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An Analysis of GRU-LSTM Hybrid Deep Learning Models for Stock Price Prediction

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ABSTRACT

Investment and national policy researchers are studying stock price forecasting, which has proven to be a challenging problem given the multi-noise, nonlinearity, high-frequency, and chaotic nature of stocks. Most forecasting models will not be successful in mining actual data from stocks if these characteristics are present. Stock pricing data has the characteristics of time series. It is evident from different studies that deep learning models perform better than machine learning models on time series data in particular. So, in this paper, we will focus on Long Short Term Memory (LSTM), Gated Recurrent Unit (GRU), and a hybrid model of them to predict the price of HDFCBANK stock. The first hidden layer is GRU and the other three hidden layers of LSTM. A hybrid model is validated using MSE, RMSE, and MAE and it outperforms all other models.

Keywords: Stock Prediction, LSTM, GRU, Deep Learning, Neural Networks, Hybrid Models, Prediction, Stock, Time Series, Machine Learning

I. INTRODUCTION

Taking a future view of the value of a stock is a notoriously difficult task. The economics theory 'The Efficient Market Hypothesis' holds that the current stock price already incorporates all publicly available information. Due to this predicting future price without additional information should be impossible. However, the existing financial markets may not be perfect and deep learning might provide insight into a hidden pattern. This paper investigates how various neural network architectures perform in forecasting the future value of the HDFCBANK stock.

For time series prediction, most systems nowadays use different implementations of RNN (Recurrent Neural Network), which has the ability to remember every information through time and to improve prediction ability by using inputs from the past. LSTM has the greatest accuracy and success in time series prediction, closely followed by GRU . GRU is a revised version of LSTM, but the processing procedure is relatively the same. As GRU uses fewer parameters, it uses less

memory, making it faster than LSTM. In spite of LSTM's time-consuming nature, it is more accurate since it uses longer sequences. Due to this, we developed a hybrid neural network by combining the power of two of the most promising neural networks.

In this study, the main objective is to demonstrate how two of the most powerful time-series analyzers, Gated Recurrent Unit (GRU) and Long Short Term Memory (LSTM), can be combined to predict HDFCBANK stock price. In order to achieve this aim, we developed a hybrid model using GRU at the front layer and LSTM at the back. The model was used to predict the HDFCBANK stock price. The prediction of the stock price has been studied in many ways in past, but still, researchers are trying to develop new models to predict the market's nature. In finance, there are many machine learning and deep learning approaches used. However, traders are always striving to outperform the market by using new techniques. Due to their uniqueness, novel approaches gain more importance as they help traders to fulfill their needs in a unique way. We present our paper as follows. In Section 2, we discuss the current literature. In Section 2, we briefly discuss the GRU and LSTM model, in Section 3, we describe our proposed model. In Section 5, we present the results of our hybrid model. And in Section 6, the paper is concluded.

II. LITERATURE REVIEW

Stock market predictions have been made with a number of different techniques in recent years. There was a wide array of methods are tested, the majority of them using machine learning and deep learning techniques. Some of these are models that only use one processing technique, whereas other investigators combined more than one technique.

A hybrid model based on CNN and LSTM was developed by Wenjie Lu, Jiazheng Li, Yifan Li, Aijun Sun, and Jingyang Wang in 2020 to predict the stock price and it concludes CNN-LSTM performs far better than other models [1]. In 2021, Srilakshmi K and Sai SC developed an LSTM-CNN hybrid model to predict TCS stock price [9]. Mundra and Ankit al, have examined time-series data to see how stock price can be predicted by historical variations in prices [2]. A hybrid approach is proposed to improve prediction accuracy, which is based on the concept of support vector machine (SVM) and Long Short Term Memory (LSTM) because these models have better performance in time-series problems [2].

In 2020 Lobana N, Ifeanyi E.O, Muhammad S, Fakhri K, and Kumaraswamy P examined Deep Neural Network (DNN) and Long Short Term Memory (LSTM) for stock price prediction and concluded that LSTM outperforms DNN [5]. M.S. Islam and E. Hossain developed GRU-LSTM neural network to predict the foreign exchange rate, and the result was far better compared to other models [14].

III.MODELS

A. Long Short Term Memory (LSTM)

An LSTM network was developed to solve the vanishing gradient problem in the standard RNN by improving gradient flow within the network. This was achieved by replacing the hidden layer with an LSTM unit. LSTM unit is composed of a cell state, forget gate, input gate, and output gate. The cell state represents the memory of the network, due to the information it carries along with it along the entire sequence. The forget gate decides what should be kept from the previous time steps. Adding relevant information from the current time step is determined by the input gate. At the current time step, the output gate determines the output value. LSTM cells are connected in a similar way as RNNs, the input vector is connected to LSTM at time t by a weight matrix, the LSTM calls at time t-1 and t + 1 are connected to the LSTM by another weight matrix and the LSTM cell is connected to the output vector of time t by a weight matrix W.

Thus, LSTM can help solve the vanishing gradient problem by recovering data that has been transferred in memory. LSTM can be used to classify process, and predict time-series with unknown duration.

B. Gated Recurrent Unit (GRU)

Gated Recurrent Unit (GRU) is a new generation of RNN, that is similar to LSTM. To solve the vanishing gradient problem of a standard RNN, GRUs utilize an update gate and reset gate. These two gates determine which information should be passed to the output. The gates can be trained to retain information from previous time steps without erasing it through time and to remove information that is not relevant to the prediction. Even in complex scenarios, GRU can perform exceptionally well if properly trained. A GRU unit is composed of a reset gate, an update gate, and a memory. A reset gate decides how much information can be forgotten from the previous time step. An update gate decides how much information should be saved from previous time steps. A memory brings information with the whole sequence and represents the memory of network.

IV. PROPOSED MODEL

The prediction method begins with the acquistion of HDFCBANK's datasets, training the model, and then predicting the rates. Finally, the model is evaluated on the basis of MAE, MSE, RMSE.

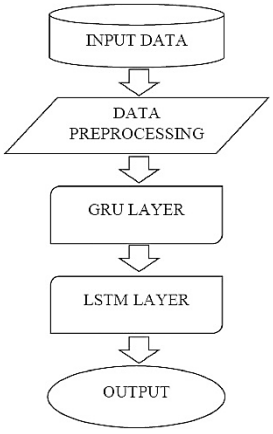

Figure 1: Proposed Model Flow (GRU – LSTM)

1) Data collection: Dataset is taken from the nsepy python library. We have collected historical time series data from 01/11/2019 to 31/03/2022 of HDFCBANK stock. Dataset contains a total of five features: Date, High price, Low price, Open price, Close price. It contains OHLC time-series dataset.

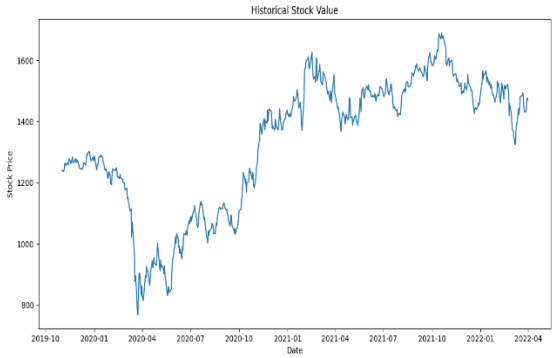

Figure 2: Dataset graph

2) Data Preprocessing: We didn't have to deal with missing values in the dataset. As, however, we are using the min-max scalar for transforming features by scaling each feature separately. This estimators scales and translates each feature individually such that it is in the given range on the training set, e.g. between zero and one.

3) Model Design: Our proposed hybrid model consists of four layers, with the first hidden layer containing GRU with 30 neurons and the other three layers of LSTM, which contain 30 neurons each. We have trained this model with the processed data from nsepy library.

At the first hidden layer, the GRU collects all the attributes of the dataset and along the way, a weighted value is generated. This data is then passed to the LSTM layer, which is the second hidden layer. Before that, we drop a random sequence of length 0.2 to avoid the overfitting of the model. Now, from the second hidden layer of LSTM, the value will be forwarded to the third hidden layer of LSTM and before that, we again drop the 0.2 length sequence. And at the last third hidden layer will give the weighted values to the last hidden

layer of LSTM. And now we will get our prediction from last the hidden layer as an output.

4) Model Validation: It is an important step to validate the model by comparing the actual data to predicted data. To measure the performance of our system, we have used MSE(Mean Squared Error), RMSE (Root Mean Squared Error), and MAE (Mean Absolute Error). MSE and RMSE can be very useful in cases where a large error is highly undesirable. This holds true for HDFCBANK prediction as well. The MAE method, however, takes the average of absolute error of all data points. MAE is less sensitive to outliers compared to MSE and RMSE, but it is useful when performance is measured on continuous data as in our case. It is better to have smaller values for these matrices.

V. RESULT AND DISCUSSION

In this section, we will see the results of our proposed model and will compare it with LSTM and GRU models. We have shown a prediction graph of them below.

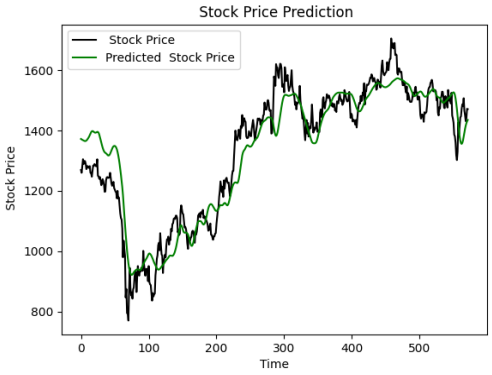

Figure 3: GRU prediction graph

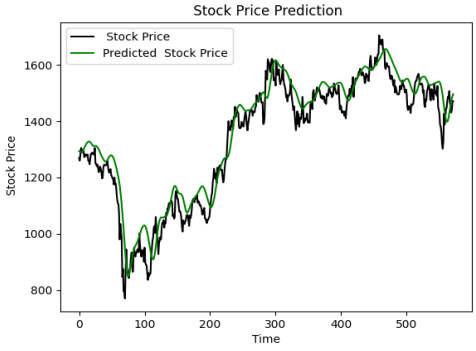

Figure 4: LSTM prediction graph

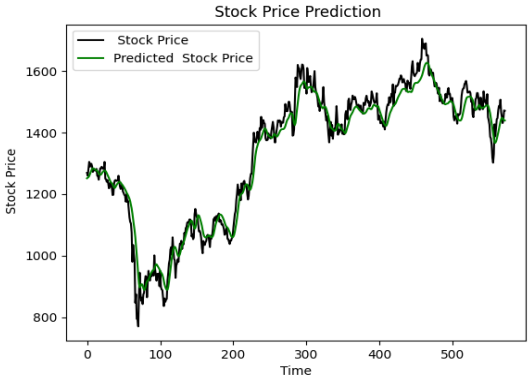

Figure 5: Proposed model (GRU-LSTM) prediction graph

Models	MSE	RMSE	MAE
LSTM	0.0050	0.0708	0.0571
GRU	0.0064	0.0801	0.0620
Proposed Model	0.0027	0.0524	0.0374

Table 1: Error Matrix

From the graph, we can clearly see that the proposed model prediction is quite accurate compared to the LSTM and GRU models. We can validate that with the help of MSE, RMSE, and MAE. We have prepared a table comparing this value for GRU, LSTM, and the proposed model GRU-LSTM.

VI. CONCLUSION AND FUTURE SCOPE

In this study, we demonstrate the use of a hybrid model that combines GRU and LSTM to predict the stock price. We have predicted the HDFCBANK stock price in this paper. We have collected the data of HDFCBANK of 1-day duration and then we have inserted the data in the GRU model where it generated the weighted value, which was then passed to the LSTM layer. It calculates another weight value to pass the value to another LSTM layer and the same is down one more time to pass the value to the last layer of LSTM. Between these hidden layers, we drop the 0.2 length sequence to make sure the model doesn't overfit. In this experiment, the GRU-LSTM hybrid model predicted HDFCBANK price more accurately than two of the most popular and reliable time series analyzers:

GRU and LSTM. Despite the model's good predictive capabilities, it suffers sometimes when the closing price or opening price suddenly increases or decreases. It is quiet in the development of the model. There are a few more improvements that need to be explored as the model provides a promising and potentially fruitful research area. In the future, we apply our model to other stocks to be more confident about our model. We are sure that it will perform well on others too still we need to check that.

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