A Project Report

on

STOCK PRICE PREDICTION USING LSTM

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B.Tech Computer Science and Engineering

Under The Supervision of
Name of Supervisor : Dr. A . Daniel
AP

Submitted By

Ishan Adhikari Bairagi(18SCSE1120018)
Anchal Sharma(18SCSE1010752)

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SCHOOL OF COMPUTING SCIENCE AND ENGINEERING
DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
GALGOTIAS UNIVERSITY, GREATER NOIDA
INDIA
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SCHOOL OF COMPUTING SCIENCE AND ENGINEERING
GALGOTIAS UNIVERSITY, GREATER NOIDA

CANDIDATE'S DECLARATION

I/We hereby certify that the work which is being presented in the thesis/project/dissertation, entitled **"STOCK PRICE PREDICTION USING LSTM"** in partial fulfillment of the requirements for the award of the Bachelor of Technology submitted in the School of Computing Science and Engineering of Galgotias University, Greater Noida, is an original work carried out during the period of January 2022 to May 2022, under the supervision of Dr. A. Daniel, AP, Department of Computer Science and Engineering/Computer Application and Information and Science, of School of Computing Science and Engineering , Galgotias University, Greater Noida

The matter presented in the thesis/project/dissertation has not been submitted by me/us for the award of any other degree of this or any other places.

Ishan Adhikari Bairagi (18SCSE1120018)

Anchal Sharma (18SCSE1010752)

This is to certify that the above statement made by the candidates is correct to the best of my knowledge.

Dr. A. Daniel

AP

CERTIFICATE

The Final Thesis/Project/ Dissertation Viva-Voce examination of Ishan Adhikari Bairagi (18SCSE1120018) and Anchal Sharma (18SCSE1010752) has been held on 13/05/2022 and his/her work is recommended for the award of Bachelor of Technology in Computer Science and Engineering.

Signature of Examiner(s) **Signature of Supervisor(s)**

Signature of Project Coordinator **Signature of Dean**

Date: 13 May, 2022

Place: Greater Noida

Abstract

Investing into stocks has become a trend in the new generation and everyone shows keen interest in putting their money and trying their luck into the stock game. But it requires deep analysis and thorough knowledge to get you through the risk and failures. There are multiple platforms which let you invest money into stocks nationally and internationally and with the boom in crypto currency, it has become evident that investments are a good way to earn and give an upper hand over others as far as income parameters are measured.

This project aims to predict the price of the selected stock and give useful and near reliable insights so that investor can have an idea of how the stock may perform in the future. This can really help assess the performance of a stock and make calculated decisions.

We intend to predict the stock using the LSTM neural network and then provide the user with a dashboard using plotly dash and Tableau for stock analysis. However stock prices are subject to market conditions and may change abruptly depending on multiple factors. Thus the project aims to give supposed prices to the investor on an approximate basis.

The future of this project can be made in a mobile based app which plugged in with previous performance of stock data will help users take advantage of the prediction at their hands.

Table of Contents

List of Figures

Acronyms

NSE	National Stock Exchange
FY	Financial Year
EMA	Exponential Moving Average
LSTM	Long Short Term Memory
GRU	Gated Recurrent Unit
RNN	Recurrent Neural Network
RMSE	Root Mean Square Error
NASDAQ	National Association of Securities Dealers Automated Quotations

CHAPTER-1
Introduction

There has been a growing upsurge in the younger generation towards getting conscious about their financial well being and the era of a steady job with real estate and other static investments has gone old. With the arrival of internet, mobiles and applications that give the power of investment right within the hands of the investor, everyone is trying to cut the cake of profits. However stock market has always been susceptible to risks despite all the profits it may provide and it requires caution to put the hard earned money into a market which at many times is highly volatile. Stock market in India has attracted a lot of investors (mostly retail) though, but the number is significant. In the starting 3 months of FY2021 it is believed that 3 crore retail investors entered the stock market. The power of stock market can be understood by the fact that despite the current crisis going on in Russia-Ukraine, investors bought stocks of worth $1 billion in 2 days in Feb. 2022. Therefore it is imperative that this huge potential is harnessed properly. A lot of time is wasted by retail or small investors in finding the right opportunity or right stock to invest. The institutional investors could easily seek professional advisory services, but that is not the case with the former. Therefore, the uncertainty of the market and the total brunt of it has to be borne by retail investors who sometimes invest a fortune in hope of gaining a fortune. Thus investment becomes a perilous task at times.

What are Stocks?

A stock is a financial instrument that represents ownership in a company or corporation and represents a proportionate claim on its assets (what it owns) and earnings (what it generates in profits). Stocks are also called shares or a company's equity. Stock ownership implies that the shareholder owns a slice of the company equal to the number of shares held as a proportion of the company's total outstanding shares. For instance, an individual or entity that owns 100,000 shares of a company with one million outstanding shares would have a 10% ownership stake in it. Most companies have outstanding shares that run into the millions or billions.

Types of Stock

While there are two main types of stock, common and preferred. The term equities is synonymous with common shares, as their combined market value and trading volumes are many magnitudes larger than that of preferred shares.

The main distinction between the two is that common shares usually carry voting rights that enable the common shareholder to have a say in corporate meetings (like the annual general meeting or AGM) where matters such as election to the board of directors or appointment of auditors are voted upon while preferred shares generally do not have voting rights. Preferred shares are so named because preferred shareholders have priority over common shareholders to receive dividends as well as assets in the event of liquidation.

Common stock can be further classified in terms of their voting rights. While the basic premise of common shares is that they should have equal voting rights i.e. one vote per share held, some companies have dual or multiple classes of stock with different voting rights attached to each class. In such a dual-class structure, Class A shares, for example, may have 10 votes per share, while the Class B subordinate voting shares may only have one vote per share. Dual- or multiple-class share structures are designed to enable the founders of a company to control its fortunes, strategic direction, and ability to innovate.

But why do companies issue “Shares”?

Today's corporate giant likely had its start as a small private entity launched by a visionary founder a few decades ago. Think of Jack Ma incubating Alibaba (BABA) from his apartment in Hangzhou, China, in 1999, or Mark Zuckerberg founding the earliest version of Facebook (now Meta), from his Harvard University dorm room in 2004. Technology giants like these have become among the biggest companies in the world within a couple of decades.
However, growing at such a frenetic pace requires access to a massive amount of capital. In order to make the transition from an idea germinating in an entrepreneur's brain to an operating company, they need to lease an office or factory, hire employees, buy equipment and raw materials, and put in place a sales

and distribution network, among other things. These resources require significant amounts of capital, depending on the scale and scope of the business startup.
Take example of the recent deal of the takeover of Twitter by Elon Musk. The deal was closed at Elon Musk's offer of $54.20 per equity share totaling a gallop of $43 billion in value.

i) **Raising Capital**

A startup can raise such capital either by selling shares (equity financing) or borrowing money (debt financing). Debt financing can be a problem for a startup because it may have few assets to pledge for a loan especially in sectors such as technology or biotechnology, where a firm has few tangible assets plus the interest on the loan would impose a financial burden in the early days, when the company may have no revenues or earnings.

Equity financing, therefore, is the preferred route for most startups that need capital. The entrepreneur may initially source funds from personal savings, as well as friends and family, to get the business off the ground. As the business expands and capital requirements become more substantial, the entrepreneur may turn to angel investors and venture capital firms.

ii) **Listing Shares**

When a company establishes itself, it may need access to much larger amounts of capital than it can get from ongoing operations or a traditional bank loan. It can do so by selling shares to the public through an initial public offering (IPO).

This changes the status of the company from a private firm whose shares are held by a few shareholders to a publicly-traded company whose shares will be held by numerous members of the general public. The IPO also offers early investors in the company an opportunity to cash out part of their stake, often reaping very handsome rewards in the process.

Once the company's shares are listed on a stock exchange and trading in it commences, the price of these shares fluctuates as investors and traders assess and reassess their intrinsic value. There are many different ratios and metrics that can be used to value stocks, of which the single-most popular measure is probably the price-to-earnings (PE) ratio. The stock

analysis also tends to fall into one of two camps that is fundamental analysis or technical analysis.

Place of Exchange - Stock Exchange

Stock exchanges are secondary markets where existing shareholders can transact with potential buyers. It is important to understand that the corporations listed on stock markets do not buy and sell their own shares on a regular basis. Companies may engage in stock buybacks or issue new shares but these are not day-to-day operations and often occur outside of the framework of an exchange.

So when you buy a share of stock on the stock market, you are not buying it from the company, you are buying it from some other existing shareholder. Likewise, when you sell your shares, you do not sell them back to the company—rather you sell them to some other investor.

Stock exchanges have been around for more than two centuries. The venerable NYSE traces its roots back to 1792 when two dozen brokers met in Lower Manhattan and signed an agreement to trade securities on commission. In 1817, New York stockbrokers operating under the agreement made some key changes and reorganized as the New York Stock and Exchange Board.

The NYSE and NASDAQ are the two largest exchanges in the world, based on the total market capitalization of all the companies listed on the exchange. The number of U.S. stock exchanges registered with the Securities and Exchange Commission has reached nearly two dozen, though most of these are owned by either CBOE, Nasdaq, or NYSE.18 The table below displays the 20 biggest exchanges globally, ranked by the total market capitalization of their listed companies.

History of Stock Exchanges

The first stock markets appeared in Europe in the 16th and 17th centuries, mainly in port cities or trading hubs such as Antwerp, Amsterdam, and London. These early stock exchanges, however, were more akin to bond exchanges as the small number of companies did not issue equity. In fact, most early corporations were considered semi-public organizations since they had to be chartered by their government in order to conduct business.

The first modern stock exchange opened in Amsterdam in 1602. There was only one stock to trade: the Dutch East India Company.

In the late 18th century, stock markets began appearing in America, notably the New York Stock Exchange (NYSE), which allowed for equity shares to trade. The honor of the first stock exchange in America goes to the Philadelphia Stock Exchange (PHLX), which still exists today.The NYSE was founded in 1792 with the signing of the Buttonwood Agreement by 24 New York City stockbrokers and merchants. Prior to this official incorporation, traders and brokers would meet unofficially under a buttonwood tree on Wall Street to buy and sell shares.
The advent of modern stock markets ushered in an age of regulation and professionalization that now ensures buyers and sellers of shares can trust that their transactions will go through at fair prices and within a reasonable period of time. Today, there are many stock exchanges in the U.S. and throughout the world, many of which are linked together electronically. This in turn means markets are more efficient and more liquid.

How Share Prices Are Set?

The prices of shares on a stock market can be set in a number of ways. The most common way is through an auction process where buyers and sellers place bids and offers to buy or sell. A bid is the price at which somebody wishes to buy, and an offer (or ask) is the price at which somebody wishes to sell. When the bid and ask coincide, a trade is made.
The overall market is made up of millions of investors and traders, who may have differing ideas about the value of a specific stock and thus the price at which they are willing to buy or sell it. The thousands of transactions that occur as these investors and traders convert their intentions to actions by buying and/or selling a stock cause minute-by-minute gyrations in it over the course of a trading day.

A stock exchange provides a platform where such trading can be easily conducted by matching buyers and sellers of stocks. For the average person to get access to these exchanges, they would need a stockbroker. This stockbroker acts as the middleman between the buyer and the seller. Getting a stockbroker is most

commonly accomplished by creating an account with a well-established retail broker.

Stock Market Supply and Demand

The stock market also offers a fascinating example of the laws of supply and demand at work in real-time. For every stock transaction, there must be a buyer and a seller. Because of the immutable laws of supply and demand, if there are more buyers for a specific stock than there are sellers of it, the stock price will trend up. Conversely, if there are more sellers of the stock than buyers, the price will trend down.

The bid-ask or bid-offer spread (the difference between the bid price for a stock and its ask or offer price) represents the difference between the highest price that a buyer is willing to pay or bid for a stock and the lowest price at which a seller is offering the stock.

A trade transaction occurs either when a buyer accepts the ask price or a seller takes the bid price. If buyers outnumber sellers, they may be willing to raise their bids in order to acquire the stock. Sellers will, therefore, ask higher prices for it, ratcheting the price up. If sellers outnumber buyers, they may be willing to accept lower offers for the stock, while buyers will also lower their bids, effectively forcing the price down.

Investing in Stocks

Numerous studies have shown that, over long periods of time, stocks generate investment returns that are superior to those from every other asset class. Stock returns arise from capital gains and dividends.

A capital gain occurs when you sell a stock at a higher price than the price at which you purchased it. A dividend is the share of profit that a company distributes to its shareholders. Dividends are an important component of stock returns. They have contributed nearly one-third of total equity return since 1956, while capital gains have contributed two-thirds.

While the allure of buying a stock similar to one of the fabled FAANG quintet Meta, Apple (AAPL), Amazon (AMZN), Netflix (NFLX), and Google parent

Alphabet (GOOGL)—at a very early stage is one of the more tantalizing prospects of stock investing, in reality, such home runs are few and far between.
Investors who want to swing for the fences with the stocks in their portfolios should have a higher tolerance for risk. These investors will be keen to generate most of their returns from capital gains rather than dividends. On the other hand, investors who are conservative and need the income from their portfolios may opt for stocks that have a long history of paying substantial dividends.

Classification of Stocks
Stocks can be classified into market cap and sector.

i) **Market Cap-wise**
Market cap refers to the total market value of a company's outstanding shares and is calculated by multiplying these shares by the current market price of one share. While the exact definition may vary depending on the market, large-cap companies are generally regarded as those with a market capitalization of $10 billion or more, while mid-cap companies are those with a market capitalization of between $2 billion and $10 billion, and small-cap companies fall between $250 million and $2 billion.

ii) **Sector-wise**
The industry standard for stock classification by sector is the Global Industry Classification Standard (GICS), which was developed by MSCI and S&P Dow Jones Indices in 1999 as an efficient tool to capture the breadth, depth, and evolution of industry sectors. GICS is a four-tiered industry classification system that consists of 11 sectors and 24 industry groups. The 11 sectors are:

1. Energy
2. Materials
3. Industrials
4. Consumer Discretionary
5. Consumer Staples
6. Health Care

7. Financials
8. Information Technology
9. Communication Services
10. Utilities
11. Real Estate

This sector classification makes it easy for investors to tailor their portfolios according to their risk tolerance and investment preference. For example, conservative investors with income needs may weigh their portfolios toward sectors whose constituent stocks have better price stability and offer attractive dividends through so-called defensive sectors such as consumer staples, health care, and utilities. Aggressive investors may prefer more volatile sectors such as information technology, financials, and energy.

Stock Market Indices

In addition to individual stocks, many investors are concerned with stock indices, which are also called indexes. Indices represent aggregated prices of a number of different stocks, and the movement of an index is the net effect of the movements of each individual component. When people talk about the stock market, they often allude to one of the major indices such as the Dow Jones Industrial Average (DJIA) or the S&P 500.

The DJIA is a price-weighted index of 30 large American corporations. Because of its weighting scheme and the fact that it only consists of 30 stocks (when there are many thousands to choose from), it is not really a good indicator of how the stock market is doing.15 The S&P 500 is a market-cap-weighted index of the 500 largest companies in the U.S. and is a much more valid indicator.

Indices can be broad such as the Dow Jones or S&P 500, or they can be specific to a certain industry or market sector. Investors can trade indices indirectly via futures markets, or via exchange-traded funds (ETFs), which act just like stocks on stock exchanges.

A market index is a popular measure of stock market performance. Most market indices are market-cap weighted, which means that the weight of each index constituent is proportional to its market capitalization. Keep in mind, though, that a

few of them are price-weighted, such as the DJIA. In addition to the DJIA, other widely watched indices in the U.S. and internationally include the:

a) S&P 500
b) Nasdaq Composite
c) Russell Indices (Russell 1000, Russell 2000)
d) TSX Composite (Canada)
e) FTSE Index (UK)
f) Nikkei 225 (Japan)
g) Dax Index (Germany)
h) CAC 40 Index (France)
i) CSI 300 Index (China)
j) Sensex (India)

The list of Top 11 Stock Exchanges on market cap scale is attached for reference.

List of Stock Exchanges by Market Capitalization Exchange	Location	Market Cap.*
NYSE	U.S.	26.11
Nasdaq	U.S.	22.42
Shanghai Stock Exchange	China	7.37
Tokyo Stock Exchange	Japan	6.0
Shenzhen Stock Exchange	China	5.33
Hong Kong Stock Exchange	Hong Kong	4.97
London Stock Exchange	U.K.	3.57
India National Stock Exchange	India	3.45
Toronto Stock Exchange	Canada	3.41
Saudi Stock Exchange (Tadawul)	Saudi Arabia	3.20
Bombay Stock Exchange	India	2.22

Effects of Inflation on the Stock Market

Inflation refers to an increase in consumer prices, either due to an oversupply of money or a shortage of consumer goods. The effects of inflation on the stock market are unpredictable: in some cases, it can lead to higher share prices, due to more money entering the market and increased job growth. However, higher input prices can also restrict corporate earnings, causing profits to fall. Overall, value stocks tend to perform better than growth stocks in times of high inflation.
The inflation in India breached the RBI's upper tolerance rate of 6% in March 2022 and has been above that since then. The effect of this can be seen on the SENSEX and NIFTY too. After touching all time highs of 60000 the Sensex has been plummeting towards a downward trajectory and the market is bear-ish.

Growth of the Stock Market Every Year

The S&P 500 has grown about 10.5% per year since it was established in the 1920s. Using this as a barometer for market growth, one can estimate that the stock market grows in value by about the same amount each year. However, there is an element of probability: in some years the stock market sees greater growth, and in some years it grows less. In addition, some stocks grow faster than others.

How Do People Lose Money in the Stock Market?

Most people who lose money in the stock market do so through reckless investments in high-risk securities. Although these can score high returns if they are successful, they are just as likely to lose money. There is also an element of psychology: an investor who sells during a crash will lock in their losses, while those who hold their stock have a chance of seeing their patience rewarded. Finally, margin trading can make the stock market even riskier, by magnifying one's potential gains or losses.

The Bottom Line

Stock markets represent the heartbeat of the market, and experts often use stock prices as a barometer of economic health. But the importance of stock markets goes beyond mere speculation. By allowing companies to sell their shares to

thousands or millions of retail investors, stock markets also represent an important source of capital for public companies.

Bull markets vs. Bear markets

Neither is an animal you'd want to run into on a hike, but the market has picked the bear as the true symbol of fear: A bear market means stock prices are falling thresholds vary, but generally to the tune of 20% or more across several of the indexes referenced earlier.

Bull markets are followed by bear markets, and vice versa, with both often signaling the start of larger economic patterns. In other words, a bull market typically means investors are confident, which indicates economic growth. A bear market shows investors are pulling back, indicating the economy may do so as well.

The good news is that the average bull market far outlasts the average bear market, which is why over the long term you can grow your money by investing in stocks.

The S&P 500, which holds about 500 of the largest stocks in the U.S., has historically returned an average of around 7% annually, when you factor in reinvested dividends and adjust for inflation. That means if you invested $1,000 30 years ago, you could have about $7,600 today.

Stock market CRASH vs. CORRETION

A stock market correction happens when the stock market drops by 10% or more. A stock market crash is a sudden, very sharp drop in stock prices, like in early 2020, around the beginning of the COVID-19 pandemic.

While crashes can herald a bear market, remember what we mentioned above: Most bull markets last longer than bear markets which means stock markets tend to rise in value over time. In 2020, the market was back to hitting record highs by August.If you're worried about a crash, it helps to focus on the long term. When the stock market declines, it can be difficult to watch your portfolio's value shrink in real time and do nothing about it. However, if you're investing for the long term, doing nothing is often the best course.

Because when you sell investments in a downturn, you lock in your losses. If you plan to re-enter the market at a sunnier time, you'll almost certainly pay more for the privilege and sacrifice part (if not all) of the gains from the rebound.

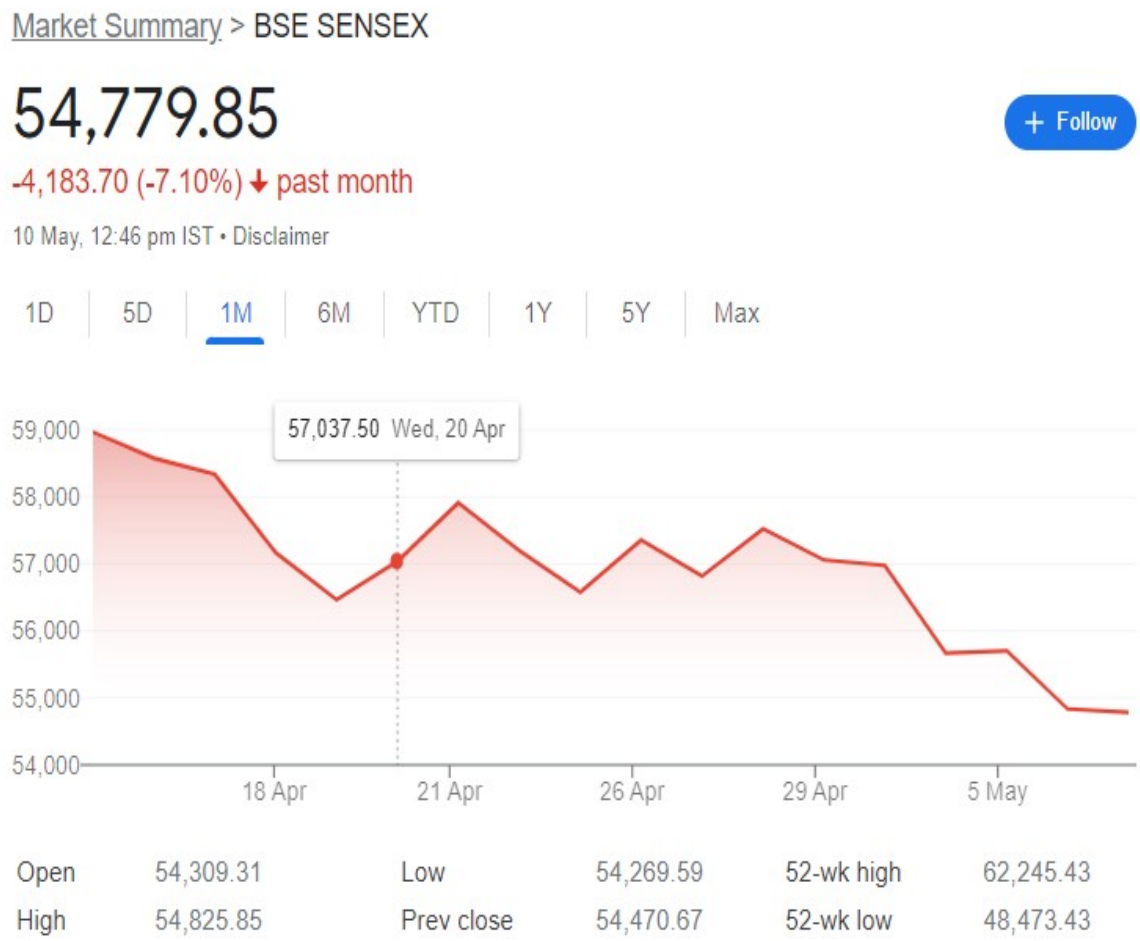

Fig.1 One Month trend of SENSEX

With plenty of Machine Learning techniques that are already serving the humanity strive towards a better future with predicting results with greater accuracy. This project also aims to appreciate the existing practices and propose a stock price predictor using Machine Learning Algorithms. But human decisions are not always rational and without accurate insights and models, decisions based on emotions and personal bias lead to losses However being cautious enough also may not help as decisions have to be based on processing of large chunks of data which at times is a matter of precise skills. As discussed above there has been a huge jump in the

number of retail investors lately, most of whom do not have access to sophisticated tools and data driven models like institutional or other large investors.
Some data driven models that retail investors may take up are linear regression and Exponential Moving Average or EMA. We can assume that a given stock is likely to follow an upward trend if the 20-day EMA exceeds the 50-day EMA. Another approach may be to join the minimum and maximum of the candlesticks by a linear regression line. The growing umbrella of deep learning and machine learning may also take retail investors or the general public for that matter under the shade of itself to generate more decisive and enhanced data driven solutions for them. Therefore we tried to harness this power of machine learning algorithms in the form of stock price prediction and decolonize these technologies so that they reach a larger number of people. The algorithm used to serve the purpose here is LSTM or Long Short Term Memory.

CHAPTER-2
Literature Survey

There exists a lot of previous research and analysis with respect to stock prediction using various machine learning or deep learning algorithms. Some of the existing researches from which we tried to inherit details are mentioned here.

Raghav Nandakumar *et al*. shed light on the advantages of LSTM and mention about the temporal dependence which is context specific and the cell remembers either for a long or short term without the need of a activation function [1].

Adil Moghar and Mhamed Hamiche also proposed RNN based LSTM for forecasting and showed that with increasing epochs the precision increases for both GOOGL and NKE assets [2].

Yulian Wen *et al*. also showed advantageous position offered by PCA-LSTM Model compared to the CNN model, MLP model and Moving Average model. They used PCA for feature extraction and other indexes affecting stock prices and then use LSTM for prediction. It was found that the RMSE and MAPE of the PCA-LSTM model were 0.221 and 1.667% respectively advocating the efficacy of PCA-LSTM based models [3].

Ya Gao *et al.* also promoted LSTM for financial prediction. They used PCA and LASSO for dimensionality reduction. LASSO is a method of estimation for simplification of the indicator set. A more refined model is achieved by making a penalty function which compresses some coefficients and even sets some coefficients to 0. Hence we can say it is a biased estimation for dealing with complex collinear data [4].

B. Wanjawa and L. Muchemi discussed the usage of ANN for prediction with 70% of the training data to predict the stock prices for the next 60 days and predicted the actual closing prices within 0.71% mean absolute percentage error (MAPE), with the highest variance -3.2% among all of the 62 days. This demonstrated a high potential for using machine learning to accurately predict stock prices [5].

A deep feed forward neural network with back propagation algorithm was used by Somenath Mukherjee *et al*. for prediction. Their model predicted the open, close, high and low values of NIFTY of the nth day using these 4 features of the $(n-1)^{th}$ and $(n-2)^{th}$ days. 8 neurons to accept values from each of the 4 features from past 2 days were used by them [6].

Y. Dai and Y. Zhang used PE ratio, PX volume, 10-day volatility, 50-day moving average, etc. for predicting long term as well as next day stock prices. Various algorithms were used ranging from Logistic Regression, Quadratic Discriminant Analysis which was the best performing with 58.2% accuracy in short term and SVM in long term with accuracy of 79.3%. They also mentioned that increasing the features leads to increase in accuracy [7].

J. Patel *et al.* used 10 technical indicator signals as inputs and tried to predict the upward or downward trend for 10 upcoming days. Naive Bayesian, ANN, Random Forest, SVM were used for creating prediction models. In their experiment the model with highest accuracy of 83.56% was random forest [8].

CHAPTER 3
Theory

For better grasp of the work at play here, a theoretical understanding of concepts is crucial. We start with discussing about a neural network

1) **Neural Network:**

Neural networks, in the world of finance, assist in the development of such processes as time-series forecasting, algorithmic trading, securities classification, credit risk modeling, and constructing proprietary indicators and price derivatives. A neural network works similarly to the human brain's neural network. A "neuron" in a neural network is a mathematical function that collects and classifies information according to a specific architecture. The network bears a strong resemblance to statistical methods such as curve fitting and regression analysis. A neural network contains layers of interconnected nodes. Each node is a known as perceptron and is similar to a multiple linear regression. The perceptron feeds the signal produced by a multiple linear regression into an activation function that may be nonlinear.

a) Multi-Layered Perceptron

In a multi-layered perceptron (MLP), perceptrons are arranged in interconnected layers. The input layer collects input patterns. The output layer has classifications or output signals to which input patterns may map. For instance, the patterns may comprise a list of quantities for technical indicators about a security; potential outputs could be "buy," "hold" or "sell". Hidden layers fine-tune the input weightings until the neural network's margin of error is minimal. It is hypothesized that hidden layers extrapolate salient features in the input data that have predictive power regarding the outputs. This describes feature extraction, which accomplishes a utility similar to statistical techniques such as principal component analysis.

b) **Application of Neural Networks**

Neural networks are broadly used, with applications for financial operations,

enterprise planning, trading, business analytics, and product maintenance. Neural networks have also gained widespread adoption in business applications such as forecasting and marketing research solutions, fraud detection, and risk assessment. A neural network evaluates price data and unearths opportunities for making trade decisions based on the data analysis. The networks can distinguish subtle nonlinear interdependencies and patterns other methods of technical analysis cannot. According to research, the accuracy of neural networks in making price predictions for stocks differs. Some models predict the correct stock prices 50 to 60 percent of the time, while others are accurate in 70 percent of all instances. Some have posited that a 10 percent improvement in efficiency is all an investor can ask for from a neural network

It is a layered network of neurons with an input layer, a hidden layer and an output layer. We feed the input layer with information or inputs and each of which has some weight, for e.g. we choose to watch a movie and we have a set of inputs that we can provide to our brains to help us decide which movie to watch. We can have actor as one criteria, director as another and genre as another. Now we may associate more weight to the actor criteria if our favorite actor is in the movie. This is the concept of weighted inputs. “A neural network attempts to learn a function that maps the input features to the output predictions, serving as a universal function approximator [9]”. We can say that a neural network is a network of multiple neurons which represent weighted sum of inputs fed to it. The output thus generated are passed through an activation function to enable non linearity and then again passed through several other neurons. Some popular activation functions used are the Sigmoid function [$\sigma(z) = 1 / 1 + e^{-z}$], the tanh function [$\Phi(z) = e^{z} - e^{-z} / e^{z} + e^{-z}$] and the Rectified Linear Unit or ReLu function [$l_j(z) = \max(0,z)$,where j represents each neuron in the network]

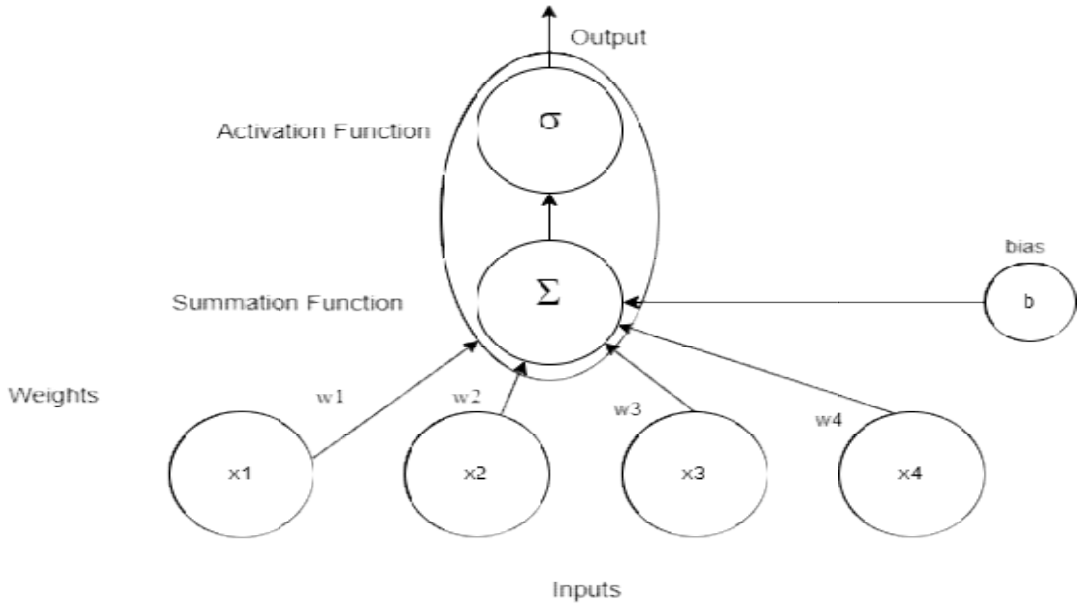

Fig. 2 A simple neural network

Now a feed forward neural network is a neural network which does not form any cycle and is unidirectional. We feed the data from previous layers into all the neurons of hidden layer and then we repeat the process if there is more than 1 hidden layer i.e. in a deep feed forward neural network. It is often called as multilayered perceptron model or MLP model.

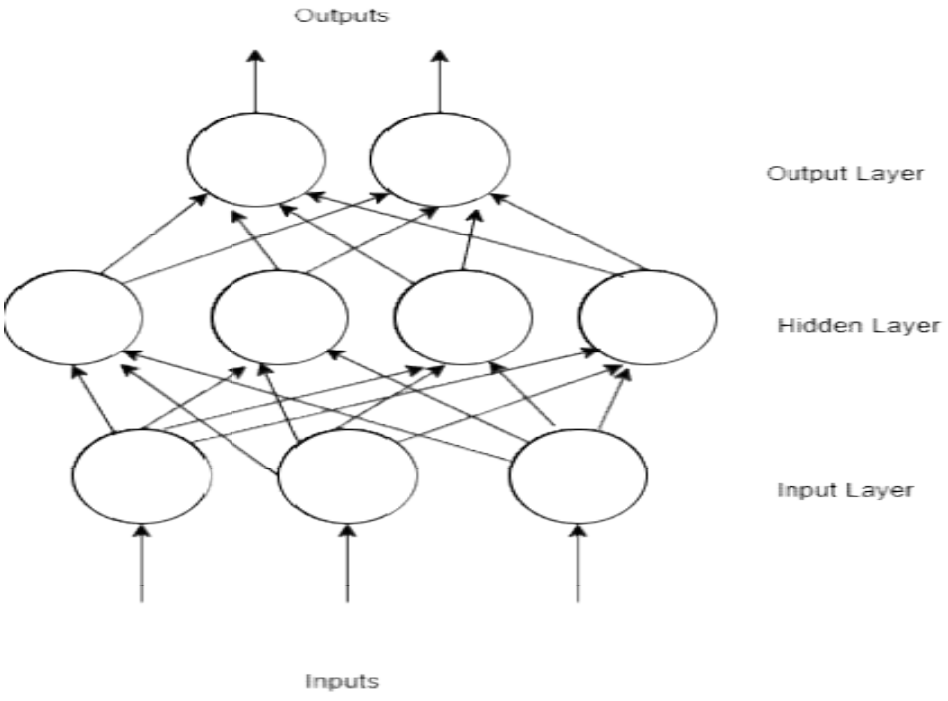

Fig. 3 A feed forward neural network

2) Recurrent Neural Network (RNN)

A recurrent neural network (RNN) is a special type of an artificial neural network adapted to work for time series data or data that involves sequences. Ordinary feed forward neural networks are only meant for data points, which are independent of each other. However, if we have data in a sequence such that one data point depends upon the previous data point, we need to modify the neural network to incorporate the dependencies between these data points. RNNs have the concept of 'memory' that helps them store the states or information of previous inputs to generate the next output of the sequence.

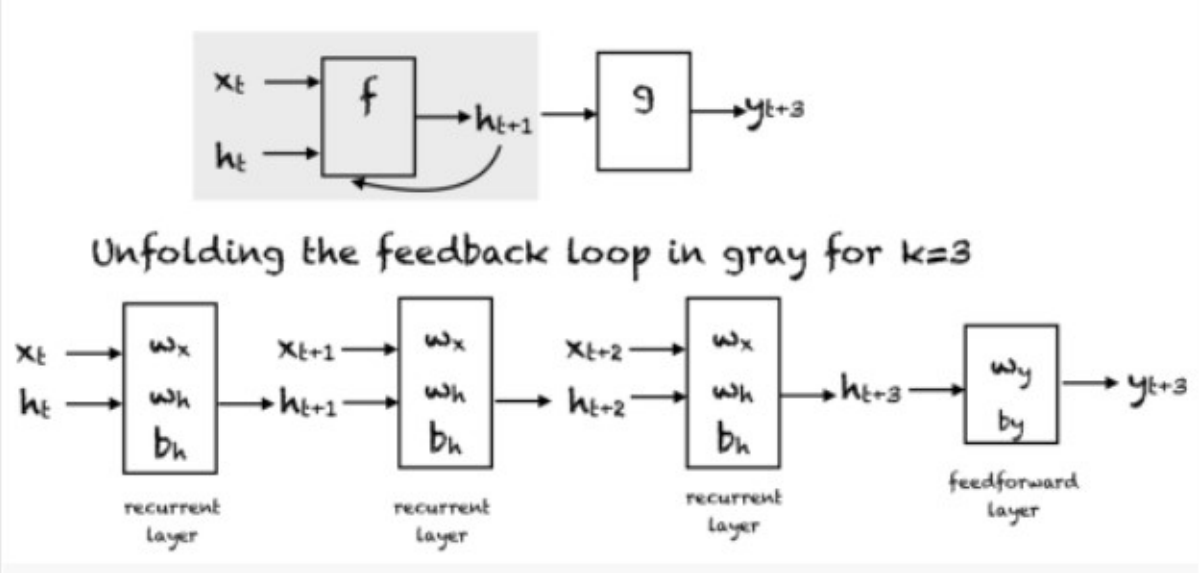

Fig. 4 RNN, compressed and unfolded representation

- $x_t \in R$ is the input at time step . To keep things simple we assume that is a scalar value with a single feature. You can extend this idea to a -dimensional feature vector.
- $y_t \in R$ is the output of the network at time step . We can produce multiple outputs in the network but for this example we assume that there is one output.
- $h_t \in R^m$ vector stores the values of the hidden units/states at time . This is also called the current context. is the number of hidden units. vector is initialized to zero.
- $w_x \in R^m$ are weights associated with inputs in recurrent layer

- $w_h \in R^{m \times m}$ are weights associated with hidden units in recurrent layer
- $w_y \in R^m$ are weights associated with hidden to output units
- $b_h \in R^m$ is the bias associated with the recurrent layer
- $b_y \in R^m$ is the bias associated with the feedforward layer

Training A Recurrent Neural Network

The backpropagation algorithm of an artificial neural network is modified to include the unfolding in time to train the weights of the network. This algorithm is based on computing the gradient vector and is called back propagation in time or BPTT algorithm for short. The pseudo-code for training is given below. The value of k can be selected by the user for training. In the pseudo-code below p_t is the target value at time step t:

1. Repeat till stopping criterion is met:
    1. Set all h to zero.
    2. Repeat for t = 0 to n-k
        1. Forward propagate the network over the unfolded network for k time steps to compute all h and y.
        2. Compute the error as $e = y_{t+k} - p_{t+k}$
        3. Backpropagate the error across the unfolded network and update the weights

RNNs can be considered as superset of feed forward neural network which have recurrent edges that introduce time to our network. When we provide input to the network and we have to remember a particular detail, RNN therefore uses the previous inputs in memory to build up to something useful. A popular use case is language translation where a particular sentence may be ordered differently in another language and hence we need multiple words or inputs from multiple time frames to predict accurately. The hidden layer here carries the word for a short term until we predict properly. The recurrent edges form cycles and help in carrying or forwarding the input to the same or another neuron.

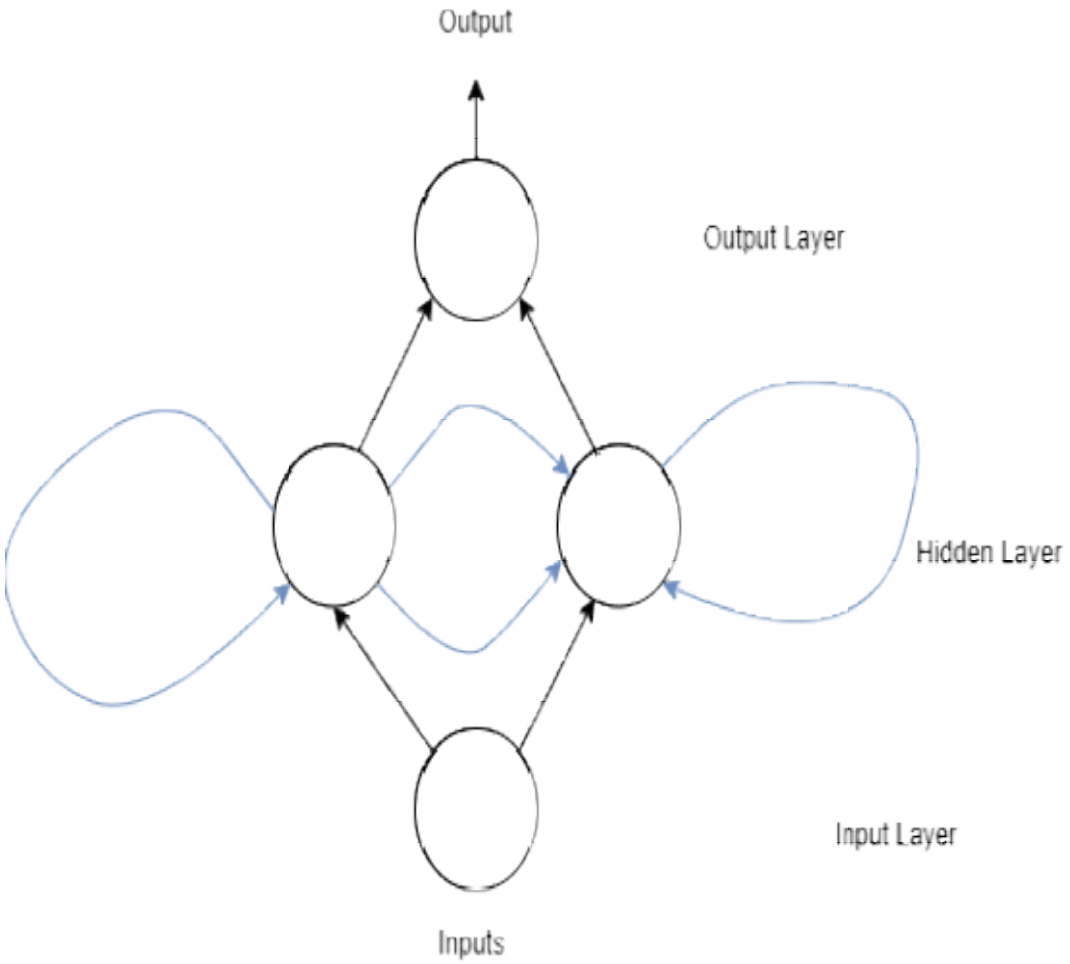

Fig. 5 A simple recurrent neural network

Limitations of RNN

To make a proper prediction, the RNN needs to remember this context. The relevant information may be separated from the point where it is needed, by a huge load of irrelevant data. This is where a Recurrent Neural Network fails.
The reason behind this is the problem of "Vanishing Gradient". In order to understand this, you'll need to have some knowledge about how a feed-forward neural network learns. We know that for a conventional feed-forward neural network, the weight updating that is applied on a particular layer is a multiple of the learning rate, the error term from the previous layer and the input to that layer. Thus, the error term for a particular layer is somewhere a product of all previous layers' errors. When dealing with activation functions like the sigmoid

function, the small values of its derivatives (occurring in the error function) gets multiplied multiple times as we move towards the starting layers. As a result of this, the gradient almost vanishes as we move towards the starting layers, and it becomes difficult to train these layers.
A similar case is observed in Recurrent Neural Networks. RNN remembers things for just small durations of time, i.e. if we need the information after a small time it may be reproducible, but once a lot of words are fed in, this information gets lost somewhere. This issue can be resolved by applying a slightly tweaked version of RNNs i.e. Long Short-Term Memory Networks.

3) Long Short Term Memory

LSTM is like improvised RNN. It was introduced in 1997 by Hochreiter and Schmidhuber [10]. It is a neural network with a hidden layer of recurrent edges. Each node in the hidden layer is however not ordinary, it is replaced by a "memory cell". "The memory cell contains a node with a self connected recurrent edge of weight 1, ensuring that the gradient can pass across many time steps without vanishing or exploding [11]". The idea of using "forget gate" was later added by Gers, Schmidhuber and Cummins in 2000 in [12]. This allowed the LSTM cell to reconfigure itself after learning and thereby releasing resources for later use.

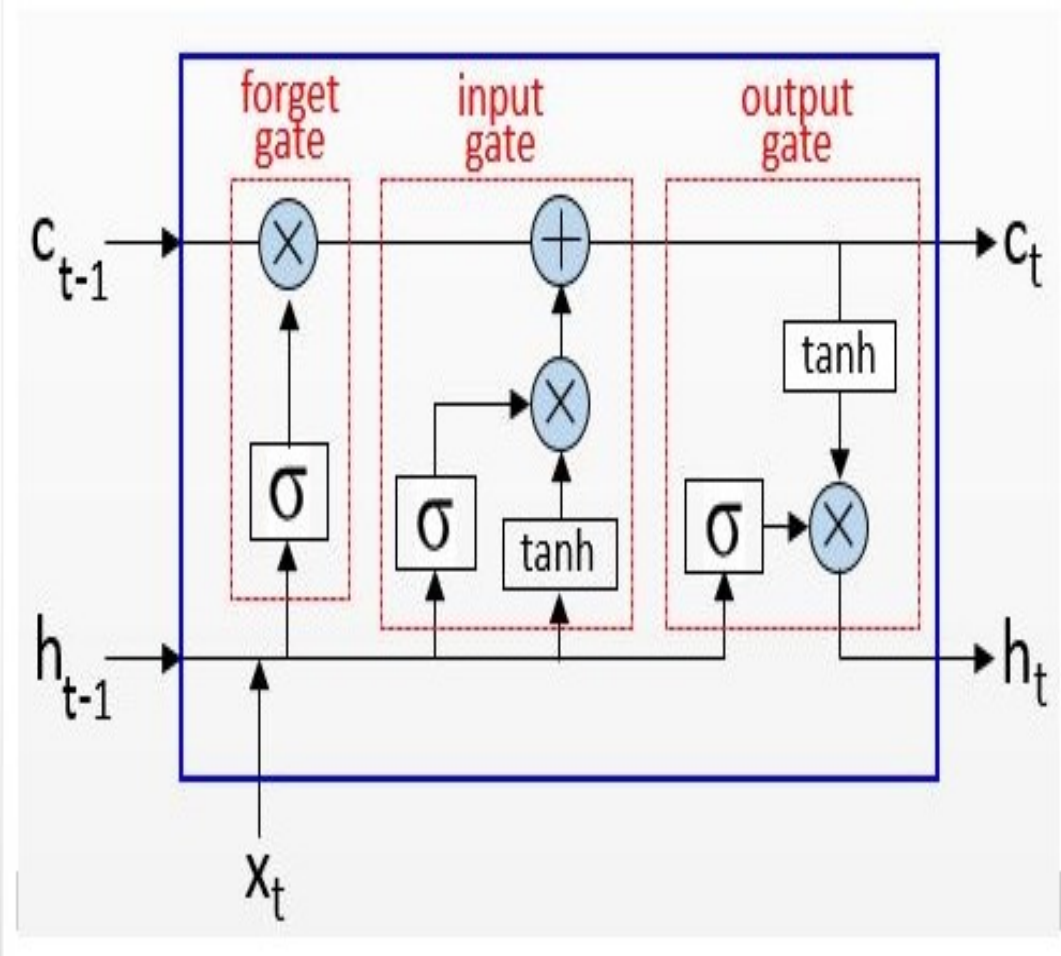

Fig. 6 LSTM Network with forget gate [13]

To understand more clearly an example of word prediction shall suffice. Suppose we need to predict a certain word based upon the input given but the text is very long, so we only carry forward the relevant word and we predict the next word based on that. But we might not need to forward it ahead and hence we may discard it and then again carry the next relevant word. So LSTM becomes very useful in more complex predictions as it smartly decides what to have for long term and what for short term.

LSTMs make small modifications to the information by multiplications and additions. With LSTMs, the information flows through a mechanism known as cell states. This way, LSTMs can selectively remember or forget things. The information at a particular cell state has three different dependencies.

We'll visualize this with an example. Let's take the example of predicting stock prices for a particular stock. The stock price of today will depend upon:

1.) The trend that the stock has been following in the previous days, maybe a downtrend or an uptrend.
2.) The price of the stock on the previous day, because many traders compare the stock's previous day price before buying it.
3.) The factors that can affect the price of the stock for today. This can be a new company policy that is being criticized widely, or a drop in the company's profit, or maybe an unexpected change in the senior leadership of the company.

These dependencies can be generalized to any problem as:

a) The previous cell state (i.e. the information that was present in the memory after the previous time step).
b) The previous hidden state (i.e. this is the same as the output of the previous cell).
c) The input at the current time step (i.e. the new information that is being fed in at that moment).

This is analogous to conveyor belts. Industries use them to move products around for different processes. LSTMs use this mechanism to move information around.

Architecture of LSTMs

The functioning of LSTM can be visualized by understanding the functioning of a news channel's team covering a murder story. Now, a news story is built around facts, evidence and statements of many people. Whenever a new event occurs you take any of the three steps.

Let's say, we were assuming that the murder was done by 'poisoning' the victim, but the autopsy report that just came in said that the cause of death was 'an impact on the head'. Being a part of this news team what do you do? You immediately forget the previous cause of death and all stories that were woven around this fact.

What, if an entirely new suspect is introduced into the picture. A person who had grudges with the victim and could be the murderer? You input this information into your news feed, right?
Now all these broken pieces of information cannot be served on mainstream media. So, after a certain time interval, you need to summarize this information and output the relevant things to your audience. Maybe in the form of "XYZ turns out to be the prime suspect".
Now let's get into the details of the architecture of LSTM network:
A typical LSTM network is comprised of different memory blocks called cells. There are two states that are being transferred to the next cell; the cell state and the hidden state. The memory blocks are responsible for remembering things and manipulations to this memory is done through three major mechanisms, called gates. Each of them is being discussed below:

i.) Forget Gate

Taking the example of a text prediction problem. Let's assume an LSTM is fed in, the following sentence:
Bob is a nice person. Dan on the other hand is evil.
As soon as the first full stop after "person" is encountered, the forget gate realizes that there may be a change of context in the next sentence. As a result of this, the subject of the sentence is forgotten and the place for the subject is vacated. And when we start speaking about "Dan" this position of the subject is allocated to "Dan". This process of forgetting the subject is brought about by the forget gate.
A forget gate is responsible for removing information from the cell state. The information that is no longer required for the LSTM to understand things or the information that is of less importance is removed via multiplication of a filter. This is required for optimizing the performance of the LSTM network.
This gate takes in two inputs; h_{t-1} and x_t.
h_{t-1} is the hidden state from the previous cell or the output of the previous cell and x_t is the input at that particular time step. The given inputs are multiplied by the weight matrices and a bias is added. Following this, the sigmoid function is applied to this value. The sigmoid function outputs a vector, with values ranging from 0 to 1, corresponding to each number in the cell state. Basically, the sigmoid function is responsible for deciding which values to keep and

which to discard. If a '0' is output for a particular value in the cell state, it means that the forget gate wants the cell state to forget that piece of information completely. Similarly, a '1' means that the forget gate wants to remember that entire piece of information. This vector output from the sigmoid function is multiplied to the cell state.

ii.) Input Gate

Okay, let's take another example where the LSTM is analyzing a sentence:

Bob knows swimming. He told me over the phone that he had served the navy for 4 long years.

Now the important information here is that "Bob" knows swimming and that he has served the Navy for four years. This can be added to the cell state, however, the fact that he told all this over the phone is a less important fact and can be ignored. This process of adding some new information can be done via the input gate.

The input gate is responsible for the addition of information to the cell state. This addition of information is basically three-step process.

Regulating what values need to be added to the cell state by involving a sigmoid function. This is basically very similar to the forget gate and acts as a filter for all the information from h_{t-1} and x_t.

Creating a vector containing all possible values that can be added (as perceived from h_{t-1} and x_t) to the cell state. This is done using the tanh function, which outputs values from -1 to +1.

Multiplying the value of the regulatory filter (the sigmoid gate) to the created vector (the tanh function) and then adding this useful information to the cell state via addition operation.

Once this three-step process is done with, we ensure that only that information is added to the cell state that is important and is not redundant.

iii.) Output Gate

Not all information that runs along the cell state, is fit for being output at a certain time. We'll visualize this with an example:

Bob fought single handedly with the enemy and died for his country. For his contributions brave _____

In this phrase, there could be a number of options for the empty space. But we know that the current input of 'brave', is an adjective that is used to describe a

noun. Thus, whatever word follows, has a strong tendency of being a noun. And thus, Bob could be an apt output. This job of selecting useful information from the current cell state and showing it out as an output is done via the output gate. The functioning of an output gate can again be broken down to three steps:

a) Creating a vector after applying tanh function to the cell state, thereby scaling the values to the range -1 to +1.
b) Making a filter using the values of h_{t-1} and x_t, such that it can regulate the values that need to be output from the vector created above. This filter again employs a sigmoid function.
c) Multiplying the value of this regulatory filter to the vector created in step 1, and sending it out as a output and also to the hidden state of the next cell.

The filter in the above example will make sure that it diminishes all other values but 'Bob'. Thus the filter needs to be built on the input and hidden state values and be applied on the cell state vector.

4.) Evolution Algorithm

Multiple explorations show that neural network model architecture and high performance hyper parameters may be auto generated by scalable evolution. A 2017 research [14] tried to discover image classification neural network via large scale evolution. It initiated with highly populated one layer models and then gradually evolving by discarding inferior models and creating newer models by combining parameters of a better model. With each iteration only 1 parameter was mutated and this advocated the use of high computation instead of human experts and led to decolonization of machine learning. It led the foundation of AutoML.

5.) Gated Recurrent Unit (GRU)

The GRU works on the lines of LSTM too. However it eases the architecture of memory cell. It only contains 2 gates that are the reset gate and update gate. The former decides what to forget when new information is passed while the latter manages the part of cell which has been already updated. There are many researches to show that LSTM performs better than GRU like [15] but GRU might work well on small dataset and it also requires lesser training time than LSTM as shown in [16].

CHAPTER 4
Design and Architecture

We also propose the usage of LSTM for stock prediction as we also believe in the efficacy of LSTM for complex prediction models.

Proposed Architecture:

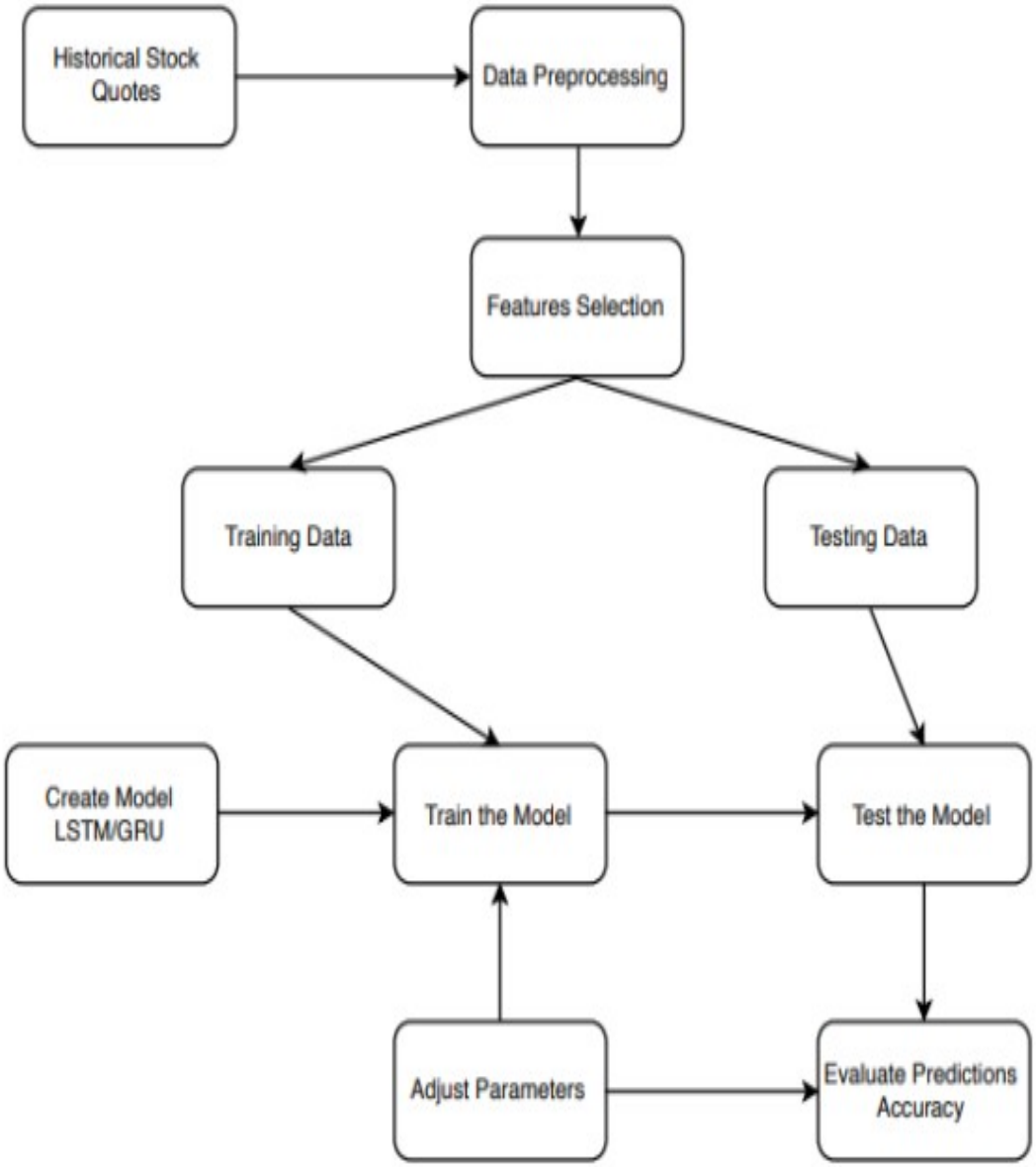

Fig.7 Proposed System Architecture

The general steps followed for the creation of the LSTM model are:

1. Importing the important features like Keras and Tensorflow and reading the concerned dataset.
2. Analyzing the closing prices of various stocks using the dataframe.
3. Sorting and filtering the dataset and then normalizing it.
4. Building and training the LSTM model.
5. Taking a sample dataset and predicting.
6. Visualizing predictions with the actual stock prices.

CHAPTER 5
Result

We assessed the stock price of Tata Global on the National Stock Exchange of India and the trend for 6 years from 2014 to 2019 is as shown in the image below:

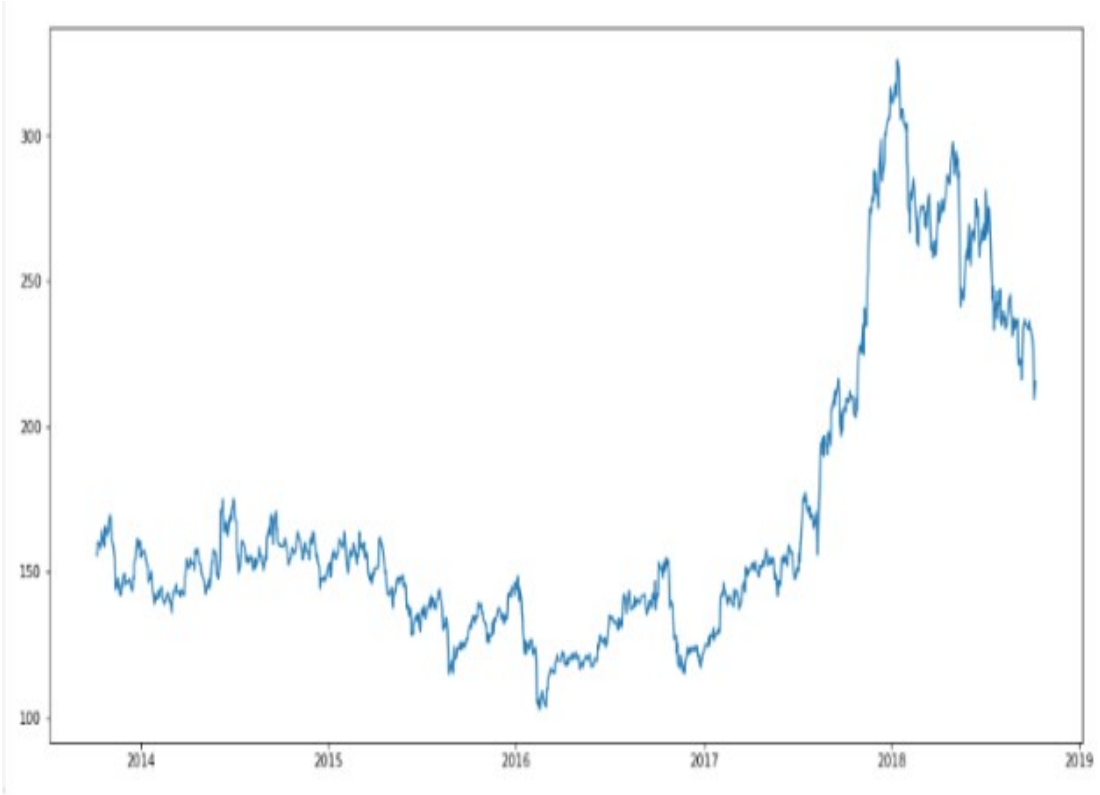

Fig. 8 6Y Trend of the selected stock

After sorting, filtering and normalizing the dataset we trained our model and then proceeded with creation of LSTM model. Around 80% of the dataset was used for training and the rest 20% was predicted by the model. The predicted value for the stock is shown in the image below where the blue and green lines represent the actual close value of the stock whereas the orange line shows the prediction by LSTM model.

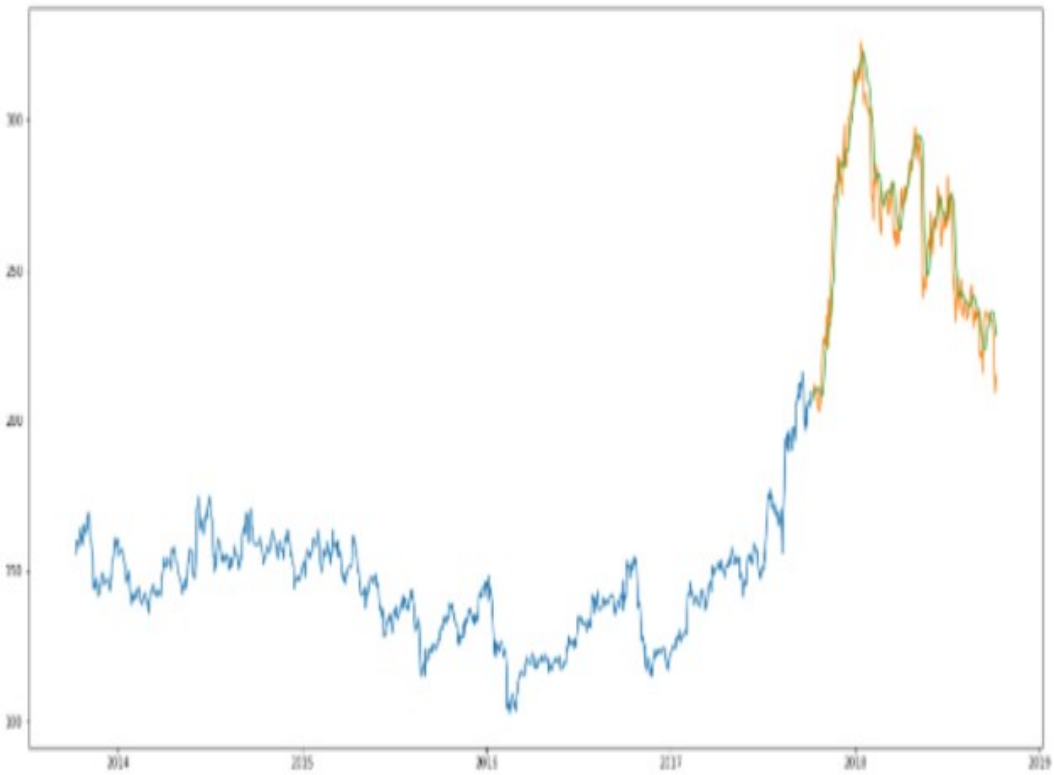

Fig.9 Price Prediction by LSTM

Fig.10 Price Prediction by LSTM (contd.)

To have an in-depth analysis of the situation in hand we used multiple visualizations and a dashboard created by Tableau.

The dual combination chart captures the underlying trend effectively.

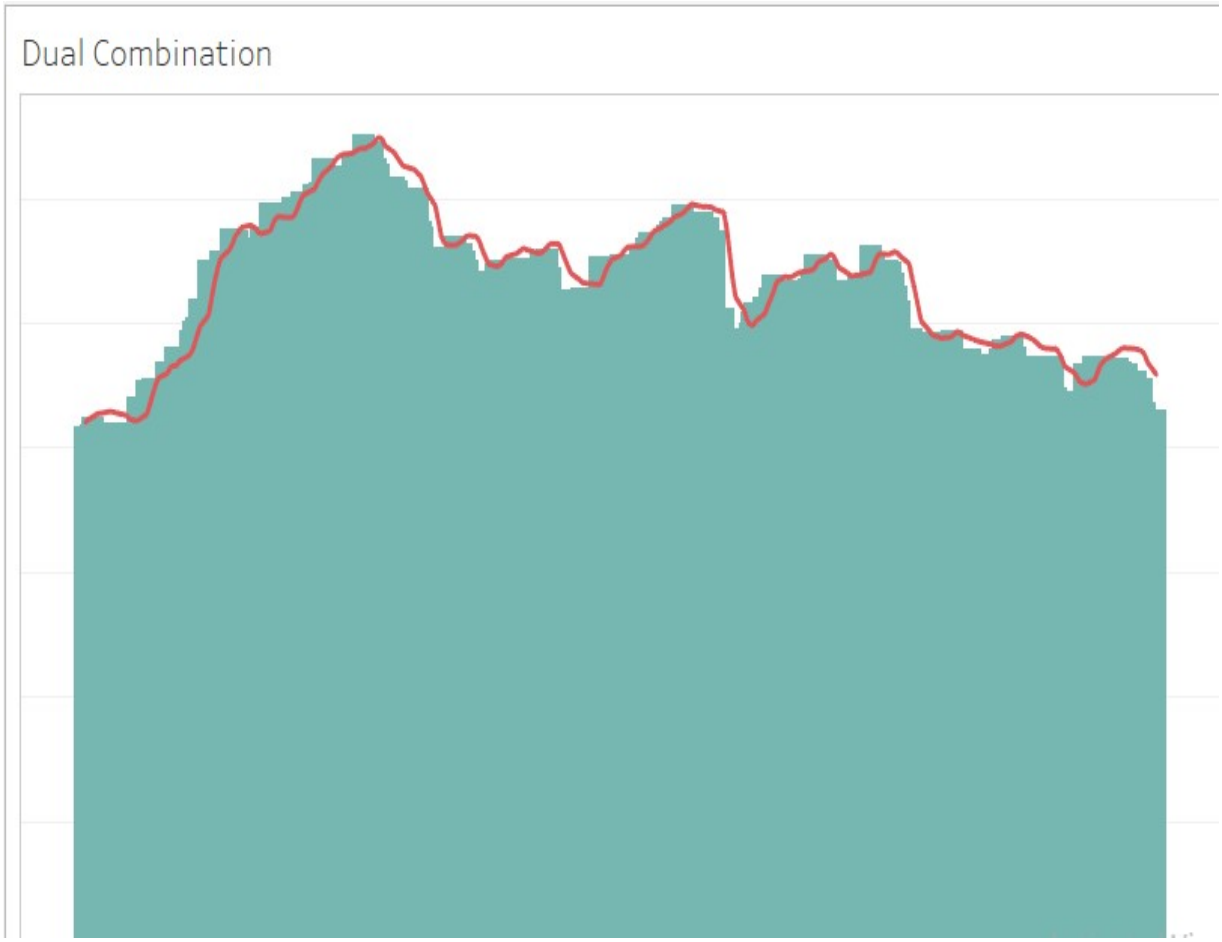

Fig. 11 Dual Combination

A comparison between stacked bars or side by side bars and dual bar charts can also be used to advocate the prediction trend efficacy.

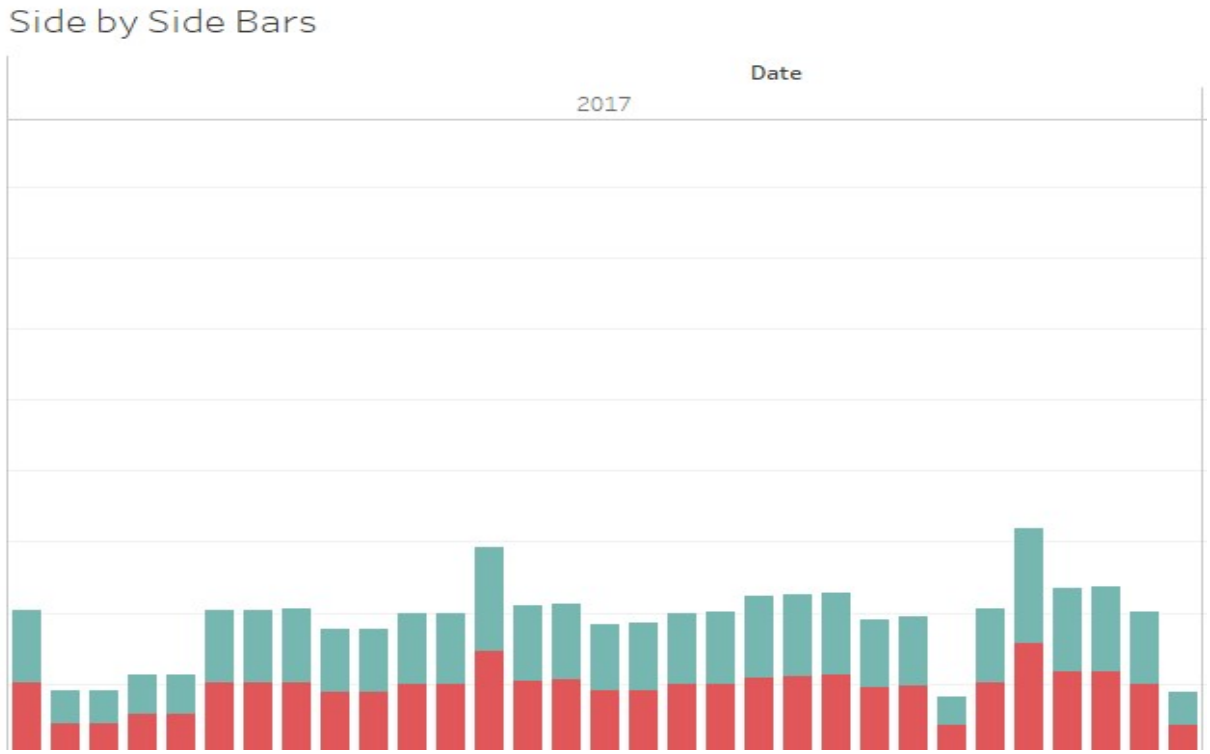

Fig. 12 Stacked Bars

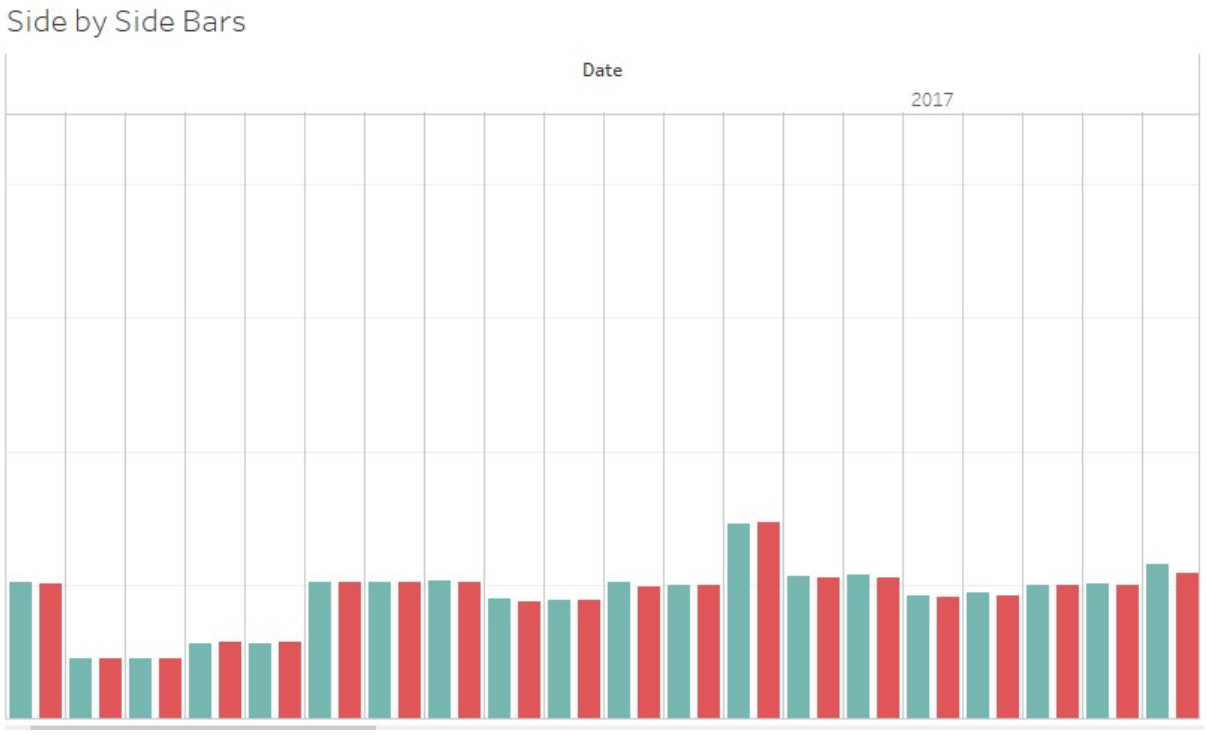

Fig. 13 Side By Side Bars

To address the shortcomings we needed the detailed view of where and by how much does the model is predicting wrong and hence the final chart where we created a calculated field in Tableau by using the difference in close and predicted values and then mapped them on a trend line to show exactly on which day by how much the model was accurate or inaccurate.

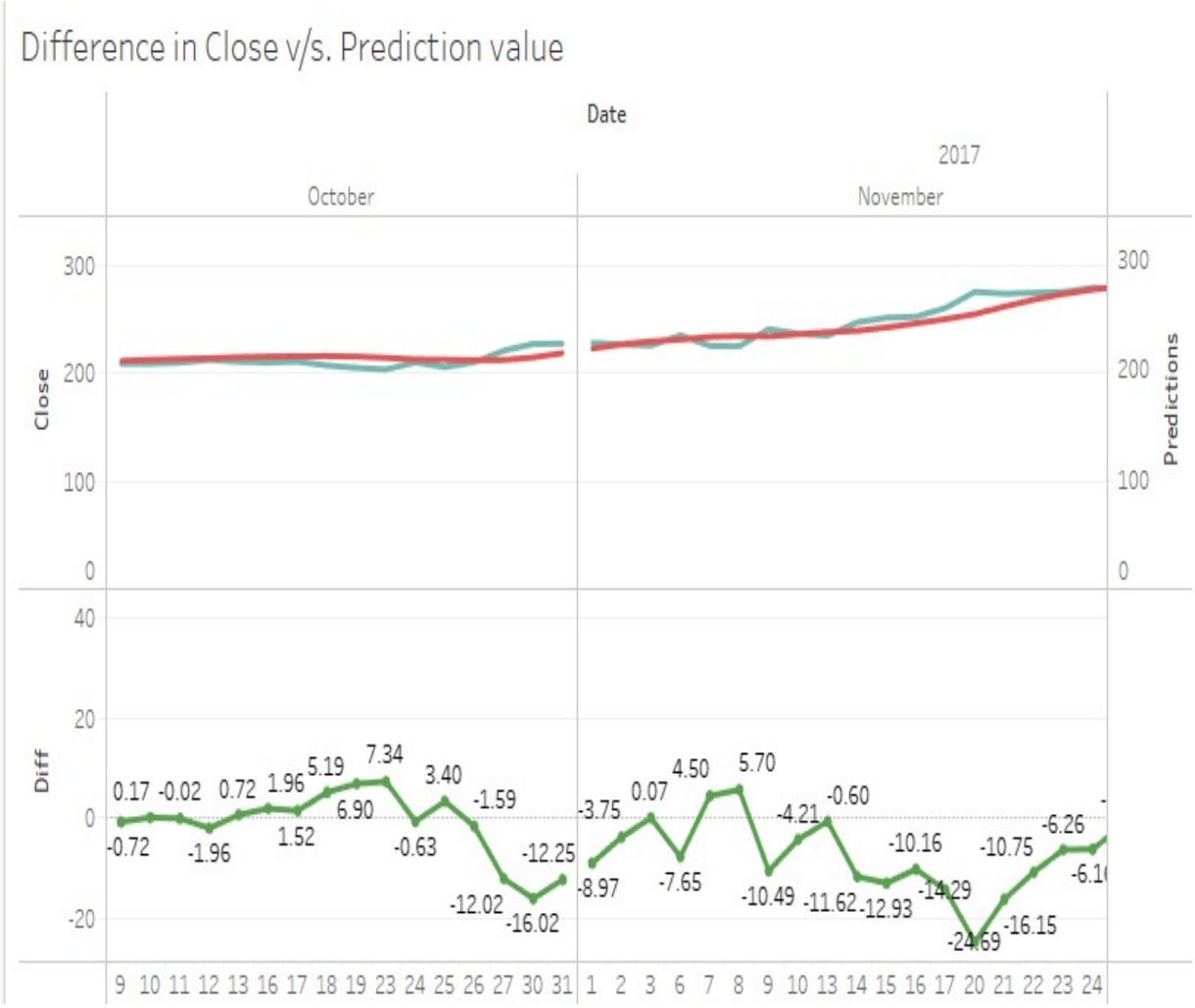

Fig. 14 Plotting the difference

Now while predicting stocks it is actually very difficult to predict exactly accurate values as they are highly volatile and generally do not follow any regular or common trend in the long term. Moreover they are always subject to risks and any major or minor event around the globe may seriously alter the trend throughout the world, hence they are highly susceptible to risks.

The final dashboard comprising of all the above mentioned charts is attached below. This dashboard can help in understanding the model with all its capabilities as well as some shortcomings and motivates us to build better models in future.

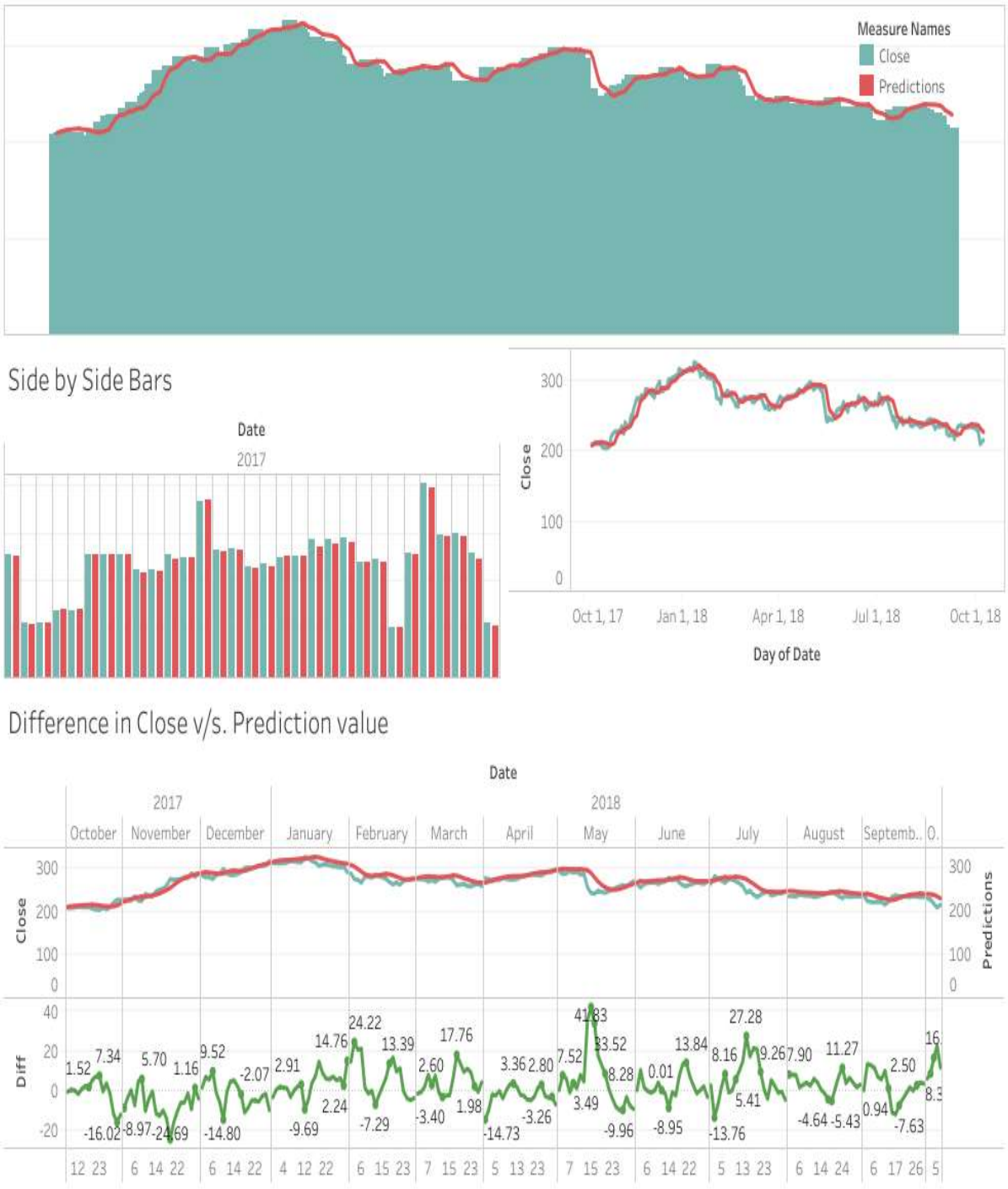

Fig. 15 Dashboard

CHAPTER 6
Merits and Future Scope

The merits of the using LSTM are discussed below:

1.) The LSTM is capable of capturing the patterns of both long term trends such as a yearly pattern and short term trends such as weekly patterns.
2.) The LSTM has the ability to triage the impact patterns from different categories of events.
3.) The LSTM could take inputs with different lengths. This feature is especially useful when LSTM is used to build general forecasting models for specific customers or industries.
4.) The different gates inside LSTM boost its capability for capturing non linear relationships for forecasting.
5.) The ability of LSTM to smartly store or discard data makes it very adaptable in a continuously changing scenario.

Since we know that LSTM is better in performance than several other algorithms as discussed in [3] an [15], it is safe to say that while forecasting the underlying trend in stock prices LSTM is one of the best choices. The model created above has also affirmed this as the predicted trend is really close to the actual one. This makes LSTM a strong candidate among others.

The future scope of the project lies in :

1.) A dashboard using Plotly dash for generating insights from multiple stock price datasets which will help the public in assessing the price and making informed decisions rather than luck based or other arbitrary decisions.
2.) A mobile application may also be created in the future to give a prediction line to the user right in their hands.
3.) Trying other algorithms and methods to further lower the RMSE value and improve the accuracy.

Acknowledgement

We would like to express special thanks to our project guide Dr. A Daniel for motivating us and continuously guiding us towards the completion of this project. We owe this great opportunity to work on the project to Galgotias University. Our reviewer Dr. Sunil Kumar for throughout evaluation of our work and navigating us with proper steering from mistakes during the course of project is also to be highly appreciated. All the researchers and authors who have already done commendable work in this field and provided generous knowledge to others are also to be thanked. The open source world of knowledge for programming, documentation and text formatting is a prestigious gift for all and the various websites and tools like “Wikipedia”, “YouTube” etc. are a boon to everyone involved in the era of computers and machine learning. There are endless of tutors and freelancers who have made available a vast array of information to us. In the end we extend gratitude to our friends, colleagues and parents with whose support this project was spun into reality.

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Acceptance and Payment Proofs

The paper is accepted for presentation in the 4th IEEE International Conference on Advances in Computing, Communication Control and Networking (ICAC3N–22) which is going to be held on 16th -17th December 2022 at Galgotias College of Engineering and Technology, Greater Noida.

Acceptance Notification 4th IEEE ICAC3N-22 & Registration: Paper ID 80 External Inbox x

Microsoft CMT <email@msr-cmt.org> Thu, May 5, 11:49 PM (5 days ago)

to me

Dear Author,

Greetings from Galgotias College of Engineering and Technology!!!

On behalf of the 4th ICAC3N-22 Program Committee, I am delighted to inform you that the submission of "Paper ID- 80 " titled " A Study of LSTM in Stock Price Prediction " has been accepted for presentation at the ICAC3N- 22 and will be sent for the submission in the conference proceedings to be published by the IEEE.

Please complete your registration by clicking on the following Link: https://forms.gle/8acy23i3UbtwLkFXA on or before 20 May 2022.

Note:
1. Final camera ready copy must be strictly in IEEE format.
2. Minimum paper length should be 5 pages.
3. If plagiarism is found at any stage in your accepted paper, the registration will be cancelled and paper will be rejected and the authors will be responsible for any consequences.
4. Registration fee once paid will be non refundable.

Regards:
Organizing committee
ICAC3N - 22

Activate Windows

Fig. 16 Paper Acceptance Mail

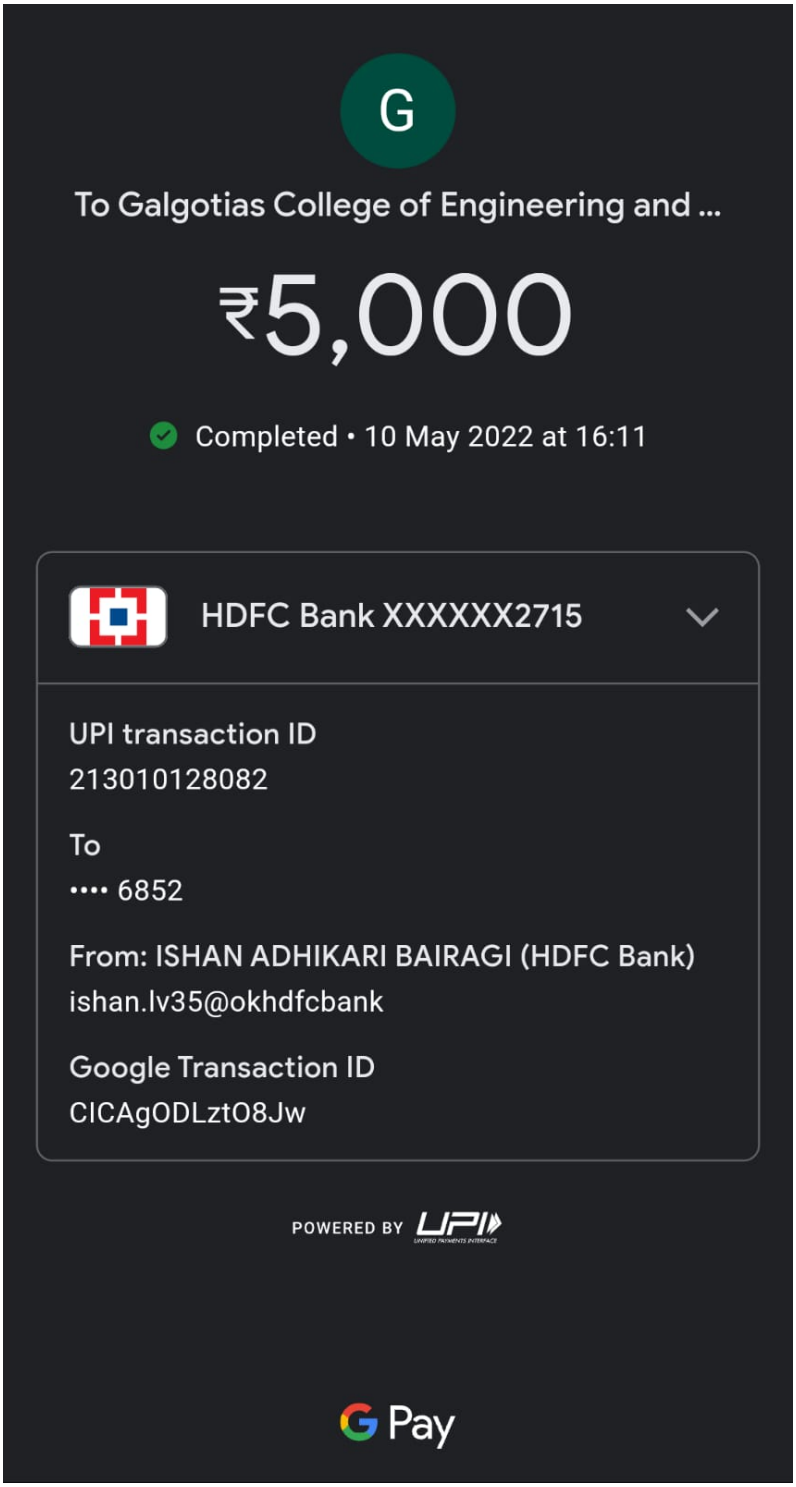
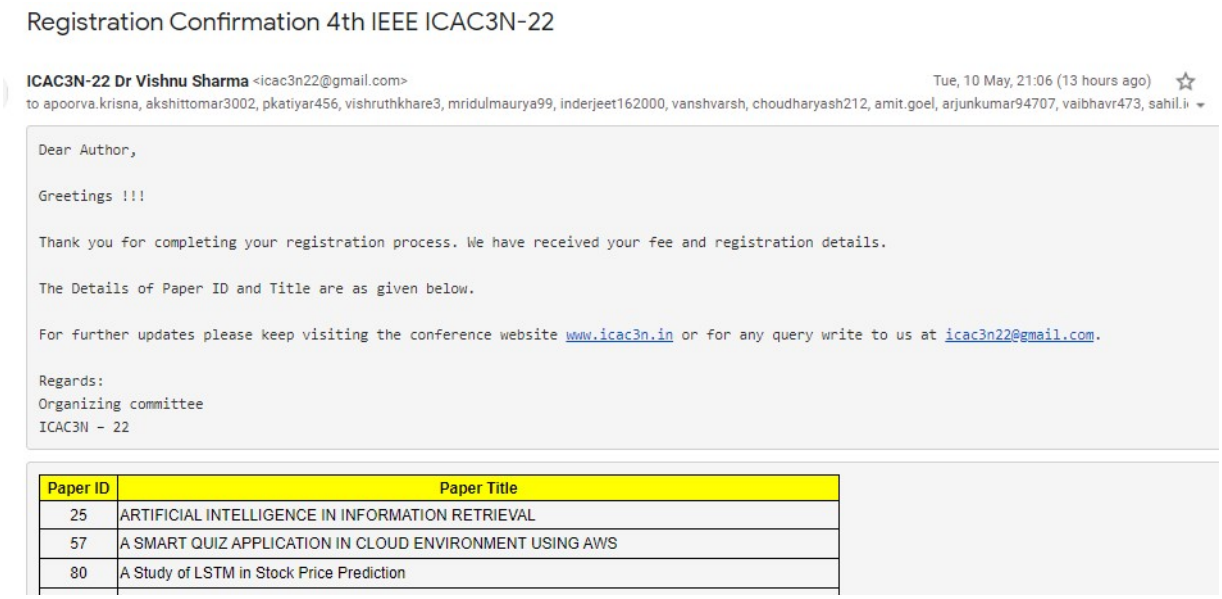


Fig. 17 Payment Receipt



Registration Confirmation 4th IEEE ICAC3N-22

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Paper ID	Paper Title
25	ARTIFICIAL INTELLIGENCE IN INFORMATION RETRIEVAL
57	A SMART QUIZ APPLICATION IN CLOUD ENVIRONMENT USING AWS
80	A Study of LSTM in Stock Price Prediction

Fig. 18 Registration and Payment Confirmation