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Improvement of Student Attendance System for Recording Student Surface Body Temperature Based on Internet of Things

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ABSTRACT

Student attendance is a system used for tracking student activity in school. Many methods are used to develop student attendance systems, such as Quick Response (QR) Code systems, Radio Frequency Identification (RFID) systems, fingerprint systems, and so on. The COVID-19 pandemic has driven technological development, especially in the student attendance system. Measuring human surface body temperature has become a protocol that must be done before entering school. Student attendance systems need to expand the function not only for attendance but also for monitoring student surface body temperature. This research aims to improve student attendance systems by adding surface body temperature measurements and recording during student presence. Recording data can be done by using the internet of things. Student presence data will be sent to school databases throughout the internet. This system uses RFID technology for student presence and a non-contact thermal sensor for temperature measurement. According to data research, non-contact thermal sensors provide a temperature reading with an average error of 1.69%, a minimum error value of 0.96%, and a maximum error value of 2.57% with a range error value of 0.35°C – 0.95°C. RFID test shows that the optimum distance for the system to read an RFID card is 0 – 2cm. The System also successfully sent presence data to the student school database through the internet. This study concludes that developed systems can track student attendance by recording the student's surface body temperature while in presence. Further work will be focused on managing data networks if this system is used with many users in the school.

Keywords: student attendance system, internet of things, temperature measurement

INTRODUCTION

Recording attendance is the main need in every school to report student activities. To record attendance, many developers build and improve student attendance systems [1]. Student attendance mainly uses to record student presence and absenteeism [2]. Student attendance system has been changing from paper-based to electronic-based [3]. Paper-based student attendance already satisfies the minimum requirements. Several issues with student attendance using paper occur when teachers want to make some reports. This issue leads to changes from paper attendance to electronic system attendance [4]. The electronic student attendance system uses Automatic Identification and Data Capture (AIDC) [5]. AIDC technology supports direct data entry to a computer without using a keyboard. Three main concepts of AIDC technology are data encoder, scanner, and data decoder [6]. Various AIDC implementations already use in research for developing student attendance systems, such as barcodes, QR codes, NFC, and RFID [7]. This attendance system solved issues from paper attendance for reporting process [8]. The Electronic student attendance system is currently used in many schools to record student activities [9].

COVID-19 first case in 2019 and became a pandemic in 2020 until 2022 [10]. Several devices and products, such as robotic logistics for helping nurses treat COVID-19 patients [11], COVID-19 vaccines [12] [13], and COVID-19 fast detections [14]. The COVID-19 pandemic has changed human activity in many aspects, especially studying activities in every school [15]. Studying in school becomes online using video conferences. The electronic attendance systems also change since the study is online. The COVID-19 pandemic teaches us that health must be a concern in every activity. Post-pandemic COVID-19, measuring human surface body temperature has become a protocol that must be done. Student in school also measures their surface body temperature before classes. It can be an issue if many students come at the same time. It can make another crowd if the measurement needs a long time to measure.

Several technologies that can be used to improve electronic attendance systems are the Internet of Things (IoT) [16]. IoT is the concept of things that connect with the internet to monitor, record, and control purposed [17]. This technology already develops for monitoring warehouses [18], monitoring tea gardens [19], and monitoring catfish farming [20]. Research for developing a student attendance system has been done. Student attendance system using RFID with local database recording has been done. This system successfully reads the RFID presence code and records it to a local website. The weakness of this research is using a local website and not providing student surface body measurements [21]. Student attendance system with NFC and providing IoT for recording also has been done. This research successfully records student attendance data in cloud databases. Weakness of this research using NFC for presence. NFC is more expensive compared with RFID. Student attendance with NFC becomes a burden for school finance [22]. Besides, this system cannot measure student surface body temperature. Measuring student surface body temperature is needed to fulfill government regulations. People with fever can be suspected of COVID-19. Human surface body temperature must be measured for every people that want to enter crowded places such as mall, school, campus, office, restaurant, and many more places.

This research aims to expand the student attendance system with student surface body temperature measurement. The attendance system proposed records not only student presence but also records student surface body temperature. The proposed system uses RFID to record student presence. Student surface body temperature is measured with a non-contact thermal sensor.

METHODS

The proposed system consists of hardware and software. The hardware consists of a microcontroller, RFID reader, LCD, buzzer, fan, and noncontact temperature sensor. This study uses ESP8266 as the main microcontroller. ESP8266 already supports with Wide Fidelity (WiFi) feature. It can be very useful since this improvement is IoT Based.

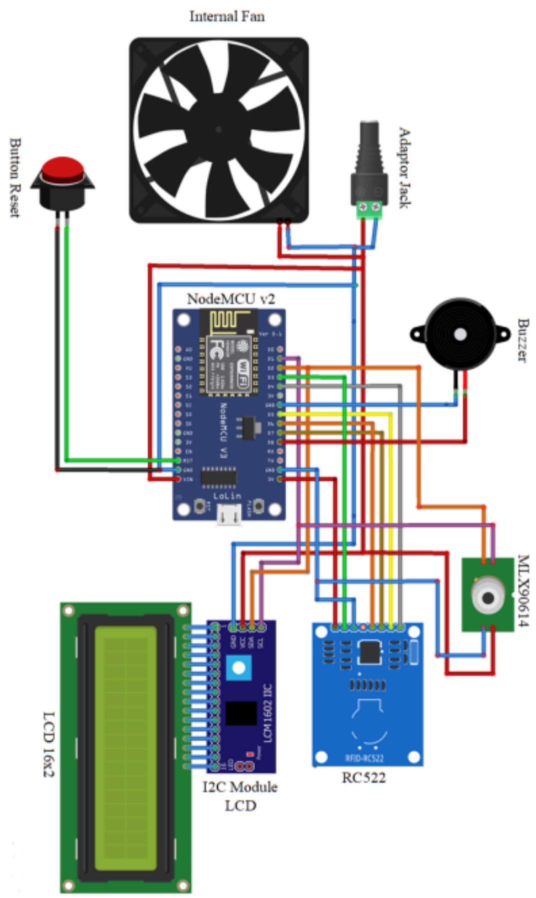

Figure 1. Wiring Diagram Proposed System

The wiring diagram for the proposed system is shown in Figure 1. The system uses an RC522 scanner to read RFID cards. The system interface uses LCD 16x2 with I2C LCD. The proposed system uses an MLX90614 sensor to measure student surface body temperature. This sensor is a non-contact temperature sensor with I2C communications. Cooling fan inside the device for temperature circulation and buzzer for pass indicator.

Table 1. Microcontroller Pin Configuration

ESP8266 Pin	Parts
D3, D4, D5, D6, D7	RC522 Scanner
D2, D1	I2C LCD
D2, D1	MLX90614
D8	Buzzer

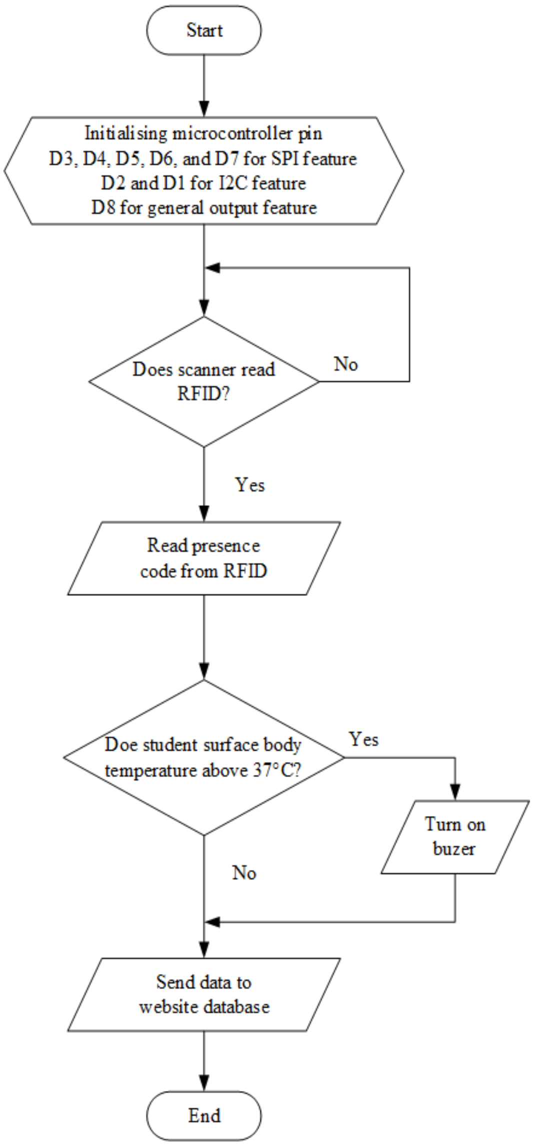

Figure 2. Proposed System Program Flow Chart

The Microcontroller pin configuration is shown in Table 1. D3, D4, D5, D6, and D7 pin connect with RC522 scanner. RC522 scanner uses SPI communication and needs RST, SDA, SCK, MISO, and MOSI configuration. LCD and MLX90614 use the same pin because of using the same communication and the I2C feature can parallel with other parts. D8 pin for buzzer control.

The proposed system needs software and builds with a program flowchart shown in Figure 2. The first step is to initialize the microcontroller pin. This step is used to activate some features in the microcontrollers, such as SPI, I2C, and digital output features. Feature needed to be related to microcontroller configuration from Table 1. The second step is waiting for the student to scan their RFID card. The System will always be scanning RFID cards until student uses their RFID presence card. After student scans their RFID presence card, the third step is reading the presence code. A presence code is a unique code representing a student from an RFID presence card. The fourth step is scanning the student’s surface body temperature. If the temperature is above 37°C, then the system will turn on the buzzer. Buzzer means the student has a fever and needs a further check. If the student’s surface body temperature is below 37°C, then the student can enter the school. All the fever student and normal student data will send to the database website for the data record.

Several experiments are needed to ensure the RFID scanner, sensor, and buzzer work like the program flow chart in Figure 2. Temperature sensors also need to validate to ensure student surface body measurement is valid with several error ranges.

$$err = \left|\frac{TR - SM}{TR}\right| x\ 100 \quad (1)$$

$$acc = 100 - err \quad (2)$$

Sensor validation uses two parameters, error and accuracy. Calculating error is shown with formula 1. err in formula 1 is the error itself, TR is the temperature reference, SM is sensor measurement. Temperature reference is obtained from the reference temperature device. This study uses a standard thermometer to gain the temperature reference. Sensor measurement is obtained from MLX90614 temperature measurement result. Validation also uses the minimum and maximum values from sensor measurement. Minimum and maximum values need to see the error range from the MLX90614 temperature sensor.

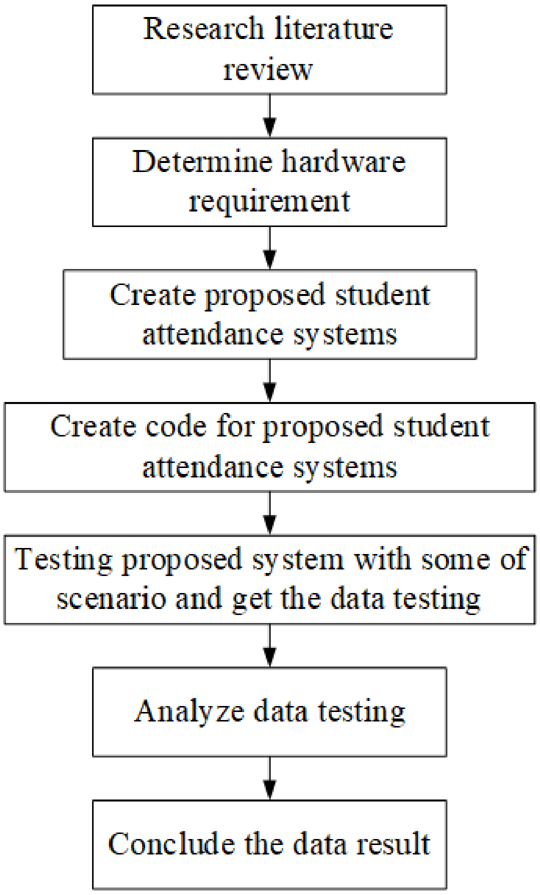

Figure 3. Research Flow Block Diagram

The Research process is shown in Figure 3. The First step is a literature review. This process consists of searching papers that provide research about the student attendance system and its development. The Second step is to determine hardware requirements. After reading many paper research, the student attendance system needs to expand more features. The feature is student surface body temperature measurement. Expanding the student attendance system needs other hardware and will be determined in the second step. After all the hardware already defines, the third step is creating the proposed system. The Proposed system refers to Figure 1. The fourth step is creating software, referred to in Figure 2. After all the hardware and software are ready, the next step is doing some testing for the proposed system. Testing consists of an accuracy test, a functional test, and a data transmitting test. Data testing will be analyzed with error and accuracy validation. If the error is close to 0 and the accuracy close to 100, then research concludes proposed system can work as desired.

Figure 4. Proposed Device Result

The development device with the proposed system has been made and shown in Figure 4. The proposed device be tested with functional tests and measurement tests. The functional test consists of reading student RFID cards with varying distances and data transmitting testing. The reading RFID cards test aims to find the best distance to read an RFID card code. The data transmitting test aims to ensure the RFID card's unique code is already received by the databases' website. The Measurement test aims to determine MLX90614's performance in reading student surface body temperature. Many parameters need to be noticed in reading student surface body temperature with a non-contact sensor.

RESULT AND DISCUSSION

Several tests to obtain data research have been done. The tests include measuring optimum distance while reading the RFID cards, measuring student surface body temperature, comparing non-contact temperature sensors with the standard thermometer, and sending all the attendance information to the database website. Testing refers to the student attendance system needed.

The first test measures the optimum distance during reading RFID cards. This test uses Mifare RFID cards. Mifare RFID card is used because many schools use this kind of student verification card with RFID. Mifare R

Table 2. RFID Card Reading Data Test

Distance (cm)	Number of Tests	Number of Success
1	10	10
2	10	10
3	10	0
4	10	0
5	10	0

The RFID card reading data test shown in Table 2 RFID card data reading focuses on various distances while reading RFID card identification and the number of successful readings. The experiment was done with 10 times repetitions. The proposed system successfully reads the RFID card 10 times for 10 repetitions when the distance is 1 cm and 2 cm. The proposed system fails to read the RFID card 10 times for 10 repetitions when the distance is 3 cm, 4 cm, and 5 cm. According to this experiment data, the proposed system gives a 100% success rate in reading Mifare RFID cards when the distance is 1cm and 2cm. The system gives a 0% success rate when the distance exceeds 2 cm. The experiment data indicate that the best distance in reading the Mifare RFID card is less than 2 cm. This is because RFID technology is built with near frequency.

Table 3. Temperature Measurement Data Tests

Distance (cm)	Sensor Reading (°C)	Actual Reading (°C)	Error Rate (%)	acc (%)
2	35.98	35.90	0.22	99.78
	37.29	37.40	0.29	99.71
	38.11	38.00	0.28	99.71
4	36.15	36.30	0.41	99.59
	36.93	37.10	0.45	99.54
	37.95	38.20	0.65	99.35
6	35.99	35.70	0.81	99.19
	37.13	37.40	0.72	99.28
	37.93	38.20	0.70	99.29
8	35.77	36.10	0.91	99.09
	36.83	37.20	0.99	99.01
	38.38	38.00	1.00	99.00
10	35.61	36.10	1.35	98.64
	36.75	37.30	1.47	98.53
	37.65	88.10	1.43	98.56

The temperature measurement data test is shown in Table 3. Temperature data reading by using a non-contact sensor focuses on two important parameters. The first parameter is the distance between the sensor and object measurement. This parameter ensures the best distance for non-contact temperature sensor measurement. The second parameter is the error rate sensor. This parameter is calculated by using formula 1. The error rate parameter is used to measure the performance of a non-contact temperature sensor. Data collection in Table 3 is obtained from an average of 10 times repetitions. Because of the difficulty in providing human body temperature with various temperatures, the temperature measurement object in this experiment is water. Water is chosen because above 60% of the human body is water. It means water can represent the human body temperature. The various temperature in this experiment is approximately 36°C, 37°C, and 38°C. This temperature estimate is selected according to the human body temperature range of fever is 37°C – 38°C and the normal human body temperature range is 36°C – 37°C. It means that if the human body temperature is below 37°C, it is normal. And if the human body temperature is above 37°C, then it is a fever and needs to make sure that the cause of the fever is not COVID-19. Minimum, maximum, and average error from 2 cm distance is 0.22%, 0.29%, and 0.27% respectively. Minimum, maximum, and average accuracy from 2 cm distance is 99.71%, 99.78%, and 99.73% respectively. This result proves that the MLX90614 sensor gives high accuracy for temperature measurement at a 2 cm distance. The minimum, maximum, and average error from a 4 cm distance is 0.41%, 0.65%, and 0.51% respectively. Minimum, maximum, and average accuracy from 4cm distance is 99.35%, 99.59%, and 99.49% respectively. This result proves that the MLX90614 sensor still gives high accuracy for temperature measurement at a 4 cm distance, although the accuracy is lower than 2 cm. Minimum, maximum, and average error from 6 cm distance is 0.71%, 0.81%, and 0.75% respectively. Minimum, maximum, and average accuracy from 6cm distance is 99.19%, 99.29%, and 99.25% respectively. This result proves that the MLX90614 sensor still gives high accuracy for temperature measurement at a 6 cm distance. However, the accuracy is lower than 2 cm and 4 cm. Minimum, maximum, and average error from 8 cm distance is 0.91%, 1.00%, and 0.97% respectively. Minimum, maximum, and average accuracy from 8cm distance is 99.00%, 99.09%, and 99.03% respectively. This result proves that the MLX90614 sensor still gives high accuracy for temperature measurement in 8cm distance, although the accuracy is lower than 2, 4, and 6 cm. Minimum, maximum, and average error from 10 cm distance is 1.36%, 1.47%, and 1.42% respectively. Minimum, maximum, and average accuracy from 8cm distance is 98.53%, 98.64%, and 99.58% respectively. This result proves that the MLX90614 sensor lowers its accuracy for temperature measurement at a 10 cm distance. The error value above 1% shows high bias for student surface body temperature measurement.

According to Table 3, the temperature measurement error rate is below 1% if the distance is less than 6 cm. the best distance for temperature measurement is less than 6 cm. The temperature measurement error rate becomes above 1% if the distance is more than 6cm. Error rate above 1% means the error value during read 36°C, 37°C, and 38°C is 0.36°C, 0.37°C, and 0.38°C respectively. In medical applications, a biased measurement above 1% should be avoided. It can be serious when a student who suspects COVID-19 enters the school or classroom rather than a normal student who is recognized as a COVID-19 suspect. If a normal student is recognized as a COVID-19 suspect, they can go to check the room and do some procedures to ensure that they don't infect with COVID-19. If a student with COVID-19 infection enters the school or classroom, all the students from the school or classroom can be infected with COVID-19 too. This situation must be avoided and ensure measurement bias is less than 1%. Accuracy is very important in the healthcare field.

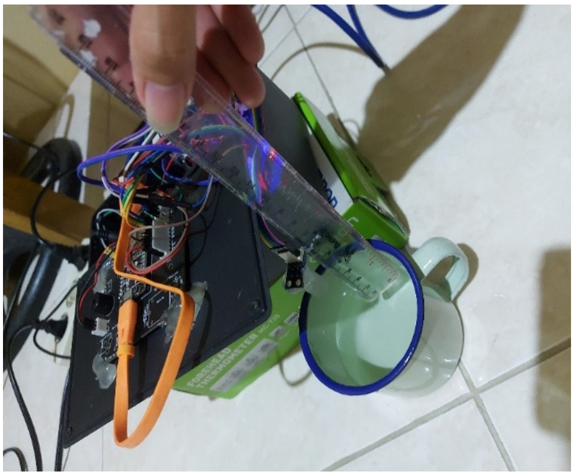

Figure 5 Temperature Measurement Data Retrieval Settings

Non-contact temperature sensors have the best accuracy when the distance between the sensor and the object is 2 cm. The distance threshold during measurement is 6 cm. A measurement distance above 6 cm will increase the measurement bias from the non-contact temperature sensor. Temperature measurement data retrieval settings are shown in Figure 5. Distance measurement in temperature data retrieval uses a ruler with various distances. The temperature object is water to represent the human body temperature. This study chose water because most of the human body's parts are water. Temperature data retrieval settings are important to ensure the data is valid before the real implementation to measure human surface body temperature.

The next test is testing to obtain overall system data performance. This test is used to make sure the proposed system will work with good performance in accordance with the program flow chart shown in figure 2. The proposed system will be tested with real students and send the data to the presence database website. Several tests and experiments need to do to measure the system's performance. Another purpose is ensuring the developed system works like the proposed scenario. Overall performance experiment consists of accuracy measurement with real people, data record to database website, and status buzzer.

Table 4. Overall System Performance

NoR	TTR (°C)	STR (°C)	Error (%)	PDS	Status
1	35.95	36.90	2.57	R	P
2	36.05	36.80	2.04	R	P
3	36.15	36.50	0.96	R	P
4	35.69	36.40	1.95	R	P
5	37.13	37.60	1.25	R	NP
6	36.73	36.10	1.00	R	P
7	37.93	37.70	0.61	R	NP
8	35.88	36.40	1.43	R	P
9	37.73	37.40	0.88	R	NP
10	36.13	35.50	1.77	R	P

Overall system testing is already shown in Table 4. In Table 4, NoR is the number of respondents. This study uses 10 respondents to test the developed system performance with different people. TTR is the thermometer temperature reading for each respondent. STR is the sensor temperature reading for each respondent. Error value calculating result is defined by Error in percent units. PDS is the data that is already recorded in the IoT platform. The R value in PDS means record and the NR value in PDS means not record. Status is the buzzer status. The P status means pass and the student can enter the class. The NP status means not pass and the student needs a further check. P and NP based on sensor measurement. If the sensor measurement read the student's surface body temperature above 37°C, then the buzzer will remain active and gives NP status. All data in Table 4 already averaging within 20 data retrieval. The average error from student surface body temperature measurement data is 1.69% ; the minimum error value is 0.96% and the maximum error value is 2.57% between TTR and STR is 0.35°C – 0.95°C. This data proves that the sensor can accurately measure student surface body temperature. The system also can differentiate fever students and normal students. The sensor also validates with standard thermometer measurement and the difference is not far from it. Overall performance experiment has been done and the system works like the proposed scenario. Data from Table 4 proves that the system already works according to the program flow chart in Figure 2.

No.	Temp	Presence Code	Time & date
1	36.49	9-11-B3-9c-7	27-01-2022 15:24:36
2	36.49	9-11-B3-9c-7	27-01-2022 15:24:09
3	36.47	9-11-B3-9c-7	27-01-2022 15:23:43
4	36.53	9-11-B3-9c-7	27-01-2022 15:23:17
5	36.53	9-11-B3-9c-7	27-01-2022 15:22:50
6	36.49	9-11-B3-9c-7	27-01-2022 15:22:24
7	36.55	9-11-B3-9c-7	27-01-2022 15:21:57
8	36.57	9-11-B3-9c-7	27-01-2022 15:21:31

Figure 6. Website Platform Display

The measurement data results will be sent to the website platform shown in Figure 6. The information recorded on the website is temperature, presence code, time, and date. This information ensures that students do not have a fever while attending class. This information can also determine students' health before entering class. If the student has a fever, they cannot enter the class. This scenario is used to mitigate the spreading of COVID-19 around the student.

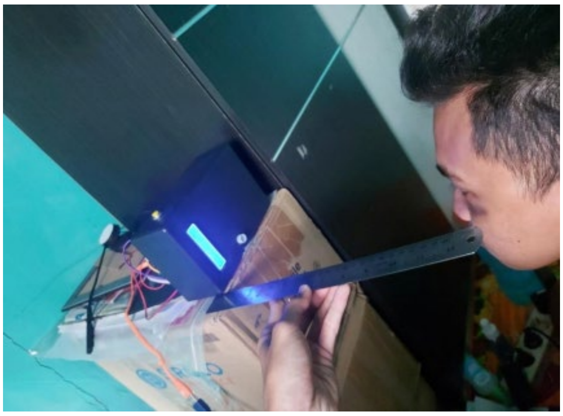

Figure 7 Human Body Surface Temperature Data Collection Settings

Data from Table 4 and Figure 6 obtain with several settings shown in Figure 7. From data Table 3, the optimum distance for the sensor to measure human body surface temperature is around 2 cm – 6 cm. Distance selection from data in Table 4 is 4cm. Distance selection considering the situation in class and the student's arm's length. The overall test proves that the system can work with the scenario. The accuracy sensor is above 99% with several settings and the RFID scanner successfully reads the presence code.

CONCLUSION

This study aims to improve the student attendance system by adding student surface body temperature measurements. This improvement is needed to keep the COVID-19 protocols in post COVID-19 pandemic. According to data research, the non-contact thermal sensor provides a temperature reading with an average error is 1.69%, a minimum error value is 0.96%, and a maximum error value is 2.57%, with the range error value is 0.35°C – 0.95°C. RFID test shows that the optimum distance for the system to read an RFID card is 0 – 2cm. Several tests and experiments prove that the accuracy while measuring student surface body temperature is above 99%. This study concludes that the developed system can be used to track student attendance by recording the student surface body temperature. Further work will be focused on managing the data network if this system is used with many users in many places, how to solve environment temperature interference, and faster the system process.

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