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Electric Load Forecasting using a Neural Network Approach

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***Abstract*— The electric Power industry is currently undergoing an unprecedented reform. One of the most exciting and potential benefit of recent developments is increasing usage of artificial intelligence techniques. The intention of this paper is to give an overview as well as the techniques for the Short term load forecasting using the weather parameter like rainfall and implementing a neural network techniques in the power systems. This prediction shows a combined approach of predicted rainfall and the ANN will help for the better forecasting of electric load at city scale.**

I. Introduction

Climate changes are related to air temperature, wind speed, precipitation level, relative humidity among others. These variables have more effect on very short-term electricity demand (minutes or hour ahead). In this context, this proposed work will present a methodology for very short-term load forecasting considering the climatic change impact. Therefore, relative humidity and air temperature are linked through the Discomfort Index, and the first with the wind speed are related through the Wind Chill. These climate indexes used in this paper for electric load forecasting together with a multiple regression model. The proposed projection technique was tested computationally and compared with real date obtained from a distribution utility located in southern Brazil. The results describe the strong dependence of the evolution of electricity demand with climatic change in the very short-term.

The climate impact in end users of electricity can be significant, for example, water-pumping requirements will increase where the climate becomes hotter but less wet due to higher water demand from irrigation, residential, commercial and municipal sector. On the other hand, this impact also depends on the mix of resources used for heating and cooling given that air conditioning could be provided by electrical means while space heating is provided by gas boilers. In the short and very short-term electric load projection the climatic variables have an important impact and should be incorporate in the projection model, as presented in. An important topic related to the consumption of electric power is the "thermal comfort", which expresses human satisfaction with thermal environment. Although the thermal comfort of each individual varies, the climatic variables.

Electric energy is in great demand by consumers because of huge consumption of energy by consumers. Basic means of meeting the demand is by increasing the generation itself. For this purpose prediction of future load requirement is essential. The development of accurate fast and robust short term load forecasting is of interest to both power companies and its consumers. Neural networks have been used in a broad range of Electrical applications. This is an application of neural networks in power system operation and control. The neural networks can be used to solve the problems of load forecasting. Most of the projects using Neural networks consider many factors such as weather condition, holidays, weekends and special sport matches days in forecasting model, successfully.

A. Electrical Load components and Characteristics:

The forecasting of the electric load at a future time is a challenging problem because of the diverse characteristics of the electrical load and the uncertainly associated with them. A typical daily variation of electric loads is shown in Fig. 1.The characteristics of the electric load depend on the nature of the users and the end use devices utilized such as motors, air conditioners, lighting. etc. From this point of view. the electric load can be separated into three major categories.

Residential
Commercial
Industrial

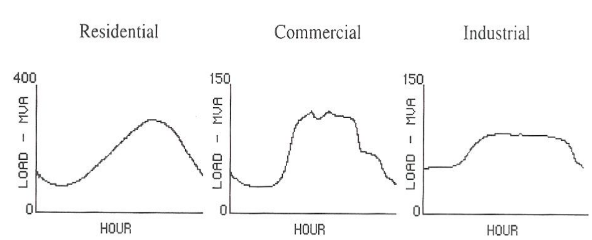

Fig 1. Daily variations of electric load

Factors influencing System Load:
The 4 major categories of factors that influence system load are:

1) *Economic factors:*

The economic environment in that the utility operates has a clear effect on the electric demand utilization patterns. Economic trends have significant influence on the system load/decline trend. Generally, these economic factors operate with considerably longer time constants than one week and thus need not be considered for Short term load forecasting (STLF). However these factors must be taken in to consideration for long & medium – term forecasting models.

2) *Time factors:*

The principal of time viz. seasonal effects, weekly – daily cycle legal and religious holidays play an important role in influencing load patterns. Seasonal effects demonstrate utilities peaking (summer/winter) and also bring out structural modifications in electricity consumption pattern. The weekly-daily cycle of the load is consequence of the work-rest pattern of the service is population. The load decreases substantially on holidays the tendency of the people to have prolonged weekends could also affect the loads on the preceding and following holidays

3) *Weather factors:*

Significant modifications in load pattern are due to meteorological factors as most of the utilities have more components of weather sensitive load such as air conditioning space heating and agricultural irrigation. The load level oscillate with the climatic conditions and has high correlation with rainfall, area temperature, snowfall etc. Temperature and precipitation are the main meteorological factor considered in load forecasting. Their significance on the system load varies not only within summer and winter but also between peak and valley of the same day. For a system covering a widespread geographical area with wide variations in several weather , climate variables in several areas may require to be considered to account for the variations in the system load. Humidity affects system load in hot and moist areas. Other factors that have impact on load behaviour are precipitation, wind speed, cloud cover, onset of darkness , light intensity etc.

4) *Random disturbances:*

These include loads such as wind tunnels, steel mills whose operations can cause large variations in electricity usage. Widespread strikes,special TV programs , bands whose effect on the load is not known a priori could cause sudden and unpredictable variations in load.

II. Artificial Neural Networks

Neural networks, with their remarkable ability to derive meaning from complicated or inaccurate data, can be used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer methods. A trained neural network can be thought of as an "expert" in the category of information it has been given to examine. This expert can then be used to provide projections given new situations of interest and answer "what if" questions.
Other advantages include:
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 away in parallel, and special hardware devices are being designed and manufactured which take advantage of this capability.
Fault Tolerance via Redundant Information Coding: Partial destruction of a network leads to the corresponding degradation of performance. In spite of that, some network capability.

A.BENEFITS OF ANN :

- They are extremely powerful computational devices. Massive parallelism makes them very efficient.
- They can learn and generalize from training data – so there is no need for enormous feats of programming.
- They are particularly fault tolerant – this is equivalent to the “graceful degradation” found in biological systems.
- They are very noise tolerant – so they can cope with situations where normal symbolic systems would have difficulty.
- In principle, they can do anything a symbolic/logic system

B. MATHEMATICAL MODEL OF A NEURON

ANN-based methods are a good choice to study the STLF problem, as these techniques are characterized by not requiring explicit models to represents the complex relationship between the factors that determine it.
Modelling:
A neuron is an information processing unit that is fundamental to the operation of a neural network. The three primary elements of the neuron model are:
1.A set of weights, each of which is characterized by a efficiency of its own. A signal xj connected to neuron k is multiplied by the weight wkj. The weight of an artificial neuron may be located in a range that includes negative as well as positive values.
2. An adder for summing the input signals, weighted by the corresponding weights of the neuron.
3. An activation function for limiting the amplitude of the output of a neuron. It is also mentioned to as squashing function which squashes the amplitude range of the output signal to some finite value.

Neurons model :Artificial neural Networks (ANNs) are made up of a number of simple and highly interconnected Processing Elements (PE)., called neurons , as depicted in Fig 1

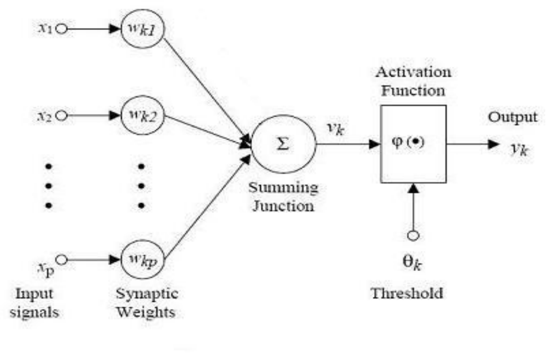

Fig 2 . Model of a neuron

C. NETWORK ARCHITECTURES

There are three primary different classes of network architectures:

1) Single-layer Feed forward Networks

In a layered neural network the neurons are organized in the pattern of layers. In the simplest form of a layered network, we have an input layer of source nodes that projects onto an output layer of neurons, but not vice versa. This network is precisely a Feed forward type. In single-layer network, there is purely one input and one output layer. Input layer is not counted as a layer since no mathematical calculations take place at this layer.

2) Multilayer Feed forward Networks

The second class of a Feed forward neural network distinguishes itself by the presence of one or more hidden layers, whose computational nodes are correspondingly called

hidden neurons. The function of hidden neuron is to intervene between the external input and the network output in some usable manner. By adding more hidden layers, the network is enabled to extract higher order statistics. The input signal is assigned to the neurons in the second layer. The output signal of second layer is utilized as inputs to the third layer, for the rest of the network.

3) Recurrent networks

A recurrent neural network has at least one feedback loop. A recurrent network can consist of a single layer of neurons with every neuron feeding its output signal back to the inputs of all the other neurons. Self-feedback relates to a situation where the output of a neuron is fed back into its own input. The presence of feedback loops have a profound impression on the learning capability of the network and on its performance.

III . LEARNING PROCESSES

By learning rule we mean a method for modifying the weights and biases of a network.

To illustrate the process a three layer neural network with two inputs and one output,which is shown in the picture below, is used.

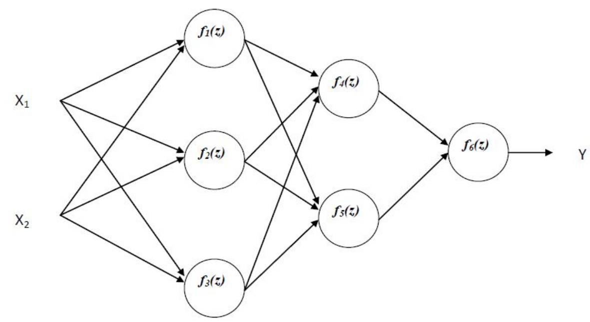

Fig 3. Three layer neural network with two outputs and single output

Signal z is adder output signal, and y = f(z) is output signal of non-linear element. Signal y is also output signal of neuron. The training data set consists of input signals (x1 and x2) assigned with corresponding target (desired output) y’. The network training is an repetitive process. In each iteration weights coefficients of nodes are modified using new data from training data set. Symbols wmn represent weights of connections between output of neuron m and input of neuron n in the next layer. Symbols yn depicts output signal of neuron n.

$y1 = f1(w11\ x1 + w21\ x2)$

$y2 = f2(w12\ x1 + w22\ x2)$

$y3 = f3(w13\ x1 + w23\ x2)$

$y4 = f4(w14\ y1 + w24\ y2 + w34\ y3)$

$y5 = f5(w15\ y1 + w25\ y2 + w35\ y3)$

$y6 = f6(w46\ y4 + w56\ y5)$

The desired output value , which is found in training data set. The difference called error signal *δ of output layer neuron.*

$\delta = y'' - y$

$\delta 4 = w46\ \delta$

$\delta 5 = w56\ \delta$

$\delta 3 = w34\ \delta 4 + w35\ \delta 5$

$\delta 2 = w24\ \delta 4 + w25\ \delta 5$

$\delta 1 = w14\ \delta 4 + w15\ \delta 5$

IV. ANALYSIS OF ELECTRIC LOAD

In the present study the Real time daily Rainfall data and Electricity load data for the year 2008 and 2009 is used in the ANN. Here the daily observed rainfall as well as load is trained in the network. It is seen that for January when rain is almost zero or no rainfall, the consumption load is purely rain independent (Figure 4 and 5) and the load curve shows almost flat line. But same analysis for the monsoon month i.e June also carried out for 2008 (figure 6) and 2009 (figure 7), which shows there is lot of fluctuations in the rainfall at three different locations (dams), Green line represents observed rainfall at Linganmakki, Red is at Supa and Purple one is at Mani. And the load fluctuating due to rainfall variation is widely observed both in year to year as well as day to day scale. Also at daily scale it is observed the electric consumption is much more during low rainfall days.

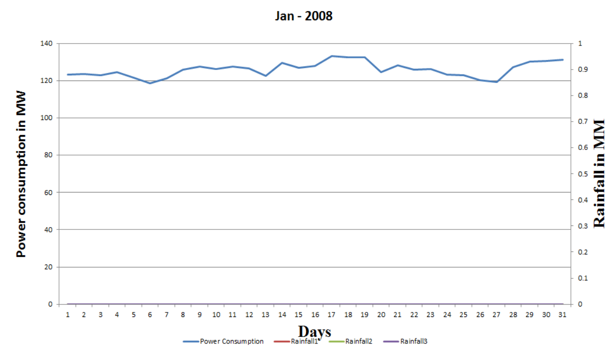

Fig 4.Rainfall data and Electricity load data for the year Jan 2008

Real time Rainfall data and Electricity load data for the year 2009

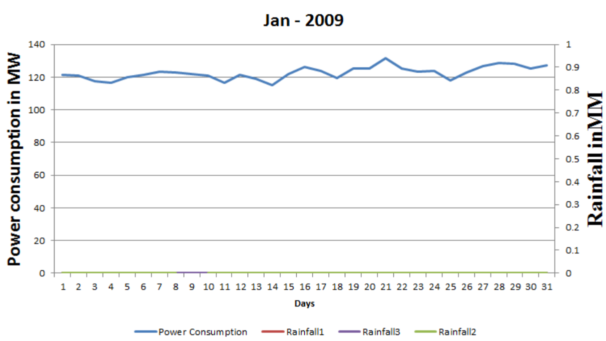

Fig 5.Rainfall data and Electricity load data for the year Jan 2009

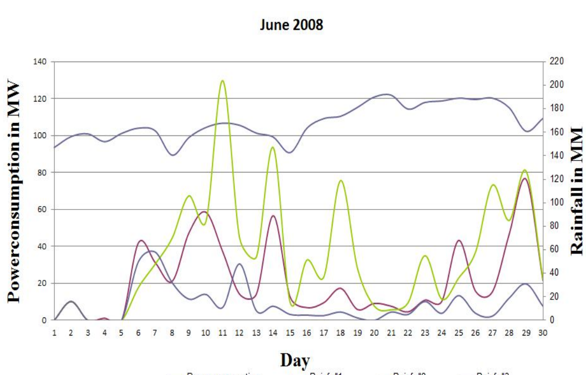

Fig 6.Rainfall data and Electricity load data for the year June 2008

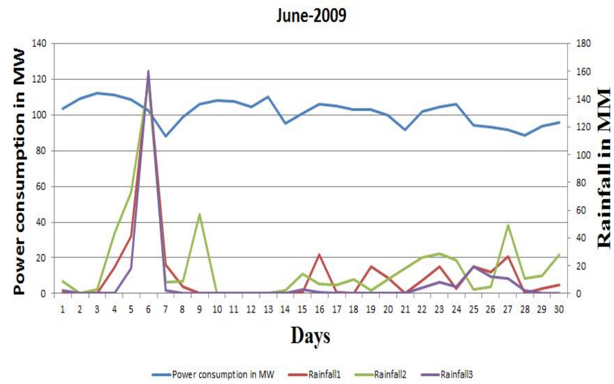

Fig 7.Rainfall data and Electricity load data for the year June 2009

RELATED WORK:

Several works have been carried out for the elecric load forecast but using the neural network- approach [1] is very much statisticaly robust , Khotanzed et al., also aopted the ANN approach for hourly temperature Forecaster with applications in load forecasting [2]. Lee et al [3] and Lu et al., the effective short term electric forecast presented. The ANN appraoch for Greek power system carried out by Bakirtzis, A.G., et. al [5]

CONCLUSION:

The total amount of electric power [in MW] consumed in an electrical power system must be balanced with an equal amount of generated power. There is no efficient way of storing large amounts of electrical energy. To maintain this power balance between production and consumption the power input to the power system must be controlled. An accurate load forecasting not only reduces the generation cost in a power system, but also provides a good principle of effective operation.

In this paper the application of neural networks in STLF power system subjects and advantages of using Neural networks and other network architectures have been discussed, which uses multiple parameters like load and rainfall. The Factors influencing System Load on a power system were discussed. Emphasis was placed on short termLoad forecasting which is important for real time operation and control of power system. Learning process means by learning rule we mean a method for modifying the weights and biases of a network is discussed. Analysis of electric load is also been discussed. Here a clear cut relation between observed rainfall and electric load consumption is established. In the future more meteorological parameters like solar radiation; temperature etc. can be incorporated for the short term prediction of the electric load at local scale.

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