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2019 Novel Coronavirus Disease (Covid-19): Thermal Imaging System for Covid-19 Symptom Detection Using Iot Technology

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Abstract

2019 Novel Coronavirus Disease (Covid-19) is the global pandemic that has become big concern for many nations around the world. The Covid-19 common symptom is fever which is able to be detected using infrared thermometer. This type of thermometer that is widely used can be a high potential exposure to the virus since it was used within close distance. Since the virus outbreak is happened in most of region in the world, a reliable device is highly demanded to measure the Covid-19 infectee in the crowds who has fever. Thermal imaging offers a great advantage of real time two-dimensional temperature measurement. With modern technology, a single image may contain several temperature points, recorded in a fraction of a second. Hence, this research proposes a low-cost system to detect the Covid-19 symptom in the crowd rapidly since it covers wider area based on IoT technology. Furthermore, the proposed system is able to capture the detected temperature using Thermal module and detect face using optical camera.

Keywords: Coronavirus, Thermal Imaging, Covid-19, Fever Measurement, Face Detection, IoT.

1. Introduction

Thermal imaging is the method of detecting Long IR range of electromagnetic spectrum that is invisible to the human eye by means of special and sophisticated cameras called an Infrared Imagers [1]. One of the technologies that are used in many sectors to do the thermal screening on a wide object such as environment was infrared thermogram [2]. The infrared thermogram is an image of temperature distribution of the target. Although the second generation of infrared detectors was in use for military applications in the latter half of the 20th century, thermal imagers used in medicine were almost exclusively scanning detector units with one to ten elements. There is interest in the use of thermal imaging for fever screening. Following the SARS (severe acute respiratory syndrome) outbreak in South East Asia, increasing use of thermal imaging had been made to screen travelling passengers at the time of pandemic fever [2]. The Covid-19 that has a same common symptom as SARS [3]–[5] which make it possible to use this technology in identifying people who has fever or high body temperature. This technology was developed later to improve its usability by applying it in to the drone, smart helmet and smart glasses that have wide range of detection since those devices can help the mobility of the officer in detecting the suspected infectee in the crowds rapidly [6]–[8]. Covid-19 virus outbreak has been widely diffused to the most of regions in the worlds. The total identified cases are over 30.6 million and 950 000 deaths as reported by WHO [9]. Preventing of transmission is important in order to suppress the infectee [10], [11]. The isolation of the patient to prevent the transmission can be done by performing the fever detection to differentiate the suspected infectee from the crowds. Covid-19 infectee has various symptoms and commonly with fever, based on 55,924 laboratories confirmed cases, typical signs and symptoms include: fever (87.9%), dry cough (67.7%), fatigue (38.1%), sputum production (33.4%), shortness of breath (18.6%), sore throat (13.9%), headache (13.6%), myalgia or

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arthralgia (14.8%), chills (11.4%), nausea or vomiting (5.0%), nasal congestion (4.8%), diarrhoea (3.7%), and haemoptysis (0.9%), and conjunctival congestion (0.8%) [12]. This symptom (fever) can be detected using device such as infrared thermometer or thermal imaging. The demand of this device is increasing since it is widely used in checking temperature of people. The previous study that similarly developed a device to detect thermal in electronic circuit, compared the price of commercially thermal imaging device with the prototype using thermal module found to be saved much of the cost [13]. This motivate the proposed prototype to use thermal camera module in performing thermal screening in order to find suspected infectee in the crowds. The face detection is also applied in the process of the temperature screening. This research aims to develop a thermal imaging system for Covid-19 detection using Iot technology for rapidly detection of suspected infectee who has fever in the crowds.

2. Material and Configuration

The implementation of hardware parts aim to obtain the data for Covid-19 detection from the crowd area. This data includes thermal measurement of environment where people gather, image of the covered environment and the point that inform the location of the device. The hardware mainly used in the implementation is AMG8833 thermal camera, OV7670 optical camera and GPS Module that connected to the Arduino Atmega as microcontroller to control the module to capture the data for every 5 second. The configuration of the microcontroller to obtain and evaluating the captured data is coded in the Arduino IDE. The code aims to get data of the modules (optical camera, thermal camera and GPS module) for every five second. This process also includes the installation of the library needed for every module. The library is used for microcontroller on accessing the modules data and control them to capture the data for certain length of time. This data is managed by the Arduino board and uploaded to the cloud using Wi-Fi module (ESP8266). Figure 1 shows the assembly of the mentioned module to the microcontroller and then upload to the cloud by the Wi-Fi module.

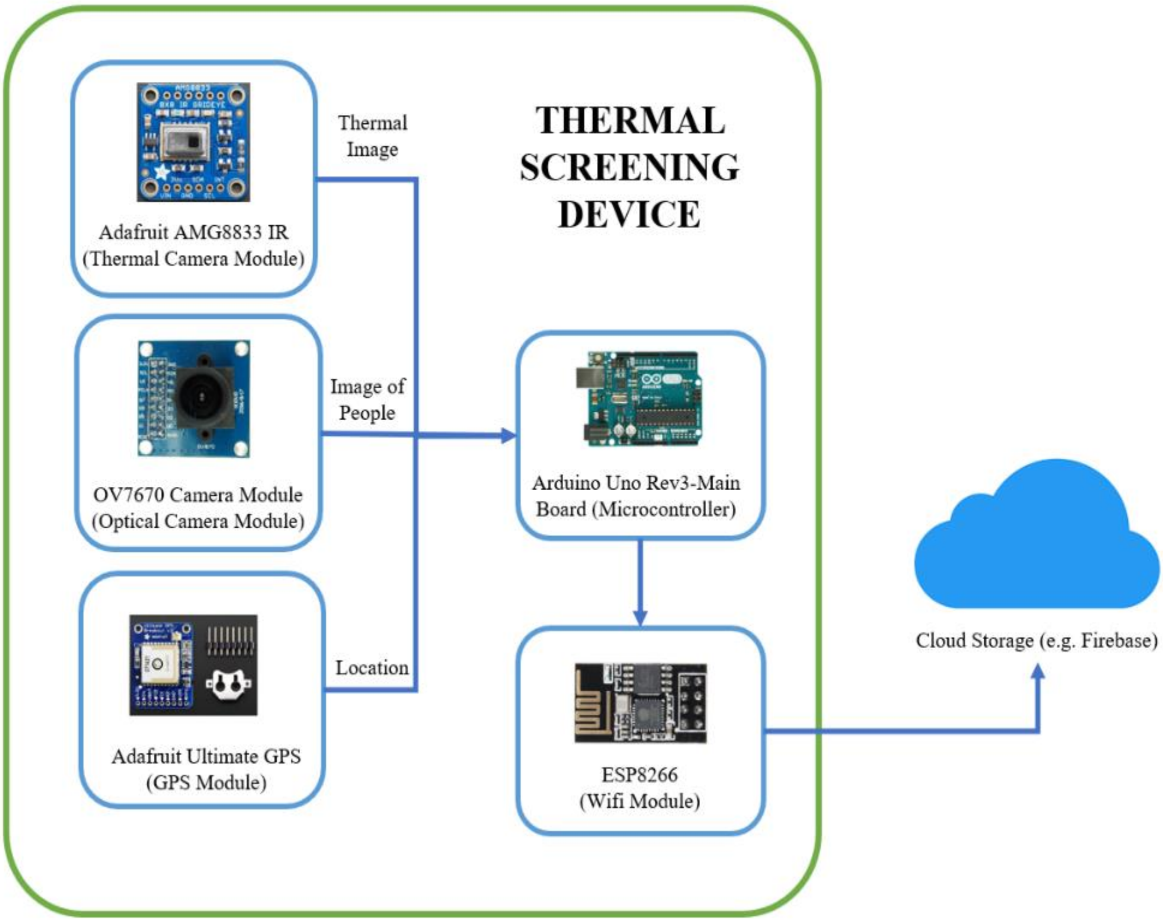

Figure 1. **The configuration of hardware for thermal screening**

The thermal camera module uses AMG8833 as the module to obtain the thermal data of the captured environment inside the camera. This module will be able to detect the temperature of the environment and represent it in array. Since the module has ability to capture the 8x8 array of the environment temperature, the single image of the captured environment will have resolution of 8x8 pixel. The OV7670 camera used as optical camera. The camera has 640x480 of image resolution. The purpose of using optical camera is for face detection of suspected infectee in the captured images. Since the thermal camera has low resolution the face detection will not work on the picture, so the optical camera is used to obtain the clear face of people. The GPS module is used for obtaining the location of the system. This module will return the data of its location in latitude and longitude. This point represents the location point where this module exists. The gathered data from modules (AMG8833, OV7670, and GPS Module) will be uploaded by the Wi-Fi module (ESP8266) to cloud storage. In this implementation, while Firebase real time database will be used for store the obtained data.

3. Result and Discussion

Every result of the modules was processed in order to get the information temperature of every people in the captured image. These processes cover the face detection implementation and thermal array matching to gain this information. The captured image by OV7670 is in 640x480 pixel which contains 307200 pixel that hold the colour value. The machine learning algorithm that detect people face will go through the image and return the square polygon of the detected face. The algorithm will return the centre point of the detected face in x and y of the pixel image. In addition, the detected faces will be matched to the thermal data to obtain the temperature value of that area. The point then will be matched to the array to get the estimation temperature of that pixel. The algorithm for face detection uses ML Kit, the SDK that provide machine learning process for mobile device. ML Kit is a mobile SDK that brings Google's machine learning expertise to the Android and iOS apps in a powerful which easy-to-use package. The algorithm will return the detected face area and the centre point of that area. The result of the face detection process using firebase ML Kit machine learning model is shown in the Figure 2. The blue dot inside the coloured square is the centre point of the detected face. The centre point of the detected face will contain the pixel to match it to the thermal array from thermal image.

Figure 2. **The configuration of hardware for thermal screening**

The thermal image is stored in the form of array with the temperature value of every pixel. Since the image has 8x8 pixel resolution, the total data in the array is 64 values. Each pixel in the thermal image will represent the temperature of the set of pixels in the optical image. Since the optical image has 640x480 pixel, the area covered by the thermal image will be 480x480 to have the same scale between those two images. The set up of both cameras are needed to be done, so they capture the same angle of image. Hence, the cropped image with 480x480 pixel is performed in the centre of the optical image. Figure 3 shows the covered optical image which is only on 480x480 pixel size. This means that one pixel of thermal image covered and give estimation temperature of 60x60 pixel in the optical image. The algorithm will match every detected centre point of the face to the thermal array that cover that face area using the following equation. The equation will calculate the returned centre point in x and y pixel location of the optical image to be converted to the pixel in the thermal image which contains the temperature for that area.

$$CentrePoint\ (x,y) = \left(\left\lfloor \frac{x}{60}, \frac{y}{60} \right\rfloor \right) \quad \text{(Equation 1)}$$

In example (Figure 3), if the point is detected in the 224 of x (column) and 92 y (row). The covered area of the thermal array only on the 480x480 pixel of the optical image, so the uncovered area by thermal array is 80 of x in each of the left and right side. Based on this, the centre point is tuned to the new point (144, 92) by subtract 224 with 80 since that the uncovered area. The new centre point then proceeded by the equation 1. This following equation will determine which thermal array that represent the optical image temperature. The result will return (2,1) means that the temperature represent the image in the 2nd row and 3rd column since the matrix array index always start from zero. The temperature value will be retrieved from that index as the temperature that represent the point. The Figure shows the temperature in the 2nd row and 3rd is 38 Celsius, then it can be concluded that the temperature in the detected face is 38. Furthermore, this step is done to all the detected face in the picture, where the detected face in the uncovered area will not be considered.

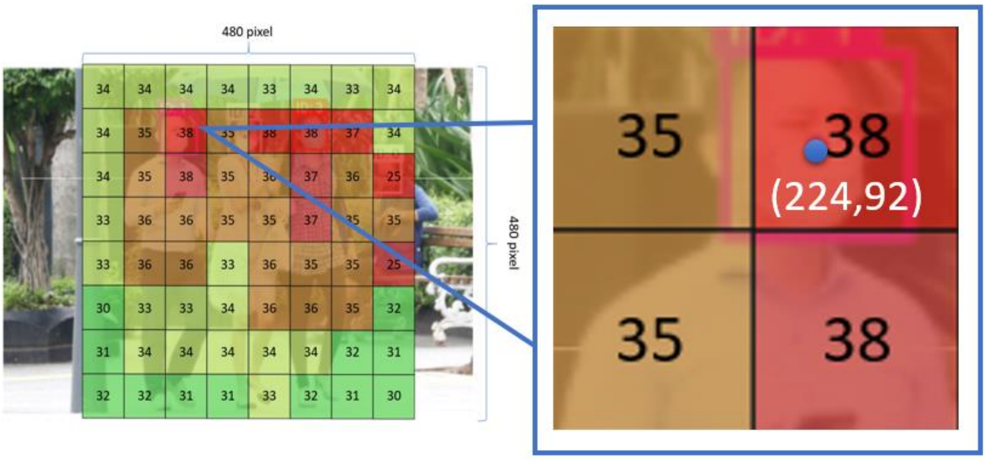

Figure 3. **The configuration of hardware for thermal screening**

Calibration of the hardware or module aims to check if the parts that assembled in the microcontroller is working correctly or not. The calibrated modules are thermal camera, optical camera and GPS module. The calibration process is a way to check if the result matched the expected one mentioned in the datasheet or the existed device. The AMG8833 may detect human up to 7 meters based on the datasheet [14], it can measure temperatures ranging from 0°C to 80°C (32°F to 176°F) with an accuracy of ± 2.5°C (4.5°F). Calibration process is performed by comparing the actual temperature obtained by IR thermometer with the obtained value of the array. The object with certain temperature value is measured by IR gun at one point and that point also compared to the array that cover the point to check the temperature. The testing process is performed in several situation. The thermal camera evaluates the temperature of the object in several defined distances at the same time with the IR gun that measure the temperature as well. AMG8833 is able to detect human up to 7 meters so the measured distance start from 1 metre to 7 meters with interval 1 metre for every tested situation. The obtained result is compared to the temperature that measured by IR thermometer. The expected difference is within ± 2.5°C since it was the accuracy defined by the thermal module. Table 1 shows the testing of thermal camera module in several distances. The table incudes the temperature of the object measured by thermal camera module (AMG8833) and the IR thermometer. The Differences of the measured temperature of both devices is also presented. It is found that the largest different or error is 2.3°C and the smallest difference is 0.8°C. The measured temperature by AMG8833 is lower than the temperature that measured by IR Thermometer. This difference is the value that needs to be added to the AMG8833 in order to satisfy the temperature measurement by IR thermometer. In the program implementation, the measured temperature by AMG8833 found to be slightly smaller, so some value needs to be added to the result to satisfy the actual temperature. This measured temperature by the AMG8833 can be slightly different from the IR Thermometer, since AMG8833 have the accuracy of ± 2.5°C. This means that the error of the measured temperature by AMG8833 can be lower or higher by 2.5°C value compared to the actual temperature of the object. The default resolution at which the AMG8833 operates is 8×8 (64 pixels) for the image obtained at this resolution when index finger is placed in front of the sensor as shown in Figure 4. The developed system is displaying the rounded temperature and the decimal value can also be displayed.

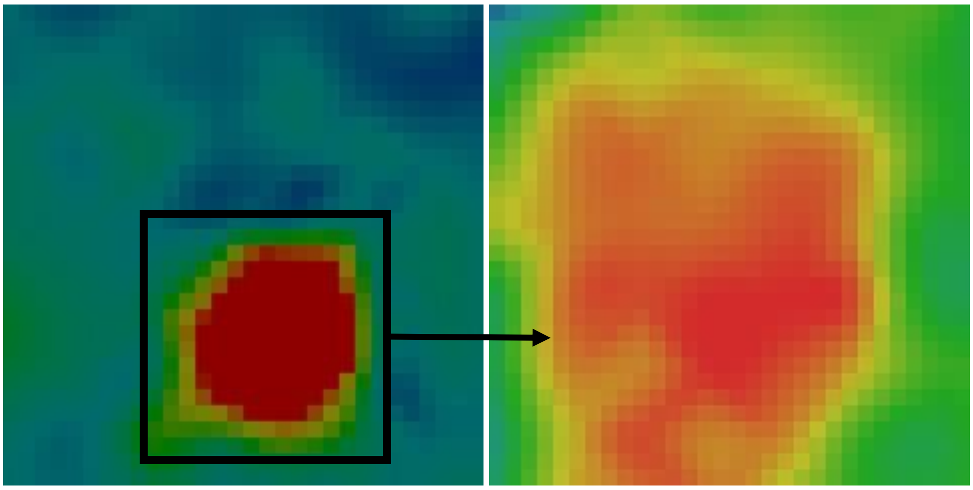

Figure 4. **Thermal image of person is placed in front of the camera**

Table 1. **The Thermal Camera Result Testing**

Distance (meter)	AMG8833	IR Thermometer	Difference
1	37.5°C	38°C	0.8°C
2	36.5°C	37.8°C	1.3°C
3	36.5°C	37.4°C	0.9°C
4	35.8°C	36.8°C	1°C
5	35°C	36.5°C	1.5°C
6	35.1°C	36.2°C	1.1°C
7	34°C	36.3°C	2.3°C

A person who identified to have fever is someone with body temperature above 38°C based on the identification in patients of Covid-19 [15] and SARS [16]. Since the accuracy of the thermal module is ± 2.5°C the data might not accurately identified. The calibration process of the thermal camera module found that the highest temperature difference between AMG8833 and the IR thermometer is 2.3°C. So, the setting of the system in deciding whether someone has high body temperature is defined as high temperature (38°C) plus the deviation or the accuracy of the thermal module in the calibration process which is 2.3°C. The temperature that decided a person to have a fever is 40.3 °C using the screening device that proposed. The capture image along with the detected temperature of people is stored in the firebase that can be accesses by other device such as phone, tablet or computer for monitoring purposes.

4. Conclusion

Covid-19 is the global pandemic that has become big concern for many nations around the world. Potential vaccines and certain particular medicine treatments are still under investigation and now being subjected to comprehensive test by leading medical research centres. However, to press the impact of Covid-19 can be done by preventing it to be spread wider. Currently, infrared thermometers are being implemented everywhere to check the body temperature in places with large number of people. The thermometer gun that may become the potential for accidental transmission in the crowds of the queue and time consuming. The proposed thermal imaging system for Covid-19 detection using Iot technology is developed for rapidly detection of suspected infectee who has fever in the crowds. With help of the face detection, the device can store the result of monitoring people temperature. This device allows the mobility of the person who do the screening so the process of infectee detection can easily and rapidly done. In the future work, the fever can be detected not only from the high temperature detected, but other signs like watery eyes due to the high temperature of the body. This sign recommended to be studied to increase the accuracy on detecting the suspected infectee.

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