Low Cost Non-Contact Rapid Body Temperature Screening using Thermal Camera for Early Detection of Covid-19 Suspect

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***Abstract*— The Corona virus disease 2019 (Covid-19) pandemic is serious infectious disease caused by the outbreak of the corona virus or SARS-CoV-2. The new adaptation or the term New Normal, is an idiom that has been talked about recently as recovery phase policy. The definition of new normal is a scenario to accelerate the handling of covid-19 in the health and socio-economic aspects. However, since new normal phase is implemented in various sectors the number of covid-19 confirmed cases were rapidly increased. This condition occurred allegedly as a result of low public awareness and enforcement of regulations by the government of new normal protocol. Symptoms with a body temperature above 37,5^0 C can be categorized as suspected of covid-19. Therefore, rapid body temperature may be used as early screening of covid-19 suspect. Many location use staff equipped with thermometer gun for screening the visitor body temperature. This scenario has drawbacks since there is closed contact between staff and visitor within body temperature screening which may cause the spread of the virus. This paper present low cost non-contact rapid body temperature screening using a thermal camera that integrate with barrier gate. Therefore, there is no staff needed for body temperature screening since visitor may check their body temperature independently. The results show the the proposed system work properly for visitor body temperature screening with the accuracy is 98,75%.**

Keywords—covid-19, screening, low cost, non-contact, rapid body

I. Introduction

The Corona virus disease 2019 (Covid-19) is serious infectious disease caused by the outbreak of the corona virus or SARS-CoV-2. The covid-19 become global pandemic that is infected worldwide in total 222 countries with a total of 72,851,747 confirmed positive cases and 1,643,339 deaths [1]. The Covid-19 not only has an impact on health problems but also on many other sectors such as transportation, education, tourism and of course the economic sector. Like other flu viruses that have had an outbreak, the growth of the corona virus can be suppressed by restricting mobility. The governments worldwide have made various policies on restricting mobility by close schools, universities, markets and public crowd. Its success in reducing the number of Covid-19 cases is greatly influenced by the awareness of the population and the firmness of the government in enforcing regulations. In Indonesia, the handling of covid-19 is carried out by Satuan Tugas Penanganan COVID-19 (the Task Force for Handling COVID-19). According to data accessed on the official website http://covid19.go.id on December 17, 2020, there were 643,508 positive patients, 526,979 recovered patients, and 19,390 deaths in Indonesia [2]. Therefore, Large-Scale Social Restrictions (PSBB) taken by the government obliged the cessation of operations in various sectors in order to reduce the covid-19 cases.

The new adaptation or the term New Normal, is an idiom that has been talked about recently as recovery phase policy. The definition of new normal is a scenario to accelerate the handling of covid-19 in the health and socio-economic aspects. The Indonesian government has announced plans to implement the new normal scenario taking into account epidemiological studies and regional preparedness. The new normal protocol consists of social/Physical Distancing, wearing mask, and washing hand with soap [3]. Under the new normal policy various sectors have implemented the new normal protocol to resume their activities. The management obliged the visitor to wear a mask, provide the washstand and visitor body temperature screening. However, since new normal phase is implemented in various sectors the number of covid-19 confirmed cases were rapidly increased. This condition occurred allegedly as a result of low public awareness and enforcement of regulations by the government of new normal protocol.

The most common symptoms of covid-19 are fever, dry cough and feeling tired. Other symptoms that some patients may experience include aches and pains, nasal congestion, headache, conjunctivitis, sore throat, diarrhea, loss of taste or smell, rash on the skin, or discoloration of fingers or toes [4]. The symptoms experienced are usually mild and appear gradually. Some people become infected but have only mild symptoms. Symptoms with a body temperature above 37,5º C can be categorized as suspected of covid-19. Therefore, rapid body temperature may be used as early screening of covid-19 suspect. The suspect then may be diagnosed with advanced diagnostic tools to confirm their condition. Many location use staff equipped with thermometer gun for screening the visitor body temperature. This scenario has drawbacks since there is closed contact between staff and visitor within body temperature screening which may cause the spread of the virus.

This paper present non-contact rapid body temperature screening using a thermal camera that integrate with barrier gate. Therefore, there is no staff needed for body temperature screening since visitor may check their body temperature independently. According to covid-19 symptoms mentioned above visitor with body temperature above 37º C can be categorized as suspected of covid-19 and barrier gate will not opened and vice versa. The advantage of used thermal camera for body temperature is thermal signature can be detected even in pitch-black conditions. Thermal imaging is a detection method that increases the visibility of objects in the dark by detecting infrared radiation from objects and creating images. The way a thermal camera works is all objects that emit infrared energy as a function of temperature. Infrared energy emitted by an object is known as heat-imaging. The hotter the object, the brighter the radiation emitted, basically thermal camera works like a temperature sensor that can detect the slightest temperature.

II. Related Works

The works in studied the infrared thermography accuracy for body temperature detection. The results show that the forehead infrared thermography (IRT) temperature showed the largest discrepancy from the core temperature and was on average 3.1ºC lower. According to the study results, the age, gender and core temperature has influence for th IRT temperatures. The results show that higher body temperature accuracy using IRT is in children and teenager and less accurate for adults. Females also showed less accurate body temperature results compared to males visitor. The study results also show that ambient temperature had minor effect since 1 ºC change in ambient temperature only changes the IRT body temperature results by 0.196 ºC in average.

The works in [5] proposed an integrated sensors platform for non-contact temperature monitoring using infrared thermometer and a capacitive humidity sensor. The capacitive humidity sensor is used in order to detect the environmental parameters such as relative humidity and ambient temperature. The environmental parameters then used to create more accurate body temperature results. The work classified the body temperature into 3 categories, below 35 C considered as "low", above 38 C considered as "high"and 35 – 38 C considered as "normal". . The visitor body temperature will be measured and the results will be displayed on dot matrix LCD display.

The high level covid-19 suspect surveillance and tracking is studied in [6] with 5 main stages. The first stages are using wearable or non-wearable device to sensing several parameters about the medical health status. The collected data then transmit into multi-edge layer nodes or central hub for data computation and analytics. The appropriate action after the computation and analytics is sent to the mobile application. The stored data may be used for tracking and tracing covid-19 suspect, recommendation and assistance for the community. The work in [7] studied the possibilities of using multiple thermal sensor array in order to provide wider monitoring area. The AMG8833 thermal camera sensor being used in this paper is an 8x8 sensor with 60° field of view (FoV) [8]. The works use two thermal camera at different angle to cover wider monitoring area.

The works in [9] describe the deep learning networks for mask classification and head temperature detection. The work used RGB camera as an input for module that classified the mask. The second module is connected to thermal camera for thermal signature detection. The third module then combines the results of both modules and displayed it on the monitor. The work in [10] proposed mobile based platform for automatic forehead fever screening. The works used a 160x120-pixel FLIRONE™ thermal imaging camera with maximum frame rate of 8 fps. Based on the work results it is had 100% sensitivity and 70% specificity for screening high temperature patients. The results also show that the thermal imaging accuracy also affected by ambient temperature. The work in [11] also studied the thermal camera for covid-19 suspect identification combined with UV disinfection. The visitor required to enter an entrance gate designed for body temperature screening and UV disinfection before enter the building. The results show promising model, however the proposed work required huge entrance gate installation.

In this paper we adopt the previous work mentioned above and proposed our non-contact rapid body temperature screening using thermal camera for early detection of covid-19 suspect devices. The proposed devices should be low cost so it can be affordable by small companies/institution but the accuracy should be prioritized.

III. Research Method

In this section, we first introduce the system design and the proposed system algorithm to implement the design.

A. System design

Currently, the development of embedded technology has grown rapidly. The application of embedded technology has been utilized in various sectors. The design of non-contact rapid body temperature screening designed using thermal camera and Arduino as controller board. The device may be connected to the barrier gate to restrict covid-19 suspect entered the building. Visitors who pass the device will be detected by proximity sensor and the thermal camera will be activated in order to capture the visitor body temperature image. Thermal camera will take the visitor thermal image and send it to the controller. The controller then processed the images and calculate the body temperature. For visitors who are detected as having a body temperature ≤ 37.5° C, system will count as covid-19 suspect and the barrier gate will not opened. The visitor with body temperature below 37.5° C will considered as normal and the system will opened the barrier gate. The proposed system design is depicted in figure 1.

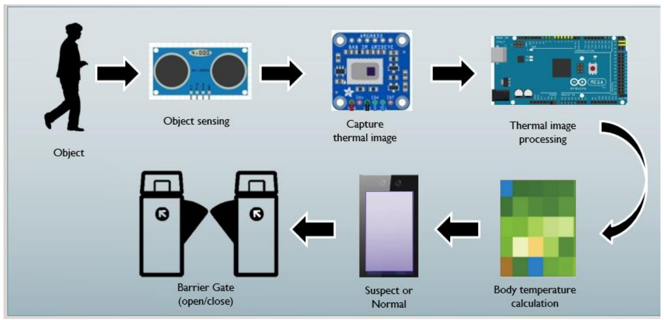


Fig. 1. Proposed non-contact body temperature screening

B. *Proposed algorithm*

The proposed design of non-contact rapid body temperature screening device using thermal camera for early detection of covid-19 suspect devices implemented using algorithm 1 below.

Algorithm 1 Proposed system algorithm.

```
Initialization
define MinTemp
define MaxTemp
define TrigPin
define AvgTemp
loop
if (no object detected) do:
        standby
ElseIf (object detected) do:
        Thermal camera active
        delay
        Thermal image capture
                for(int i=1; i<=MAX_PIXEL_ARRAY_SIZE; i++){
                temp to RGB
        Image segmentation
                for(int i=1; i<=MAX_PIXEL_ARRAY_SIZE; i++){
                SumSegmentedTemp = sum i < MinTemp
                TotalArrayLength = count i < MinTemp
        Image calculation
                calculate AvgTemp = SumSegmentedTemp / TotalArrayLength
        Body temperature
                if (Avgtemp < MaxTemp) do:
                        show msg normal
                        trigPin gate active
                gate open
            delay
            gate close
                else if (Avgtemp > MaxTemp) do:
                show msg suspect
                trigPin gate not active
                gate locked
                Endif
Endif
```

IV. Results and Discussion

Fig.2 shows a non-contact rapid body temperature screening devices schematic diagram consisting of a thermal sensor, Arduino, LCD display, and Relay. The thermal sensor captures the temperature image of the conditions around the sensor. Arduino as a data processor and control over the output. Relay as executor of control which is connected directly to the barrier gate. LCD is an indicator that displays a thermal image and the condition of the object based on the captured thermal image. The device is able to detect object with a distance ranging from 30 cm to100 cm. The object in this case is a visitor who is entered the building. The visitor temperature image will be captured using the principle of infrared waves then the image results are displayed on the LCD along with their status according the body temperature calculation, namely normal or suspected of Covid-19. Based on these circumstances, this prototype controls the barrier gate. Barrier gate will open automatically when the visitor is in normal body tempreture. However, if the object is in a suspected covid-19 condition, the barrier gate will be locked (unable to open).

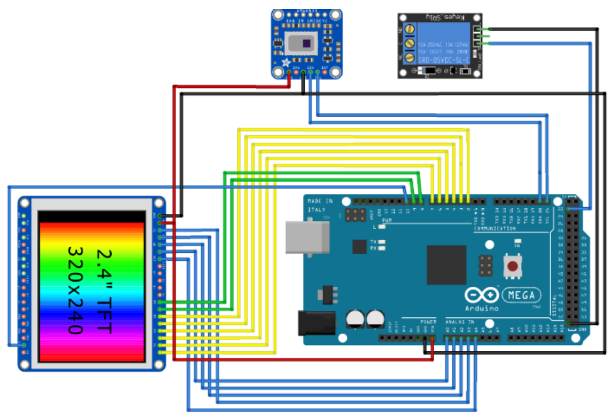


Fig. 2. Schematic diagram

After all the components are assembled according to the scheme, Arduino programming is carried out to read and process the data captured by the thermal sensor. The thermal sensor data is an array measuring 8 x 8 (64) bits. To distinguish between room temperature and human body temperature, segmentation process is carried out so that only human temperature data is processed for data accuracy. In other words, the array used may be less than 64 bits depending on how much data is considered as human body temperature. After the segmentation process, the data is processed to obtain an average of body temperature value. However, because the captured temperature value still has a difference with the actual human temperature value, a calibration process is carried out. The calibration process begins by comparing the thermal camera sensor value with the actual temperature value captured with calibrator in this case a thermometer gun. Table 1 shows the results of comparing the sensor values with the thermometer gun values before calibration process. The error rate is calculated using equation 1 below.

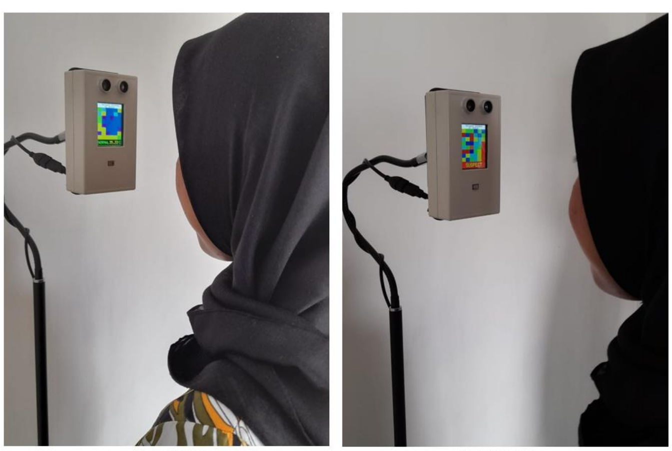
$$Error\ rate = \left(\frac{data\ collected\ by\ sensor - data\ collected\ by\ calibrator}{data\ collected\ by\ sensor}\right) \times 100\% \quad (1)$$

TABLE I. UNCALIBRATED THERMAL CAMERA SENSOR ACCURACY

No	Thermal camera sensor (ºC)	Calibrator (ºC)	Error (ºC)	Error rate (%)
1	31,33	36,3	4,97	13,69
2	31,4	36,3	4,9	13,50
3	32,16	36,4	4,24	11,65
4	31,77	36,4	4,63	12,72
5	31,12	36,4	5,28	14,51
6	31,52	36,4	4,88	13,41
7	31,46	36,4	4,94	13,57
8	33,24	36,4	3,16	8,68
9	32,99	36,5	3,51	9,62
10	32,44	36,5	4,06	11,12

Table 1 shows that there is a huge difference with the average error rate 12,25% between the thermal sensor value and the calibrator value, which ranges from 3 to 5 ^{0}C. The thermal sensor also did not show proper human body temperature range. Thus, the calibration process is continued by performing logarithmic regression to reduce the difference. Based on the logarithmic regression process, a logarithmic coefficient 1.9 and interception value of 1.5 was obtained. This parameter value is then used in programming to make the temperature accuracy.

The testing process is carried out by bringing objects with temperatures below 33 ^{0}C, between 33 ^{0}C to 37.5 ^{0}C, and above 37.5 ^{0}C. Temperature below 33 ^{0}C assumes that the object is not a human being so the prototype will be in standby position. The temperature is in the range of 33 ^{0}C to 37.5 ^{0}C which means that the object is a healthy human being so that the prototype will control the barrier gate to open with the aim that the object can enter through the barrier gate. Then if the temperature is detected above 37.5 ^{0}C, the prototype will control the barrier gate to remain closed by concluding that the object is a suspected covid-19. These three conditions along with the temperature image are displayed on the LCD, namely: standby, healthy, and suspected covid-19. Figure 3 shows one of the prototype test results.



a. Normal b. Suspect

Fig. 3. System testing results

The testing results after the calibration process is shown on Table 2. It can be seen that the error of temperature value is ranging from 0 to 0.08 ^{0}C. This difference / error value is sufficient to apply to the device. The accuracy is affected with the proximity of the object to the thermal sensor and the ambient temperature. The results show that the average error rate is 1,25 % therefore the accuracy is increased to 98,75%.

TABLE II. CALIBRATED THERMAL CAMERA SENSOR ACCURACY

No	Thermal camera sensor (ºC)	Calibrator (ºC)	Error (ºC)	Error rate (%)
1	36,36	36,3	0,06	0,17
2	36,36	36,3	0,06	0,17
3	36,4	36,4	0	0,00
4	36,38	36,4	0,02	0,05
5	36,34	36,4	0,06	0,16
6	36,37	36,4	0,03	0,08
7	36,36	36,4	0,04	0,11
8	36,46	36,4	0,06	0,16
9	36,45	36,5	0,05	0,14
10	36,42	36,5	0,08	0,22

V. CONCLUSSION

The results show that proposed non-contact rapid body temperature screening using thermal camera for early detection of covid-19 suspect is working properly to detect and classify the visitor body temperature. The results show that the average error rate is 1,25 % therefore the accuracy is 98,75%. The accuracy is affected with the proximity of the object to the thermal sensor and the ambient temperature.

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