Prediction of Gold Price using Deep Learning

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***Abstract*— Gold has been the original value and medium of exchange from many centuries. Gold price prediction in India in 2021 according to the last previous rededication is Rs 60,300. By predicting gold price investors will have an idea about when to buy or sell the commodity. Gold price is directly linked to the country's currency and hence affects the stock price. It is seen that the decrease in stock price increases the gold price. This paper is mainly aiming on the early prediction model using Long Short Term Memory (LSTM) and its variance. The proposed model is compared with the widely used linear regression algorithm. It is observed that the Mean Absolute Percentage Error (MAPE) value of Linear Regression, Vanilla, and Stacked LSTM is 10.94, 2.649, and 2.5009 respectively. From the values of MAPE it is observed that LSTM has outperformed compared to Linear regression. Hence early prediction of gold price helps investors to invest or sell the gold at the best possible price.**

Keywords— Prediction, MAPE, LSTM, Linear Regression, MAE,R^2, RMSE.

I. Introduction

In India, the gold industry accounts for about 2.5 million people and handout around 30 billion dollars to the domestic economy [1].Gold plays a very important role in the Indian export market which is a major foreign exchange earner [1]. The gold standard is a financial system where the value of gold is linked to the currency of the country. The gold price has an immense effect on Indian stock price [1]. It is seen that gold and stock price are inverse to each other [1]. Historically it is proved that gold performs well when the stock market is downbeat [1]. A high gold price indicates a non-healthy economy since investors buy gold to protect themselves from the financial crisis. Gold shares are exchange-traded securities that give the owner a complete advantageous possession interest in a trust. Over the years, investing in gold has developed as an ideal fence for resilient markets due to the lack of metal. Recently, gold prices have been increasing constantly. Hence predicting the gold price can help investors to decide when to buy or sell the gold. Various methods are used to predict the gold price over the years such as the Long Short Term Memory-Convolution Neural Network (LSTM-CNN) model, Artificial Neural network, k-nearest neighbors (knn), Autoregressive Integrated Moving Average (ARIMA), Genetic algorithm, and etc. These methods have resulted in some useful information.

In this direction, these are few research studies discussing on gold price prediction. Sami et al [2], using Artificial Neural Network and Linear Regression predicted gold price considering economic indicators of various countries and companies and obtained the accuracy of 66.67%. Further, Latifa et al [3], using Dynamic Ordinary Least Squares (DOLS) model, ARIMA model, and Generalized Auto Regressive Conditional Heteroskedasticity (GARCH) model proved that increase of 1% in oil price increases 0.54% in the gold price. He also proved that the factors such as Oil, Nifty Index, Consumer Price Index(CPI), United States Dollar (USD) to Indian Rupees(INR), International Gold price, and interest rate has high level of influence over the price of gold. Akash Dutt Dubey [4] conducted systematic review of Adaptive Neuro-Fuzzy Inference System Grid Partition (ANFIS-GP) and Neuro-Fuzzy Inference System Subtractive Clustering (ANFIS-SC). He proved ANFIS-GP outperformed ANFIS-SC. ChunmeiLiu[5]; using Neural Network and Back Propagation-algorithm developed a forecasting model for the gold price and obtained the error square of 0.0015 and 0.0009 for Genetic Algorithm Neural Network and Genetic Algorithm - Back Propagation Neural Network. Zhanhong et al [6] conducted a systematic study to integrate LSTM-CNN with an attention mechanism to predict the tendency of gold price with Root Mean Squared Error(RMSE) and MAPE values as 3.07 and 1.54. Abhay et al [7], using Linear Regression to develop a prediction model for forecasting the gold price and obtained R-square as 98.76%. Suranart et al [8], using Neural Network and Radial Bias Function developed a model to predict gold price and obtained MAPE as 5.756 and 3.589 respectively. Futian eat al [9], using Genetic Algorithm Regularization Online Extreme Learning Machine (GA-ROSELM), Support Vector Machine and ARIMA conducted a systematic study to predict gold price with Mean Absolute Error (MAE) as 5.68, 7.40 and 5.83 respectively.

Based on the literature, the following lacunas are identified:

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1 Many studies forecasting in predicting the gold price are based on classical machine learning algorithms. However, it was not explored the deep learning algorithms.

2 In the literature, the recently developed variants of LSTM were not considered on predicting the gold price.

The present study aims at using the variants of LSTM such as Bidirectional LSTM, Vanilla LSTM, and Stacked LSTMfor the prediction of the gold price and then to compare the results with the Linear Regression model.These newly developed variants of LSTM model could provide improved performance due to wide applications and evolution.

The paper is organized as follows:Section 2 describes the methodology,Section 3 present the obtained results, Section 4 discusses the result through discussion and Section5 concludes the paper.

II. Methodology

The proposed framework is described below.

A. *Dataset*

The implementation of the research work is carried out using open source libraries such as pandas,numpy,keras and tensor flow. For the implementation of algorithm python programming language was used. The dataset used for this research work is taken from “world gold council's” website. This dataset is for the global gold prices from 1978 to 2018. This dataset consists of various currencies; we have considered the gold price in Indian rupees. The size of the dataset is478*25.

The features considered in this dataset are currencies and date. The data set is split into 80% training set and 20 % of testing set.

B. *Architecture of the framework*

The detailed framework of the proposed methodology is shown in the Figure.1

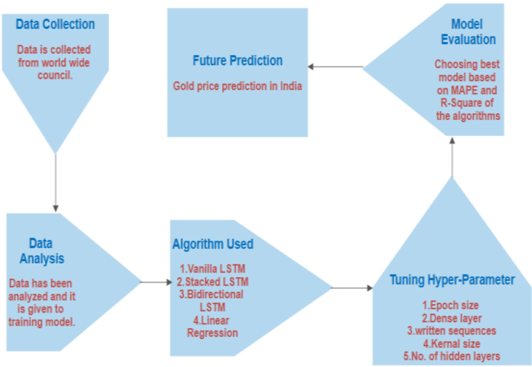

Figure.1: Proposed Methodology Framework

The data was collected from the world gold council website, which further was analyzed for missing or null values. This data has been split into training and testing data, which is then fed for training using some of the deep learning models. Hyper tuning of the data yields us for better performance of the models with the help of different parameters. The models are then evaluated for testing data. After evaluation of the model, the one which gave the best result for MAPE, MAE, RMSE and R-Square will be used for prediction of gold price.

C. *Algorithms Used*

The aim is to forecast the gold price using a regression algorithm and LSTM. In regression we are using linear regression and three different flavors of LSTM i.e., vanilla, stacked and bidirectional, to predict gold price and compare them.

1. *Linear regression:*

$Y = a + bX + e$

- Variable used for predicting is known as the predictor variable, denoted as X
- The variable which is being predicted is known as criterion variable denoted as Y
- Intercept as a, Slope as b, Error term e

2. *Bidirectional LSTM:*

The forward and backward hidden state updates are as follows:

$$\vec{H}_t = \phi\left(x_t w_{xh}^{(f)} + \vec{H}_{t-1} W_{hh}^{(f)} + b_h^{(f)}\right)$$
$$\overleftarrow{H}_t = \phi\left(x_t w_{xh}^{(f)} + \overleftarrow{H}_{t+1} W_{hh}^{(f)} + b_h^{(f)}\right)$$

- x_t is mini batch input at time t
- Φ is hidden layer activation function
- $\vec{H}_t$ and $\overleftarrow{H}_t$ is forward and backward hidden states for this time step
- $w_{xh}^{(f)} w_{hh}^{(f)} w_{xh}^{(b)} w_{hh}^{(b)}$ are weights
- $b_h^{(f)} b_h^{(b)}$ are model parameters

  output layer computes the output O_t

$$O_t = H_t W_{hq} + b_q$$

- H_t is hidden state w_{hq} is weight matrix b_q is bias.

3. *Vanilla LSTM:*

Forward pass of an LSTM unit with a forget gate is:

$$f_t = \sigma_g\left(w_f x_t + U_f h_{t-1} + b_t\right)$$
$$i_t = \sigma_g(W_i x_t + U_i h_{t-1} + b_i)$$
$$O_t = \sigma g(W_0 x_t + U_0 h_{t-1} + b_0)$$
$$\tilde{c}_t = \sigma_g(W_c x_t + U_c h_{t-1} + b_c)$$
$$c_t = f_t \odot c_{t-1} + i_t \odot \tilde{c}_t$$
$$h_t = o_t \odot \sigma_h(c_t)$$

- Initial values are co = 0 and ho = 0, operator ⊙ denotes the Hadamard product.
- x_t input vector to the LSTM unit, f_t forget gate's activation vector.
- i_t input/update gate's activation vector, o_t output gate's activation vector, h_t hidden state vector also known as output vector of the LSTM unit.

- $\tilde{c}_t$ cell input activation vector, c_t cell state vector, W weight matrices, Ubias vector. $\sigma_g, \sigma_c, \sigma_h$ sigmoid function and hyperbolic tangent function.

4. *Stacked LSTM:*

$$f_t = \sigma\left(w_f x_t + w_{hf} h_{t-1} + w_{cf} c_{t-1} + b_f\right)$$

$$i_t = \sigma(W_{xi} x_t + W_{hi} h_{t-1} + w_{ci} c_{t-1} + b_i)$$

$$O_t = \sigma(W_{xo} x_t + W_{ho} h_{t-1} + W_{co} c_t + b_0)$$

$$c_t = f_t \odot c_{t-1} + i_t \odot tanh(W_{xc} x_t W_{hc} h_{t-1} + b_c)$$

$$h_t = o_t \odot tanh(c_t)$$

- x_t is an input of the model
- W_{xj} for j ∈ {i, f, o, c} are the weights that connect the input.
- f_t, i_t, O_t, c_t and h_t to be the values of the input gate, forget gate, output gate, memory cell and hidden state at time t.

III. Results

The performance of the model is evaluated using,R^2RMSE, MAE and MAPE. From the Table I it is observed that vanilla LSTM and stacked LSTM has outperformed other models in R-Square, RMSE, MAE and MAPE.

From Figure.2, it is observed that Bidirectional LSTM has higher variationin predicting the gold price compared to the actual values therefore resulting in higher error of -20728.9and 100 errors for R^2 and MAPE and 0.929 and 0.927for RMSE and MAE respectively.

Figure.2: Bidirectional LSTM

From Figure.3, it is observed that Linear Regression model has given higher predicted values than the actual value, thus resulting to an error of 61.93 and 10.94 error for R^2 and MAPE and0.153 and 0.121for RMSE and MAE respectively.

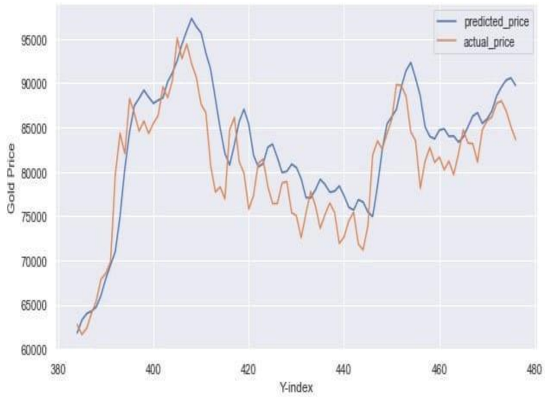

Figure.3: Linear Regression

From Figure.4 and Figure.5 it is observed that vanilla and stacked LSTM has predicted values more approximate thus resulting in a very smaller R^2, MAPE, RMSE and MAE values.

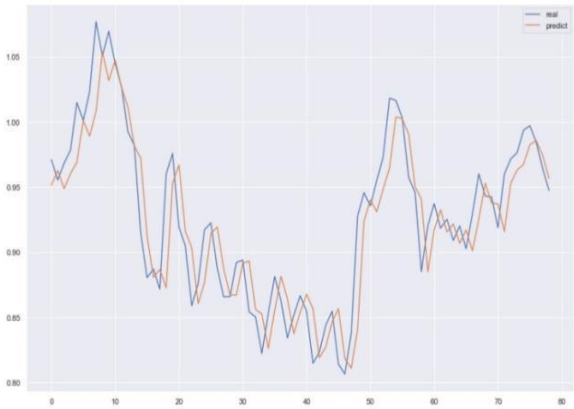

Figure.4: Vanilla LSTM

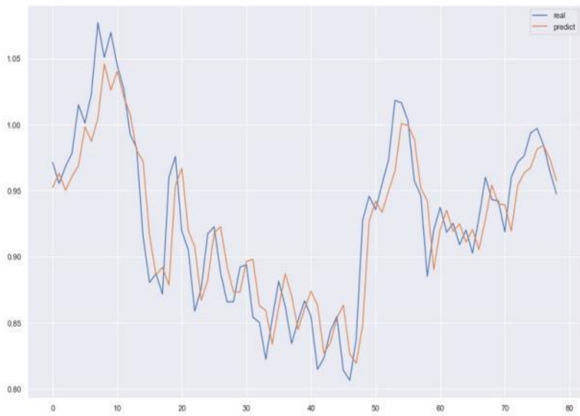

FIGURE.4: Stacked LSTM

TABLE I. PERFORMANCE OF DIFFERENT MODELS

Methods	R^2	*MAPE*	*RMSE*	*MAE*
Linear Regression	61.35	10.94	0.153	0.121
Bidirectional LSTM	-20728.9	100	0.929	0.927
Vanilla LSTM	79.76	2.649	0.0292	0.022
Stacked LSTM	79.22	2.5009	0.0291	0.022

IV. DISSCUSSION

In this study the algorithms used are linear regression, bidirectional LSTM, vanilla LSTM, stacked LSTM for forecasting, and the proposed study uses two methods of performance measurement for the accuracy of our model namely R^2 , RMSE, MAE and MAPE. This implementation showed that bidirectional LSTM gave maximum error compared to other methods. Further it was found that linear regression gave more error than vanilla and stacked LSTM while vanilla and stacked LSTM gave the sameR^2, MAPE, RMSE and MAE.Regression and variants of LSTM (bidirectional LSTM, vanilla LSTM, stacked LSTM).

The performance of the methods is evaluated using R^2 ,MAPE, RMSE and MAE. The result of this study indicated that vanilla and stacked LSTM models have provided lessR^2, MAPE,RMSE and MAE compared to other models, showing their efficacy. It is interesting to compare the results of this study with the state-of-the-art methods available in the literature as shown in the Table II. In comparison with the previous studies, our implementation has a better accuracy model.

TABLE II. COMPARISION OF EXISTING REASEARCH

Existing Work	Algorithms Used	Results Obtained
Sakir Bingol, Safaa Sadik	Multiple Regression and SVM	Obtained MAE and R^2 for Multiple regression as 126.92 and 0.89 and for SVM as 217.6 and 0.73 respectively.
KhanOksinSuranart, SupapornKiattisin	Neural Network, Radial Basis Function(RBF)	Neural Network and RBF obtained MAPE of 5.756 and 3.589 respectively.
Ziyan Xie,, Yiwen Zhong	ARIMA, SVR, Back Propagation.	MAE for ARIMA ,SVR,BP,LSTM are 2.71, 2.56, 2.33, 1,84 and RMSE for the same is 3.36, 3.23,2.99 and 2.27 resp.
Zhanhong He, Junhao Zhou	CNN-LSTM	Obtained MAPE of 1.54E+00 and RMSE of 3.07E+01.
Futian Weng, Zheng Wang, Muzhou Hou	GA-ROSELM, SVM , ARIMA	MAE obtained was 5.68, 7.40 and 5.83 respectively.
Pr. Latifa Ghalayini1, Sara Farhat2	Dynamic OLS model, ARIMA model,GARCH model	Increase of 1%in oil Price increases 0.54% in gold price
AkashDuttDubey	ANFIS-GP, ANFIS-SC	MAE for ANFIS-GP is 10.82 and for ANFIS-SC is 10.88and RMSE as 15.9 and 16.2 resp.
Proposed work	LSTM & its variants, Linear Regression	R^2MAPE, RMSE and MAE values for Linear Regression are 61.35, 10.94, 0.153 and 0.121 and for Vanilla and Stacked LSTM,R^2 is 79.76 and 79.22, MAPE is 2.64 and 2.50, RMSE is 0.029 and MAE is 0.022 for both.

V. CONCLUSION

The strength of the proposed model involves inclusion of LSTM and its variants in comparison with Linear Regression model. The current study evaluated using R2, RMSE, MAE and MAPE; the result shows Vanilla and Stacked LSTM outperformed other models. Although the prediction of gold price of Linear Regression model is predicted very close to the gold price but a high R^2,MAPE,RMSE and MAE is found. Even though availability of many methods proposed for gold price forecasting, there is still no optimal solution to forecast the gold price as it depends a lot onexternal factors which cannot be modeled accurately.

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