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Application of Advanced Back Propagation Algorithm in Electric Load Forecasting

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Abstract

Now a day's load forecasting leads an immense area of research in power system. It helps to generate the power with minimal cost and ensure the reliability of power systems. It is so much attractive because accurate load forecasting is a challenging task for its difficulties. This paper presents the load forecasting for the Power Grid Company Bangladesh Ltd. (PGCB) by using Advanced Back Propagation Algorithm. It is advanced because here the adaptation mechanism is used to update hidden layer. And it uses newly designed data set where only that kind of inputs are chosen which give the best prediction output. These inputs are chosen by trial and error method. The data are collected from PGCB to train the system. This paper has proposed to train the network in summer for reducing load shedding and in winter, holidays to minimize the power loss as well as the cost of generation. Experimental results show that the system provides the load forecasting with high accuracy.

Keywords: Load forecasting, PGCB, Artificial neural network, Back propagation algorithm.

1. Introduction

Load forecasting extremely shows its importance in operation and planning of power system. It helps in reducing the cost of generation, transmission and distribution. Load forecasts can be divided into three categorists: short-term forecasts, medium-term forecasts and long-term forecasts [17]. Short-term load forecast is that in which load is forecasted from one hour to one week, medium-term is that in which the time duration is one week to one year and in long-term forecasting the load is forecasted for larger than one year. Many methods are used for load forecasting such as regression methods [1]–[2], similar-day approach [3], expert systems [3], [4]–[5], time series [1] & [6], neural networks. Among these methods, neural networks have been widely used [15]. But in PGCB there is used statistical method for load forecasting which is not so adequate because it has the accuracy problem. And it is found after investigation that in statistical method, PGCB able to make only 70% accurate load forecasting. So accurate forecasting of load is essential for PGCB to maintain its distribution in an effective manner. Many researches show that the using of ANN makes the load forecasting much reliable. It helps to predict the load demand and provide more accurate result than statistical system and expert system.

In Bangladesh accurate load forecasting is urgently needed. Because without this the power management is hampered and the load side equipments are damaged day to day and produces so many unwanted oscillations in the generation sectors which are the cause of great power loss and the curse for generator stability. And for load shedding it also affects badly on daily activities of people. The load forecasting helps to reduce the load shedding by proper distribution of power. This paper presents the advanced back propagation algorithm with newly designed data set to predict the load demand and train up the system to forecast the electric load for Power Grid Company of Bangladesh Ltd. Here the data are collected from the PGCB website and model of the network is trained up with summer's data to reduce load shedding and with the holydays and winter's data to distribute the power efficiently as well as to reduce

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the cost of power generation. Minimal number of inputs is used which is enough for training and testing the network. And adaptation technique is used to set the number of neurons at hidden layer. After proper training the network is tested for 50 days of winter and summer seasons of Bangladesh. With the test result here, the error is investigated properly and tries to reduce the error by using proper sensitivity analysis.

This paper is organized as follows: Section II describes the basic of ANN; section III introduces the Back-Propagation Algorithm, section IV provides the idea of Load Shedding. Daily load condition and the amount of load shedding of PGCB are given at section V. Section VI describes the proposed model of ANN and in the section VII the paper is concluded.

2. Artificial Neural Network

ANN is a connectionist computational system. It does not follow a linear path but execute its performance in parallel throughout a network of nodes. The key feature of ANN is that it can learn and learn like human brain. Now a day's ANN becomes the most attractive tool in power system planning and energy management. It has the structure that process the data in a similar way the human brain does. It consists with a number of interconnected artificial neurons that process external and internal information in parallel. It can be designed with single layer or multi layers. The layer to layer connections are strengthen by the weights and activation function is used to take the output in a desired range. And a tow layer feed forward network is shown in Fig. 1 with one hidden layer.

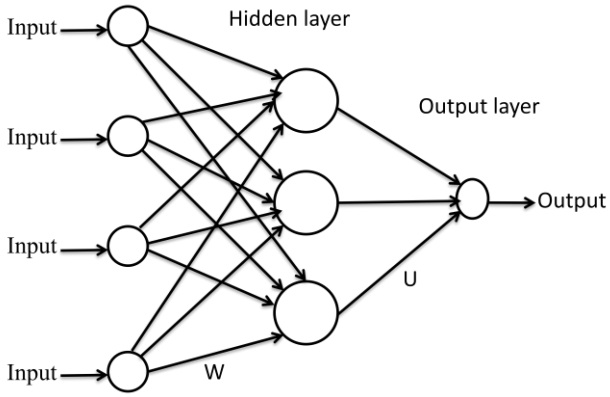

Fig. 1 A two-layer feed-forward neural network.

ANN introduces a fabulous performance for nonlinear functions. Here particular input leads specific target output. It contains one or more hidden layers. The proposed network has only one hidden layer because more hidden layers make the system complex and interrupt the learning system by its exogenous behavior.

3. Back Propagation Algorithm

The back-propagation algorithm is most used training algorithm in load forecasting, but it has so much variety. This network learns from many inputs for a desired output. Actually, it learns from example. It requires a dataset of the desired output to make up a training set. The typical back propagation network structure for short term load forecasting is a three layer network, with the nonlinear sigmoid function as the transfer function [7]–[8]. The input variables of this can be historical data [9], hour of day index [9], [10]–[11], day of week index [10]–[11], wind speed [10], sky cover [10], rainfall [10]. It also requires the activation function like sigmoid function. Here we use

the tan-sigmoid function as activation function. The simplest implementation of back propagation learning updates the network weights and biases in the direction in which the performance function decreases most rapidly, the negative of the gradient [12]. The iteration of this algorithm is,

$$x_{k+1} = x_k - a_k g_k \tag{1}$$

Here x_k is a vector of biases and weights, g_k is gradient and a_k is the rate of learning.

If the hidden layer of back propagation is increased, it consumes more time to train up so only one hidden layer makes the train up system simple and helps to be speedy.

In this paper an advanced back propagation algorithm is used. Which is advanced because of the adaptation mechanism is used in hidden layer. It is found in many researches that the difficulties are arisen in choosing the number of neurons in hidden layer by trial and error basis. For that reason, the adaptation mechanism for hidden layer is introduced in this paper where the numbers of neurons in hidden layer are adjusted automatically with the change of input pattern.

4. Power Grid Company of Bangladesh

Power Grid Company of Bangladesh Ltd. (PGCB) was created under the restructuring process of Power Sector in Bangladesh with the objective of bringing about commercial environment including increase in efficiency, establishment of accountability and dynamism in accomplishing its objectives [14]. It makes the relation between the generation sectors and the the ditribution sectors. All the generated power of Bangladesh is summed up in PGCB and try to distribute them with the priority of demand. But it has a great problem in load forecasting. It also can not predict the load shedding for that reason power is lost and many unwanted disturbance is occurred. So if the actual prediction can be made up about the load then it can maintains it works more smothly. Everyady it shows 600MW to 700MW load shedding which is not so correct. For that reason it cannot give the exact signal of load variation to the generators. And generating station fails to provide appropriate protection for generators which causes the damage of the total system. Sometimes in Bangladesh some power plant are injured badly for only the proper prediction of load and load shedding. The load distribution of PGCB for everyday is shown in Fig. 2. This graph is consisted with four curves. Here violet curve represents the system total; cyan curve represents the west grid load; deep pink curve represents the inter connected load and another curve represents the east grid load.

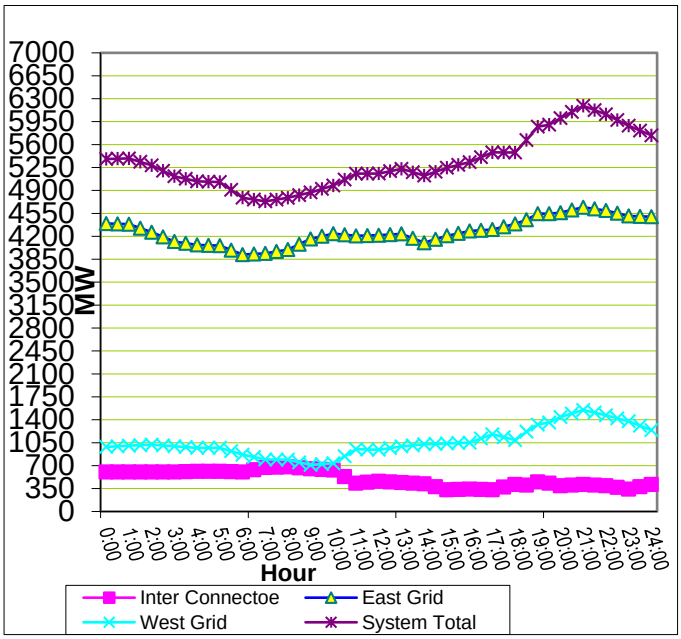

Fig. 2 Daily Load Curve of PGCB.

5. The Proposed Model of ANN

The proposed ANN model is based with two layers feed forward ANN. It consists with 22 inputs and one hidden layer with auto adjustable neurons. The output layer has only one neuron. Here tan-sigmoid function is used as activation function.

A. The input vector

It consists with the daily data of summer, rainy and winter season and the data of Friday, government holiday, Eid festival and Durga puja which represent the holiday. Here two indexes for year and month, three indexes for season, seven indexes for day per week, four indexes for holiday, four indexes for historical data and two indexes for weather are used.

Here indexes of [1:12] represent the month, the seasons are represented by [1:6] indexes, [1:7] indexes is used for week, [0, 1] for Friday and other events. At first a problem is raised that the value of data of PGCB is so large. But ANN shows its expertness for only that data which value is in the range of 0 to 1. For that purpose, all the data is brought in the desired range by dividing with the maximum value and then it is provided to the modeled network. The half hourly data for the high load variation periods of the day, typically 11:30, 12:30, 13:30, 14:30, 18:30, 19:30 and 20:5 which were represented by the fractions (11.5, 12.5, 13.5, 14.5, 18.5, 19.5, and 20.5) respectively.

The input pattern is considered from the load variation events. And only that kind of inputs are chosen by trial and error basis for which the network shows a great performance by providing the output nearer to the actual value. That means for which inputs the error is nearer to zero that inputs are considered. Sometimes some inputs found that makes greater error and try to make network unstable.

The figure of input indexes is shown in Fig. 3.

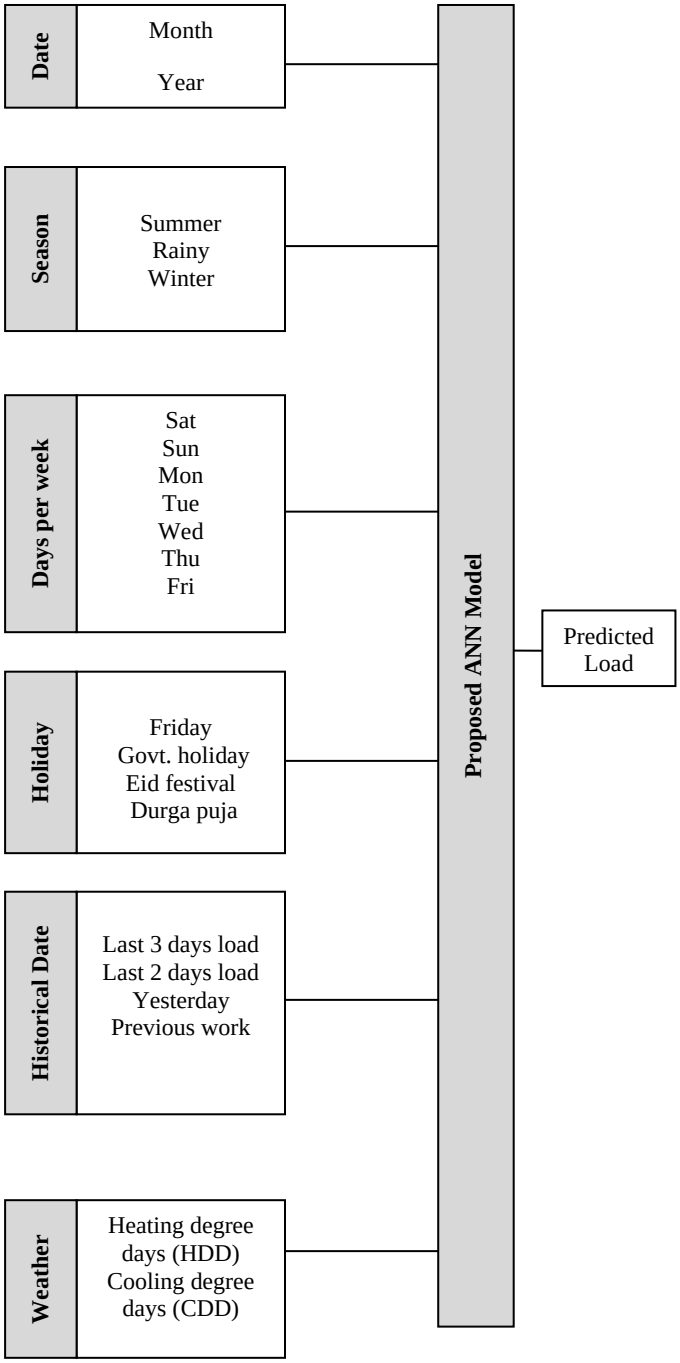

Fig. 3 Indexes of inputs.

B. Hidden layer

We've used only one hidden layer for the simplicity and we use auto adjustable technique for updating the hidden layer. Here we've seen that the variation of number of neurons make error. We observed that over or fewer than desired numbers of neurons the amount of error is such a pattern that tends to make system unstable. Because it produces some unwanted oscillations. So, to maintain stability and for removing unwanted oscillations here auto adjustable technique is chosen.

C. Data processing

It is essential before training to process the data. For processing data, we use the following equation:

$$y_s = \frac{(y_{max}-y_{min})(x-x_{min})}{x_{max}-x_{min}} + y_{min} \quad (2)$$

Here y_s is scaled data element, x is the original data element for each input and target vectors, x_{max} and x_{min} are the maximum and minimum value corresponding data element respectively and y_{max} and y_{min} are scaled data maximum and minimum value. Our activation functions also help to process data as an inputs of hidden layer and output layer.

D. Weight correction

At first, we take the random weights. Then we calculate every neuron error (Error = Target-Actual output). This error is then used to correction the weights. By correcting the weight each neuron gets closer to the target.

E. Train the network

The training goal was set at 0 so as to ensure zero tolerance to the network computational error [16]. For training the network we use fixed learning rate which helps to change the weights and we also used automated regularization of back propagation algorithm. The stability of the system depends on learning rate. The greater the learning rate, system goes into unstable. Here we use 0.05 learning rate. In training the problem is over-fitting. We see a large error when it is tested and for this to improve the generalization, an automated regularization technique is developed in this model [12]. To reduce the error is the main objective of training. For using regularization, the objective function becomes:

$$f = \beta\varepsilon_d + \alpha\varepsilon_w \quad (3)$$

This performance function causes the network to have smaller weights and biases, which make the network response to be smother and less likely to over-fit [12].

F. Simulaion result

The error was calculated by comparing the forecasted load and the actual load. The mean absolute percentage error is used to evaluate the performance and it is defined as:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\frac{|t_i-\alpha_i|}{t_i} \times 100 \quad (4)$$

Where α_i is the forecasted load and t_i is the actual load, n is the number of data points. The proposed network is tested for 50 days of winter and summer season, 2013. The simulation result of testing is given below in Fig. 4 which shows the relation between forecasted load and actual load and also provides the sense of error. In Fig. 4 the blue color curve shows the forecasted load and the red one shows the actual load. The simulation result makes it clear that the forecasted load is so close to the actual load and for simple visualization purpose there only shows the load forecasting in between 1 to 50 days of year which represents the winter season and in Fig. 5 it is observed the relation between actual load and forecasted load for summer season.

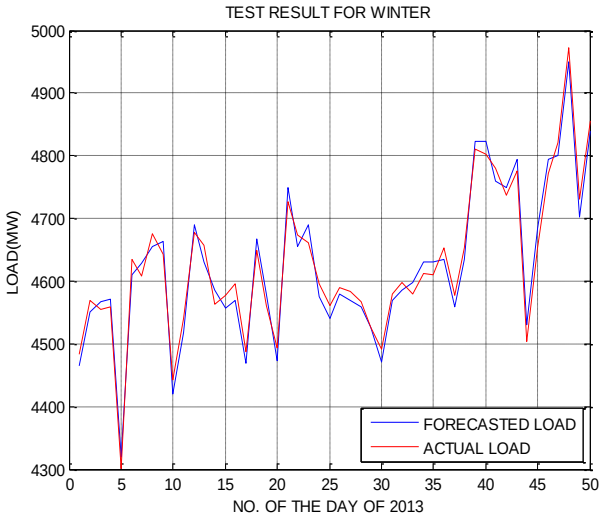

Fig. 4 The forecasted load with actual load in winter.

And the simulation result of load forecasting of summer season, 2013 is given below in Fig. 5.

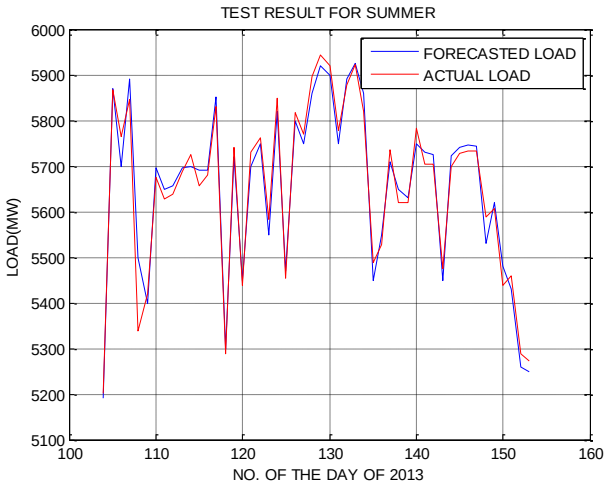

Fig. 5 The forecasted load with actual load in summer.

6. Conclusion

This paper investigated the ANN-based load forecasting for PGCB. It predicts the demand and generation of load and helps to reduce power loss as well as the load shedding. It proposed the necessary ANN model and the training method. Here it seems that load forecasting with ANN is effective, accurate and helps to proper operation of power system. The proposed Artificial Neural Network provides minimum 95% accurate load forecasting and load shedding prediction which introduces a remedy for the blackout. It also can help in reducing oscillation of generator. It also can be used with Adaptive controller for better voltage stability. Further development of this paper is the application of echo state networks in load forecasting with load shedding forecasting but with an improved network which will provide these two outputs at the same time not separately.

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