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Stock Price Volatility and Forecasting using Hybrid Model of LSTM & GRU Technique

[1]Rajnandini Rawat, [2]Dr. Amit Shrivastava, [3]Dr. Ritu Shrivastava
M. Tech. Scholar, Department of Computer Science and Engineering, SIRT, Bhopal[1]
Professor, Department of Computer Science and Engineering, SIRT, Bhopal[2]
Professor & Head, Department of Computer Science and Engineering, SIRT, Bhopal[3]

ABSTRACT: The stock market is an emerging network that offers an infrastructure for all financial transactions from the world in a dynamic rate called stock value, which is devised using market stability. Prediction of stock values provides huge profit opportunities which are considered as an inspiration for research in stock market prediction. Long short term memory (LSTM) is a model that increases the memory of recurrent neural networks. Recurrent neural networks hold short term memory in that they allow earlier determining information to be employed in the current neural networks. For immediate tasks, the earlier data is used. We may not possess a list of all of the earlier information for the neural node. The long short-term memory (LSTM) and gated recurrent unit (GRU) models are popular deep-learning architectures for stock market forecasting. Various studies have speculated that incorporating financial news sentiment in forecasting could produce a better performance than using stock features alone. This study carried a normalized comparison on the performances of LSTM and GRU for stock market forecasting under the same conditions and objectively assessed the significance of incorporating the financial news sentiments in stock market forecasting. Both the LSTM-News and GRU-News models are able to produce better forecasting in stock price equally.

INDEX TERMS – **Stock Market, LSTM, GRU.**

I. INTRODUCTION

In a prediction process, various social behaviours, like economic activities, data, and weather indices and so on are some of the significant factors. However, predicting the stock market is a very challenging problem in time series analysis [1]. Recently, the stock market has been considered as the main resource for economic development in India. On the other hand, stock market prediction is very complex due to various factors, such as political events, investor's sentiment and economic conditions. Usually, stock market series are nonparametric, dynamic, disordered and noisy in nature. Thereby, stock market prediction is a significant problem due to these challenging features [2, 3]. In addition, stock price volatility prediction is a recent research area in time series, and it plays a vital role in decreasing investment threat. Although, stock price tendency not only relies on historical trend but also its correlated social characteristics. Moreover, world's economy is hugely dependent on the stock markets of every country since billions of dollars are traded each day. The stock market has non-linear and highly variable time series data, and time series data is a collection of data estimated based on time to obtain different activity status [4]. Generally, the stock market is referred to as a complex financial system, which involves various company stocks, and also changes in price are varying upon time for each company [5, 6].

Nowadays, stock markets play a vital role in economic operations. The prediction of the stock market index is a significant one to several stakeholders in the market. The stock market price imitates total present information based on the Efficient Market Hypothesis (EMH). Eventually, various sources are generally separated as quantitative data and qualitative description. The quantitative data includes turnover rate, historical prices and so on, and qualitative descriptions have social media posts, annual reports, news, announcements and so on. Generally, qualitative data is shapeless, and hence extraction of required signals from them is insignificant. Therefore, dealing with qualitative data is a challenging one [7].

Because of the importance in current age financial trends, stock value prediction has huge interest between shareholders, experts and managers. Even though, the stock market prediction is considered a difficult and undecided issue because of different characteristics, namely noise, irregularities, daily market trends, political influence and insecurities present in the stock market. Alternatively, traders and investors rely upon trading analysis, past and present stock data. The stock market is considered as a dynamic financial system as it includes several elements or stocks and the price changes heavily depends on time [8].

Basically, stock market prediction includes exposure of market trends based on the time. Every stock market investor's plan is to improve the profit from their investments and decrease the correlated risks. Even though various factors, like political events, investor's sentiment, economic limitations and so on affect the stock market [9], the forecasting of the stock market index is highly significant for several stockholders in the market.

Besides, the overall economic development is majorly dependent on stock market, thus the analysis of behaviours and future prediction is very useful for attaining economic targets. Consequently, the core ingredient of stock market prediction is a trading system, which includes various elements for prediction, trading policy and risk analysis. The main purpose of trading element is to generate a collection of stocks, which increases overall return with regards to the risk of stocks in a group [10, 11].

II. STOCK MARKET PREDICTION

Stock market prediction is a significant task for the financial decision-making process and investment. Even though stock price prediction is a key problem in the financial world, it contributes to the growth of efficient methods for stock exchange transactions. Generally, stock markets are in the form of non-stationary, non-linear and uncertain even so financial experts recognized it is complex to produce precise predictions. Stock market prediction is a challenging job due to its high dynamic and unstable. Stock market prediction plans to compute the future value of a company stock trade on exchange as well as consistent prediction of future stock prices obtains high profits to investors. Various researches applied numerical data and news for the prediction of the stock market. Commonly, based on the number of information sources, the stock market prediction technique is experimented on selecting the numerical data by analysing the news data [12].

In basic, forecasting behaviours are separated into three levels, such as short, medium and long. Furthermore, stock market movements are influenced by various macroeconomical aspects, like bank exchange rate, commodity price index, investors' expectations, bank rate, general economic conditions, investor's psychology, firms' policies, institutional investors' choices, political events and so on [8, 9]. Additionally, stock value indices are computed using higher market capitalization stocks, whereas several technical parameters are also employed to obtain statistical information about stock price values [13]. In the stock market, there are two assumptions for predicting stock price value. The first one is EMH stating at any time, stock price completely confines all identified information about stock where all identified information's are utilized through market participants and also random price variations obtains new random information's.

Therefore, stock prices execute a random walk, that is every future price does not follow any patterns or trends. This assumption deduces fluctuations, so incomplete or delayed information controls the stock market prices. In addition, an exterior incident influences successive stock market prices, although the precise prediction of a stock price is complex. From the prediction perception, it can be categorized into two types, namely stock price trend and stock price forecast. The stock price trend is also named as classification, and stock price forecast is also termed as regression [14]. Basically, the time duration for stock price trend prediction is highly related with previously selected features [7].

The prediction of stock market future price is very significant for investors, because of the identification of suitable movement of stock price decreases the risk of future trend calculation. The industry, economy and other correlated features are considered to compute the intrinsic value of a company, which helps to forecast stock prices from fundamental analysis method. Stock market decision-making technique is a very complex and significant job because of unstable and complex nature of the stock market. It is necessary to discover a huge quantity of valuable information created through the stock market. In addition, every investor has an imminent requirement for identifying future behaviours of stock prices.

Although, it helps the investors to achieve the best profit by identifying the best moment to sell or buy stocks. Normally, trading in stock market can be performed electronically or physically. The investor becomes the owner or partnership of a particular company, while an investor obtains a particular company share. Furthermore, financial data of the stock market is very complex in nature, so for predicting stock market behaviour is also complex. The stock market prediction helps the investors to take investment decisions by offering strong insights regarding stock market behaviour for reducing investment risks.

III. PROPSOED METHODOLOGY

The market volatility study is more important for policy implications and financial market participants for their future earnings. The Up and Down in the market will add a wedge for the market. The SEBI can improve their reforms of National Stock Exchange to educate the investor in terms of risk involved, return and fluctuation in the market.

In this thesis new solutions that overcome aforementioned challenges in share market prediction strategy adopt the long short term memory (LSTM) technique.

Long Short-Term Memory (LSTM) is one of many types of Recurrent Neural Network RNN, it's also capable of catching data from past stages and use it for future predictions.

In general, an Artificial Neural Network (ANN) consists of three layers:1) input layer, 2) Hidden layers, 3) output layer.

In a NN that only contains one hidden layer the number of nodes in the input layer always depend on the dimension of the data, the nodes of the input layer connect to the hidden layer via links called 'synapses'.

The relation between every two nodes from (input to the hidden layer), has a coefficient called weight, which is the decision maker for signals.

The process of learning is naturally a continues adjustment of weights, after completing the process of learning, the Artificial NN will have optimal weights for each synapses.

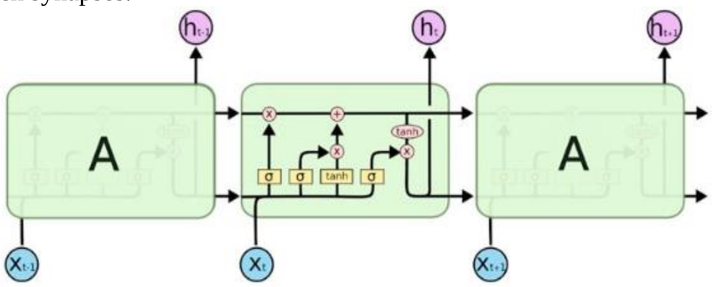

Fig. 1: The internal structure of an LSTM

The principal component of LSTM is the cell state. To add or remove information from the cell state, the gates are used to protect it, using sigmoid function (one means allows the modification, while a value of zero means denies the modification.). We can identify three different gates:

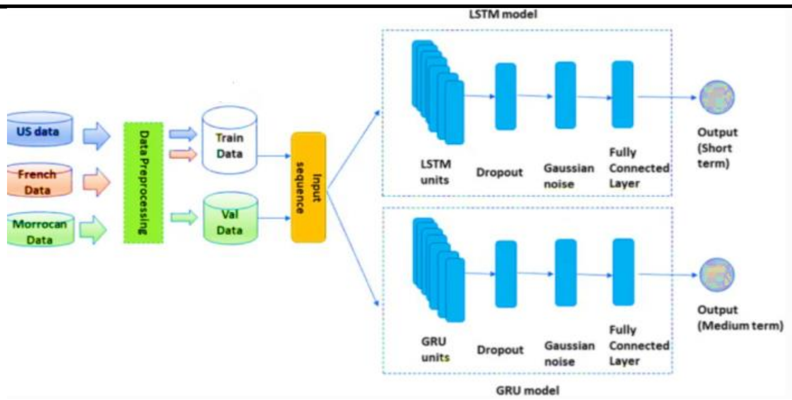

Fig. 2: Flow Chart of Proposed Methodology

Forget gate layer: Looks at the input data, and the data received from the previously hidden layer, then decides which information LSTM is going to delete from the cell state, using a sigmoid function (One means keeps it, 0 means delete it). It is calculated as:

$$f_t = \sigma(w_f[h_{t-1}, x_t] + b_f) \qquad (1)$$

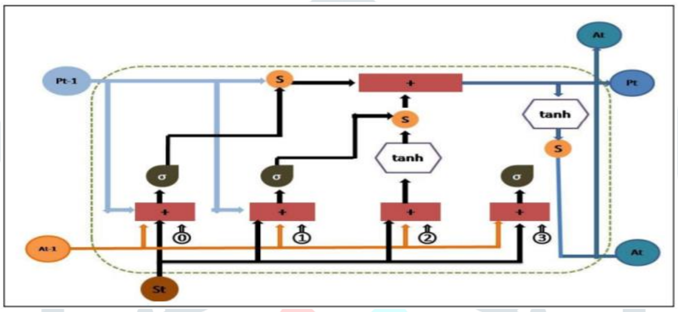

Fig. 3: Working of LSTM

Input/Update gate layer: Decides which information LSTM is going to store in the cell state. At first, input gate layer decides which information will be updated using a sigmoid function, then a Tanh layer proposes a new vector to add to the cell state. Ten the LSTM update the cell state, by forgetting the information that we decided to forget, and updating it with the new vector values. It is calculated as:

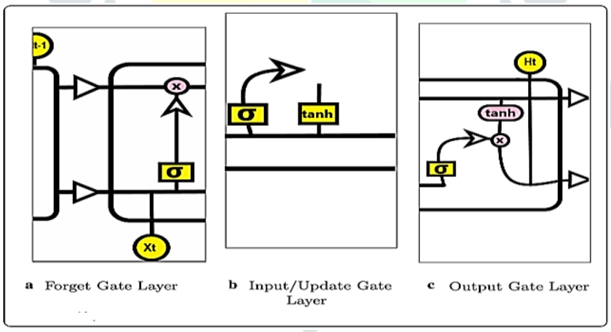

Fig. 4: LSTM Layer

$$i_t = \sigma(w_i[h_{t-1}, x_t] + b_i) \qquad (2)$$

and

$$\tilde{C}_t = tanh(w_c[h_{t-1}, x_t] + b_c) \qquad (3)$$

Output Layer: decides what will be our output by executing a sigmoid function that decides which part of the cell LSTM is going to output, the result is passed through a Tanh layer (value between − 1 and 1) to output only the information we decide to pass to the next neuron. It is calculated as:

$$O_t = \sigma(w_o[h_{t-1}, x_t] + b_o) \qquad (4)$$

and

$$h_t = O_t \times tanh(C_t) \qquad (5)$$

Gated Recurrent Unit (GRU):-

Gated Recurrent Unit GRU was introduced in 2014 by Cho et al. To solve the vanishing gradient problem experienced by classical recurrent networks.

Same as LSTM, the input value interacts with the information from the previous state to calculate the different values of intermediate gates which will subsequently be used to decide on the value to be output.

GRU is simplified and only update gate (zt) and reset gate (rt) are introduced. In GRU, the update (or input) gate decides how much input (xt) and previous output (ht-1) to be passed to the next cell and the reset gate is used to determine how much of the past information to forget. The current memory content ensures that only the relevant information needs to be passed to the next iteration, which is determined by the weight *W*. The main operations in GRU are governed by the following formulae.

Update gate:

$$z_t = \sigma\left(W_z * [h_{t-1}, x_t]\right)$$

Reset gate:

$$r_t = \sigma\left(W_r * [h_{t-1}, x_t]\right)$$

Table 1: Training parameter data of LSTM and GRU

Model	Sequential – RNN
Type	LSTM, GRU
Hidden Units	7
Input shape	1,1
Verbose	False
Output layer	(TimeDistributed(Dense(1)))
Loss Function	MAE (Mean Absolute Error)
Optimizer	ADAM
Compilation Time	0.01620 S
Total params	260
Trainable params	260
Non-trainable params	0
Epoch	100
Batch size	128

IV. **SIMULATION RESULTS**

Steps as follows proposed work **LSTM and GRU**

1. Import important libraries
2. Download and access historical dataset

https://finance.yahoo.com/quote/USO/history/

3. Show data in pandas data frame

	index	Date	Open	High	Low	Close	Adj Close	Volume	close_10	close_50	Daily Return
0	0	2006-04-10	546.000000	548.000000	541.359985	544.159973	544.159973	484738	NaN	NaN	NaN
1	1	2006-04-11	546.559998	547.119995	538.400024	545.599976	545.599976	162138	NaN	NaN	0.002646
2	2	2006-04-12	545.760010	550.479980	542.479980	542.719971	542.719971	156038	NaN	NaN	-0.005279
3	3	2006-04-13	540.000000	551.919983	539.200012	550.559998	550.559998	70088	NaN	NaN	0.014446
4	4	2006-04-17	553.599976	559.200012	549.440002	558.320007	558.320007	114713	NaN	NaN	0.014095

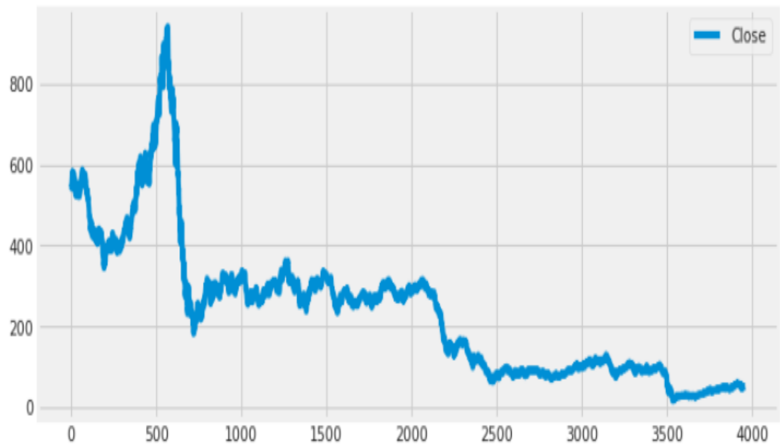

Fig. 5: Closing Price of Perform Exploratory Data Analysis

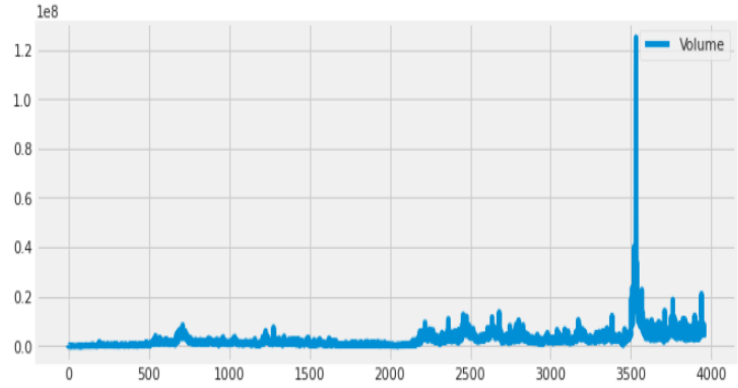

Fig. 6: Volume of Perform Exploratory Data Analysis

Fig. 7: USO Closing Price of Perform Exploratory Data Analysis

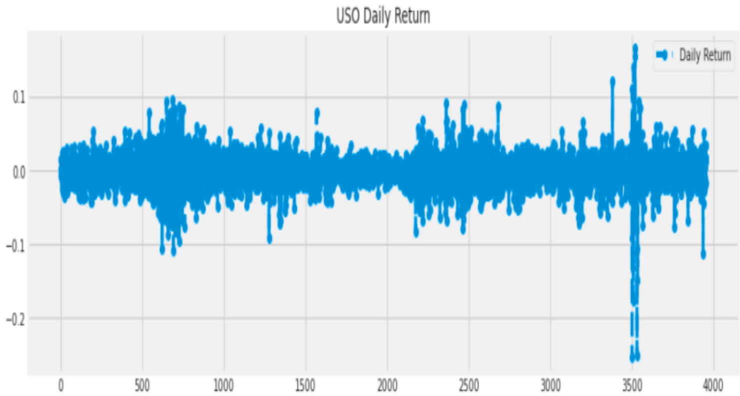

Fig. 8: USO Daily Return of Perform Exploratory Data Analysis

Fig. 9: USO Daily Closing of Perform Exploratory Data Analysis

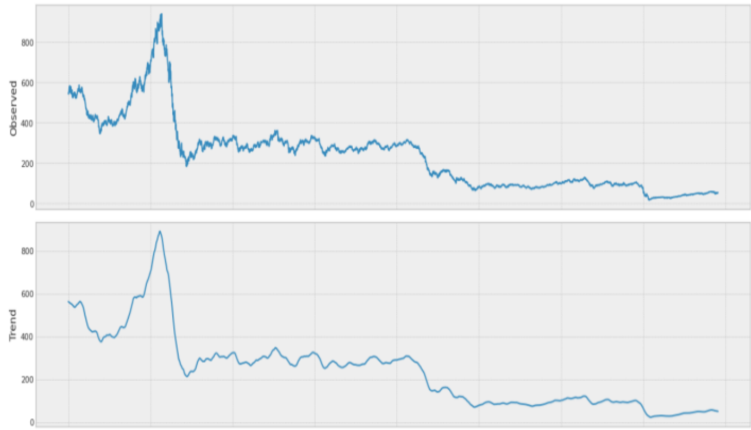

Fig. 10: Observation of Perform Exploratory Data Analysis

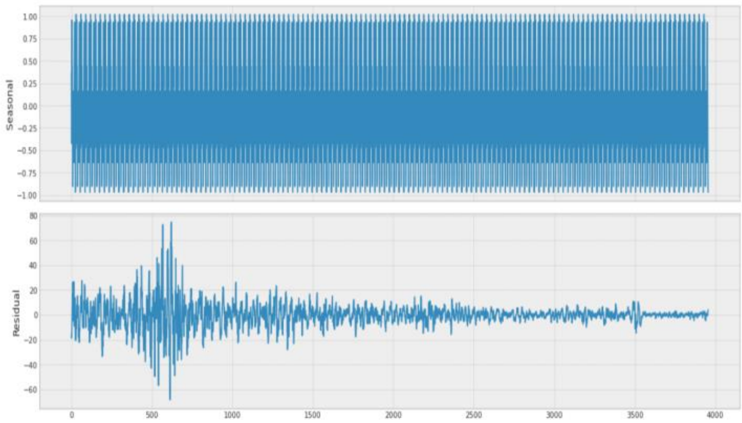

Fig. 11: Trend of Perform Exploratory Data Analysis

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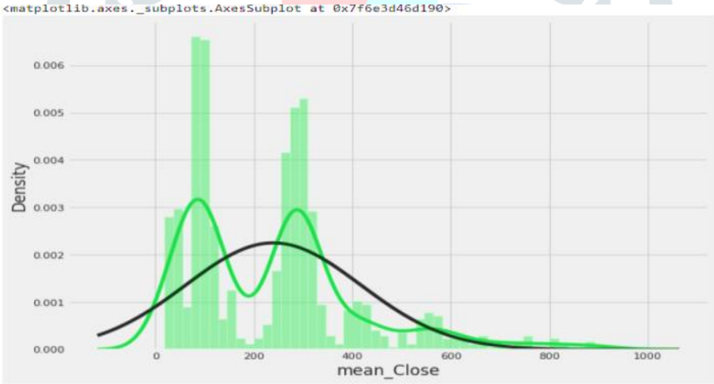

Fig. 12: Density of Perform Exploratory Data Analysis

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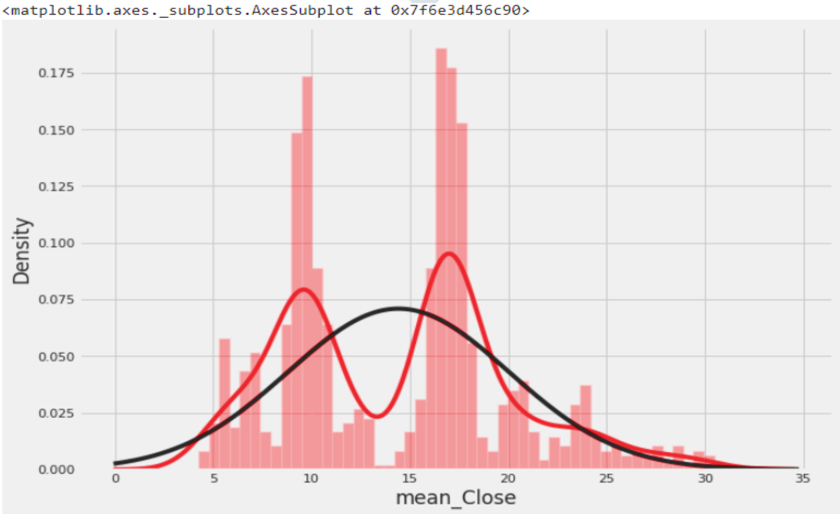

Fig. 13: Mean Deviation of Perform Exploratory Data Analysis

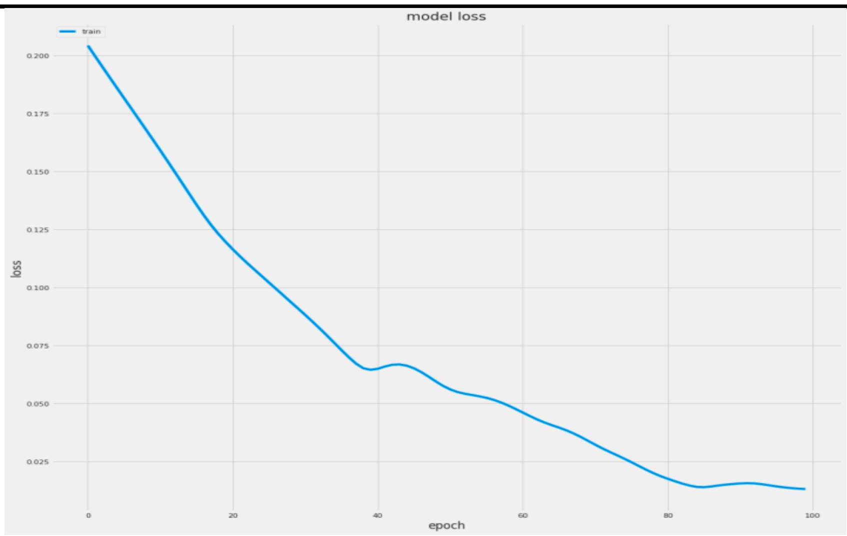

Fig. 14: Model Losses of Perform Exploratory Data Analysis

Fig. 15: Prediction and Forecast of Perform Exploratory Data Analysis

Table II: Comparison of Previous and Proposed Work

Model	Loss MAE	RMSE
Shravan et al. [1]	0.00345	0.05875
Proposed Model	0.00026	0.01615

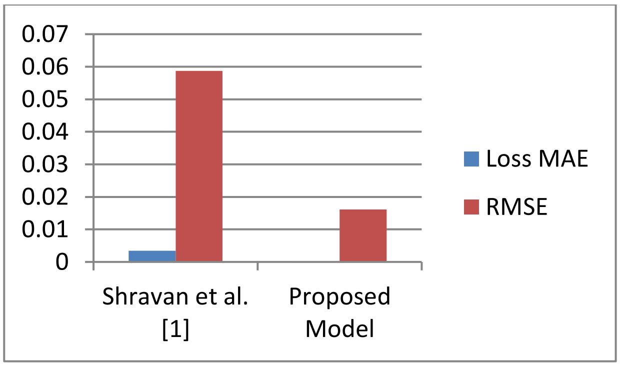

Fig. 16: Graphical Representation of Previous and Proposed Work

V. CONCLUSION

This paper proposes a new trading strategy tailored for the Moroccan market, driven by two models (LSTM and GRU) forecasting. Customized decision rules for each stock complete the proposed trading strategy. Both deep learning models provide accurate short term and medium term forecasting. The proposed work is 92.46% improvement loss mean absolute error (MAE) compared to previous Shravan et al. It is also improvement of 72.51% root mean square error (RMSE) compared to previous Shravan et al.

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