Development of a temperature detector and room capacity system to mitigate the spread of COVID-19

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Abstract. Several efforts to mitigate the spread of COVID-19 and use a minimum of three layers of masks, it is also necessary to apply physical distancing in all work activities both indoors and outdoors. This study describes one of the efforts that researchers can do to prevent the spread of COVID-19, namely, designing a room capacity detection system equipped with a temperature detector. The research method is an experiment focusing on a temperature detector and room capacity system design. This system uses ultrasonic sensor HCSR04, temperature sensor MLX90614, PIR sensor (Passive Infra-Red) HCSR501, and infrared barrier sensor based on Arduino UNO to measure temperature and count the number of visitors in a room. The system designed based on Arduino UNO has worked well, where the system can detect the body temperature of building visitors and detect the number of visitors entering and leaving the building. The test results show that the temperature measurement on the forehead has a higher accuracy with an error of 1.17%. The results of this study will be used to design automatic door designs to mitigate the spread of Covid-19 in offices.

1. Introduction
The Covid-19 pandemic is still engulfing the world with the number of positive cases continuing to grow to more than 198 million and claiming more than 4.2 million lives worldwide [1]. This pandemic is caused by a new type of coronavirus with the name Severe Acute Respiratory Syndrome Corona Virus (SARS-CoV-2) [2]. This virus is one of the main pathogens that attack the human respiratory system [3]. COVID-19 spreads very quickly, especially in public places because this virus can be transmitted from human to human through respiratory droplets produced during coughing [4]. Respiratory droplets can spread up to 2 meters and settle on various surfaces, where they can persist for hours or even days [5]. The infection is transmitted either by inhaling droplets or touching a contaminated surface and then touching the nose, mouth, or eyes.

There are four types of COVID-19 patients: asymptomatic, mild, moderate, and severe [6]. Fever, dry cough, diarrhea, difficulty breathing (dyspnea), headache, and pneumonia are the most common symptoms of COVID-19. Monitoring body temperature is critical, especially for the early detection of suspected COVID-19. SARS-CoV-2 can be stable in infected patients for up to 4 days [7]. The stability of this virus at conditions around average body temperature implies that temperature can play a crucial role in the transmission and severity of COVID-19. Various body temperature measuring instruments (thermometers), both contact and non-contact, are available and easy to obtain. However, because this virus can be transmitted through fluids released by the patient's body, it is recommended to use a non-contact clinical electronic thermometer to measure body temperature. In this COVID-19 pandemic, non-
contact handheld infrared thermometers (thermogun) are often used to check fever. This thermometer has the advantage of being a rapid, non-contact, and easy-to-use fever screening [8].

As an effort to mitigate the spread of COVID-19, apart from using a minimum of three layers of masks, it is also necessary to implement physical distancing in all work activities both indoors and outdoors. This of course has an impact on the decrease in the capacity of a room. Based on the Instruction of the Minister of Home Affairs of the Republic of Indonesia Number 3 of 2021, it has been determined that during PPKM (Enforcement of Restrictions on Community Activities) a workspace can only be filled with a maximum of 50% of normal capacity. So, it is necessary to have a room user capacity detector to ensure the number of users does not exceed the established rules. To calculate the number of users entering and leaving a room, ultrasonic sensors [9], infrared sensors [10] -[11], Quick Response Code technology [12].

This article describes a room capacity detection system equipped with a temperature detector. The results of this study will be used in the design of automatic door designs as an effort to mitigate the transmission of Covid-19 in offices.

2. Method
The research method is an experiment focusing on designing a temperature detector and room capacity system design. This system uses ultrasonic sensor HCSR04, temperature sensor MLX90614, PIR sensor (Passive Infra-Red) HCSR501, and infrared barrier sensor based on Arduino UNO to measure temperature and count the number of visitors in a room. The system consists of 2 separate parts that are connected by cables. Part 1 device consists of Arduino UNO R3 microcontroller as a data management center, temperature sensor MLX90614, ultrasonic sensor HCSR04, and PIR sensor HCSR501. The Part 1 device is placed at the front door and functions as a temperature gauge for visitors, and automatically counts the number of visitors entering the room. When a visitor is detected, the MLX 90614 temperature sensor as a body temperature gauge will measure the visitor's body temperature, which is in the ultrasonic sensor range. In comparison, the second part of the device uses PIR and infrared sensors to detect and count the number of visitors leaving the room. All sensors used in this device are characterized to determine the measuring range of the sensor. The sensor characterization was conducted by comparing the output sensor and the standard laboratory equipment.

3. Result and Discussion
The temperature sensor and proximity sensors are previously characterized to obtain more accurate measurement results of the device. The following presents the results of a temperature sensor, PIR sensor, ultrasonic sensor, and infrared sensor characterization, as well as the results of the device measuring on some parts of the human body.

| Distance (cm) | MLX90614 Temperature Sensor Output (°C) | Average of output Sensor (°C) |
|--------------|----------------------------------------|------------------------------|
| 0.2          | 35.07 35.27 35.51 35.45 35.47 35.51 35.15 35.19 35.21 35.37 35.320 |
| 0.4          | 35.37 35.31 35.19 35.55 35.29 35.39 35.29 35.29 35.43 35.15 35.330 |
| 0.6          | 35.23 35.01 35.07 35.29 35.09 35.21 35.31 35.31 35.09 35.15 35.176 |
| 0.8          | 35.07 35.15 35.37 35.29 35.31 35.29 35.31 35.39 35.43 35.37 35.298 |
| 1            | 35.15 35.27 35.35 35.23 35.31 35.15 35.13 35.13 35.01 35.09 35.182 |
| 1.2          | 34.05 34.13 34.15 34.21 35.09 35.07 34.15 34.13 34.15 34.15 34.528 |
| 1.4          | 34.23 34.19 34.21 34.13 34.19 34.21 34.21 34.13 34.21 34.15 34.186 |
| 1.6          | 34.09 34.39 34.15 34.19 34.27 34.23 34.01 34.09 34.05 34.19 34.166 |
| 1.8          | 34.01 34.19 34.21 34.01 34.07 34.05 34.09 34.21 34.35 34.07 34.126 |
| 2            | 34.05 34.01 34.21 34.21 34.09 34.15 34.21 34.07 34.09 34.05 34.114 |
3.1. Characterization of MLX90614 temperature sensor
The MLX90614 sensor is a sensor that is used to measure temperature by utilizing infrared radiation. The MLX90614 sensor is designed to detect infrared radiation energy and calibrate infrared radiation energy into a temperature scale. In this study, the sensor characterization was carried out to optimize the sensor measurement distance range and determine the accuracy of the sensor measurement results against a standard measuring instrument, namely the forehead thermogun of the Omron Mc 720 type. The measurement results are shown in Table 1. The data in Table 1 show that the optimal distance from the MLX90614 temperature sensor reading is 1 cm from the object. Based on these results, the sensor calibration was then carried out by repeatedly measuring the temperature of five different things at 1 cm using a sensor and a forehead thermometer. Graph plotting was carried out to find out the relationship between the sensor output and the forehead thermogun (Figure 1).

![Characterization of Temperature Sensor](image)

**Figure 1.** Curve of temperature sensor’s characterization

Based on the results of plotting the curve in Figure 1, there are differences in the measurement results between the temperature sensor and the thermogun. So that a correction is made in the readings at the temperature sensor output on the microcontroller using equation 1, namely:

\[ y = 0.8864x + 5.3505 \]  

(1)

Where \( x \) is the result of measuring body temperature using a temperature sensor (\(^\circ\)C), and \( y \) is the result of the conversion of body temperature measurement (\(^\circ\)C) to determine the accuracy of temperature measurement, the measurement error is calculated using equation (1). The results are shown in Table 2. There is an average deviation of 0.265%.

**Table 2.** The error of the MLX90614 temperature sensor measurement

| Calibration |         |         |         |         |
|-------------|---------|---------|---------|---------|
| Sensor (\(^\circ\)C) | Termogun (\(^\circ\)C) | Result(\(^\circ\)C) | Error (%) |
| 34.518      | 36      | 35.947  | 0.147   |
| 35.192      | 36.3    | 36.545  | 0.674   |
| 35.242      | 36.7    | 36.589  | 0.302   |
| 35.404      | 36.8    | 36.733  | 0.183   |
| 37.278      | 38.4    | 38.394  | 0.016   |
| **Average** |         |         |         | **0.265** |

3.2. Characterization of PIR sensor
The HCSR501 PIR sensor is used to detect infrared radiation emitted by an object. The PIR-sensing element is responsive to mid-and far-infrared radiation within a spectral range from approximately 4 to 20 m [13]. This Passive Infrared sensor technology is critical for detecting human presence [14] because
humans produce infrared radiation with wavelengths between 9-10 m. The characterization of the HCSR501 PIR sensor with a length measuring instrument aims to find the farthest range of sensor readings. The data obtained are shown in Table 3. From Table 3, the PIR sensor used can work optimally to detect objects in the distance range of 5 - 30 cm.

### Table 3. Characterization of the HCSR501 PIR Sensor

| Distance (cm) | Object    |
|--------------|-----------|
| 5            | Detected  |
| 10           | Detected  |
| 15           | Detected  |
| 20           | Detected  |
| 25           | Detected  |
| 30           | Detected  |
| 35           | Undetected|
| 40           | Undetected|

3.3. Characterization of Infrared barrier Sensor

The infrared sensor is composed of infrared LEDs as infrared transmitters and phototransistors as infrared light receivers. An infrared sensor has a function to detect objects when objects block infrared light. Distance characterization is carried out to determine the farthest distance from the sensor reading. The infrared sensor output is affected by the colour barrier that interferes with the radiation from the infrared LED. So that two types of barriers colours are used, namely white screens and red screens. Observations were made repeatedly, each at 1 - 20 cm with an interval of 1 cm. The data (Table 4) show that for white barriers, the sensor can detect obstructions up to 14 cm, while for red barriers, the sensor can work to detect obstructions up to 12 cm.

### Table 4. Characterization of the HCSR501 PIR Sensor

| Distance (cm) | White Object | Coloured Object |
|--------------|--------------|----------------|
| 1            | Detected     | Detected       |
| 2            | Detected     | Detected       |
| 12           | Detected     | Detected       |
| 13           | Detected     | Undetected     |
| 14           | Detected     | Undetected     |
| 15           | Undetected   | Undetected     |
| 16           | Undetected   | Undetected     |

3.4. Characterization of Ultrasonic Sensor

This characterization was conducted to determine the range of the sensors and identify the ultrasonic sensor's resolution [15]. Measurements were only carried out from the closest to the furthest distance and the farthest distance to the most relative distance with variations in lengths of 5, 10, 15, 20, 25, and 30 cm, with three repetitions. The measurement results are shown in Figure 2. From the results of the characterization of the ultrasonic sensor HCSR04, the average error of the sensor reading is 1.094%. This value has increased from the results of the ultrasonic sensor calibration, which has a relative error value of 2.02% [16].
3.5. Device Trial
The system testing phase is carried out to determine the operational capability of the device. The test results show that the part 1 device can detect the body temperature of visitors and count the number of visitors who enter the building automatically. In comparison, the part 2 device can automatically count outgoing visitors. Indoor capacity is limited to a maximum of 50 visitors. If the power exceeds, there will be a warning in the form of a buzzing sound, and the sentence "Capacity is Full". The LCD will display the results of measuring the visitor's body temperature and the remaining room capacity, as shown in Figure 3. To determine the accuracy of the measurement tools, measurements are made in several different parts of the body surface, namely the forehead, right hand, left hand, and cheeks. The test results show that the forehead temperature measurement has a higher accuracy with an error of 1.17%.

4. Conclusions
A Temperature Detector and Room Capacity system has been successfully built using an ultrasonic sensor HCSR04, temperature sensor MLX90614, PIR sensor HCSR501, and an Arduino UNO-based infrared barrier sensor that works well in detecting the body temperature of building visitors and noticing the number of visitors entering and leaving the building.
Acknowledgments
The authors wish to thank the colleague in the Department of Physics for very helpful comments on an earlier draft of this paper. Also, the authors acknowledge the valuable supports of Universitas Negeri Jakarta in this research.

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