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Article

Yemeni Riyal Exchange Rate Prediction Using Predictive Models Based on Artificial Intelligent

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Abstract

Foreign currency, such as the dollar, plays a fundamental role in controlling market prices in many countries, because the import and export process takes place through these foreign currencies. Predicting the exchange rates of these changing currencies is a task with great challenges. The main purpose of this paper is to build a system based on Artificial Intelligence to predict the exchange rate between US Dollar (USD) and Yemen Riyal (YER) for the next day or several days in the future. The artificial intelligence exploit two techniques, Recurrent Neural Network (RNN) and Machine Learning (ML). The proposed model uses recurrent Neural Network that exploits long short-term memory (LSTM) and machine learning with three models (Linear Regression Model, Random Forest Regression and Gradient boosted regression) to predict the currency USD/YER for the next day or several days in the future with the highest accuracy. The objective function of training and testing the prediction models to find out performance of proposed models by calculating the root mean square error which came out to be very low. The best results were obtained using Random Forest Regression model in root mean square error training that reached 0.0448 and the best result in root mean square error testing was obtained using Linear Regression model that reached 0.1070.

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1. Introduction

Since the last few decades, the foreign exchange markets in the world have witnessed an increase in all parts of the world. The exchange rate is an important parameter and crucial parameter in businesses and companies which has made forecasting of exchange rates an important area in all business sectors. A small change in the exchange rate affects an increase in the prices of the products and this forces the seller to pay more money, which creates problems and a burden on the citizen. Therefore, the economic stability of countries is important in in the stability of the foreign exchange, as economically stable countries have a more valuable currency. And therefore the exchange rate becomes easier to predict, while unstable countries have a less valuable currency, and the currency becomes more difficult to predict. Investors around the world choose economically stable countries to build their companies and deposit their money in their banks in their own currencies. In recent years, the exchange rate in Yemen has become unstable due to economic instability, and this has led to fluctuations in exchange rates, which made predicting exchange rates very difficult. Therefore, in this paper, we decided to build a system for predicting exchange rates between Dollar and Yemen Riyal. There are systems that are used to forecast exchange rates, but they are complicated and their accuracy is weak, which makes prediction less reliable and therefore it was necessary to find more efficient and reliable systems. In recent times, the use of artificial intelligence in many sectors has become very important, especially in the economic sector, such as predicting exchange rates and stock prices in companies or banks. This paper presents a system to predict the exchange rate between the Dollar and Yemen Riyal using artificial intelligence that uses Recurrent Neural Network and Machine Learning due to the high accuracy of prediction. We tested all models on the dataset and found that the best model is linear regression model that has minimum root mean square error in testing prediction that reached 0.1070.

The paper is organized into six section: The second section presents the background material and previous work which is most related to the field of this research. In section 3 the methodology is presented. Proposed techniques and how they're implemented are given in section 4. The experiment results of the proposed method presented in section 5. In section 6, conclusions and the future work of the research are presented.

2. Related Work

We present an overview of literature that relates to work presented here. The change in currency exchange rates sometimes leads to a large loss in trade operations in the event that it was not properly predicted [1]. So, one of the most direction of research in economic sciences is exchange rates prediction using artificial intelligence. Jefferson et al. [2] presented a paper for Canadian–US exchange rate prediction using different artificial intelligence models and applied a comparison between the performance of these models. Kamruzzaman et al. [3] presented three models of neural networks that predict the Australian exchange rate against six foreign currencies. These neural networks showed an ability to predict exchange rates closely. Reference [4] proposed Turkish prediction rate using different neural network models. Weigend et al. proposed prediction models for the German exchange rate against the dollar based on neural network and stochastic walking model, and the results for neural networks were better [5].

Mehreen R et al. [6] presented a paper for exchange rate predictions which made a novel approach to predict exchange rate by using CGP

and RNN called (RCGPANN). Podding et al. [7] presented the results of the German exchange rate prediction model against the dollar, and the results obtained were compared with the regression analysis model. In [8], authors propose a system that making comparison between two different model (ANN and RNN) which used to predict exchange rates Rupees/ US, Rupees/ Euro and Rupees/ Pound Sterling. The paper by [9] presented the results of a prediction comparison between the US dollar and the German dollar using neural networks and linear models. Fernando et al. [10] presented a paper that compared the efficiency of various artificial neural network to stock prices prediction. Multilayer perceptron has been built with Levenberg Marquardt, GRU and LSTM for stock market prediction. In this paper, prediction model of the exchange rates between Dollar against Yemen Riyal has been built using recurrent neural network that uses LSTM model and machine learning with three models (Linear Regression Model, Random Forest Regression and Gradient boosted regression).

3. Methodology

In this section, we will discuss the method that used to build a system for predicting exchange rates between Dollar against Yemen Riyal by using three main phases approach. The following steps summarize the methodology used to achieve the proposed method:

3.1. Dataset Collection

The dataset was obtained from the website [11]. The dataset contains the USD/YER exchange from date 16-jun-2016 to 31-jun-2020. This data consists of 1077 days of data for exchange rates are as listed in the Table 1 and shown in Figure 1.

Table 1. USD_YER exchange rate.

Date	Rate
16-jun-2016	250.1
17-jun-2016	250.15
20-jun-2016	249.935
.....	.....

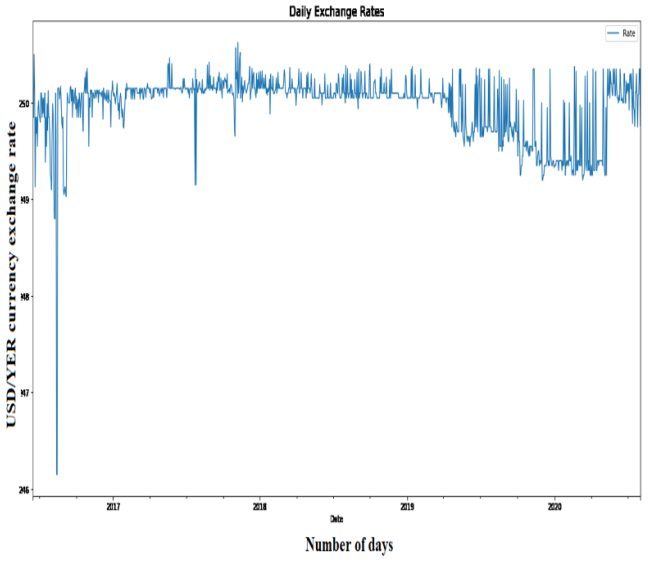

Figure 1. Plot of currency exchange rate value for USD _ YER.

3.2. Training Phase

After preparing data, we start training the model on the collected dataset with the following steps:

- **Load Dataset:** In this step, dataset is loaded to fit the training phase.
- **Data preprocessing:** This step is aimed to normlize the dataset between zero and one.
- **Training Using LSTM model:** In this step the system was trained by the LSTM model and the dataset was divided into 80% for training and 20% for testing. Figure 2 shows the proposed model for predicting exchange rates using the LSTM model.
- **Training Using Machine Learning Models:** In this step the system was trained using Machine Learning Models (Linear Regression Model, Random Forest Regression and Gradient boosted regression). The dataset was divided into 80% for training and 20% for testing. Figure 2 shows the proposed models for

predicting exchange rates using the using Machine Learning Models.

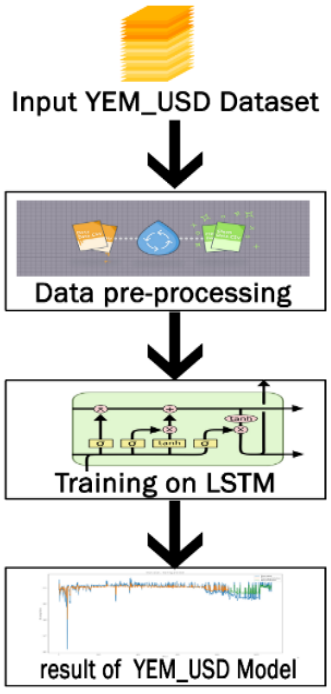

Figure 2. The proposed model for predicting exchange rates using the LSTM model.

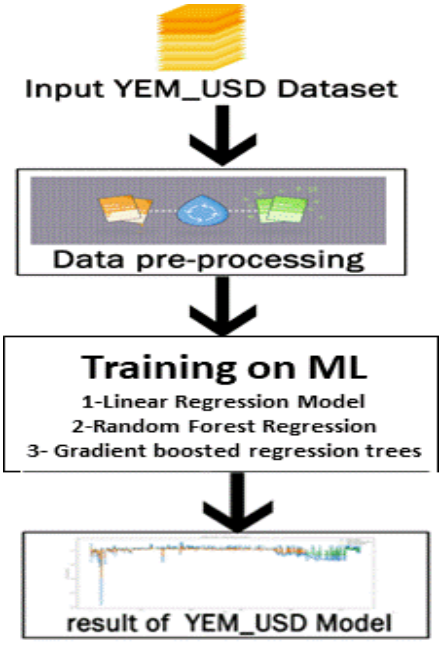

Figure 3. The proposed model for predicting exchange rates using the using Machine Learning Models.

3.3. Testing Phase

At this phase, future data is entered for the system to make predictions based on the training model that was done. The testing phase consists of following steps:

- **Data pre-processing:** This step is aimed to normalize the dataset between zero and one.
- **Prediction phase:** Prediction phase is the last phase, in which all models (LSTM, Linear Regression Model, Random Forest Regression and Gradient boosted regression) produce accurate prediction of USD/YER exchange rate for the next day.

4. Techniques

In this section, we will discuss proposed techniques that used to build an effective system that able to predict the exchange rates between Dollar against Yemen Riyal for the next day.

4.1. Artificial Neural Network

Artificial neural networks are part of artificial intelligence that is used to simulate the human brain and has many practical applications, including pattern recognition and also in the fields of prediction [12]. ANN contains a collection of nodes called neurons which connected together by link called edge as shown in Figure 4. This edge used to transmit the signal between neurons. Each edge has weight value which increase or decrease in self-learning process. ANN has three layers: input, hidden and output layer.

Input layer: Data will input to the neural network by using input layer.

Hidden layer: These layers used to process a data that come from input layer.

Output layer: After processing the data in the previous layer, it is passed on to the output layer.

Each input in the input layer has value denoted by Xn. and every edge in neural network has weight value denoted by Wn.

The value of the output layer denoted by Yn which calculate as the following equation 1:

$$Y = \text{Activation\_function}(\sum_{j=1}^{n} Xj * Wij) \quad (1)$$

The activation function as see in rule1 used to determine if the value will pass (1) or not (0).

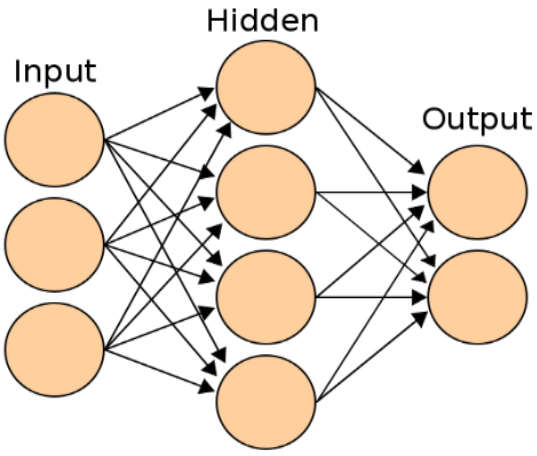

Figure 4. Architecture of ANN.

4.2. Recurrent Neural Network

A RNN is a class of neural networks that differs from other types by contain internal memory which used to store the inputs that come from each node (see Figure 5). This difference making the RNN more precise than others. One of the limitations of recurrent neural networks is that they have short-term memory. This memory was not enough if there are long series of information. So, LSTM built to solve this problem.

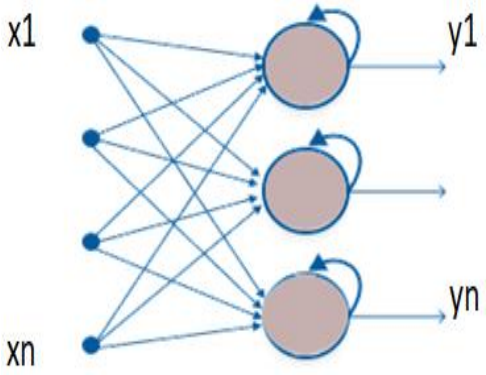

Figure 5. Architecture of Recurrent Neural Network.

- **Long Short Term Memory:** LSTM is specific type of RNN that introduced by Hochreiter et al. [13] which used to learn the long-term dependency. It is containing cell state, input gates, output gates and forget gates as shown in Figure 6.

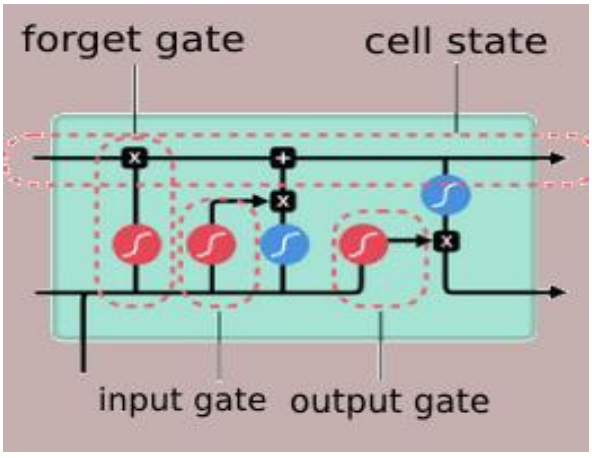

Figure 6. LSTM gates.

- **Input gate.** This gateway is used to discover the value of the input used to update the memory and combines the previous output with the new input and passes it through the sigmoid activation function. An input gate has an equation of the following form:

$$it = \sigma(Wi.[ht-1.Xt] + bi) \quad (2)$$

Were (σ) is the a logistic sigmoid function, *Wi* and *bi* are the parameter to learn, Xt is the input sequence, ht is the hidden state of the encoder at time t. A candidate layer gate has an equation of the following form:

$$C't = \tanh(Wc.[ht-1.Xt] + bc \quad (3)$$

Where *tanh* is the hyperbolic tangent function, *Wc* and *bc* are the parameter to learn, $C't$ - this internal memory of the cell [14].

- **Forget gates.** This gate is used to detect details that should to remove them from block which used sigmoid activation function. If the value of output (ft) is 0 then previous output will remove and keep it if (ft) =1 in the number of $C't$. A forget gates has an equation of the following form:

$$ft = \sigma(Wf.[ht-1.Xt]) \quad (4)$$

- **Output gates.** This gate determines the value of

internal state is passed through (0 and 1) to the output gate. An output gate has been shown in the following equations 5 and 6.

$$ot = \sigma(Wo.[ht - 1.Xt] + bo) \quad (5)$$

$$\text{ht} = \text{ot} * \tanh(\text{C't}) \quad (6)$$

4.3. Machine Learning

Machine Learning methods are part of artificial intelligence which used for prediction. The proposed model uses three ML algorithms including, linear regression model, random forest regression and gradient boosted regression.

Linear Regression Model: The Linear Regression is a part of machine learning, that is used to fit predictive model to a data can be used to predict future data. A linear regression model looks as a line has an equation as follows:

$$\hat{y}=w[0]*x[0]+...+w[p]*x[p]+b \quad (7)$$

where x[0] to x[p] are the features, w and b are the parameter to learn and ŷ is the prediction model [15].

Random Forest Regression: Random forest is a part of machine learning was introduced by Breiman in 2001, by integrating between classification and regression tree [16]. The Random forest is construct by integrating the multiple decision trees randomly, that trains several trees in parallel. The results are aggregated, through model averaging as shown in Figure 7.

Gradient Boosted Regression: The gradient boosted regression is a machine learning technique, which is a grouping of trees in a sequence where each tree corrects the errors of the previous tree, making the model smaller in terms of memory and making predictions faster and thus the model becomes more powerful. Figure 8 shows the structure of Gradient boosted regression.

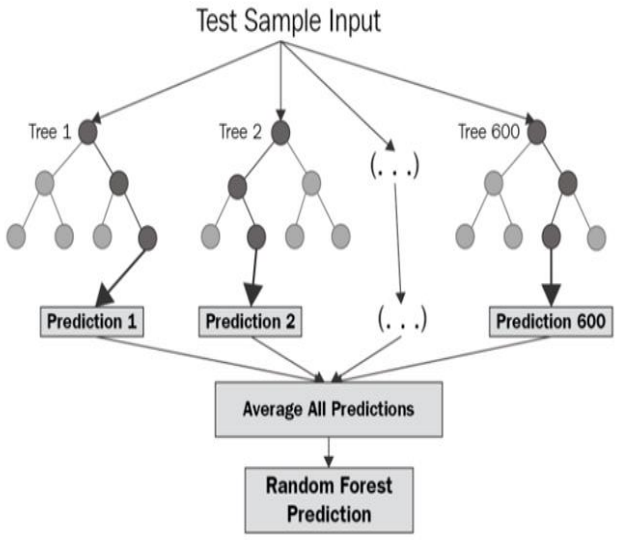

Figure 7. Random Forest structure.

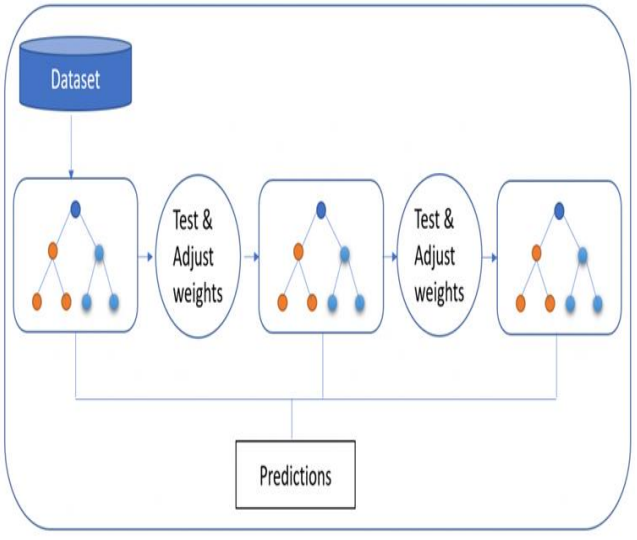

Figure 8. Gradient boosted regression structure.

5. Results

In this paper, exchange rate prediction model has been built between US Dollar (USD) and Yemen Riyal (YER) for the next day and or several days in the future using predictive models based on Artificial Intelligence. The proposed models, namely Recurrent artificial neural network model (LSTM) and Machine learning models (Linear Regression, Random Forest Regression and Gradient boosted regression) can be used to build an effective system that able to predict the USD/YER exchange rate for the next day. Every model shows independent performance. There are

two different currencies Dollar and Yemen Riyals presented in our dataset. We have selected one dollar against Yemen Riyal. Data was analyzed using proposed models and was provided experimental evaluation of these models in Table 2. The Table 2 summarizes the results for the training sets and the prediction results in the testing sets with 100 epochs and 20 batch sizes by using proposed models (LSTM, Linear Regression, Random Forest Regression and Gradient boosted regression) to predict the exchange rate of USD/YER for the next day. As demonstrated in the below table, the best result was obtained using Random Forest Regression model in root mean square error (RMSE) of training that reached 0.0448 and the best result of prediction in root mean square error of testing was obtained using Linear Regression model that reached 0.1070.

Table 2. Prediction performance of the model.

Model	RMSE training	RMSE testing
LSTM	0.2485	0.3580
Linear Regression	0.0531	0.1070
Random Forest Regression	0.0448	0.1185
Gradient boosted regression	0.0450	0.1157

The result of prediction values of training and testing can be seen in Figure 9. From the below plot we can note that the blue line denoted to the actual daily USD/YER exchange rate values, the yellow line represented the data which used as training data and the green line represented the predicted values for testing set.

6. Conclusion

The main conclusions of this paper is to predict USD /YER currency exchange rate for the next day by using predictive models based on Artificial Intelligence techniques. This paper describes tow artificial intelligence techniques, RNN and ML, and presents a comparison between LSTM and models of ML (Linear Regression, Random Forest Regression and Gradient boosted regression). The objective function of training and testing the prediction models are to minimize the error in the model. The best result with the Random Forest Regression model in RMSE of training that reached 0.0448 and the best result of prediction of testing was obtained using Linear Regression model that reached 0.1070. In the future searches, we will propose another types of currencies such as Euro and Pound Sterling to predict exchange rate between Yemen Riyals and them. Also will propose others algorithm that will give better result.

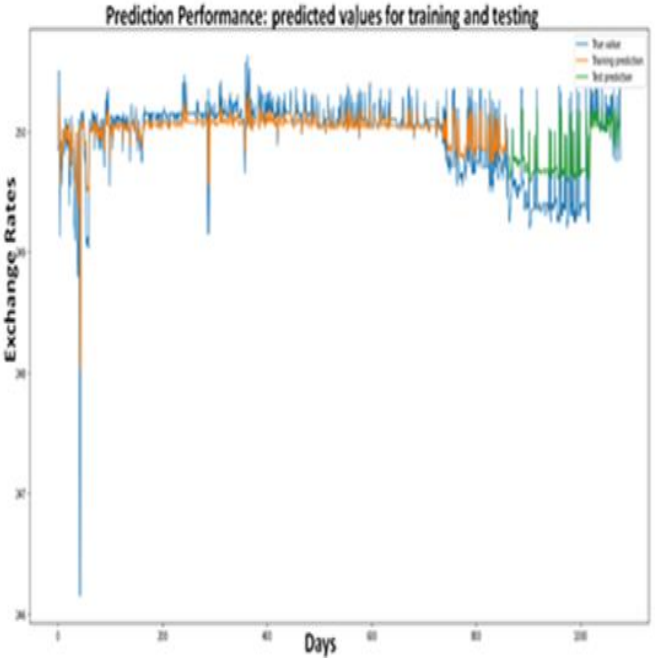

Figure 9. Prediction Performance of USD/YER currency: actual USD /YER vs predicted values for testing set.

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