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Forecasting of Currency Exchange Rates Using ARIMA, ABC with DNN

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***Abstract*:**
The foreign exchange market is one of the largest markets in the world. In this market, the selling and buying of another currency takes place, which is crucial for currency trading on the international market. In this paper, an Instant Prediction System (IPS) is proposed to predict Foreign Exchange Currency rate (FOREX) based on deep learning with optimization and Autoregressive integrated moving average (ARIMA) model. ARIMA is a popular linear time series model used for forecasting for the last couple of years. The present research, with Deep Neural network (DNN) and Artificial Bee Colony (ABC) as an Optimization Algorithm is a promising and highly accurate alternative to the traditional linear methods. By considering the advantages of ARIMA, DNN with ABC model in a linear and non linear modeling a hybrid model is designed. Experimental results are computed with the real time dataset obtained from FOREX site http://fx.sauder.ubc.ca/data.htmlfrom the year (01/01/2015-31/12/2018) and the indices such as Mean average Precision (MAP), Mean Absolute Percentage (MAPE) Error and accuracy are evaluated. The average prediction accuracy examined for the proposed IPS system is 98.22%.

Keywords: Foreign Exchange Currency rate, ARIMA, ABC, DNN.

I. Introduction

The availability of assets and momentary can provide us a comfortable life (Lawrence, 1997). The attention has been devoted to examine and predict the future value as well as trends of the financial market.Different forecasting methods have been projected and implemented, each one has its own pros and cons [1].In present time, with an online trading application, the stock market has become one of the ways in which even small investors can make good profits. So it would be pretty attractive if we can predict market behavior precisely so that investors can make a decisionthat when and where they have to invest their money [2].Although, due to the very instant fluctuations in the financial market, it becomes very difficult to examine the financial time series and hence becomes tough for the researchers to develop a forecasting

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model. Also, there are number of factor that affects the stock market such as: business cycle, interest rate, political situation, monitory policies and many more [3].

With the rapid growth of economy and modernization, money markets have become an important part of our daily life. Accordingly, the stock sample has been incredibly focused on the open topic. FOREX is linked to exchange rates of the foreign currencies. The obtained ratio provides essentialinformation, which is used for currency interchange in the global money market [4]. FOREX rate is affected by a number of reasons such as political, economical and even psychological position of the investor as well as the traders and the available data is noisy, unstable and chaotic in nature.These factors are highly influenced the FOREX market as these are strongly interlinked with each other. The interaction among those factors is very erratic, unstable and dynamic, which makes the prediction of FOREX rate complex [5].

These features show that there is no information available from previous behavior of such markets to fully capture the dependency between future market rates and the past. In such cases, one common assumption is that historical data should include all these behaviors [6].The trading of exchange at accurate time can provide investors a great profit, but the wrong investment of money leads to a big loss. To get rid of these losses, a suitable tool with best method can minimize the effect of mistakes and hence increase the profitability. As a result, historical data plays a key role in the forecasting process [7]. Even though, well-known conventional prediction techniques provide acceptable quality predictions for many fixed forecasting systems, these methods appear to be unsuitable for an unstable and chaotic system such as exchange rates, interest rates, and stock prices. The purpose of this paper is to explore the use of technology based on deep neural networks to predict FOREX rate [8].

For the last couple of years, the well known technique proposed by Box and Jenkins' named as –Auto Regressive Integrated Moving Average (ARIMA) was utilized for time series forecasting [9]. Due to its popularity, ARIMA model finds application in different fields and can be employed to analyze a number of novel modeling techniques.But ARIMA is a general and one-sided model, which works based on the line and probability of the predicted time series and it will not have the right technique to predict exchange rates [10].

The deep learning is a powerful solution to the above mentioned problem. DNN is of the most commonly and effective method that works in the similar fashion as that of human brain [11]. It comprises of more number of neurons to carry the information, learning the structure by recalling method as that of human brain. Based on these features, DNN is capable to learn about that object/ things and hence provide solution for them. Therefore, this method is mostly used to solve and analyze the problem in different fields [12].

II. Related Work

A number of researchers have worked on to test the performance of monetary model. Studies conducted by Frenkel (1976) and Bilson (1978) [13] following the early detection of the monetary model yielded unsatisfactory results. Later , in 1983, Meese and Rogoff [14] have claimed that the financial model was not able to perform better than random Walk(RW) model, which indicates that the conversation rates move in a completely unplanned and unexpected way and this phenomenon is named as the Meese-Rogoff puzzle. Further state-of-the-art empirical studies have failed to significantly justify a strategy to the meese-rogoff puzzle and show that the financial version can defeat the naive rw version, particularly in the quick term. (Ni and Yin 2009)[15]. Kim et al. (2010) have illustrated that the forecasting capability of the non-linear monetary system has been increases with the increase in the forecasting period from one quarter to 16 quarter ahead. However, no one existing model can perform better compared to the RW model for the period of one ahead forecasts [16]. In 2016, Huber have presented a monetary prediction model for USD/EUR

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exchange rate utilizing non-linear multi-variant model and the performance has been analyzed based on RMSE factor. This model has been performed better compared to the previous one month prediction model. In general, these studies have proposed that the financial model of the exchange rate has an predictive power when considering the linear regulatory method, and that its predictive power expands with longer forecast days.

Chandar et al. (17, 2015), have applied Artificial Neural Network (ANN) to forecast Indian Rupee (INR) foreign exchange rates against four other currencies such as PS, USD, EURO and Japanese Yen (JYEN) using their historical data. Five specific ANN-based models such as GD (traingd- Batch gradient descent) GDM (traingdm- Batch gradient descent with momentum) GDA (traingda-Variable Learning Rate Back-propagation) RP (trainrp –Resilient Back propagation) LM (trainlm- Levenberg-Marquardt) are considered using existing learning algorithms. The performance o forecasting in the proposed work has observed through these widely used three mathematical computations such as Root Mean Square Error (RMSE), Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE). It has been seen that the model based on Levenberg-Marquardt performs better than other algorithms.

In the research work presented by Tang and Fishwick [18], Wang and Leu [19], Abbas[20], have demonstrated that the ANN technique works well compared to ARIMA model. Particularly, for discontinues data series as well as for a number of periods ahead forecasting, ANN perform well. In [21] the Ghezelbash and Keyniahaspresented a common working description of ANN model that is used in monetary time series applications. Also, the authors have covered a number of useful applications in their paper. Also, the ability of backpropagation neural network to predict an exchange rate has been examined by Dunis et al.[22].The problem of single period ahead forecasting has been resolved by Wang [23]. Klein and Rossin [24] have concluded that the performance of stock exchange prediction model has been influence by available dataset.In 2019, Amit and Nagpur [25] have presented a forecastin model for multi currency exchange rates using ANN, Support Vector Regressor (SVR) and Long Short-Term Memory (LSTM). The performance has been measured based on MSE and R square factor.

III. Methods used

In this paper, an Instant Prediction System (IPS) is designed using DNN as a machine learning approach in combination with ARIMA model for the prediction of FOREX rate. The detail description of both ARIMA and DNN is provided in the following section.

In this paper we cover two objectives which are mention below.

1) To collect data from various sources for foreign currency exchange rate.

Here we collected data from (01/01/2015-31/12/2018) of INR/USD (Indian rupees to Dollar),CAD/USD(Canadian dollar to USDollar) ,AUD/USD(Australian Dollar to US Dollar, EUR/USD(Euro to USDollar),MXN/USD(Mexican Peso to USDollar),NZD/USD(Newzland dollar to USdollar),GBP/USD(British pound to USdollar),JPY/USD(Japanese yen to USdollar)from http://fx.sauder.ubc.ca/data.html

2) To design an Instant Prediction System (IPS), which performed in three steps;

Step-1- Use ARIMA model for linear regression.

A time series power regression model is designed using ARIMA for linear regression. Further deep neural layered based conjugate scale algorithm is to be applied followed by optimization supported through swarm Intelligence.

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3.1 ARIMA model

It is a statistical model, which is mostly used for analysing as well as forecasting time series data. ARIMA stands for "AutoRegressive Integrated Moving Average" as well as attached the entry of integration. Briefly, these terms are defines as:

AutoRegressive (AR): Used to find the dependent correlation among the present and prior observations.

Integrated (I): The differentiating factor added to make time series stationary.

Moving Average (MA): It represents that the regression error in reality is a linear combination of the error terms and the value of which exists contemporaneously at different instance in the past.

The ARIMA model was introduced by Box and Jenkins and stated that it is the most popular scheme used for forecasting. The ARIMA model has considered that the future value is a combination of linear variables of past experience and the past error computed can be expressed as;

$$y_t = \alpha_0 + \vartheta_1 y_{t-1} + \vartheta_2 y_{t-2} + \cdots + \vartheta_p y_{t-p} + g_t - \beta_1 g_{t-1} - \beta_1 g_{t-2} - \cdots \ldots \ldots \beta_q g_{t-q}$$

$\mathbf{y_t}$ → Actual Value

g_t → Random Error at instant t

α_i and ϑ_j → Coefficient of p and q , which represents AR and MA polynomials respectively.

This model basically follows three steps named as (i) model identification, (ii) parameter estimation and (iii) diagnostic checking. The ARIMA (1,0,1) can be expressed as;

$$y_t = \alpha_0 + \vartheta_1 y_{t-1} + g_t - \beta_1 g_{t-1}$$

ARIMA version is absolutely a data oriented approach, which is accommodated from the data structure itself. The accuracy of ARIMA model is limited due to the availability of non linear dataset in terms of FOREX rate. Therefore to solve this problem, a hybrid model in combination to DNN approach has been used to deal with the nonlinear data pattern of FOREX data [26].

Step -2 use ABC (Artificial Bee Colony) used for optimization.

3.2 ABC

ABC is a swarm inspired optimization approach used to optimize the non linear data obtained from the ARIMA model. It mainly comprises of three bees; employedonlooker and scout bees. The upper and lower limit of the solution has been defined using objective function. Employed bee is used to select food source (linear data)randomly. Then, the quality of the food that is the accuracy of the linear data is determined using onlooker bee. A new solution is generated using scout bee [27].

Step-3-Then Deep neural network has been used for prediction. In deep neural network I have taken 10 inputs,20 hidden layer .

3.3 DNN

When soothing the linear constraints of the model, the possible number of nonlinear structures that can be used to describe and predict the time series will be very large. A good quality nonlinear model should be sufficient to capture a few of the nonlinear phenomena in the data. DNN is one such model that can approximate a variety of nonlinearities in the data by passing data through number of hidden layers [28].DNN algorithm comes under artificial intelligence learning scheme that works in the same fashion as that of human brain. In this, the units are interconnected in the similar way as that of artificial neurons given by Hinton 1992.

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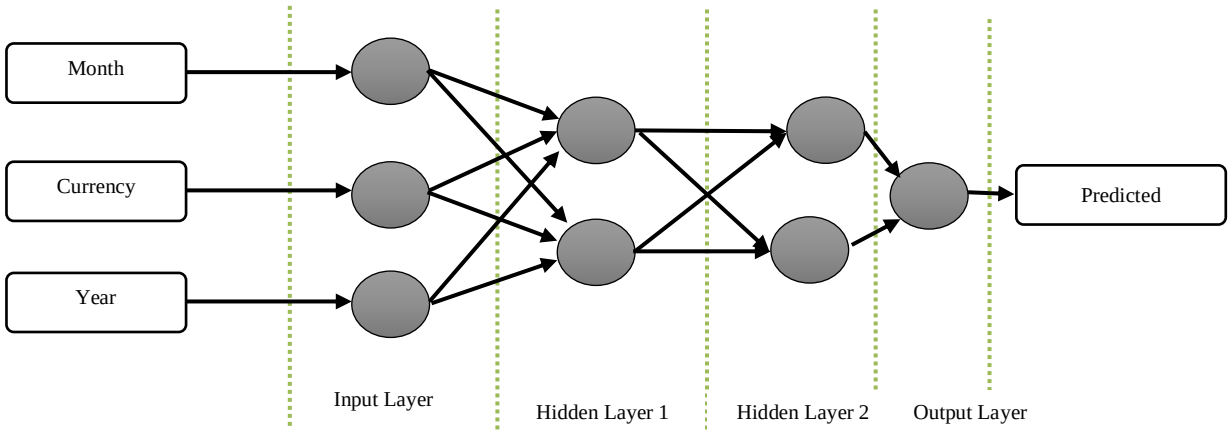

Figure 1: Architecture of DNN [29]

Deep learning is a method of machine learning that involves the extraction, or modeling, of data attributes using complex multilayer filters. Since deep learning is a very general way of modeling, it is able to resolve complex problems, such as statistical problems&ordinary language processing. This approach is significantly different from traditional programming and former machine learning methods.Deep learning can not only give outcomes where other methods do not work, but also allows you to form a more accurate model or reduce the time to create it; pay for it accounts for even greater computing power. The important characteristic of deep learning is the presence of more than one layer between the input and output as indicated by hidden layer shown in Figure 2. Usually, when talking about deep learning, they imply the use of DNN(deep neural network). However, there are several algorithms that implement deep learning using other types of layers.A DNN for a real task can have more than ten hidden layers. Its topology can be simple or pretty complex.The more layers in the network, the more characteristics it can identify. However, the more layers in the network, it will take more time to calculate, and the more difficult it will be to learn.

The neurons with the same properties are grouped into a single layer. The layer is the representation of set of nodes that are used to forward information to the other linked layer as well as the external environment. The DNN with 20 hidden layer, 10 input neurons and one output layer is shown in Figure 2.

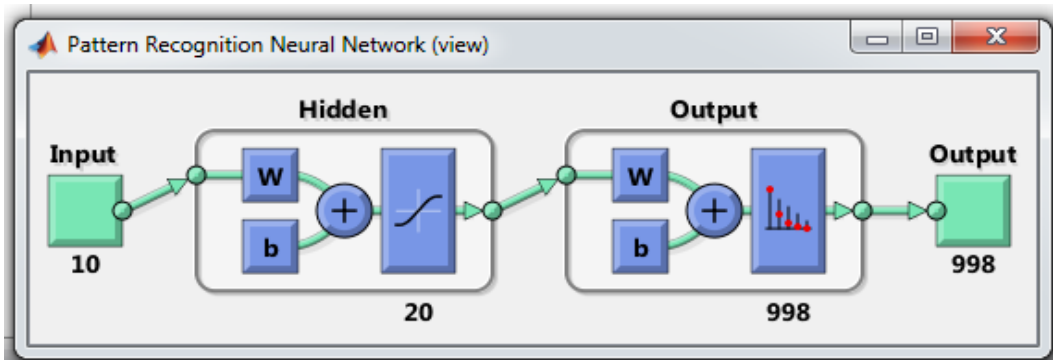

Figure 2: DNN Training Structure

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The extracted features from the raw financial data such as mean, variance, log (data), tanh (data), max (data) and min (data) are provided as input data to the DNN input layer. These data is processed in the hidden layer as per the biased value and then the out value is forecasted.

Also, to test and compare results two optimization approaches ABC and Firefly has been used and computed results are discussed in section IV.

3.4 FireflyAlgorithm

In this research, DNN is used as a prediction model and to work it properly, the input data is optimized by reducing its features using Firefly as a feature reduction approach. This approach helps to find out the most appropriate features from the original dataset so that the performance of the prediction model has been improved. Both statistics and optimization techniques has been employed on the available data reduction. The detail of Firefly is provided below:

It is a metaheuristic algorithm, designed by Xin-Shi Yang and inspired by the flashing characteristics of fireflies. The algorithm works by following the three main steps:

i. The flies are unisex and moved towards each other despite of their sex.
ii. The attraction of flies depends upon their brightness, the fly of higher brightness moves towards the lower brighter one.
iii. The brightness of the flies is measured based on the objective function.

IV. Results and Discussions

This section describes the computed results executed in MATLAB simulator on the dataset obtained from various FOREX rates. The forecasting accuracy of the proposed hybrid model (ARIMA with DNN) has been measured based on three different indices as defined below;

i. Mean Absolute Percentage Error (MAPE)

$$MAPE = \frac{100}{N}\sum_{t=1}^{N}\left|\frac{e_t - y_t}{d_t}\right|$$

N→ Number of Forecasting periods,

e_i→ Actual Stock price at instant t

y_t→Forecasting stock price at instant t [30].

ii. Mean average Precision (MAP)
iii. Accuracy

4.1 Dataset

The data has been collected from various sources for foreign currency exchange rate.The sources like online exchange rate forecast database (http://fx.sauder.ubc.ca & http:// www.imf.org/external/np/fin/data/rms_mth.aspx) etc. From these sources a set of input (corresponding to a day, week or month) values are taken.Compare to the simple ARIMA model. The values computed to determine the effectiveness of the proposed IPS model is listed in table 1.

Table 1: Comparison of forecasting indices

Currency Types	With ARIMA			ABC with DNN			Firefly with DNN		
	MAP	MAPE	Accuracy	MAP	MAPE	Accuracy	MAP	MAPE	Accuracy
INR/USD	0.68	0.257	70.23	0.89	0.0031	99.001	0.74	0.06254	79.83
CAD/USD	0.62	0.328	65.28	0.88	0.0067	94.58	0.72	0.06895	74.62
AUD/USD	0.54	0.402	56.55	0.85	0.0022	99.00	0.69	0.0655	76.83

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EUR/USD	0.57	0.327	59.75	0.84	0.004	98.67	0.75	0.0525	80.325
MXN/USD	0.60	0.357	62.38	0.90	0.001	99.58	0.72	0.0635	75.67
NZD/USD	0.61	0.3012	64.97	0.91	0.0054	97.68	0.71	0.0615	74.89
GBP/USD	0.65	0.4125	69.72	0.95	0.0039	98.24	0.79	0.0498	82.14
JPY/USD	0.68	0.4895	70.28	0.97	0.00297	99.08	0.81	0.03256	85.64

Figure 3, shows the point to point comparison of original, predicted value using ARIMA and proposed IPS model. ARIMA (0, 1, and 0) model is utilized to predict the FOREX rate of the eightdifferent currencies. The computed results indicated that the proposed IPS model provides better forecasting outcomes .

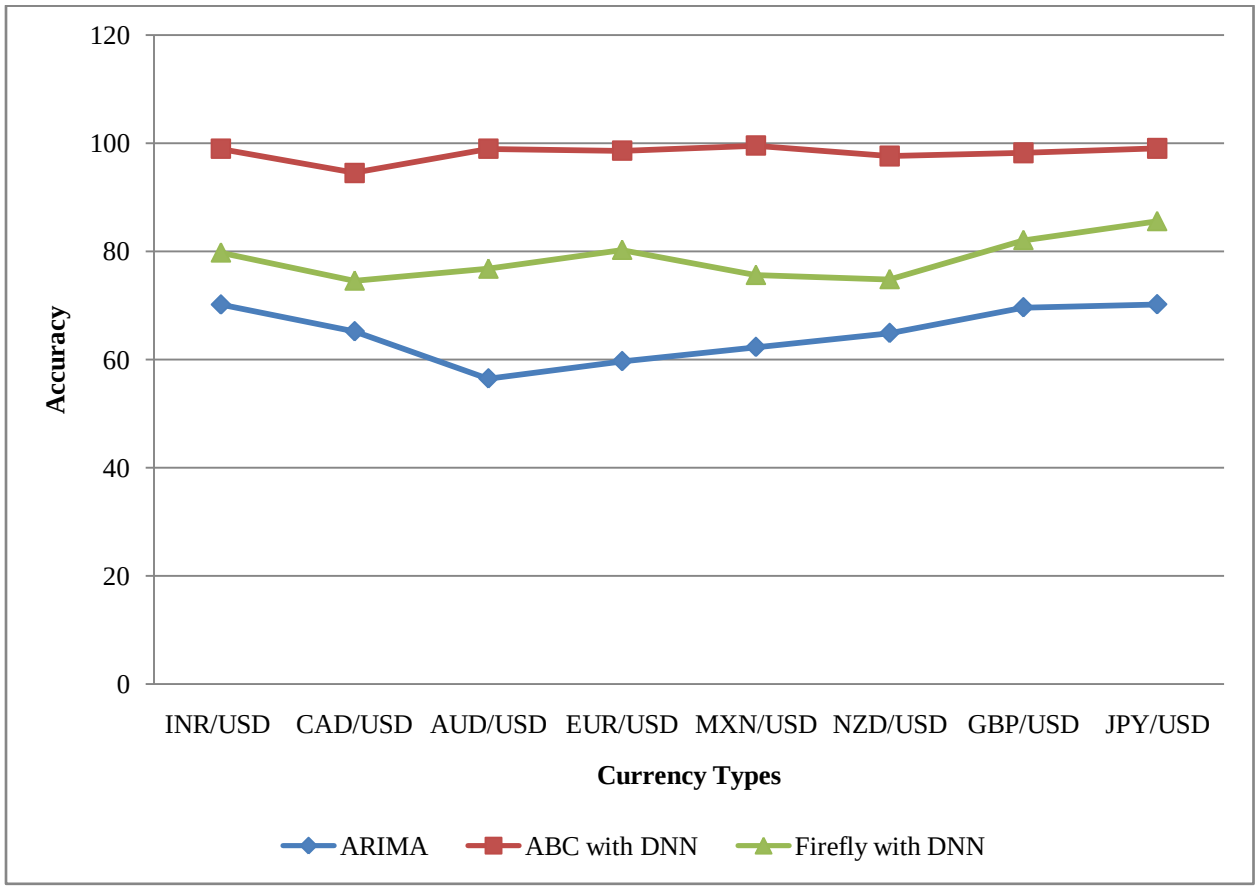

Figure 3: Accuracy

The accuracy of the designed IPS system to predict FOREX using three different techniques such as ARIMA, ABC with DNN and Firefly with DNN as indicated by the blue, the red and the green color respectively is shown in Figure 3. The graph indicated that the prediction accuracy using proposed ABC with DNN algorithm is higher followed by firefly with DNN and Simple ARIMA model.The maximum prediction accuracy of 99.58 has been achieved for MXN/USD dataset.

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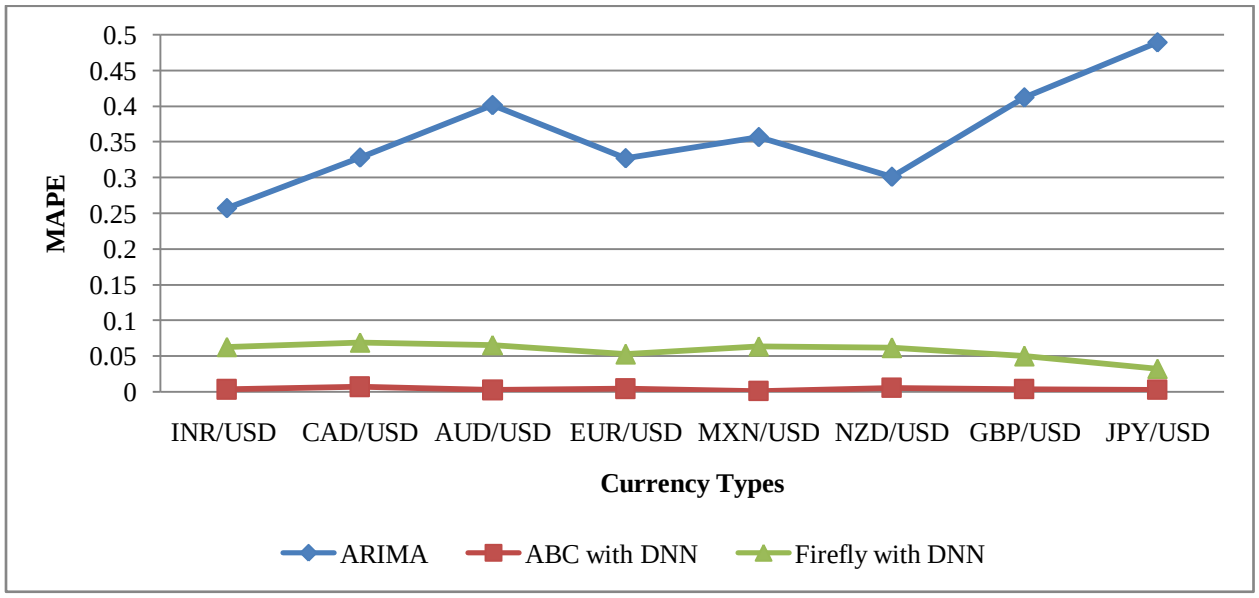

Figure 4: MAPE

The MAPE values examined for eight different currency types predicted using three different algorithms is depicted in Figure 4. It is clearly seen that the percentage error analyzed using ABC with DNN is less compared to ARIMA and Firefly with DNN approach, which indicates that the proposed approach predict with higher accuracy compared to other techniques. This is possible only, ABC algorithm selects appropriate features from the uploaded test data, which helps for better training and hence predict accurate data during testing process. The minimum error analyzed using proposed technique is 0.001.

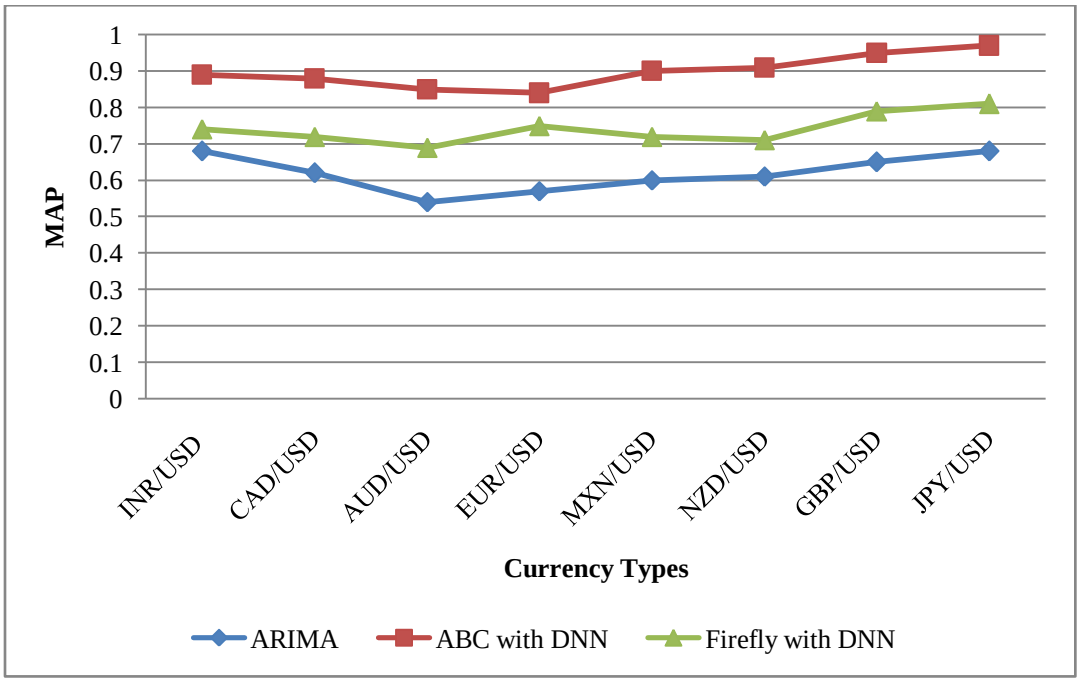

Figure 5: MAP

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The average mean detected for the proposed IPS system is shown in Figure 5. It represents the average of precision and recall. Since, the values of precision and recall lie between 0 and 1. Therefore, the mean average precision should be lie between 0 and 1. As shown in Figure 5, the average mean examined for the proposed work is higher than that of remaining techniques.

V. Conclusion

In this paper, using the prior knowledge of ARIMA model, ABC and DNN approach, we presented a novel model named as Instant Prediction System (IPS) and apply it to forecasting the FOREX rate of different currencies such as: INR/USD, CAD/USD, AUD/USD, EUR/USD, MXN/USD, NZD/USD, GBP/USD and JPY/USD for showing the effectiveness of the proposed IPS model. From the results, it has been analyzed that the presented model not only formulate good forecast but also suggest to the investors about the best and the worst situations. From the results it has been concluded that the designed IPS system for the prediction of FOREX currency performed well and gives better results in terms of accuracy, MAPE and MAP. The average of accuracy, MAPE, MAP analyzed for the proposed work is 98.22%, 0.0036 and 0.898 respectively.

References

1. Pandey, T. N., Jagadev, A. K., Dehuri, S., & Cho, S. B. (2018). A novel committee machine and reviews of neural network and statistical models for currency exchange rate prediction: An experimental analysis. *Journal of King Saud University-Computer and Information Sciences.*
2. Nyoni, T. (2018). Modeling and Forecasting Naira/USD Exchange Rate In Nigeria: a Box-Jenkins ARIMA approach.
3. Henríquez, J., &Kristjanpoller, W. (2019). A combined Independent Component Analysis–Neural Network model for forecasting exchange rate variation. *Applied Soft Computing*, *83*, 105654.
4. Nanda, S. K., Vyas, R., &Vamshidhar, H. K. (2018, November). Forecasting Foreign Exchange Rate Using Robust Lagueree Neural Network. In *2018 3rd International Conference and Workshops on Recent Advances and Innovations in Engineering (ICRAIE)* (pp. 1-5). IEEE.
5. Bui, L. T., &Dinh, T. T. H. (2018). A novel evolutionary multi-objective ensemble learning approach for forecasting currency exchange rates. *Data & Knowledge Engineering*, *114*, 40-66.
6. Henríquez, J., &Kristjanpoller, W. (2019). A combined Independent Component Analysis–Neural Network model for forecasting exchange rate variation. *Applied Soft Computing*, *83*, 105654.
7. Nayak, R. K., Mishra, D., &Rath, A. K. (2019). An optimized SVM-k-NN currency exchange forecasting model for Indian currency market. *Neural Computing and Applications*, *31*(7), 2995-3021.
8. Jan, J. H., &Gopalaswamy, A. K. (2019). Identifying factors in currency exchange rate estimation: a study on AUD against USD. *Journal of Advances in Management Research.*
9. Nyoni, T. (2019). ARIMA modeling and forecasting of inflation in Egypt (1960-2017).
10. Bakar, N. A., &Rosbi, S. (2019). Forecasting method for Ethereumcryptocurrency with autoregressive integrated moving average (ARIMA) model using high frequency data. *Religación. Revista de CienciasSociales y Humanidades*, *4*(17).
11. Ince, H., Cebeci, A. F., &Imamoglu, S. Z. (2019). An artificial neural network-based approach to the monetary model of exchange rate. *Computational Economics*, *53*(2), 817-831.
12. Zhu, E. (2019). Study on Exchange Rate Volatility under Cross-border RMB Settlement Based on Multi-layer Neural Network Algorithm. *Optical Memory and Neural Networks*, *28*(1), 58-64.

May – June 2020
ISSN: 0193-4120 Page No. 7676 - 7685

13. J. A.Frenkel, (1976). A monetary approach to the exchange rate: doctrinal aspects and empirical evidence. *The scandinavian Journal of economics*, 200-224.
14. Meese, R. A., &Rogoff, K. (1983). Empirical exchange rate models of the seventies: Do they fit out of sample?. *Journal of international economics*, *14*(1-2), 3-24.
15. Ni, H., & Yin, H. (2009). Exchange rate prediction using hybrid neural networks and trading indicators. *Neurocomputing*, *72*(13-15), 2815-2823.
16. Kim, B. H., Min, H. G., &Moh, Y. K. (2010). Nonlinear dynamics in exchange rate deviations from the monetary fundamentals: an empirical study. *Economic Modelling*, *27*(5), 1167-1177.
17. Chandar, S. K., Sumathi, M., & Sivanandam, S. N. (2015). Forecasting of Foreign Currency Exchange Rate Using Neural Network. Int. J. Eng. Technol, 7, 99-108.
18. Tang, Z., &Fishwick, P. A. (1993). Feedforward neural nets as models for time series forecasting. *ORSA journal on computing*, *5*(4), 374-385.
19. Wang, J. H., &Leu, J. Y. (1996, June). Stock market trend prediction using ARIMA-based neural networks. In *Proceedings of International Conference on Neural Networks (ICNN'96)* (Vol. 4, pp. 2160-2165). IEEE.
20. Abbas, O. M. (2015). Neural Networks in Business Forecasting. *International Journal of Computer*, *19*(1), 114.
21. Ghezelbash, A., &Keynia, F. (2014). Design and implementation of artificial neural network system for stock exchange prediction. *African Journal of Computing and ICTs*, *7*, 153-160.
22. Dunis, C. L., Laws, J., & Schilling, U. (2012). Currency trading in volatile markets: Did neural networks outperform for the EUR/USD during the financial crisis 2007–2009?. *Journal of Derivatives & Hedge Funds*, *18*(1), 2-41.
23. Wang, S. (1998). An insight into the standard back-propagation neural network model for regression analysis. *Omega*, *26*(1), 133-140.
24. Klein, B. D., &Rossin, D. F. (1999). Data quality in neural network models: effect of error rate and magnitude of error on predictive accuracy. *Omega*, *27*(5), 569-582.
25. Amit R. Nagpure (2019) Prediction of Multi-Currency Exchange Rates Using Deep Learning. *International Journal of Innovative Technology and Exploring Engineering (IJITEE)* ISSN: 8 (6), 2278-3075.
26. Pai, P. F., & Lin, C. S. (2005). A hybrid ARIMA and support vector machines model in stock price forecasting. *Omega*, *33*(6), 497-505.
27. Hong, W. C. (2011). Electric load forecasting by seasonal recurrent SVR (support vector regression) with chaotic artificial bee colony algorithm. *Energy*, *36*(9), 5568-5578.
28. Bao, T. Q., & My, B. T. T. (2019). Forecasting stock index based on hybrid artificial neural network models. *Science & Technology Development Journal-Economics-Law and Management*, *3*(1), 52-57.
29. Zhang, G. P. (2003). Time series forecasting using a hybrid ARIMA and neural network model. *Neurocomputing*, *50*, 159-175.
30. Pai, P. F., & Lin, C. S. (2005). A hybrid ARIMA and support vector machines model in stock price forecasting. *Omega*, *33*(6), 497-505.