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Advanced Air Conditioning using Thermal Imaging and Occupancy Detection

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Abstract: ***The body temperature of humans differs from one person to another, and therefore it becomes difficult to set the optimal temperature of the room. The total room temperature depends on the number of persons present and their body temperatures. The occupancy detection of a room and determining its temperature are dependent on each other. In this paper, A novel approach for determining the room temperature along with occupancy detection and correspondingly giving the input to air-conditioner is discussed. This paper would also provide a solution to determine the number of persons that can leave a room to ensure less congregation of corridors. For getting a definitive body temperature of individuals, we will be using the MLX90640 module, which produces a thermal image and makes it possible for the extraction of temperature data. PIR sensors are used for occupancy detection purposes and an ultrasonic sensor for the congregation problem. These are both implemented using Arduino IDE, whereas raspberry pi handles the temperature data. Finally, using the mean temperature data, the temperature of the air conditioner will be set.***

Keywords: MLX90640, Occupancy detection, Passive Infrared Sensor, Room Temperature.

I. INTRODUCTION

In our modern society, technology is proliferating, from the generation of vacuum tubes to transistors. We have seen many changes in our daily life, where IoT has an important role. Home automation is one of them, which helps us in controlling all our home appliances using our smartphone or digital assistant. The term IoT stands for the Internet of Things; it controls or manages any electronic or electrical item using the internet. It makes our life comfortable and relaxed. Many works that need time can be solved within a few moments. There are three types of automation: Industrial automation, Home automation, Building automation. We are using Home automation in our project.

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In our project, home automation plays an important role. We use home automation to control our home appliances, and here we will focus on controlling the Air conditioner automatically. To do this process, we will use the concepts of THERMAL IMAGING.
It is a process where the infrared wave is used to detect the heat signatures of the object.
The second part of our project is occupancy detection and crowd management. This concept is based on ULTRASONIC and PASSIVE INFRARED technology. Ultrasonic detects the breadth of the corridor and informs its capacity. In contrast, the passive infrared detects motion and tells the number of people present in a room.

II. PREVIOUS WORKS

Nasreen Nesa and Indrajit Banerjee have made use of measurable used sources like temperature, humidity, light, and CO2 for detecting the occupancy. They also provided the monitoring system of the building through HVAC control systems. Mang Ye, Xiangyuan Lan, Zheng Wang, Pong C. Yuen have made use of a two-way network that is formed with the use of bi-directional dual-constrained top ranking (BDTR) loss and gave an analysis to the discriminating feature signs.
Ishaan Arora and Vanmathi C have used the method in which the temperature of the room was decided based on various data available, and an appropriate predictive based algorithm was selected. Students of the University of California at Berkeley, have made use of the system where they can detect the measurements of occupancy based on temperature and CO2 concentration. RWTH Aachen University students have adopted an open network system that helps with the multiple sensor inputs by focusing on and merging data input. The standard sensor input is used for analyzing the thermal comfort.
The students of Korea Electronics Technology Institute, Bucheon have adopted a measurable system for detecting and tracking the body movement in the sensory concerning CCD fusion field.
The researchers from Stony Brook University have made use of the Rotatable-PIR sensor for occupancy detection, and they also focused on localization, activity tracking, etc.
The students of Yonsei University have made use of the combination of hand detection and tracking observations as algorithms and stored them into a single system named guiding system for tracking and detection.

III. FEATURES OF MLX90640

In our project, the main component we are using is Melexis MLX90640. It is fully calibrated. It has 32-pixel into 24 pixel IR array. It has a digital interface, and it is used for an industry standardized 4-lead TO39 package.

It is tiny in size, having NETD of just 0.1K RMS at a refresh rate of 1Hz. It has two different FoV (Field of View) options, and those are 55° x 35° and 110° x 75°. The rate of Programmable refresh is 0.5Hz to 64Hz. The supply voltage for this MLX90640 is 3.3V. Current consumption is also very less(<23mA).

It is generally operated within -40°C to 85°C temperature, and objects can be measured up to 300°C temperature.

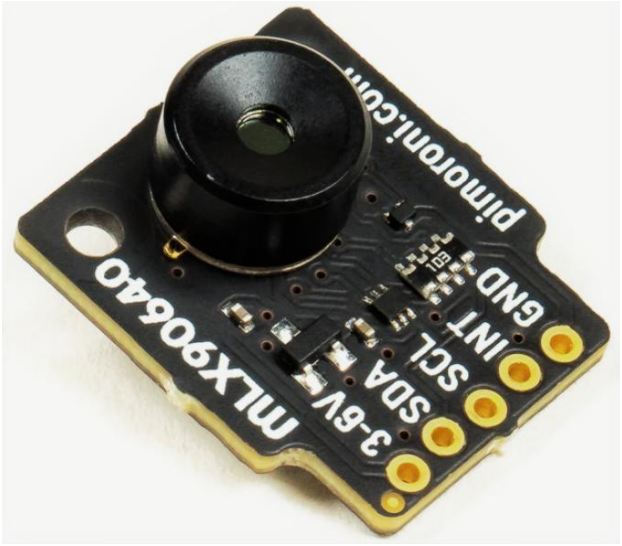

Fig. 1 MLX90640

IV. PROPOSED SYSTEM ARCHITECTURE

The proposed system design is given in Fig. The system consists of various sensors like PIR sensors and ultrasonic sensors. The Raspberry Pi is connected with the Arduino UNO and MLX90640 Thermal Camera Module. The IR LED detects the input and output, and the Air Conditioner is self-adjusted automatically according to the measurements.

Components

A. ***Arduino Uno*:** It is a microprocessor that has a certain amount of memory for storage and executes the program using Arduino IDE.

B. ***Raspberry Pi***: It is a microcontroller that has a memory of a few gigabytes that gives it a sound processing and computing capabilities.

C. ***PIR sensor*:** A digital sensor that turns high when any motion is detected and low when there is no motion. It has a 120-degree area of coverage.

D. ***MLX90640 Thermal Camera Module***: It is a thermal sensor module that can detect a wide range of temperatures from -40 to 300 degrees Celsius with very high accuracy.

E. ***IR LED*:** The LED glows when it gets power. But it emits light in the IR (infrared) frequencies. If the infrared LED is working, it will appear on the result bar as an output.

F. ***Ultrasonic Sensor*:** It measures the distance to an object using ultrasonic sound waves, and it will detect the range for occupancy.

G. ***Arduino IDE***: It is a software that is used for programming all the different types of Arduino boards. This software supports various languages for the ease of users.

H. ***Raspbian*:** It is a Debian based free operating system, which is the optimization for the Raspberry Pi hardware and comes with thousands of packages precompiled for ease of installation on your Raspberry Pi.

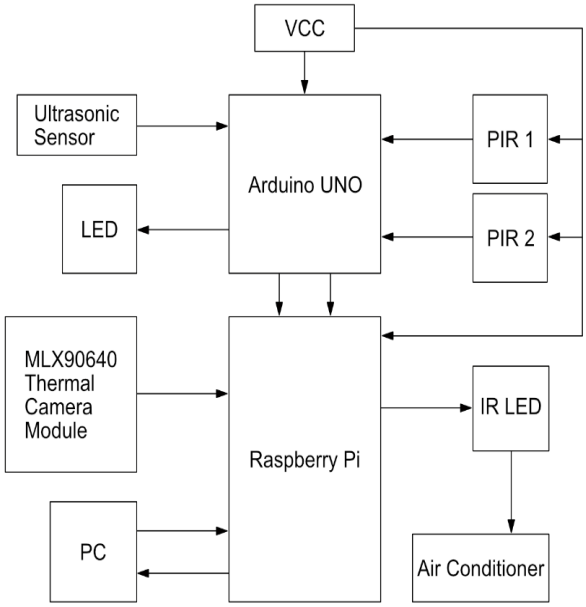

Fig. 2 System Architecture

V. IMPLEMENTATION

The main components that handle the processing and working of the project are the Arduino UNO and Raspberry Pi. They both handle individual aspects of the project. The raspberry is used mainly for thermal imaging, and the main objective of UNO is occupancy detection. They both are combined to ensure minimal fallacy. Initially, the Arduino UNO is connected to an ultrasonic sensor and 2 PIR sensors. Firstly, the ultrasonic sensor measures the width of the corridor and calculates the number of individuals that can travel through it simultaneously. This estimate will then be shown at the output terminal to avoid crowding of the exits/corridors. The PIR sensor is a digital sensor which senses the motion around it, If PIR1 is high and then PIR2 becomes high, this is considered as an entry of a person. In the inverse situation, when PIR2 becomes high first and PIR1 second would be considered as an exit. Green and Red LEDs are connected at the output terminals to indicate entry/exit, respectively. The count of the people inside the room will be sent to the raspberry pi.

MLX90640, a thermal camera module, has a wide field of view with a suitable temperature measurement range. This module is connected to Raspberry Pi at the I2c terminals. The I2c ports in a microcontroller are used to operate low-speed devices. This module will detect the temperatures of the individuals inside the room as they pass through and simultaneously keep a count of the number of people. MLX96040 would additionally function as a secondary occupancy detector. The count obtained by MLX90640 would then be compared to the Arduino data. If there are any unaccounted individuals, then it means that they have not passed through the MLX module or are out of range. The temperature readings will then be sent to Raspberry pi, which will calculate the optimal temperature for the room.

This data will then be sent to the IR LED module, which will transmit a particular frequency to set the temperature of the air-conditioner. There are many air-conditioners available in the market, depending on the brand, the specific frequency will be set to ensure the steady functioning of the device. By examining the figure, we can understand the connections and passage of data. The distinctive part of this project would be the use of the MLX90640 to get the thermal readings of the people as compared to using an expensive thermal camera that cannot be integrated into an air-conditioning system. MLX90640 is fast and minuscule and is quite well suited for domestic and professional use.

Fig. 3 Arduino IDE

VI. RESULTS AND DISCUSSION

The experiments carried out have been successful. Though the system is functioning correctly, specific observations were made. The ultrasonic sensor can ascertain the width of the corridor but has to be set at a certain height for its proper functioning. Setting at an average height will give erroneous data as its path would be interrupted by people. The MLX array gives a good quality thermal image considering its compactness. The temperature data of the individuals were retrieved from the array, and the data was sent over to the air conditioner for setting the temperature.

Table. I Occupancy Detection

Individuals Entering	PIR Value	Individuals Exiting	PIR Value	Total Individuals
1	1	0	0	1
2	2	1	1	2
4	4	1	1	5
3	3	2	2	6
2	4	3	3	5

VII. CONCLUSION AND FUTURE SCOPE

In this project, an advanced air conditioning system using a thermal camera with occupancy detection was designed. In our project, firstly, the air-conditioning system measures the human temperature from the persons who are present in the room by using a thermal camera.

It sets the room temperature with the help of raspberry pi, considering the average human temperature. Secondly, The detection of persons is done through Arduino Uno using PIR sensors.

The measurement of the corridor/exit is done by the use of an ultrasonic sensor. The proposed system has extensive usage in the years to come as it comes under IoT devices. The system once enabled, can count the total number of persons in a room and set the room-temperature without needing input from the user.

So whenever an individual enters a room or exits one, the temperature changes automatically. This system can be implemented in meeting rooms, conferences, etc. which will save a lot of human effort.

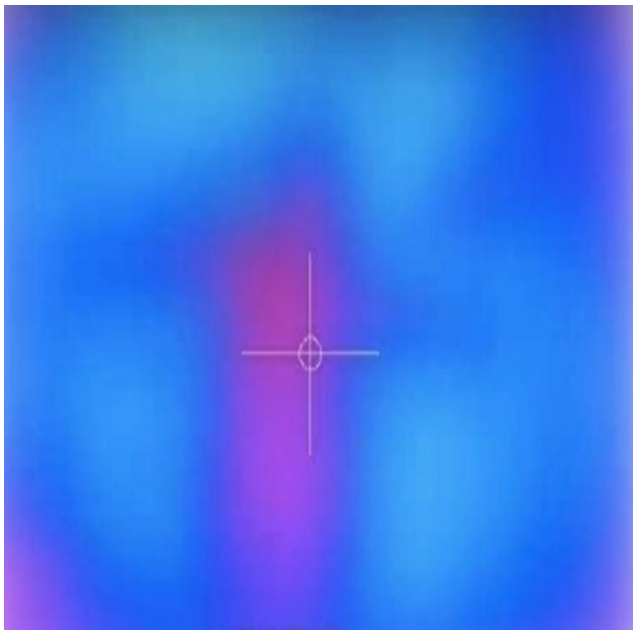

Fig. 4 Thermal Image

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