Forecasting Europe Nuclear Electric Power using Artificial Neural Networks

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ABSTRACT

Recently, research activities in artificial neural networks (ANNs) have proved that neural networks have powerful pattern classification and prediction abilities. ANNs have been used successfully for a variety of tasks in many fields of business, industry, and science. The results are indicated with perfect efficiency compared to traditional models, and it was able to minimize the error. The goal of this study was to forecast Europe's nuclear power using nonlinear autoregressive (NAR) models. The most important findings are that neural networks perform better at predictive analytics due to the hidden layers. Linear regression models use only input and output nodes to make predictions. The neural network also makes use of the hidden layer to improve prediction accuracy. This is because it 'learns' in the same way that humans do. It is recommended that additional research be conducted in the following areas. Intelligent forecasting methods are being used as an alternative to traditional forecasting methods.

Keywords: machine learning, · artificial neural networks, time series forecasting

INTRODUCTION

The recent upsurge in research activities into artificial neural networks (ANNs) has proven that neural networks have powerful pattern classification and prediction capabilities. ANNs have been successfully used for a variety of tasks in many fields of business, industry, and science. To achieve this, neural networks must be studied and simulated. The neural network of a person is a component of his or her nervous system, and it is made up of many interconnected neurons (neural networks). Artificial neural networks are prediction methods that are based on simple mathematical models of the brain. They make it possible to have complex nonlinear relationships between the response variable and its predictors. A neural network is a layered network of interconnected "neurons." Predictors (or in-puts) make up the bottom layer, and forecasts make up the top layer (or outputs). There could also be "hidden neurons" in the intermediate layers. Artificial neural networks are a new and promising method for time series prediction (ANNs). Artificial neural networks (ANNs) are a new and promising method for forecasting time series. ANN applications' success can be attributed to their distinct features and powerful pattern recognition capabilities. ANNs are data-driven, self-adaptive, and nonlinear methods that do not require specific assumptions on the underlying data generation process, unlike most traditional model-based forecasting techniques. These characteristics are especially appealing in practical forecasting situations where data is plentiful or easily accessible, but the theoretical model or underlying relationship is unknown. Furthermore, ANNs can capture any type of complex relationship due to their universal functional approximation ability. ANNs have an advantage in approximating nonlinear relationships in business data because the number of possible nonlinear relationships is typically large. Artificial neural networks are superior to traditional models in terms of prediction methods in several studies (Ashour and Abbas, 2018a, 2018b; Ashour, Jamal and Helmi, 2018; Abbas *et al.*, 2020; Abdul *et al.*, 2020; Ashour and Al-Dahhan, 2021; Ashour, 2022; Ashour and Alashari, 2022). In this paper, the time-series data for Europe Nuclear Electric Power is used in the application part. Introduction, methodology, theoretical aspect, practical aspect, results, and conclusions comprise the three major sections of the paper.

Method

Time series A time series is a collection of observations of a quantifiable quantity that are ordered by in-dices. While making a decision, you can use a time series analysis to analyze, describe, and explain a phenomenon over time. One of the most important objectives of time series analysis is prediction, which means that future series values are predicted based on current values (Ashour and Abbas, 2018a; Anbalagan *et al.*, 2020; Ashour and Al-Dahhan, 2020; Ashour, 2022).

Neural Network

Neural Networks are a type of artificial intelligence. The connection between inputs and undesired outputs is weighted and layers adjusted to achieve network learning.

In many applications, the multifaceted perceptron network (MLP) is one of the most basic models. It describes complex relationships between independent and dependent variables using nonlinear functions (Ashour, 2022). The MLP was first applied to the classification of complex problems. These models are overly complex, requiring numerous local minima to minimize error functions, and implementation is often difficult. Figure 1 illustrates how to create an NRT to forecast a time series based on its previous values (y_{t-1}, y_{t-2}).

A nonlinear autoregressive model, which can be automatically written in this format, is a network of neural systems for the projection of time series (Helmi, Jamal and Ashour, 2018; Munim, Shakil and Alon, 2019; Wirawan, Widiyaningtyas and Hasan, 2019; Anbalagan *et al.*, 2020; Ashour and Al-Dahhan, 2021; Ashour and Alashari, 2022):

$$y_t = r(y_{t-1}, y_{t-2}, \ldots\ldots y_{t-d}) \qquad (1)$$

The function r(.) It is unknown before long and the formation of the neural network aims to approximate it by optimizing network weight and optimizing neurons (Minu, Lineesh and Jessy John, 2010; Helmi, Jamal and Ashour, 2018; Derbentsev *et al.*, 2019; Ahmed *et al.*, 2020; Jamal *et al.*, 2021; Ashour, 2022; Ashour, Ahmed and Al-dahhan, 2022).

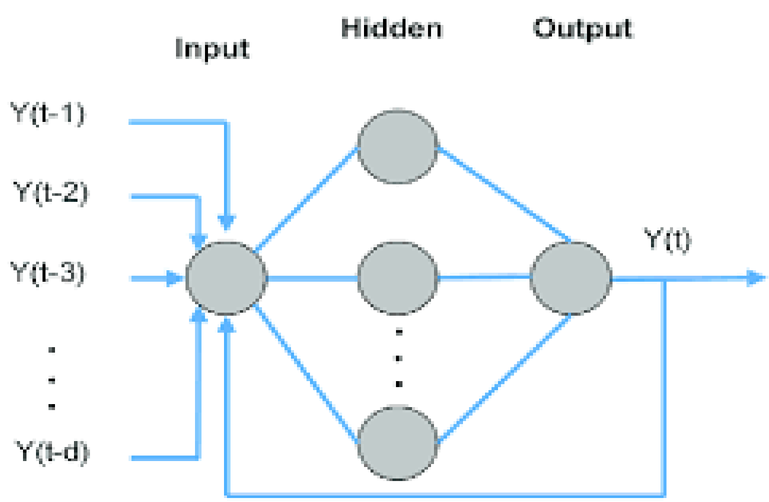

Figure 1. construction of a nonlinear autoregressive neural network (Jamal *et al.*, 2021; Ashour and Alashari, 2022).

Measuring Error Accuracy

To performance the accuracy of the error results, the following indicators were used root mean square error (RMSE) and mean absolute percentage error (MAPE) (Helmi, Jamal and Ashour, 2018; Wirawan, Widiyaningtyas and Hasan, 2019; Anbalagan *et* *al.*, 2020; Ashour and Al-Dahhan, 2020; Ashour, Al-Dahhan and Al-Qabily, 2020).

$$RMSE = \sqrt{\frac{\sum e_t}{n}} \qquad (2)$$

$$MAPE = \frac{\left|\sum \frac{e_t}{y_t}\right|}{n} \qquad (3)$$

Where:

$e_t = y_t - \hat{y}_t$

Result and Decision

The time-series data for Europe Nuclear Electric Power is used throughout this section to assess the accuracy of the prediction methods. Figure 2 shows Europe's Nuclear Electric Power (Electricity generated using the thermal energy released from the fission of nuclear fuel in a reactor) from 1980 to 2006, source: united states Energy Information Administration.

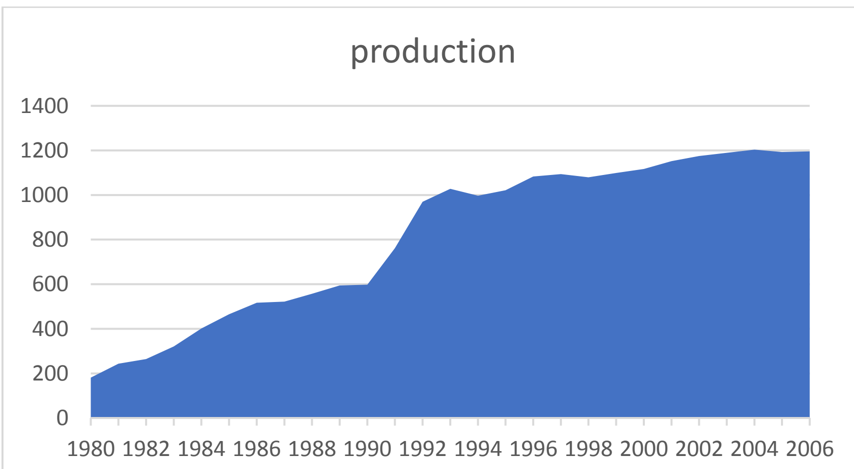

Figure 2**.** shows Europe Nuclear Electric Power by year

As shown in Figure 2 a rise in production rates and the series includes a trend. The results of the model forecasting were calculated. To generate results, the MATLAB high-level programming language is used to estimate neural network forecasting results. After several tests, the number of nodes in the hidden layer with one layer that works best is 15 nodes. The observations at shift 1 are the input nodes of this time series, the prior (lag) observations are $_{t-1}$, that is, Y_{t-1}, and the output is Y_t. The network performance results are shown in Figures 3, 4, and Table 1.

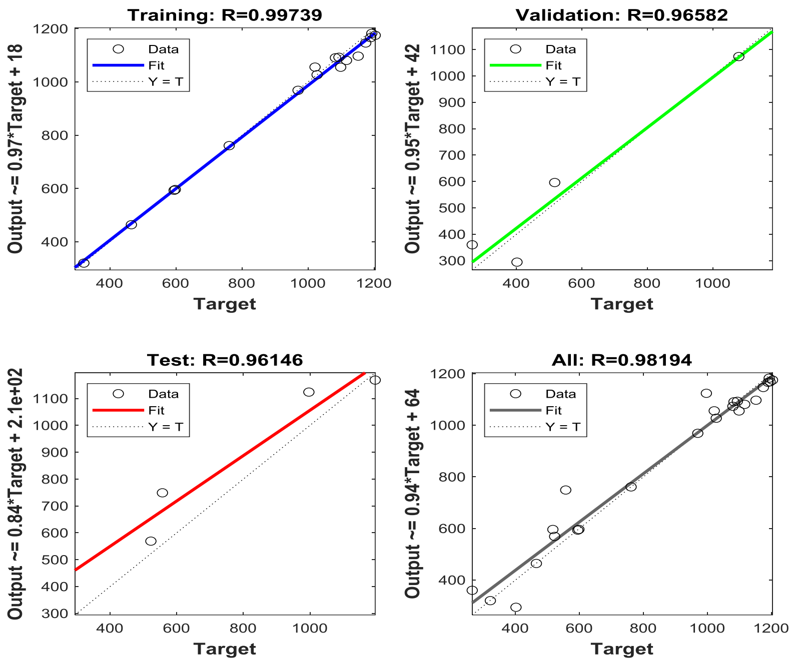

Figure 3. Network evaluation in training and testing

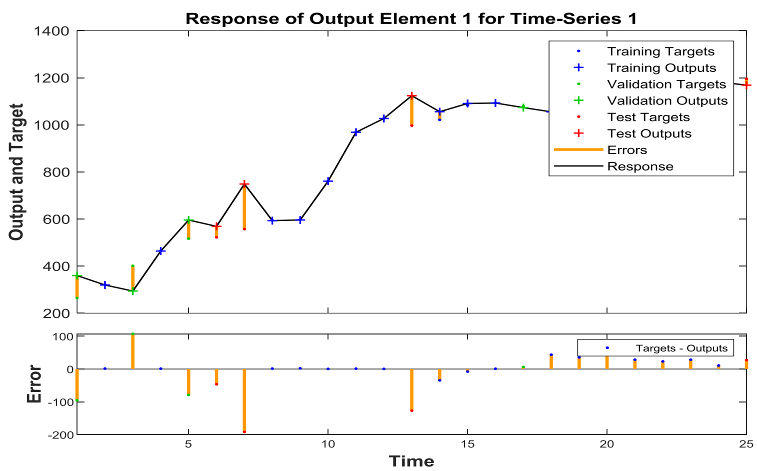

Figure 4. Output response

Table1. Error accuracy

RMSE	60
MAPE	6.4

Figures 3–4 show that the values of R and the response of the output element for both the training and validation data sets are nearly identical to those for the test set for all developed neural network models. The error accuracy valuation measures have a significant impact, as shown in Table 1.

CONCLUSIONS

Artificial neural networks have emerged as an important tool for time series forecasting. ANNs have many desired features that are quite suitable for practical forecasting applications. ANNs have achieved remarkable successes in the field of electric power forecasting. It is, however, important to note that they may not be a panacea for every forecasting task under all circumstances. Forecasting competitions suggest that no single method, including neural networks, is universally the best for all types of problems in every situation. Thus, it may be beneficial to combine several different models in improving forecasting performance. Indeed, efforts to find better ways to use ANNs for forecasting should never cease. This discovery implies that NAR can be used to generate more accurate forecasts. The current findings support the usefulness of NAR in predicting time series, whether linear or non-linear.

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