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Heat Vision Based Light Automation

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Abstract
The Human Detection project utilizing thermal sensors aims to detect individuals or groups in the surrounding environment and respond accordingly. For instance, it can adjust lighting in a room or on a street to accommodate the presence of an individual instead of illuminating everything. Thermal sensors can also detect the presence of people and cars, making street lighting smart and adapting to the lighting situation accordingly. This technology can save up to 70% of energy costs while maintaining safe streets in high-crime areas and creating room for photovoltaic cells. Accurate occupancy tracking and temperature control are crucial in any organization or society, particularly in crowded places like hospitals or malls. To address this issue, we are introducing a data-driven electronic and sensor-based system that can detect the overall environment's temperature. This system is not a simple machine that gives a single output related to human temperature, but it provides real-time data to detect other parameters for multiple applications.

Keywords: IoT, Thermal Camera, Home automation, Temperature Measurement.

1. Introduction

IoT, which stands for Internet of Things, is the use of interlinked gadgets embedded in tangible surroundings to improve existing procedures or conceive novel scenarios that were previously inconceivable. This technology provides a simpler and self-monitoring solution that facilitates proficient handling of everyday duties, which can otherwise be laborious. Forbes anticipates that the IoT sector will be worth $520 billion by 2021.

Our project, the Heat Vision Based Light Automation IoT system, is a creative and futuristic approach that utilizes thermal imaging and image processing algorithms to mechanize the management of air conditioning and lighting systems. The system employs non-contact thermal sensors to measure the temperature of an individual or group in a room, which is then processed by the image processing module to figure out whether lights should be turned on or off. The purpose of this system is to optimize energy efficiency by making sure that lights are only activated when needed. Also, the system can be controlled remotely via a mobile app, granting users the ability to adjust settings from anywhere.[8]

Temperature sensors play a critical role in modern applications such as smart homes, security systems, and industrial automation by detecting human presence and movement. These devices measure temperature changes and provide precise readings through an electrical signal. Traditional thermometers have evolved into advanced sensors like infrared sensors and thermistors, offering improved accuracy to within a fraction of a degree. In various industries, the precision and reliability of temperature sensors are paramount for effective temperature control. Their absence can lead to potential hazards, posing challenges in maintaining consistent temperatures.

Human detection systems, applicable in driver assistance, smart lighting, and security, are essential. Currently, we are developing "Heat Vision Based Light Automation" technology to enhance temperature control in these areas. This innovative system utilizes advanced heat-sensing capabilities, employing state-of-the-art image processing algorithms and non-contact thermal sensors for high accuracy.

The Heat Vision Based Light Automation system allows users to regulate surrounding temperatures conveniently through a user-friendly mobile app interface, making it suitable for applications like smart homes and commercial buildings. This system is an innovative technology that has the potential to transform temperature control. Its advanced features, accuracy, and ease of use make it an ideal solution for various applications.

2. Related Work

Heat vision-based home automation enables remote control of home appliances based on temperature variations. This literature survey delves into the current state-of-the-art in such systems, emphasizing the use of infrared sensors to detect temperature changes. With a rising interest in recent years, these systems offer programmable features to perform tasks based on detected temperature variations.

One of the early works in this area was presented by Jain et al. (2015) who developed a heat vision-based home automation system that used a Raspberry Pi microcontroller and an infrared sensor to control a fan based on the ambient temperature. The authors showed that the system was able to effectively regulate the temperature in a room. [1]

Another study by Raman et al. (2016) presented a heat vision-based home automation system that used a combination of infrared sensors and a Wi-Fi module to remotely control the temperature of a room. The authors demonstrated that their system was able to effectively control the temperature of a room, and also had the ability to send notifications to the user's smartphone when the temperature exceeded a certain threshold.[2].

In a study by Gupta et al.(2017), a heat vision-based home automation system was developed using a Raspberry Pi and an infrared sensor to control the temperature of a room. The system was able to effectively regulate the temperature in the room, resulting in energy savings of up to 15%. [3].

In a study by Gopalan et al. (2018), a heat vision-based home automation system was developed using a combination of infrared sensors and a microcontroller. The system was able to detect temperature changes in the environment and control various home appliances, such as fans and air conditioners, to maintain a comfortable temperature in the room. [4]

In a study by Kumar et al. (2019), a heat vision-based home automation system was developed using a neural network to predict the optimal temperature for a room based on various factors, such as the time of day, the number of occupants, and the weather conditions. The system was able to effectively control the temperature in the room, resulting in energy savings of up to 25%. [5]

In a more recent study, Singh et al. (2020) developed a heat vision-based home automation system that used a neural network to predict the optimal temperature for a room based on the time of day and the number of occupants. The authors demonstrated that their system was able to accurately predict the optimal temperature, resulting in energy savings of up to 20%. [6]

In a study by Singh et al. (2021), a heat vision-based home automation system was developed using a machine learning algorithm to predict the temperature changes in the environment and control various home appliances, such as heaters and air conditioners, to maintain a comfortable temperature in the room. The system was able to effectively control the temperature in the room, resulting in energy savings of up to 30%. [7]

The studies presented in this literature survey demonstrate the effectiveness of such systems and pave the way for future research in this area.

3. Methodology

In this home automation system is centered around a powerful Raspberry Pi unit that acts as the control hub for all operations. This system can manage household appliances such as lights and fans by utilizing data obtained from a variety of sensors. One such sensor is a thermal camera that captures thermal images, which are then used to determine optimal temperature settings for the room. Additionally, a standard camera captures regular images that allow for more precise monitoring of the environment.

Ambient light levels are monitored through an LDR sensor, which allows for the automation of lighting in the room. To conserve power, the system employs a machine learning model that uses the captured images to detect the presence of humans. If no one is present, the system will automatically turn off appliances. If a human is detected, the system extracts thermal data from the captured images and performs heat analysis. Based on this analysis, an appropriate and efficient temperature is set to suit individual requirements.

For people present in the room, the automation system can control lighting by turning it on or off and adjust the fan's temperature based on the individual's body temperature. Since the system works with both ambient temperature and human body temperature, it can provide continuous updates on the environment's temperature. An mlx sensor allows the system to create a comprehensive home automation solution. Lastly, the system can even take pictures of specific individuals and send them to the owner for monitoring purposes.

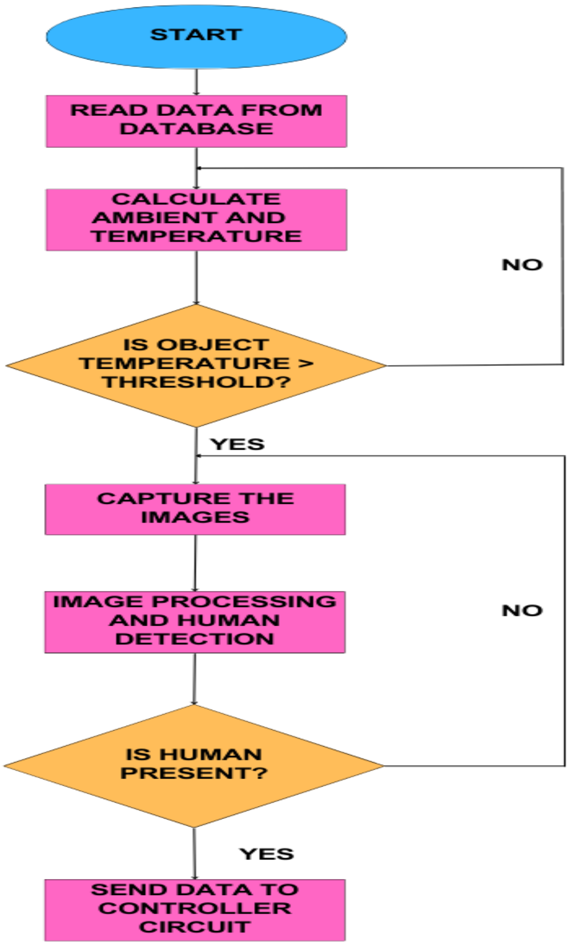

Fig.1 Flow Chart of system

4. Representation and Explanation

The program flowchart for our Raspberry Pi-based system involves using the Raspberry Pi to capture images from a camera, process the images, detect humans, calculate temperature, and update/send the information. The thermal camera MLX90640 is connected to the Raspberry Pi via I2C communication, while the Pi Camera is connected via CSI communication to capture images for human detection and image enhancement.

The Raspberry Pi operates on a Python program that retrieves user settings by reading data from the cloud via the urllib Python library. The URLs are fetched using the urllib module of Python's URL handling module.

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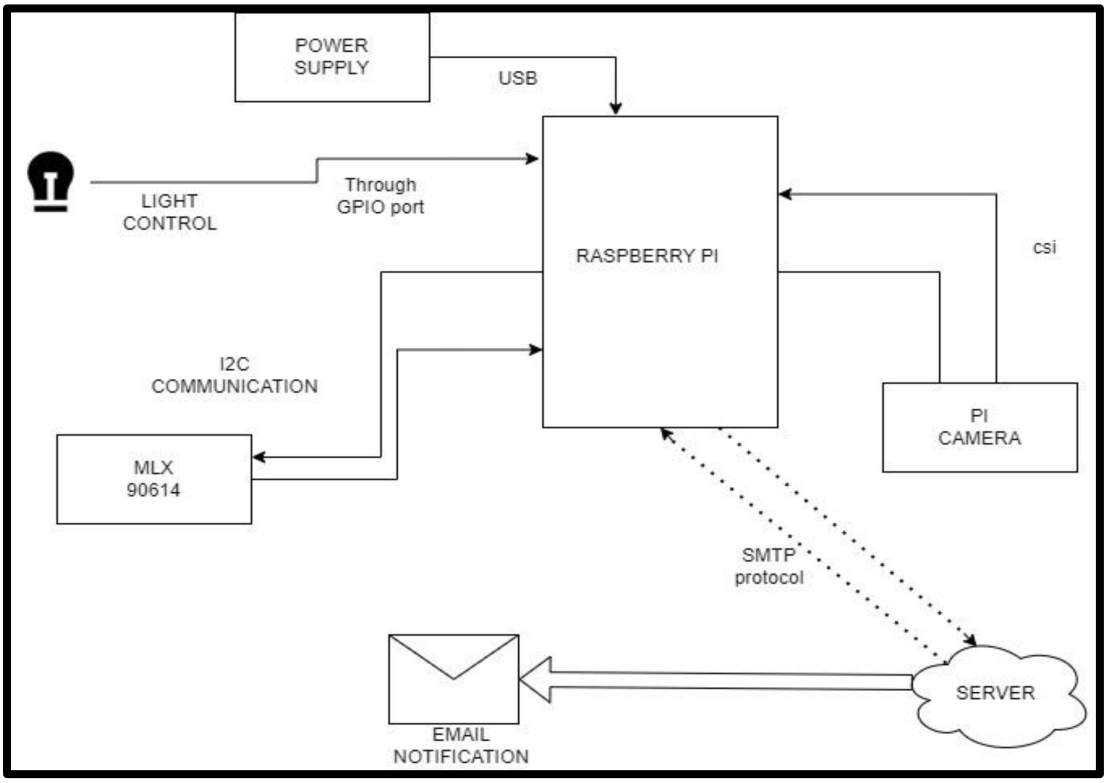

Fig.2 Schematic representation

The program is designed to capture images from both cameras, process the raw data from the MLX90640 camera using a formula and procedure specified by the manufacturer to obtain useful pixel values, and obtain a thermal image. This thermal image is processed along with the image from the Pi camera to make both images consistent in properties. Both images have the same size, pixel count, and color space (RGB), making them suitable for human detection and temperature extraction.

If the system fails to detect the presence of humans, it captures the image again and repeats the entire process until humans are detected. The calculated information is then transferred as data to the Raspberry Pi for updating and sending.

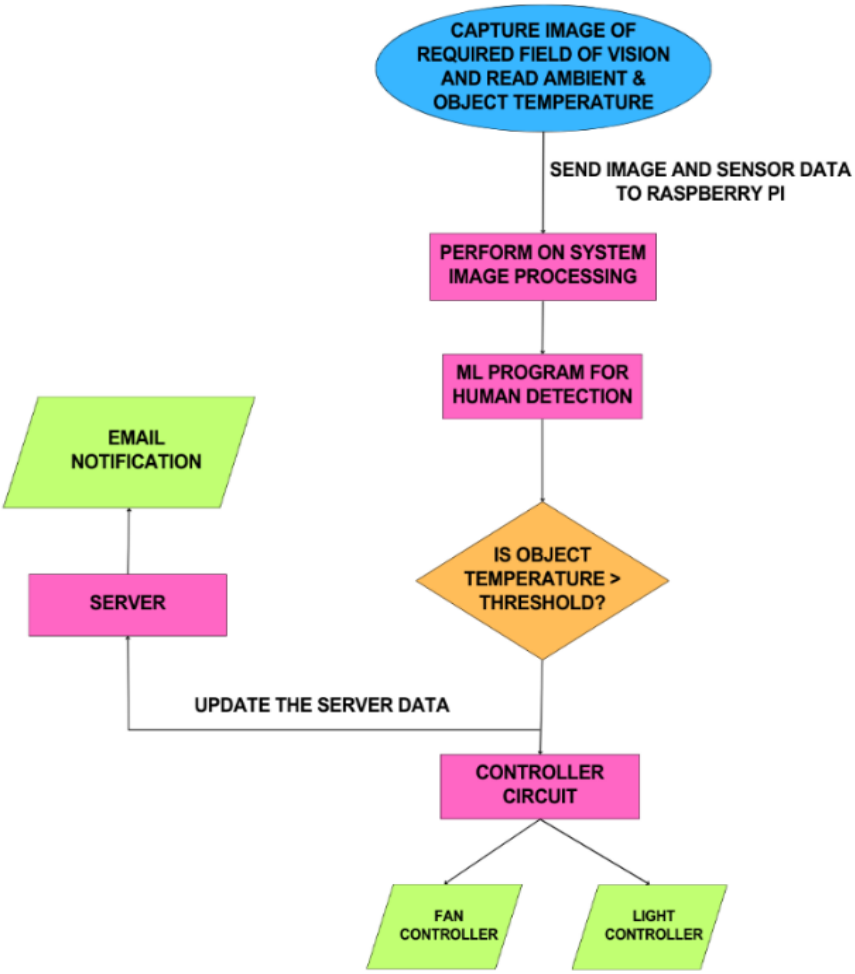

Fig.3 Block Diagram

In this system all the devices are connected to the Raspberry Pi, which serves as the central hub. A web interface is designed to remotely access the devices connected to the Raspberry Pi using their dedicated IP address. The sensors are calibrated with the Pi to obtain real-time data, which is used to regulate the connected devices and displayed on the web interface. The interface is accessible from anywhere in the world via the Internet.

Home automation is a network of electronic interfaces, communication devices, and hardware that allows integration of everyday devices with each other through the Internet. The devices are equipped with sensors and connected through WIFI, which enables remote management using a smartphone or tablet, irrespective of the user's location. This technology offers various functionalities, such as controlling lights, locking doors, and adjusting the temperature.

In these system is composed of three primary components: sensors, controllers, and actuators. The sensors are responsible for monitoring environmental conditions in the home, such as temperature, humidity, and motion detection. Using this data, the system can adjust settings according to the user's preferences. The controllers are devices such as personal computers, tablets, or smartphones, which allow the user to send and receive messages about the status of the automated features in the home. Finally, the actuators control the mechanism or function of the home automation system, such as light switches, motors, or motorized valves. These actuators can be programmed to be activated by a remote command from the controller, enabling remote operation of the home automation system. A variety of sensors are currently available on the market that can provide readings for temperature and humidity. What sets this sensor apart from others is its ability to measure the temperature of objects, rather than just the temperature of the surrounding environment. In previous applications, the DHT11 Sensor and LM35 have been widely used to measure atmospheric humidity and temperature.

However, for the purpose of creating a model that can measure object temperature without physical contact, the infrared-based MLX90614 sensor from Melexis Microelectronics Integrated Systems is used. This sensor operates on the principle of an infrared thermopile sensor to measure temperature and consists of two units to provide temperature output. The detection unit contains an infrared detector, while the processing unit performs data calculation through digital signal processing (DSP).
The sensor operates according to the Stefan-Boltzmann law, which relates the energy emitted by a black body to its temperature. Simply put, all objects emit infrared energy, and the power of this energy is directly proportional to the temperature of the object.

The MLX90614 sensor converts the calculated value into a 17-bit analog-to-digital converter (ADC), which can be accessed using the I2C communication protocol. These sensors can measure both ambient and object temperature, with a resolution calibration of 0.02°C.

5. Implementation

A. Interfacing MLX90614 with Raspberry Pi:

- Enable I2C interface on Raspberry Pi by going to the settings.
- Download the PyMLX90614 package

B. Pi Camera interfacing with Raspberry Pi:

- Enable camera interface on Raspberry Pi by going to the settings.
- Test the camera by taking a picture with the name "image" and storing it on your desktop.

C. Setting up SMTP email with Raspberry Pi:

- Go to the Google account management page by clicking on the user icon in the top-right corner of the Google homepage and selecting "Manage your Google Account".
- Click on "Security" and scroll down to "Less secure app access".
- Enable the "Less secure app access" option.
- Repeat the above steps with any other email accounts that you want to send or receive emails from using the Python script.
- Download the necessary packages for sending emails via SMTP.
- Once all the required libraries are installed, open the ssmtp.conf file and enter the sender's email details.

D. SMTP libraries
Python is a programming language that provides a built-in library called "smtp lib" for sending emails using Simple Mail Transfer Protocol (SMTP). SMTP is a protocol used for sending and routing email messages between servers. With the smtp lib module, Python allows users to create an SMTP client session object that can be used to send emails to any Internet machine with an SMTP or ESMTP listener daemon.

Here are the steps to follow for sending emails using Python:
- Set up the SMTP worker: Before sending emails, we need to set up an SMTP server that can handle the email communication. The SMTP server requires a host address, port number, and login credentials for authentication. These details must be entered into the code for the SMTP server to be set up correctly.
- Create the MIME Multipart message object: The next step is to create a MIME (Multipurpose Internet Mail Extensions) message object. This object contains the message headers, such as From, To, and Subject fields, and the message body. It is created using the email.mime library in Python.

- Load the message body: The message body is the actual content of the email message that will be sent. It can include plain text, HTML, or other formats. The message body is loaded into the MIME Multipart message object created in the previous step.
- Send the message: Once the SMTP server is set up, and the message is created, we can send the message using the SMTP worker object. We use the SMTP's "sendmail()" function to send the message to the specified email address. This function takes three arguments: the sender's email address, the recipient's email address, and the message object.

E. Python SMTP secure

To ensure that your emails sent through Python are secure, it's crucial to encrypt your SMTP connection using SSL (Secure Sockets Layer) or TLS (Transport Layer Security) protocols. Unauthorized access to your message and login credentials can be prevented with proper encryption. To send emails with attachments via SMTP (using the smtp lib) without plagiarism, follow these steps:

- Develop a MIME object that outlines the message's structure and content.
- Include the sender and recipient email addresses in the MIME object.
- Add a subject line to the MIME object.
- Append the email's body and attachments to the MIME object.
- Begin an SMTP session with the correct security settings and port number.
- Verify the login credentials for the SMTP server.
- Transmit the email and end the session

6. Result

To conduct testing, we provide the sensors with two distinct temperature inputs: the ambient temperature of the room and the temperature of a human body present in the room. The sole function of the sensor is to detect and measure the temperature of the room as well as that of any individual present within its range. As soon as an individual enters the proximity of the mlx sensor, the automation system kicks in and the light/fan turns on or off based on the current setting. Furthermore, the system continually monitors the temperature of the human body and adjusts the speed of the fan accordingly to ensure optimal comfort level.

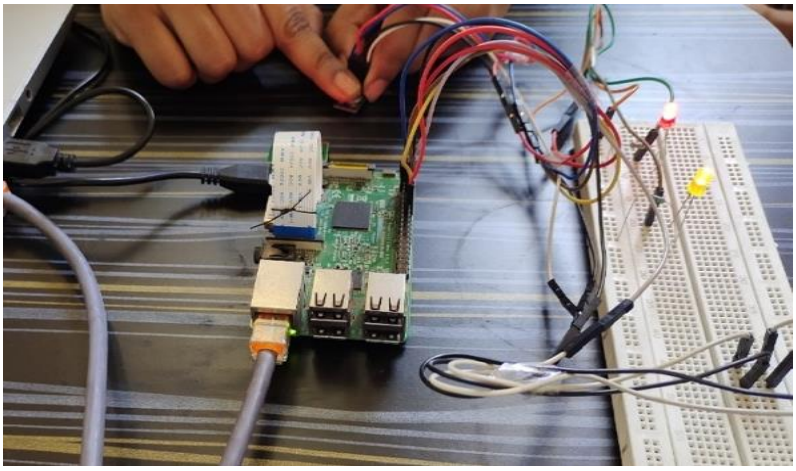

Fig.4 Testing in process of the project

7. Conclusion

Our cutting-edge system revolutionizes temperature control by continuously monitoring real-time body temperature, offering unparalleled comfort. It dynamically adapts to body temperature changes, reducing sweating without manual intervention. The system intelligently conserves energy by detecting human presence and adjusting fan speed, ensuring sustainability. With advanced features like capturing images on temperature threshold exceedance, the system prioritizes user comfort and energy efficiency. Despite the cost, the inclusion of a high-quality pi camera enhances accuracy and aids in human detection for comprehensive analysis

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