Prediction Analysis of Electrical Load Using Simulation Methodology

K. Ayaz

Abstract- The most used thing in today's world is energy (power). We use energy in various forms in our daily life like electricity, LPG, solar energy, wind energy, chemical energies in form of batteries and many other forms. Energy performance and its usage have direct impact on consumer's life. Electrical load forecasting has much importance in the field of smart electrical grids and it plays a vital role in proper planning of electrical load and power systems. It helps in optimization of generating units and dispatching in real time. Forecasting of electricity load demand is a key task for the effective operation and planning of power systems. It was concluded that a comparative study of different model types seems to be necessary. Several models were developed and tested on the real load data .Most of them use a MLP (Multilayer perceptron) network, regressive models, genetic algorithms etc. We carried out short term electrical load forecasting for California Energy Market data, using ANN (Artificial Neural Network) and Plant Identification technique, both techniques implemented in MATLAB software. Error is calculated between actual and forecasted load as MAPE (Mean Absolute Percentage Error).

Index Terms- Artificial Neural Network (ANN), MLP (Multilayer Perceptron), MAPE, Smart Grid (SG)

I. INTRODUCTION

LOAD forecasting has become in recent years one of the major areas of research in electrical engineering. Load forecasting is the technique for prediction of electrical load. In a deregulated market it is much need for a generating company to know about the market load demand for generating near to accurate power. If the generation is not sufficient to fulfill the desired demand, there would be problem of irregular supply and in case of excess generation the generating company will have to bear the loss [2]. In current scenario everything is moving toward smartness same is the case for power systems they need efficient devices, intelligence techniques and proper planning for their operations. Load is such a quantity that varies with real time for every second and affects our system directly or indirectly. Generation of electrical power is mainly dependent on electrical load for that purpose we must have idea of our load so that effective dispatching and optimization can be done [3]. It is used by power companies to anticipate the amount of power needed to supply the demand. It tells about the scenario of present and future load demand. It has many applications including energy purchasing and generation, load switching, contract evaluation, and infrastructure development. Load forecasting is however a difficult task. First, because the load series is complex and exhibits several levels of seasonality [5]. Second, the load at a given hour is dependent not only on the load at the previous day but also on the load at the same hour on the previous day and previous week. Load forecasting is categorized into short; medium and long term forecasting depend upon days, months and yearly prediction respectively [5]-[7]. Short term forecast are used to schedule generation and transmission purpose. Medium forecast is used for fuel purchasing and long term forecast is used to develop power supply etc. The load forecasting techniques can be divided into two categories such as parametric or non-parametric techniques. The linear regression, auto regressive moving average (ARMA), general exponential technique and stochastic time series techniques are some examples of parametric (statistical) technique. The main drawback of parametric technique is its capability in abrupt change of any types of environment or social changes [8].For short term forecasting several factors should be considered like[i] Time factor [ii] Weather data [iii] Possible customers' classes. The medium- and long-term forecasts take into account [i] The historical load [ii]Weather data [iii]The number of customers in different categories [iv]The appliances in the area and their characteristics including age [v] The economic and demographic data and their forecasts [vi]The appliance sales data and other factors [10].

II. DESCRIPTION

[i]Fuzzy inference is used to correct the similar day load curves of the forecast day to obtain the load forecast, further the parameters for fuzzy inference are optimized which further improves the forecasting results [4]. It can be concluded that the use of neuro fuzzy systems will be useful for better predicted output. Accurate load forecasting is very important for electric utilities in a competitive environment created by the electric industry deregulation [6] - [9]. The BP (back propagation) network is a kind of multilayer feed forward network, and the transfer function within the network is usually a nonlinear function such as the sigmoid function. The typical BP network structure for STLF (short load term forecasting) is a three-layer network, with the nonlinear sigmoid function as the transfer function [10]. Keeping all the factors in consideration I discuss two techniques for the forecasting of electrical load and then compare their results to suggest which technique came out with better results. The techniques we implemented:

- **ANN (Artificial Neural Network)**
- **Neural Predictive Control**

Both techniques are implemented in MATLAB software.

Artificial Neural Network

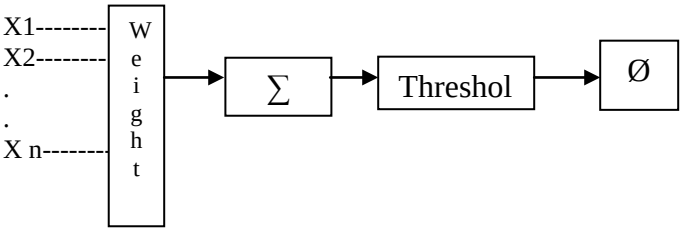

Fig.1 Block Dig of ANN

Figure 1 represent block diagram of ANN, which consist of input, weights, threshold and transfer functions. Input can be historical load, temperature factor, weather, humidity. Function can be sigmoid, sinusoidal, and linear. Depend upon results different weights can be adjusted to achieve better performance.

Neural Predictive Control

Plant Identification model or neural predictive control is built in tool box in MATLAB .Its working principle is such that plant model is made in Simulink file and is import to neural predictive control tool box, different parameters of tool box are adjusted according to requirements and perform training, testing and validation. After that prediction can be done.

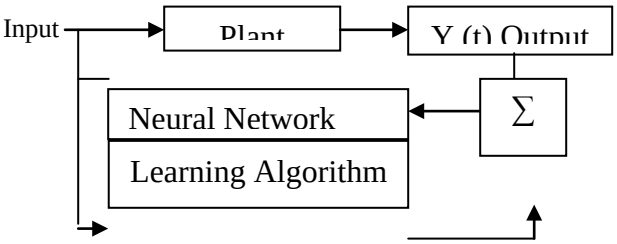

Figure.2 Block Dig for Plant Identification Model
model evaluation

The electrical load data of California Energy Market is categories into:

- Training
- Testing
- Validation
- **Training**

Training is actually a machine learning process; the data is provided to machine and is trained on particular data. In this process machine is able to known the algorithm, and after that it is ready to test.

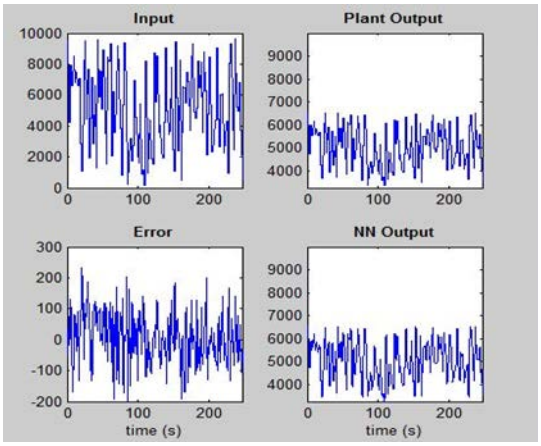

Fig.3Training Result

- **Testing**

Testing is also a learning process it may consist of historic data. It is a testing phase that determined whether machine is trained exactly or not. Testing is second phase in this process after successful testing data is further processed for validation.

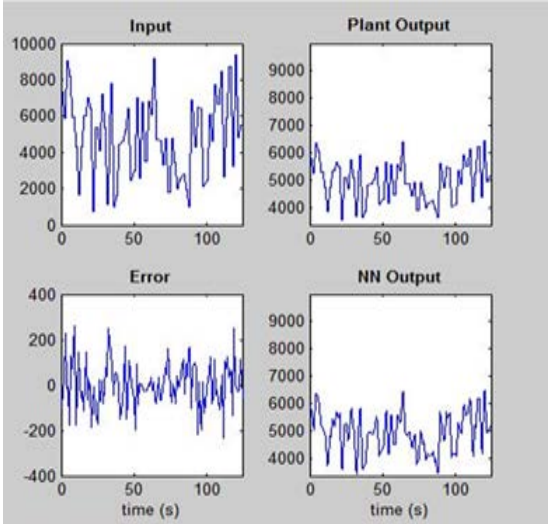

Fig.4Testing Result

- **Validation**

Validation is a checking phase, which shows that results coming from training and testing are valid up to what extent. First of all system is trained on historical load and different parameters (time, temperature etc.) and then it is processed for testing .Testing may include new or historical data. This process is actually a machine learning process. The trained and tested data is further processed for validation. The results of trained and tested data are compared with validation and check mean absolute percentage error. Forecasting can be done when machine become fully trained.

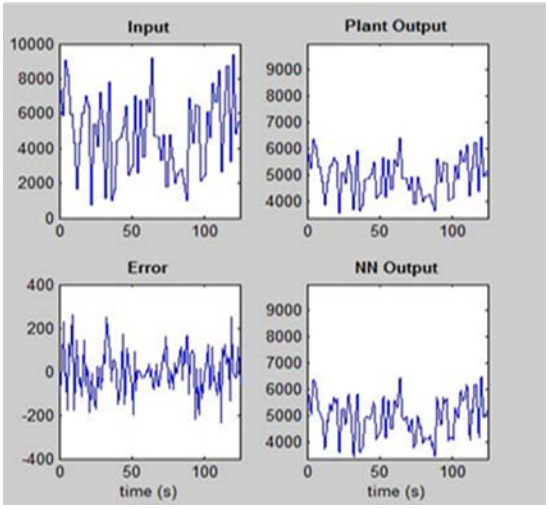

Fig.5 Validation Result

- **Plant Input, Output**

Fig.6 is the neural plant input and output graph. X-axis contain days of year while Y-axis represent electrical load in Megawatt.

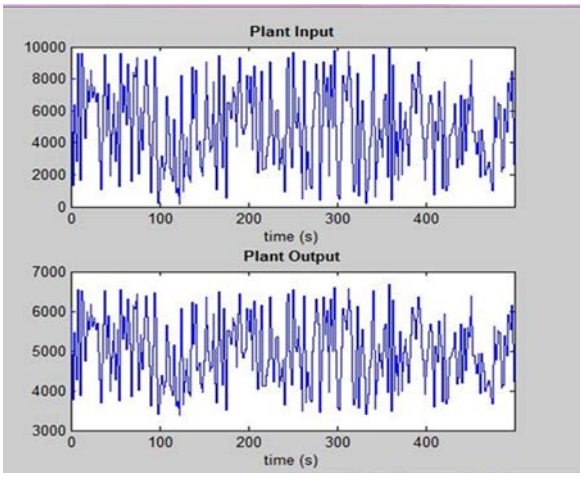

Fig.6 Input, Output Result

Model Implementation Over One Year

Fig.6 represents the result of Artificial Neural Network training over one year .Blue line represent actual load curve, red curve shows training result while the error between actual and trained curve is represented by green curve. X- Axis represent days of year and Y axis represent error .It can easily be seen from graph that error is 0.000035 and trained data is nearly equal to actual one.

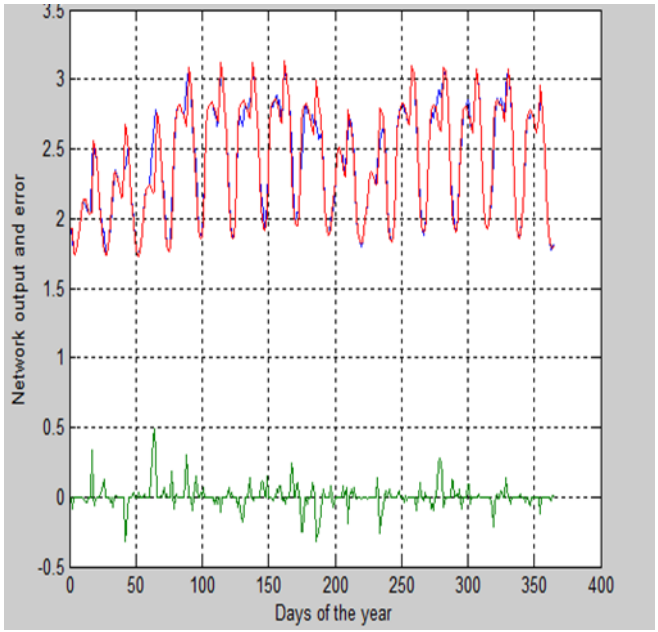

Fig.7 Training Result of ANN

Prediction on Basis of Training

We used trained ANN to predict the electrical load of next day on hourly basis.

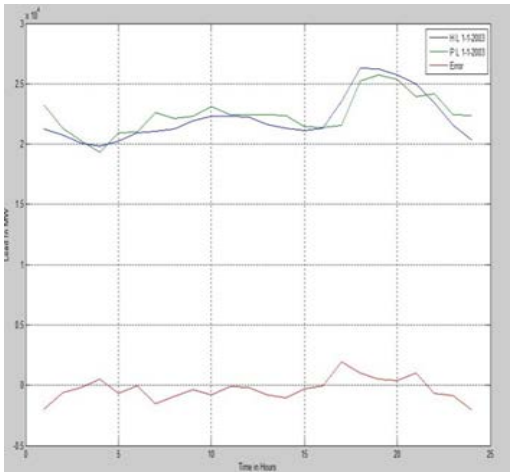

Fig.8 Prediction on basis of Training

Here blue line represent historical electrical load and green line represent the predicted electrical load of same day both loads are plotted to compare them and error is plotted. The red line represents error between them. The maximum error is 12.3% of the total.

Calculation for Mean Average Percentage Error

$$MAPE = [1/n \sum | \text{Actual} - \text{Forecast}/\text{Actual} | * 100]$$

TABLE I
Calculation of MAPE

Month	Actual	Forecast	Absolute % Error
1	112.3	124.7	11.0%
2	108.4	103.7	4.3%
3	148.9	116.6	21.7%
4	117.4	78.5	33.1%
MAPE			17.6%

Mathematical Formulation

MAPE=100*X*∑ {[Vri-Vpi]/Vri}/n
ME=max [Vri-Vpi]
i =1, 2, 3……., n
Δw (i) p= α*x (i)*e (p)
To calculate weather factor parameter
F {w} =β (0) +β (j)*x (j)
Neuron uses following transfer function in NN
X=∑x (i)*w (i) Y= {+1 if x >= Ø}
{-1 if x < Ø}
This type of activation function is said to be sign function
W (p+1) = w (i) +α*x (p)*e (p)
Perceptron learning in ANN

III. CONCLUSION AND FUTURE DIRECTIONS

Load forecasting is necessary for proper planning of Power system. It has its applications in trading electricity market, real time dispatching, great importance in SG, automation and control, saves natural resources (coal, gas, petrol).It saves time and time is money. Improvement in results can be achieved by taking the historical load data of more and more years. Accurate forecasting can be done by making computations simple and logical.

In near future I will extend our work to combine load forecasting with demand response program and explain application of load forecasting in field of SG.

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