Rapid Internet of Things (IOT) Prototype for Accurate People Counting and Saving Energy in Smart Buildings

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Abstract **– According to various IoT researches, large amount of energy in buildings is wasted. A building automation system (BAS) is used in obtaining occupancy quantity in a pre-determined thermal zone that can adjust the building operation smartly to provide enough lighting, heating, cooling and ventilation capabilities to the people. Hence, an occupancy counting device which can be widely used at low prices which is highly desirable with low failure rate, good usability is required. In this work we present a prototype of IoT (Internet of Things), which gathers room occupancy information to help operate energy efficient buildings. The proposed IoT system is developed using sensors and Raspberry Pi module. Our prototypes are mounted in two pairs between a door frames. When a person walks through the door frame, face detection is performed through Pi camera and count is obtained using sensors. Therefore, the change in occupancy of a thermal zone is calculated and updated. The proposed design is completely made of electronic components and the cost is affordable. Based on the above count the energy such as light, fans and air conditioners is effectively monitored. In summary, the design proposed is compact, non-intrusive, simple to use, low failure rate and cost-effective for intelligent buildings.**

Keywords– BAS, Internet of things, Sensors, Energy Efficient.

I. INTRODUCTION

Building Automation System offers the opportunity to implement energy management systems which track and respond to the energy needs of a commercial building. A building management system eliminates the costs of heating and air conditioning depending on occupancy and zone requirement. It deals with the collection of occupants count which is very much necessary to save the energy used in that area. Traditionally, it was done manually involving paperwork. The main function of the system is to scan for the human faces which generate an exact count of the occupants. Based

on the count value of an occupant the energy will be optimized accordingly by considering the threshold value. Personnel entry and exit to the building zone are detected and tracked by an advanced passive infrared method along with PI Camera in the proposed IoT system, whose performance is considered to be a good estimated occupancy.

A. Objectives

The main objective of this system is that, in auditorium one needs to watch and control people entering into that auditorium. If that place is completely full of public and if it's not possible to control others coming in. The people waiting outside may not know the condition whether the seats are vacant or not. Large amount of energy will be still consumed even after the people leave the auditorium.

II. PROPOSED SYSTEM

We are developing a building automation system using internet of things (IoT) technology, in which we ensure energy efficient smart building by keeping track the count of the occupants and further automating the appliances by,

- The system first detects the occupant's motion using passive infrared sensor and pi camera scans for the human faces.
- If the scanned occupants face matches with the features of the dataset of human beings then it
- generates a count.The system automates electrical appliances such as light and fan used in that zone depending on the count value.
- The LDR light sensor is used for the automation of light, when the occupant enters the zone the light is turned on. Depending on the count value, if the occupant count crosses the predefined threshold value then an additional light is turned on.
- The temperature sensor is used for automating fan, as the temperature inside the zone crosses the threshold value then fan is automatically turned on.
- The system makes use of a fire sensor, when the zone is identified with either smoke or flame then the sensor is triggered by sending an email requesting for help.
- LCD displays have been used along with this system to

display the count, temperature, humidity values.

For energy efficient smart buildings, we are using the Internet of Things (IoT). This technology provides advanced technique like alerting the control room immediately when a fire accident breaks down. The major problem faced is the estimated amount of resources to heat, cool and ventilate buildings is immense. Much of this resource is lost because the structures are absolutely uninhabited. This involves interactions whether or not the environment is populated or not at a specific moment. So this system overcomes the problem in a minimally intrusive way.

III. SYSTEM DESIGN

The system consists of Raspberry Pi module, control unit, relay, infrared sensor, LDR light sensor, temperature sensor, fire sensor, Pi camera and LCD display.

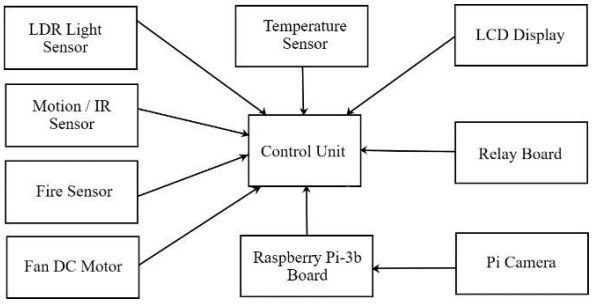

Fig. 1 Block diagram of prototype main component description:

a. Raspberry Pi:

Fig. 2 Raspberry Pi

The 3rd generation Raspberry Pi 3 Model B is a Raspberry Pi that is single board computer sized by credit card can be used for many applications and replaces Raspberry Pi Model B+ and Raspberry Pi 2 Model B. While maintaining the popular Raspberry Pi 3 Model board format B brings you a more powerful, 10x faster processor than the first-generation Pi to Raspberry.

b. LDR Light Sensor:

Fig. 3 LDR Light Sensor

Light control and home appliances are usually manually operated and controlled on many occasions. But the process of controlling appliances can cause power wastage due to human carelessness or unusual circumstances. To solve this problem we can use the light- dependent resistor circuit to control the light-intensity-based loads.
An LDR o

c. Temperature Sensor:

Fig. 4 Temperature Sensor

The fundamental concept of the temperature sensors operating is the voltage around the terminals of the diode. As the voltage increases, the temperature often rises, followed by a decrease in voltage between base and emitter transistor terminals in a diode. In addition to this, Encardio-Rite has a vibrating wire temperature sensor that operates due to temperature change on the theory of stress change. The vibrating wire temperature meter is constructed based on the idea that dissimilar metals have different linear expansion coefficients with difference in temperature. It consists primarily of a stretched wire with a high magnetic tensile strength, the two ends of which are fixed to any dissimilar metal in such a way that any changes in temperature directly influence the tension in the wire and hence its natural frequency vibration.

d. Fire Sensor:

Fig. 5 Fire Sensor

Within the wave length range 760-1100 nm, both the digital and analog signal can be received by the flame sensor. As sensor senses the flame, the high-level signal will be emitted by the digital signal. The output voltage is determined by the size of the flame by analog signal. The larger the scale of the fire, the greater the voltage output.

e. IR Sensor:

Fig. 6 IR Sensor

Whenever an object is put in front of the sensor, the IR LED Infrared light is reflected back as it reaches the target and falls on the Picture Diode. The diode of photographs then starts to act. As a result, the voltage at the non-inverting input of the LM358 will be greater than that at the inverting input. Because the LM358 functions as a comparator, its performance will become HIGH and the LED glows on board.

f. Pi Camera:

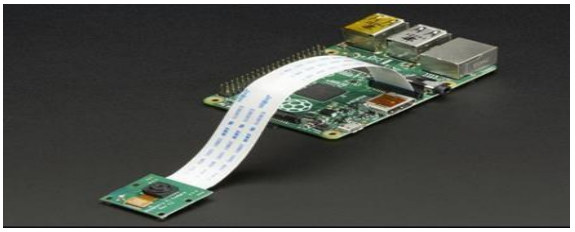

Fig. 7 Pi Camera

It could be used to catch Raspberry Pi camera module Photograph and take footage in high definition. You should put it to use the camera libraries to create results. Photography Module has a fixed- focus 5-megapixel sensor Supports Modes 1080p30, 720p60 and recording. It interconnects via 15 cm ribbon cable to Raspberry Pi's CSI connection. The Camera fits with all Raspberry Pi 1 versions, as well as Pi2-Pi2. It is accessible through MMAL (Multi-Media) Abstraction Layer), Linux video framework interface to software and there are several third parties Libraries built for it, such as the Pi camera library Python. The camera module is used extensively for building surveillance applications and camera traps in wildlife.

IV. IMPLEMENTATION

The implementation of this system provides effective detection of the occupants entering into the building and monitoring the energy supplied at a low cost. This system provides safety measures when there is a fire accident in the predefined area. The system "Building Automation System" accomplishes the following objectives:

- Detection of occupants count using Pi camera and automating the electrical appliances such as light and fan.
- Generating an alarm message when there is a fire break down in the specified zone.

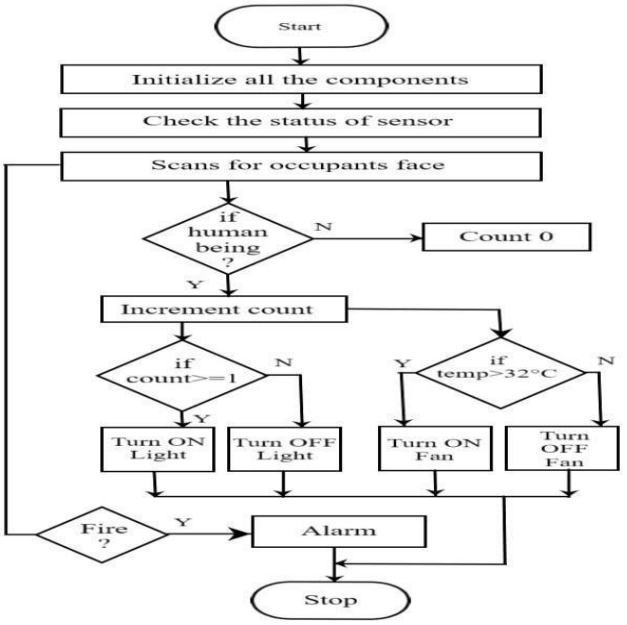

Fig. 8 Flow chart of Energy Efficient Prototype

This building automation system works as follows, when an occupant enters the predefined area first the motion is detected using an infrared sensor. Once the motion is detected the pi camera which is connected to the Raspberry Pi module is used for the face detection of humans. If the

features of occupant's match with the humans then count is incremented. With the increment in count value it means that the occupant has occupied the zone which leads for the light to turn on using the LDR light sensor.

If the total number of occupants present in a predefined area crosses the threshold value then an additional light will be turned on. As and when the zone becomes vacant the light is turned off automatically. Temperature sensor is used in the automation of fan, when the occupants are present automatically the humidity becomes high. If the humidity crosses the limit then the fans are turned on. It is required to ensure the safety in any smart building by providing the necessary precautions. In this system we make use of fire sensor to detect fire accidents. When there is a smoke or fire that has been detected by a sensor then an alarm mail will be sent to the control room to take necessary steps. So that respective actions can be taken by the controlling authority.

V. RESULT

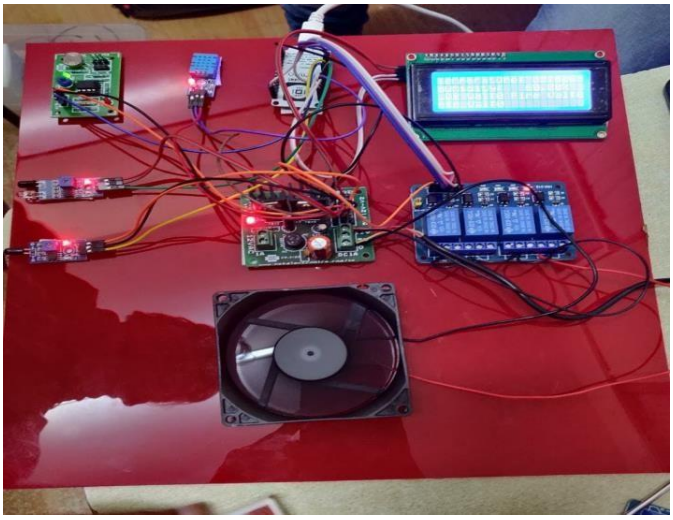

Fig. 9 System Prototype

Fig. 10 Reading of Sensors

VI. CONCLUSION

This work provides a forum for developing an active occupancy counting system based on infrared. This design proposal accurately counts the entry of personnel and exit to zone of building. The projected occupancy of the building is sent to a Raspberry Pi, which helps wireless contact with users of building automation devices. The whole architecture of the hardware and software was implemented in this report, and tested. Experimental findings show that the concept proposed gives an average counting 97 per cent accuracy. In fact, the simulation of building resources demonstrates a substantial effect of implementing this IoT prototype in a building and reduces energy significantly. In short, our IoT platform is versatile, compact and simple to use or upgrade, robust, accurate, low-complexity, non-intrusive, and cost-effective.

ACKNOWLEDGEMENT

We are so much thankful for our project guide, Prof Kavya T C, who supported us during the project completion and also helped us to improve the manuscripts significantly.

REFERENCES

[1] Qian Huang, Kane Rodriguez, Nicholas Whetstone, Steven Habel (2019). Rapid Internet of Things(IoT) prototype for accurate people counting towards energy efficient buildings. Journal of Information Technology in Construction (ITcon), Vol. 24, pg. 1-13,http://www.itcon.org/2019/1

[2] International Journal & Magazine of Engineering, Technology, Management and Research. ISS No:2348-4845 http://www.ijmetmr.com/

[3] International Journal of Research.

[4] International Journal of Innovative Research in Computer and Communication Engineering. http://ijircce.com/

[5] Agarwal, Y., Balaji, B., Gupta, R., Lyles, J., Wei M., and Weng, T. (2010). Occupancy-Driven Energy Management for Smart Building Automation. Embedded Sensing Systems for Energy- Efficiency in Building, pp. 1-6.

[6] Ahmed, H., Faouzi, B., and Caelen, J. (2013). Detection and Classification of the Behaviour of People in an Intelligent Building by Camera. International Journal on Smart Sensing and Intelligent Systems, Vol. 6, pp. 1317-1342.

[7] Akkaya, K., Guvenc, I., Aygun, R., Pala, N., Kadri A. (2015). IoT-based Occupancy Monitoring Techniques forEnergy-Efficient Smart Buildings. IEEE Wireless Communications and Networking Conference, pp. 58-63.

[8] N. Fathima, A. Ahammed, Banu, B.D. Parameshachari, and N.M. Naik, "Optimized neighbor discovery in Internet of Things (IoT)," In Proc. of International Conference on Electrical, Electronics, Communication, Computer, and Optimization Techniques (ICEECCOT), pp. 1-5, 2017.