UPGRADE AND COMPARATIVE TESTING OF INFRARED THERMOMETER SENSORS OF A SOCIAL DISTANCING GATE

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***ABSTRACT**: This project upgraded the temperature sensor of a social distancing gate by using MLX90614-DCI for automatic body temperature monitoring. The Arduino UNO accepts and manages the sensor's instructions and monitors social distance and temperature. The whole system was created using the IDE environment with C++. The infrared distance sensor alerts the oncoming person at the gate's entrance. With one meter separating the two people, the ultrasonic sensor monitors the person entering the gate. When social distance is not maintained, the built-in speaker sounds an alarm. The infrared proximity sensor, on the other hand, recognizes the individual approaching the gate. The body temperature of person entering the gate is measured using an infrared thermometer sensor and expressed in degrees Celsius. The IR temperature sensor measures the person's temperature, which is then displayed on the LCD panel. Comparison between the readings of the old and new sensors was taken and analyzed using descriptive statistics and dependent samples t-test. Results show a significant difference in the temperature readings between the old and new thermometer sensors.*

Keywords: Arduino UNO, Social Distancing Gate, COVID-19 Pandemic, Infrared Temperature Sensor, Paired Sample T-test

1. INTRODUCTION

The coronavirus (COVID-19) pandemic has been regarded as the largest threat to public health since the 1918 influenza pandemic. To date, it has claimed the lives of at least 50 million people and has infected one-third of the world's population. The number of COVID-19 cases and fatalities rapidly increased, and its final effects on the world remain unpredictable. Uncertainty surrounding its terrifying health effects may be just as frightening as grim estimations [1]. The COVID-19 virus can be easily transmitted through personal contact from person to person. Therefore, people need to be prevented from having close contact with each other [2]. The battle against the coronavirus that has affected the world for almost three years continues, although several measures have been implemented to control the spread of the virus. As of January 2023, the recorded COVID-19 cases have reached 664,873,023 with 6,724,248 fatalities [3].

The Philippines has undergone through different phases of community quarantine guidelines. These included the Enhanced Community Quarantine (ECQ) with heightened restrictions on movement, personal movement, and business operations, and imposed severe restrictions on food and essential services provisions; Modified Enhanced Community Quarantine (MECQ) where freedom of movement and essential services and jobs were restricted; General Community Quarantine (GCQ) that only allowed limited movement, 75% workforce staffing of public offices and industries, limited transportation, and flexible learning arrangements; and Modified General Community Quarantine (MGCQ) which eased and allowed socio-economic activities with minimal public health standards [4]. Currently, most of the country is under alert level 1 which is the lowest alert status, and to this date, the Department of Health is eyeing to propose the introduction of alert Level 0 because of the improvement of the COVID-19 situation in the country [5]. In the recent advisory of the Inter-Agency Task Force (IATF), some parts of Negros Oriental, Philippines remain under Alert Level 1 status including its capital Dumaguete City while other cities and municipalities are under Alert Level 2. Per IATF, Alert Level 1 allows Intrazonal and interzonal movements; gaming establishments are not allowed except authorized by them or by the Office of the President, a maximum of 50% indoor venue activities for vaccinated individuals and 70% for outdoor venue capacity, and, other activities may be held subject to the approval from the Local Government Unit (LGU). Moreover, in Alert Level 1, public and private establishments, organizers of events, and local governments shall implement administrative controls, engineering controls, and wearing of face masks whenever required [6].

The threat of prominent COVID-19 variants including Alpha, Beta, Delta, and Omicron has been evident since the pandemic's beginning [7]. Droplets from coughing and talking of an infected person transmit the virus to others. Precaution and prevention are two of the most crucial steps that may be used in preventing the virus from spreading. There is always a 1-meter social distance requirement which is an effective means of preventing the virus from spreading [8][9][10]. Social distancing reduces contact between people who are infected with a disease-causing virus and reduces the rate and scope of disease transmission in a community [11]. However, some people do not follow this protocol especially if no one is monitoring. Therefore, one way to execute this health protocol would be to make a simple, reliable, and easy-to-use physical distance alert system [12]. In addition to social distancing, ongoing body temperature monitoring in various settings is still practiced. One of the most prevalent signs that a person is infected with coronavirus disease is fever, which is frequently detected with non-contact infrared thermometers [13]. When a person's body temperature rises above 37.5°C, they frequently display feverish symptoms caused by the Covid-19 virus. Body temperature is important in the initial screening. But here, even the officer may disseminate or become infected with the Covid-19 virus since the filtration procedure typically employs a device called a thermogun. To overcome this problem, it is necessary to have a method in place before students reach the school grounds to measure their body temperatures [14][15]. During the COVID-19 epidemic, the accuracy of body temperature monitoring has indeed taken on greater significance. The reliability of remote temperature monitoring is a hotly debated subject, particularly when these readings are intended to accurately and quickly identify unwell persons. It is challenging to take reliable readings at the entrance to public events because working distance, body-device angle, light levels, and a number of other metrological and arbitrary factors all considerably alter the data gathered using ordinary contactless infrared point thermometers. Non-contact infrared sensors have been commonly used at the entrances of hospitals, airlines, public transport, churches, institutions, marketplaces, offices, and public spaces, in general, to check people's body temperatures since the COVID-19 outbreak [16].

Arduino Uno has been widely used to build apparatus that can automatically detect certain quantities such as voltage supply and temperature among others. The sensor turns the light signal into voltage using the fault detection concept, which is then processed by the Arduino UNO development board. The IOT system's fiber fault monitoring is controlled by an Arduino UNO processor, which also serves as a microcontroller for instructions from the sensor. However, Arduino must be used to build some instructions. The command will be transmitted to Arduino UNO for data processing once it is ready. The experiment's output will be the monitored data on defect detection [17]. Other situations may also call for the use of skin temperature detectors that utilized infrared sensors to identify a person's presence and turn on the light [18]. A passive infrared receiver (PIR) connected to an Arduino Uno served as the sensor. In addition, Arduino Uno is also capable of taking and displaying digital images, controlling LED message boards, running sound and light shows, monitoring its surroundings, and Bluetooth wireless communication with other electronic devices. It can also use sensors to capture GPS information about a journey's course, speed, and altitude [19].

The objectives of this study are to upgrade the social distancing gate from MLX90614ESF-BAA-000-TU-ND to MLX90614_DCI infrared thermometer sensor as proposed by Alvarez et al. (2022) [20] and compare the temperature readings of the upgraded apparatus to the original system.

2. METHODOLOGY

The methodology of this research included two major steps. Firstly, the social distancing gate of Alvarez *et al.*(2020) was upgraded. Secondly, the temperature readings of the old social distancing gate and upgraded were compared using repeated measures design analyzed through dependent samples t-test.

For the upgrade, necessary components such as an Arduino Uno, buzzers, infrared and ultrasonic sensor, power supply, new infrared thermometer sensor, and LCD display were needed. The components were connected to the Arduino R3 using the appropriate wiring and pins. The code was uploaded to the Arduino R3 which allowed it to collect data from the infrared thermometer sensor and measure the temperature of a person passing through the gate. An alarm through the buzzer was added to monitor the human's temperature. The system also used the ultrasonic sensor to measure the distance between the person and the gate. If the distance was less than a certain threshold, another alarm would trigger through the buzzer to remind the person to maintain a safe distance. The temperature and distance measurements were displayed on the LCD display for monitoring purposes. The automated social distancing gate was upgraded using MLX90614 DCI infrared sensor to transform signals coming from the object into electrical signals which then convert into digital that enable human temperature measurement. Necessary adjustments were done to test the upgraded social distancing gate's functionality.

To elaborate, Arduino UNO, which has 14 input/output pins, has been selected as a microcontroller to accept and manage the instructions from the sensor. Thus, it was programmed using an IDE environment. The infrared distance sensor was used to notify the incoming person at the entry of the system. The ultrasonic sensor was concerned with monitoring the incoming person inside the gate with a distance of 1 meter between two individuals. When social distance was not maintained, the speaker was utilized to sound an alarm. The infrared proximity sensor, on the other hand, detected the person entering the gate. The person entering the gate's body temperature was measured using an infrared thermometer sensor and expressed in degrees Celsius. The IR temperature sensor detected a person's temperature, which was shown on the LCD panel. Lastly, the buzzer notified if violations occurred.

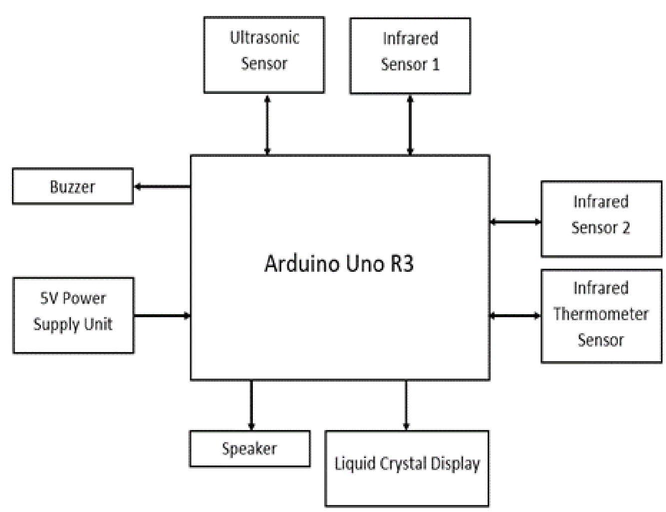

Figure 1. System Block Diagram

The entire block diagram for tracking a person's temperature and social distance is shown in Figure 1. It is made up of various important parts, including an Arduino R3, buzzers, infrared sensors, an ultrasonic sensor, an infrared thermometer sensor, a power source, and an LCD display.

Hardware Implementation

Hardware is constructed for the implementation of the social distancing gate. Figure 1 shows the connections of each material to the ARDUINO UNO. It displays the overall block diagram for the MLX90614-DCI infrared sensor-equipped social distancing gate. Moreover, the prototype as shown in figure 2 is presented on which its materials are connected to each other.

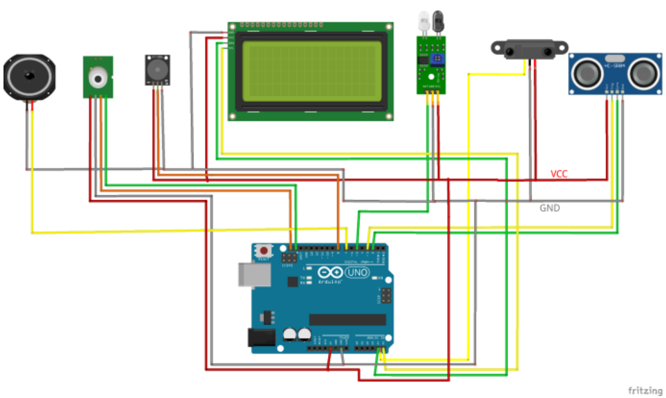

Figure 2: Upgraded Social Distancing Gate with MLX90614-DCI infrared sensor prototype

Experimentation Overview

To compare the old and new infrared thermometer sensors, a repeated sample research design analyzed through dependent samples t-test was used. First, temperature readings were obtained using the old temperature sensor by placing the hand about 5 mm in front of the sensor for thirty (30) trials. Additionally, the temperature sensor of the social distancing gate was replaced with the new one (MLX90614-DCI). Subsequent temperature readings were then taken with the new sensor in place. Finally, SPSS 27 was used to obtain the dependent samples t-test of the data.

3. RESULTS AND DISCUSSION

Hardware Results

The flow of the study is described in Figure 1 showing the prototype of the social distancing gate with the corresponding materials used in the set-up of the system. Driven by Arduino Uno and with an upgrade to its IR thermometer to sensor module GY-MLX90614-DCI, the system has now a long-range 50-cm distance temperature detecting capacity, higher power supply ranging from 3-5V, has an integrated sensitive thermophile detector chip and signal conditioning ASSP, high accuracy and resolution of the thermometer gives highly accurate and precise results even if placed in high-temperature environments.

EXPERIMENTATION RESULTS

Table 1 shows the temperature readings before and after the infrared temperature sensor was replaced.

Table 1. Descriptive Statistics of IR Thermometers

	OLD SENSOR	NEW SENSOR
	MLX90614ESF-BAA	**MLX90614-DCI**
Trial	Temperature (℃)	Temperature (℃)
1	34.67	34.45
2	36.60	34.57
3	36.95	34.61
4	32.80	34.11
5	28.63	34.87
6	38.10	34.35
7	29.45	34.97
8	33.71	34.93
9	34.33	34.93
10	32.91	35.03
11	35.15	34.93
12	28.01	35.03
13	34.25	34.95
14	33.99	35.11
15	35.23	35.01
16	28.07	35.07
17	34.53	34.83
18	34.75	35.07
19	34.43	35.07
20	34.29	35.15
21	35.09	35.11
22	34.15	35.09
23	34.37	35.53
24	34.09	35.49
25	34.03	35.35
26	34.85	35.37
27	34.89	35.05
28	34.43	35.07
29	35.59	35.03
30	34.23	35.21
Mean	***33.89***	***34.98***
SD	***2.39***	***0.31***

Figure 3 visually reveals the data presented in Table 1. Clearly, the accuracy of the temperature readings obtained while using the new sensor is very visible in the graph as depicted by the red line. Moreover, the large fluctuations that depict the inaccuracy of the old sensor are also very visible especially during the first half of the 30 trials as presented by the blue line.

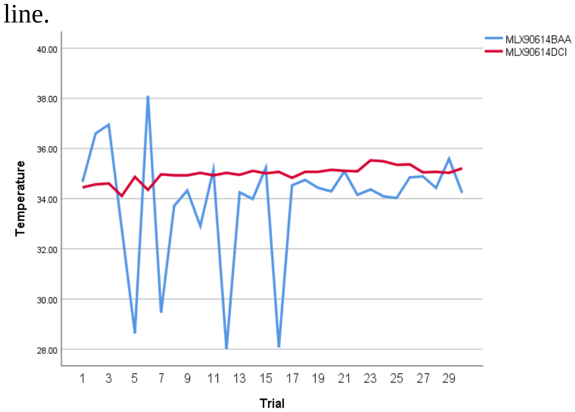

Figure 3. Temperature Comparison between Old and New IR Thermometer Sensors

Furthermore, the dependent samples t-test disclosed that there is a significant difference in the temperature readings between the old system with MLX90614ESF-BAA-000-TU-ND (*M*=33.89, SD=2.39) and the new using MLX90614-DCI sensor(M=34.98, SD=0.31). The new sensor was more accurate in monitoring the human temperature of the social distancing gate, t(29)=-2.437,p=0.21. This highlights the need to upgrade the sensor to obtain higher accuracy in temperature readings which is attained in this project. This is most important since inaccurate temperature readings would lead to misdiagnosis of fever infection. This is in consonance with the results of Amoateng-Adjepong, et al. on the significance of accurate thermometry [21], especially during pandemic times [22].

4. CONCLUSION AND RECOMMENDATION

An upgrade of the infrared thermometer sensor of a social distancing gate using Arduino Uno is carried out in this paper. C++ is utilized to create the program and temperature readings are displayed on an LCD. Moreover, the results of the dependent samples t-test successfully presented that a more accurate reading is achieved when the old MLX90614ESF-BAA sensor is replaced with MLX90614-DCI. It is further recommended that solar energy may be used to energize the entire system due to the minimum voltage requirement which is only 5V.

5. ACKNOWLEDGMENT

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