Proposal of Face-Traceable Fever Detection System

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1. Topic Definition

Project Objective: To develop a device capable of detecting and monitoring the temperature of individuals through facial recognition. The device will send an alert email if the detected temperature exceeds the predefined threshold. It will include the target's facial image and temperature.
Basic Case: Fixed cameras will be positioned at the entrance of airports or shopping malls to capture the temperature of pedestrians and show it on the Raspberry Pi's screen.

Advanced Case: Feature continuous facial tracking and provide ongoing temperature reports.
Limited: The device can only track one face at a time, and the administrator can disable this feature.
Application Scenario: The device will be placed in a hospital ward and continuously track the target's face within a 180-degree range, recording temperature readings every 5 minutes and generating charts. Alerts will be sent, if the target's face is lost or their temperature falls below the alert threshold.

Energy-efficient: Allowing the device to low-power sleep mode if no new targets are detected.
Challenges:

- Accurately locating facial positions on dynamic human subjects and synchronizing the coordinates with the thermal camera for temperature measurement.
- Using unique labels to targets within the same time period to avoid duplicate alerts.
- Utilizing the Raspberry Pi's servo motor to rotate the camera.

2. Background Research

There are two types of temperature measurement methods available today: direct contact and non-contact. Contact methods have high accuracy and breadth, but require labor, time and consumables, and increase the workload of caregivers. In addition, contact methods restrict the subject's movement and may cause discomfort. Non-contact temperature measurement does not require contact with the skin. Common non-contact methods include infrared thermometry and thermal imaging. One of these methods, thermal imaging, offers many advantages, such as being unaffected by changes in light and working well in the dark.

The team of Lin et al. (2019) then proposed a thermal camera-based, automated continuous body temperature measurement system using a low-cost and low-resolution LWIR camera for measurement. By applying deep learning-based face detection, target tracking and calibration transformation equations, the forehead temperature of the subject can be extracted in real time. They claim that the experimental results have "mean absolute error (MAE) and root mean square error (RMSE) of 0.375°C and 0.439°C, respectively, with real-time continuous measurement capability" (Lin et al., 2019).

Although they have achieved good accuracy in the experimental results, the results have some shortcomings at present. For example, the subject must remain stationary during the experiment and the thermal imaging camera is mounted 40-80 cm in front of the subject. This is not ideal for applications in crowded places.

Another academic group led by Gupta et al. (2021) attempted to screen for potential COVID-19 infection by using thermal imaging cameras integrated with an attendance management system to help detect employees for fever. Specifically, by integrating thermal imaging cameras with an access control system, automated employee fever detection is achieved and offers advantages in terms of early screening and employee safety. However, it is important to note that the model may have thermal camera accuracy and context-specific limitations, and is only applicable to sites with employee records.

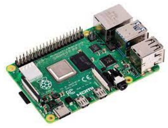
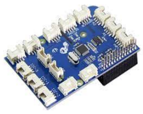
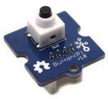
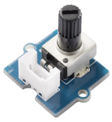
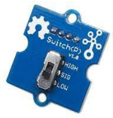
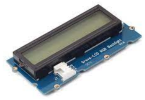
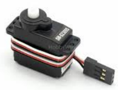
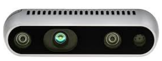
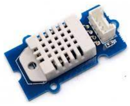
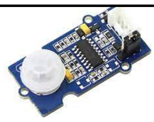
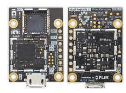
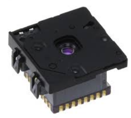
Some potential drawbacks were mentioned in the paper, such as the accuracy of the cameras and the fact that infected people did not show a higher body temperature or that uninfected people showed a higher body temperature. In addition, the solution is only applicable to places with employee records, as this is the only way to integrate it with access control systems. The solution is also not applicable to places such as shopping centers, theaters, and subway stations. These shortcomings need further consideration and improvement.

2.1 Reflection

The background provides insight into the current importance of temperature monitoring and the advantages of using thermal imaging cameras for non-contact temperature measurement. However, existing methods have some limitations and drawbacks, such as the need for the subject to remain stationary, limitation of the measurement distance, and restriction to specific sites. By drawing on and utilizing a combination of non-contact body temperature measurement techniques learned from background research, deep learning face detection algorithms, and real-time monitoring and alert systems. Our project can provide a convenient, accurate and reliable solution for face temperature monitoring and contribute to early screening and protection of employees and the public in crowded and site-specific settings.

3. Our Project

Our project is dedicated to use Raspberry Pi and thermal sensor to get the human body temperature and send alerts when a fever is detected, such as automatic emails, etc.
Specifically, we will use a total of these components in this project:

 **Raspberry Pi 4 Model B 4GB**	 **GrovePi+**	 **Grove - Button(P)**	 **Grove - Rotary Angle Sensor**	 **Grove - Switch(P)**	 **Grove - LCD RGB Backlight**
 **Micro Analog Servo Motor**	 **RealSens Depth Camera D435**	 **Temperature & Humidity Sensor**	 **Grove - PIR Motion Sensor**	 **PureThermal 2**	 **FLIR Lepton 2.5**

Most of the modules we use use the Grove interface, and here we use GrovePi+ to connect these components to the Raspberry Pi, a modular electronic building system designed to simplify the development process. It provides a simple, standardized way to connect various modules, with the benefits of ease of use, reliability and stability.

During development we focused on 5 main areas

1. How to take body temperature make sure is accurate

We use RealSens Depth Camera to detect the face and use and PureThermal 2 and FLIR Lepton 2.5, which is thermal sensor to get the temperature of the face, in this part, we use the now mature face recognition technology to read the face position, because PureThermal 2 and FLIR Lepton 2.5 can only transmit the heat signal, which makes it difficult to get the face information through the heat signal, so we choose to use the clearer RealSens Depth Camera to accurately read the face position, so that we only need to use the thermal sensor on the corresponding pixel point to get the face temperature. This part we need to check the consistency of the images of the two cameras and the RGB camera through some algorithms.

Also considering that the temperature provided by the thermal sensor is only the surface temperature of the face, which may be influenced by the ambient temperature, we use the temperature sensor to obtain the ambient temperature, and then use some algorithms and experiments to determine the influence factor and eliminate the influence of the ambient temperature on the body temperature.

On the other hand, we also consider the inaccurate way of single measurement, so we consider the average of multiple measurements, for example, we choose the average of 5 frames of the meaningful temperature provided by the thermal sensor to get a more accurate temperature.

3. Human-computer interaction

In terms of human-computer interaction, we have also considered a lot, we added a screen and a lot of buttons and knobs and such modules to display human readable information and directly in the device to make some settings, for example, the screen can display the current detection of human temperature, and has detected the number of frames, while the minimum number of frames can also be set directly on the device, just like the menu, while taking into account the need for multi-frame measurement, where we designed a servo to control the camera swing left and right, if the measurement is not yet complete but the person is not in the center of the screen, then the servo will control the camera rotation to ensure that the person in the center of the screen

4. Save energy and Performance optimization

Set the switch to manually turn off the whole system at any time and also turn it on at any time to save energy resources, and set the hibernation system to turn on only the motion sensors and turn off other components when no one is around to save power resources.

Considering the limitations of Raspberry Pi's performance and the fact that we need to run two graphics hardware at the same time, we need to make some performance optimizations while ensuring the accuracy to ensure the running speed

4. Project Plan

4.1 List of Milestones & Schedule

Timeline	Milestones	Comment
Week 4 ~ Week 5	Project Plan & Proposal Composition	Done
	Project Demo / Verifying Prototypes	Mostly Done
Week 5 ~ Week 7	Face Detection / Tracking algorithm Development	Prototype Verified
	Thermal Camera Setup & Tuning	In Progress
	Motion Sensor for Human Activity Detection	In Progress
	Face Tracking with Servo	/
	Menu & Instruction Development on Screen	
Week 7 ~ Week 8	Power Saving Mode Setup for Modules	/
	Ambient Temperature Influence Data Collection & Tuning	
	Email alarm & report collection	
Week 9	Project Integration, Debugging and Fine Tuning	/
Week 10	Demonstration / Final Report Composition	/

4.2 Risk Assessment (category, severity, response)

Risk Type	Risk	Severity	Response
Schedule	Group members sick/absent that causes the plan postponed	Medium	Give up less important parts from performance improvement to peripherals (importance low to high). Core parts are in the first place to make sure they are completed.
	Unexpected challenges postpone the development progress	Medium	
Progressive	Coding files corrupt or lost for some unexpected causes	Extreme	Use Github for code management to keep a backup. Make updates on git for every new progressive work.
Device	Peripheral devices have compatibility issues that causes the system not work as expected	Low	Create some hands-on system prototypes in the early stage, and test the functionality of modules to ensure their effectiveness.
	Module(s), device parts corrupt during development	Extreme	Carefully handle everything; Record and backup progressive accomplishment performance each milestone completed.
Methodology Feasibility	Algorithms have severe defects and not feasible in project implementation	Low	Using code prototypes provide evidence for algorithm feasibility
Performance	Ambient temperature could cause biasing effects on result accuracy	Medium	Video Record Ambient Offset

Reference

J. -W. Lin, M. -H. Lu and Y. -H. Lin, "A Thermal Camera Based Continuous Body Temperature Measurement System," *2019 IEEE/CVF International Conference on Computer Vision Workshop (ICCVW)*, Seoul, Korea (South), 2019, pp. 1681-1687, doi: 10.1109/ICCVW.2019.00208.

Gupta, A., Sudhanshu Maurya, Mehra, N., & Kapil, D. (2021). *COVID-19: Employee Fever detection with Thermal Camera Integrated with Attendance Management System.* https://doi.org/10.1109/confluence51648.2021.937707