PIR Sensor Based Motion Detection using Fuzzy Controller

Sreejith Damodaran, Bhavani Sridharan

ABSTRACT: ***The prime task of the Smart grids is to manage the power demand and the power supplied during the peak conditions at least possible cost. When the adequate scheduling of the consumer power requirements were done for the residential users, Electricity Costs (EC) can be minimised to an extent. For an feasible and reliable energy management Automatically restrained Heat ventilation and Air conditioning (HVAC) in the residential zone is used. These systems play an crucial role in balancing power requirements and supply during the peak durations. The automatic control of the HVAC systems are based on the customized programmable and communicable thermostats. These systems Assists the consumers in scheduling and prioritising their demand and usage. Specifications like Demand response programs (DR), Time of use (TOU), Real time pricing (RTP) motivates the consumers to minimize their power consumption during the peak hours of load. With the fluctuating pricing scheme of electricity it is impossible for the consumers to schedule their priorities and preferences of power usage. Hence this analysis is framed in a way to assist them with the automated customized thermostat along with motion sensor to regulate the demand and supply of the power during peak periods in cost effective manner. This automation is made using fuzzy logic, WSNs, and smart grids. The experimental procedure was simulated and the results were demonstrated in the MATLAB simulation software. The results showed the development in energy conservation without endangering the thermal amenity of the user.***

KEYWORDS: Demand Response (DR), Electricity Cost (EC), HVAC, RTP, TOU, CCT. .

I INTRODUCTION

The efficient management between the power supply and the requirement of the consumers has many challenging concerns like increasing demand, expensiveness of the energy supplied, environmental responsibility, etc.

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The fluctuating pricing of the electricity and their changing tariffs with respect to TOU and RTP has considerable consequences to the consumers[1]. Thus consumers end up with huge sum of electricity bill. The energy costs can be effectively reduced by avoiding the wastage of power in residences. This is effective when continuous monitoring of the power usage is done. Smart metering techniques are used to monitor and measure the appropriate usage of power[2]. These smart meters notifies the consumers during excess usage of power and alarms them to reduce the usage thus by reducing the energy costs spend over the excess power.

Many recent technologies and the developed equipments aims at the conservation of energy. many different alter techniques are available to measure and monitor power consumption in the residential zones[3].

Customized thermostats are pioneer in managing the power usage , reducing the energy costs and providing satisfactory supply of power[4]. Constrained input and lacking communication between the sensor and equipment are the challenging drawbacks of the customized thermostats[5,6].

To overcome the disadvantages of the customized thermostats new Customized communicable thermostats (CCT) along with the motion sensors[7] were designed based on the WSN. these devices are programmed in such a way that the inputs are provided with respect to the specifications like TOU and RTP. The corresponding offsets are fixed by the consumers so as to limit the excess power utility at peak periods. For this utility the intelligent methodologies like fuzzy logic and neural sensors were used. PIR motion sensors are used to estimate the consumer's state through the Hidden Markov Model (HMM).

In many energy monitoring techniques the pricing specification alone are considered to reduce the costs but they fail to monitor the energy requirement at the high peak instances. Also there is lack of constant interaction between the smart grids and the consumers[8,9].

To eliminate these drawbacks the current study proposes an novel autonomous integrated unit of the fuzzy logic, WSN and smart grids to manage the

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power supply and requirement in the residential zones. The proposed design of the Customized communicable thermostats (CCT) aims at restraining the excess power usage through residential HVAC systems thereby reducing the energy costs. The proposed system is effectively framed to shed all the excessive power at the peak load instances and to reduce the peak-to-average ratio.

Assuming that Smart metering system is used to record the signal pricing and to measure the required power. The acquired data is transmitted over WSN. This set up simplifies the complexity of the circuit by eliminating the use of individual sensors for each appliances. Automated restrained HVAC systems are also capable of monitoring the system failures and to indicate the replacement of air filters. This microcontroller based energy control system makes use of 16F877A controller with high operational performance to regulate all the processes. The uncertainty prevailing in the system are effectively regulated by the fuzzy controller[10]. Due to the existence of several uncertainties and the dynamical behaviour of the HVAC system, fuzzy controllers are employed to regulate the temperature variations in the air conditioning.

The motion sensors are used to find the user states such as active, away and sleep , and transmit the corresponding state input to the controller unit to operate the control system[11]. PIR controllers are used as the motion sensors in the proposed model.

Fuzzy controller is used in the estimation of the temperature specifications of various appliances and surrounding environment. When there is no active input from the PIR sensor the cost factor analysis is done to minimise the wastage of power.

II. PREVIOUS STUDIES

Hyungna Oh et al.,(2006) proposed a computerized energy regulating system for the residents. This technique was considered to be pioneer in the application of smart technology in power conservation. But due to the lack of interaction between the consumer and the system this technique was ineffective.

An encouraging power saving algorithm based on the specifications like pricing, usage time, for managing the requirement and consumption of power was suggested by Amir-Hamed et al., (2009). In this method proper scheduling of the power requirement and usage is done using the grids so as to reduce the energy costs. Yet this method has an drawback of increased circuit complexity due to grids[12].

Optimal energy management system was designed by Yu-Kai Chen et al., (2011). This system obtained power equilibrium and battery State Of Charge (SOC) was maintained at the appropriate value for long duration using smart grids. But the cost factor was not considered in this design.

To overcome the cost factor lack in the previous design Ciabattoni et al., (2015) proposed an new technique to minimize the energy cost. The device has several equipments like clamps, plugs, Controller, etc. The real time monitoring of the power and voltage difference values, fuzzy logic could predetermine the power consumption of the household appliances. But no automated systems were availed for monitoring instead it required manual monitoring causing failure of the system[13].

Azim Keshtkar et al., (2015) also suggested an intelligent and efficient technique with the fuzzy controller and WSN. In this technique the thermostats were programmed to regulate the power supply as per the demand and to shed off excess power usage at the peak load instances. But during the normal instances excess power was not managed properly. That disadvantage was overcome in this current analysis by using an motion sensor to regulate the power usage with the demand of the consumer in an satisfactory method. Depending upon the input acquired from the PIR controllers the temperature of the HVAC system is varied there by eliminating the power overflow or excess usage of power, resulting in reduced energy costs.

III. METHODOLOGY

A. DETERMINING INPUT PARAMTERS

The designing of an autonomous customized communicable thermostat involves the determination of precise feed and response parameter specifications. The proposed CCT involves the usage of fuzzy logic, smart grid and PIR controllers. More than one parameters are taken as the input for efficient management of the HVAC system. The considered parameters are External temperature, Consumer state, energy pricing and power requirement at that instant.

Only one response is obtained from the system. It is the offset temperature of the HVAC system, to regulate the power usage. As these feed parameters are interrelated to each other fuzzy logic is used to tradeoff between them. Another added advantage of fuzzy logic is that no statistical modeling of the controller is required.

External temperature is considered as an important input parameter because the temperature outside the residency decides the load requirement of the HVAC system. It is also essential to determine the presence of consumer in the

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controlled space. With the presence and away of the consumer the temperature of the HVAC system is altered thereby reducing the power usage.

B. MOTION DETECTION USING PIR CONTROLLER

The motion sensor used in the proposed design is the passive infrared ray controller. this controller is used to detect the skin resistance of the consumer to determine the existence state of the consumer in the controlled space. The response of the PIR controller is fed to the fuzzy controller depending on which the sensors are operated. Depending upon the acquired input values the temperature of the room is estimated and maintained. PIR controller is used to detect the energy produced by the skin of the consumer. When the radiated energy from the consumer is detected by the PIR controller the HVAC system is operated based on the energy sensed. In the absence of the consumer the HVAC system is turned off eliminating the power wastage.

C. FUZZY CALCULATIONS

The ultimate aim of this design is to maintain the indoor temperature level of the HVAC system in a consumer satisfactory manner with the efficient management of the power usage. The designed thermostat should conserve energy reducing the energy cost without disturbing the consumer usage and comfort. The humidity level to be maintained should range between 30%-60%. To maintain this level the fuzzy controller needs knowledge about the external temperature. Depending upon this value the smart fuzzy controller decides the temperature to be maintained inside the controlled space. If the prevailing temperature outside is very cold and the energy price is high at that instance, with the presence of the consumer for longer duration in the controlled space the temperature to be maintained inside is selected accordingly from the fuzzy table. The advisable temperature to be maintained in the closed space should not exceed 22^{o}C and should not be less than 18^{o}C. The methodology of the proposed CCT is shown in the Flowchart illustrated in the Fig.1.

IV. RESULTS AND DISCUSSION

The fuzzy table corresponding to the input and output specifications are given in the Table.1.

Table.1. Fuzzy I/O Table

Fuzzy Rule	Input Parameters				Output (deg)
	Ext. temp	Energy Pricing	Duration	Cons. status	
1	Very cold	L	L	P	18
2	Very cold	H	H	P	15
3	Very cold	H	H	A	23
4	Very cold	H	L	P	18
5	Cold	H	H	P	15
6	Cold	L	H	P	15
7	Cold	L	L	A	22
8	Cold	M	H	P	15
9	Cold	H	H	P	19
10	Cold	H	L	P	15
11	Normal	H	H	P	22
12	Normal	L	H	P	20

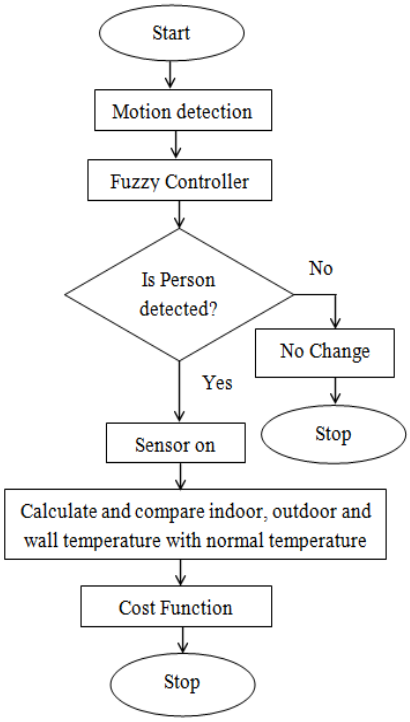

Fig.1. Methodology Flowchart Of Customized

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Communicable Thermostat with PIR controller

The proposed design of the thermostat which is customized and communicable was simulated along with the PIR controller in MATLAB simulator. The controller embedded along with the simulator was validated for different input values. The given condition is that to satisfy the consumer comfort level at low pricing. To validate the proposed design the acquired input specifications were combined in 12 different ways to produce corresponding results. Two different mode suggestions were given in tradeoff with the power consumption and consumer comfort. They are economical mode (EM) and comfort mode (CM). In EM, the selected temperature range of the controlled space was less than 23^{o}C and higher than 19^{o}C, whereas in CM the selected temperature range was less than 22^{o}C and higher than 18^{o}C. The corresponding offset temperature level with the varying input specifications was determined and shown in the fuzzy table. From the table.1. it is evident that the proposed design effectively respond to the varying pricing range and temperature. Thus the PIR controller integrated with the smart grids and WSN to control the HVAC system of the residential zone was successfully implemented and simulated. This control system does not require any consumer intervention or manipulations. This system is build based on the intelligence model of the Fuzzy controller.

V. CONCLUSION

In this article customized communicable thermostat integrated with the PIR controller for motion sensing , WSN for transmitting feed and response parameters, smart grids to pre-determine the load requirement was analysed and discussed. This approach was an novel technique in the automatic energy conservation methodologies. Based on the requirement and comfort of the consumer EM and CM modes were availed in this design. The proposed design was validated against the varying input specifications and the corresponding results were tabulated . Thus this CCT was efficient in controlling the load usage at the peak load instance, eliminates the surplus power wasted in the absence of the consumer and properly pre-schedules the temperature of the controlled space with the updating temperature thereby regulating the power requirement and supply cycle of the residential zones. Smart grid unified HVAC system efficiently minimizes the peak average ratio of the load as well.

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