Soft Computing Techniques In Load Forecasting

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Abstract - Load forecasting is of vital importance for any power system. It helps in taking many decisions regarding energy purchasing and generation, maintenance, etc. Further, load forecasting provides information which is able to be used for energy interchange with other utilities. Over the years, a number of methods have been proposed for load forecasting. This paper focuses on short term load forecasting by using a hybrid model of neural networks and fuzzy logic.

Keywords - *fuzzy, load forecasting, neuro fuzzy, neural networks, regression.*

I. INTRODUCTION

An important constituent for efficient power system energy management is load forecasting. Load forecasting is the study to estimate active loads ahead of the actual load occurrence. For an electric utility the estimate of future demand is necessary in managing the production and purchasing in an economically reasonable way. It plays a crucial role in helping the electric utility to make unit commitment decisions, to reduce the reserve capacity and to schedule device maintenance plan properly. It plays a key role not only in reducing the generation cost but is also essential to improve the reliability of power systems. For short term operations and also for long term planning, accurate load forecasts are critical for utilities. The quality and accuracy of this forecast have large influence on the quality of the electrical distribution system planning. Electric load forecasting in power systems is very important task for ensuring reliability and economical operation. The operation planning of electric systems as well as the maintenance and fuel reserve planning are all based on the load forecast results.

II. TYPES OF FORECAST

Depending the period of the forecast done, it is classified into three different types. They are:

- Short term load forecasting, which forecasts within a time period of one day to one month.
- Medium term load forecasting, which forecasts within a time period of one month to one year.
- Long term load forecasting with a time period of more than one year.

In this, we are focusing on the short term load forecasting Short term load forecasting (STLF) refers to forecasts of electricity demand (or load), on an hourly basis, from one to several days ahead. In the daily operations of a power utility, the short term load forecasting is of vital importance. It is required for unit commitment, energy transfer scheduling and load dispatch. The short term load forecasting has played a greater role in utility operations with the emergence of load management strategies. The development of an accurate, fast and robust short-term methodology is of importance to both the electric utility and its customers.

Short term load forecasting has gained more importance and greater challenges with the recent trend of deregulation of electricity markets. Precise forecasting is the basis of electrical trade and spot price establishment for the system to gain the minimum electricity purchasing cost in the market environment. In the real-time dispatch operation, forecasting error causes more purchasing electricity cost or breaking-contact penalty cost to keep the electricity supply and consumption balance.

III. FORECAST TECHNIQUES

Short term load forecasting includes both conventional techniques & artificial intelligence techniques.

A few of them have been listed below.

- Regression method
- Fuzzy logic approach
- Neural network approach
- Neuro-fuzzy approach, etc.

Regression method is a conventional approach whereas the rest three are artificial intelligence methods.

The main important single-most parameter in the short term load forecast is the relationship between the load and the weather. This relationship is to be understood for making a reliable load forecast. The relationship between the weather and the load varies with the day of the week, segment of the day, season, etc.

The weather-load relationship varies with the season, day of the week, and segment of the day.

Several factors, such as time factors and weather data, etc should be considered for short-term load forecasting. The load is influenced by the weather conditions. As a matter of fact, the most important factor in short term load forecasting is the weather. There are a lot of weather parameters available such as temperature, humidity, wind cover, sunshine, etc. But only temperature and humidity are the most commonly used parameters.

IV. NEURAL NETWORKS

An artificial neural network is a mathematical model or computational model that is inspired by the structure and/or functional aspects of biological neural networks.. The motivation for the development of neural network technology stemmed from the desire to develop an artificial system that could perform ''intelligent'' tasks similar to those performed by human brain.

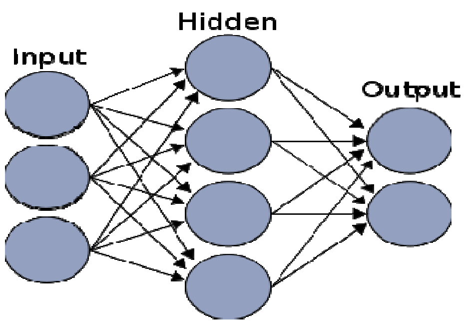


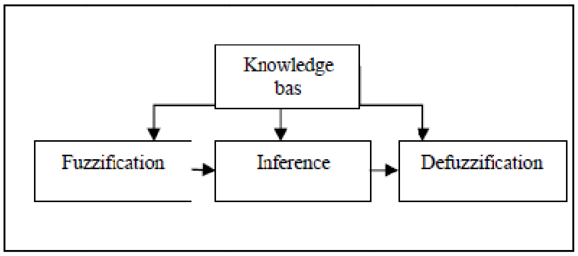
Fig: Artificial Neural Network

When load forecasting is dealt by using neural networks, we must select one of the number of the available architectures (such as Hopfield, back propagation, Boltzmann, etc), the number of layers and elements, the connectivity between them , usage of unilateral or bilateral links and the number format to be used by inputs and outputs.

There will be differences in the estimation of performance depending on the different models. Generally back propagation is used. A back propagation network topology includes 3 layers r 4 layers, the transfer function may be linear or non linear or a combination of both. The network may be fully connected or non-fully connected. The application of neural networks in power utilities has been growing in acceptance over the years. The main reason behind this is because the capability of the artificial neural networks in capturing process information in a black box manner.

V. FUZZY LOGIC

Fuzzy logic is a form of many-valued logic; it deals with reasoning that is approximate rather than fixed and exact. In contrast with traditional logic theory, where binary sets have two-valued logic: true or false, fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Furthermore, when linguistic variables are used, these degrees may be managed by specific functions. Under fuzzy logic an input is associated with certain qualitative values. For instance the temperature of a day may be ''low'', ''medium'' or ''high''.



In the operation and management of power systems, fuzzy load forecasting plays a paramount role. Fuzzy logic usage has got several advantages. There is no need of a mathematical model mapping inputs to outputs and the absence of a need for precise inputs. Properly designed fuzzy logic systems can be very robust when used for forecasting with such generic conditioning rules. An exact output is needed in many situations. The logical processing of fuzzy inputs is followed by ''defuzzification'' to produce precise outputs.

VI. NEURO-FUZZY MODEL

In the field of artificial intelligence, neuro-fuzzy refers to combinations of artificial neural networks and fuzzy logic. Neuro-fuzzy was proposed by J. S. R. Jang. Neuro-fuzzy hybridization results in a hybrid intelligent system that synergizes these two techniques by combining the human-like reasoning style of fuzzy systems with the learning and connectionist structure of neural networks. Neuro-fuzzy hybridization is widely termed as Fuzzy Neural Network (FNN) or Neuro-Fuzzy System (NFS) in the literature. Neuro-fuzzy system incorporates the human-like reasoning style of fuzzy systems through the use of fuzzy sets and a linguistic model consisting of a set of IF-THEN fuzzy rules. The main strength of neuro-fuzzy systems is that they are universal approximators with the ability to solicit interpretable IF-THEN rules.

Several different ways to combine fuzzy logic with neural networks technique have been proposed by researchers in order to improve the overall forecasting performance. A neuro fuzzy system is about taking an initial fuzzy inference systems and tuning it with a back propagation algorithm based on the collection of input-output data.

The objective of the work is to develop an algorithm to forecast hourly load, by incorporating weather conditions like temperature, humidity, etc. In this work, an attempt is made to implement the above forecast using fuzzy set classified neural network approach.

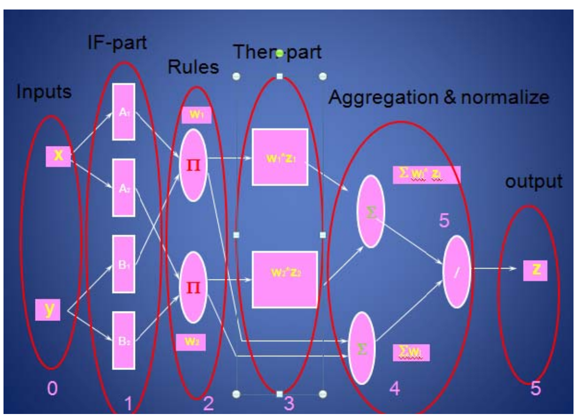


Fig: Neuro-Fuzzy Model

The work presented here is divided into three steps:

- Fuzzy Set Based Classification: Classification of training data using Fuzzy Set.
- Training of Neural Network: Training of the neural network for each hour of each day for which the load is to be forecasted using the training data of that particular class to which that hour belongs.
- Short term load forecasting: Forecasting of hourly load using trained neural network.

VII. MULTIPLE LINEAR REGRESSION

Multi linear regression is an approach to modeling the relationship between a scalar variable y and more than one explanatory variable denoted by x1, x2, etc. This is extensively used in practical applications. This is because models which depend linearly on their unknown parameters are easier to fit than models which are non-linearly related to their parameters and because the statistical properties of the resulting estimators are easier to determine.

Regression is used to fine tune the initial estimates of the load. It is done only if the number of records in the similar set exceeds a certain minimum number. Statistically, this minimum is one plus the number of variables used in regression. Similar set of data is adjusted and regression is made over it using a certain subset of weather variables. It gives a weight factor for each variable. And hence, the least-square error estimation of the load is determined for each hour in the target segment. Linear or nonlinear regression may be used. Only if the range of regression is limited, the linearity is justifiable. Although the load is known to be a nonlinear function of all the significant variables, a linear model may be assumed if the samples are all within a small neighborhood around the target point. It might be necessary, however, to use nonlinear models. This would be done by replacing one variable or more by certain point function. This might be useful to account for certain known non-linearity, especially at extreme temperature points.

In the multiple linear regression method, the load is found in terms of explanatory variables such as weather and non-weather variables which influence the electrical load. The load model using this method is expressed in the form as:

$$y(t) = a_0 + a_1 x_1(t) + \cdots + a_n x_n(t)$$

Where, y (t) = electrical load.

$x_1(t), \ldots, x_n(t)$ = explanatory variables correlated with y (t). .

$a_0, a_1, \ldots a_n$ =regression coefficients.

The explanatory variables of this model are identified on the basis of correlation analysis on each of these (independent) variables with the load (dependent) variable. Experience about the load to be modeled helps an initial identification of the suspected influential variables. The least square estimation technique is usually used for the estimation of the regression coefficients.

In the MLR application, the hourly load is modeled as: (i) Base Load Component and (ii) Weather Sensitive

Component which is function of different weather variables. These weather variables include dry bulb temperature, dew point temperature and wind speed. The relationship between the weather sensitive component and most of the weather variables is not linear, but are rather transformed from current and previous lag time values.

VIII. DATA COLLECTION

LOAD data used in this work was collected from APTransco for the month of November and the weather data was collected from NARL (National Atmospheric Research Laboratory), Gadanki.

IX. SIMULATION AND RESULTS

For evaluating our proposed load forecast, the model was implemented in MATLAB. The model was trained by using back propagation algorithm with the help neural network training tool.

The graphs obtained are as shown.

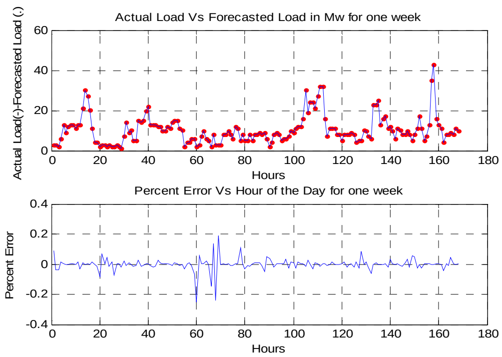


Fig .1(a): Forecast for a week

Mean error for a week = -0.0014.

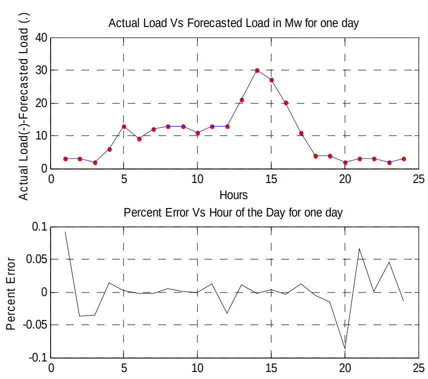


Fig .1(b): Forecast for a day

Mean error for a day=0.0011

Through multi linear regression the following values were obtained.

Conventional table for a week:			
S.No	***Actual Load***	***Predicted Load***	***Error***
1.	9.333333	9.356504	0.02317
2.	10.04167	9.30103	0.74064
3.	6.916667	10.04993	3.13326
4.	7.208333	11.2611	4.05276
5.	15.375	11.44601	3.928986
6.	11.04167	10.54919	0.492479
7.	11.95833	9.911242	2.047088

Fig .1(c): Multi linear regression

Mean error by multiple linear regression = 14.418/7 =2.059.

X. CONCLUSION

The neural network model for short term load forecasting was studied in this work. Also the load is forecasted for a week by the multiple linear regression method.

Mean error for a week by neuro fuzzy model=-0.0014.

Mean error for a week using regression method=2.059.

According to the comparison of the mean errors, the neuro-fuzzy model is better when compared to the conventional multiple linear regression method. Also for future work, the load forecasting model can be further improved by including other parameters like windfall, etc.

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