

COMPARING THE PERFORMANCE OF PREDICTIVE MODELS CONSTRUCTED USING THE TECHNIQUES OF FEED-FORWARD AND GENERALIZED REGRESSION NEURAL NETWORKS

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ABSTRACT

Construction of predictive model is primarily aimed at using the known attributes to determine the present or the future unknown attributes for efficient planning and decision making. The accuracy of predictive model is therefore, paramount to achieving network outputs that are well correlated with the known or target output. In this paper, two predictive models are constructed using the techniques of feed-forward and generalized regression neural networks. Experiments are conducted with a Matlab software and the performance of the two models is evaluated for accuracy. Their simulated outputs are compared to determine their response to untrained data. Findings from this study show that, the generalized regression neural network consistently shows a more accurate result. The Mean Absolute Error computed for the two models also reveals that, feed-forward neural network records higher error value.

Keywords: Predictive model, Feed-forward network, Generalized Regression, Prediction, Back- Propagation, Neural network.

INTRODUCTION

Construction of a predictive network model requires making a transformed set of data to undergo a number of training procedures. In the process, the dataset to be modelled iterates for a specified number of epochs and subsequently converges; the relationship between the input attributes and the target attribute is thus established. The developed network model can then be used to generate a prediction of the target attribute from the new untrained attributes. This is to allow prediction of unknown information by making use of the already known data. The known data is normalized in the course of pre-processing to the format suitable for predictive modelling.

In the process of normalization, string datasets are coded to numeric values of choice. Several methods are known to be appropriate for making such normalization and Kantardzic (Kantardzic, 2011), listed decimal scaling, min-max and standard deviation as effective normalization techniques. There are several techniques known for constructing a predictive model, this study proposed comparing two of the prominent neural network techniques. The present paper aimed at investigating the accuracy of each technique, especially when dealing with structured data.

While Feed-Forward Neural Network (FFNN) technique requires back-propagation algorithm for training, Generalized Regression Neural Network (GRNN) technique does not require this. Hence, the generalized regression neural network does

not face the frequently encountered local minima problem noticed in feed-forward back propagation applications (Cigizoglu, 2005). However, both techniques have been widely used for problem solving and well reported for model construction.

Findings from this paper would guide on the choice of these techniques for prediction. The rest of this paper is organized as follows: In the next section, construction of predictive model using a neural network is briefly discussed. In section 3, some related work reported in the literature is reviewed. The materials used and the proposed method are presented in section 4, while in section 5, the experimental results are presented and discussed. The study is concluded in section 6.

ARTIFICIAL NEURAL NETWORKS

The techniques of Artificial Neural Networks (ANNs) for model construction are well-established modelling method. A neural network is a biologically inspired non-linear parallel computing paradigm for information processing and exploratory analysis, having a distinct ordering among the sets of neurons arranged as input and output layers with zero or more processing hidden layers that are interconnected by signal channels and fine-tuned by a training algorithm (Chattamvelli, 2009). In neural networks, the neurons are connected by links, and each link has a numerical weight associated with it. Weight are the basic means of long-term memory in ANNs (Negnevitsky, 2011). The capability of a single neuron is very limited; a number of neurons can be connected in order to boost the processing power of the network. A typical neuron is represented in Figure 1.

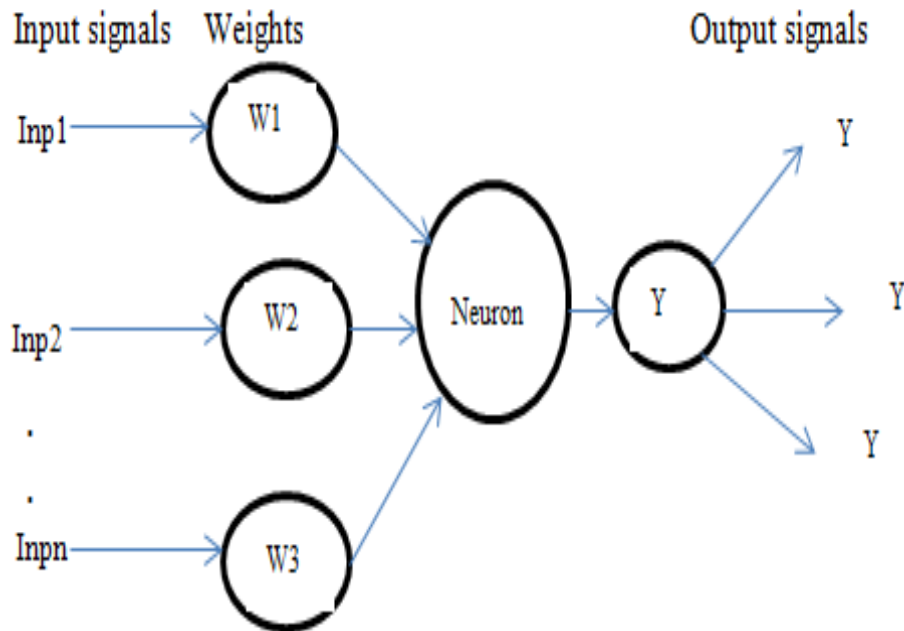


Figure 1. The neuron

To propagate error signal involves moving from the output layer and in the backward direction towards the hidden layer. The error signal at the output of neuron k at iteration p as defined in (Negnevitsky, 2011) is:

$$e_k(p) = y_{d,k}(p) - y_k(p)$$

where $y_{d,k}(p)$ is the desired output of neuron k at iteration p and $y_k(p)$ is the network output. It has been observed that one of the fundamental application problems in computing today is the development of systems that can carry out the rapid, reliable, automatic recognition and classification of complex patterns. Artificial neural networks are naturally suited to solving, pattern classification problems through machine learning (Hancock, 2012).

RELATED WORK

Predictive models using the techniques of neural networks are well reported in the literature. Both FFNN and GRNN have been used to construct useful predictive models. The study in (Kutyłowska, 2014), uses the multi-layered perceptron which is a feed-forward neural network to create a model for failure rate prediction. From the engineering point of view, the model trained with the back propagation algorithm, was evaluated to have given an acceptable convergence. The study opined that, the model created can be used for water utility in the future to establish the level of failure frequency and to plan the renovation of the most deteriorated pipes. Also, a study by Mishra and Desai (Mishra & Desai, 2006) constructs a predictive model using feed-forward neural network to forecast drought for effective planning and management of natural resources. The paper compares a number of neural networks techniques such as direct multi step, recursive multi step and stochastic model. The paper presented the potentials of the three models to effectively forecast drought over a lead time.

Pijanowski et al. (Pijanowski, et al., 2002) uses the technique of FFNN to create a land transformation model for forecasting of land use changes. The technique has also been reported for prediction of waste water treatment (Hamed, Khalafallah, & Hassanien, 2004). The technique is also found useful in Chemistry, especially for the molecular classification and pattern recognitions (Burns & Whitesides, 1993).

Study in (Cigizoglu & Alp, 2006) uses GRNN in the modelling of river sediment yield. Unlike FFNN, the generalized regression neural network does not require an iterative training procedure as in back propagation method and the resulting estimations from the developed model were found to be significantly superior to conventional method results. Leung et al. (Leung, Chen, & Daouk, 2000) developed a model using GRNN for the purpose of forecasting exchange rate and compares its performance with a variety of forecasting techniques and reported that, apart from having a higher degree of prediction accuracy, GRNN performs statistically better than other evaluated models compared in the study for different currencies. GRNN has also been reported to have performed well in prediction to forecast plant disease (Chtioui, Panigrahi, & Francl, 1999), and modelling of plasma etching (Kim, Kim, Kim, 2003). The effectiveness of using neural network for prediction as reported in a review carried out in (Adya & Collopy, 1998) is well elaborated and shows that, both techniques are well suitable for prediction and can be relied upon. The proposed study would further reveal the strength of these techniques and their areas of weaknesses.

MATERIAL AND METHODS

In this section, the material and methods used is discussed. The study explores a cross-country database for sector investment and capital, retrieved from the open data repository of the World Bank ("A Cross-country Database for Sector Investment and Capital – An open repository of the World Bank," 2014). The study aimed at modelling the capital investments, which is here referred to as input attributes and Gross Domestic Product (GDP), which is here referred to as the target attribute. The 570 data sets comprised of 4 input attributes and 1 target attribute. Experiments are conducted to create predictive models based on the two techniques (FFNN and GRNN) and these are implemented using the public data set, after all the required pre-processing.

Experimental procedures

Experiment I. The first model is created using FFNN technique and trained with 400 data sets; the same number is used to create the second model using GRNN technique. GRNN does not use training algorithm, the basic configuration of FFNN during the experiment is represented in Table 1, and its structure is shown in Figure 2.

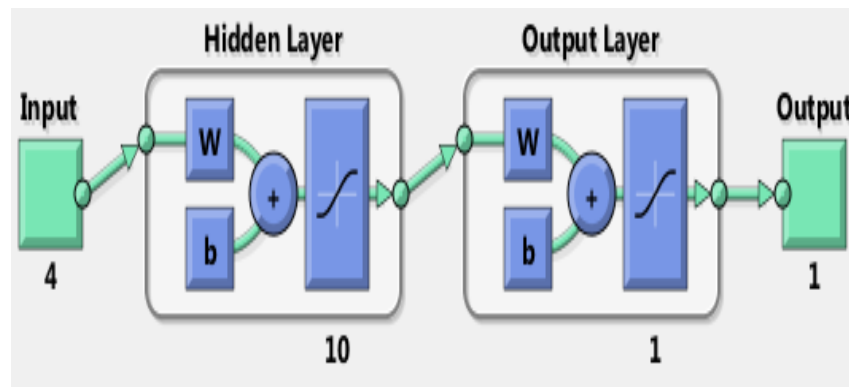


Figure 2. Feed-forward neural network structure

Table 1: FFNN configuration

Algorithm	Data Division: Random Training: Levenberg Marquardt
Network properties	Network type: Feed-forward BP Performance: Mean Square Error Number of Neurons: 10
Network Parameters	Epochs: 1000 Goal: 0 Min grad: 1e-7 Validation checks: 8 Mu: 0.001

The GRNN model is represented in Figure 3. It uses purelin transfer function towards the output layer.

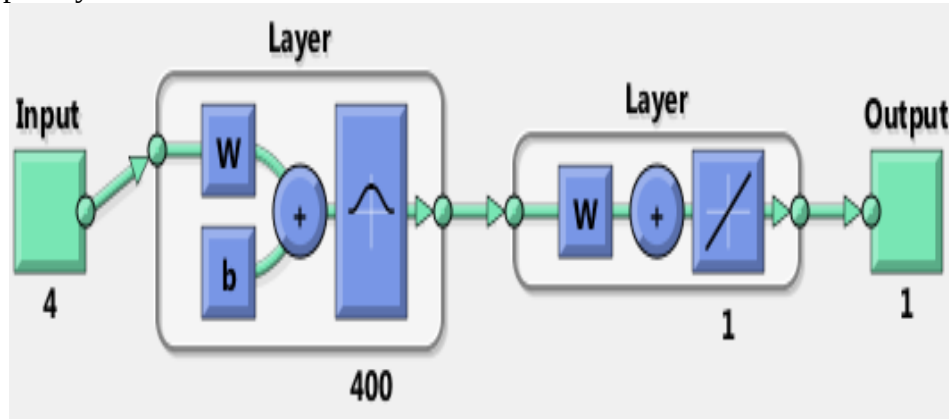


Figure 3. Generalized regression neural network structure

Experiment II. Each predictive model created is evaluated using the untrained 170 data sets. In order to establish the accuracy of each model, the Mean Absolute Error (MAE) associated with each model is computed and compared. The computation of MAE is based on (1):

The network output values of the test instances are $p_1, p_2, \dots, p_n$; the target values are $t_1, t_2, \dots, t_n$ while n is the number of sample dataset.

RESULTS AND DISCUSSION

In this section, the output results are discussed. The performance of the predictive model created using FFNN technique is represented in Figure 4. It can be seen from the figure that, the best performance is recorded at iteration 49, before it finally converges at epochs 55 to avoid over-fitting.

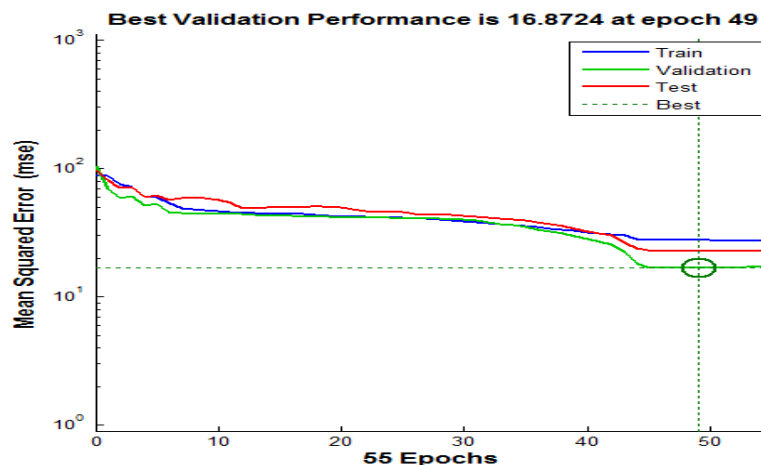


Figure 4. FFNN training performance

Each model is simulated with a view to achieving the target shown in Figure 5. The expected output comprises of 170 sample data, plotted against the Gross Domestic Product.

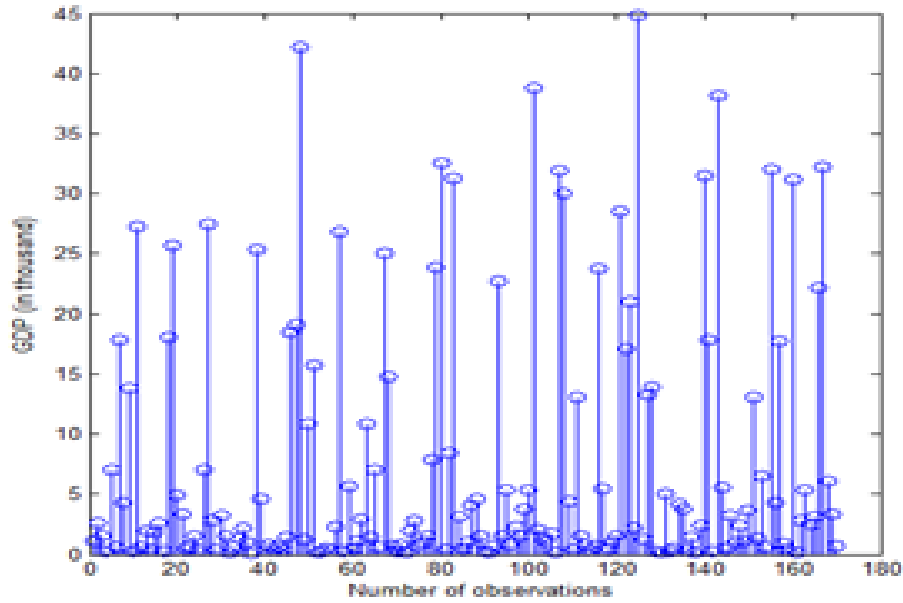


Figure 5. The Target Outputs

Figure 6 shows the result of simulating the model created using the technique of generalized regression neural networks, with a new data set not previously known to the network model. Comparing this to the target in Figure 4, it can be observed that, there are some GDP values above 35 that are not predicted.

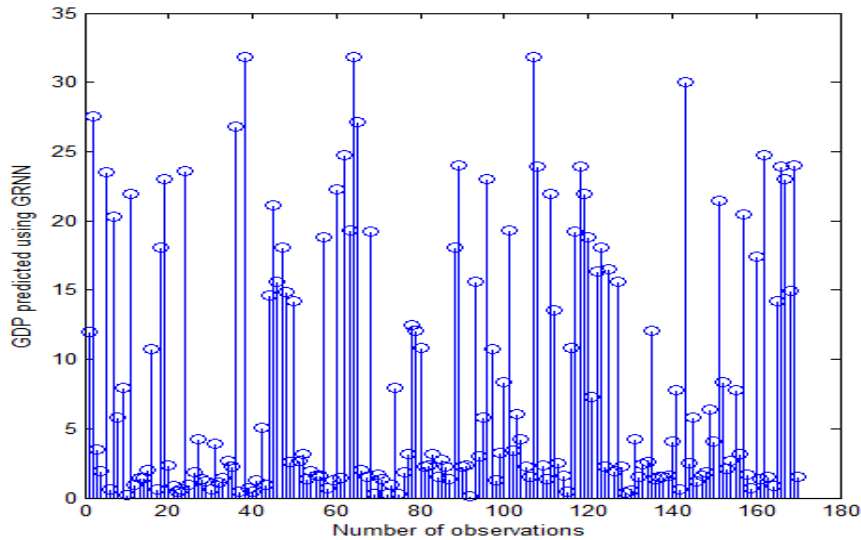


Figure 6. Simulated outputs using GRNN

Similarly, Figure 7 shows the result of simulating the model created using the technique of feed-forward neural networks, with a new data set not previously known to the network model. Comparing this figure to the target in Figure 4, it can be seen that

FFNN has challenges of predicting GDP between 30 and 35. Several values predicted as 40 cannot be traced to the target.

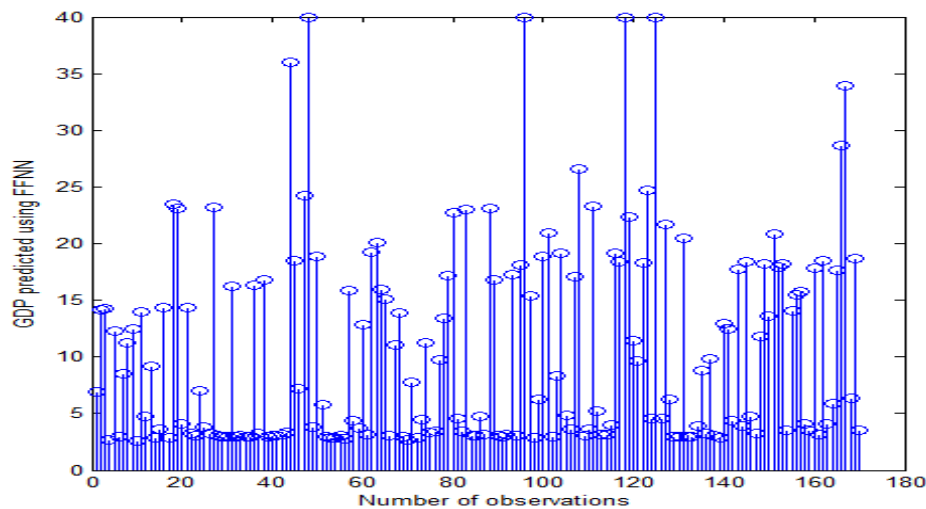


Figure 7. Simulated outputs using FFNN

In order to be more specific with the error values associated with each simulated result for the two models, the MAE is computed and the values are tabulated as shown in Table 2. The choice of error measurement for the simulated results in this paper is MAE; as performance measure using MAE does not tends to exaggerate the effect of outliers since all sizes of errors are treated evenly according to their magnitude (Witten, Frank, & Hall, 2011).

Table 2. Result of mean absolute error of the simulated outputs

Neural network technique	Size of data for model construction	Simulated data	Error
FFNN	400	170	6.879
GRNN	400	170	5.793

CONCLUSION

This paper presents the results of comparing the accuracy of the predictive models created using two prominent techniques in neural networks. Experiments are carried out to create a feed-forward neural network and generalized regression neural network models. The models are created using Matlab Software and implemented using 570 public datasets. The performance of these models is evaluated using a new set of data not previously known to the two models. Mean Square Error is computed for both models in order to determine the accuracy and reliabilities of these models. The results of comparing errors associated with each model show that the generalized regression neural network has lower error and performs much better.

The present study has shown that, the generalized regression neural network is suitable for predictions and can reliably be used to make useful estimations; GRNN can also compete with other techniques that are well known for predictions.

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