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Electric Load Forecasting using Neuro-Fuzzy Systems

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ABSTRACT

In energy sector, the load forecasting is the most noteworthy task, as it secures the trustworthiness and reduces the operational cost of a power plant. The companies make funds and decision on selling energy from the generating companies, and setting up for maintenance and development. It is therefore completely essential to have some awareness of prospect power load. Precise forecast of electric load is not easy, because it is determined largely by variables that hook up "uncertainty" and whose relation with the load is not given directly. The Electric load is characterized as a nonlinear and non stationary procedure that can experience quick changes due to weather, cyclic and financial variations. A huge number of the conventional forecast models are unsuitable for this modeling because of their obligation of linearity and seasonality. Researchers implemented various techniques to unravel the load forecasting assignment.

KEYWORDS: Fuzzy logic, Load forecasting, Multi linear regression, neural network

I. Fuzzy logic: Fuzzy logic makes use of human common sense. Fuzzy Logic approach is mostly useful in solving cases where no deterministic algorithm available or it is simply too difficult to define or to implement, while some intuitive knowledge about the behavior is present.

Most real life physical systems are actually non-linear systems. Conventional design approaches use different approximation methods to handle nonlinearity. Some typical choices are, linear, piecewise linear, and lookup table approximations to trade off factors of complexity, cost, and system performance. A linear approximation technique is relatively simple, however it tends to Limit control performance and may be costly to implement. Piecewise linear technique works better, although it is tedious to implement because it often requires the design of several linear controllers. A lookup table technique may help improve control performance, but it is Difficult to debug and tune. Furthermore in complex systems where multiple inputs exist, a lookup table becomes impractical due to its large memory requirements. Fuzzy logic provides an alternative solution to non-linear control because it is closer to the real world. Non-linearity is handled by rules, membership functions, and the inference process which results in improved performance, simpler implementation, and reduced design costs.

Typical Fuzzy Logic control implementation involves three steps:

Fuzzification: converting the crisp inputs to membership functions which comply to intuitive perception of system status.

Rules processing: calculating the response from system status inputs according to the pre-defined rules matrix (control algorithm Implementation).

De-Fuzzification: converting the Rules processing results to crisp Output/s to feed into the control devices.

II.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.

III.Neural network

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.

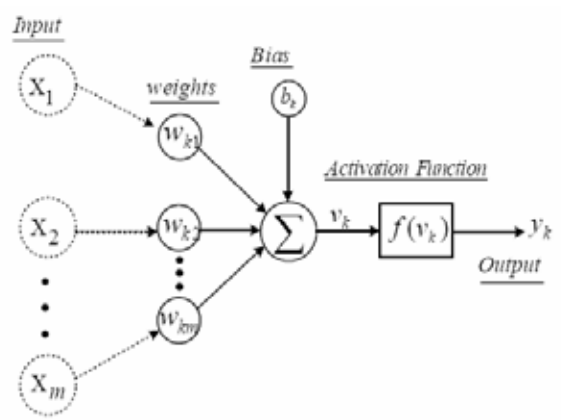

Fig: 1: Artificial Neural Network model

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 or 4 layers, the transfer function may be linear or non linear or a combination of both. The net-

work 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.

IV. 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.

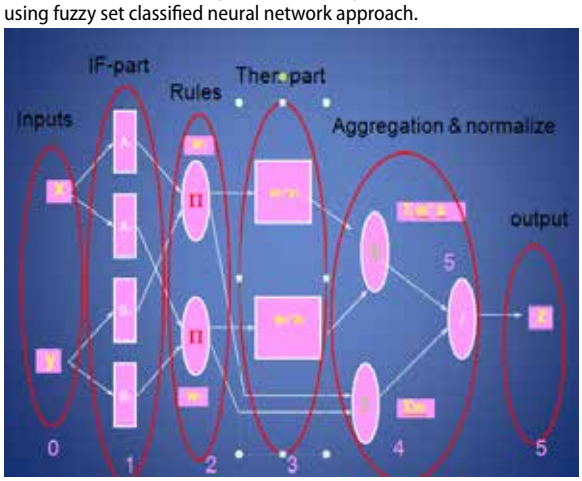

Fig:2: Neuro-Fuzzy Model

V.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.

$$x_1(t), \ldots, x_n(t)$$

x(t) = explanatory variables correlated with *y(t)*.

an $a_0, a_1, \ldots a_n$ =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.

VI.Simulation And Results

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

The graphs obtained are as shown,

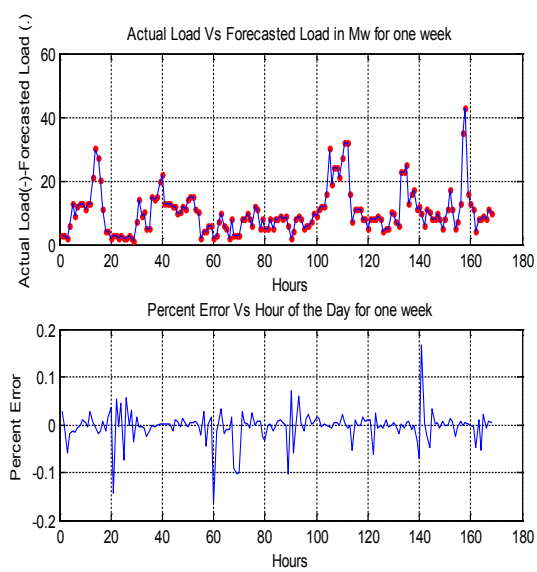

Fig .3(a): Forecast for a week

Mean error for a week = -0.0040

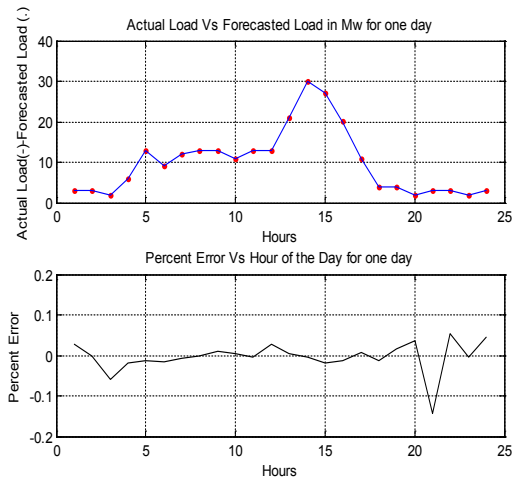

Fig .3(b): Forecast for a day

Mean error for a day= -0.0035

Through multi linear regression the following values were obtained.

Conventional table for a week:			
S.No	Actual Load	Predicted Load	Error
1.	9.333333	8.495647	0.837686
2.	10.04167	8.638387	1.403283
3.	6.916667	8.608843	1.69218
4.	7.208333	9.284813	2.07648
5.	15.375	11.65637	3.718628
6.	11.04167	13.15567	2.114
7.	11.95833	12.03527	0.0769

VII.Conclusion: Various techniques for load forecasting have been discussed here. The hybrid model of neural network and Fuzzy logic for short term load forecasting was studied in this paper. Also the load is forecasted for a week by the multiple linear regression method. The Mean error (for a week) in case of Neuro fuzzy model is -0.0040 and 1.70274 in case of regression method. Neuro-fuzzy model is better when compared to the multiple linear regression method.

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