Electricity Load Prediction Using Artificial Neural Network By Back Propagation

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Abstract— This paper presents a data mining approach to forecast the power consumption of a geographical region based on the meteorological data. Artificial Neural Network using Back Propagation is the data mining approach adopted here. The research is conducted using meteorological and load consumption data in Kerala region over the period of 2011- 2012. The historical data containing temperature, humidity, public holidays and the daily load consumption values are used for training the system. A predictive model is then built which gather information from the training data set and generates knowledge for predicting the demand of the region. Results on statistical significance tests assert that the proposed method can be used as an effective model to study the load consumption pattern which in turn helps to forecast the electricity demand of a region.

Keywords— Data Mining;Artificial Neural Network;Back Propagation.

I. INTRODUCTION

For best utilization of electricity, power prediction plays a significant role in energy management. Load forecasting helps a country to plan, schedule and manage its energy generation to satisfy the growing needs. Forecasting demand helps to plan the means to satisfy the demand, efficient use of existing energy sources, new infrastructure to be build. It also helps in meeting the fluctuating demand, giving information about consumption pattern.

Load forecasting is challenging because it may depend upon a number of factors such as the day, season, meteorological data and holidays. Some researches may find all data to be useful but for some it may not be. Forecasting may depend on the attributes that are considered. Load forecasting can be classified into short term, medium term, or long term. There are a number of methods for electricity forecast which includes fuzzy logic, Artificial Neural Network (ANN), Support Vector Machine (SVM), Regression etc.

We adopt ANN with back propagation for load prediction. In recent years, ANN as the consequence of their predominant capability in defining the nonlinear topography between different nonlinear variables has become an approved procedure in the load forecasting area. We are designing a system for short term forecasting. The input considered are meteorological and holiday values. The meteorological value includes minimum temperature and humidity, maximum temperature and humidity. The system is built with two models. First one is the training model which trains the system and the latter is the prediction model which forecast the required load.

In the training phase the preprocessed data is fed to the system. Preprocessing the data is an important step in data mining as the input data greatly affects the performance of the system. Outlier removal and the min-max normalization are the two preprocessing techniques adopted. The training percentage can be selected by the user. The system will be trained better if more data is presented to it. The accuracy of the system is then checked with the remaining data known as the test data.

After the training phase the system is then ready to predict the load, given the required inputs. A python script is used to get the meteorological value from the wunderground database for the next 10 days. User can select the weekday for which the demand prediction has to be made. Section 4 gives a brief about the methodology adopted.

II. RELATED WORK

There are a number of researches going on this field. Different data mining techniques have been adopted to predict the load. Omer F. Demirel, Selim Zaim has used both SVM and neural network to forecast electricity demand for Turkey. Hoda K. Mohamed, Soliman M. El-Debeiky, Hassan M.Mahmoud, Khaled M. El Destawy presented a model for forecasting long term electricity load in Egyptian Electrical Network [6]. The demand is attributed to a total of eleven parameters-total energy consumption, total energy generation, energy losses, load factor, GDP, electricity price, population, temperature, humidity.

Tso[5]presents three modeling techniques for the prediction of electricity energy consumption in two year seasons: summer and winter. The three predictive modeling techniques are multiple regressions, a neural network and decision tree models. The base ARIMA model with just one seasonal pattern can be extended for the case of multiple seasons. An example of such an extension was presented in [3]. A combinatorial problem of selecting appropriate model orders is an inconvenience in the time series modeling using multiple seasonal ARIMA. Another disadvantage is the linear character of the ARIMA model.

A neural network with back propagation momentum training algorithm was proposed in the paper Artificial Neural Network (ANN) trained by the Artificial Immune System (AIS) presented by M.B. Abdul Hamid and T.K. Abdul Rahman for load forecasting in order to reduce training time and to improve convergence speed for short term load forecasting model [7]. This algorithm has specific benefits such as accuracy, speed of convergence, economic and historical data requirement for training etc. The major benefit of this algorithm over back propagation algorithm is in terms of improvement in mean average percentage error (MAPE). P.Sibi, S.Allwyn Jones, P.Siddarth [4] has carried out a research on different activation functions that can be applied to the neural network.

III. ANN

Artificial neural networks (ANN) are computational models inspired by the human brain. At their core, they are comprised of a large number of connected nodes, each of which performs a simple mathematical operation. Each node's output is determined by this operation, as well as a set of parameters that are specific to that node. By connecting these nodes together and carefully setting their parameters, very complex functions can be learned and calculated.

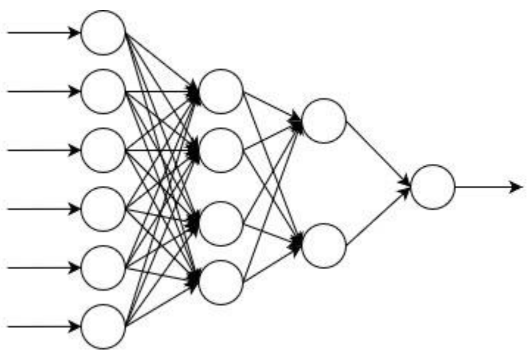

Fig 1 : Neural Network Layout

There are three layers in a neural network. These are input, hidden and output layer. Only a single input and output layer is present and any number of hidden layers can be present.

Once an input is presented to the neural network, and a corresponding desired or target response is set at the output, an error is composed from the difference of the desired response and the real system output. The error information is fed back to the system which makes all adjustments to their parameters in a systematic fashion. This process is repeated until the desired output is acceptable.

IV. METHODOLOGY

A. Data Collection

Two sets of data are collected. One set consists of meteorological data and the other set is about the state's electricity consumption. The meteorological data is collected from the database stored by wunderground. This data consists of minimum and maximum temperature of the day, minimum and maximum humidity of the day. In addition to it the dates of holidays are also collected. The electricity consumption data consists of the daily demand of the state. It is collected from the Electricity Grid of the state. These data are collected for the years 2011and 2012.

B. Data Integration

All the data collected i.e. the electricity demand data, meteorological data and holiday data is combined to form a single data set. This data is combined based on the corresponding date.

C. Data Preprocessing

Data pre-processing is an important step in data mining. The performance of a system is highly dependent on the input data. So, the data fed to the system should be free of noise and missing values. In the pre-processing stage we deal with outlier removal and normalization.

Outlier removal: An outlier is an observation point that is distant from other observations. An outlier may be due to variability in the measurement or it may indicate experimental error.
The interquartile range (IQR) is a measure of variability, based on dividing a data set into quartiles. Quartiles divide a rank-ordered data set into four equal parts. The values that separate parts are called the first, second, and third quartiles; and they are denoted by Q1, Q2, and Q3, respectively.

- Q1 is the "middle" value in the first half of the rank-ordered data set.
- Q2 is the median value in the set.
- Q3 is the "middle" value in the second half of the rank-ordered data set.

$$IQR=Q3-Q1 \quad (1)$$

$$Up=Q3 + (IQR*1.5) \quad (2)$$

$$Low=Q1 - (IQR*1.5) \quad (3)$$

Outliers are those values which are greater than up value and lesser than Low value. These values are detected and removed.

Min – Max normalization: Normalization is a process of scaling down the attribute values into a specified range. There are two reasons for normalization. First to eliminate the influence of one factor over another (i.e. to give features equal chances), second reason is that the gradient descent which is used for back propagation converges faster with normalized data than with un-normalized data. Here we are using a simple technique called Min-Max Normalization.

$$v' = \frac{v - min_A}{max_A - min_A}(new\_max_A - new\_min_A) + new\_min_A. \quad \ldots(4)$$

D. Data Mining

After the preprocessing of the data, now we have data which is free from missing values, noise and outliers. These data are now fed to the system for training. The percentage of data for training can be specified by the user. Usually 80% of data is given for training. The user interface also provides selection of preprocessing techniques.

The Fig 2 depicts the system architecture. The system is provided with 6 inputs. They are minimum temperature and humidity, maximum temperature and humidity, holiday and the weekday. The neural network consists of one input layer with 6 nodes, two hidden layers with 4 and 2 nodes respectively and an output layer with a single node (Fig 1). As there is no general rule to find the hidden layers it was fixed using trial and error method. The activation function used is log sigmoid function. It is applied to both hidden and output layer nodes.

Initialization of weights: The weights are initialized randomly in the range 0-1. Later it gets updated to positive or negative values as the system progresses.

Termination condition: Here the termination condition is on reaching the no. of epoch specified and it is within a minimum error specified. The epoch specified in this work is 100000 and minimum error is 0.005.

As the preprocessed input is fed the required processing is done in each node and the weights are updated. The learning process will terminate based on the termination condition. Now we have a trained model which is capable of predicting the load.

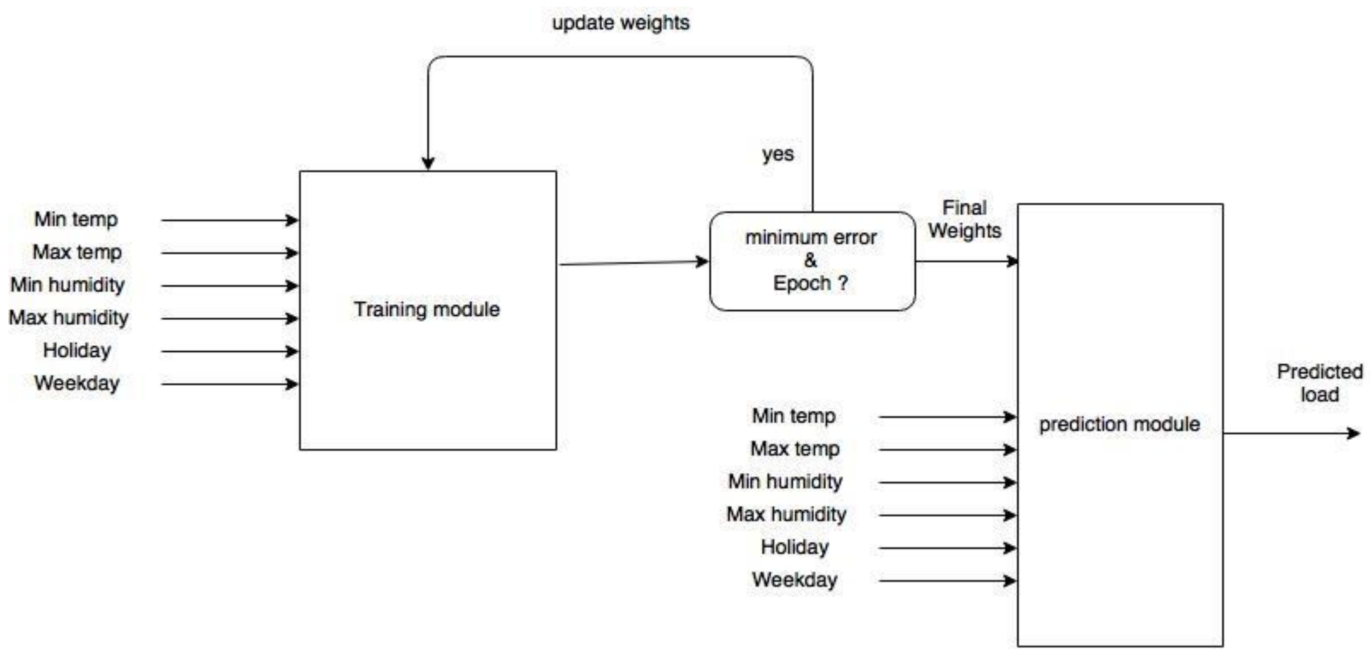

Fig 2: System Architecture

The rest of the input i.e. the test set is provided to the prediction module and tested. Then load is predicted by the system when providing with the necessary inputs.

E. Visualization of knowledge

Better training occurs when more data are presented to the system. So for training 80% of data are used. After training, the remaining 20% of data is fed to the model for representing the knowledge. An x-y graph which is plotted using java is used for this purpose. The graph gives a plot between the actual load and the load predicted by the model. The x axis corresponds to the sample number and the y axis corresponds to the load. The red colored line shows the actual load and the green colored line shows the predicted load.

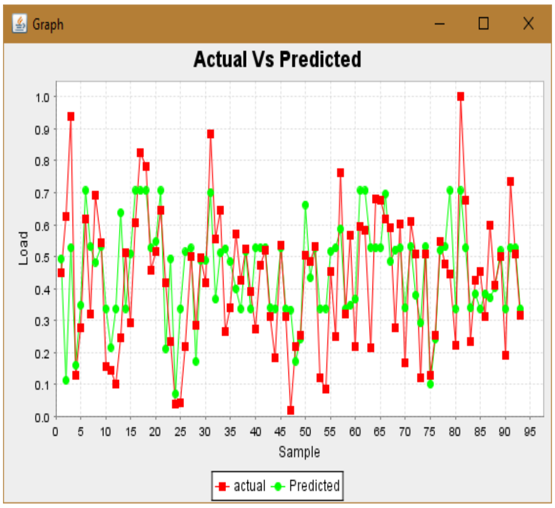

Fig 3: Actual vs Predicted load

V. CONCLUSION

In this paper we presented an approach to predict load using meteorological and holiday values. The existing system predicts the energy consumption only based on historical load consumption data. It does not consider the meteorological factors. Studies have shown that meteorological data also plays a major role in the load consumption. Also existing system fails to determine the load which may fluctuate since they depend only on the known pattern. In this paper we propose a model which is capable of learning patterns and making prediction without degrading the accuracy. Results obtained assert that the proposed model have the potential for load forecasting which make it suitable for real time applications.

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REFERENCES

[1]. Navjot Kaur and Amrit Kaur.Predictive Modelling approach to Data Mining for forecasting electricity consumption;2016 IEEE.

[2]. Jiawei Han, Micheline Kamber.Data Mining: Concepts and Techniques. Morgan Kaufmann publications. 2nd ed.;2006

[3]. Taylor, J.W.Short-Term Electricity Demand Forecasting Using Double Seasonal Exponential.

[4]. P.Sibi, S.Allwyn Jones, P.Siddarth, Analysisof Different Activation Functions Using Back Propagation Neural Networks, Journal of Theoretical and Applied Information Technology; Vol. 47 No.3.

[5]. Tso GKF, Yau KKW. Predicting electricity energy consumption: A comparison of regression analysis, decision tree and neural networks. Energy 2005; vol 28 pp 1761-1768.

[6]. Hoda K. Mohamed, Soliman M. El-Debeiky, Hassan M.Mahmoud, Khaled M. El Destawy . Data mining forelectrical load forecasting in egyptian electrical network.Computer Engineering andSystems;IEEE,2006,460-465.

[7]. M. B. Abdul Hamid and T. K. Abdul Rahman. Short Term Load Forecasting Using an Artificial Neural Network Trained by ArtificialImmune System Learning Algorithm.12th International Conference on Computer Modeling and Simulation (UKSim); 2010, p. 408-413.