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Design of an Energy Efficient Load Management System Using Artificial Neural Network

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Abstract: ***Electricity usage is increasing day by day due to the changing life style of home user and an increase in appliances in the home area network. The proposed system the home energy management system will monitor, manage and control the usage of home appliances. This project presents the design of an autonomous household control system using Artificial Neural Network (ANN).The ANN is used to generate the energy efficient load patterns. The household control system interfaces sensors and control loads with PIC controller. The server can control all the loads depend on the real-time data from the relevant sensors which are connected with controller. To avoid the shortage of power the ANN Algorithm is implemented in this system.***

Index terms: Electricity, ANN, energy management.

I. INTRODUCTION

In day to day life the hunger for electricity is becoming more and more at the same time the availability of electricity is less. Due to the development of new technologies in the field of eletronics has tremandous growth. So that the usage of home appliances are increasing rapidly. The main environment problem is the usage of home energy management. The very challenging vision is to reduce the energy usage in homes.The previous methods, they shows the energy information, monitor and controlled the home management. In the past 5 years the electricity usage of home appliances and the expected proportianate for power supply is decreasing in the coming years. The available of power supply and the generated power supply has huge gap. Due to the factor such as global warming and modernization. Based on consumers behaviour the energy management technique could be used during different times for different appliances.

The previous research of the paper is used neural network. They provide the fast and dynamic response in the wide operating range. To improve the power quality for that purpose the ANN algorithm is used. It is used to design for shunt active filter for current controller and voltage controller. It is also applicable for non linear loads[1]. The home energy management systems the user will monitor, manage and control all the appliances and reducing the monthly electricity bill. They used the WEEMAN architecture used to sense the load current and calculate the power in each appliances. In that the every switch board is connected with smart meter. The smart meter makes the decision to control the load by using the architecture. Here, the algorithm is used availability based management algorithm. It learns about the previous usage appliances and collect real time power consumption. If, the smart meter is failure the entire system gets failure[2]. The system is mainly used to reduce and manage the home energy usage. It shows the energy consumption of the whole home and the appliance. All the appliance are connected to the electrical outlets. The electrical outlets is used to measure the energy measurement. They does not used the microcontroller, so it provides high cost of each individual appliances are connected with electrical outlets[3]. Through the generated the renewable energy is given to the load management system. The amount of energy should be scheduling to load by scheduler. They used the priority scheduling algorithm is usage appliance based on algorithm then the loads gets manage[4].

In this paper, through the ANN algorithm the above problems are overcome. It is used to monitor, manage and control the load management is implemented using MATLAB/SIMULINK. The algorithm used is feedforward neural network which is used to generate the reference current signal and generate the gate signals. It is also applicable for non linear loads. The automatic household control system all the appliances of loads are controlled and managed by using ANN. Then the loads get ON/OFF through the load management system.

II. SYSTEM OVERVIEW

i. Process description:

The heart of a neural expert system is the inference engine. The inference engine controls the information flow in the system and initiates inference over the neural knowledge base. A neural inference engine also ensures approximate reasoning.

In a rule-based expert system, the inference engine compares the condition part of each rule with data given in the database.

When the IF part of the rule matches the data in the database, the rule is fired and its THEN part is executed.

The precise matching is required (inference engine cannot cope with noisy or incomplete data).

Neural expert systems use a trained neural network in place of the knowledge base.
The input data does not have to precisely match the data that was used in network training.
This ability is called approximate reasoning.

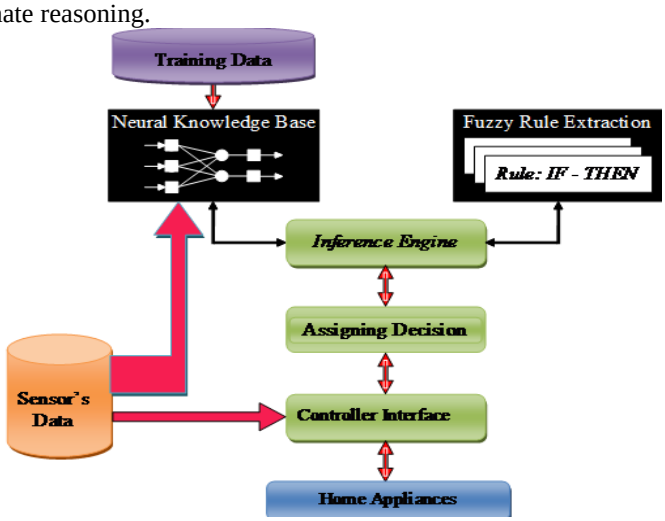

Figure 1:Process Description

RULE EXTRACTION

Neurons in the network are connected by links, each of which has a numerical weight attached to it. The weights in a trained neural network determine the strength or importance of the associated neuron inputs.

INFERENCE

An inference can be made if the known net weighted input to a neuron is greater than the sum of the absolute values of the weights of the unknown inputs.

ALGORITHM

The artificial neural network is also called as the neuro-fuzzy system. A Neural Network which is functionally equivalent to a fuzzy inference model. Neuro-Fuzzy System can be trained to develop IF-THEN fuzzy rules and determine membership functions for input and output variables of the system. Expert knowledge can be incorporated into the structure of the neuro-fuzzy system. At the same time, the connectionist structure avoids fuzzy inference, which entails a substantial computational burden.

The structure of a neuro-fuzzy system is similar to a multi-layer neural network. In general, a neuro-fuzzy system has:

- Input and Output layers, and
- Three hidden layers that represent membership functions and fuzzy rules.

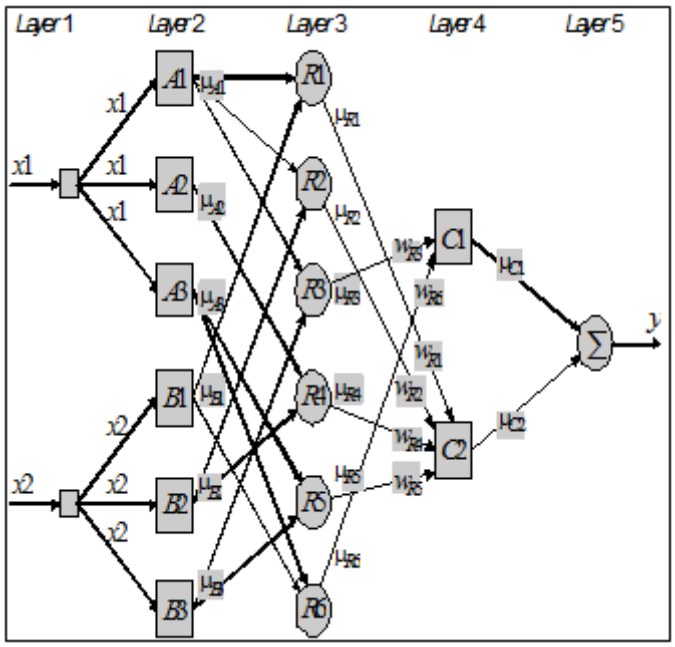

Figure 2 : Neural Network Model

Each layer in the neuro-fuzzy system is associated with a particular step in the fuzzy inference process.

***Layer* 1** is the input layer. Each neuron in this layer transmits external crisp signals directly to the next layer.
***Layer* 2** is the fuzzification layer. Neurons in this layer represent fuzzy sets used in the antecedents of fuzzy rules. A fuzzification neuron receives a crisp input and determines the degree to which this input belongs to the neuron's fuzzy set.
***Layer* 3** is the fuzzy rule layer. Each neuron in this layer corresponds to a single fuzzy rule. A fuzzy rule neuron receives inputs from the fuzzification neurons that represent fuzzy sets in the rule antecedents. For instance, neuron $R1$, which corresponds to *Rule* 1, receives inputs from neurons $A1$ and $B1$.
***Layer* 4** is the output membership layer. Neurons in this layer represent fuzzy sets used in the consequent of fuzzy rules. An output membership neuron combines all its inputs by using the fuzzy operation union. This operation can be implemented by the probabilistic OR. The value of μ_{C1} represents the integrated firing strength of fuzzy rule neurons $R3$ and $R6$.
***Layer* 5** is the defuzzification layer. Each neuron in this layer represents a single output of the neuro-fuzzy system. It takes the output fuzzy sets clipped by the respective integrated firing strengths and combines them into a single fuzzy set. Neuro-fuzzy systems can apply standard defuzzification methods, including the centroid technique. We will use the sum-product composition method.

ii. Hardware description:

The automatic household control system based on two section Monitoring system and floor section the figure are shown below.

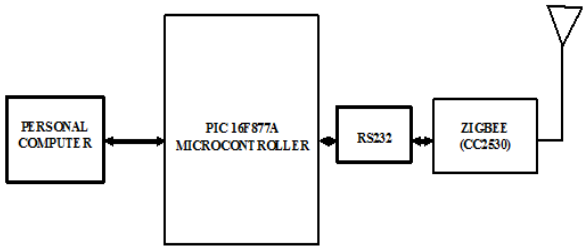

Figure 3: Monitoring Section

In monitoring section, the PIC controls the state of the load depends on the real time data through Laptop using ZIGBEE. The load condition for ON or OFF is predictable using micro controller in each floor nodes. This information about the load is transferred to the main control section through the Zigbee.

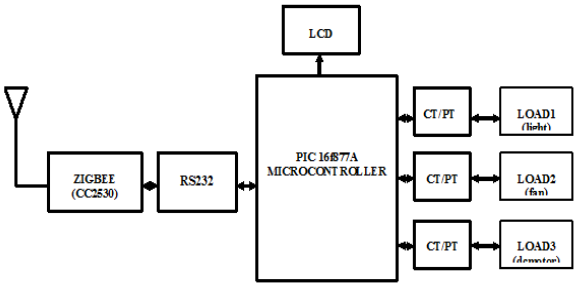

Figure 4: Floor Section

In floor section, the entire loads are connected with I/O Ports through Relay. In main control section MATLAB Input is given through UART. MATLB processes the input values and predict the control input of loads and transfer to the controller using serial port interface. Now the main controller receives the signal and pass this to the load using Zigbee of each node.

a. PIC16F877A Microcontroller

PIC16F877A is an 8-bit microcontroller based on CMOS FLASH and has 44-pins. It has 256 bytes of EEPROM, 368 bytes of RAM, 8 channel 10-bit Analog-to-Digital convertors, two capture/compare/ PWM, Serial Peripheral Interface SPI, I2C, two 8-bit timers, two Comparators, single 16-bit timer and a Universal Asynchronous Receiver Transmitter (USART). The operating voltage ranges from 2v to 5.5v.

b. Zigbee IEEE 802.15.4

Zigbee is a communication protocol which is used to create Personal Area Network. It consumes low power and transmission ranges between 10-100 meters Line Of Sight (LOS). It has data rate of 256 Kbps, long battery life time, secure networking and widely used in low data rate applications. It is less expensive and simpler than other WPANs (such as Wi-fi or Bluetooth). Zigbee chip has integrated microcontroller, radio and flash memory (256 KB). It operates in 2.4 GHz band. XBEE-PRO S2 is an widely used zigbee device. It is a RF modem which has integrated chip antenna. It has 22 pins and 132 GPIO (General Purpose Input and Output).

c. RS232

RS232 is a serial communication protocol. It was developed by EIA (Electronic Industries Alliance). It provides communication between DCE (Data communication/Circuit Equipment) and DTE (Data terminal equipment). In the electrical characteristics, logic 1 represents -3v to -25v and logic 0 represents +3v to +25v. It has data rate up to 20Kbps. RS232 circuit has MAX 232 which is used as a logic level converter. MAX 232 converts EIA-232 to 5v TTL/CMOS levels and TLL/CMOS levels into EIA-232 levels.

d. LCD 2X16 LM

It is a 16 characters and 2 lines LCD display. It has built in LSI HD44780 controller. It is powered with +5v. Display colour is gray for LM016L and New-gray for LM016XMBL. Display area size is 61(Width) x 15.8(Height) mm and character size is 2.96(Width) x 4.86(Height) mm.

e. CT/PT

The CT is a step up transformer and series of line is used to measure the current. It is used to sense the power of each line to measure the current. The PT is a step down transformer and across the line is used to measure the voltage between two lines used to measure potentiometer.

III. SIMULATION MODELS AND RESULTS

The simulation model of ANN is based on MATLAB implementation. The neural network is design with input layer and output layer and hidden layer. By using this network the data gets trained by using levenberg-marquardt algorithm.

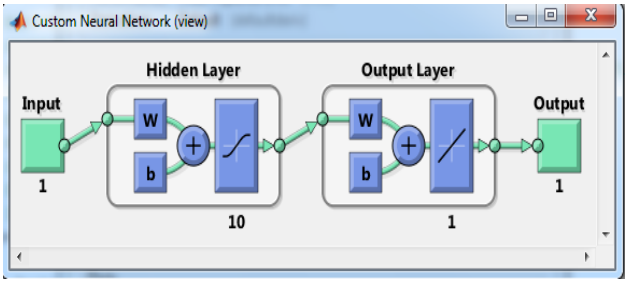

Figure 5: Neural Network Layer

Due to the input, the data gets trained by the membership function fig 6.

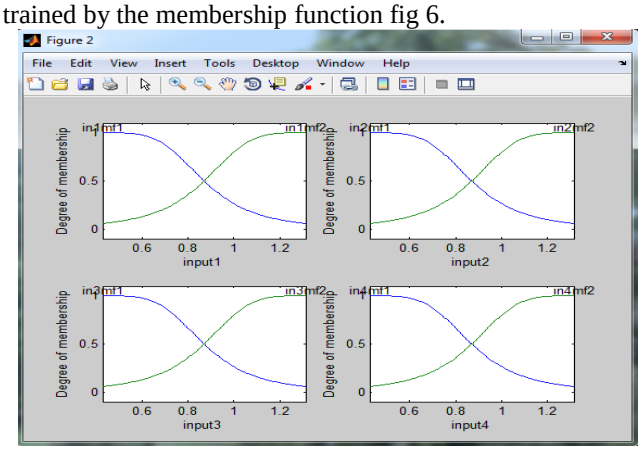

Figure 6: Trained Data

The neural network performance by mean square error fig 7.

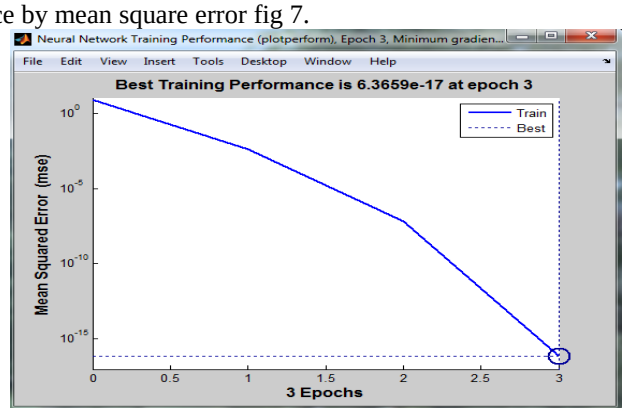

Figure 7: Neural Network Training Performance

The neural network training is used to train the data by using levenberg-marquardt algorithm is used in fig 8.

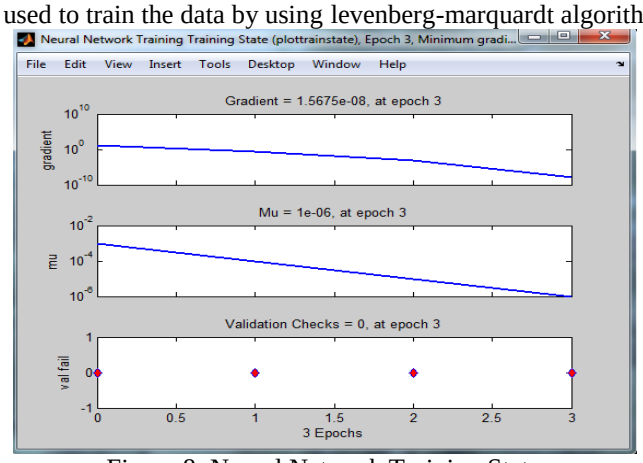

Figure 8: Neural Network Training State

The data is trained by plotfit is used to reach minimum gradient is reached fig 9.

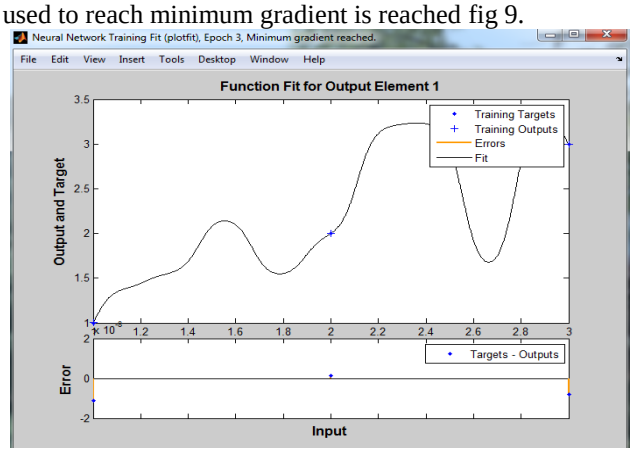

Figure 9: Neural Network Training Fit

IV. CONCLUSION

The developed model to manage and control home management system by using ANN. It provide fast and dynamic response in a wide operating range. Due to load management it provides high performance. The implementation only the load management using ANN. At future we can extend this work for load sharing also.

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