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Short Term Load Forecasting by Using ANN & ANFIS

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ABSTRACT: Load forecasting has become in recent years a major area for research. Electricity supplier use forecasting models to predict the load demand of their customer to increase/ decrease the power generated and minimize the operating cost of producing electricity. Most traditional forecasting models and several artificial intelligence techniques specially neural network have been tried out for this task. The purpose of this paper is to compare two artificial intelligence techniques, artificial neural network (ANN) and adaptive neuro-fuzzy interference system (ANFIS). By using that two techniques, the load in next 24 hours is calculated. By using that two technique the exact load for a specified hour of a specified day and of a specified month can be calculated and the corresponding time which is required to forecast load by using these techniques is also shown on GUI system. So from the results of ANN and ANFIS we can compare the two techniques and find out most accurate method for load forecasting.

KEYWORDS: Short term load forecasting, Artificial neural network (ANN), Adaptive neuro-fuzzy inference system (ANFIS)

I.INTRODUCTION

Short term load forecasting accuracy play a very important part in power system. Forecasting electrical loads in power system up to 24-hour lead-time have been good economically as well as it is advantageous also. The forecast information can be used to give optimal energy interchange between utilities, thereby saving valuable fuel costs. Forecast also significantly affects important system operating decisions such as load dispatch, unit commitment, and maintenance scheduling. In power system operation, load dispatch means minute to minute economic allocation of load to the generating units to meet varying demand at minimum cost with required degree of system security. For secure economic loading of plant, provision of short term load forecast of the demands at the principle supply points of the network is to be done.

For short term load forecasting several methods like statistical and artificial intelligence techniques have been used. Statistical methods like autoregressive moving average and linear regression which are hard computing techniques utilize linear analysis. Since short term load forecasting is an important guideline for safe scheduling and economic management of power system, various techniques have been put forward[1,2,3,4,5].Conventional technique include fuzzy logic inference[6,7,8], regression techniques[9], time seriesapproaches[10,11,12], expert system based methods[13] are commonly used methods. Regarding forecasting under practical condition various types of artificial neural network (ANN) have been proposed for short term load forecasting[14,15]. These method enhanced forecasting accuracy compared with conventional time series and regression method. Methods such as artificial neural network and fuzzy logic are combined for predicting short term load of electric system. ANFIS builds a fuzzy inference system(FIS) whose membership function parameters are adjusted either by a back propagation algorithm alone or in addition with least square method. This adjustmentallows system to learn and build any nonlinear and complex record through educational input output data[16,17,18].

This paper combines neural network and fuzzy system for short term load forecasting. Section 2 reveals brief information about artificial neural network(ANN). Section 3 gives information about adaptive neurofuzzy inference system

II.ARTIFICIAL NEURAL NETWORK

Over the past few years, Artificial Neural Networks (ANN) play an important role in computational work and is now being proposed as a powerful computational tool. ANN structures arejust like that of the biological nervous systems.

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The potential benefits of neural networks is because of its high computation rates which is provided by large parallelism. The testing phase of neural networks takes little time compared to its training phase. Hence ANN offers potentially faster solutions for problem solving. They are more adjustable and provide a great degree of robustness and fault tolerance. The basic structure of an *ANN* consists of processing unit, called neurons and fully interconnected one-way signal channels, called connections. Every input is multiplied by a corresponding weight, which is analogous to the biological neuron's synaptic strength. All of the weighted inputs are then added to determine the activation level of the neuron. Nearly all neural network architectures are based on this model. There are several types of neural architectures. By far, the most widely used is the multi-layer back-propagation system. The back-propagation approach can deal with problems which require pattern mapping. That is, given an input pattern, the network produces an associated output pattern. A back-propagation based *ANN* employ three or more layers of processing nodes. The inputlayer receives external inputs while the output layer is responsible for generating output. The layer "sandwiched" between these two layers is called the hidden layer; the number of hidden layers and hidden nodes may vary in number and are empirically chosen for a given problem. A back-propagation neural network is trained by supervised learning. The network is presented with a training data set made up of pairs of patterns i.e., an input pattern paired with a target output. Upon each presentation, weights are adjusted to decrease the inequality between the network's output and the target output.

III.ADAPTIVE NEURO-FUZZY INFERENCE SYSTEM (ANFIS)

Recently ANFIS is a new Artificial Intelligence (AI) tools emerged from a general category of intelligent networks known as adaptive networks. It is a network structure connected by links which are in specific direction and consist of a number of nodes [4]. Each node serve as a process element and the links specify the relationship between the nodes. The output of these nodes depends on parameters which are modified related to the nodes means nodes are adaptive. The learning rule determines how these parameters should be modified to minimize error within prescribed limit, which measures the deviation between the actual output and a desired (target) output. In the general case, each node in an adaptive network consisting of different node, weights or parameters related with them. The main learning rule is the back propagation learning rule or in some cases it may be combined with other learning mechanisms to give speed up the convergence of the learning process[12].

ANFIS are a class of adaptive networks functionally equivalent to fuzzy inference systems [13]. The shape of a fuzzy membership function bank on a set of parameters, and with the change in these parameters changes the shape of the membership function. So the nodes of an adaptive network are convenient for the representation of the fuzzy system membership functions and a modifying network type structure can be adapted to represent the fuzzy inference system. By the use of any learning rules related to adaptive networks, the parameters related with the membership functions will inevitably modified through the learning process to model closely the relation described by a set of known input/output pairs.

The main objective of the ANFIS design is to optimize the ANFIS parameters. There are two steps in the ANFIS design. First step is to design premise parameters and the second step is consequent parameter training. There are several methods suggested for designing the premise parameter such as grid partition, fuzzy C-meansclustering and subtractive clustering. First finalized the premise parameters, and then consequent parameters are obtained based on the input-output training data. A hybrid learning algorithm is a well-known learning algorithm used to train the ANFIS for this purpose. ANFIS uses a hybrid learning algorithm to describe the membership function parameters of single-output, Sugeno type fuzzy inference systems (FIS).

ANFIS used for Load Forecasting:-

This work involves exposing the capability of using ANFIS in load forecasting. ANFIS provides a method for the fuzzy modeling procedure to study information about the historic data in order to calculate membership function parameters that best permit the associated fuzzy inference system to track the historic data input/output[2,5,8].

The steps in the application of ANFIS can be explained as follows:

1. Initialization

Get ANFIS structure that specifies the rules and initial parameters of the fuzzy inference system for learning purposes. The MATLAB Fuzzy Toolbox consist of 11 built-in membership function types. In our project, a membership function which is used is generalized membership function.

2. Subtractive Clustering

When the number of inputs is greater than four, the number of rules will be more and invokes the so called curse of dimensionality. Subtractive Clustering minimize this problem by dividing the data into groups called clusters,

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and generate a FIS with a minimum number of rules which are necessary to distinguish the fuzzy qualities related with each of the clusters.

3. Fuzzy C-Mean Clustering

Fuzzy C-means FCM is a data collecting technique where each data point belongs to a cluster to some degree that is described by a membership grade. The output of FCM builds a fuzzy inference system by building membership functions to represent the fuzzy qualities of each cluster.

4. Training ANFIS

Using the historic data, ANFIS modify the membership function parameters by using singly a back propagation algorithm or in combination with a least square estimation so as to minimize some error measure defined by the sum of the squared difference between actual and desired outputs. This means that the fuzzy system has learned from the historic data they are modeling.

Application of ANFIS for Load Forecasting:-

The application procedure involves five steps:
1.Gathering the data
2.Normalizing the data
3.Selection of ANFIS structure
4.Training
5.Testing

Data Collection:

From Maharastra State Load Dispatch Center (MAHASLDC), the hourly state demand for the last three years (2018-2020) was obtained.

Normalization

After collecting historical data, the next step is the normalization of all the data so that each value falls between 0 and 1. The normalization program was written using MATLAB Platform. Thenormalization is done because the membership function must vary between 0 and 1.

ANFIS Structure

You can choose any type and number of membership function.In our project we have used two generalized bell membership functions on each input for ANFIS. ANFIS are characterized by two steps known as training and testing. During training, membership function parameters (membership function shapes) are modified according to the desired input/output relationship to be learned. The training of the network is done many times until convergence is obtained. During testing step, new data is used which is not used during the training process.

For the training of network normally back propagation and least square learning techniques are used. It requires a set of input and output (target) pairs. Generally by presenting an input pattern to the network, an output pattern is produced. According to the difference between the output produced and thetarget, membership function shapes are modified to reduce the output error.

IV. SIMULATION RESULTS

In this research, graphical user interface (GUI) system is designed which shows ANN & ANFIS results for next 24 hour & for previous 24 hours for a particular time of particular day and of particular month as shown in Fig 1. In this project, maharastra state load demand for any particular hour of next year can be predicted. In this project ANN & ANFIS are trained simultaneously to predict load demand for future hour. Additionally this GUI system shows time required by ANN & ANFIS for training.

The amount of the accuracy of any methods in load forecasting is determined by getting the obtained values of system model and comparing it with real data.Hence, Mean Absolute Percentage Error (MAPE) is used here for error analysis

$$MAPE = \frac{1}{N}\sum_{i=1}^{N}\frac{(La - Lf)}{La} \times 100$$

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where *La* denotes the actual load value, L*f* is the forecasted load value, and *N* represents the number of hours of which load is considered for forecasting load.

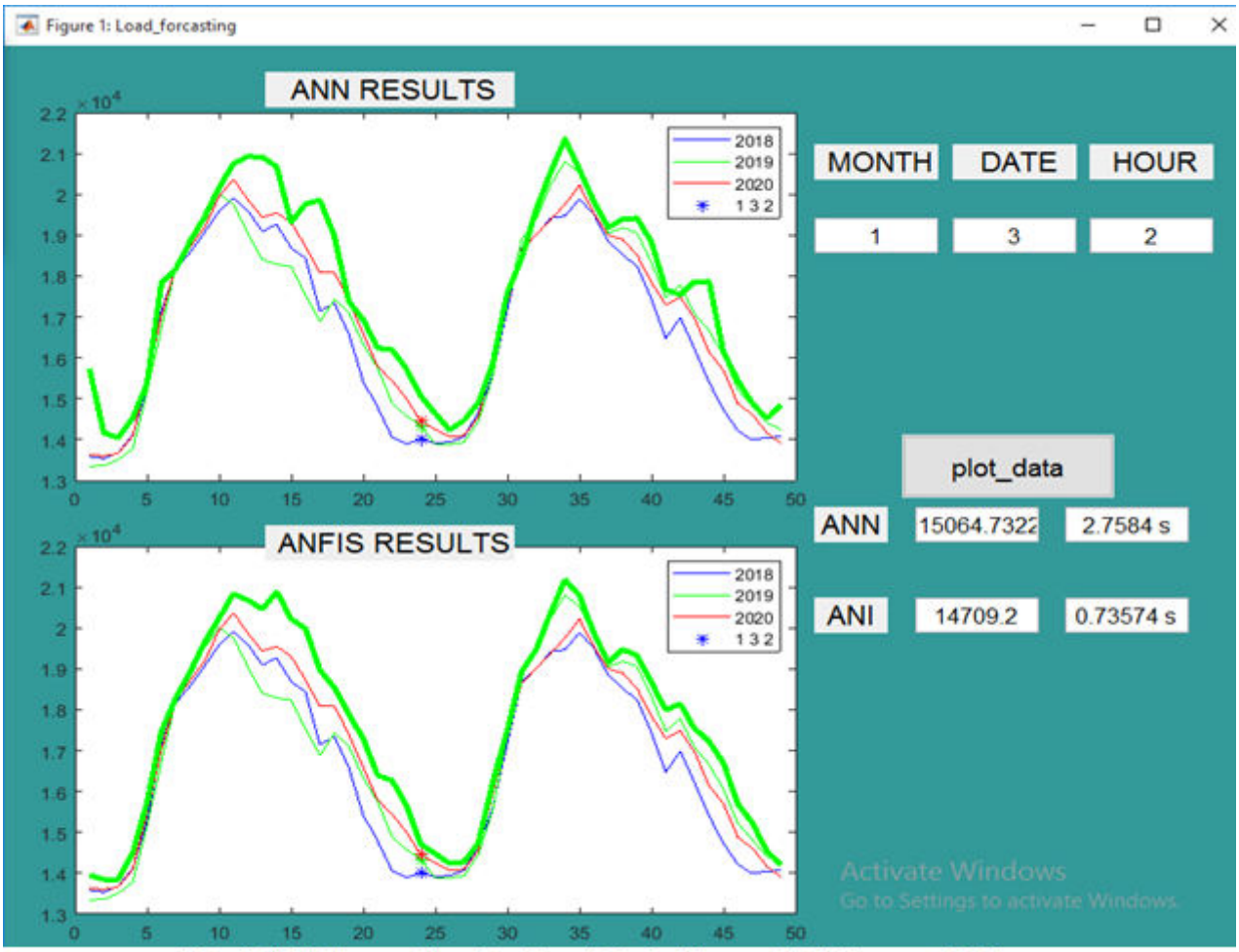

Fig. 1 GUI System Showing Result for 2nd hour of 3rd January 2021

The following table will give the comparison between ANN & ANFIS.

Methods	ANN	ANFIS
Training Periods	2.7584 s	0.73574 s
% MAPE Value	7.37 %	7.31 %

V. CONCLUSION

From tabulated result it is found that for the same amount of data ANN requires 2.7584 s and ANFIS requires 0.73574 s. Also regarding error MAPE value for ANN is 7.37 %and for ANFIS it is 7.31 %. Hence by comparing results of these two methods it is clear that ANFIS is better method for load forecasting than ANN

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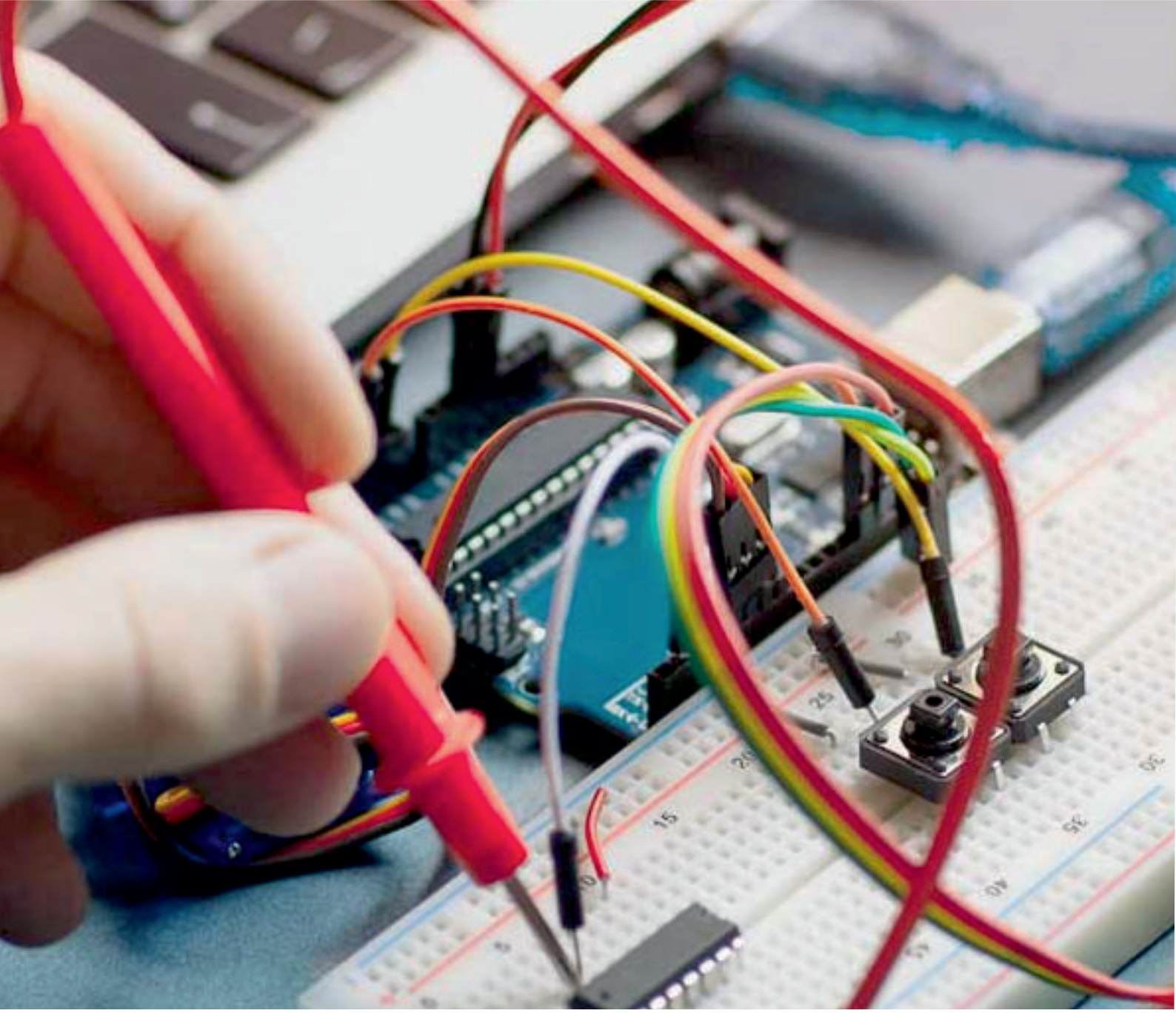

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