International Journal of Advanced Technology in Engineering and Science
Vol. No.3, Special Issue No. 01, September 2015
www.ijates.com
ijates
ISSN 2348 - 7550

ROLE OF OCCUPANCY SENSORS IN ENERGY MANAGEMENT

Dr.A.Kanagaraj[1], Ms S.Sharmila[2]

[1]Assistant Professor, Department of Computer Science, Nehru Arts and Science College, Coimbatore (India)

[2]Assistant Professor, Dept of Computer Science,NGM College, Pollachi, (India)

ABSTRACT

Nearly 40% of total energy consumption in the world is accounted for Heating, ventilation and air conditioning systems. Smart sensing system can greatly decrease the energy usage in building. A review of occupancy sensors especially to detect human presence in home for energy conservation has been presented in this paper. The characteristics of the sensor and the basic requirements for making smart sensor network have been investigated. Occupancy sensors, offer an inexpensive and effective means of reducing energy costs by turning off electronic devices when rooms or space are unoccupied. Many manufacturers now offering electronic devices with built-in occupancy sensors. The development of the ubiquitous computing combined with occupancy sensors for real implementations for home networks has been investigated.

Keywords: Occupancy Sensors, Heating, Ventilating, Air Conditioning, Energy Management, Intelligent System

I. INTRODUCTION

Heating, ventilation and air conditioning (HVAC) is the single largest contributor to a home's energy bills and carbon emissions, accounting for 43% of residential energy consumption in the U.S. and 61% in Canada and the U.K., which have colder climates [1, 2, 3]. Studies have shown that 20-30% of this energy could be saved by turning off the HVAC system when residents are sleeping or away [4]. These savings, however, have been difficult to realize: typical residents will not manually adjust the thermostat several times a day, and programmable thermostats are too difficult for most people to use effectively. In fact, recent studies have found that households with programmable thermostats actually have higher energy consumption on average than those with manual controls because users program them incorrectly or disable them altogether [5, 6].

An important obstacle to energy conservation is the weak financial incentive for individual homeowners. A 20-30% reduction in HVAC energy would translate to a savings of about $15 per month for the average household in the U.S. [8]. For many people, this small monetary saving does not justify the difficulties of optimizing HVAC operation on a daily basis. At the national scale, however, these same savings translate to over 100 billion kWh at a cost of approximately $15 billion annually, and would prevent approximately 1.12 billion tons of pollutants from being released into the air each year [9, 10]. It is a classic tragedy of the commons [11]. To address this situation, a new solution must be created that "just works" and saves energy without requiring daily thought or action by household residents.

In this paper, we propose a solution called the smart thermostat that uses occupancy sensors to automatically turn off the HVAC system when the occupants are sleeping or away from home. Our approach uses wireless motion sensors and door sensors, which are inexpensive and easy to install; they cost about $5 each off the shelf and can be installed in minutes using double-sided tape. The smart thermostat uses these sensors to infer when occupants are away, active, or sleeping and turns the HVAC system off as much as possible without sacrificing occupant comfort.

The first main challenge of this approach is to quickly and reliably determine when occupants leave the home or go to sleep. Motion sensors are notoriously poor occupancy sensors and have long been a source of frustration for users of occupancy-based lighting systems, which often turn the lights off when a room is still occupied. For the smart thermostat, these mistakes would lead to more than just user frustration: frequently turning off and on the HVAC system can cause uncomfortable temperature swings, shorten the lifetime of the equipment, and even cause energy waste due to frequent equipment cycling. Furthermore, a longer time-out period is not an adequate solution because it would waste energy by conditioning unoccupied spaces; the smart thermostat requires occupancy monitoring that is both quick and reliable. This system analyzes patterns in the sensor data to quickly recognize leave and sleep events, allowing the system to respond within minutes without increasing false detection rates.

The second main challenge of this approach is to decide when to turn the HVAC system back on. Preheating the house could waste energy if the system is activated too early. On the other hand, heating only in response to occupant arrival could also waste energy because, at that point, the house must be heated very quickly; many multi-stage HVAC systems have a highly efficient heat pump that can be used for slowly preheating, but a lower efficiency furnace or electric heating coils must be used to heat the house quickly. Since the smart thermostat cannot predict exactly when occupants will arrive, it is difficult to decide which approach will be more efficient on any given day. Instead, the system uses a hybrid approach that minimizes the long-term expected energy usage based on the occupancy patterns of the house: it slowly preheats the house with high efficiency equipment at a time t and, if the occupants return before that time, it quickly responds by heating the home with the lower efficiency equipment. The time t is chosen based on the equipment efficiencies and the historical distribution of occupant arrivals, balancing the expected costs of preheating too early and preheating too late.

II. RELATED WORKS

Chun-Liang Hsu and Sheng-Yuan Yang, presented new methodology of intelligent energy-saving system to accomplish the goal of real energy-saving from the view-point of system-orient strategy instead of materials. In this system design included sensors of temperature, humidity, luminance, CO_2, and power detector(smart outlets) in addition to designing backend intelligent agent technology to quickly response to the feedback control system through hybrid network of ZigBee and Bluetooth technology which would sensor the running parameters and environment factors of energy-saving system.

Shwetak N. Patel, Matthew S. Reynolds et al., developed an approach for whole-house gross movement and room transition detection through sensing at only one point in the home. This system considers to be one member of an important new class of human activity monitoring approaches based on what we call infrastructure mediated sensing, or "home bus snooping." This system provides solution which leverages the existing ductwork infrastructure of central heating, ventilation, and air conditioning (HVAC) systems found in many homes. Disruptions in airflow, caused by human interroom movement, result in static pressure changes in the HVAC air handler unit. This is particularly apparent for room-to-room transitions and door open/close events involving full or partial blockage of doorways and thresholds. The system detects and records this pressure variation from sensors mounted on the air filter and classify where certain movement events are occurring in the house, such as an adult walking through a particular doorway or the opening and closing of a particular door. In contrast to more complex distributed sensing approaches for motion detection in the home, this method requires the installation of only a single sensing unit (i.e., an instrumented air filter) connected to an embedded or personal computer that performs the classification function. Preliminary results shows the system can able to classify unique transition events with up to 75-80% accuracy.

Magnus Boman, Paul Davidsson et al., investigatedthe usefulness of agent technology in the domain of power distribution and building automation. A system consisting of a collection of software agents that monitor and control a small office building using the electrical devices present in the building has been developed. Communication between agents and devices is achieved via the existing power lines. The objectives of the application are both energy saving by controlling lights, heating, ventilation, etc. and enhancement of customer value by taking into account the personal desiderata of the people in the building.

Sunil Mamidi, Yu-Han Chang et al., implemented a multi-modal sensor agent that is non-intrusive and low-cost, combining information such as motion detection, CO2 reading, sound level, ambient light, and door state sensing.This system can greatly decrease the energy usage of HVAC systems in many building applications, by enabling the operator to shut off HVAC to unoccupied rooms. The system showed the live test bed at the USC campus, these sensor agents can be used to accurately estimate the number of occupants in each room using machine learning techniques, and that these techniques can also be applied to predict future occupancy by creating agent models of the occupants. These predictions will be used by control agents to enable the HVAC system increase its efficiency by continuously adapting to occupancy forecasts of each room.

Hung-Cheng Chen, Teng-Fa Tsao et al., designed and implemented an active intelligent energy conservation system utilizing hybrid wireless sensor network (HWSN) which incorporates ZigBee wireless sensor network (WSN) with Bluetooth control network (BCN). This research also proposes an ontological information agent built in back-end server to provide the system with intelligent control strategy in order to effectively achieve the goal of energy conservation. With the proposed agent, the feedback control commands are decided and then delivered through Bluetooth control network to control the power-consuming facilities. After practical operating the intelligent energy conservation system for 4 whole months, totally 22.44% electricity power is saved with the help of intelligent energy conservation system. The effectiveness of the intelligent energy conservation system with ontological information agent is encouraged.

A.A.NippunKumaar, Kiran.G et al., examines the use of Wireless Sensor Networks interfaced with light fittings to allow for daylight substitution techniques to reduce energy usage in existing buildings. This creates a wire free system for existing buildings with minimal disruption and cost.

Vangelis Marinakis, HarisDoukas et al., presents prototype software tools for energy data collection, store, processing and control, enhancing the interactivity of building automation systems towards energy and environmental management of buildings. The pilot appraisal is focused on the remote control of active systems in the tertiary sector buildings, such as air-conditioning system, especially during the summer peak hours, while maintaining desirable comfort.

Changsu Suh, Young-Bae Ko et al., addressed in their paper about the new smart device with the various sensing ability as well as the wireless communication in order to implement the real ubiquitous house. Moreover, they suggested the new intelligent home scenarios based on the newdevices and embedded systems. To show the realistic of their works, they developed a small model house by using their smart devices, RFID and embedded devices. Their works can be contributed the developing of the ubiquitous computing and the real implementations for home networks.

Jiakang Lu, TamimSookoor et al., demonstrated about how to use cheap and simple sensing technology to automatically sense occupancy and sleep patterns in a home, and how to use these patterns to save energy by automatically turning off the home's HVAC system. This approach is called as smart thermostat. They evaluated this approach by deploying sensors in 8 homes and comparing the expected energy usage of our algorithm against existing approaches. They demonstrated that their approach will achieve a 28% energy saving on average, at a cost of approximately $25 in sensors. In comparison, a commercially-available baseline approach that uses similar sensors saves only 6.8% energy on average, and actually increases energy consumption in 4 of the 8 households.

Subhas C. Mukhopadhyay, AnuroopGaddam et al., reviewed of wireless sensors and sensor networks, especially for in-home monitoring of elderly people. The characteristics of various sensors for monitoring applications have been studied. The requirements of the sensor for making a smart sensor network have been investigated. A typical in-house developed system for home monitoring and elder-care application has been presented. A few patents on the sensors for home monitoring have been reviewed.

III. CHARACTERISTICS OF WIRELESS SENSORS

The rapid development of microelectronics, micromechanics, integrated optics and other related technologies has enabled us to develop various kinds of sensors, both wired and wireless, which enable to sense and measure data more efficiently and accurately. Efficiency relates to the speed of measurement, energy consumed for the measurement and processing resources required.

Wireless sensors have more advantages when compared to wired sensors. They are flexible and can be easily reconfigured. They can be used in places geographically far apart to monitor activities remotely. They also generally consume less power. Wireless sensing units integrate wireless communications and mobile computing with transducers to deliver a sensor platform which is inexpensive to install in numerous applications. Indeed, co-locating computational power and RF communication within the sensor unit itself is a distinct feature of wireless sensing.

For selecting a sensor, both static and dynamic properties must be considered. These properties play a significant role in the performance of the sensors and the sensor networks. The static characteristics of a sensor are defined as the way a sensor affects the measurement performance due to its inherent features. The static characteristics of a sensor are its accuracy, error bands, span and zero, resolution of measurement, sensitivity (gain), repeatability, bias and drift, dead band, saturation, hysteresis and linearity.

International Journal of Advanced Technology in Engineering and Science
Vol. No.3, Special Issue No. 01, September 2015
www.ijates.com
ijates
ISSN 2348 - 7550

The dynamic characteristics of a sensor are defined as the capability to handle rapid changes in the input. The following factors affect the input of a sensor, delay (response time), rise time, overshoot and settling time. When designing a sensor module or a sensor network, not all the characteristics of the sensors are necessarily considered. Depending upon the application and the environmental factors a chosen sub-set of characteristics of the sensors are considered by the designer.

IV. OCCUPANCY SENSORS

Occupancy sensor is a sensing module which houses one or many transceiver nodes and base stations. It uses a wide range of RF communications techniques. Through software, the sensor may be configured to measure and monitor various physical parameters such as force, temperature, motion etc. Since the Occupancy sensors employ RF communication, a network of these sensors is considered as a "Wireless Sensor Network". The tasks performed by these wireless sensor networks include measuring the relevant quantities, monitoring and collecting data, assessing and evaluating the information,formulating meaningful user displays, and performingdecision-making and alarm functions.

Figure 1 shows the block diagram of aOccupancy sensors network for monitoring of human presence in home to control power consumption by electrical appliances [1, 2]. The sensing units (SUs) not only have the necessary transducers to monitor an electrical device, they also house the RF transceiver modules to communicate with the central controller unit (CCU). The data communication on the wireless network may follow one of many industry standards or a proprietary protocol.

4.1 Detecting Movement of People

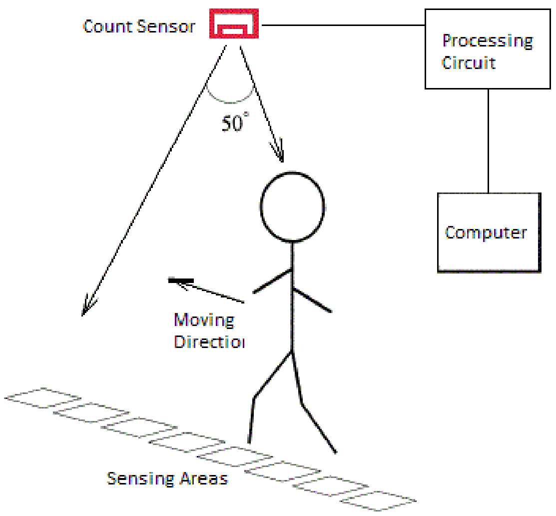

Figure 1: Detecting Movement of People by Sensor

A person passing through a doorway is a brief event, and the size of the individual can vary, decreasing the likelihood of detection. However, we still wanted to explore the feasibility of detecting those events. Though occupancy sensor variations can be observed in the static pressure as individuals moved through various doorways. Unlike the door events, the changes in pressure are very short-lived. There is a slight change in the static pressure and then the pressure settles back to its original state. The effect is dependent on the location of the supply and return vents relative to the doorway and the ratio of the size of the person to the size of the doorway.

4.2 Collecting Data

Occupancy patterns play a significant role in intelligent home energy management system. To investigate the impact of occupancy patterns on the performance of smart thermostat, occupancy sensors can be used to collect data from intelligent home.

The system deployedoccupancy sensors and door sensors in home to collect occupancy and sleep information. These homes include both single-person and multi-person residences.

V. DESIGN CONCEPT OF INTELLIGENT ENERGY MANAGEMENT SYSTEMS

In recent years, energy management systems are currently being developed to be applied in buildings, namely the "intelligent buildings", for energy and environmental management.

In the past, less "intelligent" systems used towards energy management, for energy consumption, with insufficient control functions and high dependence on the human factor [6]. Nowadays, the modern trend of energy management systems is based on "intelligent" model development for energy and environmental management of buildings for the assurance of the necessary indoor air quality, lighting, humidity with the minimum possible energy cost [7].

5.1 Building Automation

The role of the Intelligent Buildings System is known and significant, since these systems can contribute to the continuous energy management and therefore to the achievement of the possible energy and cost savings. The Intelligent Buildings System are generally applied to the control of active systems, i.e. Heating, Ventilation, and Air-Conditioning (HVAC) systems, while also determining their operating times. In the above efforts, the performance of the Intelligent Buildings System is directly related to the amount of energy consumed in the buildings and the comfort of the buildings' occupants.

The majority of recent developments in Intelligent Buildings System have followed the advances made in computer technology, telecommunications and information technology. In this context, a number of modern techniques and methods have been proposed in the international literature for improving specific systems' controls.To the best of our knowledge, techniques for control electronic appliances in home, have been proposed for the control of power consumption.

Building automation consist a fundamental part of the energy management systems. In this context, the decentralized building automation system contains heating, lighting, air conditioning and other building functions monitoring and supervision, providing high standards of comfort, security and energy saving potential. In particular, the wireless automation system can transmit multiple digital and analog signals in long distances.

5.2 Interactive with Software and Decision Making

The collected data is transferred to control system to store for further analysis. The software which is used for decision making process received data's from central system and analyzed by using threshold values. Then based on the output the appliances can be controlled and power is consumed.

5.3 Lighting Management

Our system first calculate the area of a space and decide the maximum number of people , after identified total human presence and the luminance parameters and sent back to control system to control how many lights in the space should be turn off and the luminance still meet with the threshold value. The decisive procedure could be in two ways, one is calculated the factor which was maximum entered people divided by entered people, and used this factor to multiply the total lights number, so we got the desired turned on lights, and then we used the detected light luminance to decide whether the luminance was enough or not, and then feedback control the lights according the judge of intelligent agent system built in central system. We could directly and dynamically decide the lights turned on or off according to the luminance sensor signals.

5.4 Air Conditioning Management

The CO2 density would decide whether the people inner the space were comfortable or not, if the density was over the threshold and made people not feel well then the air conditioning would proceed to winding function rather than cooling to release the condition. If there were no people in the space, then the air-conditioning would be turned off. If the number of people was more than threshold we set, then the air conditioning would be turned on. If the temperature was higher than 28°C, then the cooling function would be turned on. As for central control air-conditioning with cool-water machines, which consumption the most electricity power, we could use time-interval method and temperature sensor to take turns turning off some cool-water machines with certain period so as to achieve the attempt to save energy.

5.5 Humidity Management

The various WSN sensor modules with ZigBee data transmission interface for sensing temperature, humidity, luminance, CO2, and number of people are well-designed. Those environmental parameters would be detected and sent to the centralized system as judged factors to be determined whether the system should proceed feedback control based on the proposed ontological information agent. These WSN modules are placed at proper location to match up the condition of environment.

VI. CONCLUSION

This paper has reviewed the usage of occupancy sensors to detect human presence in home to save energy through improved control of electronic devices. This system is based on interconnection between devices and sensors, which has the capability of receiving and transmitting the data through wireless communication. Then the collected data's are stored in central system for further processing. Further stored data's are compared with threshold value and depending on the situation the actions are performed.

REFERENCES

[1] Chun-Liang Hsu and Sheng-Yuan Yang, "Design of Sensor Modules of Active & Intelligent Energy-saving System", IEEE, pp.2096-2099, 2011.

[2] Shwetak N. Patel, Matthew S. Reynolds, et al., "Detecting Human Movement by Differential Air Pressure Sensing in HVAC System Ductwork: An Exploration in Infrastructure Mediated Sensing", Springer, Pervasive 2008, LNCS 5013, pp. 1–18, 2008.

[3] Magnus Boman, Paul Davidsson et al., "Energy Saving and Added Customer Value in Intelligent Buildings", SE-372 25 Ronneby, Sweden.

[4] Sunil Mamidi, Yu-Han Chang, "Improving Building Energy Efficiency with a Network of Sensing, Learning and Prediction Agents", AAMAS 2012, 4-8 June 2012, Valencia, Spain.

[5] Hung-Cheng Chen, Teng-Fa Tsao, et al., "Intelligent Energy Conservation System Design Based on Hybrid Wireless Sensor Network", IPCSIT, vol. 23, 2012.

[6] A.A.NippunKumaar, Kiran.G, et al., "Intelligent Lighting System Using Wireless Sensor Networks", IJASUC, Vol.1, No.4, December 2010.

[7] Vangelis Marinakis, HarisDoukas, et al., "Interactive Software for Building Automation Systems", EPU-NTUA, National Technical University of Athens.

[8] Changsu Suh, Young-Bae Ko, et al., "The Design and Implementation of Smart Sensor-based Home Networks", Daejeon, Republic of Korea.

[9] Jiakang Lu, TamimSookoor, et al., "The Smart Thermostat Using Occupancy Sensors to Save Energy in Homes", SenSys'10, November 3–5, 2010.

[10] Subhas C. Mukhopadhyay, AnuroopGaddam, et al., "Wireless Sensors for Home Monitoring - A Review", Recent Patents on Electrical Engineering, 1, pp.32-39, 2008.

AUTHORS BIOGRAPHY

Dr. A. Kanagaraj MCA., Msc., M.Phil., PhD., Dir., is a teaching professional living in Tamilnadu, India. Currently he is working as an Assistant Professor in Nehru Arts and Science College, Coimbatore, India. He has around two years of Industrial Experience and 5 years of Research Experience as Project Fellow. He has experience in handling UGC - Major Research Projects. He has published many papers in National / International Journals and Conferences. He is a life member of the Indian Science Congress.

MsS.SharmilaMCA., M.Phil., is a teaching professional living in Tamilnadu, India. Currently she is working as an Assistant Professor in NGM College, Pollachi, Coimbatore, India. She has more than four years of teaching experience. She has published many papers in National / International Journals and Conferences. Her interested areas are Data mining, Software Testing and Software Engineering.