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Analysis of Power Supply and Demand in Maharashtra State for Load Forecasting Using ANN

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ABSTRACT

The power system energy management system plays a crucial role in load forecasting. Load forecasting lowers production costs, increases spinning reserve capacity, and improves power system reliability. Financial institutions, power suppliers, and other participants in the electric energy market, such as transmission, generation, and distribution, rely heavily on load forecasts. The allocation of generation for economic reasons is a critical goal of short-term load forecasting. For short-term load forecasting, this research provides a solution paradigm based on an artificial neural network. Dry bulb temperature, Dew point temperature, humidity, and load data are the inputs used to forecast the load. To minimize the error function generated from computed and actual load, the back propagation algorithm was implemented.

Keywords: Short term load forecasting, Back Propagation, Artificial Neural Network.

I. INTRODUCTION

Every day, the amount of power required increases, and it varies during the day. The electricity constraint is usually greater at nightfall, and this is referred to as the peak period; it is also noticed that the evening peak is higher than the morning peak. At night, all types of users, including farmers, small industries, and small company endeavours, require power to operate their equipment.

As a result, demand during this time period surpasses supply. Our electrical generation is primarily reliant on natural resources such as coal, oil, and gas, all of which will run out one day. There are no substantial hydro potential resources, nuclear project investment costs, or current public outcry, and no research into non-conventional energy producing systems.

People in Maharashtra have been experiencing significant electricity shortages, especially during peak hours of the day. It is also obvious that the deficit doubles during certain months of the year. In a normal scenario, supply and demand are out of sync. As a result, MSEDCL has implemented load shedding. When calculated the annual average demand and supply for the last five years, it is discovered that in

2011, demand exceeded 19000MW during peak hours of the day, giving us an idea of future electricity needs.

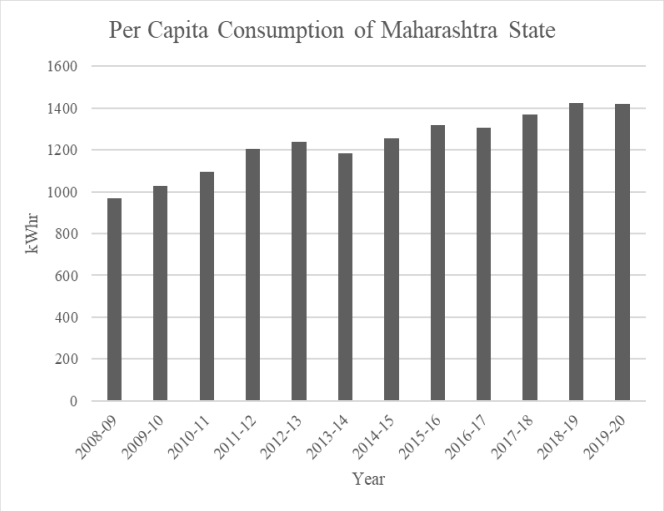

Fig 1: Per Capita Electricity consumption in Maharashtra State

The fig 1 shows the per capita electricity consumption in Maharashtra state from year 2008 to 2020. The per capita consumption for year 2008-09 is 969.4 kWhr and at year 2020 it is 1417.73 kWhr. There is an increase of 46% in per capita power consumption from year 2009 to 2020.

The main objective of the research work is to develop a solution methodology and algorithm to forecast, hourly peak load; by incorporating weather conditions i.e., dew bulb temperature, dew point temperature and humidity. In this work, an attempt is made to implement the above forecast using an artificial neural network approach, i.e., backpropagation algorithm and Levenberg Marquardt algorithm.

II. LOAD FORECASTING IMPLEMENTATION ALGORITHM

Back Propagation (BP) alludes to a wide group of ANN, whose design comprises of various interconnected layers. The learning algorithm of BP is based on the Deepest Descent technique. The proper number of hidden units limits the error of the non-linear function of high complexity. BP is a systematic technique of training multilayer ANN. It is designed on a high mathematical foundation and has excellent application potential. The networks include sensory units that represent the input layer, one or more hidden layers of calculation nodes, and the output layer of the calculation nodes. Input signals on a layer-by-layer basis propagate through the network in the forward direction. These neural networks normally allude to as a multilayer perceptron's as shown in Figure 2.

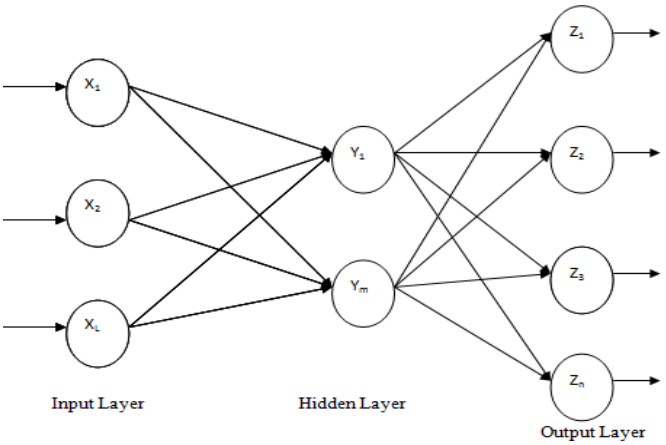

Fig 2 Multi-Layer Fed Forward Network.

Error back propagation basically, an implementation of multilayer perceptron in such a supervised manner with the help of comprehensive algorithm, with success to solve some difficult and different variations. This algorithm depends on the error of learning error correction. While considering the different layers of the neural network, there was basically two passes while learning error back propagation first one is the forward pass and second one is the backward pass. Within the forward pass, it was a type of activity pattern that can be applied on the sensor node of the neural network, and its effect is propagated by the layer via the network layer [38]. Finally, due to the actual response to the network, a set of output has been created. In case of forward pass, the load was considered to be mounted on the network. On the basis of error correction rule, the load was adjusted in the network in case of backward pass which was quite different from the forward pass case. Error signal can

be generated by the difference of the network output and the desired output and further the generated signal was transferred within the network but in the backward direction due to which it was called error backpropagation.

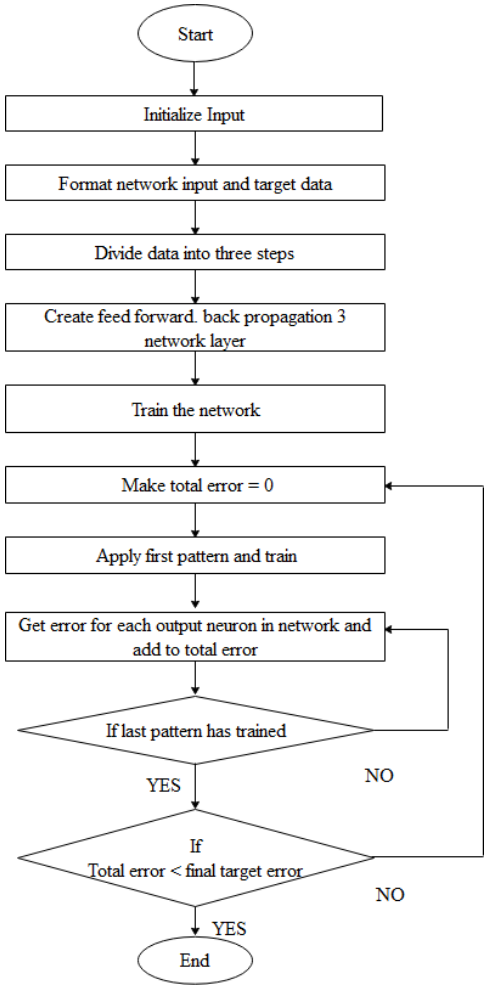

Fig 3: Back Propagation Flowchart

Back propagation method was utilized for the estimation of weight within the network [39], as shown in fig. 3 shows back propagation flowchart. for the analysis of the network, this method considered the loss function with respect to output of the neural network need to be analyzed which typically means that the desired target value is known. BP is a supervised learning method. It was basically a formation of rule by the feed forward neural network by the utilization of chain rule for each layer of the network.

The relative error between the actual and forecasted load demand has been obtained to ensure the accuracy of forecasts. If the error obtained is positive, it symbolizes over forecast indicating that the forecasted load is greater than that of the actual load. For negative values, the case is vice versa. The accuracy is computed by calculating the mean square error (MSE) and root mean square error (RMSE) given as follows,

$$MSE = \frac{1}{N}\sum_{i=1}^{n}(Load_{actual} - Load_{forecasted})^2$$

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{n}(Load_{actual} - Load_{forecasted})^2}$$

III. LEVENBERG-MARQUARDT SOLUTION METHODOLOGY

There are five major steps to obtain the result or to train the network. The five steps are briefly explained below one by one and the flowchart is shown in Figure 4.

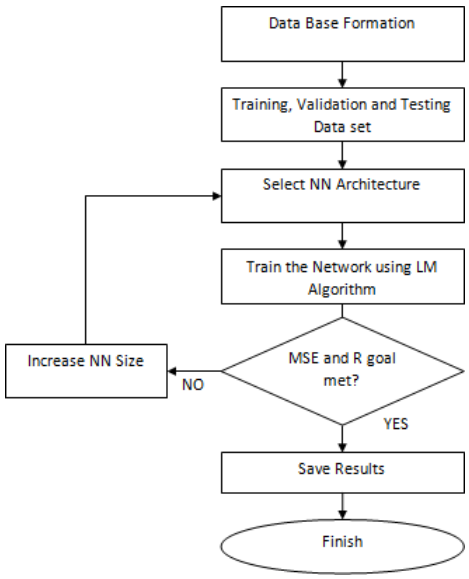

Figure 4: Flowchart of training and testing of ANN

A. Data Collection and Preparation: The chronological data were composed for this research. The chronological load data is taken from the 33kv Old Power House Rahatgaon, Amravati

and the weather data are acquired from the internet. The one-month load data and weather data are used for the training the network.

B. Data Pre-processing: Scaling of raw input data is normally important to diminish the bias caused by a various measuring unit of original input variables. The approach utilized for scaling the network input and target was to standardize the mean and standard deviation of the training set.

C. Network Structure Design: The next step behind rending the training and validation data set is to outline the structure for neural networks. This has to do with choosing a network topology and the resolve of the input nodes, output nodes, number of hidden layers and the number of hidden nodes. The network topology is mostly determined based on the sort of task to be performed by the planned network. The multilayer feedforward neural networks have been effectively applied for prediction. The number of input nodes is usually set equal to the number of input variables.

The following are the input variables for this research

a) Dry bulb temperature

b) Dewpoint temperature

c) Humidity

The output of the neural network represents the forecasted load data for the forecasting day. The determination of the number of hidden layers and the number of neurons within the hidden layers is an important decision within the plan of neural networks. Too many hidden neurons cause many trainable weights, which might build a neural network to become erratic and unreliable. On the other hand, too few hidden neurons limit the learning ability of a neural network and improve its approximation performance [40]. However, there is no distinct guideline for deciding the number of neurons in the hidden layers. The usual practice is by using trial and error which cannot yield an optimum network design and therefore the method is time-consuming.

D. Network Training: After the network has been outlined, the following stage is to train the network. The training of an artificial neural is an iterative method that has to do with changing the association weight. BP algorithmic rule has been generally used in the past as a fundamental learning, algorithmic rule for training feed-forward neural networks; in any case, it takes a long time in training due to the nature of gradient descent. Several techniques are utilized to enhance the execution of back propagation, among them one is by Levenberg Marquardt. Levenberg Marquardt is embraced for training the neural network amid this research. Levenberg Marquardt is the numerical optimization-based technique in which performance index is to be optimized.

IV. RESULT AND DISCUSSION

Back propagation was considered as the important ingredient in the short-term forecasting. For the forecasting purpose, hourly data was collected from the Punjab electricity board for the various days that helped in the training of the technique as well as for forecasting purpose and also the weather data is taken from the Meteologix India web site. The dew point temperature, dry bulb temperature, and humidity are taken as input and the load data is taken as the output. To train the network data, the data are divided into three parts, i.e. Validation, Training, and Testing. The BP algorithm is used to train the network and implemented in MATLAB.

The inputs dew point, dry bulb temperature, humidity and load are presented in figure 5.

(i) Dew Point Temperature: It was basically a temperature value at which the air losses its control over the water vapor due to which some of the air molecules converted in to the water droplet and this particular temperature was lower than the temperature.

(ii) Dry Bulb Temperature: whenever the thermometer was used for the measurement of temperature then it is called dry bulb temperature basically, it was atmospheric

temperature read by the thermometer whenever it was exposed in the surrounding.

(iii) Humidity: it was nothing but a water droplet which was present the atmosphere but they were completely invisible for the human was basically a water molecule in the gaseous state. As humidity increases, ability of body to resist the sweating capacity reduces due to reduction in the rate of evaporation of moisture from the body.

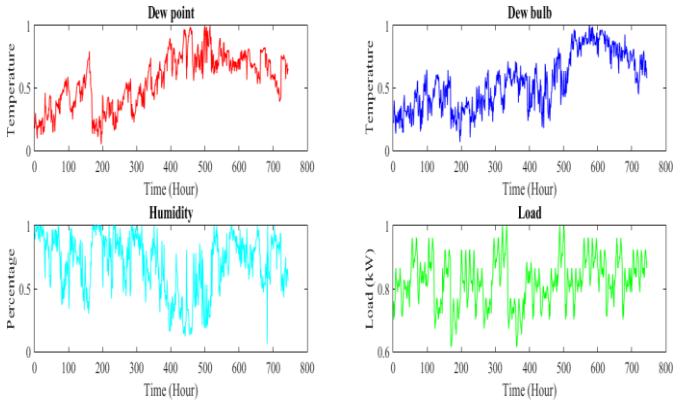

Figure 5: Representation of input data

The network is trained for 5000 iterations with the presented data. In this, the training function is 'trainlm' and the activation function is sigmoid. It is observed that the mean square error is 0.0061 and root mean square error is 0.0784 after training it is also observed that the actual load and forecasted load have so much variation or fluctuations as shown in Fig. 6. As there is a large variation between actual and forecasted load obtained by BP algorithm. So, load forecasting has also been done by Levenberg Marquardt algorithm.

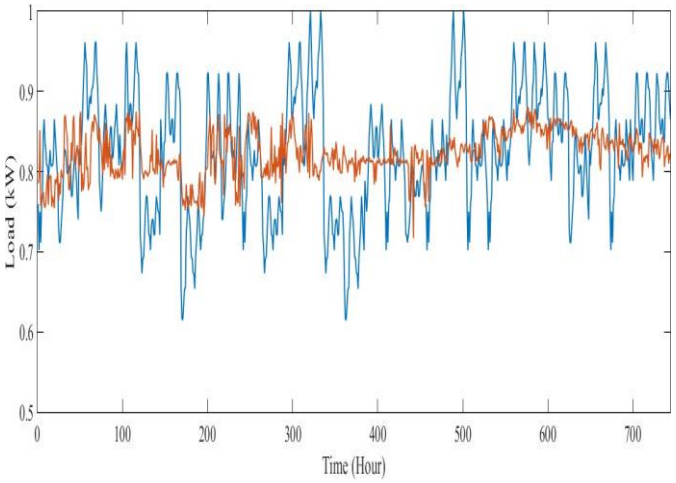

Figure 6: Representation of Actual and Forecasted Load

A. Single layer Network

In case of single layer network, there was single input layer as well as single output layer. Further, the neurons present in the input layer received the signals at the input terminal whereas the neurons present in the output layer received the output signal in a similar way. The input cells were connected to the similar output cell by the utilization of synaptic link carrying weight with it. Due to which this was considered as the feed forward neural network as the inverse operation cannot be possible in this network.

TABLE I

REPRESENTS THE DIFFERENT SIZE OF THE HIDDEN NEURON AND ERROR IN SINGLE LAYER FEED-FORWARD NETWORK.

Hidden Neuron size	MSE	RMSE
3	0.0063	0.0796
6	0.0071	0.0843
9	0.0075	0.0866
12	0.0069	0.0834
15	0.0071	0.0843
18	0.0073	0.0857
21	0.0072	0.0852

Despite of the fact that the network having two layers still it was considering as a single layer due to single output layer receiving signal from input layer [39].

The data is forecasted with different sizes of the hidden layer and the best results are observed when hidden neuron size is 3 as shown in Table 1. The Figure 7 represents the actual load and forecasted load in the hidden neuron size of three.

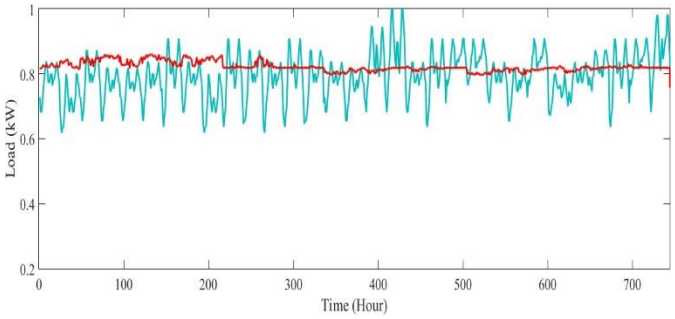

Figure 7: Represents the actual load and forecasted a load of hidden neuron size three.

B. Multilayer Network

As its name indicates is formed from multilayers. So, architectures of multilayer feed- forward network possessing an auxiliary layer considering between the input layer and the output layer. The hidden neurons present within the middle layer was considering for the computational purpose.

TABLE III
REPRESENTS THE DIFFERENT SIZE OF THE NEURON AND ERROR IN MULTILAYER FEED-FORWARD NETWORK.

Hidden Layer 1	Hidden Layer 2	MSE	RMSE
3	6	0.0070	0.0835
6	9	0.0067	0.0819
9	12	0.0071	0.0843
12	15	0.0069	0.0831
15	18	0.0078	0.0883
18	21	0.0072	0.0849
21	24	0.0075	0.0866

The major importance of hidden layer as the computational work performed by the layer before the input signal received by the output terminal [39]. The input hidden layer weight was basically, a synaptic weight links formed by the combination of input neurons and the hidden neurons.

The Table II shows that while changing the neuron size of the hidden layer the error is also changed and the Figure 8 shows the actual load and forecasted a load of the hidden layer having less error.

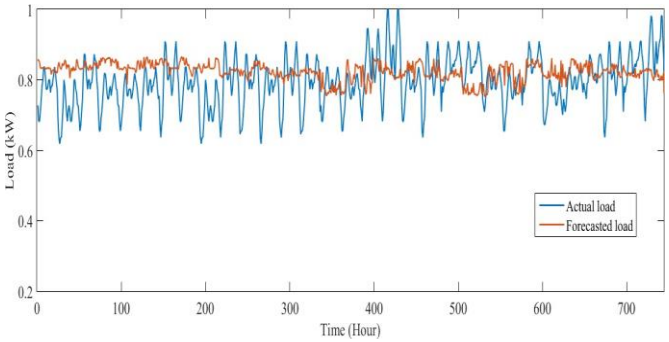

Figure 8: Represents the actual load and forecasted load of the hidden neuron size six and nine.

V. CONCLUSION

In this work results obtained by using ANN technique for short-term load forecasting for the Amravati city, Maharashtra has been analysed. The most widely used technique in ANN is BP algorithm and LM algorithm. The forecasting has been evaluated on the basis of calculating Mean Square Error and Root Mean Square Error between the actual value and forecasted value. Three inputs namely Dew point temperature, Dry bulb temperature and Humidity have been taken as input. The effect of change in number of hidden neurons and number of hidden layers is also studied. The following observations are made:

1. The BP algorithm results into lower error compared to LM algorithm for same input.
2. One hidden layer is sufficient for the formulation of Load forecasting problem.
3. The increase in hidden neurons increases the error.

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