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Distinctive Assessment of Neural Network Models in Stock Price Estimation

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Abstract

INTRODUCTION: Due to its potential to produce substantial returns and reduce risks, stock price prediction has garnered a lot of attention in the financial markets.
OBJECTIVES: A comparison of neural network models for stock price prediction is presented in this research report.
METHODS: Through this study, I aim to compare, on the basis of the precision and accuracy, the performance of different neural network models for stock price prediction. LSTM model along with RNN model accuracy in predicting the next day's stock price i.e., which model can predict closest to the actual value.
RESULTS: It is found that LSTM works better than RNN in predicting a value closer to the actual open price stock value.
CONCLUSION: A comparison between the models shows LSTM is the more accurate model.

Keywords: Stock, Neural network, prediction, Precision, Machine learning

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1. Introduction

Stocks are a way to represent the ownership of a company or an organization, often also called shares or equity. When people or organizations buy stocks, they become shareholders and get a stake in the business, that is, they own some part of the business/organization. Typically, public corporations that want to raise money issue stocks. Forecasting of stock prices refers to the technique of predicting the future prices of stocks. It involves analyzing previous data and forecasting the nature and direction of future price movements using an array of methodologies, including statistical models and machine learning algorithms.

Due to the dynamic nature and complexity of the financial markets, predicting stock prices is a difficult task to undertake. It necessitates taking into account a variety of variables, including investor behaviour, market sentiment, industry trends, firm performance, and industry and industry developments. Though perfect prediction is impossible to reach, researchers and professionals try to find techniques and technologies to get predictions as close to the actual value as possible, that helps investors plan their actions wisely. Stock price prediction helps investors to plan their actions in regard to how to invest and where to invest their bucks based upon machine learning algorithms which are data driven. Not only does it help professionals and/or investors with buying, but selling, achieving higher profits, allocating portfolios efficiently as well, making it an important aspect of today's stock world. Coming to the traditional approach of stock prediction, it based its results on factors like fundamental analysis, technical analysis, economic state and analysis, sentiment research on platforms like twitter, the time and economic season. Though it worked somewhat efficiently and even if applied today may give hit or miss results, the modern approach to stock prediction has rendered it inert due to its higher accuracy and

precision for stock predictions, the effect of being based on machine learning algorithms and its data driven, accessible and accurate abundance.
The stock market could become, yet again, a field of daily life that machine learning can potentially benefit with stock price prediction technology. Ever since the inception of automated predictors and algorithms, they have proven to be better in every aspect, be it accuracy or accessibility or precision. They offer forecasting powers and room for growth in the financial sector and also the technological sector equally. Since machine learning algorithms and approaches work on data and its analysis, they learn from new trends and utilize the results to better fit their model over time and increase their accuracy at the same time. They can effectively handle huge amounts of data and incorporate it in their results and algorithms, eliminating the need to update and renew the model and analysis, thus making them the first choice of investors and professionals in the stock world.

This paper presents analysis of already existing machine learning models used for stock price prediction and their comparison to find out the most efficient and accurate prediction model available in the current scenario. Using pre-existing knowledge and data available, the accuracy of each model and their description is presented.

2. Literature Review

Since it is a widely studied field, there have been numerous papers and academic works on the topic. M. K. Ho et. al. studied and presented, in 2021, the comparison between three models for stock prediction on historical data of Bursa Malaysia closing prices [1]. Using metrics for quantifiable comparison like MAPE (Mean Absolute Percentage Errors) and RMSE (Root Mean Squared Errors), they evaluated three models for their study, namely, LSTM, ARIMA and NN. They presented the result that the LSTM model outperformed ARIMA and NN on their data set, with 90% accuracy.

Malav Shastri et. al. used sentiment analysis and neural networks and a hive ecosystem for data cleaning and presented a model in their 2019 paper [2]. They proposed a novel model which gave results with 90% accuracy and above. Authors performed sentiment analysis through a Naive Bayes classifier and assigned a score to the news headlines, to understand the correlation of news to stocks. The neural network model used inputs from sentiment analysis and historical stock data to create forecasts, while also using an effective data cleaning technique, hive ecosystem. Their proposed model gave above 90% accuracy in maximum cases, making an efficient, accurate and precise model for stock prediction.

A study to expand the use of extracted data from text mining for market analysis and incorporation with neural network to make informed decision about the stock market was done by Navpreet Kaur [3]. The paper highlights the integration of fuzzy logic for smoothing out the data and the importance of structured data extraction from unstructured text data. The findings and the methodology can be applied to any field where predictions and/or decisions are to be made, not limited to stock price prediction.

Narsingh Bahadur Singh et. al. in their paper, proposed a model using a LSTM model fused with fractional derivatives, for time series prediction [4], a novel model. Their novel model had better accuracy and precision than ARIMA and GARCH models, along with improved memory property. These model results, however, don't specifically aim at exact prediction of the stock price, but the decision of an individual on holding a stock long term, which is in turn based upon stock price movements and direction.

A paper introducing a model based on LSTM in deep learning by D. Mahendra Reddy et. al. compares the introduced model to pre-existing SVM and Backpropagation algorithm models [5] The authors of this paper came upon an interesting relationship between knowledge and prediction accuracy of the model. They found that the prediction accuracy increases with the size of knowledge they were operating on with their novel LSTM model. This provides a new and accurate way of forecasting stock prices.

Jaromír Vrbka et. al. proposed an Artificial Neural Network (ANN) trained on Prague stock exchange for accurate stock price prediction [6]. They generated a perceptron with multiple layers (MLP) and RBF (Radical Basis Function) networks for the forecasting and their findings give us networks that are applicable in the real world. Though the model specifically was trained on the Prague Stock exchange data, it demonstrates a method to make accurate predictions and help investors make informed decisions about buying and selling stocks.

A paper presenting the comparison between ARIMA, ANN and LSTM by Qihang Ma in 2020, uses these models to give an idea to the investors and individuals as to which model to choose for forecasting [7]. The findings suggest that LSTM has the highest accuracy and predictive ability among all, putting ANN in the second position and ARIMA in third, in terms of performance.

A study highlighting the implementation of LSTM, CNN and SVM and a comparison between them by Li-Pang Chen in 2020, based on four different stocks, analyzes the respective models' performances on stock price data, including open price, close price, daily high price, daily low price, adjusted close price and volume of trades as predictors [8]. The study of this paper results in the conclusion that LSTM and SVR outperform CNN with respect to accuracy of predictions.

Using the National stock exchange (NSE) of India data set, C. Anand, in his 2021 paper [9], compares the performance of machine learning models, namely, CNN, LSTM, RNN, MLP, SVM for stock prediction, by training them with day-wise closing price. The findings show that CNN outperformed all the other models in this case, and even though this model is trained for NSE of India, it gives results for other stock markets as well, in regard to accuracy.

Paper by Yanlie Gu et. al. proposes the use of deep learning and integration of knowledge of human stock traders with AI, neural networks, to create an intelligent trading system for the stock predictions [10]. This research takes a step further and uses LSTM-based deep neural network for time-series data analysis to introduce a model with lower risk and higher earning rate per year. Though working on historical data imposes the risk of fully trusting the predictions for the future, the model proposed takes a step further into developing intelligent systems.

A paper using procedural neural networks (PNN) for stock price prediction presented by Jiuzhen Liang et. al. explores a model that uses both spatial and temporal information in a sync fashion [11]. Authors constructed two different structures of PNN for time series problems and it's modelling. Using the Yahoo stock market historical data for their model training and testing, they compared the results of the simulations with PNN, BNN, HMM and SVM, arriving at the conclusion that PNN is indeed a more accurate and better approach than traditional models and outperforms the other studied models. It should be noted, the model eliminated the sliding time window, adding to its effect.

Operating on New York stock exchange data with two models, ARIMA and ANN, Ayodele Ariyo Adebiyi et. al. meticulously created a study for their comparison [12]. The authors used Dell Inc, stock data for this procedure. The authors proceeded to list the results found that neural networks outperformed the ARIMA model and gave better results all over.

Hungchun Lin et. al. put forward a novel model using technologies to input data, like GAN with GRU, and discriminator for real and predicted stock price, with technology like CNN, in their 2021 paper [13]. The data used for the model was derived from Apple Inc. stock closing price with additional features, generated results which the authors quantified using RMSE. The findings suggest that the proposed model performed better than all the other pre-existing models like ARIMA, LSTM and GRU. An interesting finding also included the effect of unexpected events on the hierarchy of accuracy between the models, i.e., the proposed model (WGAN-GP) performed better in unexpected times, like COVID-19 and basic GAN outperformed the same in normal periods.

A brief characterization of a few of the models and studies mentioned is tabulated below, providing an overview of the diverseness of this field and its implementation.

Table 1. Different literature reviews and methods

Reference Number	Title	Drawbacks
[1]	ARIMA	LSTM outperforms this model
[1]	NN	LSTM outperformes this model
[4]	LSTM based model	Specific stock price prediction is not its strong suit.
[6]	ANN	Data specific results don't give an accurate review.
[8]	CNN	Models like SVR outperform it.
[10]	AI integrated LSTM model	Historical data hinders future predictions' reliability.
[12]	WGAN-GP	Better performer during unexpected times rather than in normal periods.

Thus, this field proposes a diverse bundle of proposed models and applications, making a wide space for financial markets and study.

3. Proposed Model

3.1 Data Description

For the purpose of comparing results of predicting stock prices, the data set chosen is the Tesla Inc. Historical data from the dates 30th June 2010 to 17th March 2017. The data contains fields/columns/divisions namely open, close, high, low, adjusted close price and volume, but only open prices are being considered [16].

3.2 RNN

RNN (Recuurent neural networks) are neural networks where the resultant outputs of the preceding steps are used as further inputs for the next steps. Neural networks' input and output don't have a dependent relationship, that is, they are independent, but RNN create a relationship to solve the problem of correlation. Some predictions are based upon the previous outcomes or predictions/outputs, thus, some sort of correlation and relationship benefit the output. Thus, RNN solves that problem by feeding the output of a particular layer to the next respective layer as input [17].

RNN's major differentiator from other NNs' is its Hidden/Memory state, which remembers some sequence or pattern information of the previous output. It performs the same tasks on all the inputs; thus, it has the same parameters for all hidden layers, further generating the output. In doing so, the introduction of the Hidden state reduces the complexity of parameters. Thus, it can incorporate the previous results for better outcomes than other neural networks [18].

An RNN cell is depicted in Fig. 1 which, when unraveled, gives us the idea of what an RNN looks like with layers and parameters.

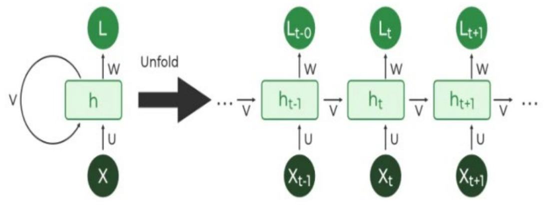

Figure 1. An RNN cell unrolled [14].

For an RNN, hidden states depict the previous knowledge and are applied by formula (1). Thus, hidden states are updated and recalculated for each state using the formula (2). Activation function and output are also generated through the formula (3) and formula (4) respectively.

$$h = \sigma\ (UX + Wh_{-1}\ + B) \quad (1)$$
$$h_t = f\ (h_{t-1} , X_t) \quad (2)$$
$$h_t = tanh\ (W_{hh}\, h_{t-1} + W_{xh}\, x_t) \quad (3)$$
$$y_t = W_{hy}\, h_t \quad (4)$$

Where, the following representation is used,
h -> state,
U, X, W, B -> parameters,
h_t -> current state,
h_{t-1} -> previous state,
W_{hh} -> weight at recurrent neuron,
W_{xh} -> weight at input neuron,
y_t -> output and
W_{hy} -> weight at the output layer.

The proposed model uses 5 layers in total, out of which one is an output layer, all with the same parameters: 'units' for specifying memory units or neurons in each layer; 'activation' parameters for specifying the activation function used, i.e., tanh; and 'return_sequences' set True for the first three layers to ensure layers return complete outputs [19]. We also apply Dropout regularization, which helps by setting a random value of dropping of connection between the layers to ensure over-fitting doesn't occur in our model. The output layer has a single 'unit' as we predict a single regression value of the stock of the next day. Loss function and metric are respectively assigned to Mean Squared Error and accuracy, giving us good results. The workflow diagram for our model for predicting the stock of the next day is as shown in Fig. 2.

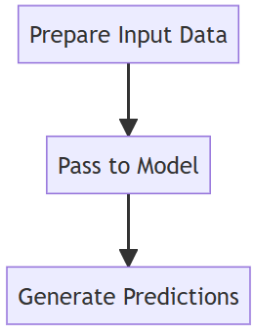

Figure 2. Workflow for RNN model.

Thus, we would get a regression value for our stock price for the next day using RNN.

3.3 LSTM Model

An LSTM network is capable of long-term dependency, which is also a short-coming of the RNN model. They have a chain like structure but with four neural network layers.

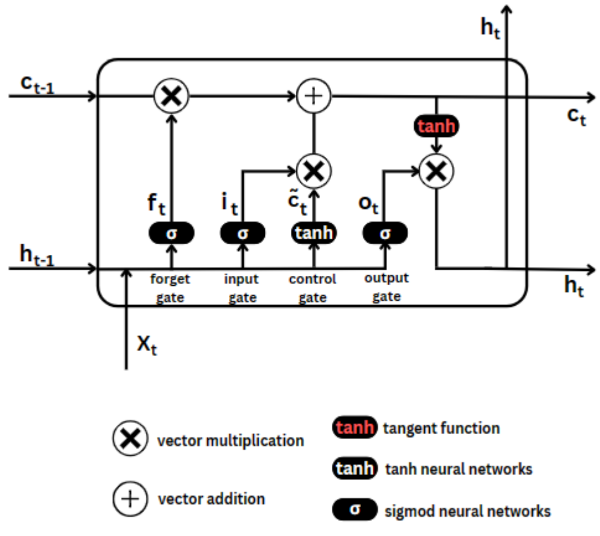

Figure 3. An LSTM cell.

An LSTM network has three gates- input, output and forget gate (Fig. 3.). These gates acquire their weights over time and decide the amount of the latest or most recent data sample to be stored in the memory and how much pre-learned data to be removed [20]. It has three gates -- input, forget, and output, which are in turn represented by i, f and o respectively. The output sent, h, comes from the learned data stored in the cell state C. For each timestamp t, the learned data from the previous timestamp t-1, is taken into account. The equations are represented in the following fashion:

$$i_t = \sigma\ (x_t U^i + h_{t-1} W^i) \quad (1)$$
$$f_t = \sigma\ (x_t U^f + h_{t-1} W^f) \quad (2)$$
$$o_t = \sigma\ (x_t U^o + h_{t-1} W^o) \quad (3)$$
$$\hat{C}_t = tanh\ (x_t U^g + h_{t-1} W^g) \quad (4)$$

$$C_t = \sigma\,(f_t * C_{t-1} + i_t * \hat{C}_t) \quad (5)$$
$$h_t = tanh\,(\,C_t\,) * o_t \quad (6)$$

Three gates have the following roles, keeping in mind the Amount of Information or AOI:

-the input gate decides the AOI to be kept in the current state cell,
-the forget gate decides the AOI to be removed from the current state cell,
-the output gate decides the amount of output the two other gates generate.

This is what makes LSMT different and unique from other networks of the same family, it can regulate the amount of information to be remembered or removed, while training on timestamps [21]. The LSTM model proposed for this study consists of two layers of 64 LSTM neurons each, upon which two dense layers, one with 32 neurons and the other one with a single unit for the regression task, are built for the prediction task. Same as RNN, loss function taken is mean squared error, 'Adam' optimization and accuracy as the metric are kept. The workflow can be described as a diagram as well (Fig. 4).

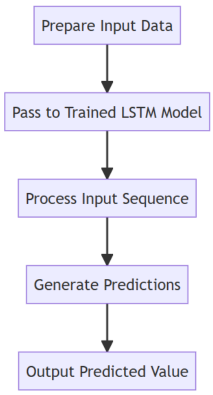

Figure 4. Workflow for LSTM model.

4. Results

Both the models rely on the machine learning algorithms NN (Neural Networks) but have a difference in their predictions. The models were formulated and derived using various preexisting models like LSTM and RNN model for prediction [15]. Revisiting the way, it handles data and gives results for plots and output prediction, findings are presented.

For the RNN model, the plot between X_test and y_test values is shown in Fig. 5. After training and testing our model and giving it a value to predict for the day after our last day in the dataset, we get the results tabulated.

Table 2. Stock Price Values

Model used	Value
RNN	16.982012
LSTM	17.014946
Actual	17.37

For LSTM model, the plot between X_test and y_test values is shown in Fig. 6. After training and testing our model, the forecast value is tabulated.

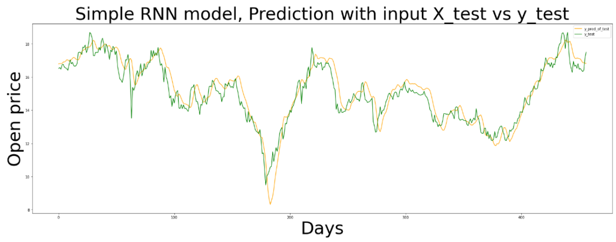

Figure 5. RNN plot.

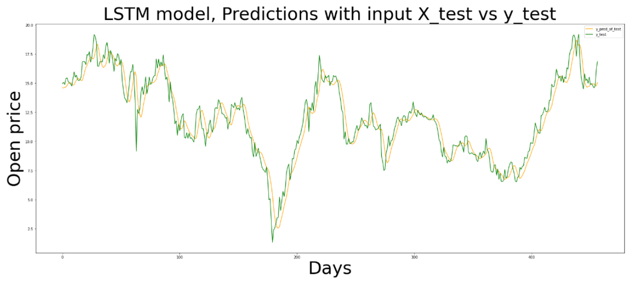

Figure 6. LSTM plot.

5. Conclusion

In this study, possible models for stock price prediction were explored, tested and trained, specifically RNN and LSTM with Tesla Inc. Historical stock price data. We did so to predict the stock price of the date exceeding the data. We got float values close to the actual value, showing our models exceed the traditional methods of stock price prediction.

From the predicted values of the models and comparing them with the actual stock open price value of 20th March 2017, we can say that the LSTM model performed better by being more accurate and precise in giving a value closer to the actual stock price of the said day. This implementation poses a way to predict stock prices in a better and more accurate way. Though both the models gave very close forecasts, LSTM outperformed RNN and can be a good way to predict prices and even better the model by incorporating it with technologies further.

References

[1] M. K. Ho, Hazlina Darman, & Sarah Musa. Stock Price Prediction Using ARIMA, Neural Network and LSTM Models. Journal of Physics, 1988(1). 2021; pp. 12041–12041 10.1088/1742-6596/1988/1/012041.
[2] Malav Shastri, Sudipta Roy, & Mamta Mittal. Stock Price Prediction using Artificial Neural Model: An Application of Big Data. Icst Transactions on Scalable Information Systems. 2018; pp. 6(20), 156085.
[3] Navpreet Kaur. Prediction of Stock Market Price using Neural Network. International Journal of Advanced Research in Computer and Communication Engineering. 2018; pp. 6(1), 308–311.
[4] Narsingh Bahadur Singh, Sugandha, Trilok Mathur, Shivi Agarwal, & K. Tiwari. Stock Price Prediction using Fractional Gradient-Based Long Short Term Memory. Journal of Physics, 1969(1). 2021; pp. 12038–12038.
[5] D. Mahendra Reddy, H. Veeresh Babu, K. Ashok Kumar Reddy, & Y. Saileela. Stock Market Analysis using LSTM in Deep Learning. International Journal of Engineering Research and Technology. 2020; pp. (4).
[6] Jaromír Vrbka, & Zuzana Rowland. Stock price development forecasting using neural networks. Shs Web of Conferences. 2017; pp. 39 01032.
[7] Qihang Ma. Comparison of ARIMA, ANN and LSTM for Stock Price Prediction. E3s Web of Conferences. 2020; pp. 218, 1026–1026.
[8] Li-Pang Chen. Using Machine Learning Algorithms on Prediction of Stock Price. Journal of Modeling and Optimization. 2020; pp. Pp. 12(2), 84–99.
[9] C Anand. Comparison of Stock Price Prediction Models using Pre-trained Neural Networks. Journal of Ubiquitous Computing and Communication Technologies. 2021; pp. Pp. 3(2), 122–134.
[10] Yanlei Gu, Takuya Shibukawa, Yohei Kondo, Shintaro Nagao, & Shunsuke Kamijo. Prediction of Stock Performance Using Deep Neural Networks. Applied Sciences. 2020; pp. 10, 8142-.
[11] Jiuzhen Liang, Wei Song, & Mei Wang. Stock Price Prediction Based on Procedural Neural Networks. Advances in Artificial Neural Systems.2011; pp. 1–11
[12] Ayodele Ariyo Adebiyi, Aderemi Oluyinka Adewumi, & Charles K. Ayo.. Comparison of ARIMA and Artificial Neural Networks Models for Stock Price Prediction. Journal of Applied Mathematics. 2014; pp. 1–7.
[13] HungChun Lin, Chen Chen, Gaofeng Huang, & Amir Jafari.Stock price prediction using Generative Adversarial Networks. Journal of Computer Science. 2021; pp. 17(3), 188–196.
[14] .27, aishwarya. Introduction to recurrent neural network.GeeksforGeeks. https://www.geeksforgeeks.org/introduction-to-recurrent-neural-network/. (2023)
[15] Ozturn, O. Stock price prediction by simple RNN and LSTM. Kaggle. https://www.kaggle.com/code/ozkanozturk/stock-price-prediction-by-simple-rnn-and-lstm/notebook (2020)
[16] S.Subhra, S. Mishra, A. Alkhayyat, V. Sharma and V. Kukreja, "Climatic Temperature Forecasting with Regression Approach," 4th International Conference on Intelligent Engineering and Management (ICIEM), London, United Kingdom. 2023; pp. 1-5.
[17] M.Sen, K. Sharma, S. Mishra, A. Alkhayyat and V. Sharma, "Designing a Smart and Intelligent Ecosystem for Autistic Children," 2023 4th International Conference on Intelligent Engineering and Management (ICIEM), London, United Kingdom. 2023; pp. 1-5.
[18] Sharma, V., Mishra, N., Kukreja, V., Alkhayyat, A., & Elngar, A. A. Framework for Evaluating Ethics in AI. In 2023 International Conference on Innovative Data Communication Technologies and Application (ICIDCA). 2023; pp. 307-312 IEEE.
[19] Ali, M. A., Matubber, M. L., Sharma, V., & Balamurugan, B. (2022, August). An Improved and Efficient Technique for detecting Bengali Fake News using Machine Learning Algorithms. In 2022 6th International Conference On Computing, Communication, Control And Automation (ICCUBEA (pp. 1-4). IEEE.
[20] A.Srivastava, S. Samanta, S. Mishra, A. Alkhayyat, D. Gupta and V. Sharma, "Medi-Assist: A Decision Tree based Chronic Diseases Detection Model," 4th International Conference on Intelligent Engineering and Management (ICIEM), London, United Kingdom. 2023; pp. 1-7.
[21] Raj, A., Kumar, A., Sharma, V., Rani, S., Shanu, A. K., & Singh, T. (2023, February). Applications of Genetic Algorithm with Integrated Machine Learning. In 2023 3rd International Conference on Innovative Practices in Technology and Management (ICIPTM) (pp. 1-6). IEEE.