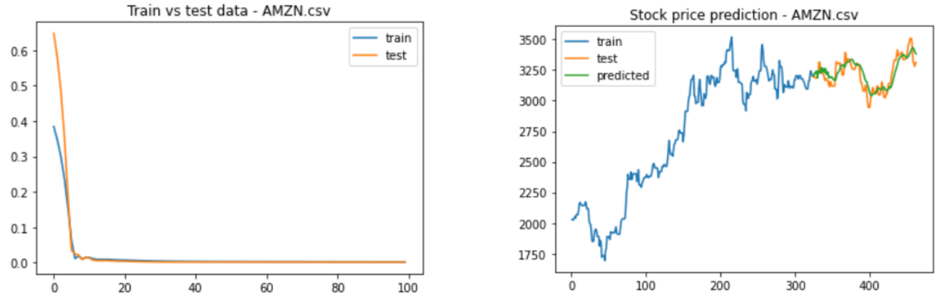
2) Optimizer:- Adam

3) Epochs:- 200

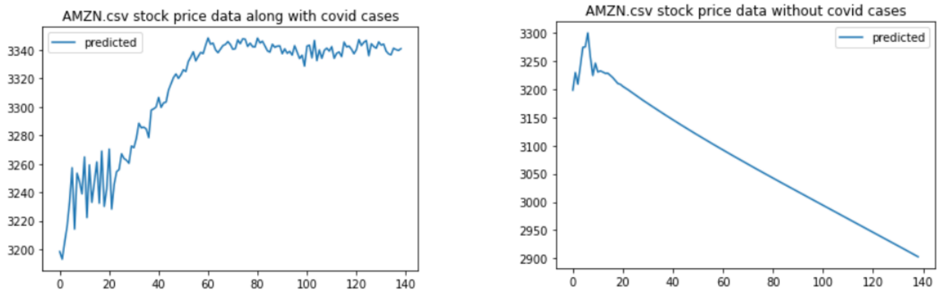
4) Batch Size:- 25

5) Verbose=2

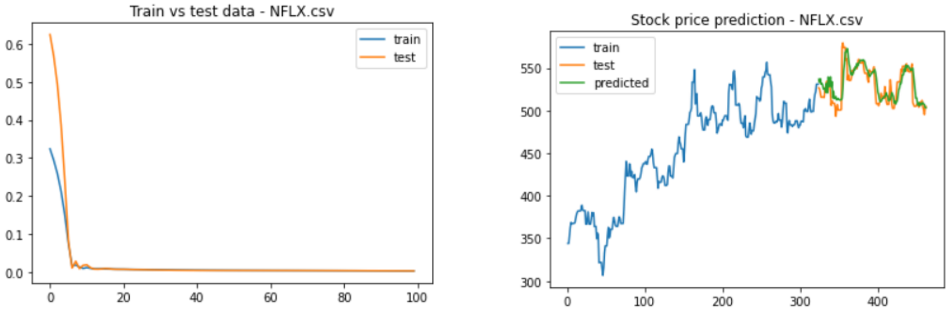
7 Results



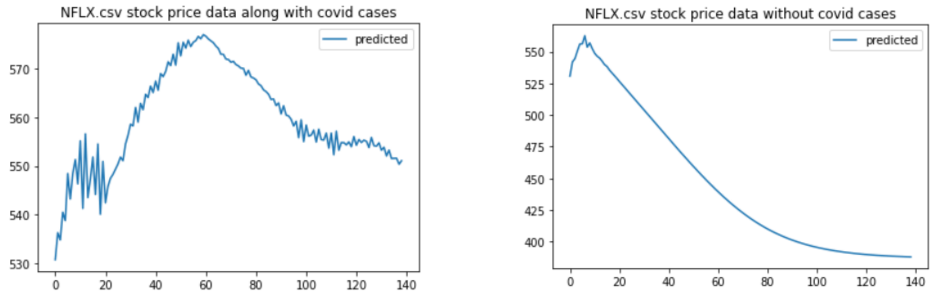
Left Img:- Train Vs Test for Amazon, **Right Img:-** Stock price prediction for Amazon with Covid-19 data



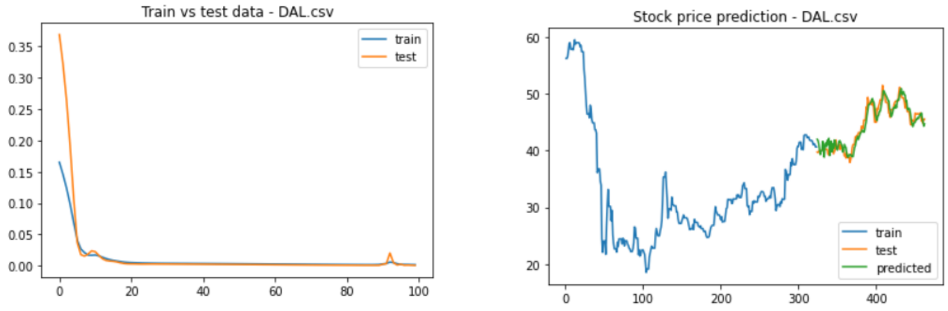
Left Img:- Predicting next 10 days stock price for Amazon with Covid-19 data, **Right Img:-** Stock price prediction for Amazon without Covid-19 data for next 10 days



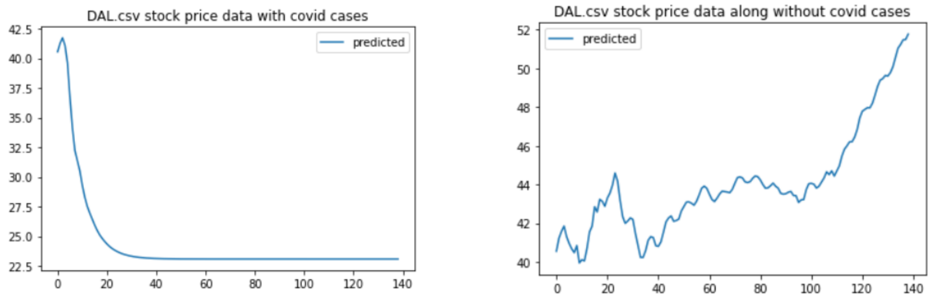
Left Img:- Train Vs Test for Netflix, **Right Img:-** Stock price prediction for Netflix with Covid-19 data



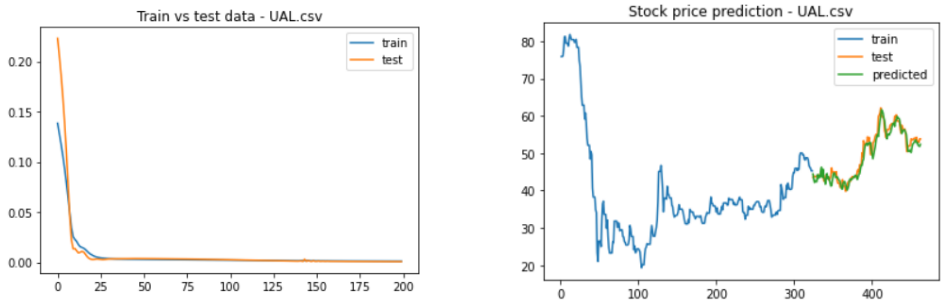
Left Img:- Predicting next 10 days stock price for Netlix with Covid-19 data, **Right Img:-** Stock price prediction for Netflix without Covid-19 data for next 10 days



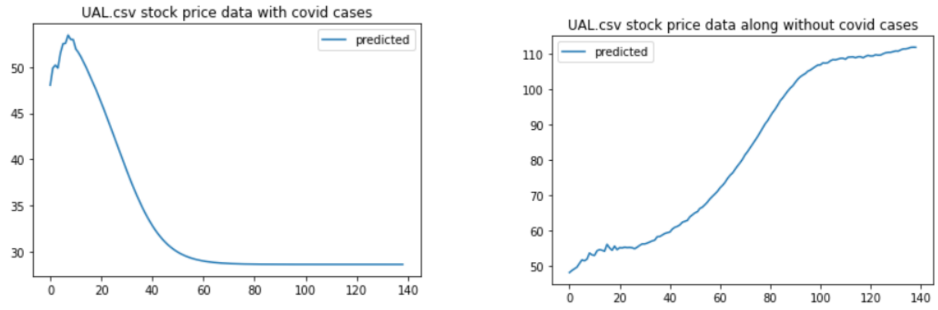
Left Img:- Train Vs Test for Delta Airlines, **Right Img:-** Stock price prediction for Delta Airlines with Covid-19 data



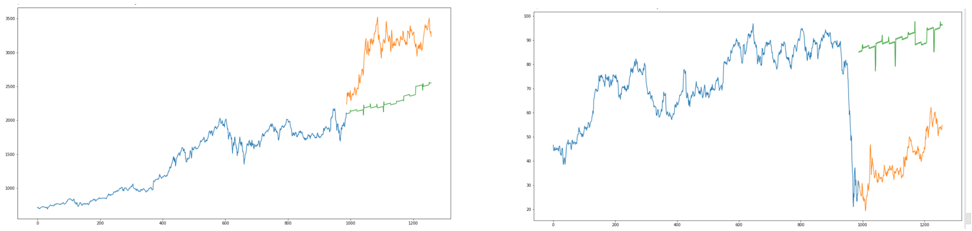
Left Img:- Predicting next 10 days stock price for Delta Airlines with Covid-19 data, **Right Img:-** Stock price prediction for Delta Airlines without Covid-19 data for next 10 days



Left Img:- Train Vs Test for United Airlines, **Right Img:-** Stock price prediction for United Airlines with Covid-19 data



Left Img:- Predicting next 10 days stock price for United Airlines with Covid-19 data, **Right Img:-** Stock price prediction for United Airlines without Covid-19 data for next 10 days



Left Img:- Linear Regression model output for Amazon, **Right Img:-** Linear Regression model output for United Airlines

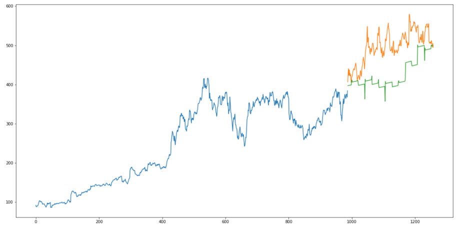


Figure:- Linear Regression model output for Netflix

8 Insights and Conclusions drawn

* One of the most important things to do is to predict how the stock market will do. Physical vs. psychological factors, rational vs. irrational behavior, and so on are all factors in the prediction. Both of these factors combine to make stock prices extremely volatile and difficult to forecast accurately.

* Stock price is affected by the news about the company and other factors like merger/demerger of the companies, economic conditions etc. There are certain intangible factors as well which can often be impossible to predict beforehand.

* Stacked LSTM model performs better than the linear regression model.

* After comparing the graphical results obtained we can say that Technology sector performed well during the pandemic compared to the Travel and Tourism sectors which took a very bad hit because of Covid-19.

* Multivariate LSTM is better when working with multiple features.

* Lesser the size of the time window while working with time series forecasting better the results(When the training data is small.

* For better predictions sentiment analysis / news analysis can be added.

9 Challenges

* Feature selection for the stock price prediction

* Understanding the historical CSV data obtained form Yahoo Finance.

* Understanding the COVID-19 data.

* Merging of the COVID-19 new cases data and stock data to generate a new dataset required to train the LSTM model.

* Analyzing the obtained results/graphs to draw conclusions.

* Choosing the correct hyper parameters for building better models.

10 Research Papers (References)

1) Impact of COVID-19 on Forecasting Stock Prices: An Integration of Stationary Wavelet Transform and Bidirectional Long Short-Term Memory

https://downloads.hindawi.com/journals/complexity/2020/1846926.pdf

2) Data science approach to stock prices forecasting in Indonesia during Covid-19 using Long Short-Term Memory (LSTM).

https://journalofbigdata.springeropen.com/track/pdf/10.1186/s40537-021-00430-0.pdf