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SHORT TERM LOAD FORECASTING USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT

Accurate short term load forecasting is an essential task in power system planning, operation, and control. This paper discusses significant role of artificial intelligence (AI) in short -term load forecasting (STLF). A new artificial neural network (ANN) has been designed to compute the forecasted load. The ANN model is trained on hourly data from the ISO New England market from 2004 to 2008 and tested on out-of-sample data from 2009. Load forecast for ISO New England market is much better with temperature data as input than without taking it. This is due to the fact that temperature and weather data are having high degree of correlation with load of that particular region. This indicates that temperature data is a very important parameter for load forecasting using ANN.

Keywords*: Mean Absolute Percentage Error, Mean Absolute Error, Neural Network, Power System, Short-Term Load Forecasting and Electricity Market.*

I. INTRODUCTION

With an introduction of deregulation in power industry, many challenges have been faced by the participants of the electricity market. Forecasting electricity parameters such as load and energy price have become a major issue in power systems [1]. The fundamental objective of electric power industry deregulation is to maximize efficient generation and consumption of electricity, and reduction in energy prices. To achieve these goals, accurate and efficient electricity load forecasting is becoming more and more important [2].

Load forecasting is a key task for the effective operation and planning of power systems. Inaccurate forecasting of electricity demand will either lead to the startup of too many units supplying an unnecessary level of reserve or excessive energy purchase, as well as substantial wasted investment in construction of excess power facilities or may result in a risky operation and unmet demand, persuading insufficient preparation of spinning reserve, and causes the system to operate in a vulnerable region to the disturbance [3].

Load forecasting is categorized as short-term, medium-term, and long-term forecasts, depending on the time scale. The forecasting of hourly-integrated load carried out for one day to week ahead is usually referred to as short-term load forecasting. Short-term load forecasting plays an important role in power systems since the improvement of forecasting accuracy results in the reduction of operating costs and the reliable power system operations [4].

The load at a given hour is dependent not only on previous loads but also on much important weather related variables. Effective integration of various factors into the forecasting model may provide accurate load forecasts for modern power industries. Various techniques have been developed for electricity demand forecasting during the past few years. Several research works have been carried out on the application of AI techniques to the load forecasting problem as AI tools have performed better than conventional methods in short-term load forecasting. Various AI techniques reported in literatures are expert systems, fuzzy inference, fuzzy-neural models, neural network (NN). Among the different techniques on load forecasting, application of NN technology for load forecasting in power system has received much attention in recent years [5]-[8]. The main reason of NN becoming so popular lies in its ability to learn complex and nonlinear relationships that are difficult to model with conventional techniques [9].

This paper discusses significant role of artificial intelligence in day-ahead load forecasting, that is, Day-Ahead hourly load forecast over a day, week & month. In this paper, artificial neural network designed using MATLAB

R15 has been used to compute the day-ahead hourly load forecast in ISO New England market. Both the hourly temperature and hourly electricity load historical data have been used in forecasting. The temperature variable is included in forecasting of load because temperature has a high degree of correlation with electricity load. The neural network models are trained on hourly data from the ISO New England market from 2004 to 2008 and tested on out-of-sample data from 2009. The simulation results obtained have shown that artificial neural network (ANN) is able to make very accurate short-term load forecast. A box plot [10] of the error distribution of forecasted load has been plotted as a function of hour of the day, day of the week.

This paper has been organized in five sections. Section 2 presents the overview of neural network used. Section 3 discusses the selection of various data and model of ANN for day-ahead forecast. Results of simulation are presented and discussed in Section 4, Section 5 discusses the conclusion and future work.

II. ARTIFICIAL NEURAL NETWORK FOR LOAD FORECASTING

Neural networks are composed of simple elements called neuron, operating in parallel. A neuron is an information processing unit that is fundamental to the operation of a neural network. The three basic elements of the neuron model are (i) set of weights, (ii) an adder for summing the input signals and (iii) activation function for limiting the amplitude of the output of a neuron. A neural network can be trained to perform a particular function by adjusting the values of the connections (weights) between elements. In load forecasting, typically, many input/ target pairs are needed to train a neural network. Neural network is mapped between data set of numeric inputs and a set of numeric targets. The neural network consists of two-layer feed-forward network with sigmoid hidden neurons and linear output neurons. It can fit multi-dimensional mapping problems arbitrarily well, given consistent data and enough neurons in its hidden layer.

III. DATA INPUTS AND ANN MODEL

The models are trained on hourly data from the ISO New England market from 2004 to 2008 and tested on out-of-sample data from 2009. The data used in the ANN model are both the temperature and electricity load hourly historical data. The temperature variable is included because temperature has a close relationship with electricity load.

For the load forecast, the input parameters include followings.

Dry bulb temperature

Dew point temperature

Hour of day

Day of the week

Holiday/weekend indicator (0 or 1)

Previous 24-hr average load

IV. SIMULATION AND RESULTS

In this paper hourly day-ahead load forecasting has been done for sample of each day, week & month of data of year 2009 using neural network tool box of MATLAB R13a. The ANNs are trained with data from 2004 to 2008 and tested on out-of-sample data from 2009. The test sets are completely separate from the training sets and are not used for model estimation or variable selection.

The model accuracy on out-of-sample periods is computed with the Mean Absolute Percent Error (MAPE) metrics. The principal statistics used to evaluate the performance of these models, mean absolute percentage error (MAPE), is defined in eq. 1 below.

$$MAPE\ [\%] = \frac{1}{N}\sum_{i=1}^{N}\frac{|L_A^i - L_F^i|}{L_A^i} \times 100 \quad (1)$$

Where LA is the actual load, LF is the forecasted load, N is the number of data points.

Various plots of the error distribution as a function of hour of the day, day of the week are generated. Simulation results of the various plots comparing the day ahead hourly actual and forecasted load for every weeks for the ISO New England market are discussed below. The ANN model used in the forecasting has input, output and one hidden layers. Inputs to the input layer are as listed above for load forecast. After simulation the MAPE obtained is 1.80 % for load forecasting for the year 2009 by using ANN as shown in figure

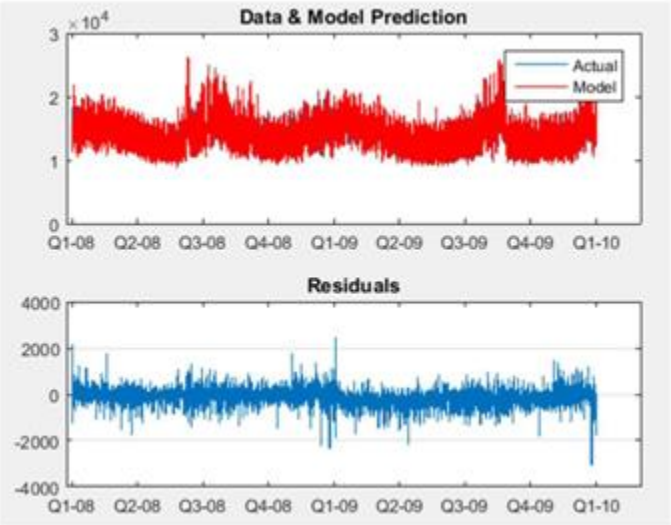

Fig.1 From 1 Jan.,2008 to 31 Dec.,2009

The box-plot of the error distribution of forecasted load as a function of hour of the day is presented in Fig. 2. It shows the percentage error statistics of hour of the day in year 2009. It is also evident that the maximum error is for the 20th hour of the day and minimum error for 1th hour of the day in year 2009.

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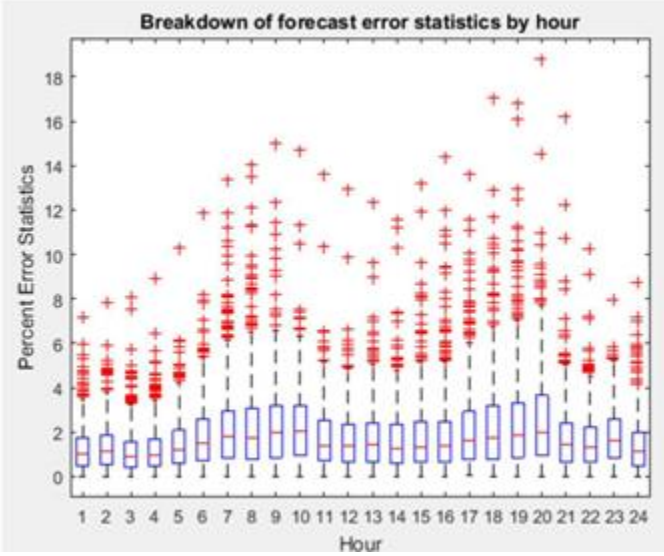

Fig. 2. Error distribution of forecasted load as a function of hour of the day in the year 2009

The box-plot of the error distribution of forecasted load as a function of day of the week is evaluated in Fig. 3 which shows the percentage error statistics of day of the week in year 2009. The maximum error is for the Thursday and minimum error for Saturday in 2009.

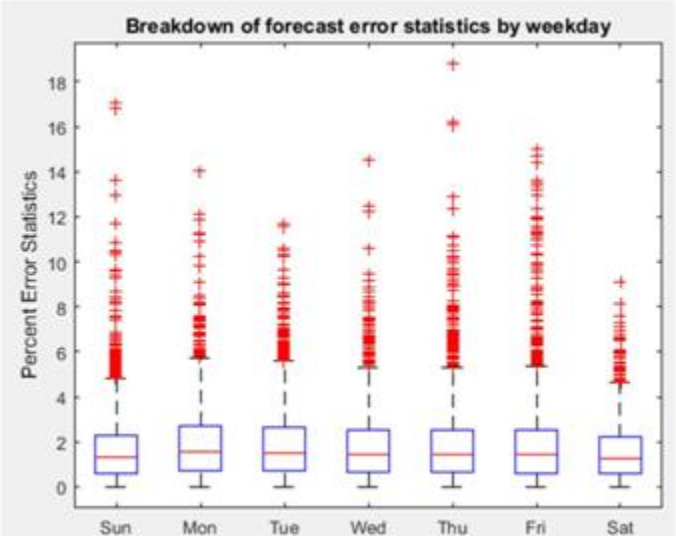

Fig. 3. Error distribution for the forecasted load as a function of day of the week in the year 2009

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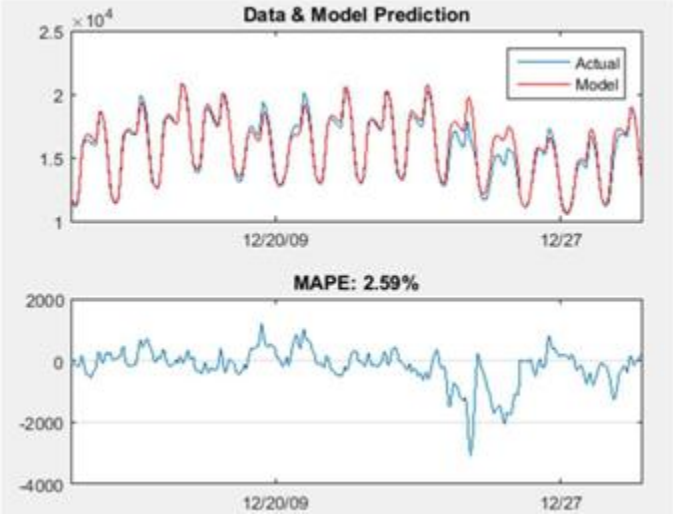

Fig. 4. Maximum MAPE is 2.59% for the forecast of 09-27 Dec., in year 2009 for day ahead hourly weekly forecast by using ANN

V. CONCLUSION AND FUTURE WORK

This paper presents an ANN model for day-ahead short-term electricity loads forecasting in ISO New England market. Its forecasting reliabilities were evaluated by computing the MAPE & MAE between the exact and predicted electricity load values. We were able to obtain an MAPE of 1.80% for ISO New England market in the year 2009 by using ANN. The results suggest that ANN model with the developed structure can perform well in day ahead load forecasting with least possible error. It has been observed that temperature plays an important role in electricity load forecasting. In future effect of other weather parameters like humidity, precipitation, and wind velocity on short-term load forecasting may be worked out.

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