Gold Price Prediction and Modelling using Deep Learning Techniques

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***Abstract*— The demand for gold never ends. The gold rate trend shows that gold is one of the best investment plans. So it is wise to predict the trend of the gold rate. Different statistical models can be used for suitable modelling and prediction of data. This paper summarizes the idea of gold rate prediction using the LSTM Network. It is always visible that the price of gold follows a nonlinear nature. The prediction of prices is commanding for the proper financial and investment plans. The gold rate fluctuation can be modelled as an exponential curve. Convolutional Neural Networks is one of the best solutions for solving nonlinearities in data and among them RNNs are best suited for time series predictions and estimations. The dataset collected from the World Gold Council is used and results have shown that the proposed architecture is one of the best financial forecasting methods.**

***Index Terms*—LSTM, Exponential, CNN, RNN, Prediction, Estimation.**

I. Introduction

Finance is imperative in our life and for the development of the economy, financial prognosticating is inevitable. Recently, economists or investigators are looking into mathematical methods to analyze the financial data with the aim of making divination accurately. Financial data processing and analysing are gaining importance nowadays. It is very hard and computationally complex to study the behaviour of financial data. Many factors are affecting the pricing of different commodities. The fluctuations in the market, economic policies, epidemics, weather conditions, etc are some of the factors that greatly affect it. The financial area is highly complex and nonlinear with profuse factors influencing the estimation. So the financial data always shows a nonlinear behaviour.

The nonlinearity in the data can be extracted to analyse the behaviour and is an exquisite nowadays so that proper financial plans can be executed. People used to go behind the gold price analysis even in the early seventies and they analysed that government policies in the US are a key factor in gold pricing [1]. Later economists used to argue that there occured an economic dependancy between gold and silver prices. But Schweikert and Karsten [2] statistically proved that there is no co-integrated relation between them in determining the price. The study of gold price volatility and market behaviour had been a fascinating topic in international finance [3, 4, 5]. Khan [6] used the ARIMA method, Box Jenkins technique to model and develop a gold prediction model. Box-Jenkins ARIMA was one of the advanced techniques of the time sequential forecasting. Eventhough the ARIMA model is good for predicting wavering variables like gold price, its limitations are that its modelling requires a long time series and forecasts could be made only for the near future [7], further substantiated by Abdullah [8]. The modelling of financial data entails different mathematical models such as ARMA models [9], Covariance Matrix estimation [10], Asymptotic Analysis [11] [12], multivariate statistical analysis [13]. Zainal et. al proposed gold price forecasting techniques using one of the optimization algorithm called Grey Wolf Optimizer (GWO) [14].

Another promising gold price prediction technique was by using Artificial Neural Network(ANN). ANN replicates the human brain mechanism to implement computing behaviour. Mombeini et. al [15] used this technique and compared with ARIMA models by analysing three performance evaluation measures viz Mean Absolute Error(MAE), Coefficient of Determination(R2), and Root Mean Square Error(RMSE). The results proved that the prediction results of the ANN model during the validation phase outperform the

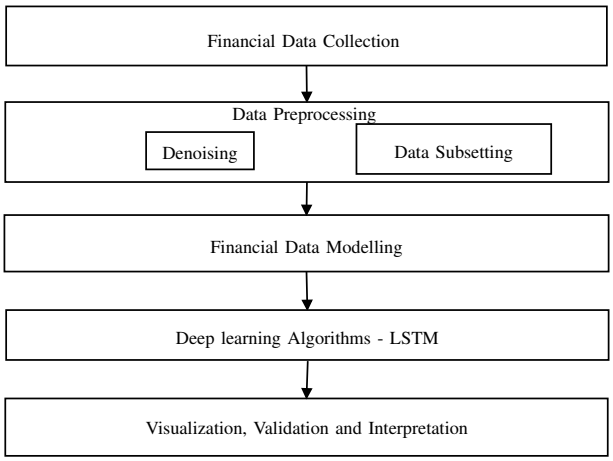

Fig. 1: Methodology of work

ARIMA model. Other prediction techniques used in this area are genetic algorithm BP neural network (GA-BP) forecasting model [16], Multiple Linear Regression(MLR) method [17], Dynamic Model Averaging [18] technique, Factor-Augmented Vector Autoregressive(FA VAR) model [5] and Empirical Mode Decomposition(EMD) model [19].

The core problem in this area is the selection of optimal analysis strategy and the asset pricing theory under nonlinear conditions. Recent advances in deep learning methods have indicated exceptional outcomes in fields as diverse as technology, healthcare, finance, human resources, retail, earthquake detection, and self-driving cars. Convolutional neural networks can detect nonlinear relationships in the characteristics of data and is now revolutionizing the field of computational science. In particular, for time series data, such as signals, passenger flow, stock prices, and so on, a long short-term memory (LSTM) is the best choice for learning temporal patterns in deep neural networks (DNNs). An LSTM network does not have a vanishing gradient problem as that of in a recurrent neural network (RNN) [20, 21] and thus it is the suitable choice to learn long-term dependencies in time series data using memory cells and gates. Many endeavors have been made to forecast stock prices using this network [22] [23]. These studies confirmed that the performance of the LSTM model outshined other models. In this paper, an LSTM network is proposed to predict the gold rate from a picture of a time series of past price fluctuations.

II. Methodology

The work methodology is as shown(Fig. 1) The data for the past thirty years, obtained from the World Gold Council has been selected for the study. The collected data is tabulated into a CSV file and is processed into a format that is suitable for study. Once the preprocessing is over, data is analysed and modelled to verify the fluctuations and nonlinearities present in it. While doing preliminary analysis on the data which contains the daily gold price rates from January 1, 1979, to July 2020 (only on trading days), it can be seen that the gold price is following an exponential curve. Deep learning techniques can very well extract the details in it. Before inputting the data onto the network, it has to be processed into a format suitable for training the network. The data is scaled to lie between a given minimum and maximum value, usually between zero and one, so that the maximum absolute value of each feature is scaled to unit size. The pre-processed data is then fed to Long Short-term Memory Networks (LSTM) to predict the sequences. The LSTM network can extricate the dependancies and can predict the variations.

III. Model

As we analyse the gold price rate over years, price rate on different days can be modelled as an exponentially growing curve. When the given data is validated against an exponential curve,it gave a best fit given by Fig. 2 Exponential smoothing model is a kind of important model among extrapolation methods. The robustness and accuracy of the method have led its widespread use in a variety of applications [24, 25, 26, 27, 28]. The exponential function is given by

$$X(t) = k_1(1 + e^{k_2 t}) \tag{1}$$

IV. LSTM

The traditional neural networks that are commonly used cannot carry out short-term time dependant prediction, since it is not based on the previous several time steps and dependencies between the time series. The networks that can extrapolate subsequent events using previous events is Recurrent Neural Network(RNN) [29]. The traditional Recurrent Neural Network cannot contemplate the effect of long-term memory in several practical applications. The LSTM has a knotty structure that allows it to easily retain information for an extended number of time steps [30].

The LSTM network, an artificial recurrent neural network(RNN), is first proposed by Hochreiter and Schmidhuber [31] and improved by Alex Graves [32]. The LSTM is an RNN with loops in them, allowing it to retain the information. LSTM layer consists of a series of LSTM units, called the LSTM model. Compared with other neural networks, the LSTM model has three multiplicative units, viz, input gate, output gate, and forget gate. The function of the input gate(represented as i_t) is to control the extent to which a new value flows into the cell and to memorize some information of the present. The forget gate(denoted as f_t)determines the extent to which values need to be remained or be

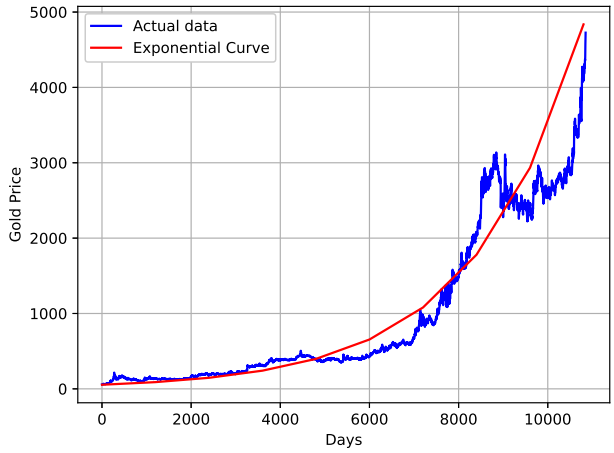

Fig. 2: Gold Price Modelling

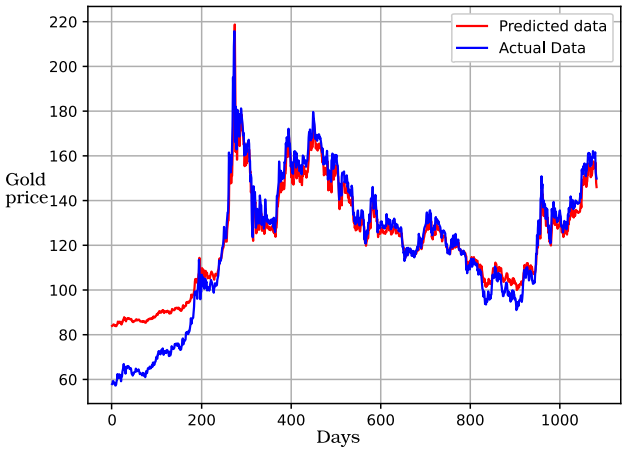

Fig. 3: Predicted Output

forgotten (uses a sigmoid function that produces 0 or 1). And the output gate(denoted as o_t) determines the range to which the value in the cell is used to evaluate the output activation of the LSTM unit.

The architecture is presented by the following equations.

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

$$f_t = \sigma(W_f.[h_{t-1}, x_t], b_f) \tag{3}$$

$$o_t = \sigma(W_o.[h_{t1}, x_t] + b_o) \tag{4}$$

Eq. (2), (3) and (4) represents the input, forget and output gate expressions respectively, which takes the weighted sum of the state of the cell at time t, the output of cell at time t-1, and the input at time t as the input of activation function to get the output. The activation function is generally a logistic sigmoid function represented by σ. b_x represents the biases for the respective gates(x) [33]. The equations for the cell state, candidate cell state, and the final output are as follows.

$$\tilde{c_t} = tanh(w_c.[h_{t-1}, x_t] + b_c) \tag{5}$$

$$c_t = f_t * c_{t-1} + i_t * \tilde{c_t} \tag{6}$$

$$h_t = o_t tanh(c_t) \tag{7}$$

V. Results and Conclusion

To obtain an authenticate dataset, the website of the World Gold Council is accessed and the data from the year 1987 to July 2020, including yearly, quarterly, monthly, and daily gold price in INR, US dollar, EURO, RMB, HK dollar, etc. per ounce. is downloaded. To be more specific, dataset specified in daily gold price (from January 2, 1979, to July 31, 2020, total 10850 trading days) in INR per ounce is chosen to make analysis prediction.

An LSTM model is developed and data is trained using this network. The optimizer chosen is 'adam' and the performance is evaluated using root mean square error(RMSE) [34]. The output of the trained network shows that the predicted data almost follows the actual data. The RMSE value obtained is 7.385 for the test data. It is very clear from the figure that, initially the price value deflected a little bit from the original value due to the convergence time. After that prediction almost follows the actual value.

In this paper, an LSTM network is designed and developed to predict the nature of the gold rate. The results indicate that our proposed model outplays traditional methods such as ARIMA, covariance matrix estimation, deep regression, SVR, CNN. Moreover, it would be better to test different types of RNNs apart from the LSTM component for our model. For instance, using bidirectional LSTM network models might obtain better results.

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