

Short Term Electric Load Prediction Using Artificial Neural Network

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Abstract

This paper uses Neural Network Toolbox in Matlab for electric load forecasting. Artificial neural network is implemented for the purpose of accurate prediction of future load. The prediction model is trained by historical data from electric system utility. The method consists of graphical user interface form Matlab to easily solve the complex problem like electric load prediction. The output of model used is then compared to actual data for validation.

1. Introduction

Artificial intelligence is finding its application in various fields of engineering problems. Predicting the future load for an electric system utility is a similar kind of problem. Any electric system utility in the scenario of deregulated economy needs to accurately perform electric load forecasting for secure and economical operation of power system. There are three basic types of load forecasting classified according to the period of forecast: (1) short term load forecast for a period ranging from one hour to one week, (2) medium term load forecast for duration of one week to one year, (3) long term load forecast for period of one year to several years.

There are various factors which affects the accurate load prediction like temperature and whether conditions. The model is build considering the above mentioned factors. Till now a number of techniques have been used for electric load prediction. These techniques are broadly classified as classic or modern. The most important methods are regression method, time series approach, Kalman filters, wavelet transform, particle swarm optimization, fourier series approach and support vector machines. In recent research artificial neural network has been

used in wide applications related to load prediction. There are other methods called as hybrid methods are also used for modeling such as fuzzy logic and genetic algorithm.

The artificial neural network, fuzzy logic and genetic algorithm are intelligent method and able to learn and gain the changes in the circumstances. These methods are called as artificial intelligence methods. Artificial neural network is based on training the network with past and current data as input and output respectively. Simulink in Matlab is a graphical user interface which helps the designer to simulate the actual mathematical model with the use various components provided in Simulink library.

Short-term load prediction is used to provide utility company management with future information about electric load demand in order to assist them in running more economical and reliable day-to-day operations.

The power load during the year followed the same the daily and weekly periods of electric load, which shows the daily and weekly cycles of human activities and behaviour patterns, with some cyclical and random changes. The impact of space cooling on the electric load is very obvious during the summer time. When the temperature increases, the demand for electricity also increases.

On the other hand, during the winter time the reverse relationship between temperature and electric demand exists because of the need for space heating. The system load is the sum of the entire consumer's load at the same time. The objective of system STLF is to predict the future system load. A good understanding of the system characteristics helps to design reasonable prediction models and select appropriate models operating in

different situations. Various factors that influence the system load behaviour can be classified into the following major categories:

- Weather
- Time
- Economy
- Random disturbance

2. Elements of Artificial Neural Network

An artificial neural network is chosen for prediction of electric load as it has the capability to approximate non-linear function present in load profile of electric system utilities. ANN refers to a class of models inspired by biological neuron system. It consists of a number of computing units working in parallel called as neurons.

A neuron (figure: 1) is a multiple input single output processing element consisting of a summation operation and activation function. Below is a brief description of the component.

Weighting functions (input links X_1-X_n): an adjustable representative of the input's connection strength.

Summation function (Σ): This component performs the weighted summation of the various inputs received by the neuron.

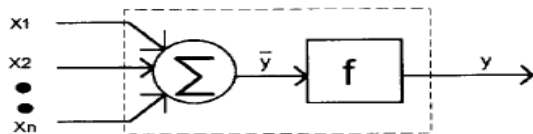


Figure: 1 Artificial Neuron.

Activation function: The output of the summation function is then taken by the transfer function. This transfer function transforms the summation output into a working output.

Transfer functions that may be used are:

- Hard limiter,
- Ramping function, and
- Sigmoid functions.

Output function: Each neuron produces an output to many other neurons. In Figure 1, it is represented by y .

Figure 2 shows the first layer of the three-layer feedforward network that is implemented in this paper. Feedforward means that inputs are progressed in a forward manner from layer to layer.

The number of input variables, number of hidden layers and the number of neurons in the hidden layers make the results change. That is why they need to be chosen very carefully.

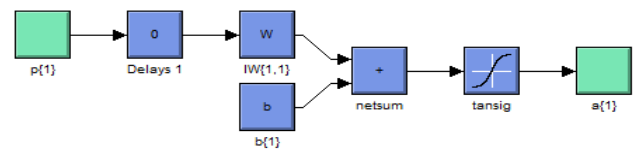


Figure: 2, First layer of three layer feedforward network

However the training procedure of the neural network helps in choosing the appropriate network configuration. Training is done to find the weights that minimize the error. The training stops when either the number of iteration has been reached or performance goal has been achieved.

The mean absolute percentage error is measured by:

$$MAPE = \left[\frac{\sum (|A_L - P_L| / A_L)}{N} \right] * 100 \quad (1)$$

Where

A_L : Actual Load.

P_L : Predicted Load

N : No. Of Hours for Which Load is predicted.

The proposed ANN structure is shown in figure 3 below. There are four inputs given to the ANN in this case, however the number of inputs can be less or more according to the data available. For example we can add data related to type of weekday, whether it is a weekday or weekend. There is single output which is forecasted load.

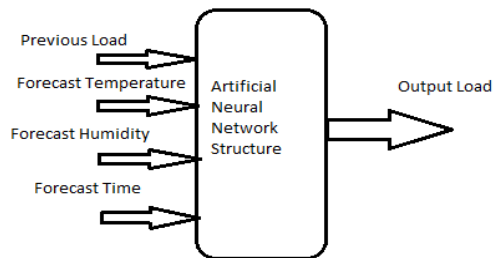


Figure: 3, Artificial Neural Network Structure

3. Prediction procedure

In predicting of electric load we have used a three layer feedforward neural network, trained by using back propagation method of training. Table 1 shows the structure or topology used in the ANN model used in this paper. As seen in the table, there are four numbers of input variables we are using to forecast the profile of electric load in future. The data used in the training.

TABLE 1

DEFINITION OF ANN INPUTS AND OUTPUT

Inputs	Description
1	Previous day load
2	Previous day temperature
3	Previous day Humidity
4	Time
Outputs	Description
1	Forecasted load

A. Neural network model:

The below shown figure explains how the neural network process the given input and produce an output that is given to the network. As the network is given the input data which is pre-processed and the processed input is given to the network that is a black box trained by the historical data which gives the predicted value related to the input given. Output of the network is post processed and shown as a graph or table.

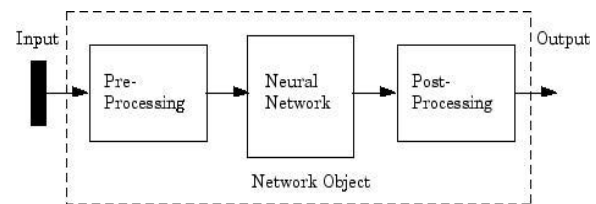


Figure: 4, Block diagram of Artificial Neural Network

B. Simulink toolbox in Matlab:

Matlab have a number of toolbox that can solve various engineering problems. But Simulink toolbox is different in a way as it can provide a graphical user interface to the designer. This makes the designing process easy as compared to writing a program for the same problem. It also provides the facility to convert the GUI into codes so that if someone wants to work with the programming the same will be available easily.

Below shown figure is the Simulink model of the ANN that is used for load forecasting. We have to give the inputs and when we run the program output can be seen by double click on the plot box (y1).

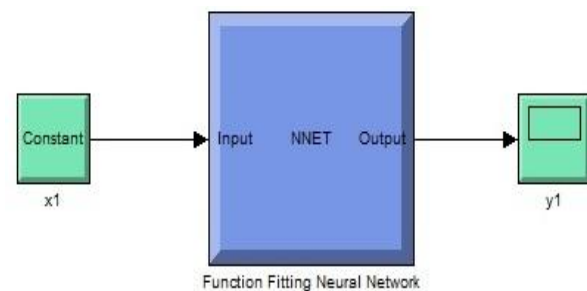


Figure: 5, Model of Artificial Neural Network in Matlab

4. Results

The ANN works as a black box that is trained using the historical data and put for prediction of the future data. Here we have trained the network using load data taken from substation of local electric utility and day ahead prediction of load is generated. Simulation results are shown in the below shown figures.

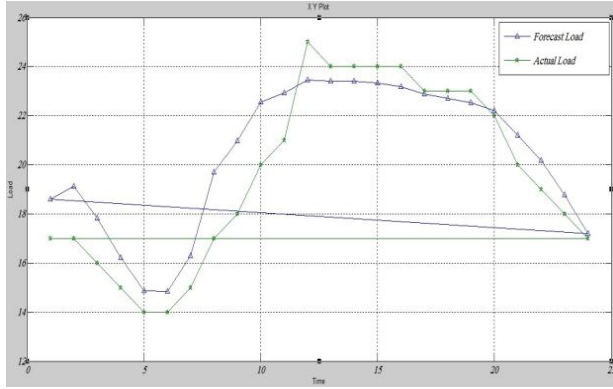


Figure: 6, Predicted Load on Day Ahead Basis (For Tuesday)

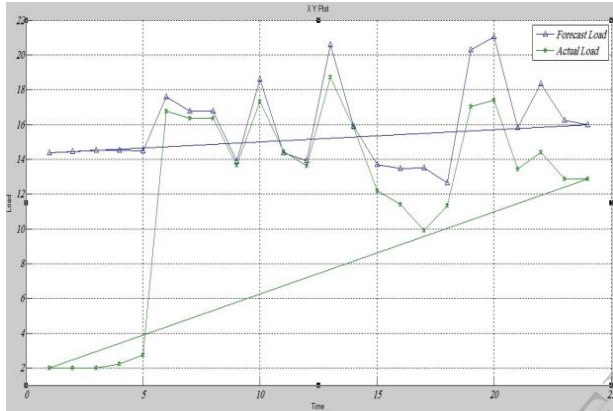


Figure: 7, Predicted Load on Day Ahead Basis (For Saturday)

As shown in the figures 6 and 7 the plot is drawn between actual load and predicted load. This shows a relation between the two curves of load. Figure 8 shows the curve of mean square error plot of training, testing and validation. Which is about 4.4% is achieved.

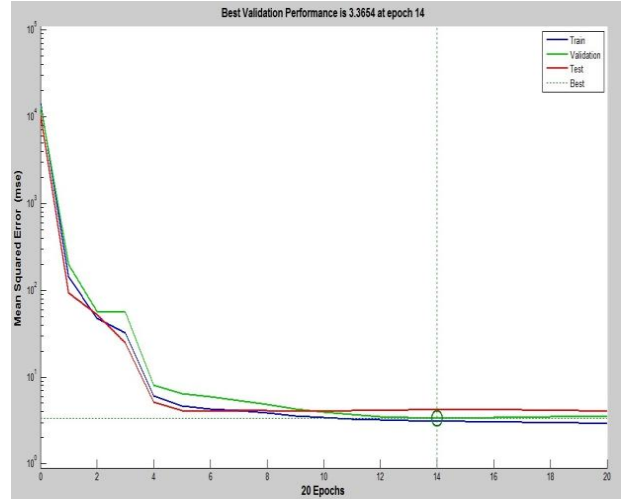


Figure: 8, Mean square error for the forecast

5. Conclusion

From the simulation results shown we can assume that artificial neural network is well suited for predicting any quantity whose historical data is available. As the mean absolute percentage error calculated below is shown.

MAPE

$$\text{(Tuesday)} = \left[\frac{|(472 - 487.3)|}{472} \right] * 100 / 24\% = 0.13\%$$

$$\text{(Saturday)} = \left[\frac{|(286.7 - 382)|}{286.7} \right] * 100 / 24\% = 1.03\%$$

The error will be lesser if we have a larger dataset with us and the variation in data is lesser.

While we have used the ANN approach for our experiment, the combined Neuro-Fuzzy approach can be tried for improvement in results.

6. Rreferences

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