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# Automatic temperature detector to mitigate the spread of COVID-19

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Abstract — COVID-19 causes a wide impact on business operations. The enterprise must mitigate the risk of COVID-19 spreading in its environment. The monitoring of the body temperature of employees can be applied as a method to prevent COVID-19 spread. However, the monitoring system must consider several factors such as a contactless system, accountability, and simplicity. The integration between the IR temperature sensor and the attendance system based on ESP32 can provide those needs. The thermal camera and face recognition for monitoring body temperature and attendance of employees actually had been implemented. However, it needs a high-cost and complex system. The use of proximity, IR, and RFID sensors is affordable to detect body temperature properly within 10 cm. The proposed system provides notification if the user gets a fever or suspects COVID-19 by detecting the body temperature. The accuracy of the sensor is adequate. It is based on the comparison testing between the proposed system and with body thermometer where the testing is performed 30 times for each condition. To deduce the comparison result, this study uses the analysis of variance method. The analysis produces F-critical (4,006) greater than F-value (0,022) which means that the proposed system and body thermometer have similar testing results. It is shown good accuracy for the proposed system.

Keywords – ANOVA, attendance system, COVID prevention, IR sensor, temperature detection



## I. Introduction

The spread of Coronavirus (COVID-19) was very massive so The World Health Organization (WHO) announces it as a pandemic [1]. Many countries get impacted by this pandemic. Hence, several countries perform activity restrictions to reduce the spread of COVID-19. However, those activity has an economic impact [2], [3]. Therefore, the government opened business activities to increase economic conditions with several requirements [4]. Social distancing and temperature checks are mandatory steps that must be conducted when people want to enter business areas such as offices, supermarkets, *etc*.

There are many tools to check body temperatures such as thermometer guns and thermal cameras. However, a thermometer gun requires an operator to operate these tools and the thermal camera has quite an expensive price. Even though, a thermal camera is more effective than a thermometer gun because there is no need for interaction at a close distance between the operator and user.

In the office area, integration of a temperature check system and employee attendance system should be performed to prevent the spread of COVID-19 and monitor the health and attendance of employees [3]. However, the system must reduce the interaction between employees to other employees or operators, so it can prevent COVID-19 transmission. The previous system uses a thermal camera and face recognition to monitor the body temperature and attendance of employees [5], [6]. It needs a high-cost and complex system [7]. The problem is several companies need a simple system with low cost to prevent COVID-19 spread. Therefore, this study has the objective of developing a simple and low-cost integrated system for monitoring the attendance and temperature of employees.

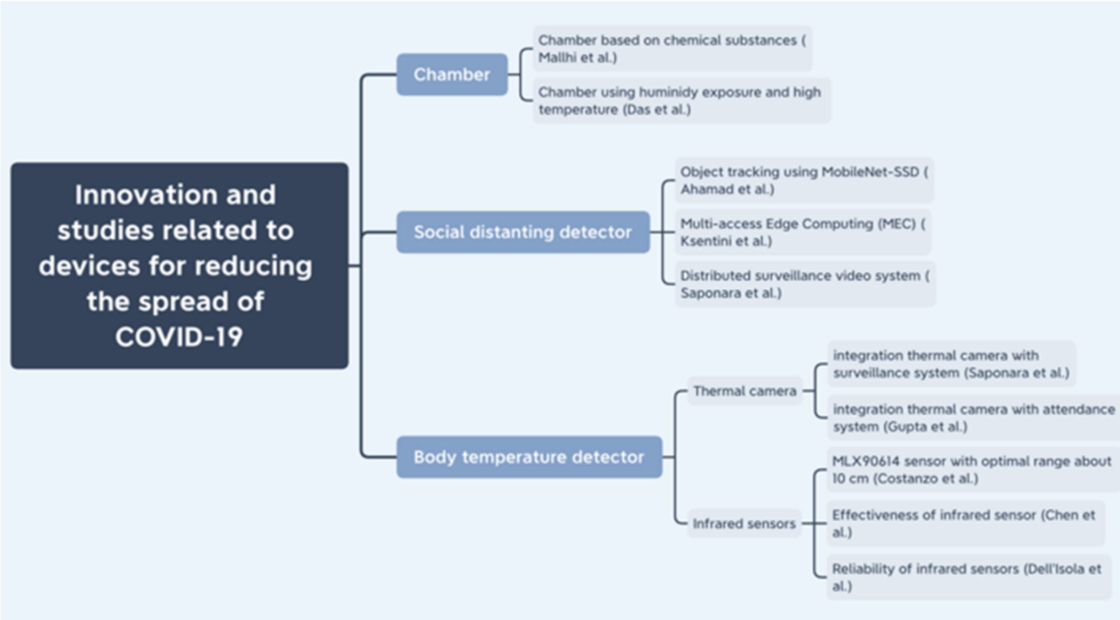


Fig. 1. The innovation and studies of devices for reducing the spread of COVID-19.

To achieve the objective, the paper is organized as follows: section II discusses the previous related works, section III elaborates on the material and method for solving the problems of this study, sections IV and V are the result and discussion, respectively, where it shows hardware implementation, testing, and data analysis. Finally, section VI concludes the paper.

## II. Related Work

In facing COVID-19, many studies develop devices to prevent the spread of COVID-19. Chamber is one of the devices where it is made to disinfect daily wear things such as clothes. During the early COVID-19 pandemic, many companies used chambers based on chemical substances such as chloroxylenol, sodium hypochlorite, and chlorine [8]. However, the use of chemical substances in the chamber becomes controversial because these substances are harmful to the human body [9]. Now, the disinfectant chamber is modified using humidity exposure and high-temperature heating [10].

In social distancing programs, there are systems built to detect the distance between people. Several approaches are used to develop these systems, such as object tracking using MobileNet-SSD (Single Shot Multibox Detector), multi-access edge computing (MEC), and distributed surveillance video systems. In MobileNet-SSD, the distance between objects was detected by creating a segmentation area [11]. This system still has a limitation when it applies in an outdoor area. MEC system uses GPS data from a smartphone as an object sign [12]. The data are collected in a server and analyzed by an algorithm to determine the distance between objects. In the distance detection system using distributed surveillance video, a thermal camera was used to obtain the video and picture [13]. Deep Neural Network (DNN) was involved to analyze the distance between objects.

For early prevention, the researchers also developed a system to measure body temperature. The body temperature is early data to determine a suspect of COVID-19. Even though, this procedure still needs a long examination until a person is stated positive for COVID-19. People will be categorized as fever or suspect of COVID-19 if their body temperature is above 37 °C [6], [14]. In several studies, there are two devices used to develop body temperature detection systems, *i.e.*, thermal cameras and infrared sensors. Integration of thermal cameras with other functions to prevent the spread of COVID-19 has been conducted in several studies such as the implementation of thermal cameras in social distancing functions [13] and the thermal cameras in the attendance system [15]. However, the use of infrared sensors as a body temperature detector is also applied in many studies because this device is cheaper than a thermal camera [7]. Moreover, it has good precision [14]. In the previous implementation, the body temperature detector involving MLX90614 infrared sensor is optimal in the range of 10 cm [16]. Furthermore, the infrared sensor has good measurement reliability where it only has uncertainty between 0.20 °C - 0.62 °C. This uncertainty is affected by several variables such as body site, the instrument of measurement, environmental conditions, and procedure [17].

In the explanation above, we can arrange several innovations and studies related to the development of devices for reducing the spread of COVID-19. These studies can be shown in Fig. 1.

In this study, we develop an integrated system for monitoring the attendance and temperature data of employees. The differences in the studies above are

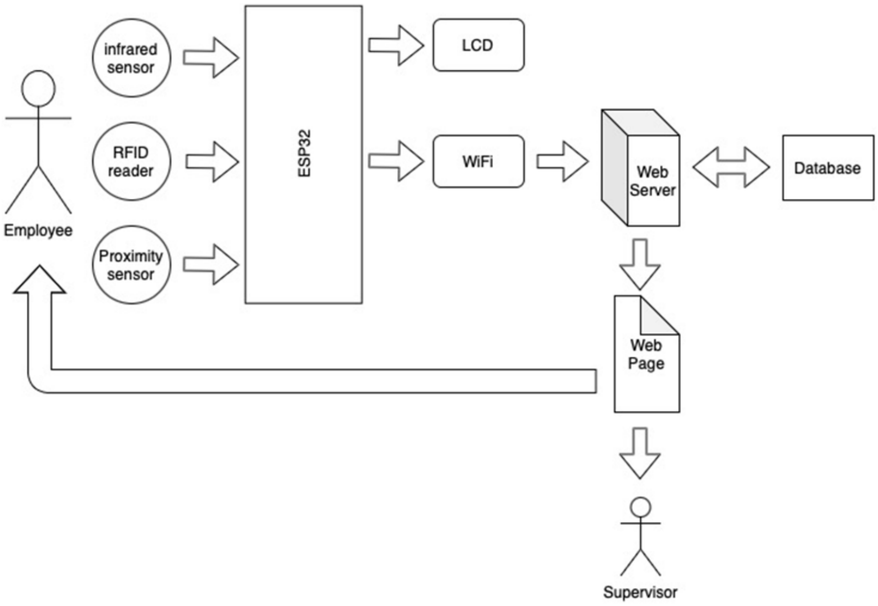


Fig. 2. Design of an integrated system for monitoring attendance and temperature of employees.

related to the cost to build the system and procedure. In the previous study, the system was built based on a thermal camera and used face detection to identify body temperature and employee attendance. This system needs complex hardware and high costs. Therefore, we propose the integration of infrared sensors as body temperature detectors and an RFID system as an employee attendance identifier. The procedure is required to accompany employees as a user in using the system properly. Several devices are applied in the system to support the procedure such as a display, buzzer, and proximity sensor.

## III. Materials and Methods

This section discusses the system design and the algorithm.

### A. System Design

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The system is developed by integrating two subsystems namely the temperature body check subsystem and the attendance subsystem. RFID card as an employee's ID card is used to activate the temperature body check subsystem and attendance subsystem. The output is saved in a database. In order to accommodate this function, the integrated system requires a system design that involves several devices as in Fig. 2.

The integrated system is built by involving an RFID reader, ultrasonic proximity sensor, and infrared sensor to obtain input data from the user. We use MLX9061 as an infrared sensor and HC-SR04 as an ultrasonic proximity sensor [18], [19]. The output is displayed on LCD and stored in a database server. In order to send the data output, we utilize the Wi-Fi module in ESP32 [20].

The system is built using the ESP32 DEVKIT V1 module which has multiple GPIO pins, two pairs of serial communication pins, and RTC [21], [22]. This hardware can also supply other embedded modules with 5 V and 3.3 V. To integrate sensor modules and output modules, ESP32 DEVKIT V1 uses a pinout part to connect with HC-SR04, MLX9061, RFID-RC522, and OLED. The hardware scheme of the proposed system is shown in Fig. 3.

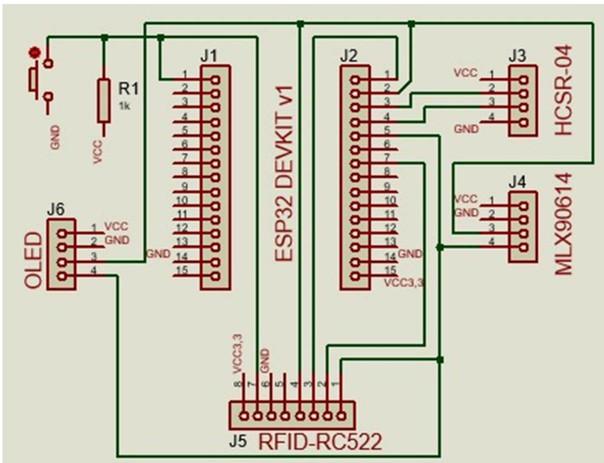


Fig. 3. The hardware scheme.

### B. Algorithm

The system interacts with two actors, *i.e.*, the employee and supervisor. The supervisor is part of the

Fig. 4. The hardware implementation.

management who monitors the attendance and health of the employee. The system also consists of two parts, *i.e.*, the embedded system part and the server part. In order to describe the interaction of employees with the proposed system, we represent the process in Algorithm 1.

**Algorithm 1** The detection process of temperature

```
VARIABLE
employee_id, notif_lcd TYPE string
dst, notif_sound, tempr TYPE integer
BEGIN
employee_id ← READ(rfid_tag)
notif_sound ← sound
notif_lcd ← lcd
IF employee_id exist THEN
    dst ← READ(user-system)
    IF dst > 10 THEN
        OUTPUT(notif_sound, notif_lcd)
    ELSE
        IF temperature > 37 THEN
            OUTPUT(notif_sound, notif_lcd)
        ELSE
            OUTPUT(notif_lcd)
        END IF
        tempr ← READ(temperature)
        db ← [employee_id,tempr]
    END IF
ELSE
    OUTPUT(notif_sound, notif_lcd)
END IF
END
```

In Algorithm 1, the proposed system detects the distance of the user and gives a warning if the distance is more than 10 cm. It is caused by the temperature sensor working properly within 10 cm [16]. The proposed system also gives a warning in sound and notification through LCD if the user temperature is more than 370C because this condition is categorized as fever or suspect of COVID-19 [6], [14]. In all conditions, the data of user ID and temperature are always saved in a database to ease monitoring the health and attendance of the user. The proposed system also provides the web as a monitoring interface.

### C. *Testing Analysis*

In order to find out the performance of the proposed system, this study compares the proposed system with the general system to measure temperature such as a body thermometer. The accuracy becomes variable to assess comparison. If the output of the proposed system has a similar result to the body thermometer, it has good accuracy. Otherwise, the proposed system has bad accuracy if it has a significant difference. The one-way analysis of variance (ANOVA) method is involved to analyze the data output of both systems. This method measures the difference between two data using variance by building two hypotheses, *i.e.* null hypothesis and alternate hypothesis [23]. The ANOVA involves two components namely within-group variability and between-group variability [24]. The procedure of ANOVA consists of four steps:

1) Hypothesis determination.
2) Significance level determination.
3) F-test.
4) Decision.

## IV. Result

In this study, the hardware system was built by integrating several components such as an RFID reader, sensors, ESP32, and LCD display. The hardware system functions as an authenticator and data collector. RFID system activates the sensors to obtain data temperature from the user and send it to the server through the Wi-Fi connection. The hardware system can be shown in Fig. 4.

The hardware system also has an ultrasonic proximity sensor to detect the distance between the user and the hardware system to optimize temperature sensor detection. If the distance is more than 10 cm, the hardware will send a notification through an LCD display like in Fig. 5 (a). Otherwise, if the sensor is able to get the user's temperature, the LCD display will show the temperature value as in Fig. 5 (b). The complete check for the system is shown in Fig. 5 (c).

## V. Discussion

To estimate the accuracy of the system, we compare the result from the proposed system with a body thermometer. We use 30 samples from the output of the proposed system and body thermometer to show the measurement performance of each tool. In each measurement sample, we use the same person and environment to keep the consistency of testing [25], [26]. The comparison result is shown in Fig. 6.

We use one-way analysis of variance (ANOVA) to find out the difference in result between the thermometer and the proposed system. Two hypotheses are built to represent the condition namely null hypothesis ($H_0$) and alternative hypothesis ($H_1$). The null hypothesis states

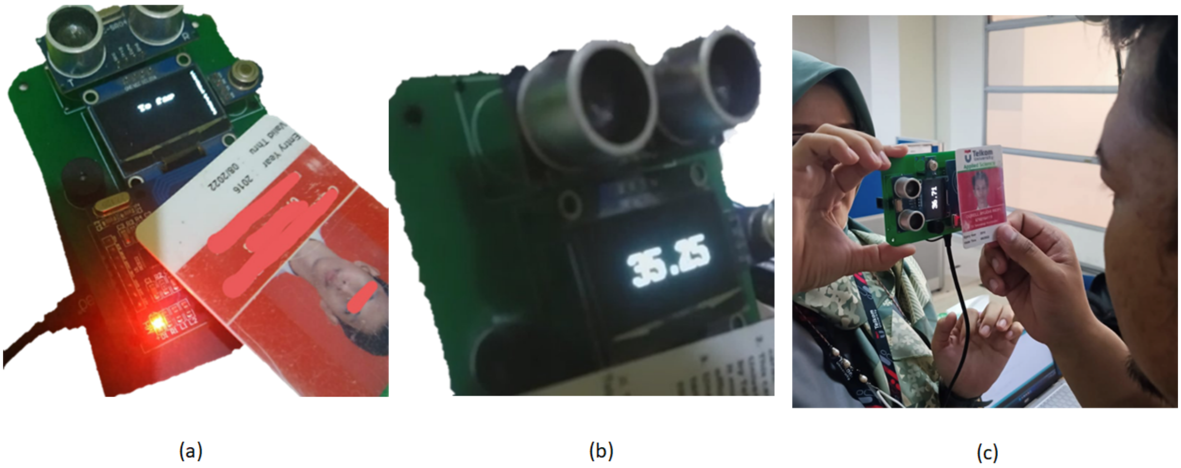


Fig. 5. The process: (a) distance detection from hardware system, (b) displays the temperature value, and (c) complete check.

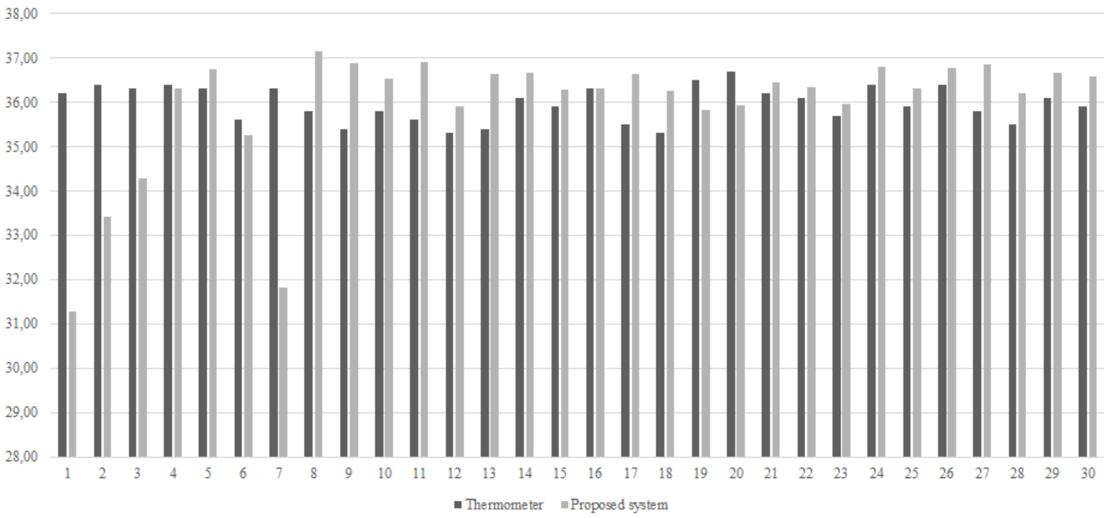


Fig. 6. The comparison result between the thermometer and the proposed system.

that the result of the thermometer and the proposed system is almost the same, while the alternative hypothesis states that the result has a significant difference [27]. The F-value and F-critical are computed to determine the selected hypothesis. If F-value is greater than the F-critical, the null hypothesis is rejected. Otherwise, the null hypothesis is accepted if F-critical is greater than F-value [28], [29]. To compute ANOVA variables, we use a confidence interval of 0.95 and the resulting output in Table 1.

Table 1. The Output of ANOVA

| **Parameters** | **Values** |
|---|---|
| Sum of Squares (SS) for between-groups variability | 0.024 |
| Sum of Squares (SS) for within-groups variability | 62.835 |
| Sum of Squares (SS) Total | 62.859 |
| Degrees of Freedom (df) for between-groups variability | 1 |
| Degrees of Freedom (df) for within-groups variability | 58 |
| Degrees of Freedom (df) Total | 59 |
| Mean Squares (MS) for between-groups variability | 0.024 |
| Mean Squares (MS) for within-groups variability | 1.083 |
| F-value | 0.022 |
| F-critical | 4.006 |

Based on the result from Table 1, F-critical is greater than F-value. It builds the decision that the null hypothesis ($H_0$) is accepted, and the alternative hypothesis is rejected. It means that the proposed system and thermometer produce a similar result which represents that the proposed system has good accuracy.

## VI. Conclusion

The business operation started activities during the pandemic COVID-19 period. The people have interacted to conduct their jobs. To mitigate COVID-19 spreading in the work environment, enterprises require to use tools for detecting the health parameter of employees like temperature. However, the temperature detector must be contactless and accountable. These problems can be solved by implementing an integrated system for detecting temperature and attendance system. The employee temperature must be mapped in the employee ID and recorded in the database. The monitoring process is performed using the website that is connected to that database. The implementation of these processes can be built using ESP32, sensors (proximity, IR), RFID reader module, Wi-Fi module, and server (web server, database). In order to measure the performance of this system, this study compares the proposed system with a body thermometer. The analysis of comparison data is performed using ANOVA. Based on the result of the F-test, the proposed system has a similar output to the body thermometer. It indicates that the proposed system has good accuracy in measuring body temperature.

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