A Critical Review on Employed Techniques for Short Term Load Forecasting

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Abstract - *The objective of this paper is to describe a forecasting model for hourly electricity load in the area covered by an electric utility. Electric load forecasting is essential for developing a power supply strategy to improve the reliability of the ac power line data network. Economic load forecasting is fundamentally important in electric industry as it has many applications including energy purchasing, generation, load switching, contract evaluation and infrastructure development of electrical system. In this paper, Short Term Load forecasting uses input data dependent on the parameters such as load for current hour and previous two hours, temperature for current hour and previous two hours, wind for current hour and previous two hours, cloud for current hour and previous two hours. The decision process in the electricity sector is a complex process because several different factors have to be taken into consideration. These comprise for instance the planning of facilities and an optimal day-to-day operation of the power plant. These decisions address widely different time-horizons and aspects of the system. So load forecasting is important to accomplish these tasks. Short-term load forecasting in power system is necessary for management and control of power system.*

Key Words: **Artificial Neural Network (ANN), Genetic Algorithm (GA), Autoregressive Moving Average (ARMA), Mean Absolute Percentage Error (MAPE).**

I. INTRODUCTION

The most used thing in today's world is energy. We use various forms of energy in our daily life as electricity, refined oils, LPG, solar energy, wind energy, chemical energy in form of batteries and many other applications. But to provide uninterrupted supply of electricity to users, there must be proper assessment of present day and future demand of electrical energy. That's why we need a technique to tell us about the demand of consumers and the exact potential to generate the power and this needs load forecasting techniques. It is used by power companies to predict the amount of power needed to supply the demand [1]. By this the situation of present and future load demand is estimated. Load forecasting is a tricky task because first, the load series is complex and exhibits several levels of seasonality and second, the load at a given hour is dependent not only on the load at the previous day, but also at the same hour on the load on the previous day and previous week and because there are many important exogenous variables that must be considered [2]. Depending on the time zone of the planning strategies [3, 4] the load forecasting can be divided into four categories namely very short term load forecasting, short term load forecasting, midterm load forecasting and long term load forecasting.

Short-term load forecasting technique that considers electricity price as one of the main characteristics of the system load, demonstrating the importance of considering pricing when predicting loading in today's electricity markets [5]. However, it is impossible to predict the next year peak load with the similar accuracy since accurate long-term weather forecasts are not available. For the next year peak forecast, it is possible to provide the probability distribution of the load based on historical weather observations [6]. Advanced load forecasting tools or applications gives appropriate future long term load requirements [7]. Load forecasting has been an integral part in the efficient planning, operation and maintenance of a power system. Short term load forecasting is necessary for the control and scheduling operations of a power system [8].

Artificial Neural Network (ANN) method is applied to forecast the short-term load for a large power system. The load has two distinct patterns as weekday and weekend-day patterns. The weekend-day pattern includes Saturdays, Sunday and Monday loads. A nonlinear load model is proposed and several structures of ANN for short term forecasting are tested. Inputs to the ANN are past loads and the output of the ANN is the load forecast for a given day.

There are large fluctuations in load and temperature which cause errors in forecasting so we use fuzzy logic method for these types of cases. Short term load forecasting problem with fuzzy logic approach has an advantage of dealing with the nonlinear parts of the forecasted load curves, and also has the ability to deal with the abrupt change in the weather variables such as temperature, moisture etc.

Traditional forecasting model is not accurate so an improved genetic algorithm model is proposed. The distinguishing feature of a GA with respect to other function optimization techniques is that the search towards an optimum solution proceeds not by incremental changes to a single structure but by maintaining a population of solutions from which new structures are created using genetic operators [9] – [11].

Various techniques for power system load forecasting have been proposed in the last few decades. Load forecasting with time leads, from a few minutes to several days helps the system operator to efficiently schedule spinning reverse allocation, can provide information which is able to be used for possible energy interchange with other utilities [12]. The idea of time series approach is based on the understanding that a load pattern is nothing more than a time series signal with known seasonal, weekly and daily predictions. These predictions provide a rough prediction of the load at the given season, day of the week and time of the day [13]-[15].

Necessity of Load Forecasting

Accurate models for electric power load forecasting are essential to the operation and planning of a utility company. Load forecasting helps an electric utility to make important decisions including decisions on purchasing and generating electric power, load switching, and infrastructure development. Load forecasts are extremely important for energy suppliers, ISOs, .national institutions, and other participants in electric energy generation, transmission, distribution, and markets.

II. SHORT TERM LOAD FORECASTING METHODS

Similar day approach, various regression models, time series, neural networks, expert systems, fuzzy logic, and statistical learning algorithms are the various methods used for the short term load forecasting. For the more accurate load forecasting technique development, improvement and investigation of the appropriate mathematical tools is required. A little description of various techniques for short term load forecasting is provided in this paper.

1. Artificial Neural Network

ANN is usually formed with many hundreds or thousands of simple developing units, connected in parallel and feeding forward in several films. Because of the fast and low priced personal computers availability, the interest in ANN's has evolved in the current digital world. The basic aim of the development of the ANN is to make the computers to offer human intelligence.

Benefits of ANN

1. They are very powerful computational devices.
2. Considerable parallelism makes them very efficient.
3. They can learn and simplify from training data, so there is no need for massive feats of programming.
4. They are particularly fault tolerant and this is equivalent to the "elegant degradation" found in biological systems.
5. They are very noise tolerant, so they can cope with situations where normal figurative systems would have difficulty.
6. In principle, they can do anything a figurative/logic system can do, and more.

To use a neural network for electric load forecasting, one must select one of a number of architectures (e.g. Hopfield, back propagation, Boltzmann machine), the number and connectivity of layers and essentials, use of bi-directional or uni-directional links, and the number format (e.g. binary or continuous) to be used by inputs and outputs. The most trendy artificial neural network architecture for electric load forecasting is back propagation. Back propagation neural networks use continuously valued functions and supervised

learning. That is, under supervised learning, the real numerical weights assigned to element inputs are determined by matching historical data (such as time and weather) to most wanted outputs (such as historical electric loads) in a pre-operational "training session". Artificial neural network is used to determine the location of fault [16]. Radial basis ANN provides better efficiency than other ANN in load forecasting [17] and power quality events classification [18]. Radial basis ANN provides higher efficiency in classification of power quality events also. Artificial neural networks with unsupervised learning don't require pre-operational training.

BIOLOGICAL MODEL

The human nervous system can be broken down into three stages that may be represented as follows:

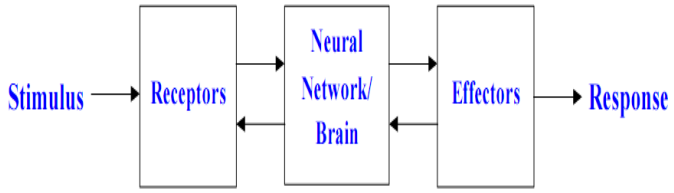

Fig-1: Block Diagram of a Human Nervous System

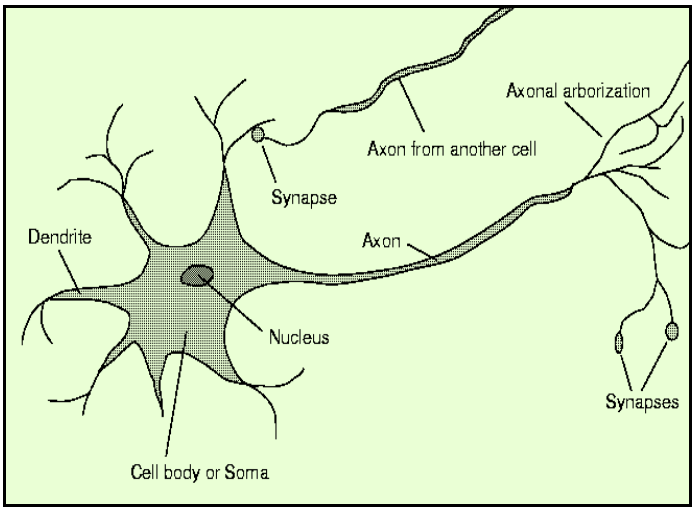

Fig -2: Schematic diagram of a Biological Neuron

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From the work reported by different researchers, it can be accomplished that the artificial intelligence based forecasting algorithms are proved to be potential techniques for this challenging job of non linear time series forecast. Different random search techniques are capable of global learning capabilities had also been tinted in combination with ANN for this challenging and interesting problem. The discussed techniques show their ability in forecasting of electrical load which ultimately condensed the operational cost of power system and increases the efficiency of operation.

2. Fuzzy logic

In recent years, application of fuzzy method for load forecasting is in the experimental stage. For the expression of the method of fuzzy expert systems that forecasts the daily peak load, is selected.

Fuzzy Expert Systems:

The concept of fuzzy system is 'fuzzy set theory', 'fuzzy if then rules' and 'fuzzy reasoning' which is a very popular framework. The structure of fuzzy inference consists of three conceptual components namely rule base containing a selection of fuzzy rules, database defining the membership functions and these are used in the fuzzy rules, reasoning mechanism that performs the inference procedure upon the rules and given facts and derives a reasonable output or conclusion.

The membership function is selected by trial and error. There are four basic membership functions namely: triangular, trapezoidal, Gaussian, generalized bell.

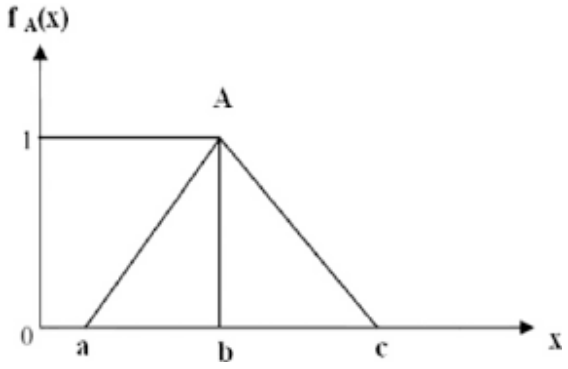

Fig-3: Triangular fuzzy membership function

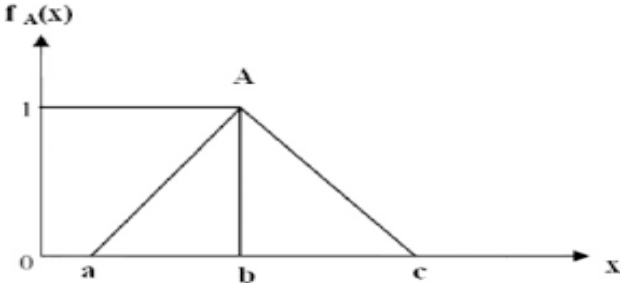

Fig-4: Trapezoidal fuzzy membership function

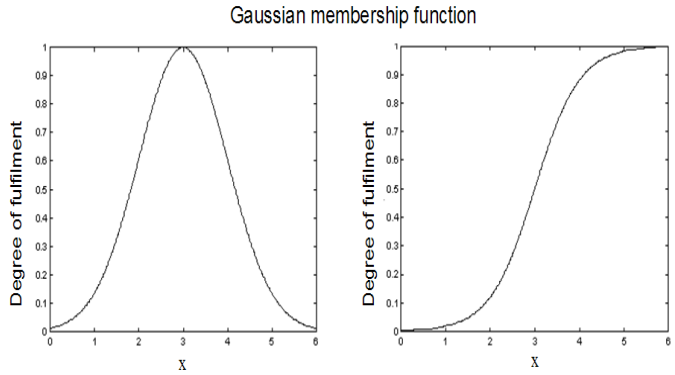

Fig-5: Gaussian fuzzy membership function

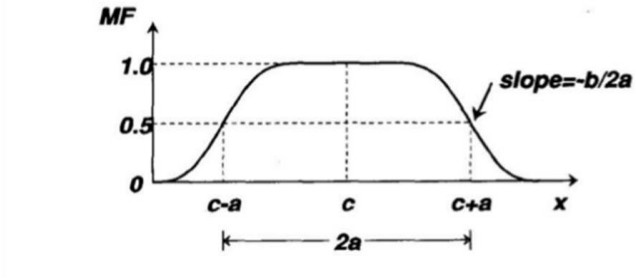

Fig-6: Generalized fuzzy membership function

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In this method, fuzzy logic is used to correct the similar day load curves of the forecast day to get the load forecast Fuzzy logic is used to evaluate the correction factor of the selected similar days to the forecast day using the information of the previous forecast day and the previous similar days in the areas that have good mathematical descriptions and solutions, the use of fuzzy logic most often may be sensible when computing power (i.e. time and memory) restrictions are too severe for a complete mathematical implementation.

3. Multiple Regression

Regression is the one of the most extensively used statistical techniques. For electric load forecasting regression methods are usually used to model the relationship of load consumption and other factors such as weather, day type, and customer class.

Modelling Cyclicality

Autoregressive moving average models have been extensively applied in the load forecasting of those studies that perform short-term load forecasting, the most popular time-series techniques that have been assumed are some formulation of Autoregressive Moving Average (ARMA) or Autoregressive Moving Average with exogenous variable (ARMAX) models. When choosing a time series model between univariate (ARMA) and multivariate (ARMAX) time-series model, the time horizon and data availability gives some indication as to which technique is reasonable.

A) ARMA Models

Amjady uses an ARIMA model to forecast load for four different types of days, which simultaneously accounts for intraday seasonality. Amjady estimates 16 ARIMA models, one for each type of day, a hot- and cold-days model within each day-type model. Using data from the Iranian National Grid and an in-sample forecast period from 1996 to 1997, Amjady finds the Mean Absolute Percentage Errors (MAPEs) to range from 1.48% (Sunday to Wednesday, hot) to 1.99% (public holidays, cold). Pappas et al. used daily load data as opposed to hourly loads from the Hellenic power market and after accounting for seasonality, they find that an ARMA model successfully fits the data.

Soares and Souza utilized the multi-equation approach and apply uni-variate ARMA models to forecast the electricity load in Rio de Janeiro. Soares and Souza proposed a stochastic model that employs generalized long memory to model the seasonal behavior of load, while Soares and Medeiros propose a two-level seasonal autoregressive (TLSAR) model. As pointed out by Soares and Souza, forecasting errors are generally quite high during the summer due to the influx of air conditioning; thus, including temperature or other exogenous variables would help resolve this issue. Poor data availability is the primary reason cited as to why temperature is excluded from the model; where temperature data are available, both studies advocate its inclusion (Soares and Medeiros; Soares and Souza.

B) ARMAX Models

It would appear that while univariate ARMA models are sufficient for short-term load forecasting, the literature agrees that including exogenous variables like temperature can potentially improve forecasting performance. Darbellay and Slama do both univariate modeling using an ARIMA model and multivariate modeling using an ARMAX model that incorporates

temperature data. Using hourly load data from the Czech Republic, Darbellay and Slama (2000) find the ARMAX model to be superior.

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An imprecise load forecast can have severe consequences for customer in the form of higher rates. So our main aim is to forecast a load which will be nearly accurate to the consumed load. Multiple model regression technique uses many highly developed models like ARMAX models, ARMA models so forecasted load have huge accuracy.

3. Genetic Algorithm

Genetic algorithm, which mechanism is based on the survival of the fittest principle of Darwinism, is a kind of artificial intelligence method; it simulates the process of organic evolution and introduces propagation, hybridation, dissociation, competition and choice to the algorithm. It improves the shift track and style of feasible solution in the multidimensional space through maintaining a set of feasible solution and resetting feasible solution and finally trends towards optimum solution. It overcomes the fault of easily falling into local minimum point using traditional optimization method, and it is a kind of global optimization method.

Genetic algorithm is a kind of non-gradient random optimal method based on natural selection and evolving notions. Its basic operation has coding, choice of fitness function and genetic operator. Genetic algorithms (GAs) represent a powerful and robust approach for developing heuristics for large-scale combinatorial optimization problems. The motivation underlying GAs can be expressed as evolution has been remarkably successful in developing complex and well adapted species through relatively simple evolutionary mechanisms. A natural question is the following, what ideas can we adapt from our understanding of evolution theory so as to solve problems in other domains? This fundamental question has many different answers because of the richness of evolutionary phenomenon. Holland and DeJong provided the first answer to this question by introducing the concept of a GA as a general search technique that mimics biological evolution with the survival of the fittest individuals and a structured, yet randomized, information exchange, like in population genetics. In general, a GA encodes the problem into a set of strings, each of which is composed of several bits, then operates on the strings to simulate the process of evolution. In the field of STELF, few GA based load forecasting methods have been reported, but encouraging results have appeared. GA is used in the applications of electricity market also in which optimal bidding strategy is obtained [19]. Recently, Srinivasan used a GA to evolve the optimum neural network structure and connecting weights for the one day ahead electric load forecasting problem.

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When forecasts short-term load using four layered neural network with genetic algorithm, the chromogene obviously reduces. It can save the operation time, effectively overcame the defection that neural network is easy to fall into the local minimum point, and achieve the forecast precision. The convergence quickly and more suitable for big sample data space, the method in this paper is feasible and effective. On the other hand, because there was many factors

influence forecasting and the indexes of performance are variable, the trend is stochastic, so, it is hard to forecast more precise, also it's a pity that this paper doesn't take weather, temperature, environment etc. into account, if all these are considered; the method will be more practical and scientific and the application of this method will wildly applied into management and control for power system and enhance the power system's safety and economy.

4. Time Series Models In Load Forecasting

Time series is a sequence of data points, measured typically at successive times, spaced at (often uniform) time intervals. Time series analysis comprises methods that attempt to understand such time series, often either to understand the underlying theory of the data points or to make forecasts. Time series prediction is the use of model to predict future events based on known past events. Time series forecasting methods are based on the premises that we can predict future performance of a measure simply by analyzing its past

results. These methods identify a pattern in the historical data and use that pattern to extrapolate future values. Past results can, in fact, be very reliable predictor for a short period into the future. For a non-stationary time series, transformation of the time series into stationary should be conducted first by using a variety of differencing operations. Model of linear filter, which is assumed to have the output of stationary load series, is then identified adequately to forecast load according to exogenous input series. This method appears to be the most popular approach that has been applied and is still being applied in electric power industry for short term load forecasting.

Time Series Methods

Traditional short term load forecasting relies on time series analysis technique. In time series approach the model is based on past load data, on the basis of this model the forecasting of future load is done. The techniques used for the analysis of linear time series load signal are as following:

1) Kalman Filter Method

The Kalman filter is considered as the optimal solution to many data prediction and trend matching. The filter is constructed as a mean square minimization which requires the estimation of the covariance matrix. The role of the filter is to extract the features from the signal and ignore the rest part. As load data are highly non linear and non stationary, it is difficult to estimate the covariance matrix accurately.

2) Box Jenkins Method

This model is called as autoregressive integrated moving average model. The Box Jenkins model can be used to represent the process as stationary or non stationary. A stationary process is one whose statistical properties are same over time, which means that they fluctuate over fixed mean value. On other hand non stationary time series have changes in levels, trends or seasonal behavior. In Box Jenkins model, the current observation is weighted average of the previous observation plus an error term. The portion of the model involving observation is known as autoregressive part of the model and error term is known as moving average term. A major obstacle here is its slow performance.

3) **Spectral Expansion Technique**

This method is based on Fourier series and the load data is considered as a periodic signal. Periodic signal can be represented as harmonic summation of sinusoids. In the same way electrical load signal is represented as summation of sinusoids with different frequency. The drawback of this method is that electrical load is not perfect periodic. It is a non stationary and non linear signal with abrupt variations caused due to weather changes. This phenomenon results in the variation of high frequency component which may not be represented as periodic spectrum. This method is not suitable and also requires complex equation and large computation time. Time series forecasting methods are based on the premises that we can predict future performance of a measure simply by analyzing its past results [20]. These methods identify a pattern in the historical data and use that pattern to extrapolate future values. Past results can, in fact, be very reliable predictor for a short period into the future. The stages of time series model are shown in following figure.

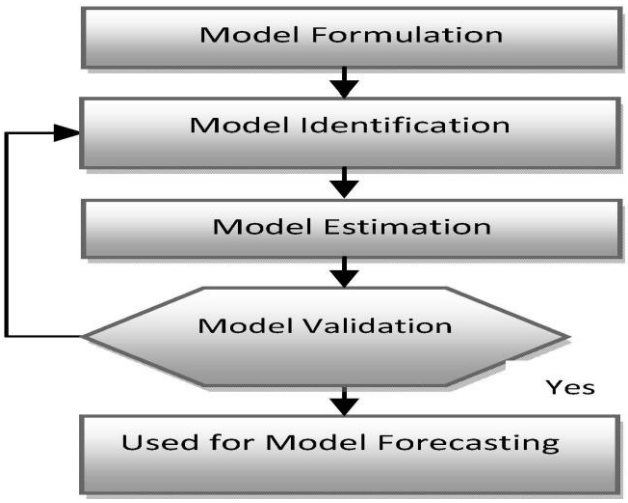

Fig-7:Stages in the time series model building

Critical review

Time series analysis gives the best order selection of Autoregressive model, this leads to decrease in the forecast errors. The results compared with actual and forecasted load values justifies that short term load forecasting by AR method is more effective and it helps

in maintaining stable, economical and secure operation of the power system.

Conclusion

Hence we have studies various type of methods for short term load forecasting. The difference among them is mostly about the predicted load accuracy which is different for all the methods. As from the total process, the Artificial Neural Network method is the most suitable due to its accuracy is higher than other methods. Also, it works on feedback system, so every time its output is compared to the desired output and an error signal is generated which is again used to reduce the error and at last a desired output with less error or higher accuracy is achieved.

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