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Study on Automatic Human Body Temperature Measurement System Based on Internet of Things

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Abstract

Body temperature plays an important role in medicine, some diseases are characterized by changes in human body temperature. Monitoring body temperature also allows doctors to monitor the effectiveness of medical treatments. Accurate body temperature measurement is key to detecting fevers, especially fevers related to infection with the SARS-CoV-2 virus that caused the recent Covid-19 pandemic in the world. The solution of measuring body temperature using a thermal camera is fast but has a high cost and is not suitable for some organizations with difficult economic conditions today. Use a medical thermometer to measure body temperature directly for a slow rate, making it easier to spread disease from person to person. In this paper, we propose a completely automatic body temperature measurement system that can adjust the height according to the person taking the measurement, has a measurement logging system and is monitored via the internet. Experimental results show that the proposed method has successfully created a fully automatic human body measurement system. Furthermore, this research also helps the school's scientists and students gain more knowledge and experience to apply Internet of Things technology in real life.

Keywords: *Body Temperature, Internet of Thing, Automation, Infrared Thermometer Sensor*

1. Introduction

Body temperature is one of the most important vital signs in human bodies. By monitoring the subject's body temperature, it is most directly known whether the patient has a fever or not, and even further can speculate on the effect of the treatment on the patient. in hospitals, the body temperature is an indicator most commonly used by physicians to judge the subject's physiological conditions. Therefore, automated body temperature measurement system has become a worldwide research issue. Since the start of the COVID-19 pandemic, thermal detection has been used to monitor body temperature as a primary prophylactic measure to keep the SARS-CoV-2 virus from spreading [1, 2]. Not only because of the COVID-19 but also there are many

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viruses and bacteria that can potentially push our healthcare systems to their limits as a result of the globalization, the overcrowding and generally speaking as a result of the modern way of life where there are high levels of social interaction

Monitoring the state of health of the human body is carried out by knowing the temperature of the human body because body temperature with a temperature above a certain limit is one indication of covid-19. To determine the surface temperature of the human body, we most often use medical thermometers and thermal camera. Human Body Temperature Thermal Camera could still be a useful tool for rapid body temperature screening in public areas such as airports, ports, railways or bus stations. However, at current, the price of Thermal Camera is still very high so it is difficult for small private clinics to use this device to measure body temperature. Especially, after experiencing the Covid-19 pandemic, the domestic economy is facing many difficulties, it is more difficult for businesses and public service organizations to arrange funds to buy thermal cameras. Compared to thermal cameras, medical thermometers are cheaper and easy to use. thermometers measure the infrared radiation emitted by an object and convert the detected energy into a temperature value. They are correctly called radiation thermometers or pyrometers [3]. However, the use of medical thermometers is mainly manual. Public service facilities often require guards to use medical thermometers to measure body temperature. This form of direct measurement makes it easier to spread the disease. Therefore, research on automating the body temperature measurement system is very necessary and suitable for the current situation.

There were many research works related to automatic temperature measurement system. A prototype of a body temperature monitoring system for the prevention of COVID-19 based on Internet of Things (IoT) using an AMG8833 thermal sensor [4]. An automatic, non-contact temperature measurement system was developed using forehead infrared thermometer [5]. However, this system has no log recording of the measurer for monitoring and control. A noncontact, automatic continuous body temperature measurement system was presented by using a single thermal camera combine with deep learning method [6]. An IoT based human body temperature monitoring and data collection system [7]. However, this system does not have an automatic height adjustment system according to the user. This paper proposes an automatic body temperature measurement system that can adjust the height according to the person measuring, has a system to record the measurement diary and monitor via the internet system.

2. Method

2.1 Hardware Design

The IoT systems have been applied in many fields such as manufacturing, agriculture [8]...In the medical field, the IoT currently has primary healthcare usage for controlling and managing dire situations during the coronavirus disease (COVID-19) [9]. The IoT node sends the sensor data to the smartphone or PC via wifi connection. The cloud server receives all the transferred information and stores them for a specified time. Therefore, the design idea is an automatic system can capable of automatically pulling the trigger of the forehead by infrared thermometer and automatically locate the forehead area to measure the temperature for the human body and send the results to authority figure in real time. The block diagram of a prototype body temperature measuring system for Covid-19 prevention using the IoT can be seen in Fig. 1. The device consists of the following parts:

a. Mechanical system: lifting the measuring head up and down to automatically determine the height of the measured person and allowing the system to automatically adjust the temperature trigger when the required height position has been reached.

b. Control system: there are two obstacle avoidance sensors, one infrared thermometer, one stepper driver and one microprocessor. Human detection sensors (Sensor 1) allows to identify people entering the measuring position. Human's forehead sensor performs the height adjustment of the measuring head so that determines the height of the person. The infrared thermometer measures human body when the measuring head reaches right position. Module ESP 32 will read the data from the infrared thermometer via I2C communication protocol and send the data to the Raspberry Pi as main microprocessor. The stepper driver controls the speed and direction of stepper motor which moves the measuring head up and down.

c. The display system shows the measured results to the LCD screen. The buzzer used to warn when the body temperature is higher than normal.

d. Raspberry pi 4 model B is use for main control of whole system. Raspberry Pi 4 Model B is also one of Raspberry Pi's product which look likes a mini pc and can be operate as a microcontroller in generally [10].

Finally, the Power supply has the function of powering the circuits, the parts are integrated on the device.

Measuring result data is displayed on the cellphone through the blink application which can be accessed in real-time [11].

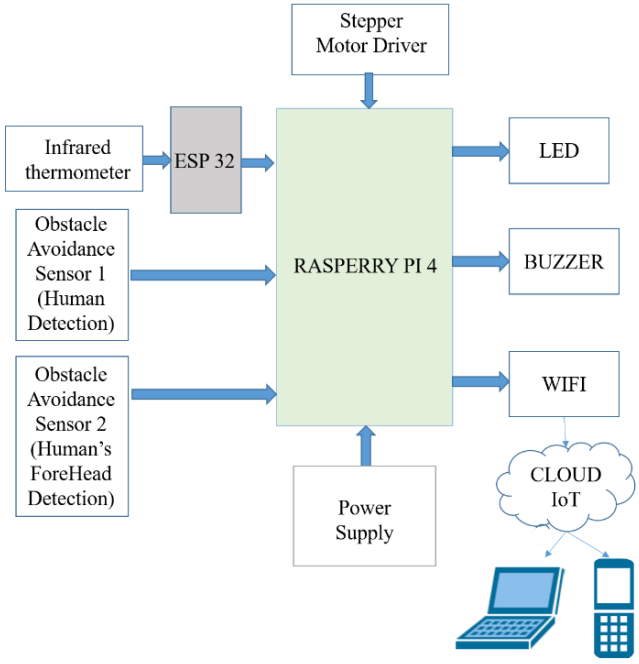

Figure. 1. Block diagram of an automatic body temperature measurement system that stores and monitors body temperature using IoT technology

2.2 Measurement Process

The sequences to perform the measurement of human body temperature are illustrated in Fig. 2. In the first loop, from the home position if the human comes in, the human sensor will ON and the measuring head moves up. While the measuring head is moving up, if the human's forehead sensor 2 will ON, that means the measuring head reached the human's forehead and the measuring head will be stop. At that time, the trigger will active the Infrared thermometer performs the measuring process. After that, the result will be shown on LED screen and the big LCD screen, simultaneously. At that time, the notification of result will be implements

by installed voice. After that, the human comes out, the human sensor and human's forehead sensor are OFF, respectively. The measuring head will stay in place and wait for the next person. After 1 minute, if no one comes in, the measuring dead will move down to home position.

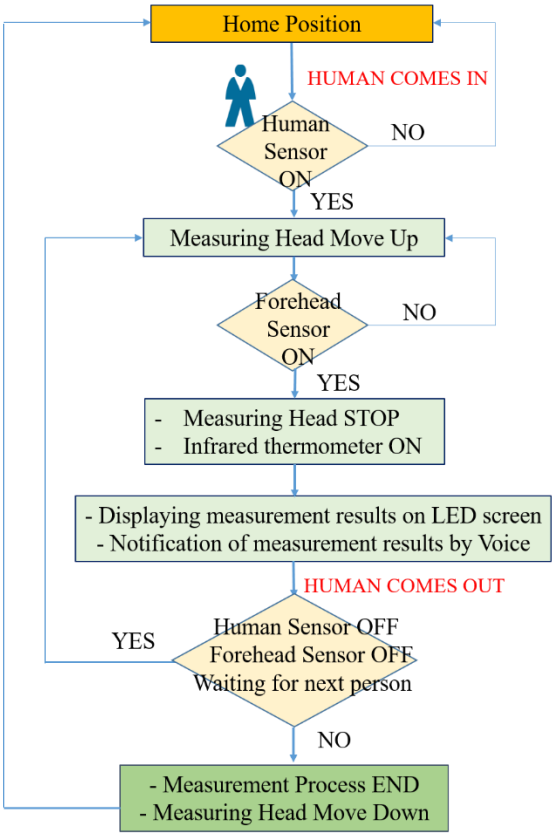

Figure. 2. Algorithm diagram describing the implementation sequence of the automatic body temperature measurement system

3. Results and Discussion

The prototype of the design of the automatic body temperature measuring system for covid-19 prevention using infrared thermometer based on IoT as shown in Fig. 3 (a). The sensor (IR Obstacle Avoidance Proximity Sensor E18-D80NK) detects human and the transmission system moves the measuring head up and down by stepper motor. Fig. 3(b) shows the measuring head includes sensor (E18-D80NK) which detects human's forehead, the under is the infrared thermometer and the led display screen. The top includes an LCD screen that displays the measurement results and a buzzer. And Fig. 3(c) shows the main controller of the whole system

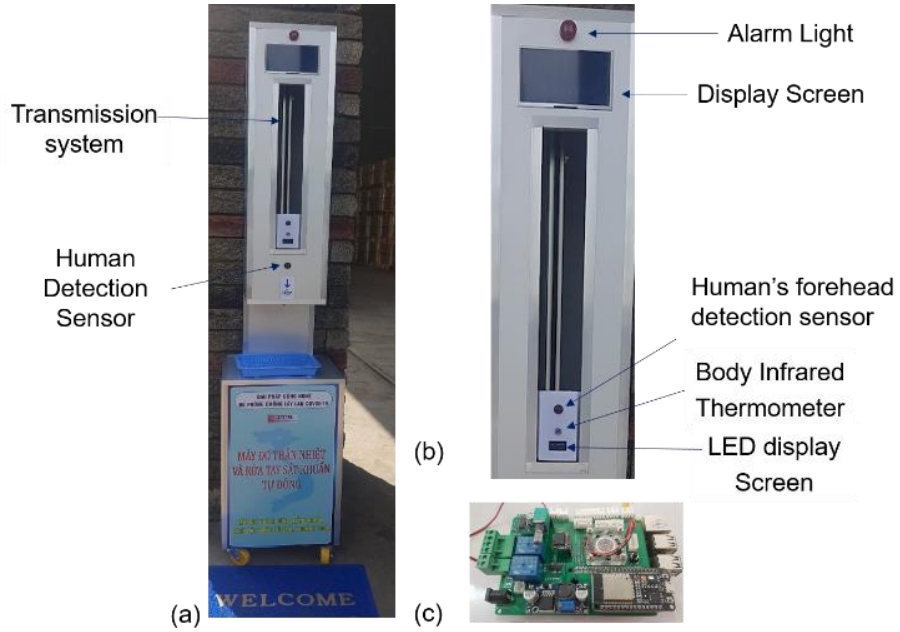

Figure. 3. (a) Automatic human body measurement system; (b) Display system of measuring Results; (c) Controller of whole system

The outputs of the system are LCD, buzzer, and cellphone or pc. The LCD will display the body temperature of the object person. The buzzer will sound when the human body temperature over 37.5oC is detected. Measuring result data is displayed on the cellphone and the pc through Blynk Cloud which can be accessed in real-time as shown in Figure 4.

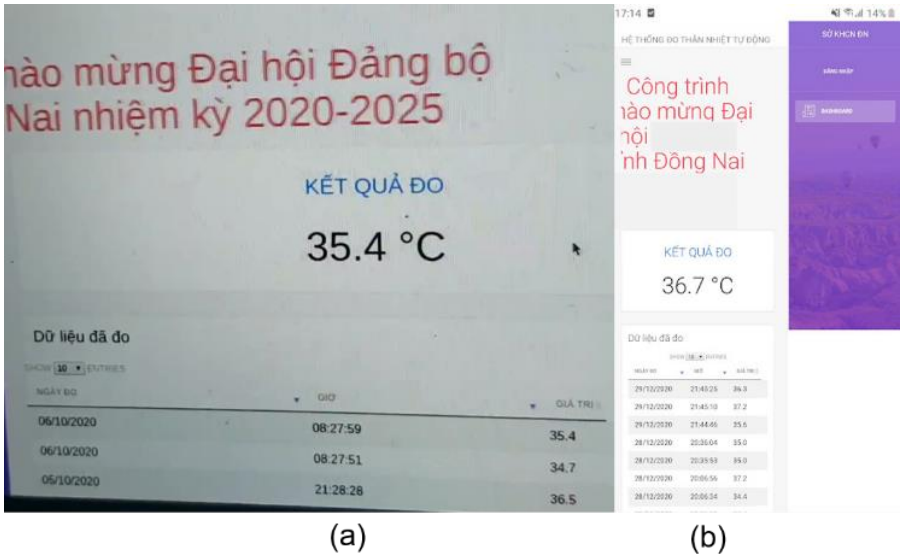

Figure. 4. (a) Measuring results display on computer and (b) measuring results display on the cellphone.

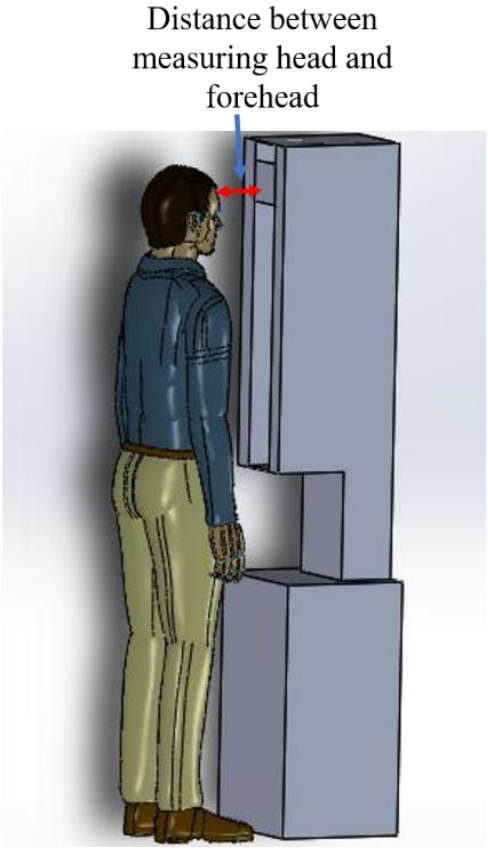

Figure. 5. Description of distance between person's forehead and measuring head

In addition, to check accuracy of the measured results according to the distance between the measuring head and forehead (Fig. 2), the test is carried out on 08 persons with different distances as shown in Table 1. The length gauges are used to determine the distance between the person's forehead and the measuring head. The results showed that the maximum error according to different measuring distances was completely within the permission limit.

Table 1. Experimental results from different measuring intervals between the measuring head and the measuring person

No	Temper-ature at Distance 4 cm (0C)	Temper-ature at Distance 8 cm (0C)	Temper-ature at Distance 12 cm (0C)	Maximum Error
Person 1	37.1	37.2	37.5	0,4
Person 2	36.3	36.5	36.6	0.3
Person 3	37.2	37.1	37.3	0,2
Person 4	36.3	36.5	36.5	0.2
Person 5	37.1	37.3	37.3	0,1
Person 6	36.8	36.9	37.1	0.3
Person 7	37.1	37.4	37.4	0,3
Person 8	36.8	36.7	36.8	0.1

In the other hand, to check accuracy of the measured results with other devices, we have compared measurement results between the proposed method with a thermal imaging camera [12] and recorded the results in Table 2. The results showed that the maximum difference of measured value between two devices was completely negligible.

Table 2. Compare the measurement results between the thermal imaging camera and the proposed system at different measuring distances

No	Temperature at Distance 5 cm (0C)	Thermal imaging camera	Difference of measured value
Person 1	37.2	37.4	0,2
Person 2	36.5	36.6	0.1
Person 3	37.3	37.3	0,0
Person 4	36.4	36.5	0.1
Person 5	37.1	37.3	0,2
Person 6	36.8	36.9	0.1
Person 7	37.1	37.0	0,1
Person 8	36.9	36.8	0.1

We have conducted a field test as shown in the Fig. 6. When someone comes in (Fig. 6(a)), the transmission system will move the measuring head move up and performs the body temperature measurement process as shown in Fig. 6(b). The measured result shows in Fig. 7. The results showed that the proposed method successfully generated an automatic human body measurement system.

(a) (b)

Figure 6. Field experimental test, (a) human comes in and (b) implementation of measurement process

Figure 7. Measured result display on both of LED screen and LCD screen

4. Conclusion

The automatic body temperature measurement system is essential for checking whether a person is likely to have a high fever, especially checking the possibility of being at risk of infection during the recent covid-19 pandemic. In this paper, we have proposed a fully automatic body temperature measurement system. Experimental results have proven that the proposed method is successful in automatically measuring body temperature and can adjust altitude according to the person measuring. Besides, the system can record measurement logs and monitor via the IoT system with fast speed and reasonable cost suitable for difficult economic conditions. of Vietnam. In addition, this research also helps the school's scientists and students gain more knowledge and experience to apply IoT technologies in real life. The equipment also installed the Provincial Public Administration Center and District Public Administration Center of Dong Nai province during the recent Covid-19 epidemic.

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