Smart Face Shield: Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning

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Practical Research

By:

Celendro, Mijay Larmeziel D.

Exconde, Mark Jeric B.

Villanueva, John Derick D.

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ABSTRACT

The pandemic and its response, which included long-term worldwide lockdowns, had a number of short- and long-term impacts on human health, society, economy, and the environment. Although markets may be a critical place of commerce and a source of many essential goods, they may also pose high potential risks of spreading infections and viruses including COVID-19. Hence, the study aimed to utilize Smart Face Shield: Arduino Based Infrared Face Shield for Protection and Temperature Scanning where its function and properties were observed and determined as an efficient yet convenient way to monitor body temperature to help prevent the spread of COVID-19. Experimental research was conducted at Barangay Lalig, Tiaong, Quezon from September 2021 to January 2022. After assembling the product, the researchers determined the physical characteristics of Smart Face Shield: Arduino Based Infrared Face Shield for Protection and Temperature Scanning. On the other hand, to determine the function of the product in terms of accuracy, battery life, charging duration, and visibility, the researchers conducted different trials from each objective. Results indicated that the Smart Face Shield: Arduino Based Infrared Face Shield for Protection and Temperature Scanning had reached the accepted physical characteristics. The case has a dimension of 29 mm x 40 mm x 159 mm of height, width and length respectively with a shape of an L-shaped rectangle. On the other hand, the face shield is a curved arc shape that has a dimension of 135 mm x 168 mm x 180 mm of height, width and length respectively. The total weight of the product is 145g. In terms of its accuracy, the reading of temperature when the product is 50cm, 75cm, and 100cm away from the subject with the use of an ultrasonic sensor was more accurate with 0.1% accuracy than only using a temperature sensor. The battery of the product would last about a maximum time of 10hrs and its charging time is about 1 hour and 30 minutes. Meanwhile, the virtual image data reflection's visibility depends on the lighting condition; it is likely to be less visible in brighter ambient lights and more visible in darker ambient light. Therefore, the study implied that the Smart Face Shield: Arduino Based Infrared Face Shield for Protection and Temperature Scanning suits the ideal qualities of a face shield. Also, it is a convenient face shield that can help prevent the spread of COVID-19.

Keywords: arduino, infrared, covid-19, body temperature, ultrasonic sensor, virtual image

Chapter I

THE PROBLEM AND ITS BACKGROUND

Technology has still risen up for the past years despite the pandemic. In the malls and airports, they use a device called ‘Kiosks’ to thermal scan the body temperatures of who passes by. As stated by imageHOLDERS (2021), fever detection is one of the methods in identifying COVID-19 and other infectious illnesses which may help to reduce the spread. Inspired by the concept of modern Smart Glasses, Mauer (2016) created an Arduino Glasses: a head-mounted display (HMD) for Multimeter. This device displays data of a multimeter in form of the virtual image reflected into the eye. The researchers then used the ideology and design of Mauer’s project to create Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning. Also, the researchers, therefore, conclude that the use of Arduino and Infrared technology inspired by the concept of thermal and virtual imaging, are the necessary means to achieve the goals of the research.

Statement of the problem

The qualitative research entitled “***Smart Face Shield: Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning”*** seeks to demonstrate and complete the following objectives:

1. To determine the physical characteristics of the Smart Face Shield: Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning in terms of:

    1.1. Dimension

1.2. Shape

1.3. Mass

1.4. Material Used

2. To determine the accuracy of MLX60914 temperature sensor combined with and without HC-SR04 ultrasonic sensor in the following conditions:

   2.1. MLX60914 temperature sensor without HC-SR04 ultrasonic sensor are set to distances 50cm, 75cm, and 100cm

   2.2. MLX60914 temperature sensor with HC-SR04 ultrasonic sensor are set to distances 50cm, 75cm, and 100cm

3. To determine the duration of time the battery would last long when used continuously.

4. To determine the duration of time the battery would recharge using a standard USB battery charger.

5. To determine the best lighting conditions to visibly read the data reflected in the reflector.

Significance of the Study

This study entitled "Smart Face Shield: Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning" aimed to come up with a new way to help prevent the spread of COVID-19. This will be convenient and useful for awareness and protection.

Moreover, this will ensure people's health safety against COVID-19. The use of Arduino and infra-red temperature sensor can greatly help in the pandemic since knowing the body temperature of a person would give great advantages while also using the face shield in protection for droplets size viruses from people nearby.

This study will be beneficial for people, especially the consumers, workers, and vendors, as well as producers to be able to reduce the potential further exposure of their health risks while browsing or selling products at public markets.

This study also benefits future researchers, in adding to the much-needed related literature review, strengthening conceptual and theoretical framework as well as pursuing this field of the proposed study and may come up with future innovations using the same materials to contribute to the development of technology.

In addition, this research can be a good starting point for another or other developmental researchers to invent a similar product that can be used to help prevent the further spread of the virus.

The study wanted to prove that with the use of the said product, people can maximize their protection, especially from the data accuracy of temperature sensors. It can be recharged up fast and last long for daily convenient and efficient use.

The findings of this study will rebound to the benefit of society considering that thermal scanning will be a great help on our daily shopping.

The Smart Face Shield: Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning can be practically useful enough since the need for protection is increasingly becoming important.

Scope and Delimitation of the Study

The focus of this research paper entitled “Smart Face Shield: Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning” is to determine the effectiveness and functionality of using Arduino and infrared technology to read nearby bodies temperature.

The findings of the study were based on the observations that were answered by the five objectives of the study: (1) physical characteristics of the Smart Face Shield Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning, (2) accuracy of MLX60914 temperature sensor combined with and without HC-SR04 ultrasonic sensor, (3) duration of time the battery would last long when used continuously, (4) the duration of time the battery would recharge using a standard USB battery charger, (5) best lighting conditions to visibly read the data reflected to the reflector.

In addition, because of the COVID-19, the study and testing of the product will be conducted within the researchers’ house premises only since they are limited to go outside considering the quarantine protocols implemented in the community. The respondent person for testing of the product needs parents’ consent to secure the safety of the person/s who test the product. However, during the process of this paper, communication through the use of digital devices and the internet will be considered for research purposes.

The study only used the available market modules and sensor since the researchers aren’t capable of producing self-made sensors or company devices that can make the product better but more expensive.

This study was conducted from September 2021 to January 2022.

Conceptual Framework

Research Paradigm

INPUT

- Arduino Nano ATMEGA328P
- MLX90614 DCI temperature sensor
- HC-SR04 ultrasonic sensor
- DS3231 real-time clock module
- vibration motor
- SSD1306 Organic Light-Emitting Diode (OLED) display
- TP4056 charging module with protection
- Switch
- Wires
- acrylic sheet
- lens
- face shield
- 3. .7v lithium-polymer (li-po) battery
- Case

PROCESS

Prepare all the materials needed.

Connect the all the pins of modules to designated pins at microcontroller.

Connect the Arduino Nano to computer and upload the code created to make each component work.

Create a 3D model for the case in SketchUp application then 3d print it.

Place the components inside the case.

Then attach the case, temperature and ultrasonic sensor to the face shield.

OUTPUT

Smart Face Shield: Arduino Based Infrared Face Shield

Figure 1. Input, Process, Output (IPO) of the Smart Face Shield: Arduino Based Infrared Face shield for temperature scanning and protection

Figure 1 shows the Input, Process, and Output wherein the inputs are the Arduino Nano ATMEGA328P, MLX90614 DCI temperature sensor, HC-SR04 ultrasonic sensor, DS3231 real-time clock module, vibration motor, SSD1306 Organic Light-Emitting Diode (OLED) display, switch, wires, acrylic sheet, lens, mirror, face shield, TP4056 charging module with protection, 3.7v lithium-polymer (Li-po) battery and case. The process shows that OLED display, RTC module, temperature sensor, ultrasonic sensor, vibration motor, charging module are to be connected to the Arduino Nano. The battery would be connected to the charging module. 3d model of the case should be created and printed. The components would be placed inside the case. Lastly, Temperature and the ultrasonic sensor would be placed on the forehead level of the face shield while the case is attached to the right side.

Definition of terms

For clear understanding, the following terms were defined conceptually or operationally:

Arduino - Open-source electronic prototyping platform enabling users to create interactive electronic objects.

Infra-red - Is electromagnetic radiation (EMR) with wavelengths longer than those of visible light.

Infra-red sensor - An infrared sensor (IR sensor) is a radiation-sensitive optoelectronic component with spectral sensitivity in the infrared wavelength range 780 nm … 50 µm.

Covid-19 - stands for Coronavirus Disease 2019 and is a highly contagious disease caused by a newly discovered coronavirus.

Temperature - is a measure of the average kinetic energy of the atoms or molecules in the system.

Quarantine Protocols - separating and restricting the movement of the people who are exposed or are potentially exposed to a contagious disease

Pandemic - refers to the proficiency of disease (especially, a virus) to spread or be prevalent to a country or the whole world, affecting almost the whole population.

Sensor - a device that detects or measures a physical property and records, indicates, or otherwise responds to it.

Thermal Imaging - Thermal imaging is simply the process of converting infrared (IR) radiation (heat) into visible images that depict the spatial distribution of temperature differences in a scene viewed by a thermal camera.

Chapter II

REVIEW OF RELATED LITERATURE AND STUDIES

This chapter presents the different local and foreign literature and studies that are relevant to the present research.

Related Studies

Local Studies

In a study conducted by Alcoran-Alvarez, et al. (2020) entitled “Automated Social Distancing Gate with Non-Contact Body Temperature Monitoring using Arduino Uno”, there is a Thermal gate with the components of Arduino R3, a Long-range Infrared proximity sensor, Ultrasonic sensor, Speaker, Infrared proximity sensor, Infrared thermometer sensor, LCD module, Buzzer.

In their research product, there is a long-range sensor (infrared proximity) that points to the ground to detect the incoming person into the gate, then the speaker sends a signal to the other person, the person that enters the limit of 1-meter social distancing after the point of entry behind the first person and within the middle of the gate the body temperature will be scanned and displayed on the LCD and the buzzer will, alarm if the person enters the gate has a body temperature greater than 37.5 degrees Celsius to notify the assigned gate personnel.

They have been proven that social distancing can be followed and at the same time/body temperature scanning of one person can also be done.

Foreign Studies

In the study entitled "Infrared thermometer on the wall (iThermowall): An open-source and 3-D print infrared thermometer for fever screening" by Abuzairi, Sumantri, et, al. (2020), they a made low-cost non-contact infrared thermometer in the wall that they called iThermowall. This device is designed to automatically measure and detect the body's temperature where there is no one to operate manual thermometers. The goal of their product is to address the obstacle in using a non-contact handheld IR thermometer, which is proven to be effective yet still depends on the operator and the distance between foreheads.

To make the product easily reproducible, the researchers used a readily accessible module and a 3-D printer. The electronic components consist of a microcontroller unit (MCU), OLED display, LED, infrared thermometer sensor, infrared proximity sensor, buzzer, charger module, step-up converter, and battery. The MCU employed open-source Arduino Nano microcontrollers to read the data from the Infrared Thermometer then write the data into an OLED display.

Moreover, according to Costanzo and Flores (2020) in their study entitled 'A Non-Contact Integrated Body-Ambient Temperature Sensors Platform to Contrast COVID-19" the combination of an infrared thermometer with a capacitive humidity sensor can provide a quick and accurate tool for remotely monitoring both ambient and body temperature in pandemic circumstances such as COVID-19. They used an infrared sensor for measuring body temperature and a capacitive relative humidity (RH) sensor for the ambient temperature, while the Arduino microcontroller displayed the data collected.

Another research entitled "IoT based System for COVID 19 Indoor Safety Monitoring" by Petrović and Kocić (2020), made an IoT device intended for contactless temperature sensing, mask detection, and social distancing check. Arduino Uno relies upon as a subsystem for contactless temperature sensing with the use of infrared sensors or thermal cameras.

On the other hand, leveraging computer vision techniques on camera-equipped Raspberry Pi is used for mask detection and for checking social distancing.

As stated in the study Nethra, Nagdeepa, et, al. (2021) entitled “Contactless Mobile Thermometer”, social distancing can’t be ensured by conventional thermometers thus the researchers decided to produce Bluetooth-primarily based contactless mobile thermometer with thermal screening functionality delivered to cellular phones. To show the temperature Arduino Nano is necessary as well as an infrared sensor. The objective of their study is to read temperature easily and handily that have broad variation for dimension temperature where you can display accurate temperature scanning in a virtual manner.

CHAPTER III

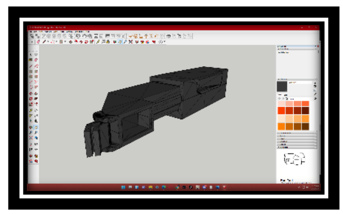
RESEARCH METHODOLOGY

This chapter presents and discusses the methodology and procedures applied in the conduct of the study. It contains the materials and methods, research design, research procedures, and statistical treatment.

Materials and Methods

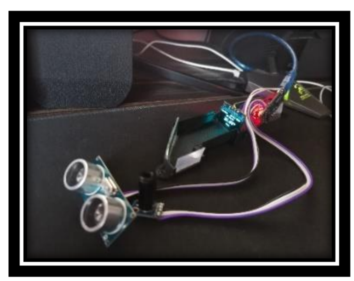
Prepare all the materials needed which are Arduino Nano, temperature sensor, ultrasonic sensor, real-time clock module, vibration motor, OLED display, switch, wires, case, lens, mirror, face shield, charging module with protection and 3.7v lithium-polymer (li-po) battery.

Using SketchUp Application, create a 3d model of the case then 3d print it.

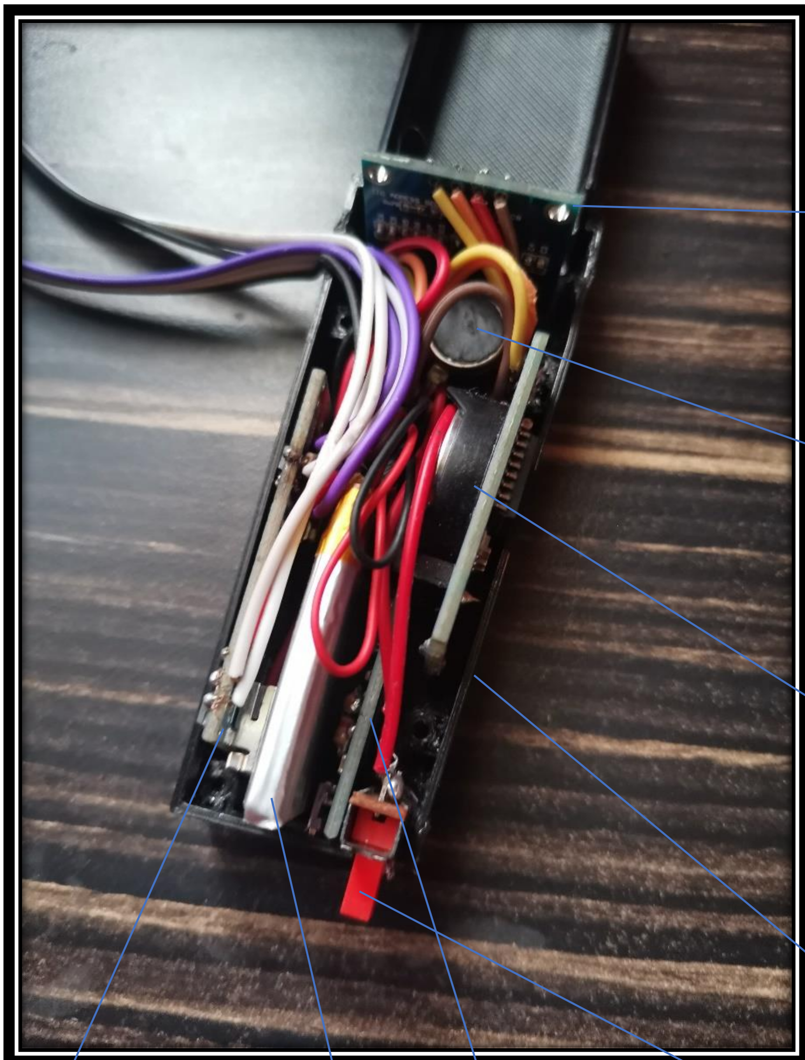


Connect each module to their respective pins of Arduino Nano. Then, solder all connected parts.

Place the components inside the case then connect the Arduino Nano to computer and upload the code created from Arduino IDE.



Attach the case to face shield. Test out the Product.



OLED Display. (Organic Light-Emitting Diodes) is a flat light emitting technology, made by placing a series of organic thin films between two conductors.

Vibration Motor. These are mechanical devices that cause vibrations to occur.

RTC Module. The DS3231 is a low-cost, highly accurate Real Time Clock that can maintain hours, minutes, and seconds, as well as, day, month, and year information.

PETG Case. Polyethylene terephthalate glycol is a thermoplastic polyester that provides significant chemical resistance, durability, and excellent formability for manufacturing.

Arduino Nano. It is a small size breadboard and flexible with a wide variety of applications.

Li-Po Battery. LiPo is a rechargeable battery of lithium-ion technology using a polymer electrolyte instead of a liquid one.

Switch. An electrical switch serves the purpose of controlling the flow of electrical current within a circuit.

Charging Module. The TP4056 is a single-cell lithium-ion battery charger with a full constant-current/constant-voltage linear charger.

Mirror. A mirror is a reflective surface that does not allow the passage of light and instead bounces it off, thus producing an image.

Fresnel Lens. Fresnel lens, succession of concentric rings, each consisting of an element of a simple lens, assembled in proper relationship on a flat surface to provide a short focal length.

Acrylic Sheet. Acrylic is a transparent plastic material with outstanding strength, stiffness, and optical clarity.

Temperature Sensor. A temperature sensor is an electronic device that measures the temperature of its environment and converts the input data into electronic data to record, monitor, or signal temperature changes.

Ultrasonic Sensor. An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal.

Face Shield. a protective covering for all or part of the face that is commonly made of clear plastic and is worn specially to prevent injury or to reduce the spread of transmissible disease

Research Design

The study employed an experimental research design to determine the functionality and capability of Smart Face Shield: Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning in detecting fever which is one of the most common symptoms of COVID-19 and its variants.

According to S. Bell (2009), experimental design is the process of carrying out research in an objective and controlled fashion so that precision is maximized and specific conclusions can be drawn regarding a hypothesis statement.

As stated by De Vaus (2006), the research design refers to the overall strategy that you choose to integrate the different components of the study coherently and logically, thereby, ensuring you will effectively address the research problem; it constitutes the blueprint for the collection, measurement, and analysis of data.

This study is experimental research for the product that needed several trials and tests to identify the functionality of the proposed Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning that will be beneficial in maintaining safety measures while going to crowded places despite COVID-19 pandemic.

Statistical Treatment

All qualitative and quantitative data that are needed were gathered.

For the second objective, the Smart Face Shield Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning was tested to determine the accuracy of both temperature and ultrasonic sensor under different distance settings (50cm, 75cm, and 100cm). Target temperature (nearest distance), trial 1, trial 2, and trial 3 were determined by collecting the average of each twenty-five (25) data in a span of 30 seconds using the formula $average = \frac{Total\ Sum\ of\ Data}{Number\ of\ Data}$. The average of trial 1, 2 and 3 are also computed using the formula $average = \frac{Total\ Sum\ of\ Trials}{Number\ of\ Trials}$ to compare the accuracy of sensors from target temperature. Also, the difference was calculated using the formula $Absolute\ Error = |Experimental\ Value - Theoretical\ Value|$ the accuracy was calculated using the formula of percentage error which is $percentage\ error = \left|\frac{Experimental\ Value - Theoretical\ Value}{Theoretical\ Value}\right| \times 100$. These formulas are from a web blog of Scott Laughlin (n.d). Furthermore, tape measure is used to navigate the right measurement of distance settings and to compare the distance given by the ultrasonic sensor.

For the third and fourth objective, the duration of time the battery would last long when used continuously and the duration of time the battery would recharge using a standard USB battery charger was determined by using a timer. Third objective consists of three settings (Max-Nom, Max-Min, Max-Cut) and each has three trials (1,2,3). Fourth objective also consists of three settings (Cut-Min, Cut- Nom, Cut-Max) and each also has three trials (1,2,3). The averages of each trials in each objective were also calculated using the formula of $average = \frac{Total\ Sum\ of\ Trials}{Number\ of\ Trials}$.

CHAPTER IV

PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

This chapter presents all the gathered data by the researchers that deal with the presentation, analysis, and interpretation of results through the researchers' observation of the Smart Face Shield: Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning. The data are presented in tabular form and followed by interpretation.

I. The Physical Characteristics of the Smart Face Shield: Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning

		Case	**Face Shield**
Dimension	**Height**	29 mm	135 mm
	Width	40 mm	168 mm
	Length	159mm	180 mm
Shape		L-shaped rectangle	Arc Curved
Mass		80 g	65 g
Material Used	**Case**	Polyethylene terephthalate glycol (PETG)	
	Lens	Fresnel lens 110mm focal length, 3x magnification	
	Reflector	Transparent acrylic sheet 1.5mm	
	Battery	Lithium-Ion Polymer 3.7v 400mAh	
	Modules	OLED display, RTC module, Arduino Nano, TP4056 module, Ultrasonic Sensor, Temperature sensor	

Table 1 The Physical Properties of the Smart Face Shield: Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning

Table 1 shows the physical properties of the Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning in terms of dimension, shape, mass, and materials. The dimension, shape, and mass of the Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning is divided into two parts: Case & Face Shield. The case's dimension measures 29 mm x 40 mm x 159 mm of height, width, and length respectively. On the other hand, the face shield's dimension measures 135 mm x 168 mm x 180 mm of height, width, and length respectively. In terms of its shape & mass, the case of the product is an L-shaped rectangle with a mass of 80g, and the Face shield is curved arc-shaped with a mass of 60g.

Also, the case of the product is made of Polyethylene terephthalate glycol (PETG), the lens is made of a Fresnel lens with 110mm focal length & 3x magnification. The reflector of the product is made of a 1.5mm thick transparent acrylic sheet, the battery used in the product is a 3.7v & 400mAh lithium-ion polymer while the modules used are OLED display, RTC module, Arduino Nano, TP4056 module, Ultrasonic Sensor, Temperature sensor.

In addition, based on the mass of the product weighs 165g and we observed that the product is not too heavy and may not cause a hassle to equip.

According to www.twi-global.com, the Polyethylene terephthalate glycol (PETG) is a thermoplastic polyester that delivers significant chemical resistance, durability, and formability in manufacturing. Also, the Polyethylene terephthalate glycol (PETG) has greater strength and durability, as well as being more impact resistant and better suited to the higher temperatures.

Moreover, the lens used in the product is a Fresnel lens, according to Magnifiers (n.d.) Fresnel lens is a magnifying glass lens that design enables the construction of lenses of large aperture and short focal length without the weight and volume of material which would be required in conventional lens design and also compare to the other lens Fresnel lens is much thinner, lighter, larger aperture, passing more ray and lower cost.

With the use of a transparent acrylic sheet, the data from the OLED was shown as a virtual image. According to www.curbellplastics.com acrylic is a transparent plastic material with strength, stiffness, and optical clarity also, it has superior weathering properties unlike other transparent plastic. Acrylic sheet is like a glass in qualities like clarity and transparency but unlike glass it is not too heavy and have much more impact resistant than glass.

II. The accuracy of MLX60914 temperature sensor combined with and without HC-SR04 ultrasonic sensor

Distance	**Target Body Temperature**	**Trial 1**	**Trial 2**	**Trial 3**	**Average Temperature**	**Difference**	**Accuracy**
50cm	35.96 °C	35.44 °C	35.58 °C	35.54 °C	35.52 °C	±0.44˚C	1.2%
75cm	36.18 °C	35.37 °C	35.43 °C	35.39 °C	35.40 °C	±0.78˚C	2.2%
100cm	36.35 °C	35.17 °C	35.16 °C	35.24 °C	35.19 °C	±1.16˚C	3.2%

Table 2.1 The accuracy of MLX60914 temperature sensor without HC-SR04 ultrasonic sensor

The first row shows the variables needed to determine the objective. In the second row, shows the accuracy of temperature that the Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning can detect if it is 50 centimeters away from the subject with an initial temperature of 35.96 °C. There are three trials conducted to determine the average temperature of a person with just using a temperature sensor and without an ultrasonic sensor. The first trial detected a temperature of 35.44 °C, the second trial was 35.58 °C, and the third trial was 35.54 °C. With these three trials the average temperature was 35.52 °C. This only means that the average temperature is quite accurate with the target body temperature with a difference of ±0.44°C and accuracy of 1.2%, considering the 50 centimeters distance.

In the third row, shows the accuracy of temperature that the Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning can detect if it is 75 centimeters away from the subject with an initial temperature of 36.18 °C. Also, three trials were conducted to determine the average temperature of a person with only a temperature sensor and without an ultrasonic sensor. In the first trial the temperature detected was 35.37 °C, while 35.43 °C and 35.39 °C as for the second and third trial. Making an average temperature of 35.40 °C. As the distance between the product and subject increased, the average temperature became inaccurate with the initial temperature, giving a difference of ±0.78°C and accuracy of 2.2%. It is because Infrared thermometer will only give an accurate reading if it is close enough with the subject.

Lastly, in the fourth row shows the accuracy of temperature that the Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning can detect if it is 100 centimeters away from the subject with an initial temperature of 36.35 °C. To determine the average temperature of a person using only a temperature sensor and without an ultrasonic sensor, there were three trials conducted. The three trials detected the temperature of 35.17 °C, 35.16 °C and 35.24 °C respectively. The average temperature for these trials was 35.19 °C. Increasing the distance with another 25 centimeters, making the product 100 centimeters away from the subject; the reading of temperature became more inaccurate with a difference of ±1.16°C and accuracy of 3.2%. It is clear that using a temperature sensor alone and not combining it with an ultrasonic sensor, the accuracy of person's temperature scanning is decreasing as the distance of from the product is increasing.

According to Fluke (2021), every infrared thermometer has a "distance-to-spot" (D:S) ratio that tells you the diameter of the area being measured compared to the distance from the target. For some instances, if your thermometer has a distance-to-spot ratio of 12:1, it measures an approximately one-inch-diameter spot when it's 12 inches from the target (about 2.5 cm at 30 cm). If you try to use that thermometer to measure a two-inch (5-cm) area from even just a few feet (1 m) away, you're not going to get an accurate result because the thermometer will also be measuring the temperature outside the area you want to measure.

Distance	**Target Body Temperature**	**Trial 1**	**Trial 2**	**Trial 3**	**Average Temperature**	**Difference**	**Accuracy**
50cm	35.51˚C	35.53˚C	35.54˚C	35.51˚C	35.53˚C	±0.02˚C	0.1%
75cm	35.62˚C	35.59˚C	35.56˚C	35.58˚C	35.58˚C	±0.04˚C	0.1%
100cm	35.59˚C	35.54˚C	35.58˚C	35.59˚C	35.57˚C	±0.02˚C	0.1%

Table 2.2 The accuracy of MLX60914 temperature sensor combined with HC-SR04 ultrasonic sensor

The first row shows the variables needed to determine the objective. In the second row, shows the accuracy of temperature that the Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning can detect if it is 50 centimeters away from the subject with an initial temperature of 35.51˚C. Three trials were conducted to determine the average temperature of a person using temperature sensor combined with an ultrasonic sensor. In the first trial the temperature detected was 35.53˚C, while 35.54˚C and 35.51˚C as for the second and third trial. The average temperature for these trials was 35.53˚C. This means that there are now only ±0.02 ˚C difference in average and initial temperature and accuracy of 0.1% with the use of ultrasonic sensor, unlike when the researchers only used a thermometer, it gave a difference of ±0.44°C and accuracy of 1.2% with just a distance of 50 cm.

In third row, shows the accuracy of temperature that the Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning can detect if it is 75 centimeters away from the subject with an initial temperature of 35.62˚C. To determine the average temperature of a person using temperature sensor combined with an ultrasonic sensor, there were three trials conducted. The first trial detected a temperature of 35.59˚C, the second trial was 35.56˚C, and the third trial was 35.58˚C. Making an average temperature of 35.58˚C. In the previous trials, when the distance between the product and subject was increased into 75 centimeters, the accuracy in readings dropped rapidly. But using an ultrasonic sensor, the reading in the temperature is still accurate despite of the increase in distance having a difference of ±0.04 ˚C in the initial and average temperature and accuracy of 0.01%.

Lastly, in fourth row shows the accuracy of temperature that the Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning can detect if it is 100 centimeters away from the subject with an initial temperature of 35.59˚C. There are three trials conducted to determine the average temperature of a persson using a temperature sensor combined with an ultrasonic sensor. The three trials detected the temperature of 35.54˚C, 35.58˚C, and 35.59˚C respectively. With these three trials the average temperature was 35.57˚C. Even the distance was expanded up to 100 centimeters, the reading of temperature is still accurate with just a difference of ±0.02 ˚C and accuracy of 0.01%. Distinct from the first set of trials when ultrasonic sensor was not used, where the temperature became more inaccurate once the distance was increased into 100 centimeters. This means that using HC-SR04 ultrasonic sensor along with MLX60914 temperature sensor will give a more accurate temperature even if the distance of the product from the subject is increasing.

According to www.pepperl-fuchs.com, most of these ultrasonic sensors are equipped with temperature probes whose measurements are used to correct the measured distances. This compensation is performed over the entire working range of the ultrasonic sensors from -25° C to +70° C and allows measurement accuracies of approximately ±1.5% to be achieved. Also, according to randomnerdtutorials.com, The HC-SR04 ultrasonic sensor uses sonar to determine the distance to an object. This sensor reads from 2cm to 400cm (0.8inch to 157inch) with an accuracy of 0.3cm (0.1inches), which is good for most hobbyist projects.

III. The duration of time the battery of Smart Face Shield: Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning would discharge.

Variables	**Voltage of Lithium Ion-Polymer Battery**	**Time Duration**		
		Trial 1	**Trial 2**	**Trial 3**
Maximum voltage – Nominal voltage	**4.2 – 3.7v**	3 hours 22 minutes	3 hours and 49 minutes	3 hours and 11 minutes
Maximum voltage – Minimum safety voltage	**4.2 – 3.2v**	7 hours and 45 minutes	9 hours and 40 minutes	7 hours and 26 minutes
Maximum voltage - Cut-off voltage of battery	**4.2 – 2.8v**	8 hours and 10 minutes	10 hours and 2 minutes	8 hours and 9 minutes

Table 3 The duration of time the battery of Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning would discharge.

The Table 3 displays the duration of time that the Smart Face Shield: Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning's battery would discharge.

Three trials were conducted to know how long the Li-Po Battery would last and discharge from its maximum voltage of 4.2 v to its nominal voltage of 3.7v. The battery lasts 3 hours 22 minutes in the first trial, 3 hours and 49 minutes in the second trial, while 3 hours and 11 minutes from its last trial and with an average time duration of 3 hours and 27 minutes.

The battery of the product is discharge after it reached the minimum safety voltage (3.2v) from its maximum voltage (4.2v). In the first trial it takes 7 hours and 45 minutes before reaching the minimum safety voltage, 9 hours and 40 minutes in the second trial, and 7 hours and 26 minutes in trial third trial and with an average time duration of 8 hours and 4 minutes.

To determine the time before the battery, reach its cut-off voltage, which is 2.8v, researchers made another three trials. And as seen on the table, on the first trial, it will take 8 hours and 10 minutes before the battery reaches its cut-off voltage, while 10 hours and 2 minutes in the second trial, and 8 hours and 9 minutes in the final trial and with an average time duration of 9 hours and 14 minutes

This only means that when the device reaches approximately 9 hours of continuous usage, it will shut down on its own due to programmed cut-off voltage of the battery (2.8v) and cut-off voltage of the charging module (2.5v). This is just sufficient since according to The Nature of the Americans (n.d.), out of 5,550 adults, over 60% of adults report spending 5 or less hours outside in nature each week.

IV. The duration of time the battery of Smart Face Shield: Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning would charge.

Variables	**Voltage of Lithium Ion-Polymer Battery**	**Time Duration**		
		Trial 1	**Trial 2**	**Trial 3**

Cut-off voltage of battery – Minimum safety voltage	**2.8 - 3.2v**	1minute and 22 seconds	1 minute and 31 seconds	1 minute and 27 seconds
Cut-off voltage of battery – nominal voltage	**2.8 - 3.7v**	29 minutes and 43 seconds	30 minutes and 57 seconds	30 minutes and 28 seconds
Cut-off voltage of battery – maximum voltage	**2.8 - 4.2v**	1hour and 15 minutes	1 hour and 31 minutes	1 hour and 28 minutes

Table 4 The duration of time the battery of Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning would charge.

Table 4 shows the time duration of Smart Face Shield: Arduino Infra-red Based Face Shield for Protection and Temperature Scanning would it charge.

Three trials were conducted to know the duration of time needed for lithium ion-polymer battery to charge from its cut-off voltage (2.8v) to minimum safety voltage (3.2v) through the charging module using a UBS cable. The battery took 1 minute & 22 seconds to charge on the first trial, 1 minute & 31 seconds to charge on the second trial, while 1 minute & 27 seconds to charge on the third trial and with an average time duration of 1 minute and 27 seconds

To determine the duration of time the battery would charge from cut-off voltage (2.8v) to nominal voltage (3.7v), three trials were also conducted. On the first trial, it took 29 minutes and 43 seconds to charge the battery. On the second trial, it took 30 minutes and 57 seconds to charge the battery. While on the third trial, it took 30 minutes and 28 seconds to charge the battery with an average time duration of 30 minutes and 10 seconds

Lastly, three trials were also conducted to determine the duration of time the battery would charge from the cut-off voltage (2.8) to maximum voltage (4.2). The battery took 1 hour and 15 minutes to charge on the first trial, it took 1 hour and 31 minutes to charge on the second trial, while it took 1 hour and 28 minutes to charge on the third trial and with an average time duration of 1 hour and 25 minutes

This only means that it will take an approximately 1 hour and a half in order to fully charge the product. According to Rayan (2021), normally, it takes 30-60 minutes to charge a LiPo battery. However, the charging time is reliant on the size of the battery or cell count. Your charger's power output and capacity are also a determinant in this case. The battery type and the voltage play an important role as well.

V. The best lighting conditions to visibly read the data reflected to the reflector of the Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning.

MATERIAL USED	Visibility			
Transparent acrylic sheet	Setting	Low	Mid	High
	Daylight	/		
	Nightlight			/
	Shady light		/	
	Fluorescent lamp light		/	
	Bulb light		/	

Table 5 The best lighting conditions to visibly read the data reflected to the reflector of the Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning

Table 5 shows the best lighting condition to visibly see the data reflected to the reflector of the Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning using an acrylic sheet as a reflector. This table shows five lighting setting (Daylight, Shady light, Night light, Fluorescent lamp light, and bulb light).

Each setting has three conditions (Low, Mid, High) which are used to determine the visibility of data reflected. In daylight setting, the virtual image data reflection is at low visibility while in nightlight setting, the virtual image data reflection is at high visibility. In the shady light, fluorescent lamp, and bulb light settings, the virtual image data reflection is at mid visibility.

This only means that the brighter the ambient light is - the lower the visibility of the virtual image, while the darker the ambient light is - the higher the visibility of the virtual image.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary, which discusses briefly the conclusions that refer to the ideas drawn from the findings of this study and recommendations, which give suggestions to the other researchers that might have similar studies about the research topic.

Summary

The study entitled “Smart Face Shield: Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning” was focused on the development of a technological device to assist people on the global pandemic and identifying its physical characteristics, functionality and efficiency.

This study would benefit people whom always go outside for work, groceries, food, and etc. This will be convenient and helpful for its functionality which helps to protect, to be aware, and monitor the temperature of the nearby people at public places.

This research sought to answer the following objectives, (1) Determine the physical characteristics of the Smart Face Shield: Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning in terms of dimension, shape and mass, (2) Determine the accuracy of MLX60914 temperature sensor combined with and without HC-SR04 ultrasonic sensor, (3) Determine the duration of time the battery would last long when used continuously, (4) Determine the duration of time the battery would recharge using a standard USB battery charger, (5) Determine the best lighting conditions to visibly read the data reflected to the reflector.

The researchers gathered data through trials and observations. After the data were gathered, the researchers presented, analyzed, and interpreted them.

With that, the researchers made conclusions and recommendations of the study.

Summary of Findings

After gathering all the needed data, the findings were revealed as follows:

1. The dimension, shape and mass of the Smart Face Shield: Arduino Based Infra-Red Face Shield for Protection and Temperature Scanning is divided into two parts: Case & Face Shield. The case's dimension measures 29 mm x 40 mm x 159 mm of height, width and length respectively. On the other hand, the face shield's dimension measures 135 mm x 168 mm x 180 mm of height, width and length respectively. In terms of its shape & mass, the case of the product is L-shaped rectangle with a mass of 80g and for the Face shield, it is curved arc shaped with a mass of 60g. Also, the material used for the case is PETG, for the lens is Fresnel lens, for the reflector is acrylic sheet, for the battery is li-po battery, while the module used are OLED display, RTC module, Arduino Nano, TP4056 module, Ultrasonic Sensor, and Temperature sensor.

2.1. The Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning was able to detect an initial temperature of 35.96 °C at 50cm distance without ultrasonic sensor in the second row. The first trial detected a temperature of 35.44 °C, the second trial was 35.58 °C, and the third trial was 35.54 °C. It has an average temperature of 35.52 °C which is ±0.44°C away from the initial temperature and accuracy of 1.2%. The product was able to detect an initial temperature of 36.18 °C at 75cm distance without ultrasonic sensor in the third row. The 47 first trial detected a temperature of 35.37 °C, the second trial was 35.43 °C, and the third trial was 35.39 °C. It has an average temperature of 35.40 °C which is ±0.78°C away from the initial temperature and an accuracy of 2.2%. The product was able to detect an initial temperature of 36.35 °C at 100cm distance without ultrasonic sensor in fourth row. The first trial detected a temperature of 35.17 °C, the second trial was 35.16 °C, and the third trial was 35.24 °C. It has an average temperature of 35.19 °C which is ±1.16 °C away from the initial temperature and an accuracy of 3.2%.

2.2. The Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning was able to detect initial temperature of 35.51 °C at 50cm distance with ultrasonic sensor in the second row. The first trial detected a temperature of 35.53 °C, the second trial was 35.54 °C, and the third trial was 35.51 °C. It has an average temperature of 35.53 °C which is ±0.02 °C away from the initial temperature and an accuracy of 0.1%. The product was able to detect initial temperature of 35.62 °C at 75cm distance with ultrasonic sensor in the third row. The first trial detected a temperature of 35.59 °C, the second trial was 35.56 °C, and the third trial was 35.58 °C. It has an average temperature of 35.58 °C which is ±0.04 °C away from the initial temperature and an accuracy of 0.1%. The product was able to detect initial temperature of 35.59 °C at 100cm distance with ultrasonic sensor in the fourth row. The first trial detected a temperature of 35.54 °C, the second trial was 35.58 °C, and the third trial was 35.59 °C. It has an average temperature of 35.57 °C which is ±0.02 °C away from the initial temperature and an accuracy of 0.1%.

3. Three trials were conducted to know how long the Li-Po Battery would last and discharge from its maximum voltage of 4.2 v to its nominal voltage of 3.7v. The battery lasts 3 hours 22 minutes in the first trial, 3 hours and 49 minutes in the second trial, while 3 hours and 11 minutes from its last trial. The battery of the product is discharge after it reached the minimum safety voltage (3.2v) from its maximum voltage (4.2v). In the first trial it takes 7 hours and 45 minutes before reaching the minimum safety voltage, 9 hours and 40 minutes in the second trial, and 7 hours and 26 minutes in trial third trial. To determine the time before the battery, reach its

cut-off voltage, which is 2.8v, we made another three trials. And as seen on the table, on the first trial, it will take 8 hours and 10 minutes before the battery reaches its cut-off voltage, while 10 hours and 2 minutes in the second trial, and 8 hours and 9 minutes in the final trial.

4. Three trials were conducted to know the duration of time needed for lithium ion-polymer battery to charge from its cut-off voltage (2.8v) to minimum safety voltage (3.2v) through the charging module using a UBS cable. The battery took 1 minute & 22 seconds to charge on the first trial, 1 minute & 31 seconds to charge on the second trial, while 1 minute & 27 seconds to charge on the third trial. To determine the duration of time the battery would charge from cut-off voltage (2.8v) to nominal voltage (3.7v), three trials were also conducted. On the first trial, it took 29 minutes and 43 seconds to charge the battery. On the second trial, it took 30 minutes and 57 seconds to charge the battery. While on the third trial, it took 30 minutes and 28 seconds to charge the battery. Lastly, three trials were also conducted to determine the duration of time the battery would charge from the cut-off voltage (2.8) to maximum voltage (4.2). The battery took 1 hour and 15 minutes to charge on the first trial, it took 1 hour and 31 minutes to charge on the second trial, while it took 1 hour and 28 minutes to charge on the third trial.

5. In daylight setting, the virtual image data reflection is at low visibility while in nightlight setting, the virtual image data reflection is at high visibility. In the shady light, fluorescent lamp, and bulb light settings, the virtual image data reflection is at mid visibility.

Conclusions

After the product testing, the researchers came up with the following conclusions regarding the effectiveness and functionality of the Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning in accordance with the objectives of the study.

1. The Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning had reached the accepted physical characteristics. The case has a dimension of 29 mm x 40 mm x 159 mm of height, width and length respectively with a shape of L-shaped rectangle. On the other hand, the face shield is a curved arc shaped that has a dimension of 135 mm x 168 mm x 180 mm of height, width and length respectively. The total weight of the case and face shield is 145g.

2.1. The reading of temperature was quite accurate with 1.2% accuracy when the product is 50cm away from the subject without using an ultrasonic sensor. The reading of temperature was inaccurate with 2.2% accuracy when the distance between the product and the subject was expanded into 75cm without using an ultrasonic sensor. The reading of temperature was inaccurate with 3.2% accuracy when the distance between the product and the subject was expanded into 100cm without using an ultrasonic sensor

2.2. The reading of temperature when the product is 50cm, 75cm, and 100cm away from the subject with the use of ultrasonic sensor was more accurate with 0.1% accuracy than only using a temperature sensor.

3. The Smart Face Shield: Arduino Based Infra-red Face shield for Protection and Temperature Scanning's Li-Po battery would last and discharge from its maximum voltage to its nominal voltage after at least more than 3hrs. After reaching its minimum safety voltage, the battery would last for approximately 7hrs up to 9hrs. The battery of the product will reach its cut-off voltage within a maximum time of 10hrs.

4. Through a charging module using a USB cable, it will take less than 2 minutes for the Li-Po battery to charge from its cut-off voltage to its minimum safety voltage. The maximum

duration of time the battery would charge from its cut-off voltage to its nominal voltage is more than 30 minutes. In able to charge the battery of the product from its cut-off voltage to its maximum voltage, it'll take at least more than an hour.

5. The virtual image data reflection visibility depends on the lighting condition; it is likely to be less visible in brighter ambient lights, and more visible in darker ambient light.

Recommendations

After drawing the conclusions of the study, the researchers hereby make the following suggestions and recommendations:

1. Use Laser integrated display projector from known smart glasses like Focal by North, to make the product's design less bulky and projected data more visible, however, it would be expensive.
2. Create a design for the Ultrasonic and temperature sensor located at the top of the face shield to make it simpler or simply relocate the sensors without affecting its overall functionality.
3. Add a Bluetooth module or WI-FI module to make the product easily accessible and provide more smartphone functionality such as message notification, call notification and etc.
4. Add a micro speaker to provide voice notification as an additional way of notifying the user.
5. Use larger capacity battery and change the resistor value on TP4056 module to make the product have longer battery life.
6. Add buttons or touch sensor to control the data presented at the OLED display.

7. Use the required lens which is a Plano convex lens which has a focal point of 100mm and 3x magnification to make the data more visibly clear.
8. Use thermal camera as an alternative to IR temperature sensor, however it would more expensive.

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Appendices

Appendix A

Picture of the Product

Appendix B

Financial Statement

MATERIALS	AMOUNT
Arduino Nano	**Php 238**
MLX90614 Temperature Sensor	**Php 1357.48**
HC-SR04 Ultrasonic Sensor	**Php 59**
DS3231 Real-time Clock Module	**Php 148**
Organic Light-Emitting Diode Display	**Php 170**
Fresnel Lens	**Php 146**
Micro DC Vibration Motor	**Php 49**
Lithium-Polymer Battery	**Php 534**
Polyethylene Terephthalate Glycol Case	**Php 400**
TOTAL	**Php 3,101**