

# Recent Application of Neural Network in Prediction of Non-Linear and Dynamic System: A Review Article

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**Abstract:** Recent applications of neural network in prediction of non-linear dynamic systems have been reviewed. Intended for significant contributions from 2010 to 2016 have been reviewed and found the various architecture of neural network like back-propagation, radial basis function, multi layer perceptron, recurrent neural network are found suitable sufficient for prediction over 17 different applications in recent years is presented through this review article.

**Keywords:** Neural Network, Prediction, Non-Linear System.

## I. INTRODUCTION

System is defined as  $y = f(x_1, x_2, x_3 \dots, w_1, w_2, w_3 \dots)$  can be treated as non-linear dynamic system where different values of 'y' are dependent to different values of independent variables  $x_1, x_2, x_3$ .

The  $w_1, w_2, w_3 \dots$  are the weights are to be adjusted to predict 'y' from inputted values of  $x_1, x_2, x_3$ . In other word  $x_1, x_2, x_3$  are called predictors of the system y. here, y is dynamic and non-linear and depending on values of  $x_1, x_2, x_3$ .

Neural network and its training algorithm are basically used to define such system by adjustment of weights  $w_1, w_2, w_3$  during training process. These weights are called trainable weights. In each epoch (iterations) the neural network may minimize the error between actual y's and its predicted values by adjustment of  $w_1, w_2, w_3$  called training process.

After training new values of  $x_1, x_2, x_3$  may possibly be given to observe predicted value of y called validation or testing. It observed that weather datasets, stock datasets, financial datasets etc are dynamic system always depending on their predictors (independent variables).

And neural network may identify the relationship between depending and independent variables. Thus in recent year many contributors are utilizing neural network for prediction of such system. In this study recent extremely significant contribution for the same is identified to obtain best architecture of neural network for prediction.

The paper is constructed in the sections. The review of literature is discussed in the second section. Third sections described the result and discussions of the review. And finally forth section concluded the paper.

## II. REVIEW OF LITERATURE

Highly significant recent contributions have been found for dynamic system prediction during the period of 2010 to 2016 has been found and classified yearly are given in this section as follows:

In 2010, Tarsauliya et al., 2010 have found financial forecasting has been challenging problem due to its high Non - linearity and high volatility. An Artificial Neural Network (ANN) can model flexible linear or non- linear relations-hip among variables. ANN can be configured to produce desired set of output based on set of given input. They attempted at analyzing the usefulness of artificial neural network for forecasting financial data series with use of different algorithms such as back-propagation, radial basis function etc.

With their ability of adapting non- linear and chaotic patterns, ANN is the current technique being used which offers the ability of predicting financial data more accurately [1]. Peralta et al., 2010 have discussed accurate time series forecasting are important for displaying the manner in which the past continues to affect the future and for planning our day to-day activities. In recent years, a large literature has evolved on the use of evolving artificial neural networks in many forecasting applications. Evolving neural networks are particularly appealing because of their ability to model an unspecified non- linear relationship between time series variables.

His contribution stated that the evaluation of two methods to evolve neural networks architectures, one carried out with genetic algorithm and a second one carry out with differential evolution algorithm. A comparative study between these two methods, with a set of referenced time series will be shown. And finally tried to improve the final forecasting getting an accurate system [2]

In 2011, Akintola et al., 2011, have found the artificial neural network is useful in stock market forecasting. They found that, In today's investment in stock markets, buyers are concerned about the economic meltdown and are afraid in investing their hard earned funds on stocks. Shares are very good financial instrument and have been found useful in times of needs as a reliable way of preparing for the future. However the sudden downward trends in stock prices movement and huge loss of capital can discourage the potential investors from buying shares. The aim of this his contribution is to develop a neural network solution that can be used to predict the values of shares so that buyers especially short time operators can know which share to acquire or sell at the appropriate time. The error back propagation algorithm is used to train a feed -forward neural Network in order to be able to predict stock prices for short time duration. Stock Prices of Bank Nigeria were used as a case study [3]. Juan José Montaña Moreno et al., 2011, have offered a description and comparison of the main models of ANN which have proved to be useful in time series forecasting, and also a standard procedure for the practical application of ANN in this type of task.

The Multilayer Perceptron (MLP), Radial Base Function (RBF), Generalized Regression Neural Network (GRNN), and Recurrent Neural Network (RNN) models are analyzed. With this aim in mind, we use a time series made up of 244 time points. A comparative study establishes that the error made by the four neural network models analyzed is less than 10%. In accordance with the interpretation criteria of this performance, it can be concluded that the neural network models show a close fit regarding their forecasting capacity. The model with the best performance is the RBF, followed by the RNN and MLP. The GRNN model is the one with the worst performance. Finally, they analyze the advantages and limitations of ANN, the possible solutions to these limitations, and provide an orientation towards future research [4]. Khan et al, 2011, have found share Market is an untidy place for predicting since there are no significant rules to estimate or predict the price of share in the share market.

Many methods like technical analysis, fundamental analysis, time series analysis and statistical analysis etc are all used to attempt to predict the price in the share market but none of these methods are proved as a consistently acceptable prediction tool. Artificial Neural Network (ANN), a field of artificial Intelligence (AI), is a popular way to identify unknown and hidden patterns in data which is suitable for share market prediction. For predicting of share price using ANN, there are two modules, one is training session and other is predicting price based on previously trained data. They used Back-propagation algorithm for training session and Multi-layer Feed forward network as a network model for predicting price. They introduce a method which can predict share market price using Back-propagation algorithm and Multi-layer Feed forward Network [5].

In 2012, Vrabe et al 2012, have designed appropriate control strategy for prediction of surface roughness as one of the important indicators of machined surface quality applying artificial intelligence. Test sample was nickel based super alloy UDIMET 720, which is used as material of jet engines components such as discs etc. Experimental data collected from tests were used as input parameters into neural network to identify the sensitivity among cutting conditions, tool wear and monitoring parameters and surface roughness. Selected parameters were used to design a suitable algorithm for control and monitoring of the drilling process. Moreover, the developed software for implementation to machine tool control system for surface roughness on-line identification through monitoring indices is described [6]. Devi et al., 2012, have found temperature forecasting is important because they are used to protect life and property. Temperature forecasting is the application of science and technology to predict the state of the temperature for a future time at a given location. Temperature forecasts are made by collecting quantitative data about the current state of the atmosphere. A neural network can learn complex mappings from inputs to outputs, based solely on samples and require limited understanding from trainer, who can be guided by heuristics. In their work, a neural network-based algorithm for predicting the temperature is presented .The Neural Networks package supports different types of training or learning algorithms .One such algorithm is Back Propagation Neural Network (BPN) technique. The main advantage of the BPN neural network method is that it can fairly approximate a large class of functions. This method is more efficient than numerical differentiation. The simple meaning of this term is that our model has potential to capture the complex relationships between many factors that contribute to certain temperature. The proposed idea is tested using the real time dataset. The results are compared with practical working of meteorological department and these results confirm that our model have the potential for successful application to temperature forecasting [7].

In 2013, Donate et al., 2013 have contributed time series forecasting by evolving artificial neural networks with genetic algorithms, differential evolution and estimation of distribution algorithm. They found that the artificial neural networks are suitable for all kind of time series forecasting [8]. Sa et al., 2013, have presented an application of artificial neural networks to the real-world problem of predicting forest. The neural network used for this application is a multilayer perceptron whose architectural parameters, i.e., the number of hidden layers and the number of neurons per layer were heuristically determined. The synaptic weights of this architecture were adjusted using the back-propagation learning algorithm and a large set of real data related to the studied problem. They also presented and discussed some examples of illustrating results that show the performance and the usefulness of the resulting neural system [9]. Vieira 2013, discussed in his thesis submitted to School of echo, and management, Lisbon, Artificial Neural Networks are non-linear mathematical models widely used in forecasting. He

intended to investigate the support these models can give to economists predicting prices movements of oil and gas companies listed in stock exchanges. Multi-layer Perceptron models with logistic activation functions achieved better results predicting the direction of stocks returns than traditional linear regressions and better performances in companies with lower market capitalization. Furthermore, multi-layer perceptron with eight hidden units in the hidden layer had better predictive ability than a neural network with four hidden neurons [10].

In 2014, Artificial Neural Network has been used by Tamizharasi et al., 2014, in non-linear systems modelling and simulation. One of the most useful and interesting factors of ANNs is forecasting. This contribution discussed the application of Artificial Neural Network to predict the long range energy consumption for a country. In their contributions the long-term energy consumption for the years ahead is predicted, exploiting ANN computational speed, ability to handle complex non-linear functions, robustness and great efficiency even in cases [11].

In other application, by Malik et al., 2014 stated that weather forecasting is the task of determining future state of the atmosphere. Accurate weather forecasting is very important because agricultural and industrial sector largely depend on it. They presets Artificial Neural Networks in weather predictions. The Neural Networks package supports different types of training or learning algorithms. One such algorithm is Back Propagation Neural Network (BPN) technique.

Weather is a dynamic and non-linear process so Artificial neural network can be used for weather prediction. They also stated that ANN is the best approach than traditional and numerical methods. Back propagation is the most important algorithm to train a neural network for weather forecasting [12].

In other special contribution such as stock price prediction by Patel et al., 2014, here, the past data of the selected stock was used for building and training the models. The results from the model were used for comparison with the real data to ascertain the accuracy of the model [13].

Rao et al., 2014, estimated bull speed using neural network where back-propagation algorithm has been used. In his contribution they pointed out the shortage that exists in current traditional statistical analysis in the stock, then makes use of back-propagation neural network algorithm to predict the stock market by establishing a three-tier structure of the neural network, namely input layer, hidden layer and output layer. Finally, they obtained a better predictive model to improve forecast accuracy [14].

In 2015, Kuna, 2015, compares existing methods for predicting time series in real time using neural networks. Focus is put on recurrent neural networks (RNNs) and

online learning algorithms, such as Real-Time Recurrent Learning and truncated Back-propagation Through Time. In addition to the standard Elman's RNN architecture, Clockwork-RNN is examined. Methods are compared in terms of prediction accuracy and computation time, which is critical in real-time applications. Part of the work is experimental implementation of the tested models and working applications in robotics and network traffic monitoring [15]. In 2016, Enyindah et al., 2016, have applied neural network approach to financial forecasting, as the world economy keeps on changing, financial institutions and investors always look forward to a system by which they can monitor the dynamic financial state of the world.

This calls for a system that could simulate and predict financial positions based on financial market trends in order to manage and identify the best package to invest in. There was aimed at developing a neural network application to predict interest rate on loan investment in Nigerian bank using the back propagation neural network. It forecast interest rate on loan investment in three areas which include commerce, education, and rent/housing.

The simulation was done using Matlab 2008. From the results obtained the Mean Squared Error values  $3.99104E-6$  in the Training,  $3.597228E-5$  in the validation and  $9.9464314E-6$  in the testing which shows that the prediction was done with minimum amount of error. In this year an another significance application is published by Shah et al., 2016, and they presented efforts to predict the stock market using Artificial Neural Networks. In their study different types of Neural Networks, their salient features along with the internal working of these networks and the various configurations that they can be run with.

They go to comment on the advantages and disadvantages of these networks. Finally selected the one network with specific configurations and use it to predict the stock prices of a few selected companies from the National Stock Index. Finally achieved best case accuracy of 98% on the dataset [17].

### III. RESULT AND DISCUSSIONS

Broad review of the contributions from 2010 to 2016 it is observed that the neural network is significant in prediction of non-linear dynamic system. It is observed that Back-propagation and radial basis function, Back-propagation and genetic algorithm, Multi-layer Perceptron, Multi-layer Perceptron models with logistic activation functions, and Recurrent neural networks is appropriate for non-linear dynamic system such as stock, time series, weather, financial, share, temperature, surface roughness, stock price, forest prediction.

The significance contributors and their model have been depicted in the following Table 1. In most cases Back-propagation model is used due to its simplicity, accuracy and appropriateness for forecasting.

**TABLE I NEURAL NETWORK MODELS FOR NON-LINEAR DYNAMIC SYSTEM [1-17]**

No.	Contributor	Application	Year	ANN Model
1	Tarsauliya et al.	Financial forecasting	2010	Back-propagation and radial basis function
2	Peralta et al.	Time series forecasting	2010	Back-propagation and genetic algorithm
3	Akintola et al.,	Stock market forecasting	2011	Back propagation
4	Juan José et al.	Time series forecasting	2011	Multilayer Perceptron, Radial Base Function, Generalized Regression ANN, Recurrent Neural Network.
5	Khan et al,	Share Market forecasting	2011	Back-propagation
6	Vrabe et al	Prediction of surface roughness	2012	Back-propagation
7	Devi et al.,	Temperature forecasting	2012	Back-propagation
8	Donate et al.	Time series forecasting	2013	Back-propagation with genetic algorithm
9	Sa et al.	Forest forecasting	2013	Multilayer perceptron
10	Vieira	prices movements of oil and gas companies listed in stock exchanges	2013	Multilayer Perceptron models with logistic activation functions
11	Tamizharasi et al.	Prediction the long range energy consumption for a country	2014	Back-propagation
12	Malik et al.	Weather forecasting	2014	Back-propagation
13	Patel et al.	Stock price prediction	2014	Back-propagation
14	Rao et al.	Stock forecasting	2014	Back-propagation
15	Kuna	Time series forecasting	2015	Recurrent neural networks
16	Enyindah et al.,	Financial forecasting	2016	Back-propagation
17	Shah et al.,	Stock market prediction	2016	Back-propagation, Multilayer perceptron, Radial basis function

**IV. CONCLUSION**

Recent 17 significant contribution during the period of 2010 to 2016 have been reviewed to identify the applicability of neural network for prediction of non-linear dynamic system such as stock market, time series, weather, temperature, energy etc. it is found that the neural network system is significant for prediction of these system.

It is also observed that the neural network is significance to minimize error 3.99104E-6 in the training, 3.597228E-5 in the validation and 9.9464314E-6 in the testing for example. It is conclude that the neural network models like Back-propagation, Multilayer perceptron, Radial basis function are sufficiently suitable for prediction of non-linear dynamic system.

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