ELECTRICITY LOAD FORECASTING BY ARTIFICIAL NEURAL NETWORK MODEL USING WEATHER DATA

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ABSTRACT

This paper discusses significant role of advanced technique in short-term load forecasting (STLF), that is, the forecast of the power system load over a period ranging from one hour to one week. An adaptive neuro-wavelet time series forecast model is adopted to perform STLF. The model is composed of several neural networks (NN) whose data are processed using a wavelet technique. The data to be used in the model are both the temperature and electricity load historical data. The temperature variable is included because temperature has a close relationship with electricity load. The calculation of mean average percentage error for a specific region under study in India is done and results obtained using MATLAB’S ANN toolbox. This study proposes a STLF model with a high forecasting accuracy. In this study absolute mean error (AME) value calculated is 1.24% which represents a reasonable degree of accuracy.

Key words: short term load forecasting, artificial neural network, power system

1. INTRODUCTION

Short term load forecasting (STLF) studies began at early 1960’s. In 1971, a load forecasting system was developed by researchers in United States which used statistical approach. Subsequent to 1990’s researchers started to implement different approaches for STLF other than statistical approach mainly due to their requirement for huge data sets to
implement STLF systems. In 2003 many STLF studies were carried using neural network models. Load forecasting occupies a central role in the operation and planning of Electric Power System. Load forecasting can be divided into three major categories: Long-term load forecasting, Medium-term load forecasting and Short-term load forecasting. STLF precedes many important roles carried in energy management systems (EMS), which continuously monitors the system and initiates the control actions in time critical situations. STLF model is critical important decision support tool for operating the electric power system securely and economically.

Load forecasting can be made by different methods like regression analysis, statistical methods, artificial neural networks, genetic algorithm, fuzzy logic, etc. In the recent years, many researchers have tried to use the modern techniques based on artificial intelligence. Of all techniques, the artificial neural network (ANN) receives the most attention. ANN is regarded as an effective approach and is now commonly used for electricity load forecast. The reason for its popularity is its ease of use and its ability to learn complex input-output relationship. The ability to learn gives ANN a better performance in capturing nonlinearities for a time series signal. Therefore, the study in this paper proposes a model comprising neural networks as its forecasting tool. This paper explores an adaptive neuro-wavelet model for Short Term Electricity Load Forecast (STLF). Both historical load and temperature data, which have important impacts on load level, are used in forecasting by the proposed model. To enhance the forecasting accuracy by neural networks, the non-decimated Wavelet Transform (NWT) is introduced to pre-process these data.

The objective of this study is conduct out short-term load forecasting using MATLAB’S ANN Toolboxes. Artificial Neural Network (ANN) Method is applied to forecast the short-term load for a large power system in one state of India. A nonlinear load model is proposed and several structures of ANN for short term forecasting are tested.

The data used in the model, both the weather and electricity load historical data were obtained from metrological office of Government of India (GOI), Pune (India) and state load dispatch center, Mumbai (India). Field visits to state load dispatch center, Mumbai (India) were done.

2. LITERATURE SURVEY

One of the first published studies was done by Heinemann et al. in 1966 which dealt with the relationship between temperature and load. Lijesen and Rosing (1971) developed load forecasting system which used statistical approach. In this study, estimated average root mean square error value was 2.1%. Hagan and Behr (1987) forecasted load using a time series model. With this model, the nonlinear relationship between load and temperature data during winter months was clearly observed. Park et al (1991) claimed that the statistical methods like regression and interpolation did not provide reliable prediction performances that of artificial neural network (ANN). The average absolute errors of the one-hour and 24-hour ahead forecasts were calculated as 1.40% and 2.06%, respectively. This method was found successful when compared with the regression method for 24 hour ahead forecasts with an error of 4.22%. Xu (2003) considered market forecasting by using various new techniques, such as wavelet, neural network and support vector machine. The author explored how different models for electricity Load and price forecast have been developed, which are
able to forecast at one or more time steps ahead. Dong et al (2003) presented an adaptive neuro-wavelet model for Short Term Electricity Load Forecast (STLF). Both historical load and temperature data, which have important impacts on load level, are used in forecasting by the proposed model. To enhance the forecasting accuracy by neural networks, the Non-decimated Wavelet Transform (NWT) is introduced to pre-process these data. Benaouda et al (2005) looked at wavelet multiscale decomposition based autoregressive approach for the prediction of one-hour ahead load based on historical electricity load data. Ching-Lai Hor et al (2005) made use of forecasting model including both climate-related and socioeconomic factors that can be used very simply by utility planners to assess long-term monthly electricity patterns using long-term estimates of climate parameters, gross domestic product (GDP), and population growt. Myint et al (2008) proposed a novel model for short term loadforecast (STLF) in the electricity market. In this study the prior electricity demand data are treated as time series. The model is composed of several neural networks whose data are processed using a wavelet technique. The model is created in the form of a simulation program written with MATLAB.

3. KEY FEATURES OF ARTIFICIAL NEURAL NETWORK BASED SHORT TERM LOAD FORECASTING (ANNSTLF)

Advantages of ANNSTLF

1. Adaptive learning: An ability to learn how to do tasks based on the data given for training or initial experience.
2. Self-Organization: An ANN can create its own organization or representation of the information it receives during learning time.
3. 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.

Limitations in the ANNSTLF

Several difficulties exist in short-term load forecasting such as precise hypothesis of the input-output relationship, generalization of experts’ experience, the forecasting of anomalous days, inaccurate or incomplete forecasted weather data.

4. MATHEMATICAL MODEL OF A NEURON

A neuron is an information processing unit that is fundamental to the operation of a neural network. The three basic elements of the neuron model are. A set of weights, an adder for summing the input signals and activation function for limiting the amplitude of the output of a neuron.
5. NEURAL NETWORK (NN) MODEL WITH WAVELET ENHANCEMENT FOR TIME SERIES FORECAST

To improve the quality of the raw input signal for time series forecast, the neural network model is enhanced with multi-scale wavelet transform. Figure below shows an illustration of the wavelet enhanced neural network model for time series forecast. The inputs given are: Hourly load demand for the full day, day of the week, min/max/ average daily temperature and min/max daily humidity.

6. MEAN AVERAGE PERCENTAGE ERROR (MAPE)

\[
MAPE \% = \frac{1}{N} \sum_{i=1}^{N} \left| \frac{P_A - P_F}{P_A} \right| \times 100
\]

; \(P_A\) = Actual load demand, \(P_F\) = Forecasted load demand, \(N\) = Number of time sections.
Following table shows the different methods of the electric load forecasting and mean absolute percentage error based on literature survey. The figure shows the neural network method is more accurate than any other methods. Therefore method used in this study i.e artificial neural network based load forecasting method is justified.

<table>
<thead>
<tr>
<th>Forecasting Methods</th>
<th>MAPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>3.74%</td>
</tr>
<tr>
<td>Time Series</td>
<td>3.13%</td>
</tr>
<tr>
<td>Expert System</td>
<td>2.74%</td>
</tr>
<tr>
<td>Fuzzy Logic</td>
<td>2-3%</td>
</tr>
<tr>
<td>Super Vector Machine</td>
<td>2.14%</td>
</tr>
<tr>
<td>Neural Network</td>
<td>1.81%</td>
</tr>
</tbody>
</table>

Figure 3 Actual v/s forecasted load for Sunday

7. RESULTS

The results obtained from testing the trained neural network on new data for 24 hours of a day over a one-week period are presented below in graphical form. Each graph shows a plot of both the predicted and actual electrical load in MW values against the hour of the day. The absolute mean error % (AME %) between the predicted and actual loads for each day has been calculated and presented in the table. Overall, these error values translate to an absolute mean error of 1.24% for the network. This represents a high degree of accuracy in the ability of neural networks to forecast electric load.
Figure 6 Neural network training after 10000 iterations

Figure 7 Mean squared error after 10000 iteration

Figure 8 Comparison between actual targets and predictions

Table 2 Mean average percentage error

<table>
<thead>
<tr>
<th>Day</th>
<th>March 3rd week</th>
<th>August 2nd week</th>
<th>January 1st week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunday</td>
<td>0.74</td>
<td>2.28</td>
<td>1.47</td>
</tr>
<tr>
<td>Monday</td>
<td>0.69</td>
<td>0.72</td>
<td>1.09</td>
</tr>
<tr>
<td>Tuesday</td>
<td>0.18</td>
<td>0.23</td>
<td>2.38</td>
</tr>
<tr>
<td>Wednesday</td>
<td>1.41</td>
<td>1.81</td>
<td>0.21</td>
</tr>
<tr>
<td>Thursday</td>
<td>1.50</td>
<td>1.07</td>
<td>0.62</td>
</tr>
<tr>
<td>Friday</td>
<td>0.62</td>
<td>1.27</td>
<td>3.08</td>
</tr>
<tr>
<td>Saturday</td>
<td>3.24</td>
<td>0.94</td>
<td>0.39</td>
</tr>
<tr>
<td>Average</td>
<td>1.14</td>
<td>1.18</td>
<td>1.32</td>
</tr>
</tbody>
</table>
8. Characteristics of the power system load
Various factors that influence the system load behavior, can be classified into the major categories as weather, time, economy, random disturbance etc.

![Weekly Load Profile](image)

Figure 9  Hour load profile of grid in this study for a week of March 2010

From the above diagram it is seen that, typically load is low and stable from 0:00 to 6:00; it rises from around 6:00 to 9:00 and then becomes flat again until around 12:00; then it descends gradually until 17:00; thereafter it rises again until 19:00; it descends again until the end of the day.

CONCLUSION

The result of adaptive neuro-wavelet time series forecast model used for one day ahead short term load forecast for the considered area under study in India has a good performance and reasonable prediction accuracy. Its forecasting reliabilities were evaluated by computing the mean absolute error between the exact and predicted electricity load values. We were able to obtain an Absolute Mean Error (AME) of 1.24% which represents a high degree of accuracy. The results suggest that ANN model with the developed structure can perform good prediction with least error and finally this neural network could be an important tool for short term load forecasting. The accuracy of the electricity load forecast is crucial in better power system planning and reliability.

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REFERENCES

[18] Z. Xu, Z. Y. Dong, W. Q. Liu,Neural Network Models For Electricity Market Forecasting
[19] Z.Y. Dong X. Li Z. Xu K. L. Teo, Weather Dependent Electricity Market Forecasting with Neural Networks, wavelet and Data Mining Techniques
Websites
8. www.mahasldc.in /Accessed in year 2012

Field Visits
1. Metrological department,Pune(India)
2. State load dispatch center,Mumbai(India)
3. State Electrcity Board office,Pune(India)

Acronymns
1. AME :Absolute mean error
2. ANN:Artificial neural network
3. ANNSTLF: Artificial neural network based Short term load forecasting
4. EMS :Energy management systems
5. GDP :Gross domestic product
6. GOI :Government of India
7. MAPE: Mean average percentage error
8. NN :Neural Networks
9. NWT: Non-decimated Wavelet Transform
10. STLF: Short-term load forecasting