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Prediction of Forex Rate Using Deep Learning: US Dollar to Sri Lankan Rupees

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***Abstract*—**Exchange rate forecasting is a vital problem in the economic aspect of every country in the world. Prediction of the foreign exchange rate is a very complex and challenging task. A more in-depth analysis and forecasting techniques assist the traders in good decision-making in their commercial activities. This paper discusses forecasting of USD to LKR foreign exchange rate using Artificial Neural Network (ANN) and Recurrent Neural Networks (RNN). This study used two variant Recurrent Neural Networks, Long Short Term Memory (LSTM) and Gated Recurrent Unit (GRU). Rectified Linear Unit (ReLU) is used as an activation function. Adam and Stochastic Gradient Descent (SGD) are used as the optimizers in this research. The study mainly compares the performance of ANN, LSTM, and GRU prediction rates with two different optimizers Adam and SDG. Mean Square Error (MSE) is used as the loss function. The study finds that GRU with Adam optimizer performs better than other approaches in terms of R2 squared (Coefficient of determination), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE). In contrast, LSTM performs better with SDG optimizer when compared to Adam.

***Keywords*—**deep learning, financial time series forecasting, recurrent neural networks, foreign exchange rate

I. Introduction

Foreign Exchange (FOREX), in today's world, is the most important liquid market and the global scale trading of currency. It is one of the risky markets, and factors such as political, correlated economies, supply and demand, and psychological factors influence the FOREX market. An exchange rate is a relative price between two different currencies. The monetary value of a country's currency for undertaking international trade for goods, finance, and services is the key to a 'country's economic condition. The Central Banks function as the authoritative body for the monetary operations of a nation. A Central Bank is given the power to manage the exchange rate as part of its fiscal, financial, and economic development policies under relevant decrees. The key instrument for the mobilization of foreign capital and savings is an exchange rate policy, in the perspective of the macroeconomy, which is essential to multiply the investments and fill the resource gaps in the domestic (Rajakaruna, 2017). The Sri Lankan government maintains a healthy and feasible relationship with the other countries, and due to this, it receives more foreign exchanges. The common currency used by Sri Lankan policymakers and the government is the American Dollar (US Dollar). In 1970, a US Dollar-cost Rs. 5.95 Sri Lankan Rupees (LKR) was elevated to Rs. 196 by March 2021. From the economic perspective, the exchange rate is generally ascertained by the demand and supply curve of the exchange rate, which is much like the standard commodity market system. The exchange rate determines the economic growth as the higher the exchange rate, the higher the promotion of economic development of a country is (Nanayakkara *et al*., 2014). Exchange rates play a crucial role in governing the changing aspects of the foreign exchange market. This study attempts to forecast the exchange rates of USD/LKR for the next 24 months from November 2020, which would help make economic decisions using deep learning techniques. Predicting exchange rates is a challenging task of time series forecasting since the rates are characteristically noise, deterministically disordered, and dynamic (Nanayakkara *et al*., 2014).

II. RELATED WORK

The related literature for the Sri Lankan Rupees to the US Dollar Currency pair prediction (LKR/USD) can be analyzed in two key ways: a review of how ANN is used to forecast exchange rates and an analysis of the algorithms used in the LKR/USD prediction.

A. Forecasting Exchange Rates Using Artificial Neural Network

In the research by Eng (Memon et al., 2020), the researchers used ANNs, which are structure approximates in machine models. The findings show that market factors are

significant in exchange rate changes, but the ANNs have not caught their correlations.

A short-term prediction model has been suggested by Memon *et al*., which could apply the model to predict multi-currency exchange rates. The study includes support vector regressor (SVR) and the short-term Memory Artificial Neural Network which offers insights for the authors to evaluate their model on top of various currency rates worldwide. Hua *et al*. researched simulation and estimation of exchange rate time series where the study introduces a fusion model of functional link artificial neural network (FLANN) based on Kernel Regression (KR). The authors use KR to remove the noise in exchange rate datasets. Then the normalized datasets are nonlinearly extended with sine and cosine expansions before being input to the FLANN model. According to the experiments carried out to evaluate the model's performance, it is understood that the FLANN-KR model surpasses the FLANN model without KR and the adaptive exponential smoothing system (AES).

Similarly, the research conducted by Majhi *et al*. also suggests using the nonlinear layer (a single layer) of artificial neural networks to build a model that could predict the exchange rates in advance. The researchers have trained the model using the historical data where the model simulation tries to predict the exchange rates one month ahead. In this sense, the model shows exceptional performance by demonstrating the highest deviation.

The research conducted by Ercan to predict the Baltic stock market uses the approach of a nonlinear Autoregressive Network that includes input as exogenous. The approach is known to be NARX, and based on two essential attributes, such as exchange rates and the former day's index values, the model has been created to forecast market rates using ANNs. Likewise, fuzzy logic and backpropagation methodologies are used in the study by Chen Lin as a hybrid model to predict the exchange rates. Here the authors consider the nonlinear features and the intervals while making the estimation.

B. An Analysis of the Algorithms used in LKR/USD Forecasting

The main goal of the study by Kuruwitaarachchi *et al*. was to evaluate the accuracy of three models: ARIMA, ANN, and SVM. The import, export, and USD currency exchange sequence for LKR data were chosen for data training. After training the data set and comparing each algorithm, it was clear that the SVM forecast outperformed the others. The research also revealed that combining SVM and SVR models improved the algorithm's forecast currency rate fluctuations. The study by (Samarawickrama and Fernando,2019) employs Artificial Neural Network models to render multi-step predictions of the Sri Lankan Rupee foreign exchange rate against three international currencies and assess the models' accuracy and, where appropriate, to find flaws. The algorithms used in this analysis were RNN, Multi-Layer Perceptron, and Long-Term Memory, Gated Recurrent Unit, and CNN architectures. Many iterations were able to predict 10-day forward exchange rates with a higher degree of precision, except for a few Gated Recurrent Unit models. The study's final result revealed that the RNN is the best model for making predictions.

(Nanthakumaran Tilakaratne, 2017) conducted research to measure the forecast performance of the most popular algorithms and determine which one was the most reliable for forecasting Sri Lankan Rupee regular exchange rates against regular exchange rates, the Euro and the Yen. To render predictions, the NAR model and the SVR model with the Gaussian function were used. The study's findings revealed that SVR models generated accurate decisions compared to ANN models.

The Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) model and the Feedforward neural network (FNNN) model were used to compare the accuracy of forecasts of USD to LKR exchange rates in the study of Nanayakkara *et al*. The response component in both models was the historical stagnated data findings and the average of the other measures, and the forecasting performance was evaluated using a number of common statistical parameters. As compared to the GARCH model, the results showed that the ANN model worked higher.

(Nanthakumaran Tilakaratne, 2017) proposed that the Scaled Conjugate Gradient (SCG) algorithm trained FFNN gradual and progressive than Bayesian Personalized Ranking (BPR) algorithms trained FFNN in an analysis to find a model that can predict the US dollar with a higher degree of accuracy than the Sri Lankan Rupee (USD/LKR) using concurrent neural networks.

A hybrid foreign-currency forecasting model with an empirical and neural model network was recommended by (C.D.TILAKARATNE, 2019). EMD methods were used to break up an initial nonlinear, non-stationary chain of multiple intrinsic modes (IMFs) functions and one residual sequence. The IMF exchange rate is calculated by using the hybrid formula to approximate the obtained residual inputs. The empirical findings showed that the regular exchange rate prediction for the Sri Lankan Rupee Euro and Yen was more reliable in relation to the EMD-FNN model.

According to recent studies, it is understood that forecasting the LKR/USD exchange rate is rare. Still, it demands serious consideration because the currency pairs entail significant business decisions and appreciate the effect of predicting financial failures. The absence of an already developed study relating to the issue is the main reason why the authors are drawing attention to the analysis and building a better predictive model for the USD/LKR currency pair.

III. METHODOLOGY AND DATA DESCRIPTIONS

A. Data Collection and Preprocessing

This paper studies the daily exchange rate of the Sri Lankan rupee/ US dollar (LKR/USD). The data set was collected from the investing.com website [14] from 1st January 2010 to 26th November 2020. The total number

of observations in the dataset is 2828. Each observation contains information about open, high, low, close, percentage change. In the preprocessing as a first step, the date column is marked as the index column. After that, data is arranged into ascending order with respect to date. Since the price's decimal points are varying, the authors have fixed it to four digits. After that, using a standard scaler, data is normalized.

In this study, 80% of the data was used to train the model and 10% of data used to validate the model and 10% of data used to test the model. The exchange rate for LKR/USD on a daily basis was generated initially, as shown in Fig.1.

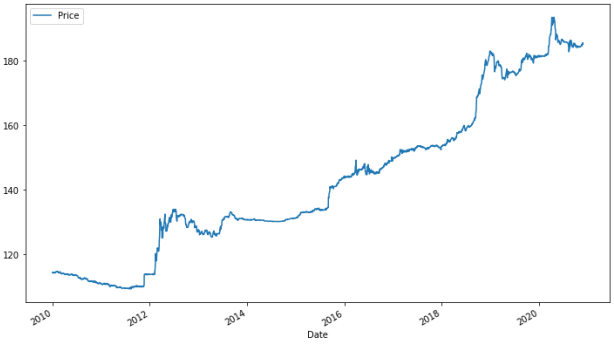

Figure 1: Exchange rate daily basis

B. Modeling

In this study, researchers use Artificial Neural Networks (ANNs) and two variant Recurrent Neural Networks (RNNs) to predict the forex rate. Those are:

1) Long Short Term Memory (LSTM)
2) Gated Recurrent Unit (GRU)

These approaches are more efficient in describing time-series dynamics due to their unique nonparametric, noise-tolerant and adaptive properties. Moreover, universal function approximates that can map any nonlinear without prior assumptions about the data.

1) Artificial Neural Networks (ANNs):: An ANN structure generally comprises the input layer, hidden layers, and the output layer. Each layer contains a set of processing elements known as neurons (units). Signals are passed from one neuron to the next through connection links. Each communication link has a weight associated with it, which multiplies the signal transmitted in a typical neural network. This study chose the input, hidden layer neurons by conducting multiple experiments. Researchers create a model using a single input, a single hidden layer with 12 neurons, and a single output layer with one neuron as the base model for this study, as illustrated in Fig.2 below.

2) Long Short Term Memory (LSTM):: LSTM is a kind of recurrent neural network (RNNs). LSTM has three gates: the input gate, the output gate, and the update gate. The desirable fact of LSTM is the explicit memory unit that helps to learn the task and retain the needed information. When information enters the LSTM, only the information satisfying the algorithm is kept in, and the forget/update gate

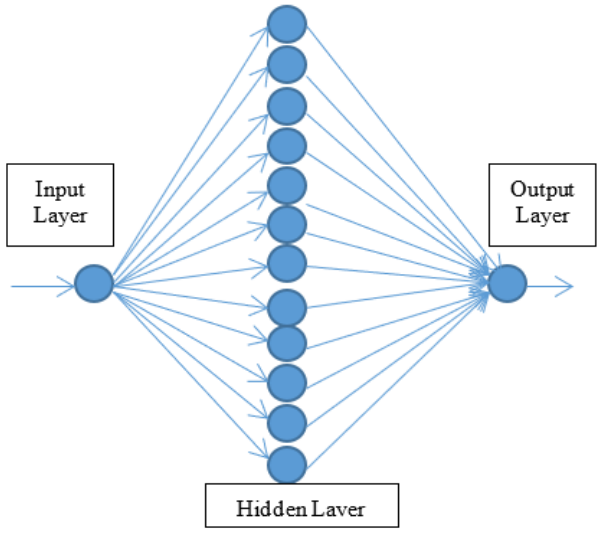

Figure 2: ANN model

forgets the rest. In this study, researchers used 125 neurons in the LSTM cell, and to identify the cell size, researchers conducted multiple experiments with different values like 40, 50, 60, etc. Fig.3. shows the single LSTM unit.

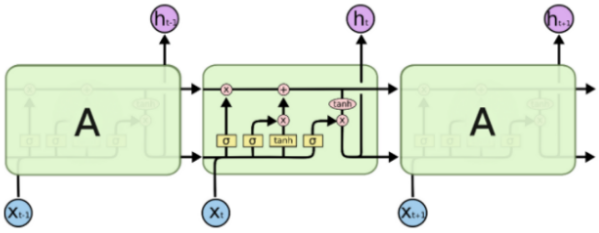

Figure 3: LSTM model

3) Gated Recurrent Unit (GRU):: GRU is also capable of remembering the long-term dependency like LSTM. GRU has an update and resets the gate. The primary difference of GRU is revealing the entire cell state to the next unit, but LSTM passes the selective information to the next unit.

4) Activation function: : In this study, researchers use the rectified linear unit (ReLU) as an activation function. The ReLU helps to improve the gradient flow.

5) In this study, researchers used two optimizers Adam and SDG. Adam [15] is an adaptive learning rate optimization algorithm designed specifically for training deep neural networks. SDG is an iterative method for optimizing and aims to minimize the loss. :

IV. Results and Discussion

In this study, researchers compare ANN, LSTM, and GRU with two different optimizers; Adam and SDG. For this study, ANN is selected as a baseline model. This study finds that GRU with Adam optimizer performs better than other R2, RMSE, and MAE approaches. Further, LSTM performs better with SDG optimizer than Adam in this study.

Fig.4 and Fig.5 respectively show the actual observation with ANN, LSTM, GRU with Adam optimize and the Actual observation with a prediction with ANN, LSTM, GRU with SGD optimizer. Table 1 illustrates the Actual value with model predicted values, while Table 2 shows the Statistical analysis of the results generated by ANN with 150 iterations, LSTM with 125 iterations, and GRU with 150 iterations.

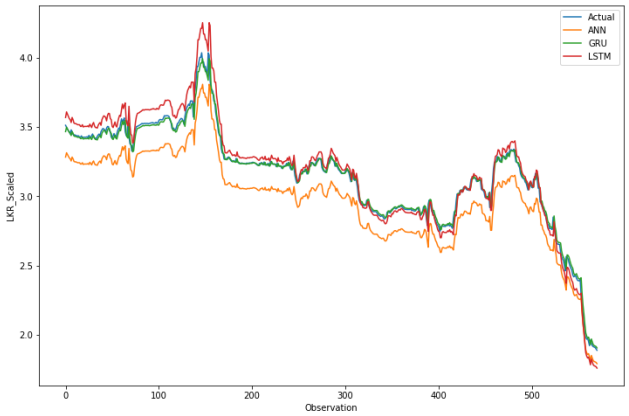

Figure 4: Actual observation with a prediction with ANN, LSTM, GRU with Adam optimizer

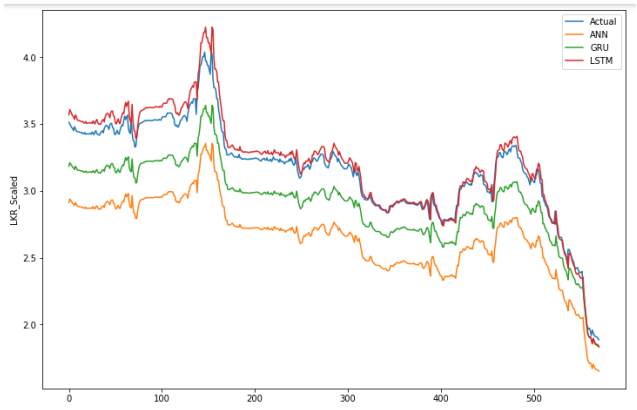

Figure 5: Actual observation with a prediction with ANN, LSTM, GRU with SGD optimizer

The prime responsibility of the Central Bank of Sri Lanka is to keep price stability by maintaining low and stable inflation. The Central Bank of Sri Lanka can utilize this approach to predict the price inflection before deciding on tex and government policies. With the Covid-19 pandemic situation, the inflation rate is very high, so this kind of approach can help the central bank to make their decision based on the prediction.

V. Conclusion

In this paper, a forecast model for LKR/USD currency pair prediction has been proposed. The currency exchange rate predictions play a vital role as the key indicators in global trading and monetary decision making.

The methodology and descriptions section explains the dataset used for the study, which consists of 2828 observations starting from 01-01-2010 to 26-11-2020. The data was visualized to interpret better the dataset employed, and it was converted into a visual. This section shows the techniques used in modeling the forecasting model. ANN and LSTM, GRU are used to build the model where LSTM and GRU are considered variants of RNN. The Adam and SDG optimizers are used to have an efficient, optimized model. The activation function for the model has been assigned with ReLU that supports the learning process and deciding between the complex patterns.

The results of the study show that GRU performs better when compared to other algorithms used. The R-Squared value for this particular algorithm is promising, and it shows the strength of how well the model suits the algorithms. This illustrates that the model has a good impact and in terms of the data collected, and the model's practicality is enhanced, including the USD/LKR exchange rate for a longer time. Therefore, the purpose of this study was to assess the artificial neural network (ANN) techniques to predict the exchange rate of LKR/USD pairs using a highly exact predictive model. The analysis thus shows that the unique nature of real-life research would increase the predictability of the LKR/USD monetary pair, which is subject to severe volatility throughout the days of the year, by using the improved prediction of ANN algorithms.

A

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Table I: Actual value with model predicted values

Actual	ANN + Adam	GRU + Adam	LSTM + Adam	ANN + SDG	GRU + SDG	LSTM + SDG
185.1	182.137	184.912	186.450	176.553	186.444	180.640
185.6	182.608	185.388	187.058	176.95	187.025	181.050
185.4	182.420	185.198	186.815	176.792	186.797	180.886
185.2	182.231	185.004	186.571	176.634	186.560	180.722
185	182.0429	184.8167	186.3288	176.4736	186.328	180.558

Table II: Statistical analysis of the results

Model	Adam			SDG		
	R2 score	RMSE	MAE	R2 score	RMSE	MAE
ANN	0.764	0.180	0.176	-0.863	0.506	0.499
LSTM	0.956	0.078	0.061	0.961	0.073	0.058
GRU	0.992	0.033	0.022	0.550	0.249	0.238

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