An Introduction to Load Forecasting: Conventional and Modern Technologies

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***Abstract*: The deregulation of the power system industry has made short term load forecasting increasingly important. Short-term load forecasting (STLF) is of great importance for the safety and stabilization of grids. In this paper I will be introducing some important things which one need to know before working on load forecasting. What methods were conventionally used and what was the necessity for new approaches and how they are better._Most traditional forecasting models and artificial intelligence neural network techniques have been tried out in this task. An extensive survey of ANN-based load forecasting models is studied. Various important factors which one need to know before working on load forecasting are discussed briefly in this paper.**

Keyword---Load Forecasting, Artificial Neural Network (ANN).

I. INTRODUCTION

Load forecasting had an important role in power system design, planning and development and it is the base of economic studies of energy distribution and power market.

The period of load forecasting can be for one year or month (long-term or medium-term) and for one day or hour (short-term) [1, 2, 3, and 4].

The medium- and long-term forecasts take into account the historical load and weather data, the number of customers in different categories, the appliances in the area and their characteristics including age, the economic and demographic data and their forecasts, the appliance sales data, and other factors [5].

Because of its importance, load forecasting has been extensively researched and a large number of models were proposed during the past several decades, such as Box-Jenkins models [6], linear-regression model, Auto-Regressive Integrated Moving Average (ARIMA) models, Kalman filtering models, and the spectral expansion techniques-based models.

Generally, these models are based on statistical methods and work well under normal conditions, however, they show some deficiency in the presence of an abrupt change in environmental variable which is believed to affect load patterns. Also, the employed techniques for those models use a large number of complex relationships, require a long computational time, and may result in numerical instabilities. Therefore, some new forecasting models were introduced recently.

As a result of the development of Artificial Intelligence (AI), Expert System [7] and Artificial Neural Networks (ANN) have been applied to solve the load forecasting problems. Artificial neural network (ANN) has been used for many years in sectors like medical science, defence, robotics, electronics, economy, forecasts, etc.

The learning property of ANN in solving nonlinear and complex problems called for its application to forecasting problems [8]. Load forecasting has become in recent years one of the major areas of research in electrical engineering. Load forecasting is however a difficult task. First, because the load series is complex and exhibits several levels of seasonality. The neural network, when grouped into different load patterns, gives good load forecast.

II. OVERVIEW OF CONVENTIONAL TECHNIQUES

Several techniques have been used for load forecasting that among its common methods we can refer to linear-regression model, Box-Jenkins models Arima models, Kalman filtering models, and the spectral expansion techniques-based models, Expert systems and ANN.

In Expert System forecast rules are extracted from expert's knowledge. Expert systems were among the first truly successful forms of AI software. But the reliability of expert's knowledge is questionable.

T. Moghram and S. Rahman [9] provide an excellent review of the existing techniques for daily load fore*cast.*

Almost all these techniques fall in the realm of statistical techniques. The only exception king application of a knowledge-based algorithm [10].

The techniques analyzed are:

- Multiple Linear Regression (*MLR*)
- Stochastic Time Series *(STS)*
- General Exponential Smoothing (*GES*)
- State Space and Kalmar Filter (*SSKF*)
- Knowledge-Based Approach (*KBA*)

MLR finds the estimates of the regression coefficients usually using the least square estimation technique. The load is represented as a linear combination of explanatory variables and a zero mean constant variance.

In the STS approach, the load y (t) is modelled, as an output of either of the following filters:

- Auto Regression (AR).
- Moving Average(MA)
- Auto Regression Moving Average(ARMA)
- Auto Regression Integrated Moving Average(ARIMA)

Of the above four filters, ARIMA filter *can* model a special nonstationarity by a differencing procedure. These models allow output y (t) to be expressed in terms of some past history and white noise. If other variables are affecting the value of y (t), the effect *of these* variables *can* be accounted using a transfer function model.

The comparison of the techniques [11] applied to same problem reveals that *STS gave* minimum error for one set of data (peak summer) whereas it gave worse results for other set of data (peak winter). STS has strong dependency on historical data and hence cannot account for abrupt changes. Overall KBA gave best results which has flexibility to incorporate changes effectively.

III. FORECASTING PROCEDURE

While forecasting load, all of the work can be divided into 4 parts and then we can handle each n every part. These parts are:

A. Identification of input variables:

The selection of input variables of a load forecasting network is of great importance. For selection of input variables two methods are available one is the statistical analysis of data and other is experience based.

As already discussed that expert models have their disadvantages so historical data must be considered.

Historical data consist of several things like- loads, temperature, wind speed, rainfall, relative humidity, cloud cover, normal day or holiday [2].

Input variables are chosen as per the convenience of the user. More the number of variables taken, closer our forecast will be.

Based on number of input variables and type of these variables is what makes a research different. In some work, rainfall is considered as a factor whereas in others it's not. Same is the case with various other factors like Sunshine, Humidity, and Wind Speed etc. To consider these type of factors or not totally depends on the availability of these and also on the convenience of the researcher. As per my views, more the number of inputs more close we will be from our required results.

B. Pre-processing of data:

The data that was obtained could not be used in its actual form because the ANN model has activation functions that work optimally in a small range and had to be pre-processed.

C. Selection of training set:

To obtain good forecasting results, day type information must be taken into account. There are two ways to do this. One way is to construct different ANNs for each day type, and feed each ANN with the corresponding day type training sets [6, 11].

The other is to use only one ANN but contain the day type information in the input variables [1, 7, and 9]. The two methods have their advantages and disadvantages. The former uses a number of relatively small size networks, while the later has only one network of a relatively large size.

The neural network's weights and bias values are initialized to small (between 0.001 and 0.0001) random values. Then the back-propagation algorithm is used to search for weights and bias values that generate neural network outputs that most closely match the output values in the training data. Training with back-propagation is an iterative process. In the demo, the training process stops after 2,000 iterations, or when a mean squared error term drops below 0.001. The behavior of the back-propagation algorithm depends in part on the values of a learning rate (set to 0.05 in the demo) and a momentum (set to 0.01).

Training the neural network as the process of adjusting the weights of neurons so that the error function is small, ideally zero. If you only had one output and one weight, this would be simple, take a few derivatives, which would tell you which "direction" to move, and make an adjustment in that direction.

But you don't have one neuron, you have N of them, and substantially more input weights. The principle is the same, except instead of using calculus on lines looking for slopes that you can picture in your head, the equations become vector algebra expressions that you can't easily picture. The term "gradient" is the multi-dimensional analogue to "slope" on a line, and descent means you want to move "down" that error surface until the errors are small.

D. *Testing the network:*

The network uses all the required data which was available to the user.

In order to see the seasonal effect, the data can also be divided into seasons with January representing summer, March – autumn, July – winter, and October – spring.

Representative month selection:

As the load consumption profile is influenced by the seasonal changes representative month are selected for each season to study the load variation pattern and function mapping ability of ANN. Months exhibiting the variation in their daily and weekly load pattern behavior are selected. The selected months are:

• Winter Season (SI) - February (Feb.)

• Pre Monsoon Season (S2) - March, May

• Southwest Monsoon Season (S3) June, September (Sept.) and

• Post Monsoon Season (S4) October (Oct.) December (Dec.)

Depending upon the load-type whether, residential, industrial etc. For residential loads, the load switching effect due to weather changes are quite frequent especially in low temperature months. It is clear that the load variation pattern changes for each season and even within a season there is a variation in load consumption profile for each month. For a small load area, the load variation pattern has the significant impact on load forecasting as compared to the large system (Having load profile of hundreds and thousands of Megawatt).

IV. WHY NEURAL NETWORK?

Neural networks, with their remarkable ability to derive meaning from complicated or imprecise data, can be used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer techniques. A trained neural network can be thought of as an "expert" in the category of information it has been given to analyze. This expert can then be used to provide projections given new situations of interest and answer "what if" questions.

Benefits of ANN:

- Adaptive learning**:** An ability to learn how to do tasks based on the data given for training or initial experience.
- Self-Organization**:** An ANN can create its own organization or representation of the information it receives during learning time.
- Real Time Operation**:** ANN computations may be carried out in parallel, and special hardware devices are being designed and manufactured which take advantage of this capability.

Some other advantages:

- They are extremely powerful computational devices.
- Massive parallelism makes them very efficient.
- They can learn and generalize from training data – so there is no need for enormous feats of programming.
- They are particularly fault tolerant – this is equivalent to the “graceful degradation” found in biological systems.
- They are very noise tolerant – so they can cope with situations where normal symbolic systems would have difficulty.

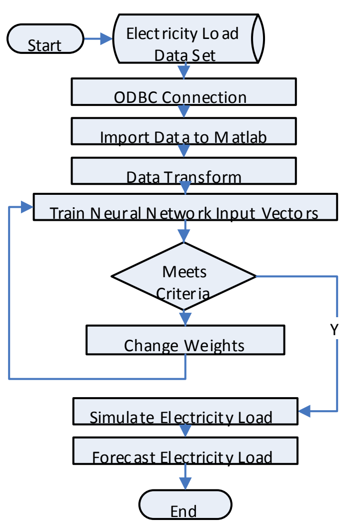
- In principle, they can do anything a symbolic/logic system can do.

V. NEURAL NETWORK ARCHITECTURE

Architecture of Electricity Load Forecasting with Neural Network:

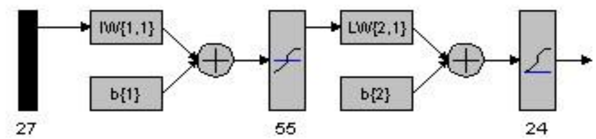
After the data imported into the Matlab workspace, the data needs to be transformed into double type, which fits for the neural network demand. Finally, train the input data until it meet with the criteria, simulate the electricity load, compared with the forecasting data with the real past electricity data. The accuracy stands for the software efficient. In order to improve the accuracy, we used to using Multi-algorithm for prediction [12].

The architecture of electricity load forecasting with neural network is as:



A. *Structure of BP Neural Network for Electricity Load Forecasting*

The Back Propagation (BP) neural network forecasting electricity is a single hiding layer network. The input vectors include 27 nodes. There 24 every hour electricity load with max temperature, min temperature and weather feature.



According to the Kolmogorov theorem, the number of inside layer neural network is square of input vectors and added another one in the end. So the hide layer number is 55 nodes [12]. The output vectors have 24 nodes for every hour electricity load of every day. The structure of neural network forecasting electricity load is shown in the above figure.

VI. CONCLUSION

As per study of various papers, various techniques are used by various researchers for load forecasting, but artificial intelligence techniques being one of the latest approaches and they provide greater accuracy to the forecasts as compared to conventional techniques. Though it requires some initial hard work but once done there are various benefits associated with this technique. Various factors which one need to know about before working on load forecasting are presented in this paper like what were the conventional methods available to us, how forecasting is done, what are the various benefits of ANN and Structure of NN. The surveyed publications and the authors' own experience lead to the conclusion that the ANN structure, input variables, number of hidden neurons, and BP algorithm parameters are mainly system dependent. The development of a more general ANN model to handle the STLF problem is a challenging problem and should be investigated timely.

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