Short Term Load Forecasting using Artificial Neural Network

Amera Ismail Melhum, Lamya abd allateef Omar, Sozan Abdulla Mahmood

Abstract— Load forecasting helps an electric utility to make important decisions including decisions on purchasing and generating electric power, load switching, and infrastructure development. Load forecasts are extremely important for developing country like Iraq, financial institutions, and other participants in electric energy generation, transmission, distribution must be studied and took a good attention. This work analyzes and discusses a comprehensive approach for Short Term Load Forecasting (STLF) using artificial neural network. Proposed architectures were trained and tested using previous two years actual load data obtained from Duhok ELC. Control in Iraq. In this study, four ANN models are implemented and validated with reasonable accuracy on real electric load generation output data. The first and second model are to predict values of one ahead day and seven days, while the third and fourth models are also to predict values of next and seven days, concerning the amount of period of disconnected time. A forecasting performance measure such as the absolute mean error AME has been presented for each model.

Index Terms— Load forecasting, artificial neural network, back propagation

I. INTRODUCTION

One of the major research areas in the field of electrical engineering which has been of great importance for many years is load forecasting. It performs as a core process for effective economic planning as well as operational decisions of electric utility companies. Accurate forecast provides basis for decisions in unit commitment, hydrothermal coordination, hydro scheduling, fuel allocation, economic load dispatch and optimal power flow calculations, which leads to savings for electric utilities. Load forecasting facilitates to maintain a balance between electricity supply and demand. [1]

Load forecasting is however a difficult task, especially for a country like Iraq whom faced many wars during the last few decades that caused destroying the infrastructure sectors especially the electricity region, although many experiments to arise the level by fixing and improving it but still didn't reach the demanded level and some of the regions the numbers of cut hours reach 17-20 hours daily, In this paper we consider Duhok which has a sort of stability in electricity demand and the amount of cut hours varies between 5-12 hours.

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Many methods have been developed for the forecasting. They are based on various statistical methods such as regression [2], Box Jenkins model [3], exponential smoothing [4]and Kalman filters [5]. However, these methods cannot represent the complex nonlinear relationships [2]. Many electric power companies have adopted conventional prediction methods for load forecasting. However, these methods cannot properly represent the complex nonlinear relationships that exist between the load, and series of factors that influence it [5]. Recently, artificial neural networks (ANN) have been successfully applied to short term load forecasting [6].

II. ARTIFICAL NEURAL NETWORK

To date, neural networks have been applied successfully to a number of engineering problems. Several researchers have demonstrated that they can be more reliable at predicting energy consumption in a building than other traditional statistical approach because of their ability to model non-linear patterns. The neural network learns the main characteristics of a system through an iterative training process. It can also automatically update its learned knowledge on-line over time. This automatic learning facility makes a neural network based system inherently adaptive [7].

ANNs have many applications, like STLF. ANN's have the ability to have knowledge of a thing never encountered before based on its similarities with things already known. ANN's are also capable of complex function mapping and noise insensitivity. These qualities are the motivation for utilizing ANN's for STLF [8].

Multilayer feed forward neural networks, as universal approximation machines, are very suitable for load forecasting because they have remarkable ability to approximate nonlinear functions with any desired accuracy. Selection of the input-output training data and input vector of the neural network play a crucial role [9].

III. BACK PROPAGATION ALGORITHM

The most popular artificial neural network architecture for load forecasting is back propagation. This network uses continuously valued functions and supervised learning. That is, under supervised learning, the actual numerical weights assigned to element inputs are determined by matching historical data (such as time) to desired outputs (such as historical loads) in a pre-operational "training session". Artificial neural networks with unsupervised learning do not require pre-operational training [6].

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A. ANN MODEL DESIGN

A standard feed forward back propagation (BP) ANN has been used for building the forecast models, having a fully connected architecture with a single hidden layer.
In face of the learning algorithm, tangent function was chosen for the middle layer. For the output layer a linear function was used.

B. DATA SELECTION

The load data is obtained from Duhok ELC. Control Region (Iraq) for 2009 and 2010 years, The data set is divided into two parts. The first part is used to construct the forecasting model. While the next part is used to evaluate the forecasting process.

C. DATA PREPROCESSING

Preprocessing dataset was performed prior to training and testing. Input/output dataset was normalized to lie between -1 and 1. Normalized dataset was divided into training and testing datasets.

Before training, it is useful to scale all the inputs and targets so that they always fall within a specified range. The following equation is used for each input and targets independently Where Ys is the scaled data element, X is the original data element for each input and target vectors, Xmax and Xmin are the maximum and minimum corresponding data element respectively . Due to the nature of sigmoid function, the outputs of the neurons fall in the interval of [-1] and [+1]. Therefore , ymax and ymin are set to 1 and -1, respectively.[10]

$$Ys = \frac{(Y\max - Y\min)(X - X\min)}{X\max - X\min} + Y\min \quad \ldots\ldots\ldots..(1)$$

D. INPUT & OUTPUT FOR ANN MODELS

The first load forecaster model is the simplest one. The ANN model uses seven inputs including load at 'day' , 'day-1' , 'day-2' ,'day-7' ,'day-8', 'day-14' ,'day-15'. Only one output node is used representing a day ahead load forecast. The second model the input for it is same as previous one but the output for it the load for seven days ahead.

While the third and fourth models the input for them are the same as the first and second model beside the amount of period of disconnected time for 'day' , 'day-1' , 'day-2' ,'day-7' ,'day-8', 'day-14' ,'day-15' and the output of them a next and seven day ahead load forecast with concerning the amount of period of disconnected time.

IV. TEST RESULT

The performance of these models for short term load forecasting has been tested for year 2009, Data was provided by Duhok ELC. Control Region (Iraq).

The load forecast was compared to the actual load data the error was calculated. The absolute mean error AME is used to evaluate the performance of these models, it is defined as :

$$AME = \frac{1}{n}\sum_{t=0}^{n}\left|\frac{At - Ft}{At}\right| \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where At is the actual load, Ft is the forecasted load, n is the number of data points. The absolute mean error AME has been calculated and presented in Table 1. Performance of the model 3 have been presented in Fig. (1) and for model 4 for next two days in Fig.(2) and Fig.(3).

Table 1 Absolute Mean Error

Models	AME
Model 1	2.3
Model 2	3.7
Model 3	0.4
Model 4	1.2

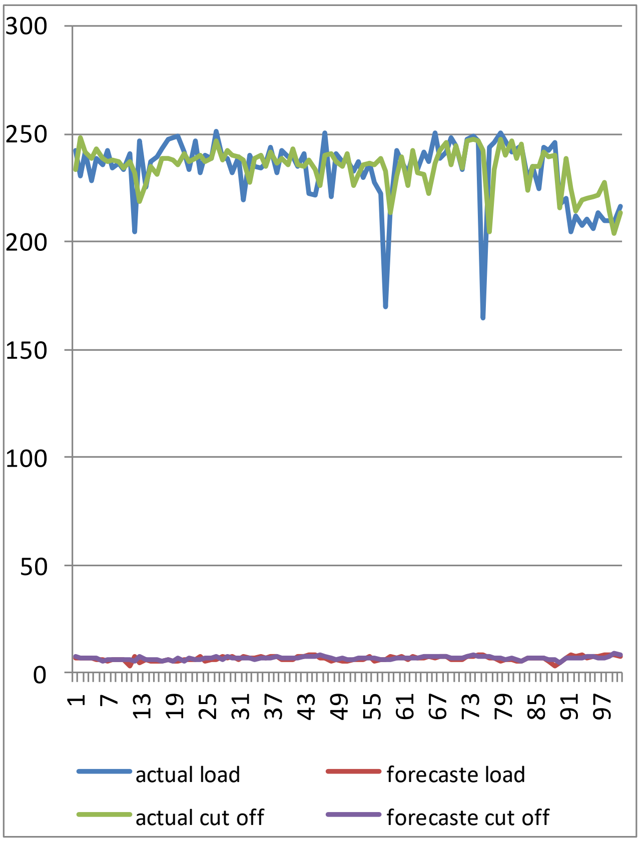

Fig.1 Model 3 next day load and cut off

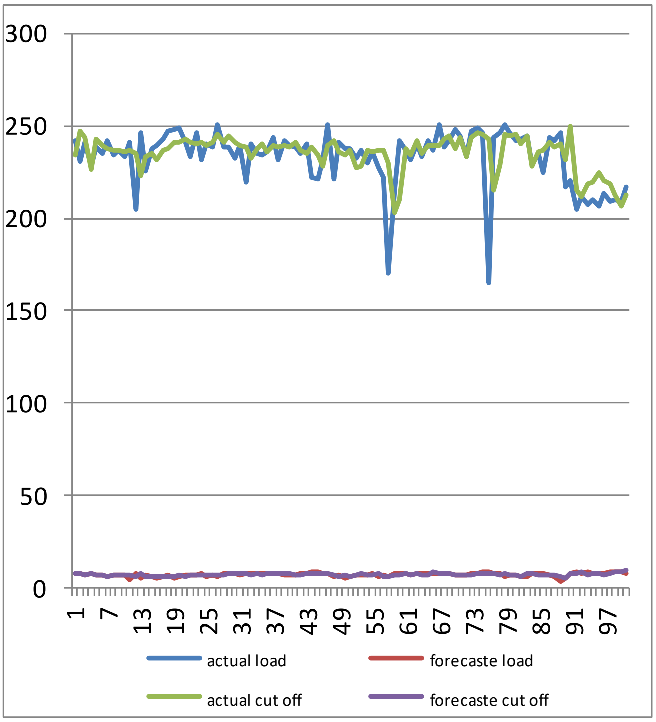

Fig. 2 Model 4 next day load and cut off

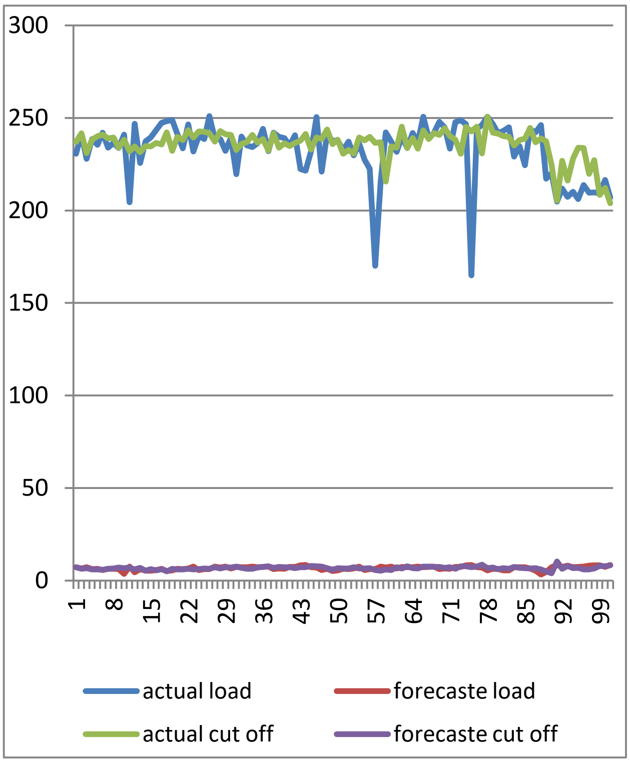

Fig. 3 Model 4 two day loads and cut off

V. CONCLUSION

The main purpose of this study is to investigate an intelligence methods for short term load forecasting, by using three layer feed-forward neural network and a back-propagation for Duhok region located in north of Iraq, which takes into account the effect of the amount of period of disconnected time on load. The results show that neural networks can be considered an efficient and applicable method to short term load forecasting.

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