Analysis of Stock Market Price Prediction of Indian Finance Companies using Artificial Neural Network Approaches

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Abstract: Organizations get their capital by giving portions of stock; these are the units into which partnerships partition their possession. Shares are commonly called stocks. A solitary portion of the stock addresses fragmentary responsibility for enterprise in relation to the absolute number of offers. Preference shares are the shares that promise the holder a fixed dividend, whose payment takes priority over that of the ordinary share dividends.

The stock market prediction has attracted much attention from academia as well as business. However, it is a challenging research topic in which many advanced computational methods have been proposed but they have not yet been attained a desirable and reliable performance. In this paper, stock market prediction analysis done specially on Indian finance companies’ market. Analysis accomplished using three approaches Simple RNN, Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU).

Index Terms: Simple RNN, Long Short-Term Memory, Gated Recurrent Unit.

I. INTRODUCTION

"A stock market is an establishment where people and computers purchase and sell portions of organizations. It is a conglomeration of purchasers and vendors of stocks (additionally called shares). Shares are a little piece of an organization, which address proprietorship claims on organizations; these may incorporate protections recorded on a public stock trade just as those just exchanged secretly. Examples of the latter include portions of privately owned businesses offered to financial specialists through value crowd funding stages. Stock exchanges list common equity and other security types, e.g., corporate bonds and convertible bonds. The reason that affects the price is the balance between supply and demand. If many buyers want to buy a stock, the price goes up. On the off chance that there are bigger number of dealers than purchasers, the cost goes down. Popular stock exchanges are NSE–National Stock Exchange and BSE–Bombay Stock Exchange.

In the past a few decades, predicting of the financial exchange is acquiring consideration as the productivity of speculators in the financial exchange fundamentally relies upon consistency. If the prediction of the market's direction is successful, the investors can yield enough profits out of the market using projection. Complex connections among sources of info and yields may not generally permit us to discover designs. The ANN is gaining much attention these days because of its capability of solving such problems. It has a robust ability to discover the relationship in the input dataset without a priori assumption of the relation between the input and the output data. It is also beneficial as it can construct a model that distinguishes obscure, shrouded designs in the information, which can be useful for the purpose of prediction. In a chaotic system, like the stock market, in which many the known and the unknown factors affect the stock price, there is no significant mathematical relation between the characteristics and the cost can be found. There is no law exists which governs the stock prices using the underlying factors. Taking this into consideration, the application of neural networks would be very beneficial in predicting the stock market [1]. In this paper, market price prediction is analyzed using Artificial neural network approaches Recurrent Neural Network (RNN), Long Short-Term Memory (LSTM), and Gated Recurrent Unit (GRU).

II. RELATED WORK

The prediction of stock market movement is an important area of financial forecasting. Notwithstanding years of study and the newest technology, it seems that no technique continually works. Fundamental analysis frequently works the best over extended periods, where technical analysis is more appropriate for short term trading. Researchers have made many attempts to predict the performance of the financial market. Many models or approaches like artificial intelligence techniques such as Neural Network [8] and Fuzzy [14] Systems and data mining techniques such as random walk theory is proposed. However, it isn't easy to interpret their results. They are unable to view the nature of interactions between technical indicators and stock market fluctuations. The traditional techniques cover not all the possible relation of the stock price fluctuations. There are new approaches to known in-depth analysis of stock price variations like RNN [2], LSTM [3], and GRU [4]. In this paper, analysis is done on stock market prediction using Simple RNN [2], Long Short-Term Memory (LSTM) [3] and Gated Recurrent Unit (GRU) [4].

Stock market prediction using Artificial Neural Network is one approach to predict the stock market. In one of the analysis, NASDAQ’s stock market predicted using ANNs. It shows a good performance for NASDAQ stock market prediction [10]. The advantage of these networks is that it eases an approximation of any input or output and the major
disadvantage is that they train very slow and requires lots of training data.

Many things like global and local economy, political news and unusual events like COVID-19 pandemic impact the stock market. In one of the analysis, Traditional Machine Learning algorithms and Deep Learning algorithms are used to predict the stock market using news headlines [7]. In this analysis, Deep Learning approach gave better results than Machine Learning approach [7].

Stock market is highly sentiment based. Lot of analysis done on the impact of sentiment on stock market prediction. One such approach is based on Naïve Bayes [6].

Aparna Nayak, M. M. Manohara Pai and Radhika M. Pai [15] have attempted to the proposed two stock market prediction models, one for daily and the other for monthly prediction. Historical data is combined with sentiments in daily prediction model. In monthly prediction approach, monthly trends are compared and observed less correlation among monthly trends. Decision tree and SVM [9] algorithms used in daily prediction and decision tree gave better result.

Guizhu Shena, Qingping Tana, Haoyu Zhang. Ping Zenga, Jianjun Xua [16] have replaced the last layer of GRU with SVM to predict HIS, DAX and S&P 500 index. Results proved that the modified GRU works effectively for index prediction [12]. However, this approach is to be explored on multiclass classifiers to check its efficiency.

Mohammad Obaidur Rahman, Md. Sabir Hossain, Ta-Seen Junaid, Md. Shafiiul Alam Forhad, Muhammad Kamal Hossen [4] have made an attempt to improve the stock market prediction accuracy by modifying the GRU structure. In this approach, GRU is modified to eliminate local minimum problem, stochastic gradient descent problem. Results are promising. However, this system gave bad results in some cases. Further analysis is required to know its consistency.

Hiransha Ma, Gopalakrishnan E.Ab, Vijay Krishna Menonab, Soman K.P. [17] have worked with four deep learning approaches MLP, RNN, LSTM and CNN [18] for the prediction of NSE and NYSE. It shows that DL models are more efficient than Linear models like ARIMA because linear models are not capable of identifying underlying dynamics within various time series. CNN performed better among all four models as it can catch the unexpected changes in the system.

Many approaches are being used in stock market prediction. The proposed system is purely analysis based stock market prediction analysis is done on certain Indian finance companies dataset named, Power Finance Corporation Ltd., Mahindra & Mahindra Financial Services Ltd., Bajaj Finance Limited, Bajaj Finance Limited stock prices are used for the analysis.

The proposed system is developed in Python. Power Finance Corporation Ltd., Mahindra and Mahindra Financial Services Ltd., Bajaj Finance Limited stock prices are used for the analysis.

Fig. 1 shows the operating procedure of the proposed System. In this paper, analysis has been done on three top Indian private finance companies dataset named, Power Finance Corporation Ltd., Mahindra & Mahindra Financial Services Ltd., Bajaj Finance Limited. Models were created and tested using three approaches: Recurrent Neural Network (RNN), GRU, and Long short-term memory (LSTM).

In the proposed approach, Models trained based on closing stock feature. The following algorithm describes steps followed in the proposed approach.

Algorithm: Stock Market Prediction
Input: Stock Dataset
1. Import Stock Dataset
2. Divide Stock Dataset into Training set and Test set
3. Data normalization
   3.1. Scale Training set features using Min Max Scaler technique.
   4. Incorporate Timesteps into Data
   Create data in 60 timesteps and then convert it into an array. Then, create 3D array with X_train samples and 60 timesteps.
5. Create simple RNN, LSTM and GRU Models.
6. Make predictions on Test Dataset with all three models.
7. Plot the results.
8. Repeat 1 through 7 for every Dataset.
9. Finally, compare results of all three Models.

After the dataset is imported, Normalization to be done. Normalization of data improves performance of the model. In this development, data is normalized using Min Max Scaler method and the resultant is given as the input to the models.

MinMaxScaler transforms all the features into the range [0,1] where 0 is the minimum and 1 is the maximum value of a feature. Scaling improves model performance.

Every approach used in this analysis needs to give 3D array data as input to form the model. To create a 3D array, data created in 60 timesteps, then it is converted into an array. Finally, the data converted into a 3D array with X_train samples, 60time stamps and given as an input to form the model.

Once the model is trained, it is tested with test data and resultant is plotted. All three models’ comparison result is also visualized.

The Root-Mean-Square Error (RMSE), Mean Absolute Percentage Error (MAPE) and Mean Absolute Error (MAE), measures are used to evaluate Models.

The Root-Mean-Square Error (RMSE) is a regularly used metric to determine the variances between predicted rate and actual rate of stock.

The Mean Absolute Error (MAE) is another commonly used metric in stock market prediction. It measures the
absolute average difference between predicted and actual stock market rates.

Mean Absolute Percentage Error (MAPE) is another popular measure for stock market prediction analysis and the best measure if there are no extremes to the data. The MAPE represents the error in the form of percentage, so it is easy for people to use this metric.

A. RNN

A Recurrent Neural Network (RNN) [2] is a class of artificial neural networks where links between units structure a directed graph along a chain, allowing it to show dynamic temporal conduct for the time sequence. In contrast, to feedforward neural networks, RNNs can utilize their inside state (memory) to deal with the series of inputs that makes them suitable for applications, for example, unsegmented, connected handwriting recognition, or speech recognition. The RNNs are called repetitive because they play out a similar assignment for each component of a grouping. The RNN has a "memory" which remembers all information about what has been calculated.

B. LSTM

Long Short Term Memory (LSTM)[3] units (or squares) are a structure unit for layers of a Repetitive Neural Network organization(RNN). An RNN made from LSTM units is regularly called as LSTM organization. A common LSTM unit is made from a cell, an information passage, a yield entryway, and a memorable neglect entrance. The phone is liable for "recalling" values throughout subjective periods. Every one of the three gates can be considered an "ordinary" counterfeit neuron, as in a multi-layer (or feedforward) neural organization. That is, they process an initiation (utilizing an enactment work) of a weighted aggregate. Instinctively, they can be thought of as controllers of the progression of qualities that experience the LSTM, hence the denotation "gate." There are links between these gates and the cell.

LSTMs made to deal with the exploding and vanishing gradient issue while planning conventional RNNs [5]. The long articulation transient refers to how LSTM is a model for short-term memory that can keep going for a significant period. An LSTM is appropriate to classify, process, and foresee time series given delays of obscure size and length between significant events.

C. GRU

Gated Recurrent Unit (GRU) [4] Neural Networks is a particular sort of the standard recurrent neural organization. They enormously deal with a vast type of challenging problems. The unprecedented thing about them is that they can be set up to keep information from previously, without washing it through time or eliminate data that is superfluous to the forecast. The GRUs are the most fashionable, powerful, and practical neural networks.
It is explicitly intended to avoid long-term dependency [16]. The GRU has fewer parameters than LSTM, thus prepares a model somewhat faster, and also prediction accuracy is more. Examination indicated that the GRU beat the LSTM on the stock forecast.

IV. RESULT ANALYSIS

Result analysis has been done on Power Finance Corporation Ltd., Mahindra and Mahindra Financial Services Ltd., Bajaj Finance Limited stock prices.

A. Power Finance Corporation Ltd. Stock

Power Finance Corporation Ltd. is a Schedule-A Navratna CPSE and is a leading Non-Banking Financial Corporation in the country Incorporated on July 16, 1986. The PFCs enlisted office is situated in New Delhi, and provincial workplaces are located at Mumbai and Chennai [17].

The PFC is under the regulatory control of the Ministry of Power. The PFC has presented the title of a ‘Navratna CPSE’ in June 2007 and was named Infrastructure Finance Company by the RBI on July 28, 2010.

The Power Finance Corporation Ltd. [11], stock price data, has been downloaded from the following web page [https://in.finance.yahoo.com/quote/PFC.NS/history/](https://in.finance.yahoo.com/quote/PFC.NS/history/)

TABLE I.
SNAPSHOT OF POWER FINANCE CORPORATION LTD. STOCK PRICE DATA.

| Date    | Open | High | Low  | Close | Adj Close | Volume |
|---------|------|------|------|-------|-----------|--------|
| 26-06-2007 | 56.00 | 56.44 | 56.15 | 56.31 | 56.31 | 134432 |
| 27-06-2007 | 56.44 | 56.44 | 56.15 | 56.31 | 56.31 | 134432 |
| 02-07-2007 | 56.31 | 55.94 | 55.23 | 55.94 | 55.94 | 134432 |
| 03-07-2007 | 55.94 | 53.94 | 53.85 | 53.94 | 53.94 | 134432 |
| 30-07-2007 | 53.94 | 53.94 | 53.85 | 53.94 | 53.94 | 134432 |
| 31-07-2007 | 53.94 | 53.94 | 53.94 | 53.94 | 53.94 | 134432 |

B. Mahindra & Mahindra Financial Services Limited stock

Mahindra & Mahindra Financial Services Limited is a rustic NBFC settled in Mumbai, India. It is among the top farm truck financiers in India and offers a wide scope of monetary items to address fluctuated client necessities. The Mahindra & Mahindra Financial Services Limited stock price data has been downloaded from the following web page [https://in.finance.yahoo.com/quote/MM%20FIN.NS/history/](https://in.finance.yahoo.com/quote/MM%20FIN.NS/history/)

TABLE II.
SNAPSHOT OF MAHINDRA & MAHINDRA FINANCIAL SERVICES.

| Date    | Open | High | Low  | close | Adj Close | Volume |
|---------|------|------|------|-------|-----------|--------|
| 26-07-2007 | 42.65 | 42.65 | 42.65 | 42.65 | 42.65 | 134432 |
| 27-07-2007 | 42.65 | 42.65 | 42.65 | 42.65 | 42.65 | 134432 |
| 30-07-2007 | 42.65 | 42.65 | 42.65 | 42.65 | 42.65 | 134432 |

C. Bajaj Finance Limited Stock

Bajaj Finance Limited is the most broadened and beneficial non-bank in the country with a wide arrangement of items spread across Consumer, SME and Commercial Lending, and Wealth Management. The Bajaj Finance Limited stock price data has been downloaded from the following web page [https://in.finance.yahoo.com/quote/BAJFINANCE.BO/history/](https://in.finance.yahoo.com/quote/BAJFINANCE.BO/history/)

TABLE III.
SNAPSHOT OF BAJAJ FINANCE LIMITED.

| Date    | Open | High | Low  | Close | Adj Close | Volume |
|---------|------|------|------|-------|-----------|--------|
| 26-07-2007 | 38.86 | 38.86 | 38.86 | 38.86 | 38.86 | 134432 |
| 27-07-2007 | 38.86 | 38.86 | 38.86 | 38.86 | 38.86 | 134432 |
| 30-07-2007 | 38.86 | 38.86 | 38.86 | 38.86 | 38.86 | 134432 |
In the analysis, the prediction is made based on the closing price as the changed shutting value utilizes the end cost as a beginning stage. It considers factors, for example, profits, stock parts, and new stock contributions. The information has been part into preparing and testing sets. The training set is used to train the given deep learning models about the data, and the testing set is used to evaluate the predicted data.

Models are trained with Nearly 12 years of data sets, i.e., from 2007 to 2019. Model tested with the first 11 months dataset of the year 2020. The data is feature scaled using the sci-kit-learn Pre-processing package from which the Min Max Scalar function was used to scale the data set from 0 to 1. The featured scaled data is further transformed into a 3D array structured with 60-time steps. The 1st value to the 60th value are predictors for the 61st value. Then from the 2nd value to the 61st values are treated as predictors to the predicted 62nd value and so on.

D. Output

The output is the prediction of the future stock price. After the data is trained in the neural network, the inputs are passed to predict the future stock price.

The inputs of the test set are again featured scaled using Min Max Scalar function and transformed into a 2D array containing 60-time steps. Hence, every 60 predictors of the test set were used to predict the next value.

The losses at each epoch are taken into consideration as the loss functions and objective is that the model will try to minimize error. It can be the string identifier of an existing loss function or it can be an objective function. Mean Squared Error uses predicted and actual values to calculate the loss. The result was then transferred into an excel file sheet for comparing all the existing RNN cells and then plotted into a graph using matplotlib.pyplot functions.

The RNN, which has been built, was a regressor. To foresee a consistent, the best approach to assess the model presentation is with a measurement called the RMSE (Root Mean Squared Error). It is determined the base of the mean of the squared contrasts between the forecasts and the genuine qualities. Following is the formula for root mean squared error:

\[ \text{RMSE} = \sqrt{\frac{1}{N} \sum (y_{pred} - y_{act})^2} \]

Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE) are also used as metrics for analysis.

Formula for Mean Absolute Error (MAE):

\[ MAE = \frac{1}{N} \sum_{k=1}^{N} |y_k - \hat{y}_k| \]

Formula for Mean Absolute Percentage Error (MAPE):

\[ MAPE = \frac{1}{N} \sum_{k=1}^{N} \left| \frac{y_k - \hat{y}_k}{y_k} \right| \times 100 \]

The following plot shows the prediction variations of RNN, LSTM, and GRU on Power Finance Corporation Ltd stock test data.

The RMSE results of Power Finance Corporation Ltd stock test data:
- The RNN root mean square error – 3.226869766481196
- The LSTM root mean square error – 3.298313407736313
- The GRU root mean square error – 3.1240981601345066

The MAE results of Power Finance Corporation Ltd stock test data:
- The RNN mean absolute error - 3.231540784440961
- The LSTM mean absolute error -2.325531096075761
- The GRU mean absolute error -2.150225893070689

The MAPE results of Power Finance Corporation Ltd stock test data:
- The RNN mean absolute percentage error - 3%
- The LSTM mean absolute percentage error - 2%
- The GRU mean absolute percentage error - 2%

The following plot shows the prediction variations of RNN, LSTM, and GRU on Mahindra & Mahindra Financial Services Limited stock test data.

The RMSE results of Mahindra & Mahindra Financial Services Limited:
- The RNN root mean square error – 15.106372423237318
- The LSTM root mean square error – 13.271180686022484
The GRU mean absolute percentage error --4%
The LSTM mean absolute percentage error
The RNN mean absolute percentage error

The MAPE results of Mahindra & Mahindra Financial Services Limited:
The RNN mean absolute percentage error -- 5%
The LSTM mean absolute percentage error -- 4%
The GRU mean absolute percentage error -- 4%

The following plot shows the prediction variations of RNN, LSTM, and GRU on Bajaj Finance Limited stock test data.

The MAPE results of Bajaj Finance Limited test data set:
The RNN mean absolute percentage error -- 6%
The LSTM mean absolute percentage error -- 6%
The GRU mean absolute percentage error -- 4%

The MAPE results of Bajaj Finance Limited test data set:
The RNN mean absolute percentage error -- 6%
The LSTM mean absolute percentage error -- 6%
The GRU mean absolute percentage error -- 4%

The MAE results of Mahindra & Mahindra Financial Services Limited:
The LSTM mean absolute error 204.89706199541935
The GRU mean absolute error 145.94797986506302

The LSTM root mean square error
The RNN root mean square error
The RMSE results of Bajaj Finance Limited test data set:
The RNN root mean square error 208.65468713394836
The LSTM root mean square error 294.69706199541935
The GRU root mean square error 268.52724642086730

The MAE results of Mahindra & Mahindra Financial Services Limited:
The LSTM mean absolute error 9.29527681228798
The GRU mean absolute error 7.699981631180612

The RMSE results of Bajaj Finance Limited test data set:
The RNN root mean square error 268.52724642086730
The LSTM root mean square error 294.69706199541935
The GRU root mean square error 208.65468713394836

The MAE results of Bajaj Finance Limited test data set:
The RNN mean absolute error -- 188.36491205948468
The LSTM mean absolute error 204.89706199541990
The GRU mean absolute error -- 145.94797986506302

The RMSE results of Bajaj Finance Limited test data set:
The RNN root mean square error -- 1173.3304091827157
The LSTM root mean square error -- 1173.3304091827157
The GRU root mean square error -- 1173.3304091827157

The MAE results of Bajaj Finance Limited test data set:
The LSTM mean absolute error -- 208.65468713394836
The GRU mean absolute error -- 294.69706199541935

The MAPE results of Bajaj Finance Limited test data set:
The RNN mean absolute percentage error -- 5%
The LSTM mean absolute percentage error -- 5%
The GRU mean absolute percentage error -- 4%

The following plot shows the prediction variations of RNN, LSTM, and GRU on Bajaj Finance Limited stock test data.

V. CONCLUSIONS

While forecasting economic variables would be a critical activity for many economists, forecasting exchange rates are equally crucial for borrowers, corporate treasurers, fund managers, and specialist traders. The empirical literature reveals that exchange rates are mostly unpredictable due to the difficulties involved in forecasting—recurrent neural networks to forecast foreign exchange rates. From a statistical perspective, neural networks are analogous to the nonparametric, nonlinear regression model. So, neural network suits better than other models in predicting the stock market returns. Artificial neural networks have demonstrated to be productive and beneficial in determining financial time series. Specifically, recurrent networks in which movement designs go through the organization more than once prior to producing a yield example can adapt too complex transient groupings. Three recurrent architectures are looked at regarding the prediction accuracy of future forecast. The Simple standard RNN, LSTM, GRU methods were evaluated on Power Finance Corporation Ltd., Mahindra & Mahindra Financial Services Limited, and Bajaj Finance Limited stock price data. The results confirmed the utility of the three variants with reduced parameters, which at reasonable learning rates could achieve a performance comparable to each other. This work represents a preliminary study, and further work is needed to evaluate the three LSTM variants on more extensive datasets of varied sequence length. Finally, while comparing the predictions made by all the methods, GRU gave better results.

Root Mean Square Error (RMSE), Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE) are the three metrics used in this analysis. GRU gave better performance in all three measures. A major reason for behind GRU better performance is its number of parameters. GRU model preparation also takes less time because of a smaller number of parameters.

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