2021 5th International Conference on Information Systems and Computer Networks (ISCON)
GLA University, Mathura, India. Oct 22-23, 2021

A Hybrid Model for Stock Price Prediction using Machine Learning Techniques with CNN

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2021 5th International Conference on Information Systems and Computer Networks (ISCON) | 978-1-6654-0341-2/21/$31.00 ©2021 IEEE | DOI: 10.1109/ISCON52037.2021.9702382

***Abstract*— Predicting the stock market can be a great tool for both long-term and short-term investors to plan and book profits, or to stop losses earlier. Forecasting accuracy is the most crucial factor to consider when choosing a forecasting method. In order to forecast stock markets, we used one of the most common recurrent neural networks: LSTM, along with it, Convolutional Neural Network (CNN) is also used. Since the prediction of stocks cannot be easily specified, it can be separated into two parts: simple analysis (sales, revenue, income, etc.) and technical analysis (historical price, VWAP, etc.). This means multiple variables can affect stock price trends, but here we have drawn a predictive time series on the historic price of a given stock. LSTM can quickly process a whole data series and adds a memory cell, which allows the network to link memories and feedback remotely efficiently. In this example we have generated a series of sequences in order to use time steps to predict a given price.**

Keywords*— *stock market, LSTM, price prediction, algo-trading

I. INTRODUCTION

The stock exchange is a set of marketplaces and exchanges where regular transactions such as buying, selling, and issuing of publicly traded company shares take place. These financial transactions are carried out through either formal exchanges or over-the-counter markets that follow a set of rules.The general aim of stocks is to increase earnings by buying stocks of companies that are expected to earn profit, and stock prices are regulated by demand and supply principles.The stock market is closely linked to the economy—some key performance indicators (KPIs) relies heavily on the increase in and fall in equity prices.A well-informed price estimation may, however, be made. In isolation stock prices seldom vary: action of one continues to affect a variety of other stocks. This feature of the flow of stock prices can be seen as a primary way of forecasting multiple stock prices at once. Because of the sheer amount and quantity of transactions that occur per minute, the preciseness and frequency of forecasts come into play; for instance, most stock prediction systems are delivered in a parallel manner. There are some problems and obstacles in the valuation of stocks.

TABLE I. KEY PERFORMANCE INDICATORS (KPI'S)

Indicator Name	Indicator Description
Open	The stock's opening price.
Close	The stock's end-of-day closing price.
Low	This is the stock's lowest intra-day price.
High	The stock's highest intra-day price
Volume	The total number of stocks traded during the trading session

II. LITERATURE REVIEW

A. Stock Price Prediction Using Long Short Term Memory

In this paper [7], to forecast their stock price at the conclusion of the day, a stock price prediction model using LSTM was developed and tested with 1 small-cap, 2 medium-cap, and 2 large-cap firms.The system's downside is that it can only anticipate the stock price at the end of the day, not for the entire week.

B. NSE Stock Market Prediction Using Deep-Learning Models

In this paper [4], ANN has mainly been used to forecast stock prices.They've used two different markets NSE and NYSE to test their model. MARUTI, HCL, AXIS BANK has been chosen to test the algorithm from NSE and Chesapak Energy (CHK) and Bank of America (BAC) have been chosen to test their algorithm from NYSE. The model discussed in the paper has worked properly for these stocks but in certain cases, other models like CNN have outperformed the chosen model. So, a hybrid model is not taken into account in this paper.

C. The Application of Stock Index Price Prediction with Neural Network

In this paper [9], To model the stock price forecast of market indices, various techniques such as Multi-Layer Perceptron (MLP), Long Short Term Memory (LSTM), and Convolutional Neural Network (CNN) have been used.Three

indices namely S&P 500, NIKKEI 225, and CSI 300 have been chosen and the closing prices of these indices haven been predicted. The model used in this paper has been very less accurate to less developed financial markets such as CSI 300. Also, their model uses as time step 20 which will take a long time if it is to be predicted for a longer interval.

D. Stock Price Prediction Using Artificial Neural Networks

In this paper [8], the prediction has been done only for a single company INFRATEL using the past 400 days intraday closing price. Past 60 days data has been used for training LSTM and ANN models whereas 400 days data is used for training ARIMA and using neural networks. From the results, it's been concluded that ANN models have been more efficient in predicting the stock price. The drawback of this system is that the price prediction for cumulative days is not done here.

E. Multi Step Prediction Using Walk Forward Validation

The models are tested following an approach known as multi-step prediction using a walk-forward validation [2, 3]. This method uses the training data for constructing its models. The algorithms are then used to forecast stock prices for the next week's daily open values. It incorporates the real stock price records of the week in the training dataset after every 7 days. The open values are projected with a prediction horizon of 5 days using this expanded training dataset, thus the forecast for the days in the following week is accessible. The model is based on an LSTM network, which scrapes the web and extracts historical stock prices based on a stock's ticker name for a defined set of start and finish dates, as well as forecasting future stock values. [1]

III. STOCK PRICE PREDICTION MODEL

A. Algorithm

Input: Historical stock price data from yahoo finance API

Output: Prediction Graph for stock prices based on stock price variation

1. Start
2. Stock data is taken from the Yahoo Finance API as a CSV file.
3. The csv file is then called by pandas data-reader.
4. The data is split into testing set and training set.
5. LSTM and CNN neural network structure is built.
6. Run the data via the built network.(Training Process)
7. Use the final layer's performance as a predictor for the next time step.
8. Repeat steps 6 and 7 before you achieve optimum convergence.
9. Use test data as input to the network to get predictions.
10. Evaluate forecasts made with real data to determine accuracy and loss. Predict the price of a stock for the next five days.
11. Send the result data to front-end to display the graph.
12. End.

Dataset is taken from the Yahoo Finance API when the user enters the symbol of the company. The data set contains information on the company's stock such as past closures, opens, high, low and the volume traded. From these datasets, we collect just 65% of the data. These data are used for model training. This educated data collection will be used to forecast the company's next five days stock price. The stock's closing price is preferred so investors would choose to buy only with the stock's closing price. Figure 1 depicts the overall operation of the stock prediction model as well as user engagement with the model through the proposed web application.

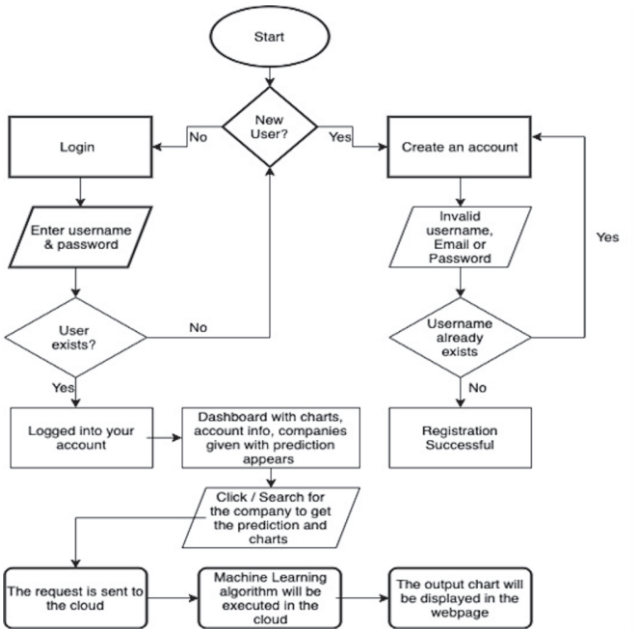

Fig. 1. Overall working of Stock Prediction model via the web-app

B. LSTM – Overview

LSTM networks are a type of recurrent neural network that is capable of learning order dependency in sequence prediction challenges.

Each LSTM neuron is a memory cell capable of storing additional bits of data. An LSTM neuron outputs its new cell state after taking its old cell state, while neurons in ordinary RNNs actually enter the hidden condition of the former and use the current input to produce a new hidden condition.The following three components or gates are provided in an LSTM memory cell as seen in Figure 2.

1. **Forget Gate:** The forget gate decides whether to substitute more recent knowledge on particular portions of the cell state. It returns values that are close to 1 for areas of the cell state that should be retained and zero for values that should be ignored.
2. **Input Gate:**This component of the network defines the criteria under which information in the cell state should be saved (or updated) based on an input (i.e. prior output of o(t-1), input x(t), and prior cell state c(t-1).

3. **Output Gate:**Depending on the input and cell state (i.e. output o(t) and cell status c(t), the information chosen is sent on to the next node in the network.

As a result, Long Short Term Memory networks are particularly adapted to exploring how price changes in one stock might affect the prices of several other stocks over time.They will also determine (in a sophisticated way) how long knowledge on some historical patterns in stock prices must be stored, to help forecast possible trends in stock price variations.

An RNN can be thought of as the addition of loops to a typical feedforward MLP network architecture. The recurrent connections give the network state or memory, allowing it to understand and harness the orderlystructure of inputsequences.

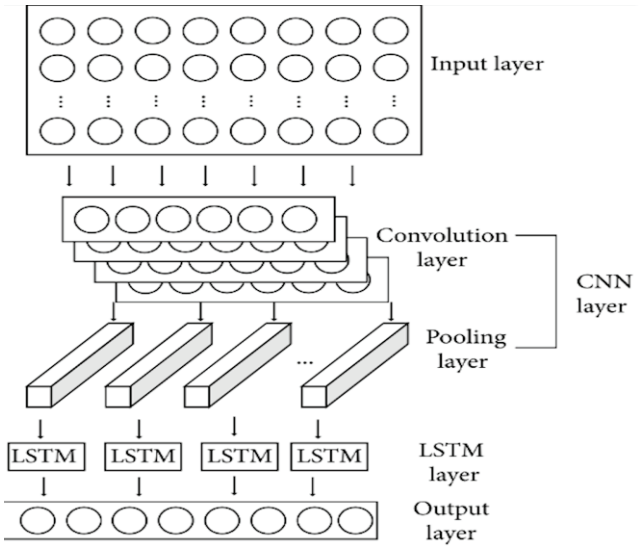

Fig. 2. An LSTM memory cell [5]

C. CNN – Overview

The CNN (Convolutional Neural Network) is a Deep Learning technique that is similar to normal Neural Networks but contains neurons with learnable weights and biases, which will take the input representation, add meaning (learnable weights and bias) to various aspects/objects in the dataset, and be able to distinguish between them. When compared to other classification algorithms, the CNN needs less pre-processing. Though filters are hand-engineered in traditional ways, CNN has the ability to take these filters/characteristics with proper education. Each core layer contains a few convolution kernels, the formula for which is listed below. The knowledge features are retrieved after convolution of the convolution sheet, but the retrieved features are extremely large. After the convolution layer, a pooling layer is applied to resize the function measurements, which solves the above issue and reduces the importance of network coaching:

$$l_t=\tanh (x_t * k_t + b_t) \qquad [6]$$

$\mathbf{l_t}$after-convolution output performance

tanh activation function

$\mathbf{x_t}$ input vector

$\mathbf{k_t}$the convolutional kernel's weight

$\mathbf{b_t}$ bias of the convolutional kernel

D. CNN – LSTM – Overview

CNN is widely used in feature engineering because of its ability to perceive visible characteristics in the sight line. The expansion function of LSTM is similar to that of a time series, which is widely found in statistics. The features of CNN and LSTM are combined to create a portfolio forecasting model supported by CNN-LSTM.The structure diagram is presented in Figure 2 and thus CNN and LSTM are the principal structures plus an input layer, a 1-dimensional convolution layer.

E. Obtaining Dataset and Pre-processing

The stock data CSV file for various companies are fetched from Yahoo Finance API. From the received dataset, we collect the following data:

1. The date of each company stock price.
2. The opening price of the stock of that particular company.
3. High-KPI: The highest intra-day price is shown by the High-key performance indicator.
4. Low-KPI: The lowest intra-day price is shown by the Low-key performance indicator.
5. Volume-KPI: Volume is the key performance statistic that represents the number of shares or contracts acquired and traded in the market on a particular day.
6. Open: The count of futures securities that are currently outperforming in the stock market is represented by the Open Interestkey performance indicator.

The retrieved dataset was then converted into a NumPy array that could be used for the prediction model by following the steps below:

1. MinMax Scalar is used to set the (feature_range= (0,1))
2. Reshape the data to the [-1, +1] range.
3. df=scaler.fit_transform (np. array(df). reshape (-1,1))
4. The time-series dataset is split into input and output parts for self-supervised learning, with sixty five percent of the data used to train the algorithm and thirty five percent used to test the model.
5. Setting the time_step to 100.
6. We built the X train, y train, and X test and y test datasets based on the time step parameter.

F. Construction of Prediction Model

The training and testing datasets are generated from the input dataset which is extracted from the Yahoo Finance API. After that, the LSTM and CNN models would be used to match the training dataset. The accuracy is assessed over the test dataset in the below mentioned manner. The CNN and LSTM (Figure 3) networks are comprised of three input layers with fifty neurons and an output layer. After the model

has been fitted, the tuning of hyper parameters will be begun. We may change back to the original form through the scaler.inverse transformation (rescaling).

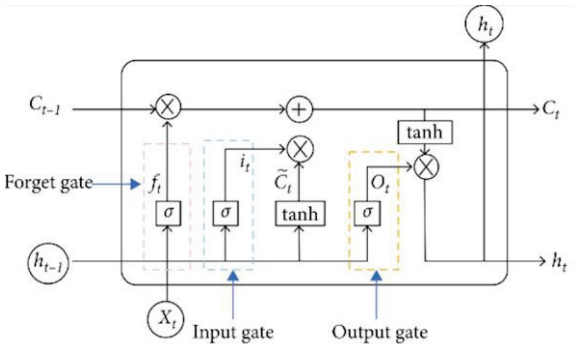

Fig. 3. CNN-LSTM structure for stock price prediction [5]

IV. Buy and Sell Signals

When an investor decides to buy or sell a particular stock, he must get the best price. To achieve that, our web-application provides buy and sell signals using Moving Averages for all stocks in the Indian Stock Exchange. We construct a simple moving average window for 10 days and 60 days. We signal a buy when the 10-day moving average exceeds the 60-day moving average. We signal a sell signal when the 60-day moving average exceeds the 10-day moving average.This strategy is followed by traders all over the world. However, the moving average window may vary from trader to trader according to their strategy.

Fig. 4. Buy and sell signals for Vodafone Idea Limited in NSE

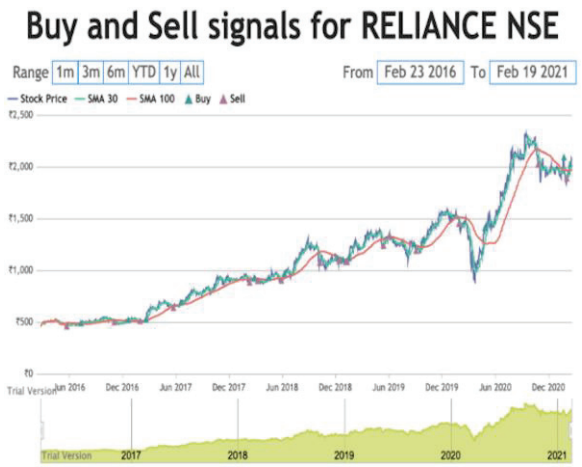

Fig. 5. Buy and sell signals for Reliance Industries in NSE

V. Prediction Results

The below figure (Figure 6) shows the previous closing prices of Reliance Industries (ticker: RELIANCE) listed on NSE India. The red line shows the predicted closing price for the same for the upcoming ten days.

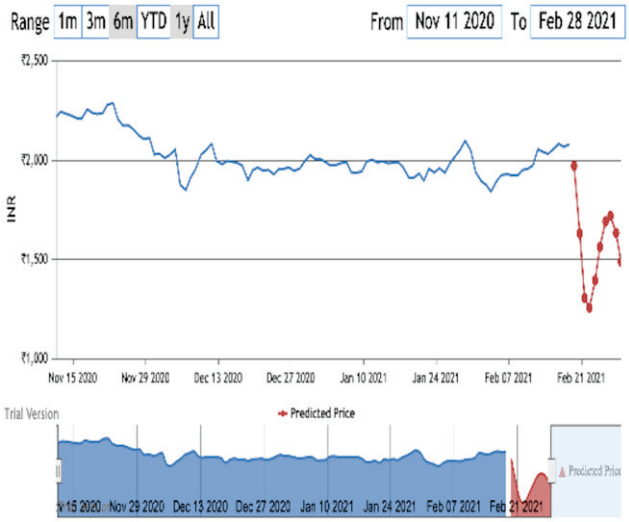

Fig. 6. Predicted closing price of Reliance Industries in NSE for the next ten days

The below figure (Figure 7) shows the previous closing prices of Vodafone Idea Limited (ticker: IDEA) listed on NSE India. The red dots show the predicted closing price for the same for the upcoming three days.

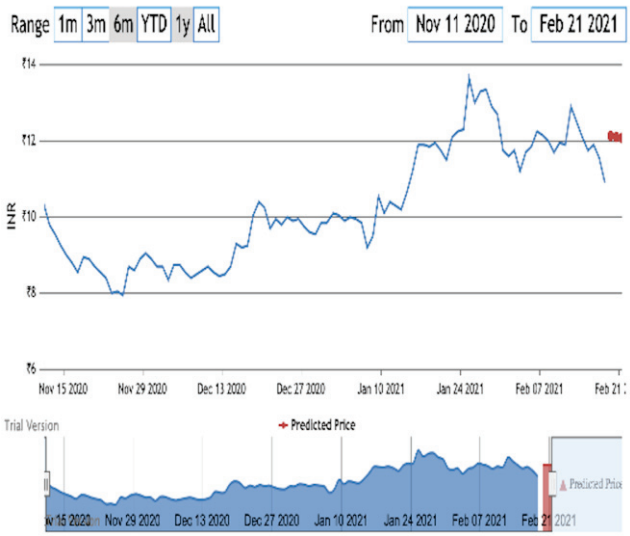

Fig. 7. Predicted closing price of Vodafone Idea Limited in NSE for the nect three days

VI. Comparison with other models

We've compared our hybrid LSTM-CNN hybrid model with standalone CNN and LSTM models for Vodafone Idea Limited and Reliance Industries in NSE. The results are shown below.

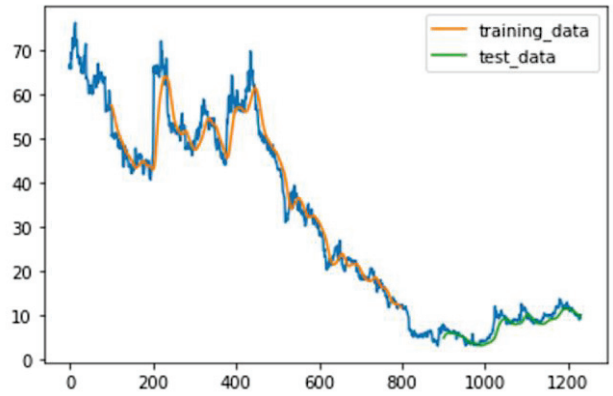

Fig. 8. Results obtained for Vodafone Idea Limited using CNN only

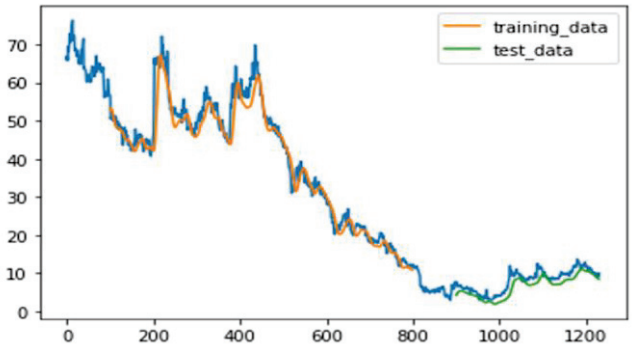

Fig. 9. Results obtained for Vodafone Idea Limited using LSTM only

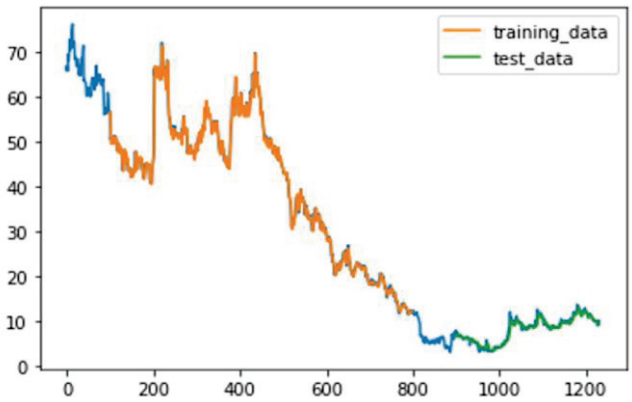

Fig. 10. Results obtained for Vodafone Idea Limited using CNN-LSTM hybrid model

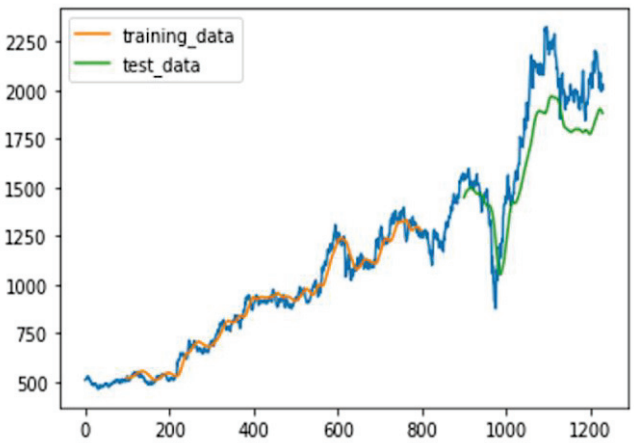

Fig. 11. Results obtained for Reliance Industries using CNN only

Fig. 12. Results obtained for Reliance Industries using LSTM only

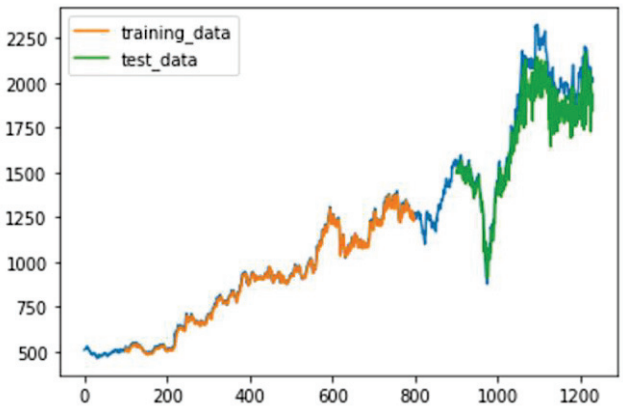

Fig. 13. Results obtained for Reliance Industries using CNN-LSTM hybrid model

As seen in the results, CNN-LSTM has the highest output of the three processes.The forecasts and R2 for CNN-LSTM were 0.90, respectively, increased by 2.8%, 0.55%, relative to the other two approaches.

The above results shows that forecasting performance of LSTM can be improved by data extraction by using CNN. This model predicted the closing price of the stocks to provide a reference for the investor.

VII. Conclusion and Future Work

We've discussed about using LSTM and RNN to construct a stock price prediction model in this paper.This has overcome the drawback mentioned in the paper "Stock Price Prediction Using LSTM" [7] in the literature review. Price prediction has been done for 5 stocks listed in the Indian Stock Exchange out of which 2 are penny stocks and 3 are stable stocks. Algorithmic Trading has been demonstrated using Moving Averages, which is a key Technical Indicator used by professional traders. These features integrated into a web-application will help new investors and traders take the right decisions. However, the price prediction of stocks discussed in this paper does not take into account the effects caused by external factors such as news, financial events, press releases done by the company as they can drive the price of a stock drastically. This can be accomplished in the future by including a news aggregator that fetches news about a certain stock and determines whether the news is positive or negative using sentiment analysis, the Random Forest Algorithm, and taking false-negative, false-positive, true-negative, and true-positive

characteristics into consideration and including those results in market prediction.

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