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Prediction of Power Consumption using Hybrid System

Priya R.L[1], Shivali Shinde[2], Payal Rajani[3], Manisha Khanchandani[4]

[1,2,3,4]*Computer Department, Vivekanand Education Society's Institute of Technology, Chembur, Mumbai.*

Abstract— In spite of the fact that India is a leading producer of electricity, there are some areas where people are still deprived of electricity. For example, the district of Gadchiroli in Maharashtra is undeveloped and it is one of the twelve districts in Maharashtra currently receiving funds from the Backward Regions Grant Fund Programme (BRGF). The prediction models implemented for such electricity consumption have limited their scope to urban areas that is residential and industrial sector and have their limitations in accuracy. The project aims to highlight the power supply condition of undeveloped regions and provide better facilities through electricity prediction model. The system will help in providing adequate supply of electricity in such rural regions of the country.

The paper proposes a novel solution through hybrid system for the prediction of consumption of electricity specifically in such backward region by considering their meteorological conditions. The hybrid system uses various parameters such as temperature humidity, rainfall, wind speed, evaporation and precipitation rate in order to obtain rough estimation of electricity consumption. Also it provide an estimation of energy requirements of rural areas and thus the government will make plans accordingly to provide adequate amount of electricity in this region.

I. INTRODUCTION

There has been energy deficits since 2004-05 in state of Maharashtra.The peak demand deficit in the state has increased from 17% in 2005-06 to 22% in 2011-12 according to report sourced by CEA[8].Due to industrial growth and agricultural developments the average electricity utility is increased. As per report obtained from [9] the un-electrified Rural Households contribute to 18.73 lakhs out of 130 lakhs.

Also, the number of unelectrified remote villages in Maharashtra were 257 [10].

Hence there is a need of a proper and precise model for analysing and predicting electricity consumption to monitor the usage as well as obtain the predicted demand for the electricity in a given region. This prediction will also ensure optimization of energy distribution particularly in rural areas where electricity supply is low. The project will also be useful for electricity generating industries. The various mathematical techniques that are used widely for such predictions include evolutionary algorithms, wavelet analysis, fuzzy logic system modeling, artificial neural networks and regressive analysis.

The following figure depicts the power supply demand needed and supply made available for Maharashtra

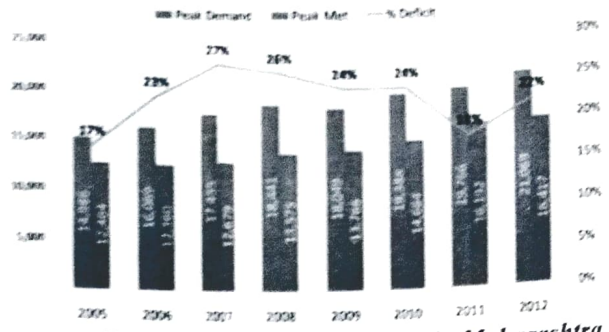

Fig 1.1 Power Supply position in Maharashtra

II. RELATED WORK

The approaches considered so far for the prediction of energy consumption include regression models, decision trees, structural models, neural models, fuzzy models, machine learning techniques and expert systems. The following depicts in brief about the study of various techniques used in the similar field:

a) *Regression models:* It can be described as a form of modeling that describes relationship between target variable and predictor variable. The prior work specifies regression tree models with the help of dataset and thus evaluating various combinations to achieve accuracy. Probabilistic linear regression and Gaussian process regression models were proposed [1] for prediction.

b) *Time Series modelling:* This method is highly used in predicting few parameters that varies overtime[2]. A time series model for short term load forecasting is proposed where the described approach forecasts the current value of a variable by using a mathematical combination of the previously observed values. However, the disadvantage of this method is that the causal variables that change on high frequency may cause low accuracy in prediction and analysis.

c) *Averaging models:* Various service operators and power generators use such models because of its simplicity. Obtaining consumption data from similar days, these models make predictions based upon linear combinations of such data. One such method is Time of the Week Average Model that studies variation of usage of power in the entire duration of the day. A long term load forecasting model using AutoRegressive Moving Average model is developed [6].

d) *Artificial Intelligence expert systems:* An overview of Artificial Neural models applied for electric load forecasting was provided[4]. Many such AI techniques, like ANNs, expert systems, pattern matching techniques can be used for forecasting. A forecasting model based on an Elman artificial neural network for the prediction of the household electricity consumption is presented [5].The problem with this approach is it cannot creatively come with new solutions for the issues and has to be trained every time for new approach.

e) *Support Vector Machines:* It can be described as a supervised machine learning algorithm that is based on the concept of decision planes that define decision boundaries. The study [7] proposes a firefly algorithm that is based on memetic algorithm to appropriately determine the parameters of SVR forecasting model. But SVMs can be extremely slow in test phase. Also they have high algorithmic complexity and need extensive memory requirements

III. PROPOSED DESIGN

In this project, an ANN model along with fuzzy logic model has been used to predict electric demand in a typical rural area examining climatic conditions since it can provide accurate results. The main

advantage of using ANN in comparison to the other models is that it has the ability to extract non-linear relationships among the variables by means of ''learning'' with training data. ANN models have appreciable computational speed and their ability to handle complex non-linear functions even when entire information may not be available.

The project differs from previous work in such a way that it deals with variable customer consumption and the prediction of energy consumption focuses on rural and backward area predictions as compared to most urban area predictions. Also in addition to this, it also evaluates the relationship between prediction accuracy and climate type. Also, it is the first prediction model to be developed for backward regions thereby initiating the use of renewable resources in generation of electricity and prediction using climatic conditions.

The objective of the proposed system is to analyze and predict the demand of electricity consumption in rural and backward regions of the country. The hybrid system accepts training data set along with electricity demands for the ERP activities such as farming usage, residential and industrial consumption. Training data set consists of all the meteorological data comprising of parameters such as temperature, rainfall, air pressure, humidity and evaporation rate. The dataset is then fed to the training unit wherein initially random weights are assigned to obtain results. In the collected data the meter readings are obtained to find out the demand in kWH. Various techniques have been investigated for optimized real time prediction and electricity estimation out of which or project uses artificial neural network logic and fuzzy logic since they provide better and accurate results.

Artificial Neural Fuzzy Networks:
ANFIS serve as a basis for constructing a set of fuzzy if-then rules with appropriate membership functions to generate the stipulated input-output pairs

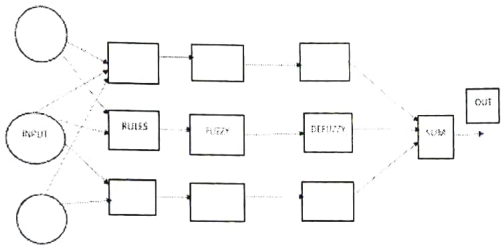

Fig 3.1 Adaptive Networks – Architecture and Learning

In our case the ANFIS is a 6-layered model as show above. The 2nd layer does the fuzzification. The 3rd layer does the de fuzzification and outputs are obtained in the layer 4.The sum of outputs is obtained in layer 5 and the prediction will thus be obtained.

Learning paradigms for Adaptive networks-

1. It is a supervised learning algorithm which can be monitored from outside.
2. links connect different nodes.
3. All the nodes are adaptive that is each output of these nodes depends on parameters pertaining to this node.
4. Learning rule specifies how these parameters should be changed to minimize error
5. An adaptive network is a multi-layer feedforward network in which each node performs a particular function on the incoming parameters
6. The choice of the node function depends on the overall input-output function relation.
7. Weights are associated with links and the links just indicate the flow of the system

8. Batch learning mode: -Update occurs after only the whole training data set has been presented.
9. On-line learning mode: -parameters are updated immediately after each input-output pair has been presented.
10. It is functionally similar to FIS
11. It has minimum constraints so very popular
12. It should be feedforward and piecewise differentiable. The model implemented for our system will be shown as below:

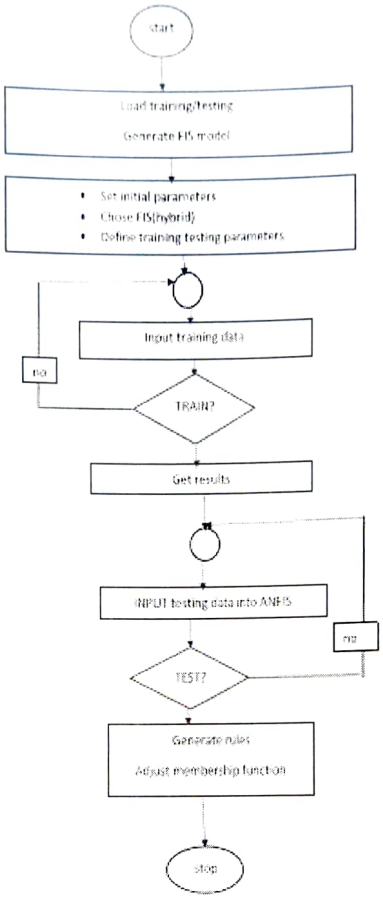

Fig 3.2 Workflow of ANFIS

The above model shows the working of the system and its workflow.The model is first fed with training data and trained according to the output until it forms a relation.Then the trained model is then fed with test data for the case study. It is FIS system based on network flow.

In the prediction unit, the hybrid logic is used by which the output of neural networks is fed to fuzzy logic for obtaining precise and accurate results. Fig.3.3 shows the conceptual system architecture of the proposed system. The Figure describes that the system will take the parameters for ideal region and train the system using ANFIS prediction model which is chosen due to its high accuracy levels as compared to other models.The weights are assigned to the parameters and their contribution in electricity consumption is obtained. The trained model will be then fed with testing parameters of the Gadchiroli region for which the output has to be predicted.

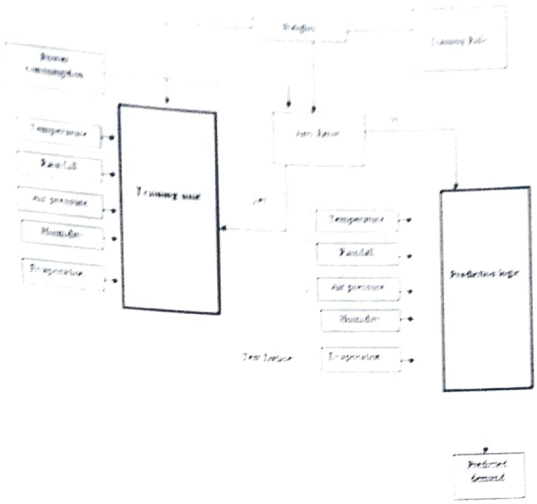

Fig 3.3: Prediction and Training model

In training unit the neural network learns from the training data and model created after training is used for input to fuzzy logic. The equations used for calculating the outputs at each of the layers g1 and g2 is by multi layered feed forward neural model equations is:

$$ZI=g2\{\sum_{j=1}^{H} wjhj + w0\}$$

H is the hidden node,w0 is the bias to the output node.Here wj is an output weight from hidden node j to output node. w0 is the bias for output node.The value for hidden node hji for j=1….H is given by

$$hji= g1\{\sum_{i=1}^{N} vijZji + vj0\}\ j=1.....H$$

Here. ji v is the input weight from input node i to hidden node j . vj0 is the bias for hidden node j . Zt,i are the lag variables where (Zt,i …...Zt,N) are (Zt−i……. Zt−N .). respectively. i =1….. N.
The error analysis and accuracy of the model will automatically reflected in the MATLAB interface

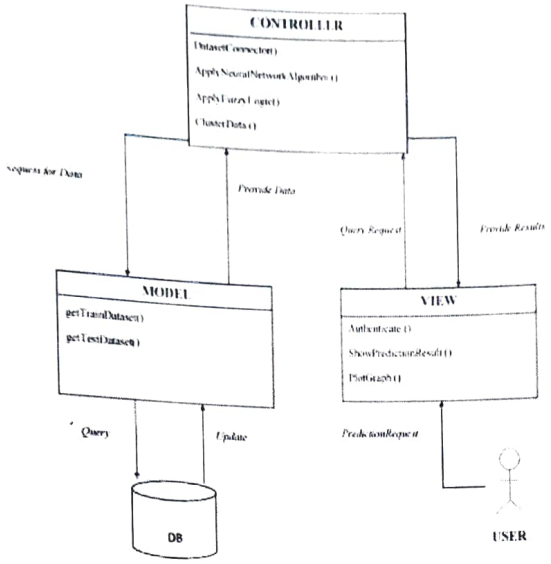

Fig 3.4: MVC model

Model–view–controller (MVC) is a software design pattern for implementing user interfaces on computers. From Figure 3.4 it is shown that the User uses the controller through the view (Websites) and when the user enters any data via forms, View will authenticate the user, respond to query, generate reports and also plot the graph for the values obtained from the prediciton controller. Controller apply ANFIS Logic and Clustering of data and get access to the database through the model. Model will help to gain the access to the data like get train and test data set which is used for training and testing the system by controller.

IV. FUTURE SCOPE AND CONCLUSION

This prediction model will highly be useful for obtaining results in case of electricity generation from renewable sources such as solar energy, wind and can be extended to parameters of tidal energy for prediction logic.

To develop sustainable energy policies, it is important that electricity prediction provides accurate results so as to meet the current demand. Majority of previous studies on electricity consumption prediction concentrate on urban areas and residential sectors primarily focusing on parameters other than weather conditions. The paper suggest a proposed design for rural areas for their agricultural activities considering climatic data. Also performed a quantitative comparison of several prediction models and proposed a neuro-fuzzy model that is suited for accuracy in real time forecasting.

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