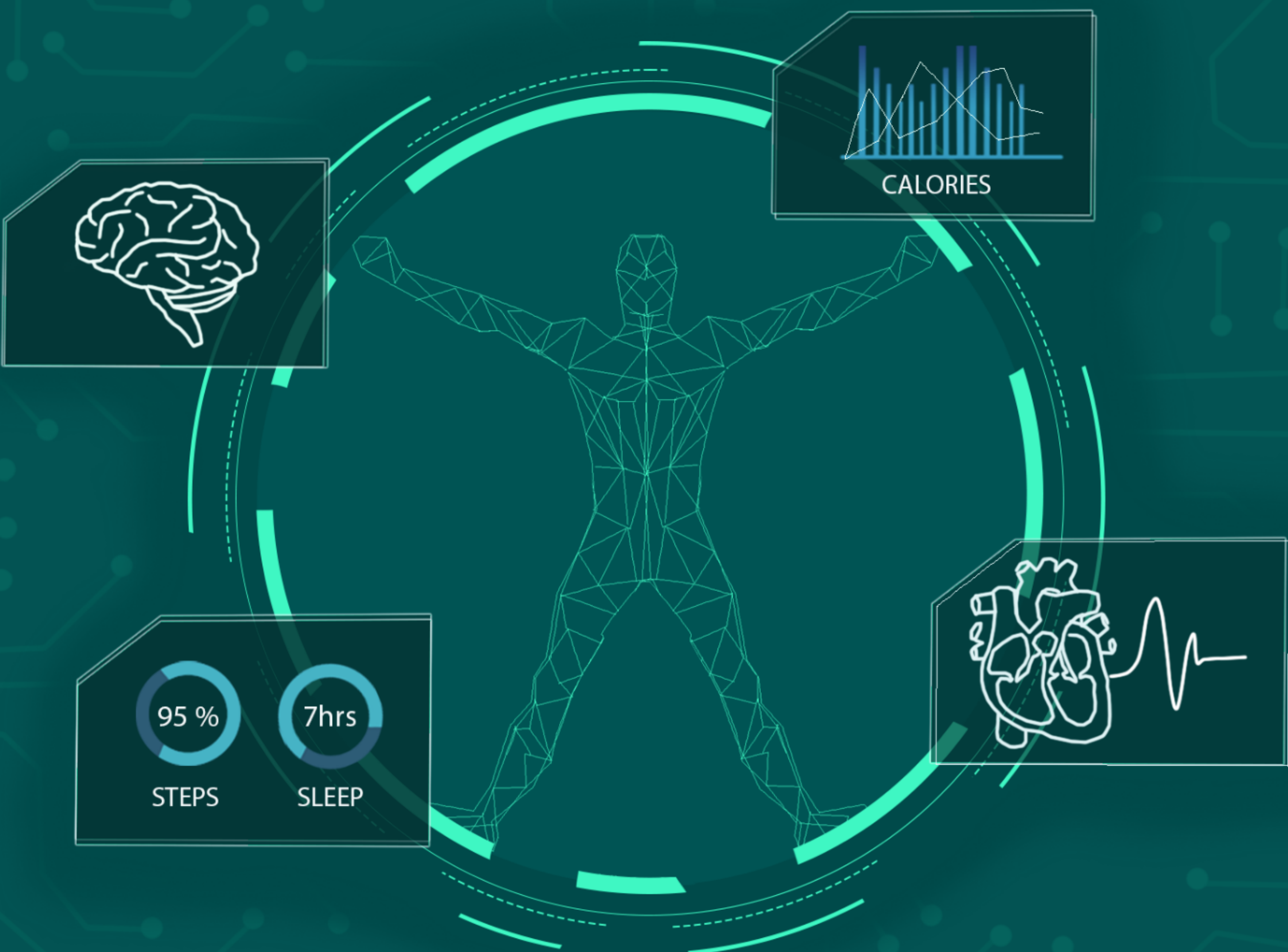
PROCEEDINGS OF ELECTRICAL ENGINEERING CAPSTONE SHOWCASE (EECS2020)

Health & Wellness

Electronic and Computer Engineering Division
Universiti Teknologi Malaysia | School of Electrical Engineering
Faculty of Engineering
Session 2020/2021



UNIVERSITI TEKNOLOGI MALAYSIA
October 2021
EECS 2020
Electrical Engineering Capstone Showcase
School of Electrical Engineering

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PREFACE

The capstone design project in the School of Electrical Engineering is a compulsory course for final year undergraduate students. This course is offered to produce community-cognizant individuals who are able to address community or industry based problems using appropriate techniques, skills, and modern engineering tools. In addition, elements such as project management and teamwork in diverse teams are included and assessed throughout the study.

This publication consists of all the work presented during the Electrical Engineering Capstone Showcase (EECS 2020), which was held on 25th January 2021 organized by the School of Electrical Engineering, Universiti Teknologi Malaysia. The EECS 2020 was the platform for more than 300 students to share and exhibit their ideas and projects which they have worked on for that semester. Panels who evaluated their work consist of academicians and industrial representatives who faithfully had provided valuable insights to further improve the students' work.

The projects reported in the Proceedings of Electrical Engineering Showcase 2021: Health and Wellness could serve as motivation and valuable information for future collaborative projects and for the betterment of the society.

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Smart People Counting System for Social Distancing during Covid-19 Pandemic

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Abstract: Maintaining occupancy limits for social distancing in the crowded area is a crucial benefit that people counting solutions are providing in the current climate. In this project, a prototype is developed to monitor and limit the number of customers in a shop or crowded area. The prototype is divided into two parts which is hardware and software. The implementation of Internet of Things (IoT) application enables the count of the number of people in a certain building or area by using the infrared sensor module and NodeMCU. The infrared sensor module is used for the detection of the existence of a person and it will count the people passing through it. All the data will be saved to the database and the IoT application will be used to display and control the number of people in the certain building.

Keywords: *Infrared sensor; NodeMCU; IoT apps; database; monitor; limit*

Introduction

As of January 27, 2021, about 100 million of people worldwide had been infected with COVID-19, or scientifically "severe acute respiratory syndrome coronavirus 2" (SARS-CoV-2), and about 2.16 million had died from coronavirus disease 2019 (COVID-19) [1]. The virus outbreak has affected both human resources and the economy around the world in a dramatical manner, resulting worldwide pandemic. Lots of businesses have successfully transferred into online operations but there are certain businesses still having a physical business. Online businesses, trading and shopping, though viable, cannot fully replace their real world counterparts yet.

The prevention and control of the COVID-19 epidemic is a major challenge for all countries. As recommended by the Ministry of Health Malaysia (MOH), social distancing is an important practice to reduce the risk of COVID-19 infection. Therefore, a capital market participant must put in place appropriate measures to avoid close contact at the enclosed area to limit the risk of exposure. There are some rules that MOH had been appointed of general equipment for the workspace at the entry and exit of an area which are:

1. Assign a doorkeeper or use automated doors where possible.
2. Hand sanitizer for individual to self-sanitize.
3. Crowd controlling by having separate entry and exit points.
4. Notice(s) at prominent and visible places to notify who are unwell, or who have been exposed to COVID-19 patients, or have just returned to or arrived in Malaysia to refrain from entering its premises.
5. Disinfect all entry and exit doors in daily manner.

This project is focused on how to control the maximum number of customers in a shop and control the movement of customers entering and leaving a shop. The objectives of this works are to develop a smart head counter to manage the customers entering and leaving the shop and also to establish an application for shop manager in order to manage the maximum number of customers in a shop for a certain period.

Topic Survey and Interview

This project was made with respect to the interview that we had made from the end user. Due to the covid-19, we created a survey on health and well-being themes and spread the survey to collect all data from the consumers. Some of the questions are:

1. The frequency going to shops / groceries / malls after Covid-19 pandemic.
2. Are visits to shops / groceries / malls and etc important?

3. Everyone you meet is following the standard operating procedure (SOP) of Covid-19 pandemic?
4. Despite the thermometer test outside every mall, are the crowds inside still worrying you of being infected by Covid-19?

Figure 1 shows 68 responses of users in terms of how many times that they are going to the shops/groceries/malls after Covid-19 pandemic with the x-axis indicate 1 as the least frequency of going to the shop and vice versa. The data showed that more than 90% of the society went to the store at least twice a week. Going to the store may increase the chances for the covid-19 to spread because by having to go to the store, they may not create a social distance in a confined place to the other customer that went to the store. To ensure that a confined place will not be crowded with people and to create a social distance, we create a smart head counter that act as a limiter for the customer in the store at one time. From the data that had been collected, it can be concluded that the work is to focus on making the smart head counter as it was necessary in order to fight the covid-19.

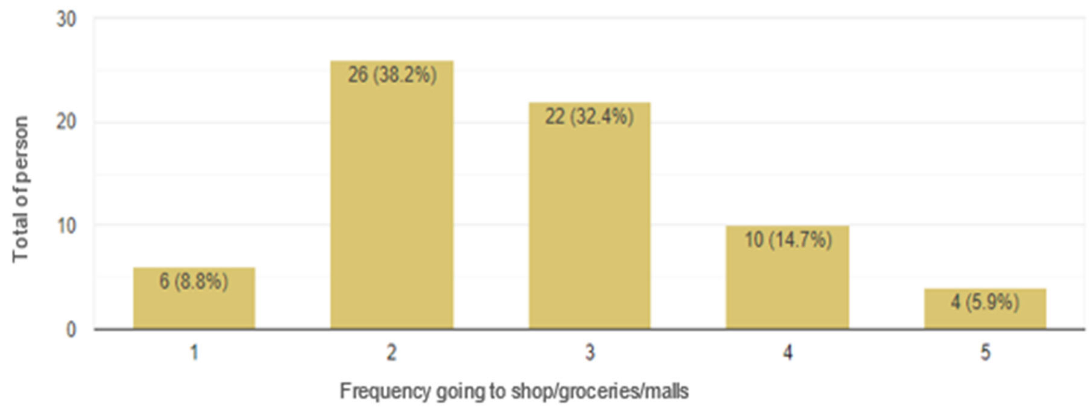

Figure 1: The frequency of users going to the shops/groceries/malls after Covid-19 pandemic.

From the findings, it was important for the society to go to the store and some of the responses they went to the store for daily essential, to buy goods, to buy something important, to ensure food stock is adequate and to buy necessities. This finding showed that having to go to the store cannot be avoided even in times of the covid-19. Therefore, for the society to grab their necessities even in time of covid-19, the smart head counter is created to ensure they could create a social distance by not having a confined place too crowded with customers in a certain time period.

Figure 2 shows 68 responses of users in terms of the frequency of meeting with people who follow SOP with the x-axis shows 1 is the least frequency of meeting with people who follows SOP and vice versa. From the data, it can be ensured that more than 30% of the respondents frequently met with people who did not follow the Standard Operation Procedure (SOP). The numbers are a big concern because having more than 30% people that did not follow the SOP may spread the virus to everyone if they had been infected. To avoid the undesirable result, we focus on forcing the people to follow the SOP of creating a social distance as instructed by the Ministry of Health Malaysia (MOH) by creating the smart head counter. From the point of view, creating this product would force the society to not be crowded in a confined place, thus helping the government to enforce the new normal.

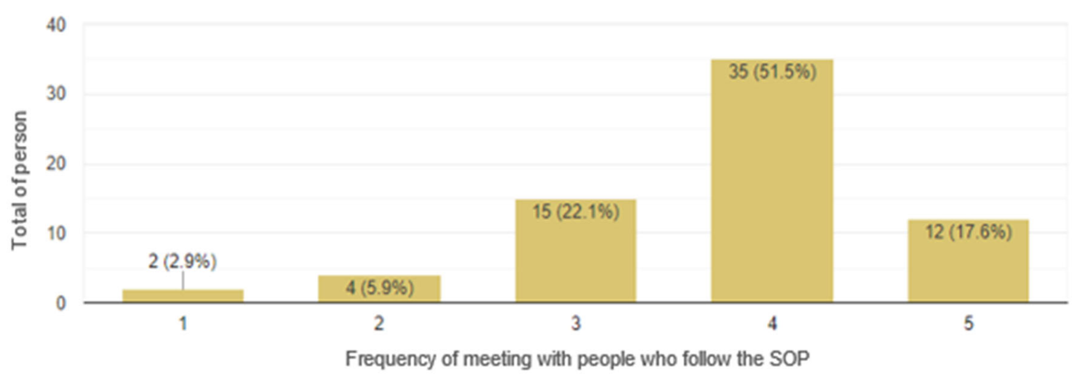

Figure 2: The frequency of users meeting with people that follow the Standard Operation Procedure (SOP).

Figure 3 shows 68 responses of users that worry if they would be infected by Covid-19 with the current SOP with the x-axis shows 5 strongly agree with the statement and vice versa. From the data, it can be concluded that most of the people in the society think that the SOP at the store, which was the thermometer measurement outside the mall still not sufficient to fight the covid-19. Due to this reason, we created the smart head counter to make sure that we could force the customer to follow the limitation of the people inside a confined place.

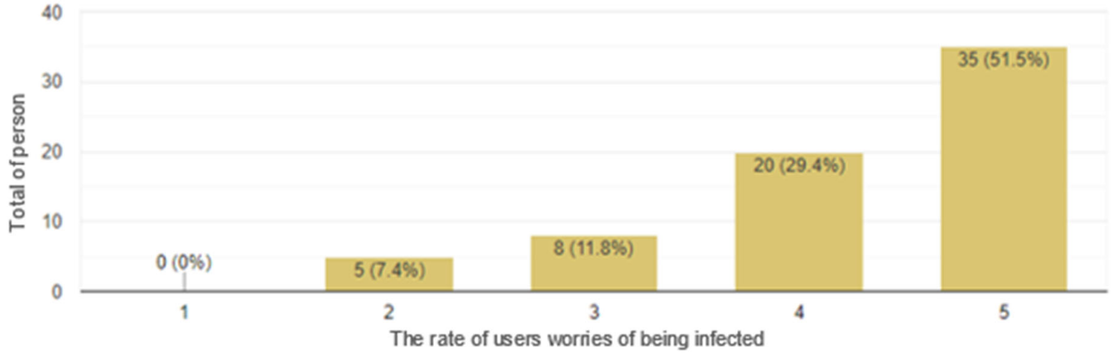

Figure 3: The frequency of users worries of being infected by Covid-19

From all the respondents' data, a smart head counter is created to ensure we can fight the covid-19 by enforcing the SOP by the government. The data showed support that creating a smart head counter is important in order to avoid the covid-19 from spreading.

Design statement

From the interview by questionnaire, the crowd situation in a certain shopping area is most likely unknown according to the experience of respondents. Most of the malls did not have a counter and display device for the visitor to obtain the total number of customers within them, to the date. According to Cito [5], in a small area with high interaction, the transmission chance of the virus is high; it supports the anxiety of respondents about the compact area interaction within malls and shops. The product must capable to monitor and control the maximum customer flow, both into and out from the area/region, and could accomplish such crowd control remotely.

These functions, based on the interview by questionnaire, could potentially solve the customer flow problem. Hence, a product that can detect the passage of customers at the entry bi-directionally to accumulate the customer number as information for upcoming visitors can solve the problem effectively. The product consists of the function of detecting passing objects, taking account of total number enter and leave the area, displaying information locally and on respective apps.

Methodology

Figure 4 and 5 shows the flowcharts of the working part of hardware and software (apps), both do not have *END* due to:

1. The hardware gadget keeps looping during operation until power off;
2. The apps only ended with the explicit return key.

Product development:

This section is the details of product development separated into Conceptual design, Hardware (including the hardware coding) and Software (apps). These procedures are the finalized steps from conceptual design towards the working product.

Conceptual Design

Some similar projects provide sketches of what the team could expect for the prototype, such as using one passive infrared sensor (PIR sensor) with Raspberry Pi in [3] and ultrasonic sensor in [4]. PIR sensor can only detect motion and simply increase the count. The ultrasonic sensor is able to detect the distance of obstacles passing through, therefore the later project proposed the dual lanes with different observation distance for the detection; entry and exit.

In this works, a pair of infrared sensors was included for passage detection in a bi-directional manner and no dual lanes needed. A microcontroller was used to compute counting, displaying and other functions on the gadget. In case of monitoring, an app was designed to connect with the prototype for remote monitoring and controlling the gadget. The conceptual drawing of the functioning product is shown in Figure 6 and 7.

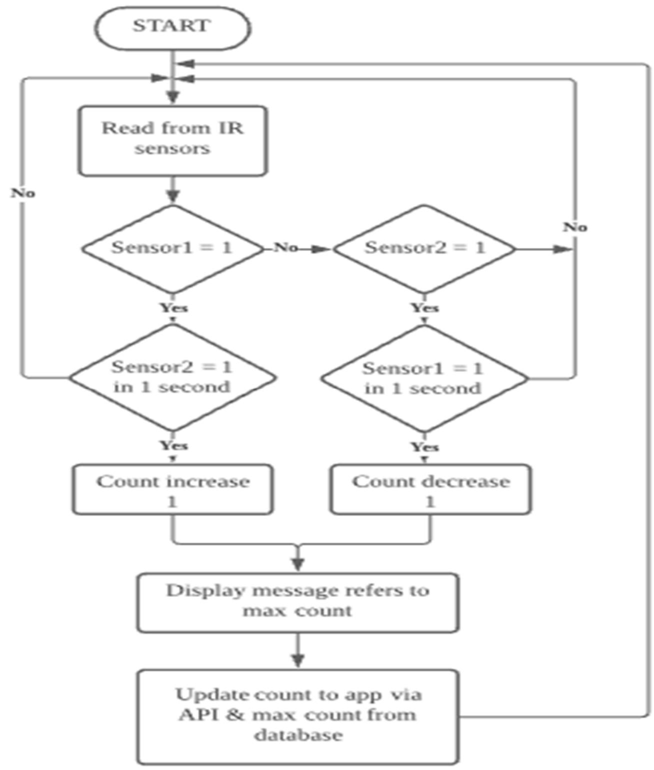

Figure 4: Hardware implementation

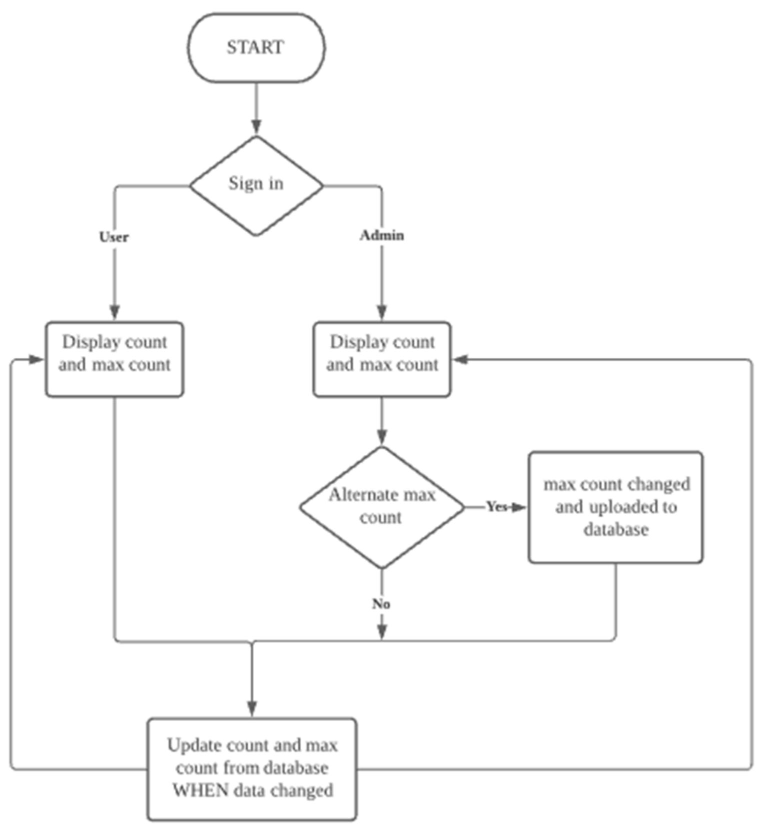

Figure 5: Hardware implementation

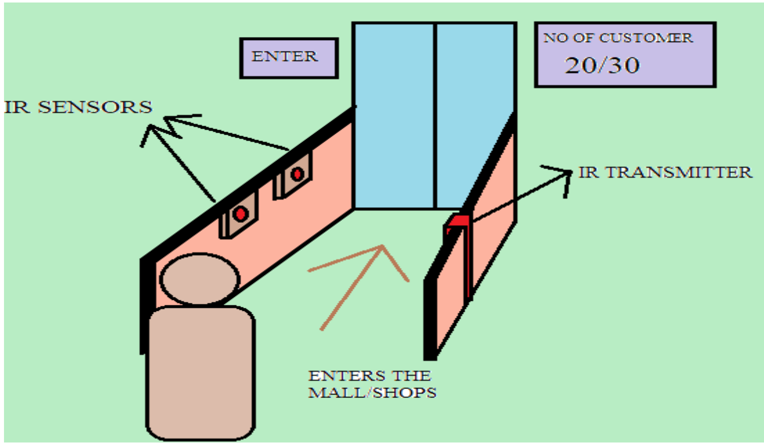

Figure 6: Conceptual art of product

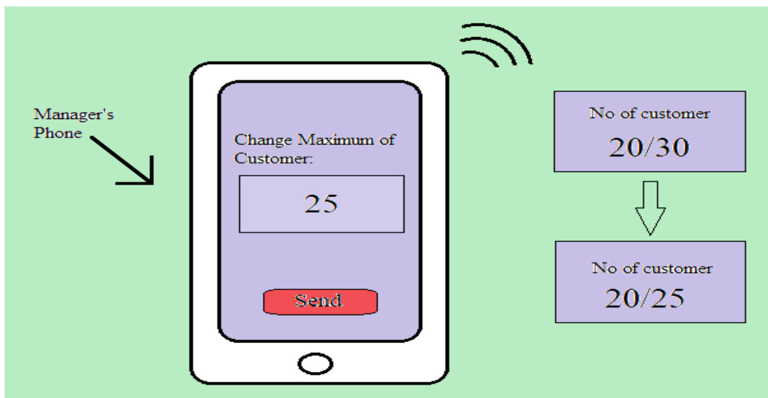

Figure 7: Conceptual art of apps interface

Hardware

Table 1 is a component list for prototype development, which consist NodeMCU, 2 infrared sensors, jumper wires, resistors, LCD, LED and breadboard.

Table 1: Component list for prototype

Component	Quantity
NodeMCU ESP8266 Lolin v3	1
Infrared Sensor	2
Jumper Wire	1 meter
LCD 16x2	1
LED red & green	1 each
Resistor (1kΩ)	2
Breadboard	1

The ESP8266 was connected with two infrared sensors, LCD and LEDs on a breadboard as shown in Figure 8. An ESP8266 pinout and connection table as shown in Table 2 is used to describe the connection.

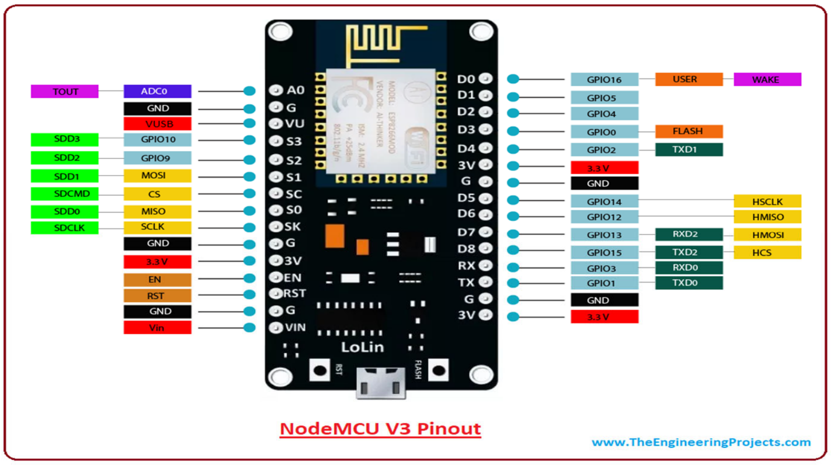

Figure 8: Pinout diagram of NodeMCU ESP8266 Lolin v3

Table 2: Pinout-to-components connections

ESP 8266 Lolin v3	Other Components
GPIO16 (D0)	LED red
GPIO5 (D1)	LCD 16x2 – SCL
GPIO4 (D2)	LCD 16x2 – SDA
GPIO0 (D3)	LED green
GPIO14 (D5)	IR Sensor 1
GPIO13 (D7)	IR Sensor 2
VUSB (VU)	Vin for components
GND (G)	Gnd for components

The components are arranged in the schematic as shown in Figure 9 using fritzing software and the completed prototype hardware is shown in Figure 10.

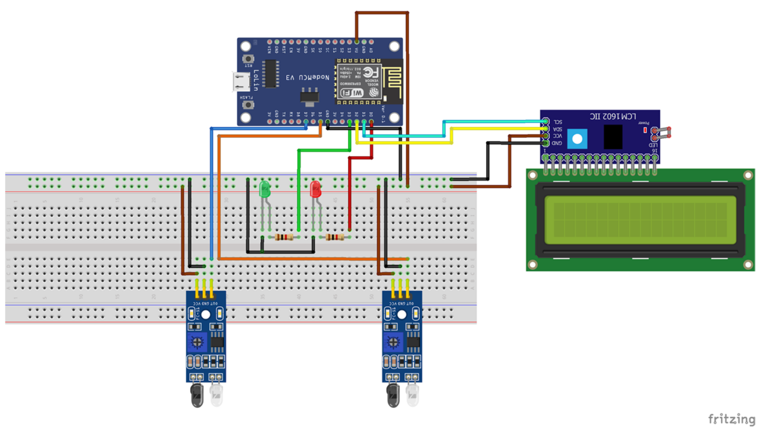

Figure 9: Hardware schematic by using fritzing

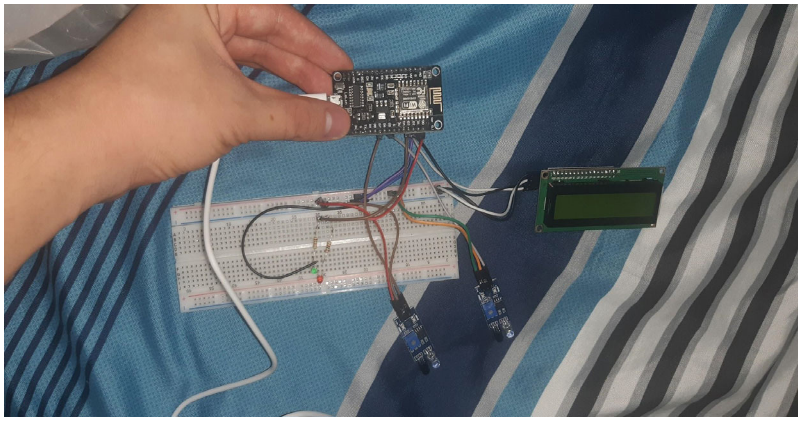

Figure 10: The completed prototype hardware

After the hardware was successfully installed, NodeMCU was then programmed with Arduino codes. The Arduino code installed into the hardware does functions as listed in the following, and can be further modified to adapt to more functions.

1. showin() uploads the count to Firebase Database, if WiFi connection is available. It also displays the information of crowdedness in the mall, and prompts the idle customer to proceed. Below shows simplified coding of the particular function.

2. takeMax() updates the hardware for the latest maximum count allowed from Firebase Database. In loop(), it was timed to run per minute.

3. initcount() is used only once per powered on of the hardware, to obtain the previous count from Firebase Database.

4. IR_looping() loops the detection of infrared sensors, and executes showin() if the gadget senses passage.
    i. A simplified coding was shown below.

5. setup() has internet connection setup, firebase setup and initcount().

6. loop() loops the IR_looping() function and has a reconnection loop within it for the hardware to work under WiFi disconnection.

Software

Software of this product is referring to the apps that have been developed to communicate with the hardware through the Internet and database for cloud storage function. The apps development tool is MIT App. Firebase Database was used as cloud storage of the product. App was designed to link with the Firebase Real time Database to monitor the count number and update maximum customers allowed in real time. When hardware detects people and updates the count into the database, apps would obtain the changed data of count and display it to users.

Referring to the admin user interface in Figure 11, choosing to change the maximum customers on the main page (left screen) will bring the user to the second page (right screen), where the user can input a desired number for updated maximum customers allowed. Hardware will update the maximum customers allowed once per minute from the database. Figure 12 is the app screen of a regular user, without privilege to change maximum customers.

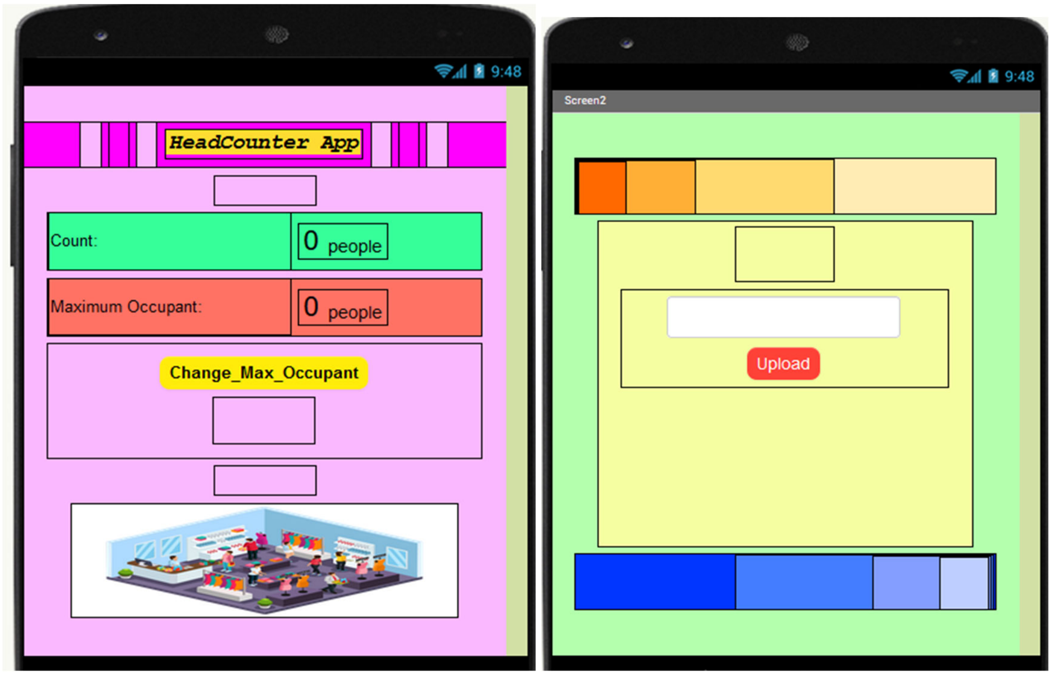

Figure 11: MIT App Inventor used in developing user interfaces (admin interface)

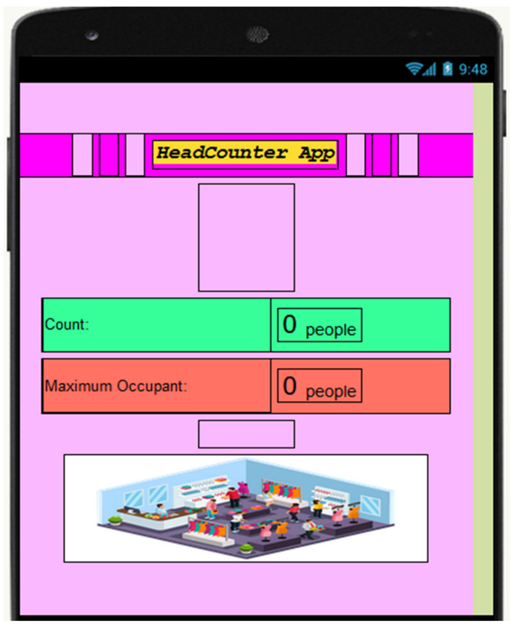

Figure 12: User interface (regular user)

Discussion on developed product

A smart head counter product to be implemented at the store is successfully created. Due to covid-19 and Movement Controlled Order (MCO0, the product cannot be tested at the store. Therefore, we created a survey to see the response of the consumer toward the product. For the consumer to understand the mechanism of our product, we attached a video in the survey before the respondent answered our survey. The video explained how our product works as shown in Figure 13.

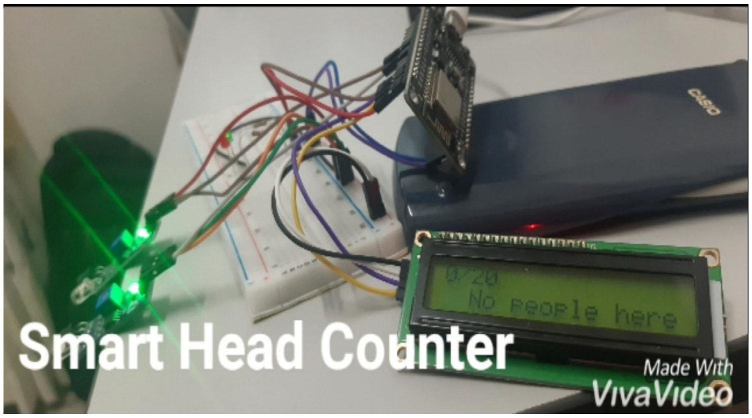

Figure 13: The demonstration video made using VivaVideo apps

This product has two components consisting of hardware and software. The video demonstrates several scenarios:

1. The hardware detected a person who entered a store via IR sensors. This increased the total number of people inside the store. The value then displayed at the LCD display and the software interface.
2. Same goes to the person who exits the store, but now the total count decreased.
3. The total occupants inside the store reached the maximum, the LCD displayed the values of total count with a warning message, while the red LED is lit to indicate the denial of upcoming entry.
4. The total occupants inside the store yet reach the maximum, the LCD displayed count and maximum occupants allowed normally.
5. The hardware detected a person who idled in front of the IR sensors. A message displayed to prompt the customer to proceed away from the detecting units.
6. The admin decided to alternate the maximum customer allowance. The "Change_Max_Occupant" button brought the admin to the second screen, where admin entered a new value for maximum customer allowance and uploaded it to Firebase Realtime Database. After 1 minute, the hardware requested update on the maximum customer allowance value.

From the data in the survey as shown in Figure 14, it is founded that 15 peoples are agreed that the device could help in avoiding the close contact between staff and customers. One of the examples was during the exchanging the tag number system. This system was used by giving a tag by a staff to the customer and when the customer finished buying their necessities, they would give back the tag number. The system was used to make sure that the total person inside the store is in a controllable value. But, the downside was this system may be one of the ways for covid-19 to spread. If there were a customer or a staff that was infected, the virus could stay on the tag and it would infect the holder during the exchange. By using our product, to control the number of customers inside a store, there won't be any contact between a staff and a customer which would make sure that the virus would not spread if there were an infected customer or staff.

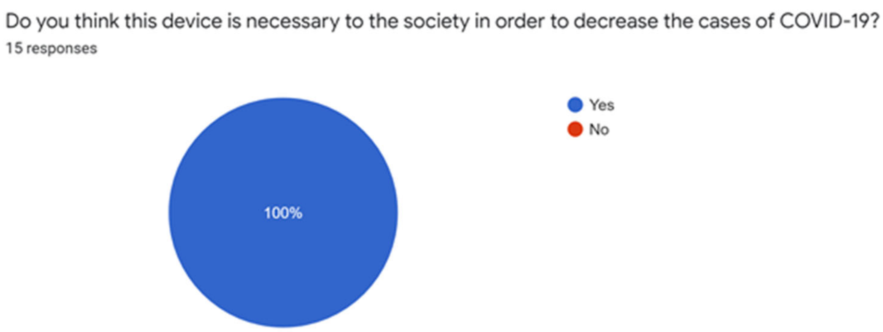

Figure 14: Necessity of the product to reducing the virus transmission cases

We also ask if the device would help the shop owner to reduce the workforce to their worker. 15 peoples are agreed that the device would reduce the workforce of the shop by having one less worker assigned to monitor the total of people entering in and out of the store. By having one less worker, this would reduce the spreading of the covid-19 and this also would help the shop owner to focus more on monitoring the distance of the customer in the store. This device would really help the shop owner to ease their monitoring work and make sure that the social distance between the customer can be enforced.

From the questionnaire, 15 peoples are agreed that this device would help in decreasing the total cases of covid-19 and some of the reasons were:

1. “Shop owners can minimize the workforce to count the customer manually which can reduce the communication between workers and customers”
2. “Reduce close contact with other people as the device would limit the total person inside the store”
3. “Can lead to creating a distance from each other.”
4. “Ease the process to fight Covid-19”

Some suggestions were received from the respondents. Below indicates the opinions from respondents on the product:

1. “Add some sound when customer enter or exit the shop so the worker is alert when the customer is entering or exiting the shop”
2. “Maybe can add temperature scanner features”
3. “Add the alarm when customer enter even when total maximum person was reached”

From the survey, it can be concluded that the user feels that the product would be helpful in order to fight the covid-19. From the 15 people that answered, we can conclude that this device was important to be implemented in every store to reduce the cases of covid-19.

Conclusion

In conclusion, the prototype to count and limit the number of people in a certain building is successfully built and functioning well. When the Infrared module detects a person passing through it, the sensor can recognize whether the person is going in or out from the building. Then, the related data will be processed by the NodeMCU and sent to the database so that the number of people can be viewed at the LCD display and inside the application in real time. The NodeMCU is well programmed by using the Arduino IDE. For the limited number of customers entering the shop can only be changed by using the manager app.

According to the online survey that had been conducted, the feedback for the prototype is well received by the user. For the future improvement, several aspects are being considered for the prototype such as adding alert sound function to the hardware when the customer is reaching the limit, improve the prototype by linking more functional gadgets to it and register the developed application so that it can be easily installed into the user’s and manager’s phone. These aspects are important to make the prototype to be competitive with the product that is available in the market. The hope for this prototype is that it can be widely implemented at the shop or crowded area and commercialized so that it can give the benefit to the community.

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Book Keeping Box for Contact Tracing (BKB)

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Abstract: From a survey conducted to analyze the effectiveness of the existing method for contact tracing process, there are still people who do not use the MySejahtera application as a method to record the entry at a place due to some factors. In order to provide a device that can offer an easy and effective method to record people entry, Book Keeping Box for Contact Tracing (BKB) is developed. The device processes image of personal details to text by using Optical Character Recognition (OCR) technology. The details are then recorded in a database for contact tracing purposes.

Keywords: COVID-19, contact tracing, OCR, ESP32-Cam, cloud, Arduino IDE.

Introduction

The breaking of COVID-19 pandemic around the world is affecting every person in every aspect such as social, economy and politic. Our country, Malaysia is not an exception from this virus. Many actions and precautions have been taken by the country to face this pandemic. Hence, a Standard Operating Procedure (SOP) is introduced to be used as a guidance in controlling the transmission of the virus. There are basic SOPs that are being implemented in the society at the moment which are to avoid crowded and cramped place, always distance ourselves from other people, wash hands and wear mask.

Nowadays, people are switching into new rules whenever they stepped out from their houses. One of the rules is recording their presence wherever their go to ease the contact tracing process. Malaysia has introduced an application called MySejahtera to check-in by using QR code technology. This application is suitable for people with all range of ages, has a good user interface and very effective in contact tracing method. However, from our survey, there are still some people who are not using this application, but are using pen and paper method instead to record their details due to absent of smartphone and other factors. By using pen and paper method, the risk of virus transmission is high as people will touch the same object without knowing whether the previous person is safe from the virus or not. Furthermore, to trace the record of people by using books is not efficient and makes it harder for the authority to trace close contacts.

With keeping these situations in mind, Book Keeping Box (BKB) is proposed to capture personal details, then convert the image to text by using OCR technology and record it in a file. A box will be placed at the shops or most visited places, and users just need to place their personal details at the space prepared and a camera will capture the document placed. Then, the image will be uploaded to cloud or google drive and will be downloaded to computer for further OCR and recording process.

Objectives

The objectives is to develop a BKB device as an alternative system to overcome the limitation of not having a smartphone and the MySejahtera app. The BKB will reduce as much physical contact as possible in contact tracing, also, will assist the authorities when implementing contact tracing.

Methodology

The project starts by understanding the problems given. The potential users and customers of such problems are the first to be identified. A study was carried out to identify on how the consumers prefer method for contact tracing, what method they prefer for entry recording and how effective data tracing using books. All the problems and needs of these potential users have been pointed out.

After completion of the survey and visiting some shops outside, the targeted user has been decided to be the owner of the shops or security guard of the building. Secondly, a set of open-ended questions was prepared for a session of interview. The interview sessions were carried out at three different areas; UTM shop, Church and another private shop.

All the information suggested by the interviewees were extracted and clustered accordingly such as the root of the problems, the possible solutions, the attitude of the users and the environment. To describe a conceptual prototype, a STEEP (Social, Technology, Economic, Environment, Political/Legal) analysis and comprehensive discussion among the team members and panels were carried out.

After that, the end user's identity is designed to provide a better perception of their needs. The potential user's profile, pain points and needs are identified and collected. In designing the character, all detail in a user's daily life routine and problems were considered. The profile for the end users is as follows:

- Age from 20-39 years old.
- Aware of technology trending

The Data Clustered for the Project is given as on the chart below:

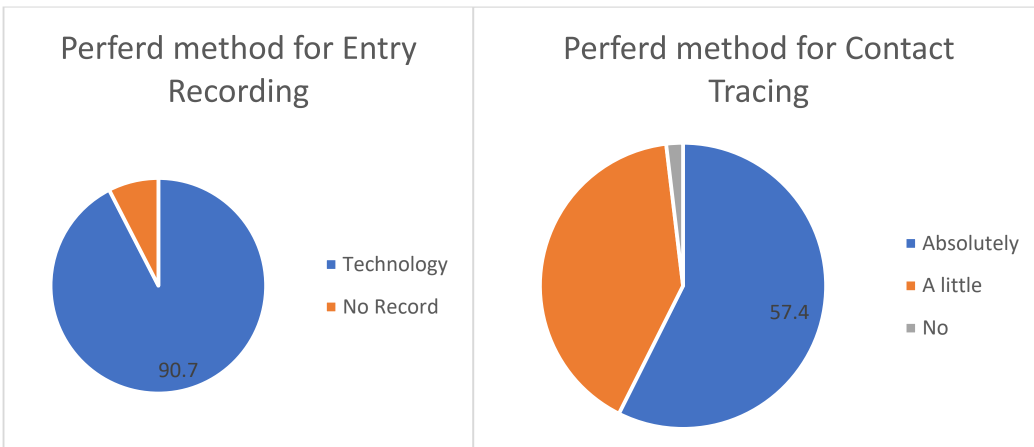


Figure 1: Data Clustering pie chart

The pain point and needs of our target user are given in Table 1.

Table 1: Pain Point and Needs

Pain Point	Need
Concern of spreading covid-19 virus using pen and paper.	Touchless device for contact tracing data.
Books Not very effective tool for data tracing	Easy and fast method of data tracing.
Some people don't have Mysejahtera application.	Accurate and accessible for monitoring.

The STEEP analysis for the product as given on Table 2

Table 2: STEEP Analysis

STEEP	STEEP Analysis Cause	STEEP Analysis Impact
Social	Do not have Mysejahetra application. Do not have smartphone	Everyone has Identification Card/ Contact Information
Technology	Some shops/building does not have QR code.	Effective information storing and monitoring
Economy	Not everyone own smartphone	Cost-effective device One-time setup
Environment	Risk of infection for sharing item. Number of crowds in the shop	Lower the risk of virus transmission. Touchless device
Political	Not effective for contact tracing using book. No alternative way than using application	Alternative method for pen and paper. Easy for contact tracing

From the details of persona which includes profile, pain points and needs, a design statement is determined. The design statement of this project is: Provide a device that can offer an easy and effective method to record people entry.

System design

To obtain a useful product, the design must consider all aspects such as user-friendly interface, affordable and the most important element which is the product must be functioning properly. Before designing a product, the framework and the system architecture of the project is overviewed by the team. Figure 2 shows the system architecture for BKB. The ESP32-Cam will be used to capture the image and send it to cloud or google drive. After that, the image will be downloaded into the computer to go through the OCR process. After the process is completed, the text file generated will be recorded in an excel file with timestamps and details.

Figure 3 shows the prototype that consists of a box with embedded ESP32-Cam and a capture button on the top of the box while Figure 4 shows the details and the guidance to operate BKB. After the document has been placed at the prepared space, the button will be pressed to wake up the system from deep sleep mode and the image will be captured. Then, the image will be uploaded automatically for the further process. Meanwhile, in terms of user-friendly interface, users can easily operate the product without worrying about the power source as the ESP32-Cam is connected to a rechargeable battery. Moreover, the prototype is lightweight as it is made of sturdy cardboard.

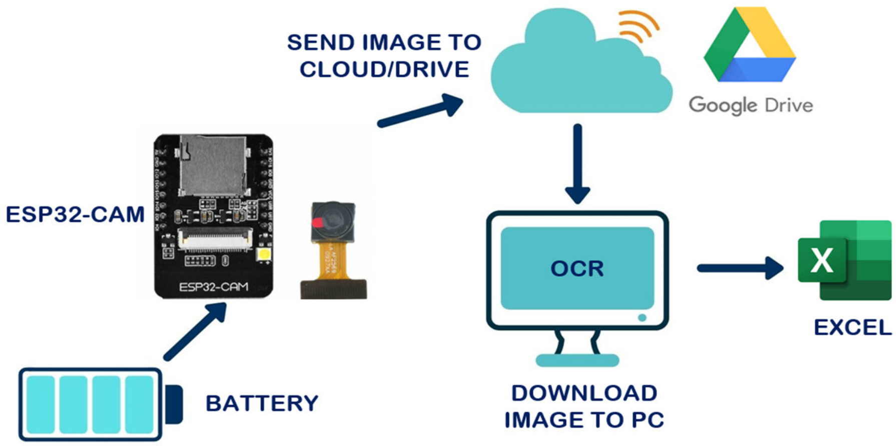


Figure 2: System architecture for BKB

Figure 3: Hardware prototype design

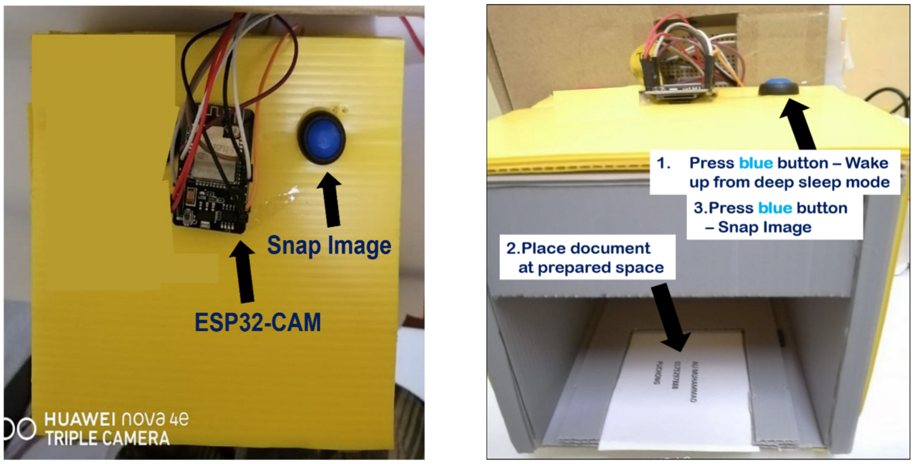


Figure 4: Hardware prototype details

Implementation

Hardware

The main implementation of the hardware is using esp32-cam as the main part of our system after intensive research and discussion comparing the prices, function, size, energy consumption and computing power. The esp32-cam is the smallest Wi-Fi BT SoC module available in the market comes with OV2640 2 Megapixel camera and built-in flash amp which support multiple deep sleep mode, image WIFI upload, micro-SD card, Bluetooth and multiple GPIO pins. Other hardware required is 10k ohm resistor, push button, jumping wire and Li-po rechargeable battery. The hardware was purchased from trusted store to ensure the quality and durability of the devices.

The hardware was initially equipped with 3 push button and LEDs, it was then modified to only one push button.To program the esp32-cam, we need an external device since it doesn't come with a USB connector. We need a FTDI programmer or Arduino Uno to connect the U0RXD and U0TXD as illustrated in the image below.

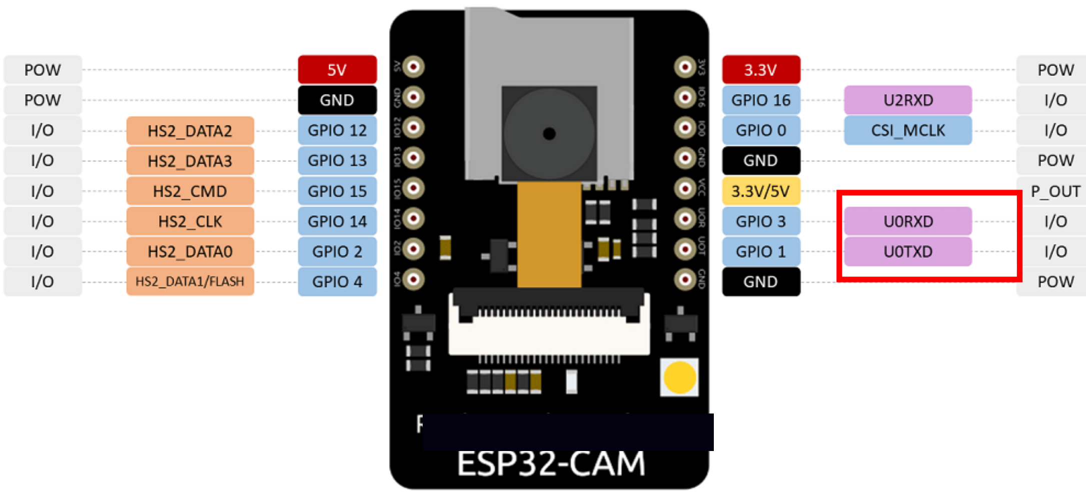


Figure 5: Esp32-cam pin diagram

In my case, I use Arduino Uno since I already had it beforehand. After uploaded the code inside the esp32-cam, removed the jumper wire connecting GND and GPIO 0. Next, press the reset button on the board.

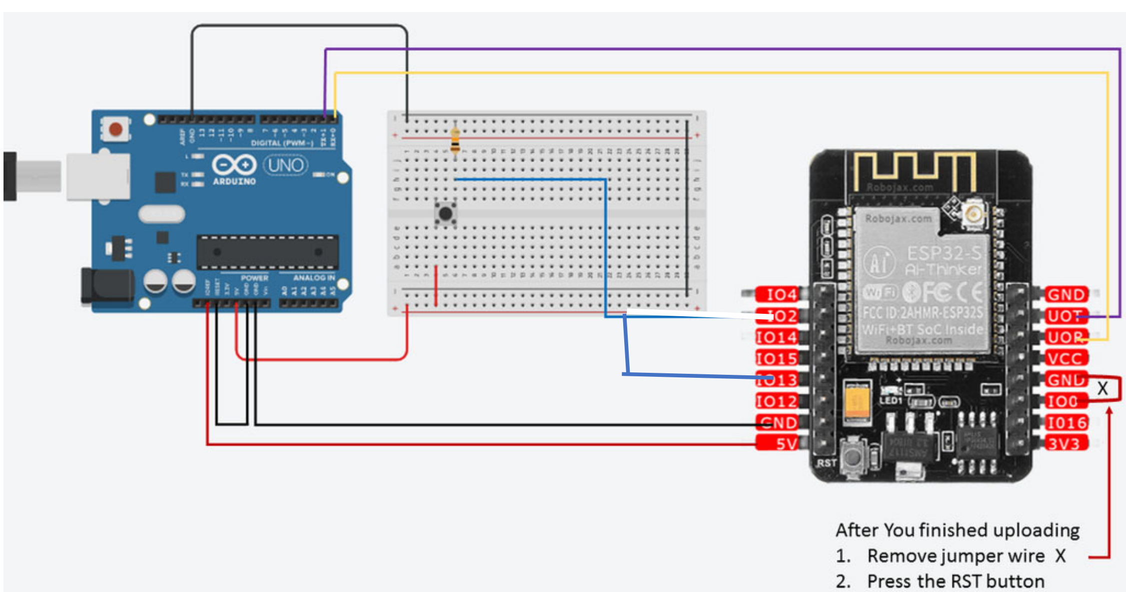


Figure 6: Programming esp32-cam circuit connection with Arduino Uno

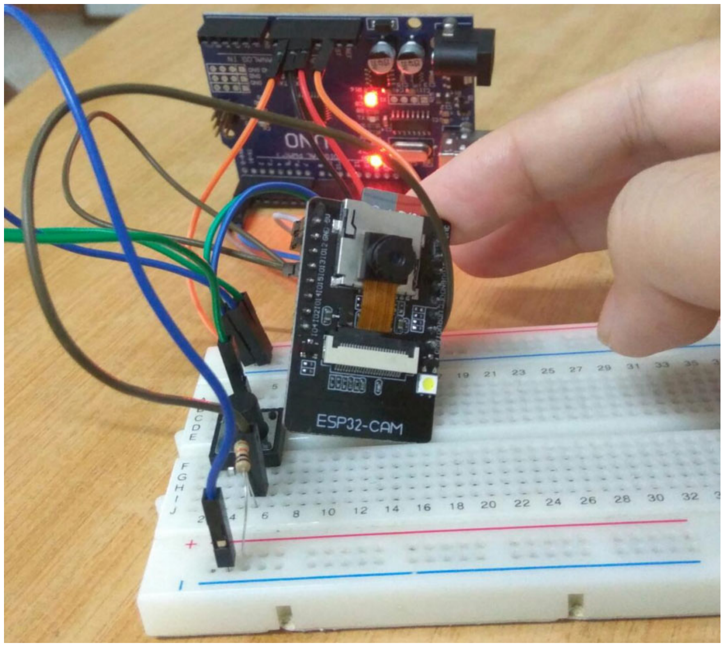


Figure 7: Implementation process of system

The dimension of the hardware was obtained to design the box of our device. The box was intended to be 3D printed but due to budget concern, it was build using hard cardboard as a cover. The final implementation of product is shown as picture below.

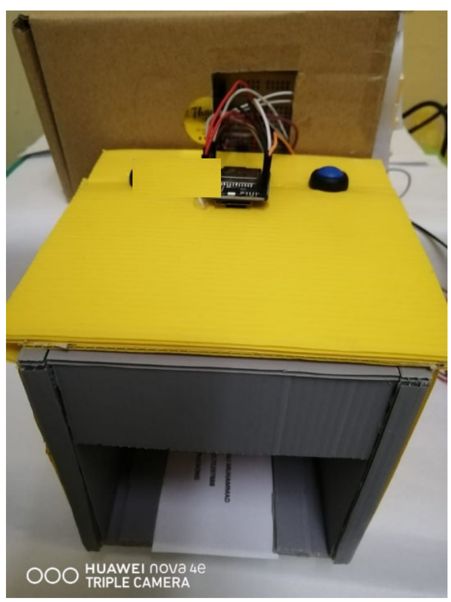


Figure 8: Final product

The esp32-cam was powered with a lithium polymer rechargeable battery hence providing a stable power supply to the 5V input pin at the node-mcu. It shown the push button connected to GPIO13 at esp32-cam and a 10k ohm resistor. The sensor OV2640 is a 2 Megapixel camera to capture the image and upload to either cloud or drive with 802.11b/g/n Wi-Fi module.

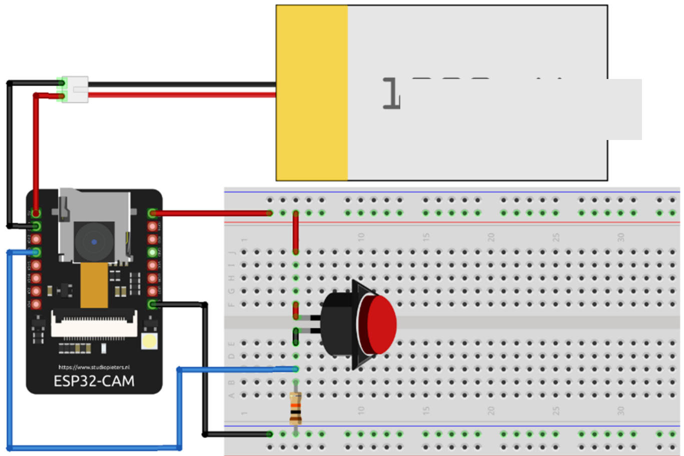


Figure 9: The circuit of final product

Software

The software contained 3 parts which is the Arduino IDE code to be programmed into the esp32-cam, the storage of images in either Google Drive or web hosting and the object character recognition (OCR) for image processing. The Google Drive provide free services given the storage of images while the web hosting required user to make payment.

Arduino IDE

The esp32-cam is in deep sleep mode with external wake-up enabled. When the button is pressed, it sends a signal to wake up the Esp32. The Esp32-cam takes a photo and sends it to the storage. It goes back to deep sleep mode until a new signal from the push button is received.

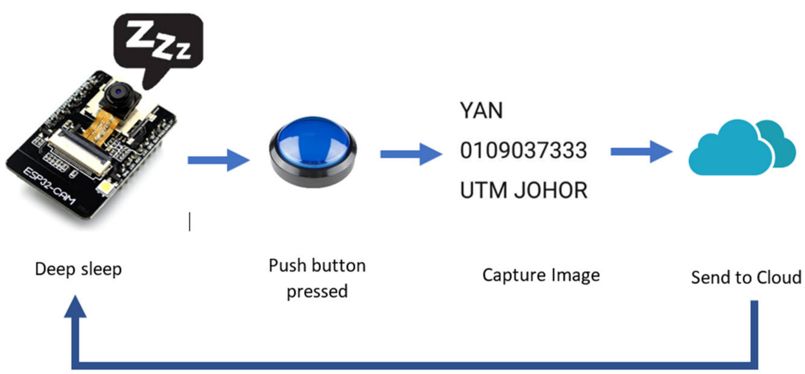


Figure 10: Overview of esp32-cam code

There is the hardware limitation which is the 2-megapixel camera is vague and unable to distinguish the alphabet character using the OCR application. The safety issue of using capturing IC images is highly concerned hence the implementation is rejected. Thus, we shifted to white printed paper. The separated IDE code to send images into Google Drive is included in Appendix 4 while cloud is included in the Appendix 5 (note: not included in the proceeding).

Google Drive

The image will be taken and uploaded into Google Drive folder to be download by user. First of all, create a Google Apps Script to receive the image from esp32-cam through Wi-Fi and stored into a Google Drive folder. Next, save the script and publish it as a web application. Publish the script as anonymous access hence anyone including anonymous people are able to access to the application. Copy the URL of the script file and copy into the esp32-cam IDE code. The code can be referred in Appendix 6.

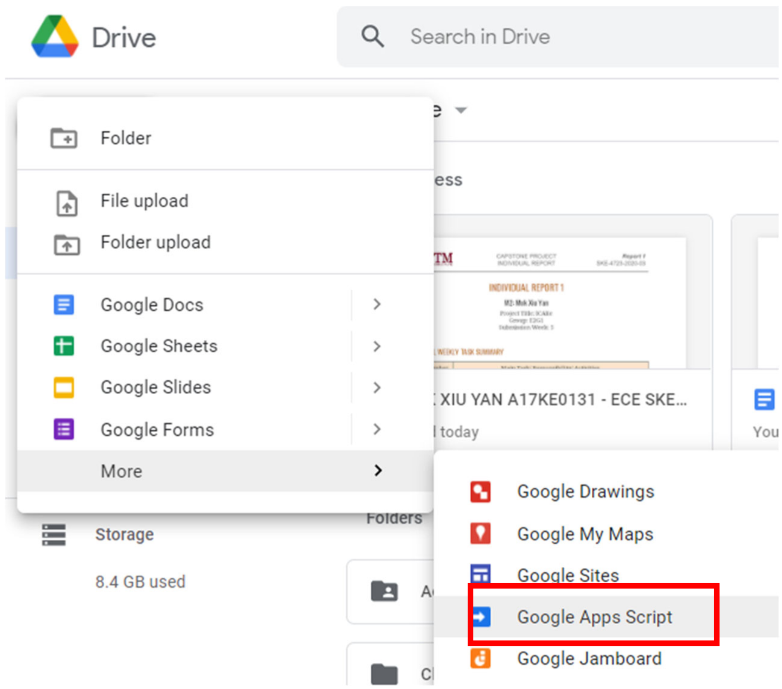


Figure 11: Creating a Google Apps Script

Web hosting

In our system, the web hosting service used is Hostinger. Create an account but free account has limited storage space which is 1GB and the speed is lower. Hence, for real implementation we will charger user for web hosting payment. The benefits of cloud storage are the we can access to the images anywhere and pay based on the usage of storage. The web page is designed to be password protected hence other people unable to access the content without the exact password.

After creating the web hosting account, go to "File Manager". Select "public_html" folder, create an empty folder named "uploads".

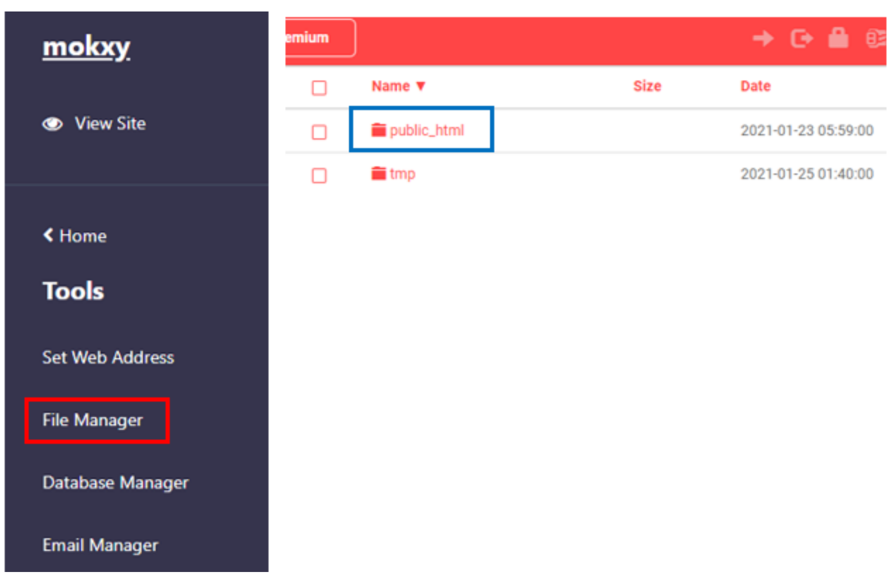


Figure 12: Location of file manager folder and public_html folder

Create a php file named "gallery.php" and the code of the php is shown in Appendix 7 (not included in the proceeding).

The next step is password protect the content which will request the user to insert the correct password to view the images. To achieve the goal, create "login.php" and "protect-this.php". Noted that password defined is "@E2G01_capstone". The code in login.php is shown in Appendix 8 and protect-this.php shown in Appendix 9. An overview of the public_html folder, all the files created is listed as shown below.

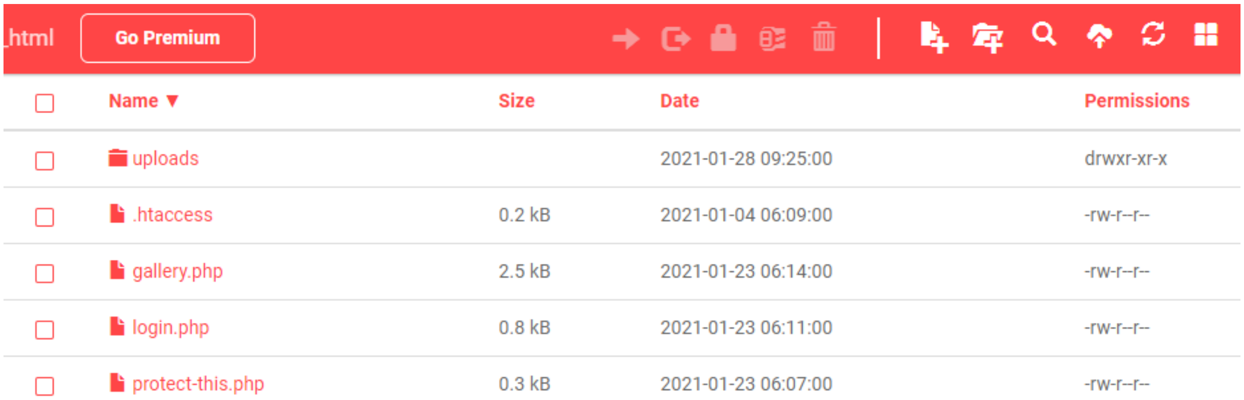


Figure 13: Overview of files in public_html folder

<u>Object Character Recognition (OCR)</u>

The batch OCR is a procedure of image processing a folder of pictures and saving it into corresponding text files. It was done initially in a command prompt line, then improved into a script file to provide hassle free operation where users just click the icon of script at desktop instead of running command line in cmd. The open source OCR application which is Tesseract needed to be installed into the computer first. After the text file is extracted from the images, it will then copy and paste to the "out" folder.

Given the directory of image stored:
C:\images
Directory of installed Tesseract application:
C:\Program Files\Tesseract-OCR\tesseract.exe
Directory of desired output text file:
C:\out

The content of script file is shown below:

```
@Echo off
for %%A in ("C:\images\*.png") do "C:\Program Files\Tesseract-OCR\tesseract.exe" "%%~fA" "%%~dpnxA"
for %%A in ("C:\images\*.jpg") do "C:\Program Files\Tesseract-OCR\tesseract.exe" "%%~fA" "%%~dpnxA"
copy C:\images\*.txt C:\out
```

The line "%~dpnxA" will save file in Drive, Path, Name without extension.

Operation

The esp32-cam is in deep sleep mode by default and enabled trigger with one push button connected at pin 13. The user required to slide in the card into the space provided. Once the button is pressed, it will send a signal to wake up the esp32-cam. Then it will capture images and upload to the cloud or drive. Figure 14 below will show the flowchart of the system.

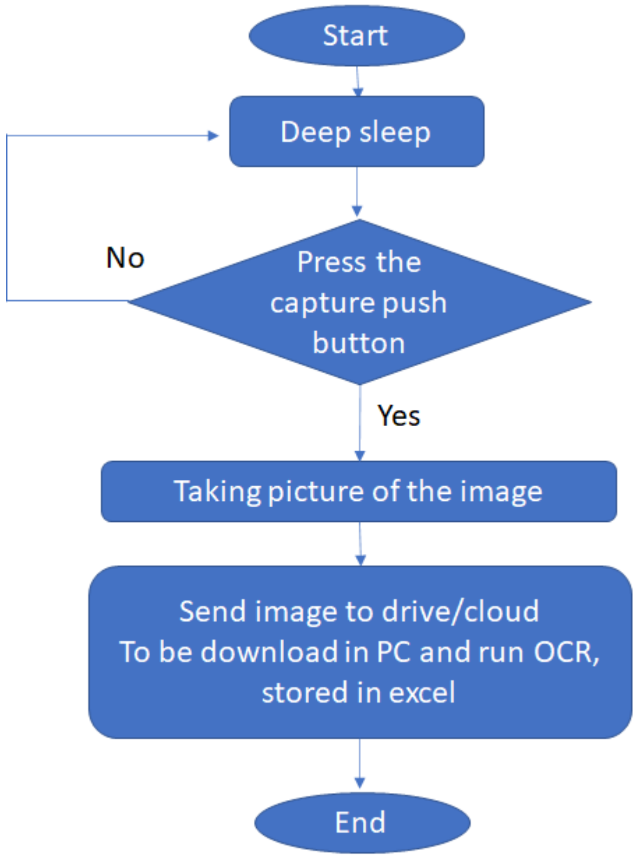


Figure 14: Flowchart of the system

The image can be downloaded from Google Drive and saved into local computer. Meanwhile, the user who used cloud storage can download with the following steps. Given website address to view the uploaded images is: https://mokxy.000webhostapp.com/login.php. Users are required to insert the password, insert "E2G01_capstone".

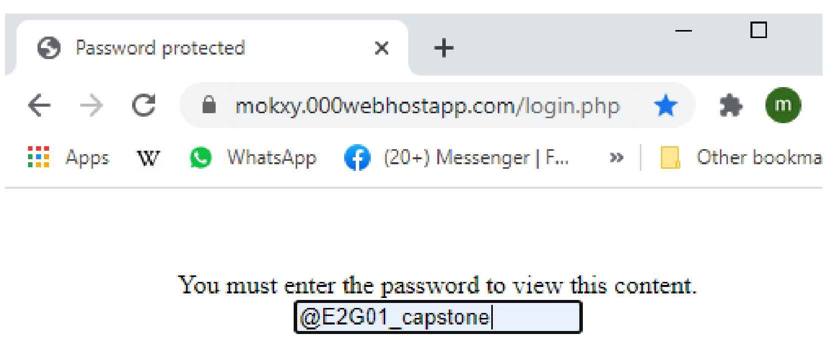


Figure 15: Login page of web site

After successfully login, users can view, delete and download the images.

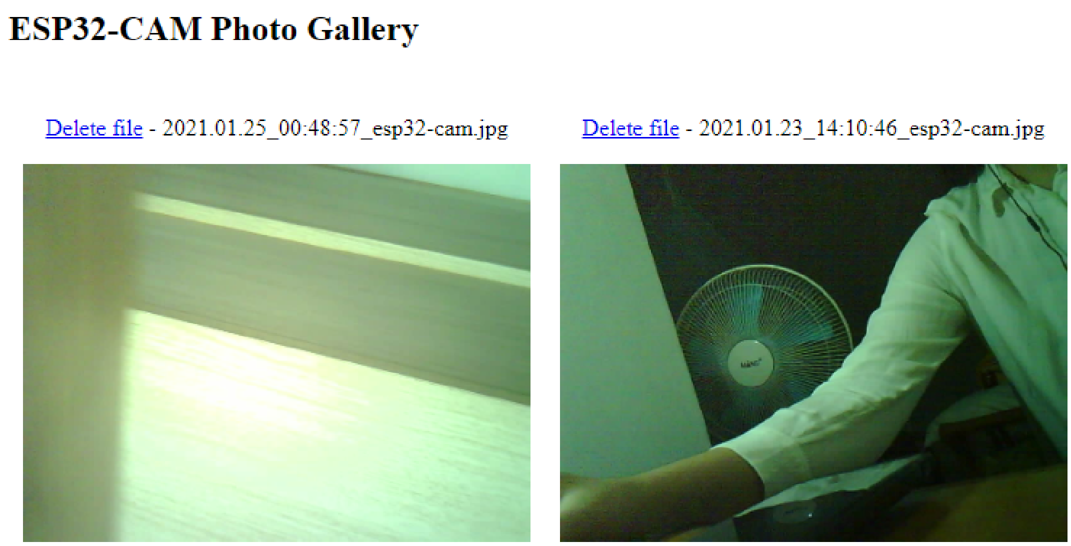


Figure 16: Image gallery page of web site

Next at the computer, first step is user need to run the BKB script file, select run as administrator.

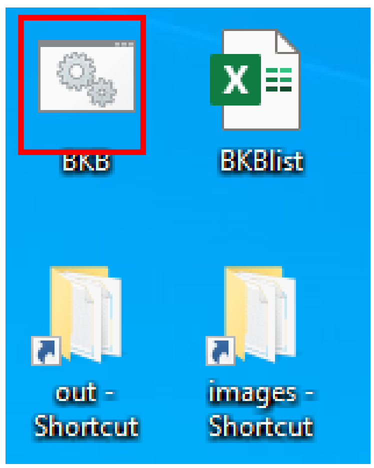


Figure 17: Overview of desktop files and the application of BKB script file

The batch OCR generated output text file of one example as shown below. The image is the input image. The text files are copied into "out" folder.

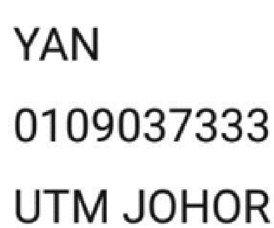


Figure 18: Example of input image

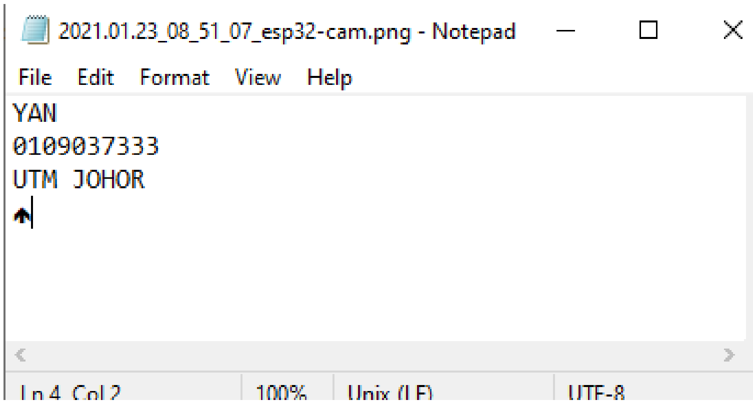


Figure 19: Example of generated output text file

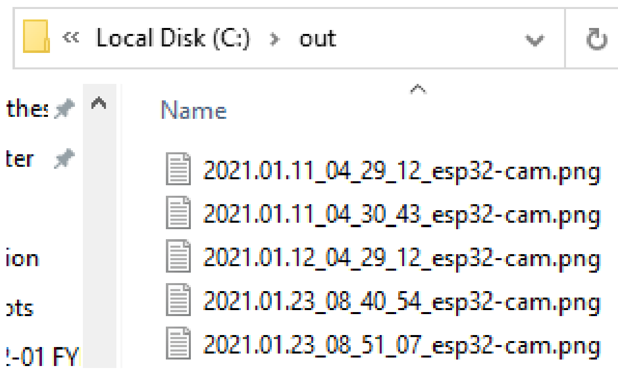


Figure 20: List of output text file in "out" folder

Second step is to load all the text file into an excel file. After created the excel file, use Power Query to load all the text files in "out" folder into one excel file. Go to data >get data > from file> from folder, and then choose the "out" folder.

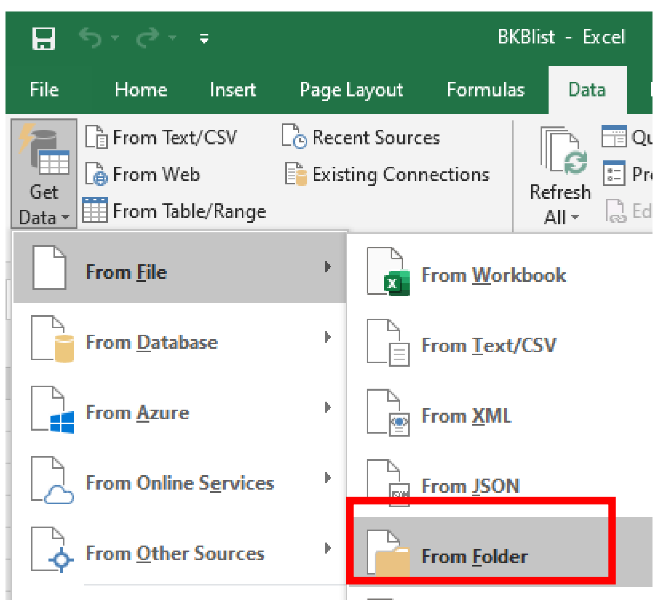
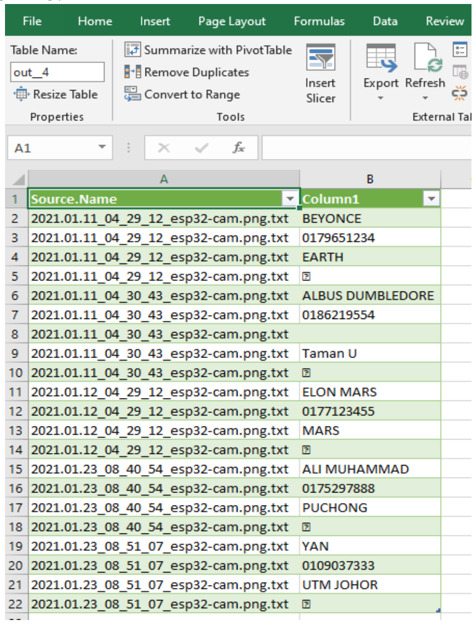


Figure 21: Steps to use Power Query

All text files loaded into one excel file to enable the user to view all the details easily. The excel file recorded name, phone number, address, date and time.



	A	B
1	Source.Name	Column1
2	2021.01.11_04_29_12_esp32-cam.png.txt	BEYONCE
3	2021.01.11_04_29_12_esp32-cam.png.txt	0179651234
4	2021.01.11_04_29_12_esp32-cam.png.txt	EARTH
5	2021.01.11_04_29_12_esp32-cam.png.txt	⊠
6	2021.01.11_04_30_43_esp32-cam.png.txt	ALBUS DUMBLEDORE
7	2021.01.11_04_30_43_esp32-cam.png.txt	0186219554
8	2021.01.11_04_30_43_esp32-cam.png.txt	
9	2021.01.11_04_30_43_esp32-cam.png.txt	Taman U
10	2021.01.11_04_30_43_esp32-cam.png.txt	⊠
11	2021.01.12_04_29_12_esp32-cam.png.txt	ELON MARS
12	2021.01.12_04_29_12_esp32-cam.png.txt	0177123455
13	2021.01.12_04_29_12_esp32-cam.png.txt	MARS
14	2021.01.12_04_29_12_esp32-cam.png.txt	⊠
15	2021.01.23_08_40_54_esp32-cam.png.txt	ALI MUHAMMAD
16	2021.01.23_08_40_54_esp32-cam.png.txt	0175297888
17	2021.01.23_08_40_54_esp32-cam.png.txt	PUCHONG
18	2021.01.23_08_40_54_esp32-cam.png.txt	⊠
19	2021.01.23_08_51_07_esp32-cam.png.txt	YAN
20	2021.01.23_08_51_07_esp32-cam.png.txt	0109037333
21	2021.01.23_08_51_07_esp32-cam.png.txt	UTM JOHOR
22	2021.01.23_08_51_07_esp32-cam.png.txt	⊠

Figure 22: Overview of content in excel file

Results and discussion

The final product of this project is called Book Keeping Box (BKB) which has the functionality of scanning the word or alphabets on any materials such as identification card (IC) or any related documents. The scanning of the word and number on the document is done by processing picture taken by ESP-32cam using Optical Character Recognition (OCR).

By referring to Figure 5 in Implementation section, by clicking the button once the camera will take picture and wake up from deep sleep mode. This approach is to reduce the energy consumption of the system that rely on battery. After that the picture will be sent to the google drive or web hosting for cloud storage as stated in Implementation section.

However, this prototype can have much more improvements when limitations such as budget and lack of equipment is solved. In producing a fully touchless system a sensor such as PIR a motion or light sensor could be used as an alternative. Also, in the design of this project, ESP-32 cam has much better price as comparison to other product but not really have the ability to create high quality picture especially on getting clear words or number. This is because ESP-32 cam only provides 2MP ability which is not enough in producing HD quality. As a solution Raspberry pi SONY IMX477 camera could be mounted in the system to produce nice picture since it is 12.3 MP with adjustable lenses for zooming activities. The price of Raspberry pi is expensive counted approximately RM200 with additional RM100 for the lenses. This is obviously our project limitation with budget only RM300.

To be clear, the operation of the system need support from a computer for the image processing using OCR to be successful. ESP 32 cam can only provide the image capturing and deep sleep features. If instead Raspberry pi 4 is use in the design, the image processing could be done directly without the use of computer. As the result, system produce will be smaller in size and suitable for any places. The price of the micro-controller is approximately RM300 and it is way out of our initial budget. One of the biggest limitations in finalize this project is the budget we received.

Conclusion

As the conclusion of the project, goal and objectives of creating contact tracing device that could replace pen and paper method is achievable. With reasonable price it offers which is only RM43, this product could have a bright future in the market. Instead of limiting our view regarding demand, this product could be used in many ways such as gate keeping, work force attendance, contact tracing and many more. Room of improvement is widely open especially when budget limitation is no longer the case. As stated in discussion section, we believe that this prototype holds a useful concept for the use of community especially when Covid 19 has change many ways of how human normally doing their activities.

Acknowledgement

This project was written based on the work done by Capstone lab students (Amirul Aiman, Mok Xiu, Ulfah 'Izz Zahin, Mohammed Ali). We would like to express our special thanks and gratitude to our supervisor, Dr. Ab Al-hadi Bin Ab Rahman as well as School of Electrical Engineering for their support and the opportunity to do this wonderful project on the title of Book Keeping Box (BKB). This subject taught us how to do a research and work on the project as a team.

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Smart Health Monitoring System from Home

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Abstract: The outbreak of pandemic Covid-19 creates situation where people have to monitor their health condition regularly. This generates the idea of developing a system which can measure body temperature, have a medical reminder with history features and provide Covid-19 updates. In this system, a nodeMCU is used as a processor unit that wirelessly communicate with the web server "Firebase" apps. MIT App Inventor is the platform used to design and develop the features functionality of apps in the system. A prototype is constructed with few functions namely contactless thermometer with accurate reading, long-distance medical reminder, details of Covid-19 updates and traceable history of consumed medicine.

Keywords: Health;Covid-19; reminder; temperature monitoring; nodeMCU; MIT app

Introduction

As the outbreak of the pandemic Covid-19, many researchers, funding agencies and health care providers are paying more attention toward people's health and wellbeing. The aims of the health and wellbeing promotion program are to prepare them to understand and monitor their own health and health care needs. Based on the 118 responses from the questionnaire, the main problems of the target users are living an unhealthy lifestyle, unable to take medicine as scheduled, curious about their own body temperature and have an unorganized medication record. In order to solve their needs, the product is designed with 3 features which are body temperature sensor, wireless medical reminder and detailed Covid-19 updates.

Due to the pandemic Covid-19, there is an increased need for the body thermometer because one of the symptoms of Covid-19 infection is high fever. Hence, the product included a body temperature sensor for users to easily check their own body temperature. Moreover, this product can provide a detailed and trustable Covid-19 case update which sources are from Kementerian Kesihatan Negeri. The temperature sensor MLX90614-BCC used in this product is calibrated and the reading is as accurate as a standard thermometer.

The total budget used on this product is RM145 which is slightly higher than the digital infrared thermometer which can be found in the market with the price of RM120. However, this product not only provides body thermometer but also other features such as medical reminders and Covid-19 updates.

In terms of environment aspect, Perspex is used as the casing for this product. Perspex is a form of acrylic sheet which is eco-friendly and can be reused as it is synthetic. Therefore, this product would not pollute the environment. This product also provides the history of consumed medicine and body temperature of the users. This feature can indirectly decrease the use of papers because all the data is stored in the data storage. According to a rapid review conducted by the Health Technology Assessment Section (MaHTAS), the Health Ministry found no scientific evidence on the adverse effects of the infrared thermometers used on the forehead. Hence, the infrared temperature sensor is safe to use in this product.

Objectives

1. To measure users' body temperature
2. To remind users for taking medicine and exercise
3. To update users of detailed and accurate Covid-19 news

Description and analysis of interview for the project

12 questions were prepared in Google Form to give a clearer direction regarding the target user in various aspects such as range of age, gender, health condition and health awareness. Few questions regarding their health condition are included in the google form so that we can have a clearer image of the problem faced by our target user. We also included some questions such as the frequency of their medical checkup, duration of using electronic gadgets and type of information they want to be updated to inspect our target user's needs. There are a total of 118 respondents who completed the questionnaire in google form.

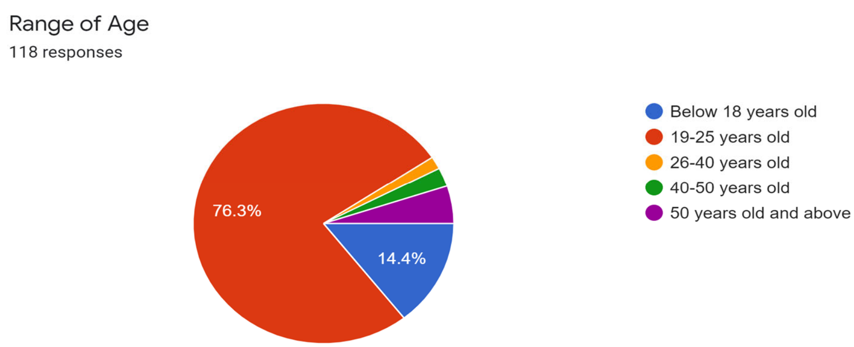


Figure 1: Pie Chart on the Range of Age

Based on Figure 1, the responses we collected are from all ranges of age from below 18 years old to 50 years old and above. 76.3 % from 118 respondents are between 19-25 years old and 14.4% are below 18 years old. All responses from all ranges of age are considered. Hence, we can assume our target users are citizens.

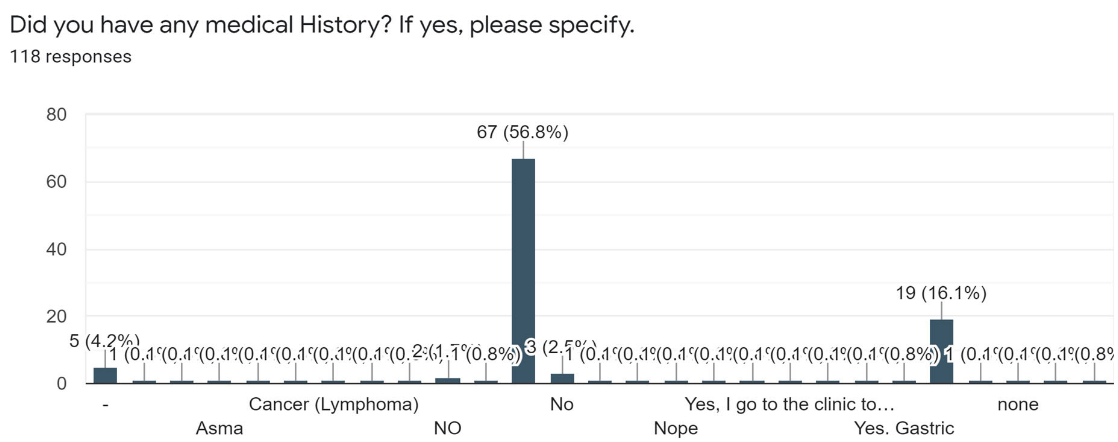


Figure 2: Bar Chart on Respondents Medical History

According to Figure 2, there are 12 respondents which are 10% from 118 respondents who have a medical history and are taking medicine. Based on this data, some reminder features can be provided for them.

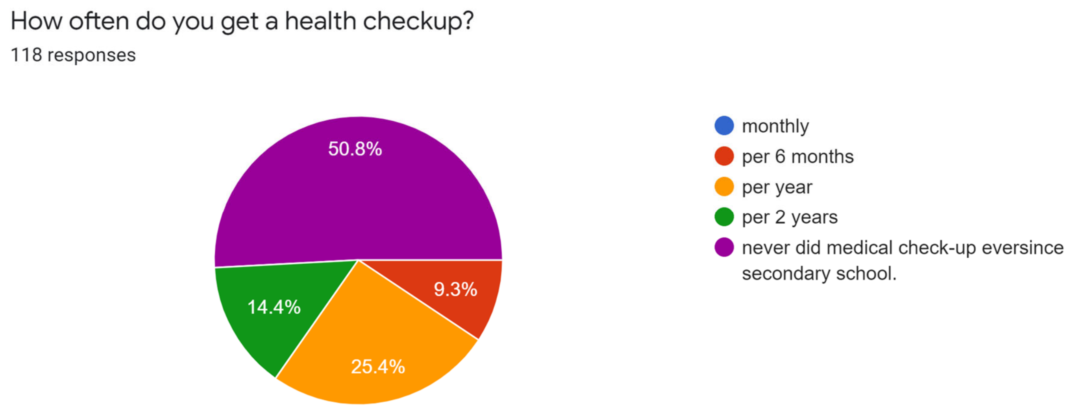


Figure 3: Pie Chart on the Frequency of Respondents Medical Check-up

Based on Figure 3, there are 50.8% of respondents who have never done a medical check-up ever since secondary school. From here, assumption can be made that the target users have low health awareness.

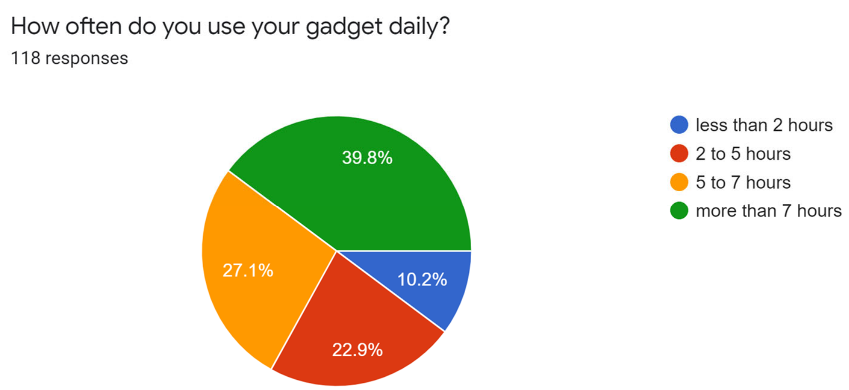
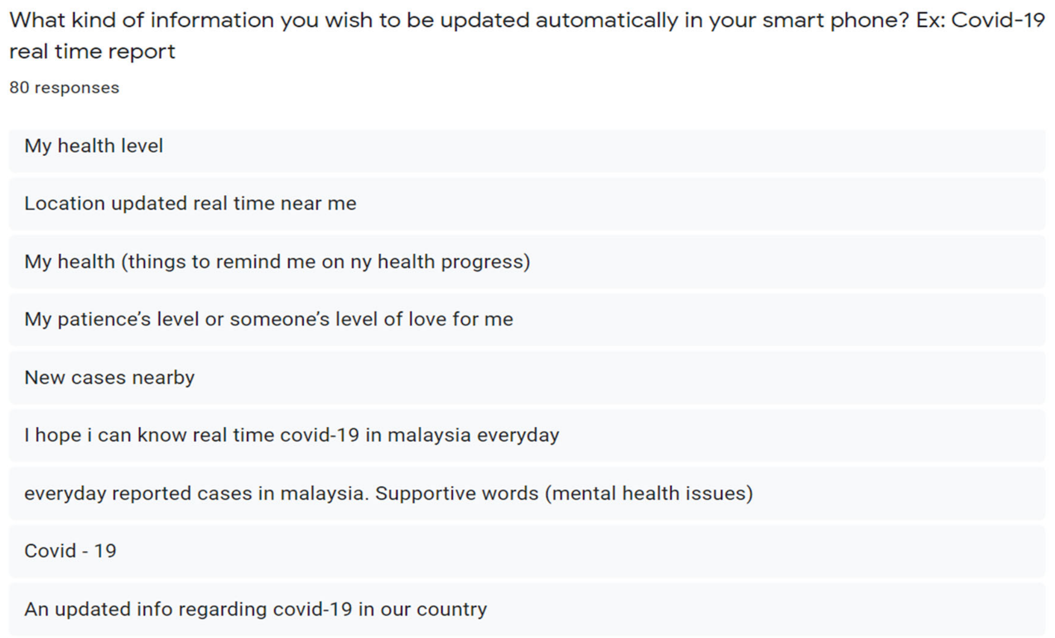


Figure 4: Pie Chart on the Time Spend using Electronic Gadgets

As shown in Figure 4, where 39.8% of respondents use electronic gadgets for more than 7 hours and 27.1% of respondents use them for more than 5 hours. Since the target users are using electronic gadgets for a long duration, software applications which can be accessed using smartphones can be included in this product.


What kind of information you wish to be updated automatically in your smart phone? Ex: Covid-19 real time report

80 responses

My health level

Location updated real time near me

My health (things to remind me on ny health progress)

My patience’s level or someone’s level of love for me

New cases nearby

I hope i can know real time covid-19 in malaysia everyday

everyday reported cases in malaysia. Supportive words (mental health issues)

Covid - 19

An updated info regarding covid-19 in our country

Figure 5: Responses on the Type of Information Need to be Updated.

Regarding the feedback from the question *“What kind of information do you wish to be updated automatically in your smartphone*?”, most of the respondents want to be updated by the news about covid-19 and some respondents want a reminder about their health progress.

Design statement

Based on all the responses, the profile of the target users are a patient and a parent who wants to monitor their children or vice versa. The target users are having problems such as living an unhealthy lifestyle, unable to take medicine as scheduled, curious about their own body temperature and have an unorganized medication record. From here, their needs can be deduced which are a medical reminder to remind themselves to take medicine as scheduled, a body thermometer and Covid-19 updates.

Hence, the design statement would be how we may help citizens to have an awareness/reminder regarding their health condition such as medical reminder and body temperature monitoring and be well informed with Covid-19 cases distributed by district information.

Methodology

Referring to Figure 6, a questionnaire is created to identify target users and survey the market as the first step. After that, the responses from the questionnaire are analyzed to identify target users' problems and needs. With this in mind, the concept and prototype is designed. A sketch diagram of the prototype is drawn. Next, the development of hardware and software is proceeded. After that, the prototype is tested for its functionality and optimized. Lastly, documentation for this project.

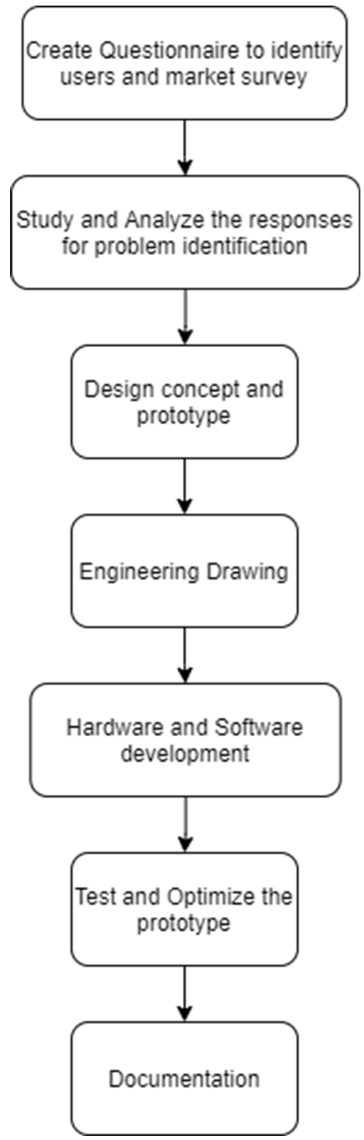


Figure 6: Methodology of the Project

Based on Figure 7, the necessary hardware components such as temperature sensors and microcontroller(nodeMCU) have been surveyed and brought during week 5 and week 6. After that, programming for nodeMCU, software interface designing, database building and testing and improvement are done throughout week 7 until week 11. The preparation for demonstration and presentation is done during week 12 and week 13.

No	Tasks	Start Week	End Week	Capstone Week 5	6	7	8	9	10	11	12	13	14
1	Conceptual Prototype Presentation	5	5	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐
2	Improvise project features	5	6	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐
3	Study the spescifications for temperature sensor and node mcu	5	6	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐
4	Buy the equipment	6	7	☐	☑	☑	☐	☐	☐	☐	☐	☐	☐
5	Nodemcu programming	7	11	☐	☐	☑	☑	☑	☑	☑	☐	☐	☐
6	User Interface Designing	7	11	☐	☐	☑	☑	☑	☑	☑	☐	☐	☐
7	Data Base Building	7	11	☐	☐	☑	☑	☑	☑	☑	☐	☐	☐
8	Testing and Improvement	7	11	☐	☐	☑	☑	☑	☑	☑	☐	☐	☐
9	Hardware Prototype Building	8	12	☐	☐	☐	☑	☑	☑	☑	☑	☐	☐
10	Hardware Prototype Design Improvement	11	12	☐	☐	☐	☐	☐	☐	☑	☑	☐	☐
11	Half-completed Product Video Shooting	9	10	☐	☐	☐	☐	☑	☑	☐	☐	☐	☐
12	Individual Report 2	8	9	☐	☐	☐	☑	☑	☐	☐	☐	☐	☐
13	Completed End Product Video Shooting	10	12	☐	☐	☐	☐	☐	☑	☑	☑	☐	☐
14	Slide Preparation for final presentation	11	12	☐	☐	☐	☐	☐	☐	☑	☑	☐	☐
15	Prototype presentation	13	13	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐
16	Individual Report 3	12	13	☐	☐	☐	☐	☐	☐	☐	☑	☑	☐
17	Poster	12	13	☐	☐	☐	☐	☐	☐	☐	☑	☑	☐

Figure 7: Gantt chart for the project

Product Development

Designing

The important feature of the developed system consists of 3 features:

1. temperature monitoring
2. Covid-19 real time update
3. Medical and Exercise Reminder with Medical History.

The design of the prototype will be based on these 3 features.

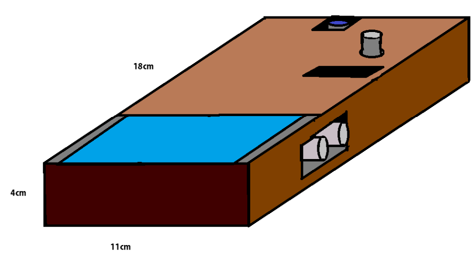


Figure 8: Concept Sketch of the developed device

Figure 8 is the concept sketch of the developed device which shows the location of the temperature sensor, reset button and the LCD display.

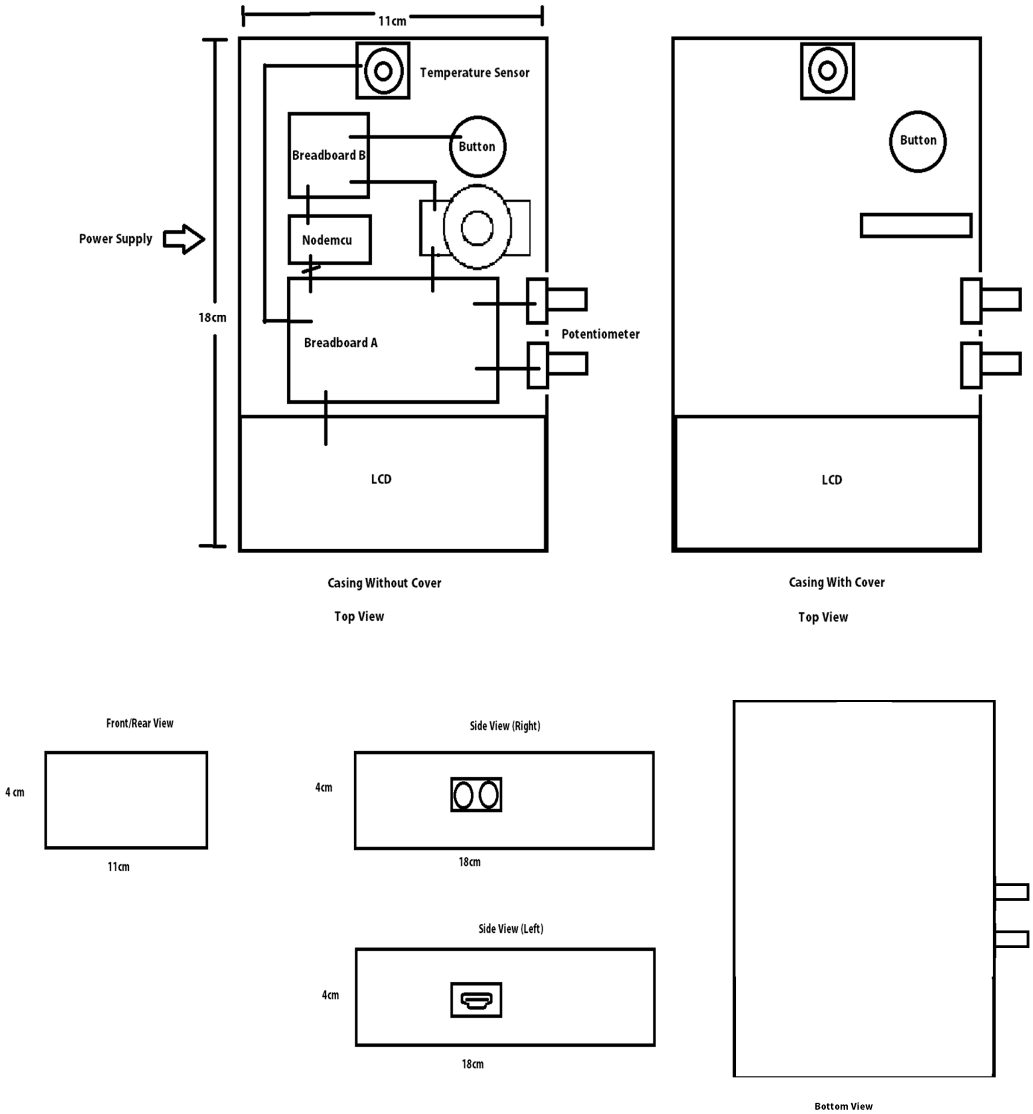


Figure 9: 2D drawing of device of the developed device.

Based on Table 1, STEEP analysis is conducted to analyze the contribution and impact of the prototype on various aspects such as sociological, technological, economic, environmental and political.

Table 1: The STEEP analysis of the developed prototype.

Aspect	Discussion
Sociological	Increase health awareness
	The increase need of thermometer due to pandemic Covid-19
Technological	Long distance reminder
	High accurate IR temperature sensor
	Real time Covid-19 cases update
Economic	Cheaper multifunctional infrared thermometer
Environmental	Reduce the number of paper used
Political	Health Technology Assessment Section (MaHTAS)

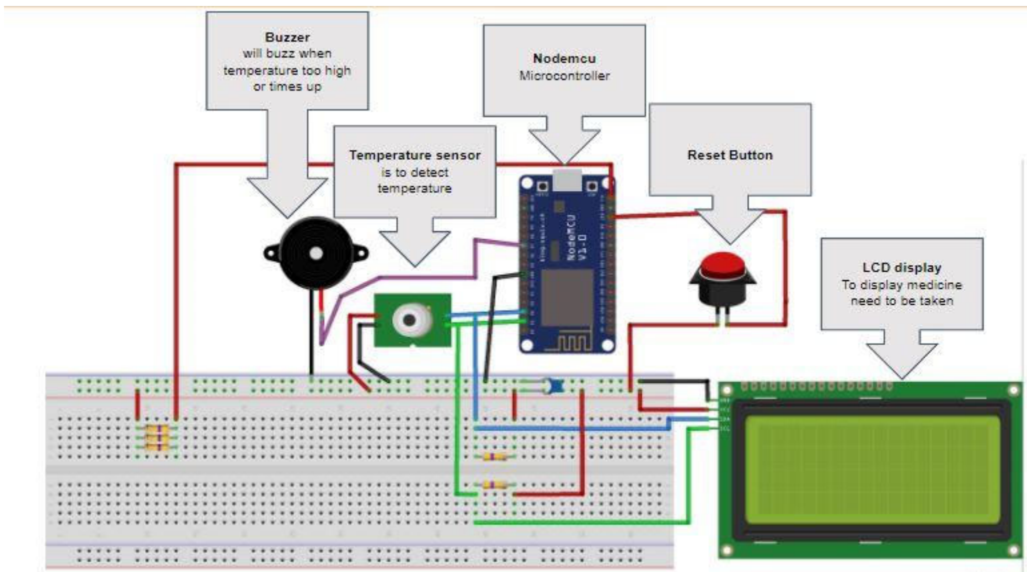


Figure 10: The schematic circuit for the system

Figure 10 shows the schematic circuit of the prototype and the connection of the hardware. Table 2 shows the list of hardware used in the prototype. NodeMCU ESP8266 is used as the microcontroller of the developed device. Infrared temperature sensor MLX90614-BCC is used because it has better accuracy and longer range of measuring temperature. Buzzer is used as an alarm for reminder features. LCD display is also included to display the name of the medicines. Reset button is used to stop the buzzer from ringing.

Table 2 : The List of Hardware

List of Hardware	
1.	NodeMCU ESP8266
2.	Breadboard
3.	Temperature sensor (MLX90614-BCC)
4.	Resistor
5.	Jumper wire
6.	LCD
7.	Buzzer
8.	Reset Button

Figure 11 shows the general overview of the flow of the coding of Arduino IDE. First, we set up the server host and authentication which allow the user to read and write on the server. Then, set up the Wi-Fi SSID and password for nodeMCU to connect to the internet. After that, connect nodeMCU to Wi-Fi and access the server. NodeMCU will send the temperature data from the sensor to the server Firebase. On the other hand, nodeMCU will also read data from the server Firebase to get the name of the medicine and set the input 'r=0' in server Firebase. Then, after the nodeMCU receives input 'r=1', it will sound the buzzer and the name of the medicine will be displayed in LCD until the reset button is clicked. After the reset button is clicked, it will set 'r=0' again in the server Firebase to stop the buzzer.

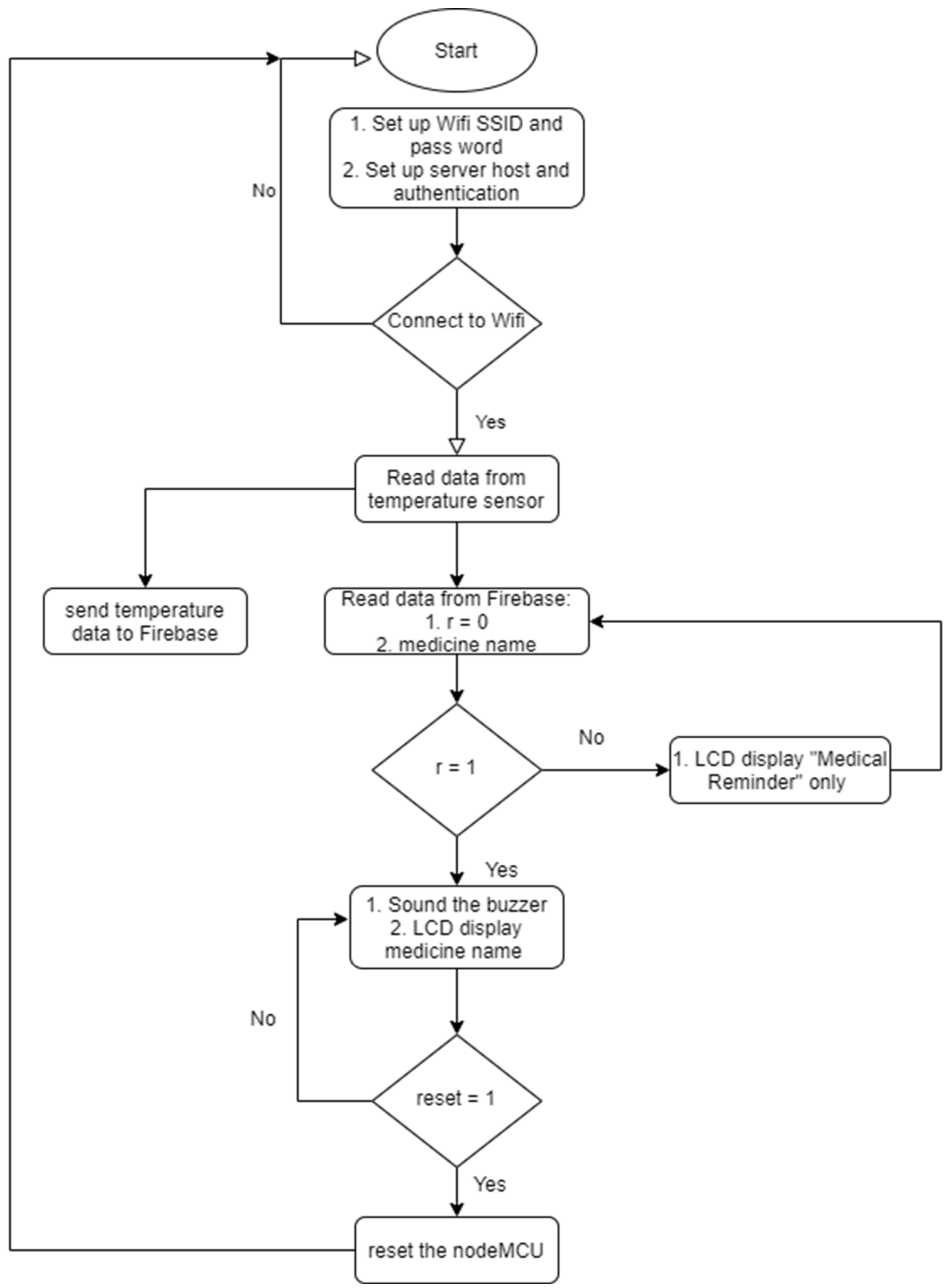


Figure 11: Flowchart of nodeMCU

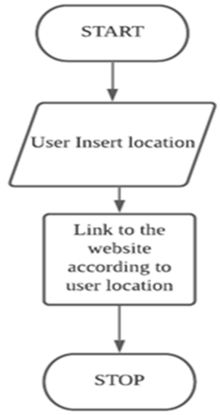


Figure 12: Flowchart for Covid-19 update features for apps

Figure 12 shows the overview of the flow for the Covid-19 update feature in the software application. First, the user will have to insert the location where they wish to get the Covid-19 update. After that, it will link to the corresponding website which shows the detailed Covid-19 update based on the user location.

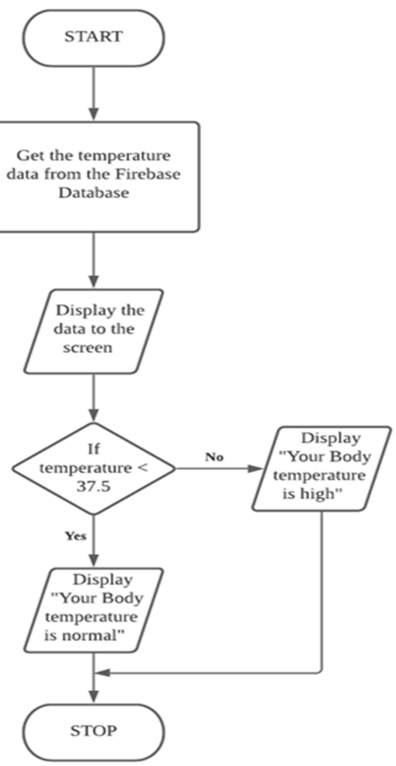


Figure 13: Flowchart of Temperature monitor features for apps

Based on Figure 13, the reading of the temperature sensor will be read from the Firebase database and then display on the screen. If the temperature is lower than 37.5 °C, it will display “Your body temperature is normal”, otherwise it will display “Your body temperature is high”.

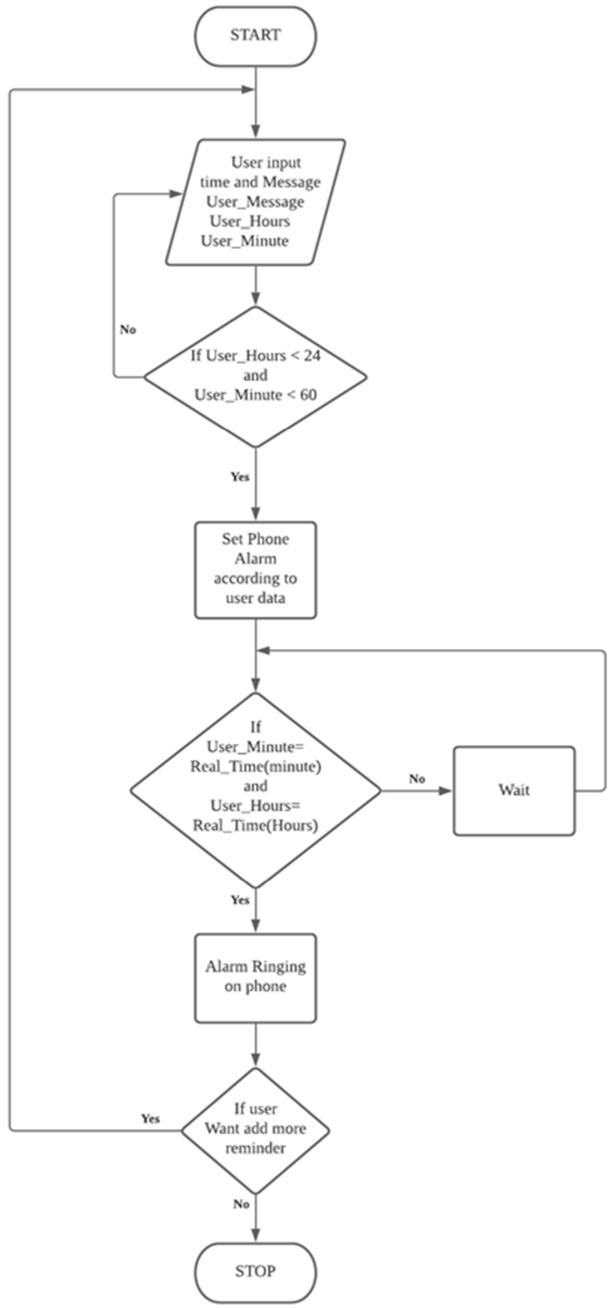


Figure 14: Flowchart of exercise reminder features for apps

According to Figure 14, the user will have to the time and message to remind themselves to exercise. Then, the phone alarm is set based on the user input data. When the time set for alarm is reached, the alarm will start ringing on phone.

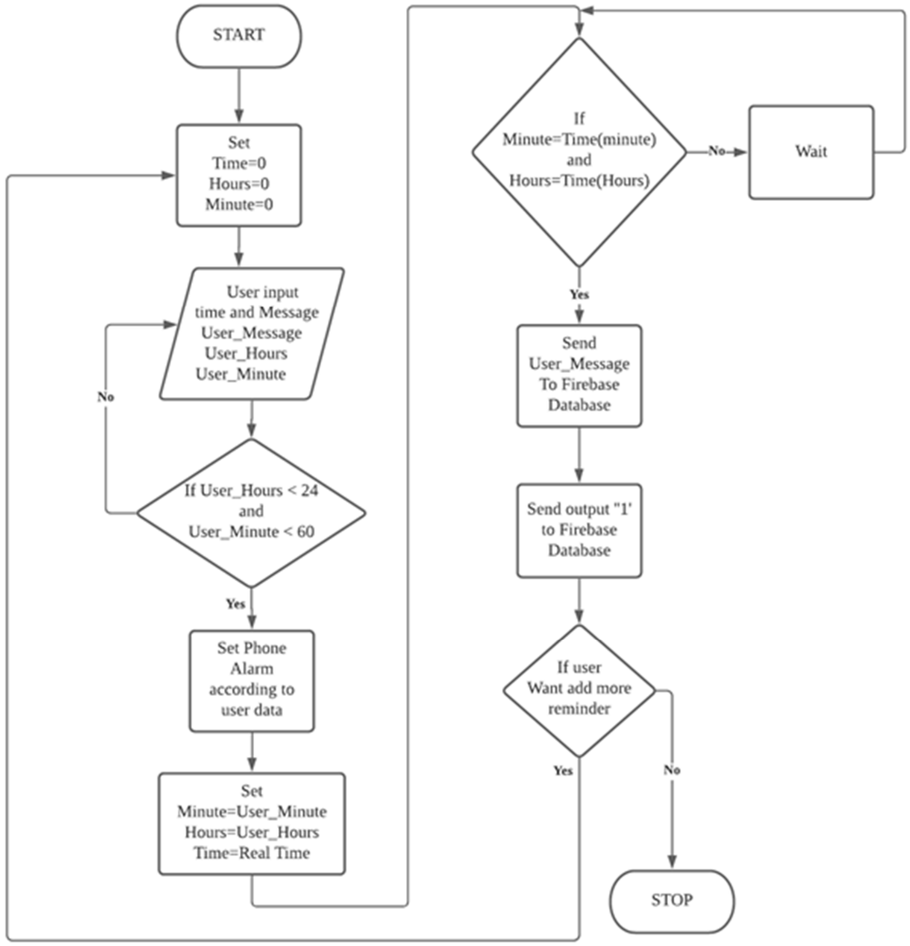


Figure 15: Flowchart of medical reminder features for apps

Figure 15 shows the flowchart of the medical reminder feature in the software apps. First, the user will be asked to set the time that they want to be remind. After that, the phone alarm is set according to the user data. When the alarm is rang, it will send output “r=1” to the Firebase database.

No	Component	Estimated Cost			Actual Cost	
		Unit Price (RM)	Qty.	Subtotal (RM)	Purchased Price (RM)	Delivery Week and Remark
1	MLX90614-BCC	65.00	2	130	135.04	Delivered
2	20 X 4 arduino LCD Display	24.56	1	24.56	24.56	Delivered
3	ESP8266 Node MCU	24.16	1	24.16	24.16	Delivered
4	Cable	7.90	1	7.90	7.90	Delivered
5	Arcylic Sheet A4	8.90	2	17.80	17.80	Delivered
6	GM SUPER GLUE 3 SECONDS	3.90	1	3.90	3.90	Delivered
			Total		213.36	

Figure 16: Bill of materials (BOM) for this project

Based on Figure 16, the total budget spend on this project is RM213.36. Two temperature sensors MLX90614-BCC is brought to act as backup in case one of the temperature sensors malfunction. Acrylic sheet and super glue are brought for the casing of the hardware device.

Implementing

Figure 17 and 18 show the final look of the prototype. The temperature sensor is located outside of the casing to avoid blocking the sensor which may affect the accuracy of the temperature reading.

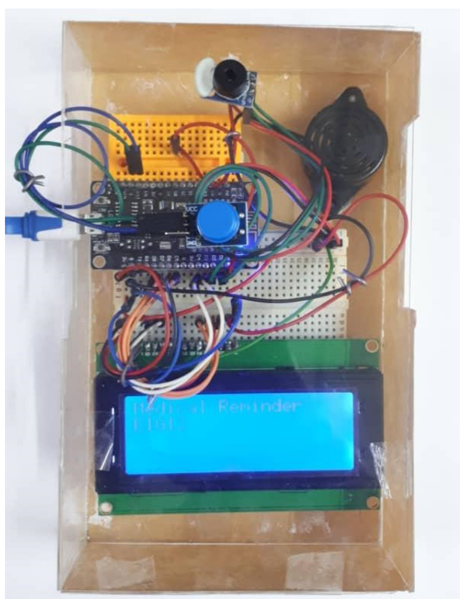


Figure 17: Electronic components in the system

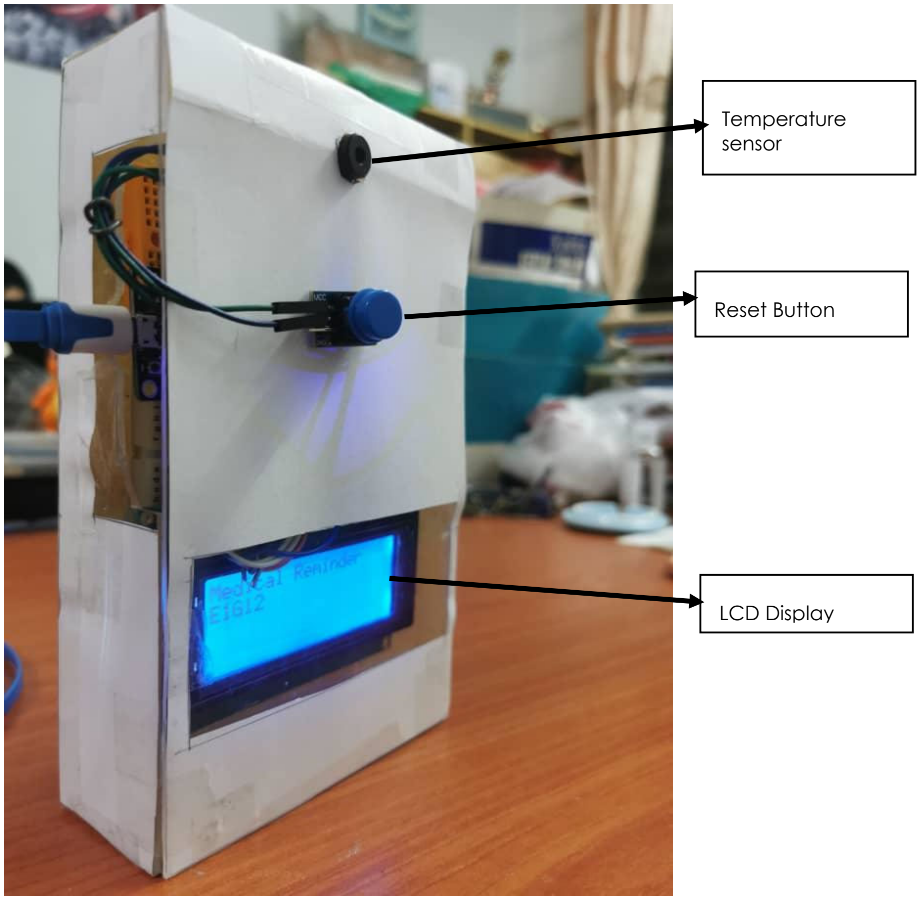


Figure 18: Final look of the prototype

The connection of microprocessor Nodemcu ESP8266 with other components such as LCD, buzzer, temperature sensor, reset button is shown in Table 3

Table 3: The pins connection of electronic components

Nodemcu ESP8266 Pin Number	Component Pin
D2	SDA
D1	SCL
D0	Buzzer
Vin	VCC
GND	GND/VSS
D3-D8	LCD
RST	Reset Button

For the apps, the interface for features namely Medical reminder, Exercise reminder, temperature monitor, Covid19 updated and medical data history are shown in Figure 19, Figure 20, Figure 21, Figure 22 and Figure 23 respectively.

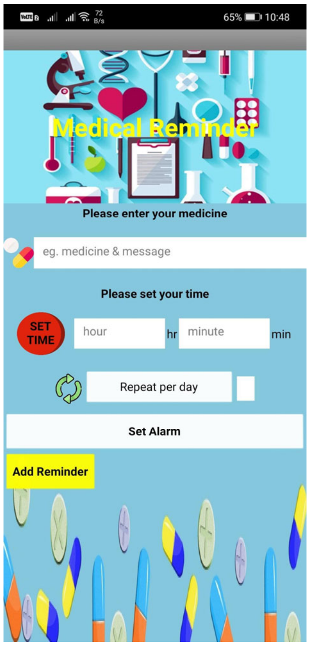


Figure 19: User Interface (Medical Reminder)

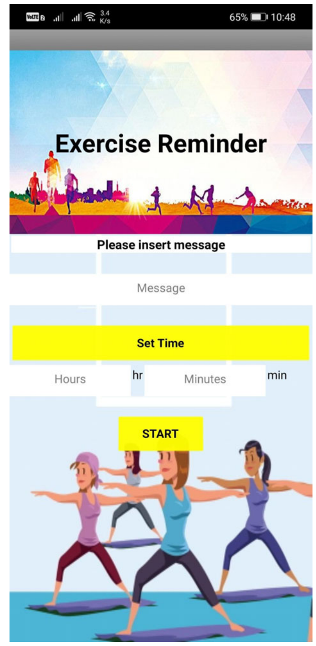


Figure 20: User Interface (Exercise Reminder)

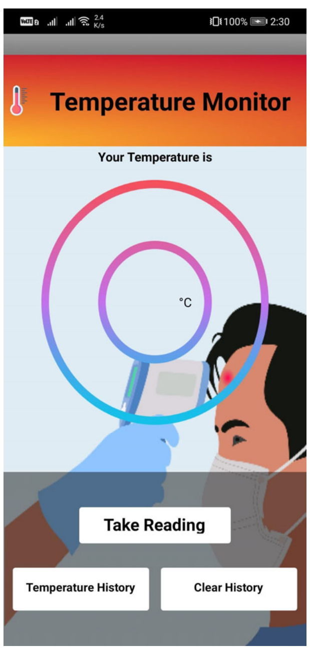


Figure 21: User Interface (Temperature Monitor)

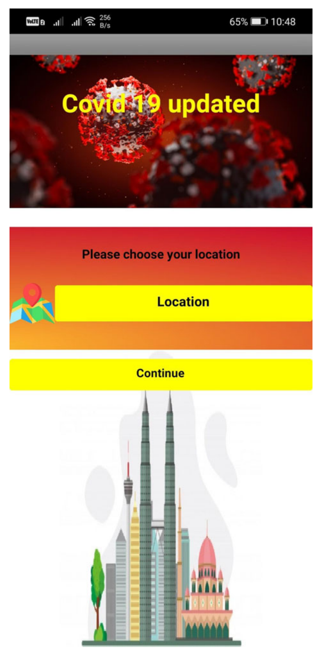


Figure 22: User Interface (COVID-19 Update)

Figure 23: User Interface (Medical Data History Review)

Operating

The operating video was recorded in this link: https://youtu.be/Hkutr9GI8tk. For Temperature Monitoring, the user will need to take the device near his forehead within a distance of 7cm (shown in Figure 24). The sensor will sense the user's temperature and respond back to the user's app.

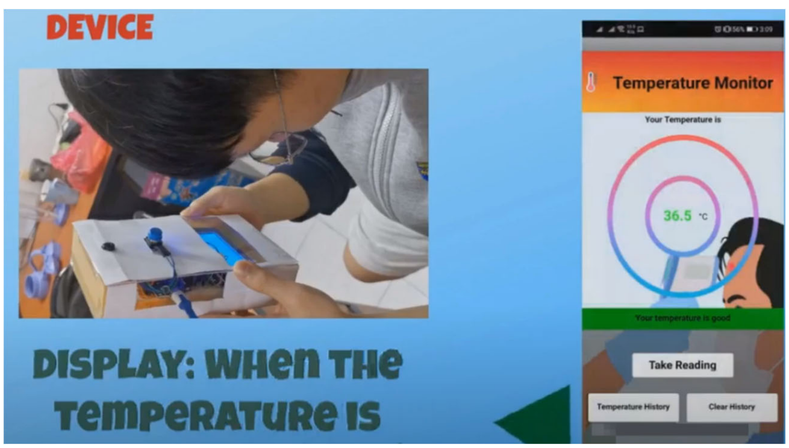


Figure 24: Temperature Monitor Features (Normal)

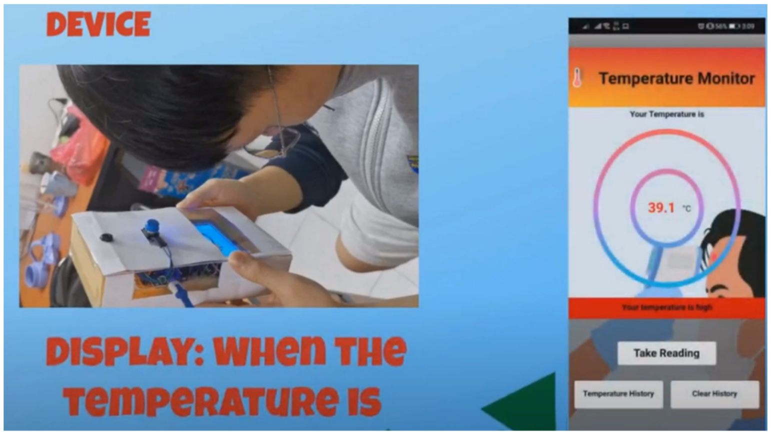


Figure 25: Temperature Monitor Features (Abnormal)

If the user's temperature is more than 37.5 degree, the buzzer on device will buzz to warn the user and displayed on the apps as shown in Figure 25. For Medical and Exercise Reminder features, users need to set the time (shown in Figure 26) for them to take the medicine and repetition they need in future via apps.

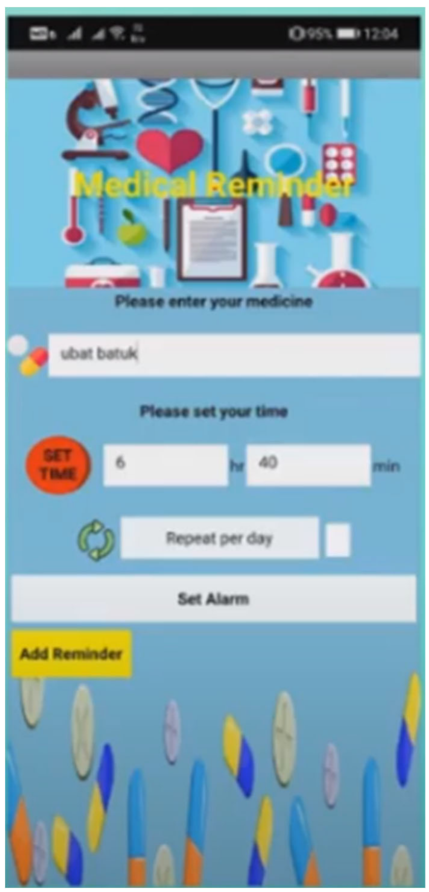


Figure 26: Medical Reminder Features (Timer Setting)

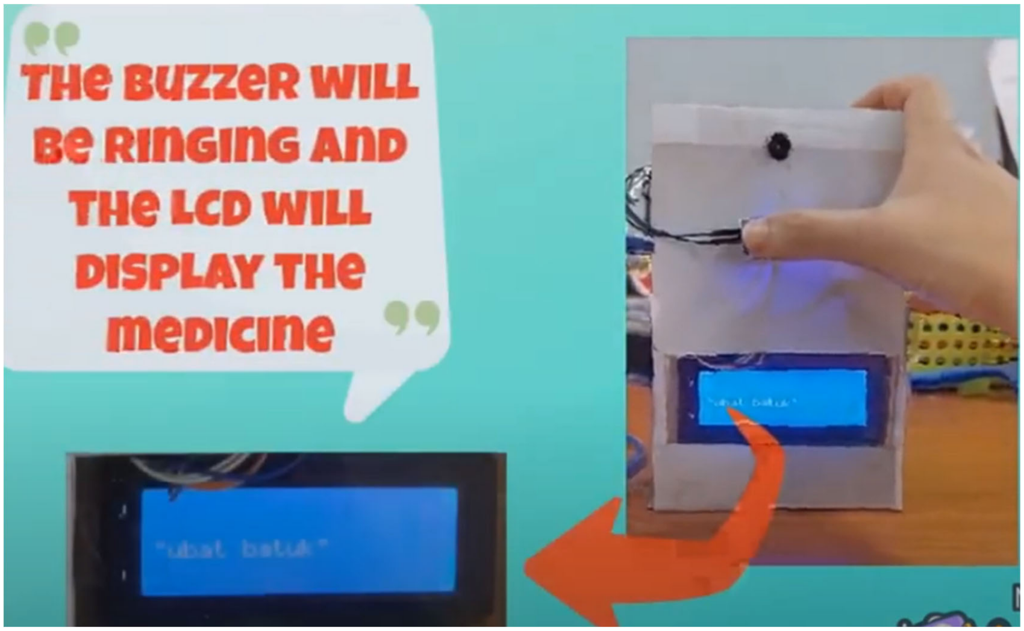


Figure 27: Medical Reminder Features (Device)

When the times up, the buzzer will ring (Figure 27), the user will need to press the reset button on the device to stop the buzz. The LCD display shows the medicine needs to be taken. The temperature recorded and the medicine taken will be recorded in the medicine history as shown in Figure 28.

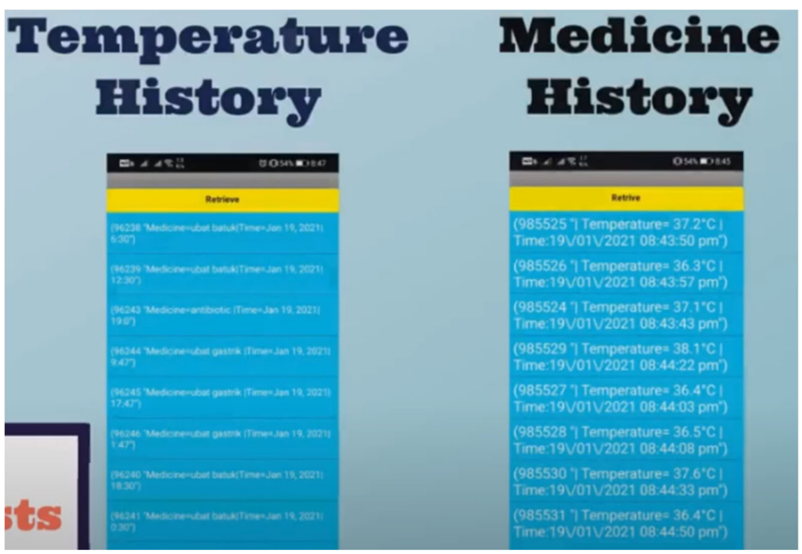


Figure 28: Medical History and Temperature History

As for covid 19 update function, users will be required to key in their location in Malaysia, the app will redirect to Jabatan Kesihatan Negeri web page and covid-19 updates will show by states and distinct (shown in Figure 29).

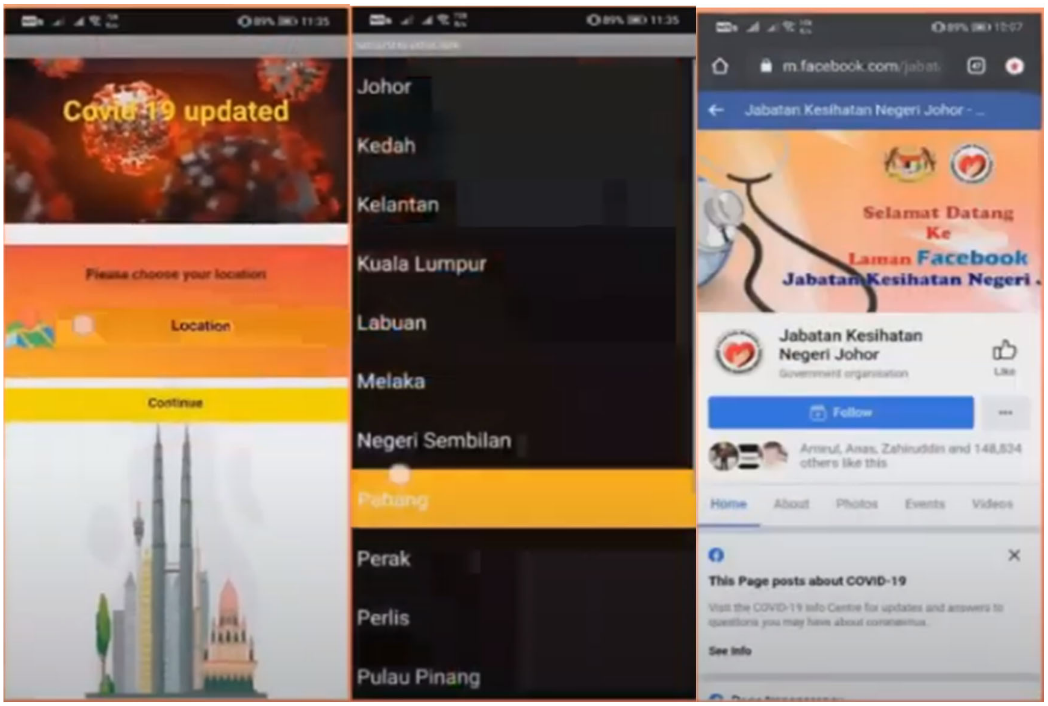


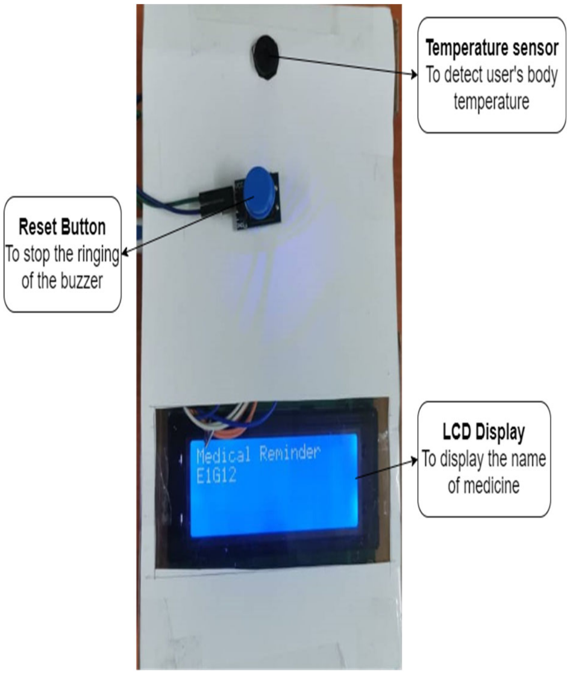
Figure 29: Covid-19 Update Features

Result and Analysis

The end user's problems are living an unhealthy lifestyle, unable to take medicine as scheduled, curious about body temperature and have an unorganized medication record. By using this product (shown in Figure 30), it can solve all the end user's problems that have been mentioned before. Figure 31 shows the interface of the developed apps namely Smart Health Care. The exercise reminder features can solve the problem of unhealthy lifestyle by reminding users to do the exercise. Then, the medical reminder features can solve the problem of unable to take medicine as scheduled by reminding the user when the time to take the medicine and the temperature monitoring can solve the problem curious about body temperature by monitoring the body temperature using this product. Next, the medical history can organize the medication record and body temperature of the users.

The benefits that have been provided by the product are detailed Covid-19 updated for user awareness and the IR temperature sensor with accurate reading for users to monitor their body temperature accurately. Next, long distance reminders for users can use the product wirelessly. Finally, a traceable history of consumed medicine for users to monitor their medicine.

Next, a google form has been created to collect the ratings and feedback from the end users. The end users need to watch our product video and to give feedback and ratings for our product. Based on the google form, there are 22 respondents and most of the respondents are 18-50 years old. More than half of the respondents give positive feedback and think this product is helpful. They think this product is helpful mostly because of the medical reminder which can help to remind users themself and their family members wirelessly. Besides, many feedbacks about improvement are collected and they are complaining about the device being too large and need additional features. The IR temperature sensor has been calibrated with the IR thermometer. However, according to Figure 32, the reading of the MLX90614 sensor is slightly lower than the reading of the IR thermometer which has a difference of 2.5°C. Hence, the adjustment and calibration can be made through coding by adding 2.5 to every reading taken by the MLX90614 sensor.



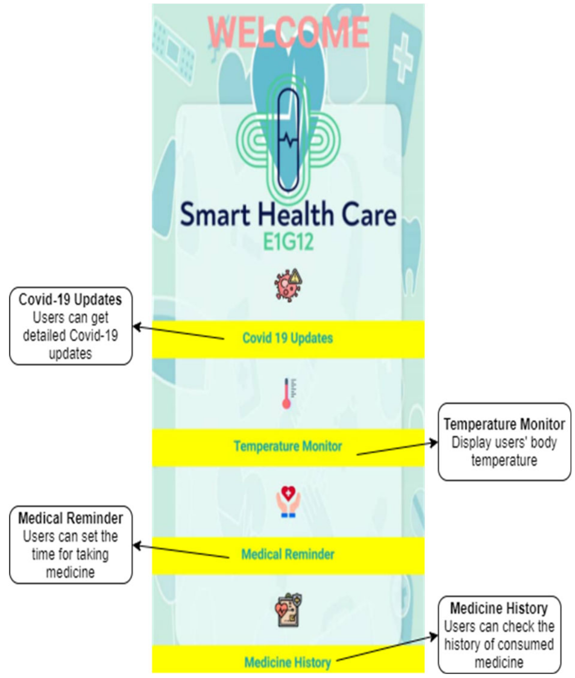


Figure 30: Prototype of the developed device

Figure 31: Software Interface of the developed system

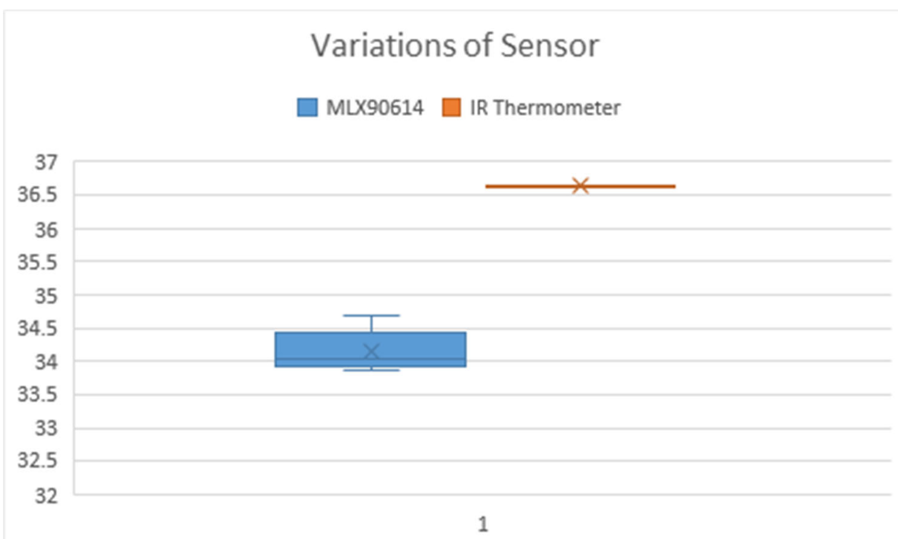


Figure 32: Variations of Sensor

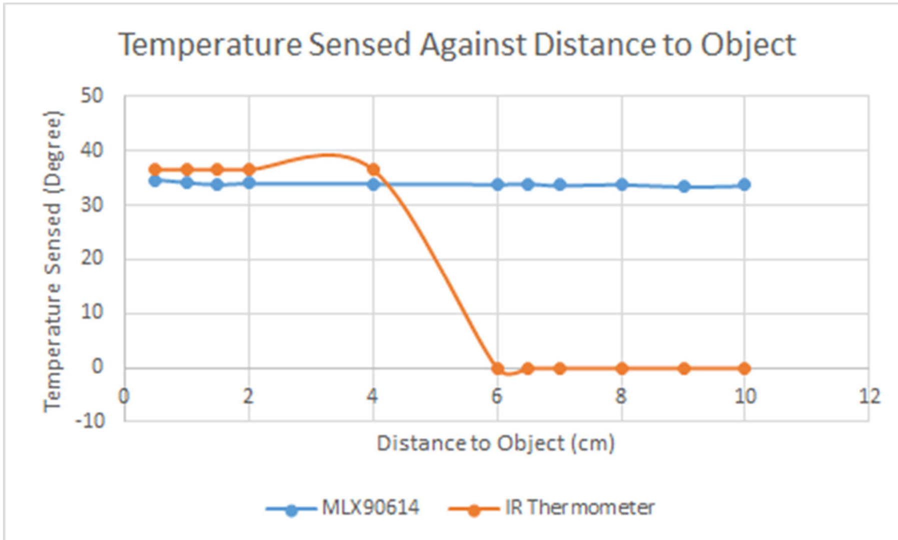


Figure 33: Temperature Sensed Against Distance to Object

Based on Figure 33, the MLX90614 sensor is capable of sensing the object temperature up to 10cm while the IR thermometer can only sense the object's temperature up until 4cm.

Innovation

Basically, the project is compared to MySejahtera App where it consisted about the information and latest news about Covid-19. For our project, we added a few additional features where not only the users could check the updates for Covid-19, but they also could avoid from the virus and the other diseases.

The product included a temperature monitor on the device where the users can monitor their body temperature as the symptom for some diseases and especially Covid-19 is fever. As for the app, we innovated a new feature compared to MySejahtera where the users can get the details and updates about Covid-19 cases based on their location. The app will direct the user to the particular Health Department page on Facebook based on the user location.

For medical reminder and exercise reminder, the features are quite similar to phone alarms where the user could easily use the reminder using the phone alarm. As for the product, there is an innovativeness where when the user sets the reminder on the app, it will alarm the user through the phone and the device as well. The feature will be beneficial to the family members as it could remind the elderly or the kids anywhere to take their medicine on time just from the phone as long as they have the device.

The last feature is a new feature where the user can track back their medicine history and temperature history. This feature may be helpful to the doctors where it kept the patients' medicine history. So the doctors can easily analyze their patient background medical based on the record.

Conclusion

In conclusion, the prototype worked successfully but it might have a security concern because the database used for the project is from an open source. So, the database is exposed to the hackers as the security is not strong enough. To compete on the market, the improvement that can be made is to reduce the size of the device as much as possible to make it easy to carry anywhere. The next improvement that can be made is using a secured database to keep any records needed but the product cost will increase as an amount of money needs to be spent there to get a secured and premium database.

Acknowledgement

The project is supported by the School of Electrical Engineering, Universiti Teknologi Malaysia and the Ministry of Higher Education under Fundamental Research Grant Scheme (FRGS/1/2018/TK04/UTM/02/40). We would also like to convey our utmost appreciation and gratitude to acknowledge with much appreciation the crucial role of our facilitator, Dr. Mohd Azhar Bin Abdul Razak who has invested his full effort in guiding the team in achieving the goal and sharing his knowledge to complete the capstone project. A special thanks goes to Dr Musa Bin Mohd Mokji as Capstone coordinator for Electronic and Computer Engineering who has drafted the guideline and planner perfectly for us to keep on the track.

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Health Monitoring System

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Abstract: This prototype has three main functions which are temperature detection, heart rate detection and range detector. These functions include three types of sensors which are temperature sensor (MLX90614), pulse sensor and ultrasonic sensor. The prototype sends the data and displays on the apps in the phone. If the temperature is not within the normal temperature, the user should refer to the nearest hospital, as for the pulse sensor the user is able to check whether their heart rate is normal or not and lastly, the ultrasonic sensor function is to detect the distance of the user for the ergonomic functions.

Keywords: temperature sensor; pulse sensor; ultrasonic sensor; ergonomic function

Introduction

Nowadays, the level of health among Malaysians is increasingly worrying. According to the Ministry of Health (MOH), diseases of the circulatory system and disease of the respiratory system has caused the largest percentage of death, 25.64% and 19.48% respectively of total death. Besides, with the current situation of the country being plagued by COVID-19 cases, preventive measures should be taken, especially among minors, the elderly, and those with a history of chronic illness. This is because they are the most easily infected and affected group because they do not have a strong immune system.

Therefore, the purpose of this prototype is to let users know their current level of health. This prototype is equipped with three types of sensors namely temperature sensor, heart rate sensor, and ultrasonic sensor. As informed by MOH, body temperature above 37 °C is one of the symptoms of COVID-19 symptoms. Therefore, the MLX90614 type sensor is used because this sensor can provide a very precise temperature reading.

Also, this prototype is equipped with pulse sensors. This pulse sensor is very important to know if heart is pumping enough blood into the body. According to Harald M. Stauss, the normal pulse rate for a human being is 72 beats per minute. If a person's pulse rate drops below 60 beats per second, it may cause that person to experience a lack of energy, dizziness, weakness, and chest pains. If these symptoms occur to you, please consult a doctor immediately.

In addition, this prototype has ergonomic features for those who work with computer for a long time with the use of ultrasonic sensor. The ultrasonic sensor has two functions which are to measure the distance of the users from the computer monitor and to determine whether the users are staying at the same position too long. If the users are getting too close to the monitor, an LED light will light up to alert the users that they are too close to the monitor. Body position that is too close to the monitor will cause eye pain if staring at the monitor for a long time. Besides, this prototype will also alert users if they are in one place for too long. This is because being in the same position for a long time will disrupt blood flow in the body. Both of these features are very beneficial to employees who spend hours doing their work in the office.

This prototype development also in line with the campaign that was introduced by the government in the year "Kempen Nak Sihat". In 7th September of 2013, MOH came out with an initiative through a campaign called "Kempen Nak Sihat." The purpose of this campaign is to encourage every Malaysian to practice a healthy lifestyle through physical activities. There a few of the contents of the campaign that can be related to this prototype, which are 10,000 steps, BMI inspection, blood pressure test, and health counselling. In addition, this prototype also does not harm the environment as most of it is made out of electronics components. One of the reasons why this is considered worth buying is because it only costs RM120 which is considered as affordable compared to the existing health monitoring system that is available in the market.

Conceiving

Development of a system needs proper findings and research before implementing it in the community in order to verify the system is functioning well. In this system development, there are several studies related to healthcare system development such as data processing, security protection for user's data and type of sensor used. Besides, it is important to ensure that the system or the devices are eco-friendly.

Thus, the first task is the conceiving part that includes design project title, data collection, data clustering and construct user personification. All the tasks for the conceiving part focus more on findings based on the project intent. The project theme is Health and Wellbeing and some aspects of the new industrial revolution need to be implemented in this project. Therefore, the concept chosen is a sensor-based system that designs a system and send the data to an application. Several studies have been done on the sensors used in healthcare projects based on articles and journals in order to get some information that applied in the project.

Title of the project is Health Monitoring Devices and the type of sensor used are based on the data collection. Regarding the data collection, an interview form has been distributed using Google form. In addition, the interview session needs to be conducted in order to get in-depth study of the user's needs. The questions are related to personality, healthcare, features needed in a device and aspects of health. The respondents are among the students, lecturer and family members. Moreover, the feedback from the respondents were analyzed in a graphical method and results showed 62 respondents successfully answering the interview questions. Figure 1 to 3 below show the data from the respondents for several interview questions that have been done.

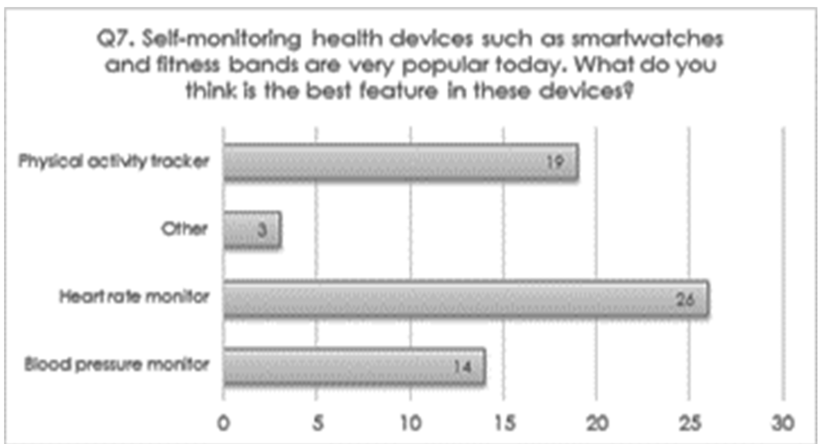


Figure 1: Respondents feedback for question 7.

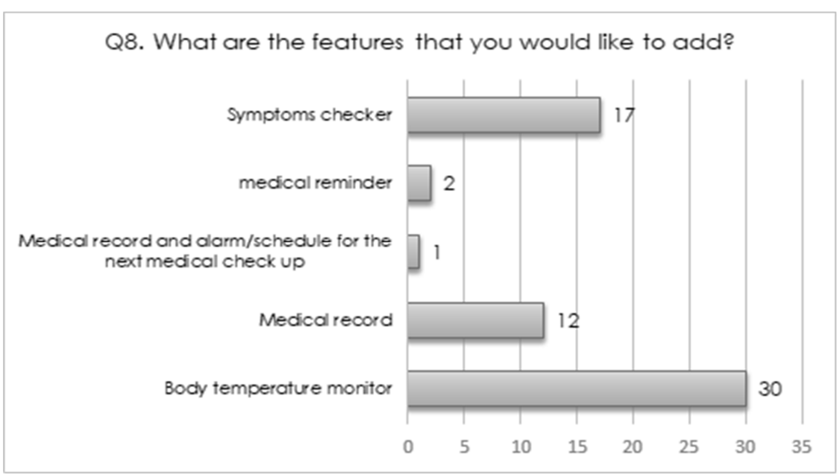


Figure 2: Respondents feedback for question 8.

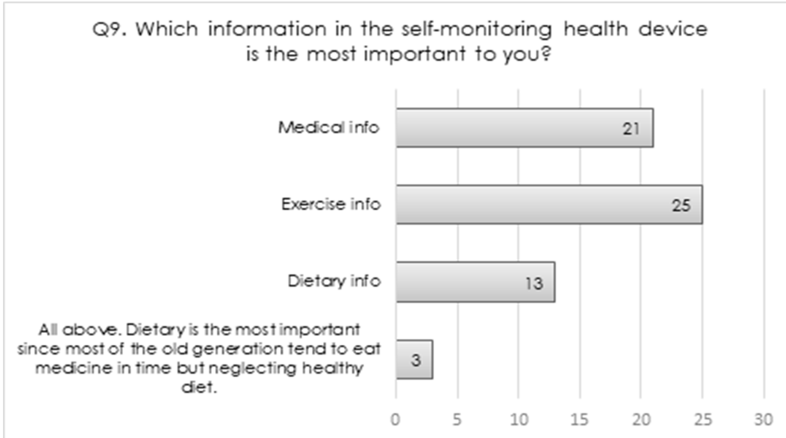


Figure 3: Respondents feedback for question 9.

Based on Figure 1 and Figure 2, most of the respondents suggest developing features for heart rate monitor and body temperature detector. Referring to Figure 3, another feedback from the respondents choosing exercise information is the priority for health monitoring devices. Apart from data analysis, the feedback from the respondents were clustered into different categories.

Table 1: E1G2 Cluster.

Categories	**Feedback (Respondents)**
Personality	Age: 19-25 (56) Good physical health (53)
Healthcare	Not undergo body checkup (37) Moderate level in basic medical knowledge (27)
Features Needed	Heart Rate Monitor (26) Body Temperature (30)
Aspect of Health	Fitness and balanced diet (28)

In data clustering, a cluster named E1G2 has been formed according to data from the respondents. Table 1 shows the clustered form based on the highest respondents from each category. The categories have been divided based on the questions from the interview session. After that, a user's personification was developed according to the E1G2 cluster.

Table 2: User's personification named Busy Rex from E1G2 cluster.

	User's Personification (Busy Rex)
Profile	1. Students 2. Actively participate in club activities 3. No time for body checkup 4. Moderate level in basic medical knowledge
Problem faces	1. Physically and mentally unhealthy 2. Lack of sleeping time 3. Easy to get sick
Needs	1. A portable system that can monitor health level 2. System with affordable price 3. Able to connect with smartphone

Referring to Table 2, a user's personification was developed including the profile, problem faces and needs. The details from the user's personification also contribute into the design statement and the objectives of the project as well. Hence, the design statement for the project is **"How we may help Busy Rex to monitor his heart rate and temperature by using an ergonomic health monitoring system that is portable, affordable and especially ensuring a comfort study environment"**.

Designing

Conceptual Sketch

Figure 4 shows the conceptual sketch of the health monitoring device. The components used in the prototype include ultrasonic sensor, temperature sensor, pulse sensor, LCD, Arduino UNO and Bluetooth module. To activate this prototype, we need a 5V power supply.

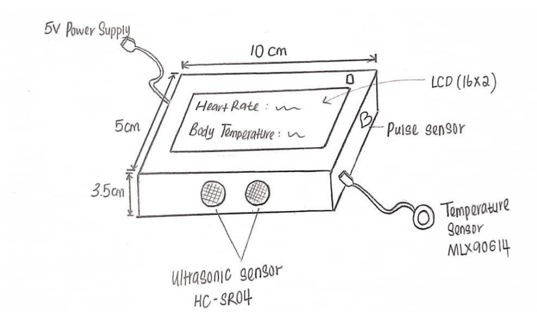


Figure 4: Concept sketch of ergonomic health monitoring prototype.

Conceptual Prototype

After completing the conceptual sketch, an actual conceptual prototype was developed as shown in Figure 5. All the dimensions need to be found when designing the conceptual sketch so that we can decide the dimensions of the complete device for us to develop the conceptual prototype.

The dimensions of each component used in the prototype are as follows:

Table 3: Dimensions of the components used.

Components used	Length (mm)	Width (mm)	Height (mm)
LCD (16x2)	80	36	12
Node MCU	58	32	1.6
Ultrasonic sensor (HC-SR04)	45	20	15
Temperature Sensor (MLX 90614)	11.5	1.7	-
Pulse Sensor	Thickness: 3 mm Diameter: 16 mm		

According to Table 3, the size of the complete prototype can be determined. This is a portable health monitoring prototype with a length of 100 mm, a width of 50 mm and a height of 35 mm.

Figure 5: Conceptual prototype of ergonomic health monitoring device.

STEEP Analysis

STEEP analysis which consists of sociological, technological, economic, environmental and political was carried out and the discussion corresponding to each aspect are shown in Table 4.

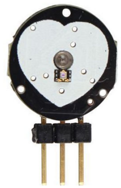
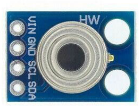
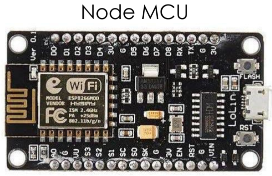
Table 4 The STEEP analysis of the developed device.

Aspect	Discussion
Sociological	Sitting in front of the computer for several hours may lead to poor blood circulation and develop various diseases such as diabetes, cardiovascular, blood clots, metabolic syndrome and so on. Hence, this project is designed to help people who work or study for endless hours in order to get better health.
Technological	This project is designed using electronic devices, the Arduino, whereby multiple sensors are connected to it. The sensors will act as input, and the input obtained will be displayed to the user's smartphone using Bluetooth.
Economic	Although many health monitoring systems have been sold in the market, not all of these systems can be purchased by all users, as some of them are quite pricey. Hence, we try our best to develop a useful and affordable system with an estimated price of lower than RM120.
Environmental	Our project can be considered as environmentally friendly as most parts of this project will not harm or destroy the environment.
Political	In 2013, Kementerian Kesihatan Malaysia came out with an initiative through a campaign called "Kempen Nak Sihat." The purpose of this campaign is to encourage every Malaysian to practice a healthy lifestyle through physical activities. There are a few of the contents in the campaign that we can relate to this project, which are 10,000 steps, BMI inspection and health counseling.

Specification of the Components Used

A good understanding about the features of components used in the prototype is essential. This helps us to properly connect the sensors and display unit (LCD) to the Node MCU. Besides, suitable codes in Arduino IDE software can be developed according to the functions required by the users. Table 5 shows the specifications of each component used in the health monitoring prototype.

Table 5 Specifications of the components used.

Components	Features
Pulse Sensor 	• Measure the heart rate of the user. • One side of the pulse sensor is the LED with an ambient light sensor and some circuitry on the other side. • When LED is placed over the vein in our fingertip or ear tips, it will emit light which directly falls on the vein. • When our heart is pumping, the veins will have blood flow inside them. • More light will be picked up by the ambient light sensor as they will be reflected by the blood, the change in received light is evaluated over time to determine our heart rate. • Healthy resting heart rate: 60-100 bpm.
Temperature Sensor (MLX 90614) 	• It is a contactless infrared digital temperature sensor that can be used to measure the body temperature accurately. • Normal body temperature: 36.0 - 37.5 °C.
Ultrasonic Sensor (HC-SR04) 	• Measure the distance between the user and the prototype. • Ranging distance: 2 cm-400 cm.
LCD (16x2) 	• Display the result obtained or the alert message.
Node MCU 	• It is an open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. • It is programmable with the Arduino IDE software via a Micro USB cable. • Used to control and interact with sensors and LCD connected to it.

Circuit Diagram and Flowchart

The complete circuit diagram was designed on Fritzing as shown in Figure 6.

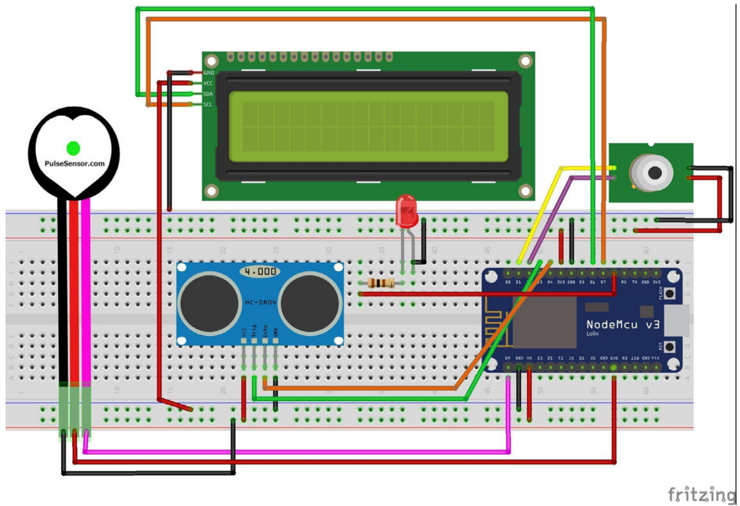


Figure 6: The schematic circuit for the system.

In this stage, the flowcharts for the temperature sensor, ultrasonic sensor and pulse sensor have been constructed as shown in Figure 7, Figure 8 and Figure 9 respectively.

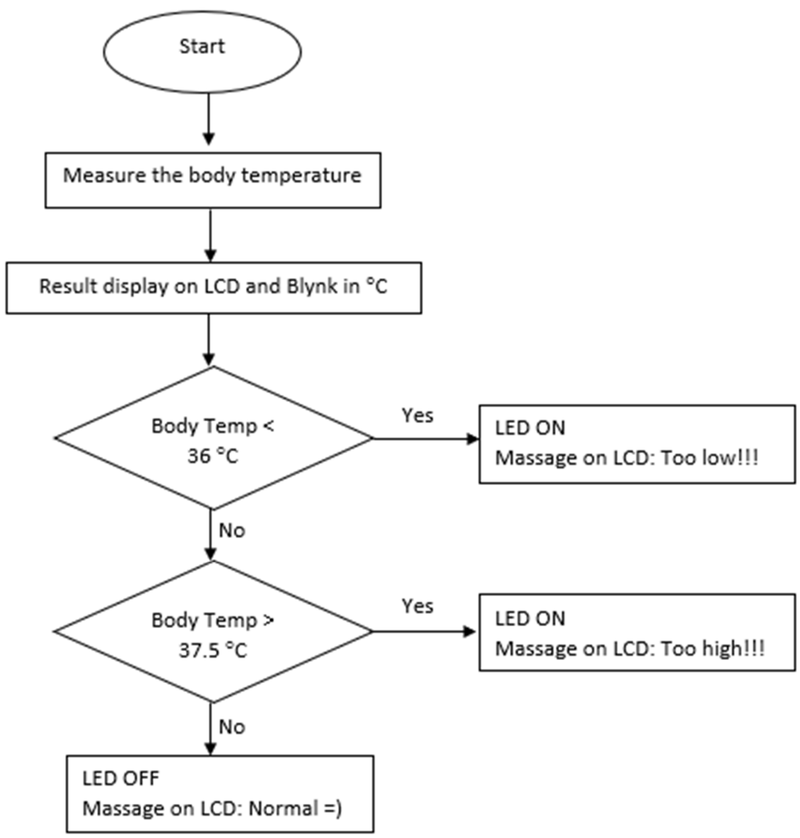


Figure 7: Flowchart for measuring the body temperature.

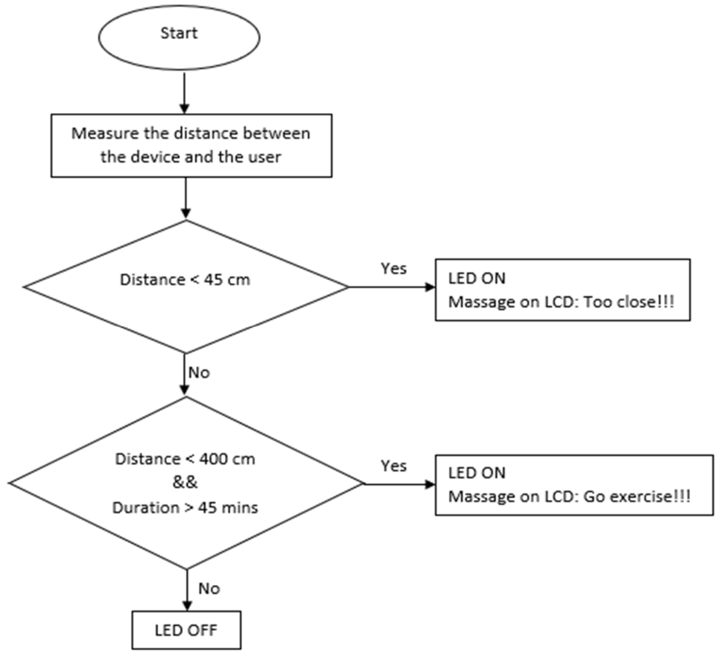


Figure 8: Flowchart for ergonomic function.

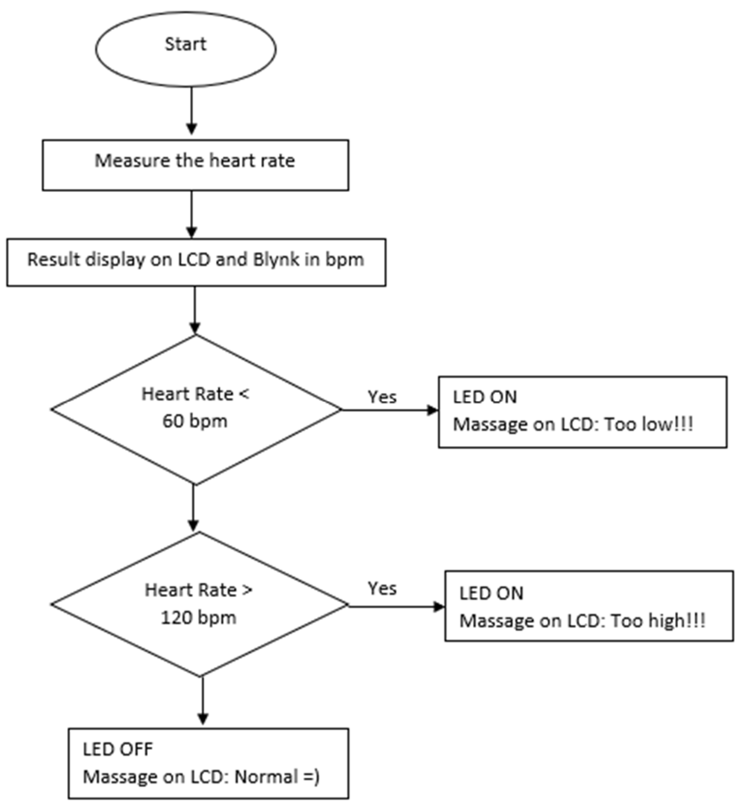


Figure 9: Flowchart for measuring the heart rate.

Bill of Materials (BOM)

Bill of materials (BOM) is a comprehensive list of parts, items and other materials required to create a prototype. The estimated and purchased price of each component used in this project has been included in BOM. Besides, the quantity purchased and the delivery week also stated in BOM. BOM for this prototype is shown in Table 6:

Table 6: Bill of materials (BOM).

No	Component	Estimated Cost			Actual Cost	
		Unit Price (RM)	**Qty.**	**Subtotal (RM)**	**Purchased Price (RM)**	**Delivery Week and Remark**
1	Pulse sensor	11.90	1	11.90	20.91	Week 5
2	Arduino Uno R3 Beginner Starter Kit	43.80	1	43.80	43.80	Week 5
3	Ultrasonic sensor (HC-SR04)	3.20	1	3.20	3.20	Week 5
4	Bluetooth Module (HC-06)	14.90	1	14.90	14.90	Week 5
5	12C LCD 1602 (2x16)	9.90	1	9.90	9.90	Week 5
6	Breadboard	4.15	2	8.30	8.30	Week 5
7	Female to Female Jumper Wire	2.90	1 set	2.90	3.00	Week 5
8	Female to Male Jumper Wire	2.90	1 set	2.90	3.00	Week 5
9	Male to Male Jumper Wire	2.90	1 set	2.90	3.00	Week 5
10	Shipping Fee for items (2) to (9)	-	-	-	38.90	Week 5
11	Temperature sensor (MLX 90614)	45.00	1	45.00	54.01	Week 6
12	Solder Gun	9.00	1	9.00	9.00	Week 6
13	Soldering Pump	2.70	1	2.70	2.75	Week 6
14	Solder tin coil	1.20	2	2.40	2.40	Week 6
15	Node MCU	33.90	1	33.90	38.94	Week 6
			Total	193.70	256.01	

Gantt Chart

Gantt chart is a project management tool. It is useful for project scheduling and planning. The tasks that need to be completed have been listed in the Gantt chart. Figure 10 shows the Gantt chart for this project:

No	Tasks	Start Week	End Week	Capstone Week 5	6	7	8	9	10	11	12	13	14
1	Circuit design	6	8		✓	✓	✓						
2	Software development	6	11		✓	✓	✓	✓	✓	✓			
3	Hardware development	6	11		✓	✓	✓	✓	✓	✓			
4	Testing	9	11					✓	✓	✓			
5	Technical report	12	14								✓	✓	✓

Figure 10: Gantt chart of the project.

Implementing

Hardware Development

The coding for the three sensors is constructed separately in the Arduino IDE software in order to ensure that each sensor can function well before combining all the sensors together. The integration of codes for three sensors was the last step in the software development. In order to make sure that the input power is enough for the sensors and LCD, the slide switch is used in the circuit. Besides, the "if" condition is used in the coding, so that different sensors can be run separately under different conditions. Users can choose the functions of the prototype using the slide switches as shown in Table 7:

Table 7: Switch status and associated function.

Functions	Switch 1	Switch 2
Measure Temperature	0	0
Ergonomic Function	0	1
Measure Heart Rate	1	1

Switch output is 1 when it connects to the voltage source while switch output is 0 when it connects to the ground. Then, the circuit was developed as shown in Figure 11 according to the pins connection listed in Table 8. Figure 12 shows the final look of the prototype which developed based on the conceptual prototype constructed previously.

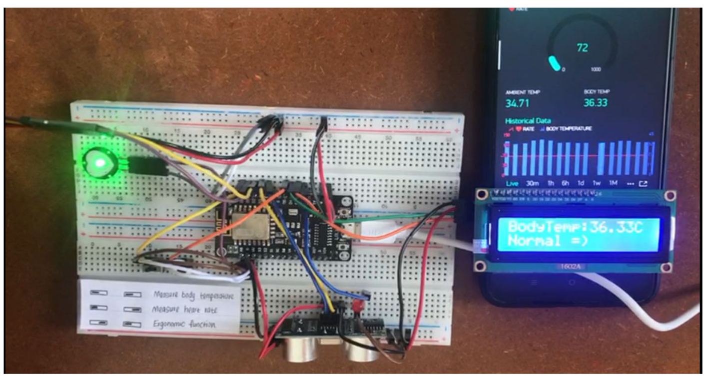


Figure 11: Circuit developed for the prototype.

Table 8: The pins connection of electronic components

Node MCU Pin Number	Component Pin
A0	Pulse Sensor
D0	Switch 1
D1, D2	SDA, SCL (Temperature Sensor)
D3, D4	Trig, Echo (Ultrasonic Sensor)
D5	Switch 2
D6, D7	SDA, SDL (LCD)
D8	LED

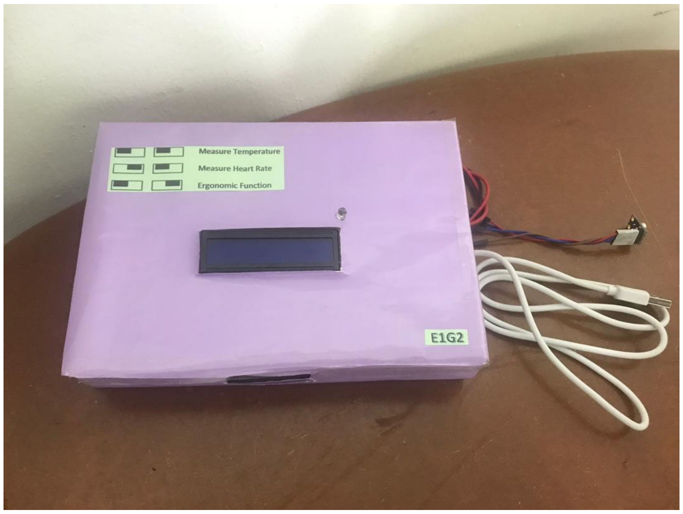


Figure 12: Final look of the prototype.

User Interface (Blynk App)

In the Blynk app, the display units used by the temperature sensor and pulse sensor of this project are "Value Display" and "Gauge" respectively. Besides, "SuperChart" is used to store the result obtained so users can check their historical heart rate and body temperature. All of the display units used are shown in Figure 13.

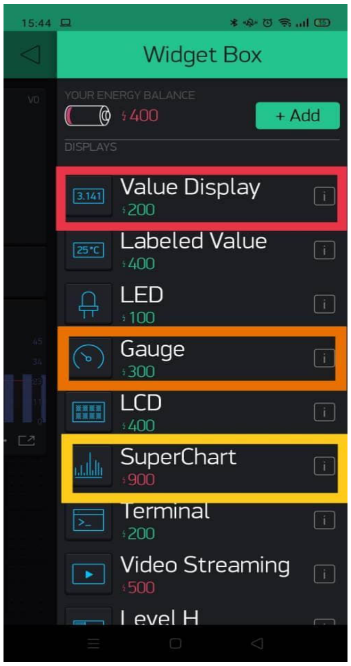


Figure 13: Widget box in Blynk app.

Besides, Figure 14 shows virtual input pins V1 and V2 that used to display the ambient temperature and body temperature respectively. The readings are obtained from the temperature sensor that is connected to node MCU.

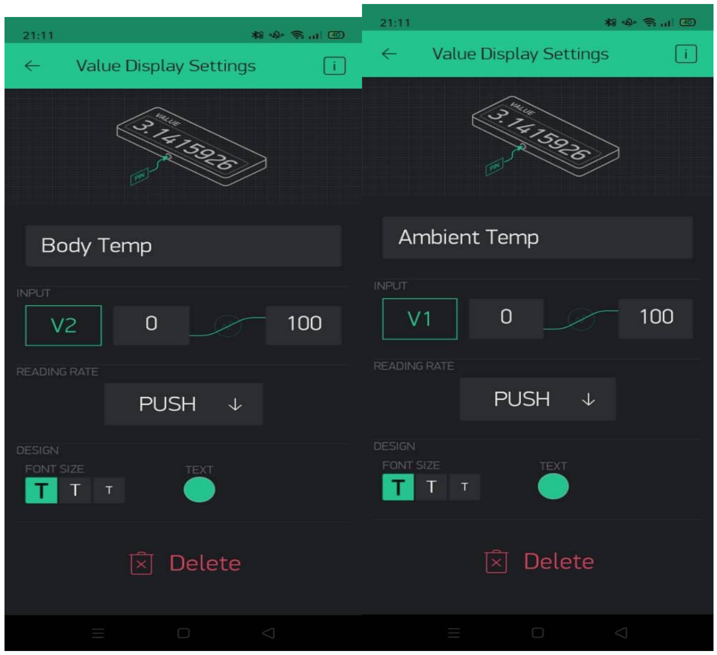


Figure 14: "Value Display" setting for temperature sensor

Furthermore, Figure 15 shows the virtual input pins V0 that used to display the heart rate of users. It obtained the reading from the pulse sensor. When building the code for the node MCU, the virtual pins for the Blynk app used need to be defined so the reading displays are correct.

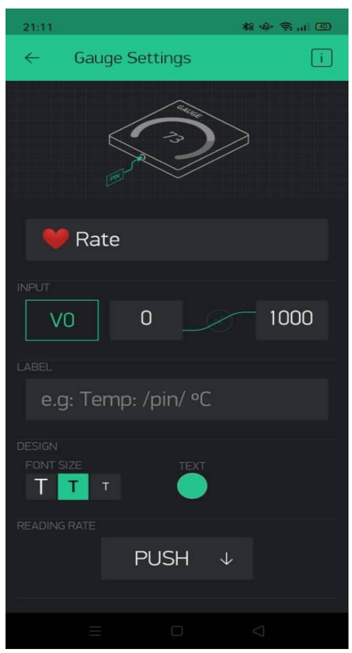


Figure 15: "Gauge" setting for pulse sensor.

In the "SuperChart" setting shown in Figure 16, data stored are the heart rate and body temperature. Users can track the result measured within one month.

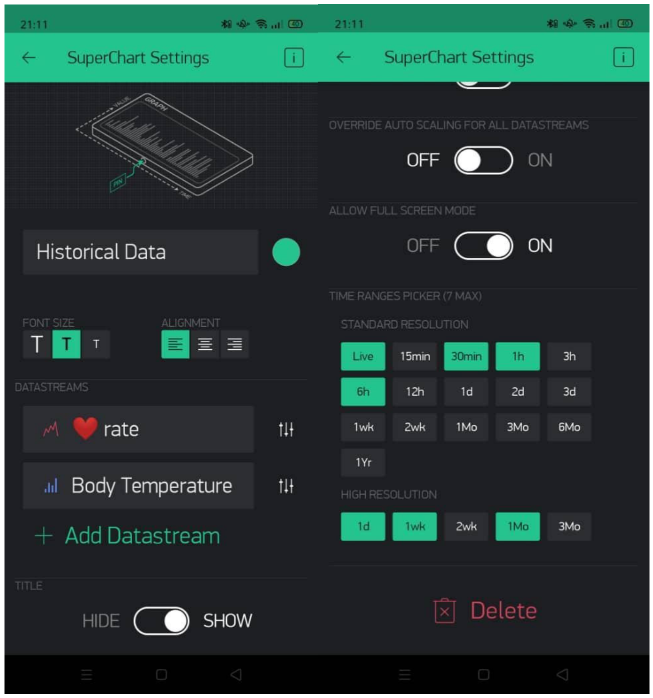


Figure 16: "SuperChart" setting for data storage.

Operating

Pulse rate

1. First, please make sure that switch 1 is at "on" state while switch 2 is at "off" state.
2. The pulse sensor is on the left side of the prototype. So, put your fingertip on the pulse sensor.
3. The pulse sensor will start to take reading of your pulse every 10 seconds.
4. If the pulse reading is lower than 60 bpm, a message "Too low!!!" will be displayed on the LCD.
5. If the pulse reading is higher than 120 bpm, a message "Too high!!!" will be displayed on the LCD.
6. If the pulse reading is between 60 to 120 bpm, a message "Normal" will be displayed on the LCD to indicate that heart beat is at optimal level.
7. The data obtained from the pulse rate sensor can be observed on the LCD display and Blynk App.

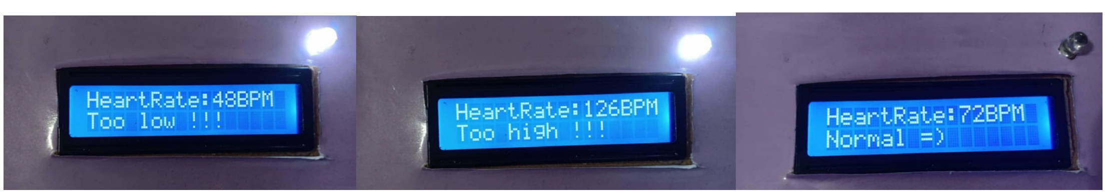


Figure 17: Heart rate display on LCD.

As shown in Figure 17, the LCD displays the user's heart rate and the LED lights up if the user's heart rate exceeds 120bpm or lower than 60 bpm. If the heart rate is within the range of 60bpm to 120bpm, the prototype will only display the heart rate reading.

Measuring body temperature

1. First, please make sure both the switches are at "off" state.
2. Take out the temperature sensor and put it on your forehead.
3. If the body temperature reading is lower than 36°C, a message "Too low!!!" will be displayed on the LCD.
4. If the body temperature reading is higher than 37.5°C, a message "Too high!!!" will be displayed on the LCD.
5. If the body temperature reading is between 36°C to 37.5 °C, a message "Normal" will be displayed on the LCD to indicate that the user's body temperature is at optimal level.
6. The data obtained from the temperature sensor can be observed on the LCD display and Blynk App.

Figure 18: Body temperature display on LCD.

Figure 18 shows the display of the user's body temperature at different readings, which are 26.49°C, 48.53°C, and 36.09°C. The prototype has been set in a way that the LED will light up if the user's body temperature is greater than 37.5°C or lower than 36°C. If the prototype senses the user's body temperature within the range of 36°C and 37.5°C, the prototype will show the reading of the body temperature only.

Ergonomic function

1. First, please make sure both the switch 1 is at "off" state while switch 2 is at "on" state.
2. Next, place the prototype next to the monitor or laptop to utilize the ergonomic function.
3. Then, the ultrasonic will start to locate the user's body position.
4. If the distance of the user's body to the monitor is closer than 45cm, the LED will light up and a message "Too close!!!" will display on the LCD to remind the user.
5. Also, if the user stays in a position for more than 30 minutes, then the LED will light up and a message "Go exercise!!!" will display on the LCD.

Figure 19: Message display on LCD for ergonomic function.

Figure 19 shows the displays of ergonomic function on LCD. The ergonomic function starts with displaying "Start Detect" once the ergonomic function is used. The message of "Too Close!!!" and "Go exercise!!!" is used as a reminder.

Result and Analysis

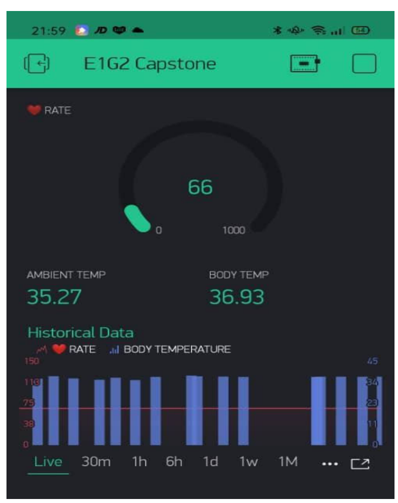


Figure 20: Displaying the result obtained from the prototype to Blynk Apps.

Figure 20 shows the data obtained from the prototype to the Blynk Apps. As can be seen, there are 3 readings that displayed on the Blynk App, which are heart rate, ambient or surrounding temperature, and body temperature. Figure 21 shows how the prototype should be placed next to the user's laptop or computer to ensure the ergonomic functions can be utilized.

Figure 21: View of the prototype.

There are two main features which are displayed on the Blynk App, which is the pulse rate data and the body temperature data. Both of these data are displayed using the "value display" and "gauge display" respectively. While the historical data is displayed using the "SuperChart" so that both pulse rate and the body temperature data can be displayed on the same chart.

The result can be obtained from the prototype that has been sent to Blynk apps via Bluetooth connection. Through Blynk App, users can view the data obtained from the prototype. Blynk App has also been developed with the convenience of storing user data for a month. The previous month's data will be deleted to allow the user to have a more organized set of data. This features on the Blynk gives a huge advantage to the user by allowing them to keep track of their current health status within the month.

Pulse sensor

Figure 22: Displaying the pulse rate on the I2C LCD.

Figure 22 shows that the user's heart rate is at 72bpm and massage "Normal" is displayed on the LCD. The LED does not light up as this prototype has been set, the light will only light up once the heart rate is lower than 60bpm or greater than 120bpm.

This prototype is also equipped with a feature which can measure the heart rate of the user. In this prototype, the SEN-111574 pulse sensor has been chosen due to its low cost and reliability. Heart rate refers to how frequently does heart contracts and relaxes in a unit of time [2]. The heart rate may vary depending on which age of the group you are in. For an adult who ages 18 years old and above, the normal resting heart rate is within 72 beats per minute [8]. Sometimes heart rate can be too low and too high when compared to normal heart rate. If the heart rate is too low, it is called bradycardia and if the heart rate is too high, it is called tachycardia. Hence, it is important to measure and monitor heart rate at all times to know your current body condition.

Temperature sensor

Figure 23: Displaying the body temperature on I2C LCD.

In Figure 23 the LCD displays the user's body temperature, which is at 36.09°C. The LCD also displays a message "Normal" to indicate the user's body temperature is at the optimum level.

High reading accuracy is one of the most important features that all devices should have. Therefore, in this prototype, an MLX90614 has been chosen as a sensor to detect the user's body temperature as it has great accuracy in taking a temperature reading. Changes in body temperature can indicate that the body is fighting off an infection. Maintaining the body temperature at an optimal temperature is very important to monitor the body's current condition. With the current situation where the COVID-19 pandemic is affecting the whole country, knowing your body temperature at all times is very important because a rise in body temperature is one of the symptoms of COVID-19.

Ultrasonic sensor

Figure 24: Ultrasonic start to detect the user's position.

Figure 24 shows that the LCD displays "Start Detect" to indicate the ergonomic function is running.

Figure 25: Displaying an alert message to the user on I2C LCD.

Figure 25 shows that the LCD displays a message "Too Close!!!" and the LED lights up, as the user is too close to the monitor screen.

Figure 26: Displaying a reminder to the user on I2C LCD.

Figure 26 shows that the LCD displays a message "Go exercise!!!" to the user, as the user is static in a position for 45 minutes. This is also equipped with an ultrasonic sensor that acts as ergonomic. The ultrasonic sensor has been programmed to have 2 types of functions, which is to detect the distance of the user's position from the monitor screen and to monitor the user's current position. It is recommended that this prototype is placed next to the user monitor to utilize the ergonomic functionality. An appropriate distance between the user's position to the monitor screen is very important to avoid eye damage for a long period. Therefore, the ultrasonic sensors in this prototype have been programmed to keep the user distance from the monitor screen by 45cm. If the user's body position is less than 45cm to the monitor screen, the LED light will turn on and a message "Too close!" will be displayed on the LCD to remind the user as shown in Figure 1.8.

Besides, sitting for too long at a desk also may harm the user's physical health. According to the health expert Dr. Edward Laskowski, a person who sat more than 8 hours a day without doing any physical activity has a risk of dying similar to those who posed obesity and smoking. Therefore, by using this prototype, LED lights will light up and a message "Go exercise !!!" will be displayed on the LCD to remind the user to do some simple physical exercise if staying in a static position within 45 minutes.

Innovation

There a few other similar devices as this project but lack of some aspects. Hence, an innovation has been made to satisfy and solve the user's problem. Table 7 shows the comparison between this prototype, household LED fingertips pulse detector and human body temperature thermometer.

Table 7: Comparison between this prototype and other similar devices.

Features	Human body temperature thermometer	Household LED fingertip pulse detector	This prototype
Description	Detects human body temperature at the forehead	Detect human heart rate by clipping on the user's fingertip.	a portable device that can detects user's body temperature, heart rate as well as detects user's movement
Function	Detects temperature	Detect heart rate	Detect heart rate, body temperature and user's movement.
Processor	unknown processor	unknown processor	Node MCU
Number of sensors	1	1	3
Data storing	No	No	Yes
App used	No	No	Blynk apps
Ergonomic function	No	No	Yes

Conclusion

In conclusion, the prototype works successfully and achieved the objectives which is to let users know their current level of health. In addition, the prototype is relevant to use in the community and also leads an effort to establish higher-quality health care for the public. The sensors implemented in the prototype show the project includes aspects of the new industrial revolution. Besides, the prototype also consists of Internet of Things (IoT) part that enables the prototype to send data to other applications that will support the prototype to be competitive on the market. However, further development for the prototype will be considered in order to improve some aspects such as the functionality, cost and prototype design as well as fulfil the user needs. Overall, the prototype successfully came out with three functions including temperature detection, heart rate detection and range detector for ergonomics parts.

Acknowledgement

First and foremost, we are really grateful as we managed to complete our Capstone project within the time given. This project cannot be completed without effort and cooperation from our group members, Elizabeth Tee Cheng Hui, Michael Benggang Martin, Mohamad Zulfahmi bin Borhan and Nor Eskandar bin Sofian.

Besides, the completion of the project would be impossible without the support and contribution of those whose names may not all be mentioned. However, we would like to set forth the people who have contributed the most in helping us to complete this project. In particular, we would like to express our sincerest gratitude to the Capstone project supervisor, Mr. Izam Bin Kamisian, for his guidance that helped us improve and the effort he had sacrificed in guiding us throughout the journey of completing this project.

Lastly, we are also indebted to School of Electrical Engineering, Universiti Teknologi Malaysia (UTM) for the financial support that they had provided for us to complete the project.

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Smart Wristband for COVID-19 Self-Quarantined User

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Abstract: The components of Health and Wellbeing involve establishing higher-quality health care for the public including those who are affected by COVID-19 pandemic, elderly and disable people. A survey was conducted by distributing the google form survey to 40 respondents. The outcome of the survey showed that their most concern is the need to monitor daily health condition. The potential users for this project is identified to be a person who is in quarantine to curb the spread of COVID-19 disease. There were cases where the hospitals were full of the quarantine patients for COVID-19. As the pandemic COVID-19 is the crisis issues now, this project proposed a Smart Wristband for self-quarantined patient. By implying the concept of Internet of Things (IoT), the data of health monitoring can be sent directly to the hospital or to the authorized personnel.

Keywords: COVID-19; wristband; NodeMCU; sensor; temperature

Introduction

The COVID-19 pandemic has swiftly changed the world in various sectors of profession. Many of individuals face difficulties to adapt and survive during this challenging period. Most of companies moved from office to home, all school closed, and our lives became a daily routine of wondering round the house.

Although everyone heard this echo throughout the quarantine, this project would really like to dedicate a paragraph to any or all the frontliners that keep working away in this insecure world as we all bunker in reception. It does take courage and determination to save lots of lives (be that through nursing patients in hospitals or shipping supplies worldwide). Smart wristband is a wristband-held device that can track the geolocation and monitor the body health condition of the quarantined patients while they are fighting the virus within the confines of their home. The device is powered by NodeMCU ESP8266 and has dual sensors that collect vital information about the patient's health.

High body temperature is among the main indicative of the development of the virus inside the body when the immune system start to launch its defensive reaction. The patients will not notice these changes immediately if they practise the conventional manual monitoring, for example taking body temperature using thermometer for every 4 or 6 hours. The smart wristband can be a solution as it enables continuous health monitoring by detecting the body temperature and heart rate value. The data also can be live streamed to the hospital or healthcare centre that responsible to monitor the patient.

Another important feature of COVID-19 patient monitoring is to track the user's location ensuring that it is always at home. The hospital will have access to a dashboard where they will be able to view all patients' health at a glance as well as a specific report that goes into the detailed location of each patient. Machine learning algorithms are also used in the application to predict the patient's temperature and heart rate in the future so that the hospital knows what to expect and what to prepare. In this case, hospitals can remotely monitor patients at home and care for them without having to spend large sums of money on human resources. A smart wristband can ensure that these patients are contained at home and are taken care of, helping the world in the fight with the COVID-19 virus.

Project Objective

The objective of this project is to continuously monitor the health condition of COVID-19 patient and to ensure that they isolate themselves at home during quarantine by tracking their geolocation. It is hoped that this project can help the authorities during COVD-19 crisis to reduce the risk of spreading the virus in communities.

Analysis of Survey

A survey regarding health and wellbeing considering improvements and monitoring of those who are affected by COVID-19 pandemic, elderly and disable people has been carried out using google form. The questionnaire is prepared according to the problems that the respondents faced, the suggested solutions and the experience for their health care during the pandemic. The survey is conducted for a total of 40 respondents and the data obtained are analysed based on STEEP criteria as listed in Table 1.

Table 1: STEEP analysis for this project

COMPONENT	DESCRIPTION
S - SOCIAL	Keep civilian safe from Covid-19
T - TECHNOLOGY	Incorporate IOT into medical sector
E - ECONOMY	Keep patient from using heavy machinery
E - ENVIRONMENT	Help doctor to monitor Covid-19 patient
P - POLITIC	Help government to control the spread of Pandemic Covid-19

From the response, it shows that most of the respondents are male which age between 18 to 25 years old. The results are shown in the pie chart of Figure 1 and Figure 2, respectively.

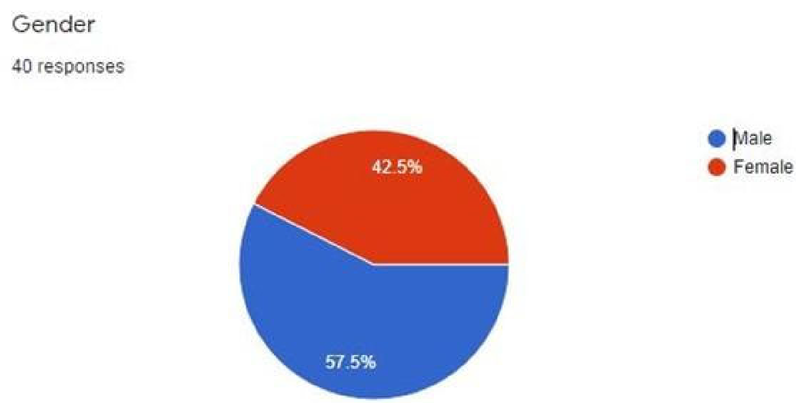

Figure 1: Pie chart of respondents' gender

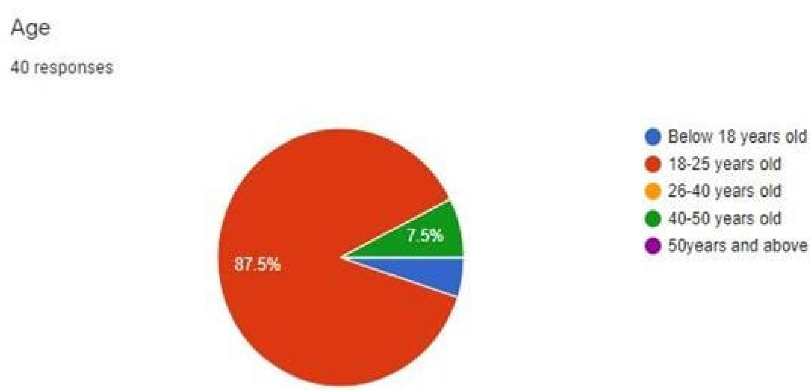

Figure 2: Pie chart of respondents' age

The pain points are identified based on the result in Figure 3 that shows 50 percent of the respondents rather go to the hospital and pay high charge and other 50 percent rather to buy equipment by themselves. This shows that they are unsure about it. In addition, there are 15 of the respondents rated for not comfortable with healthcare device nowadays. Therefore, this shows the pain points that they felt, and this would be the major aim for this capstone project.

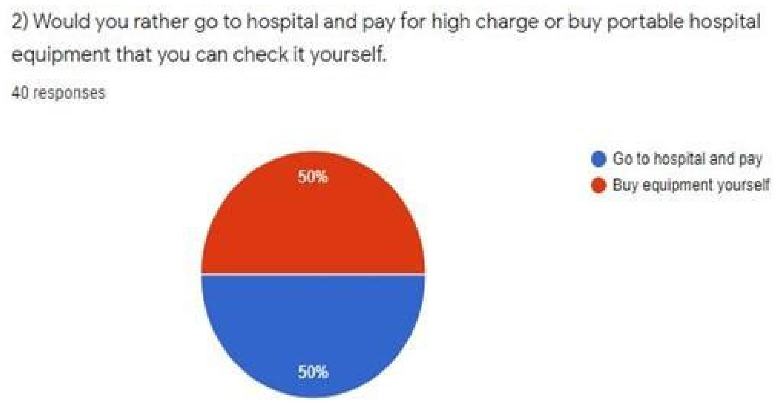

Figure 3: Result of questionnaire survey

The personification of a user is designed to give a better visualization about the user's needs. The personification includes the profile, the weak points, and the needs of the user. To design the character of the person, all the details about the habits and problems of the user's daily life were considered. The pain points and needs of the person have been tabulated in Table 2. The user's profiles are as the followings:

- A 20+ years old of male that are not smoking and has no history of asthma
- Very concern about his health condition
- Prefer to buy any health equipment to monitor his health condition

Table 2: Pain points and needs

PAIN POINT	NEEDS
No confident to buy commercialized health device	Prefer to do basic medical check-up without going to hospital
Have doubts about the accuracy of current health equipment	Like to monitor health at all times through a smartphone
Unsure of comfortability with current healthcare devices	Like a reduce cost and risks for medical treatment

Design Statement

Currently, hospitals and law enforces track covid-19 patients using a pink wristband. However, patients unfortunately have been known to hide their wrists band and not comply to self-isolation orders. Hence, a smarter solution is demanded.

Methodology

The hand sketching of initial idea to address the identified problem is illustrated in Figure 4 and the developed idea is shown in Figure 5. Based on these, the 3D modelling for the device has been developed as shown in Figure 6 (front-view) and Figure 7 (rear-view).

The device features will include the followings:

1. This device is expected to have a long operational hour (up to 3 weeks' operational time)
2. This device is not meant to be switched off by the user. It is expected to be worn by the user at all times. So, no switching circuitry is needed.
3. This device is expected to deliver a real-time information to the monitoring devices.

Figure 4: Initial conceptual sketch

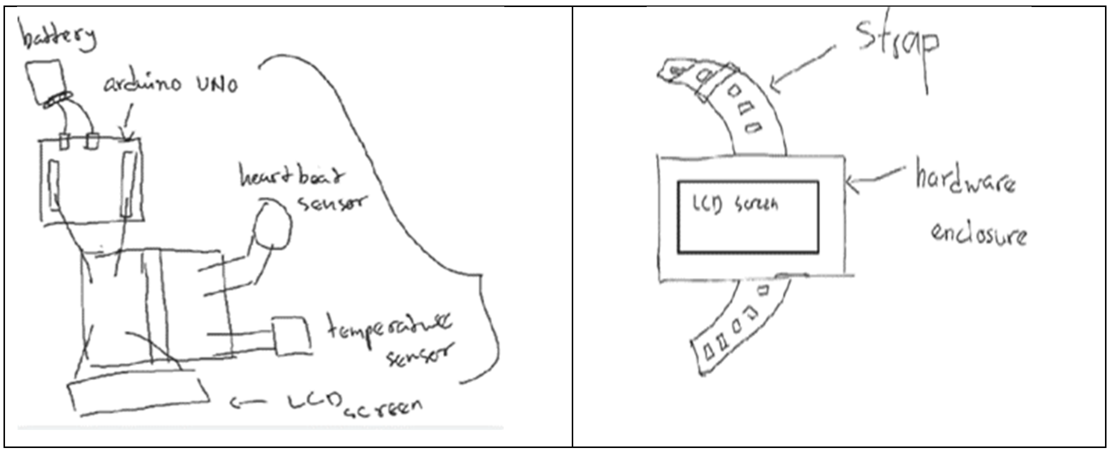

Figure 5: Development of the conceptual sketch

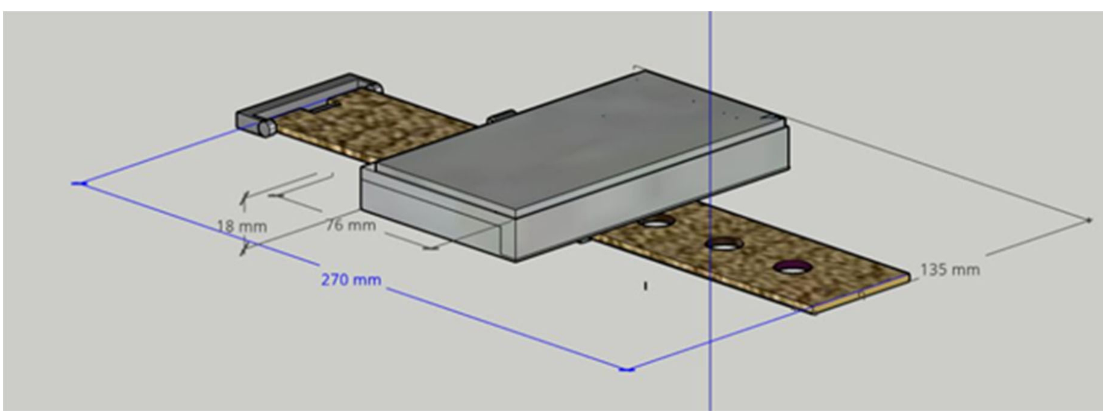

Figure 6: 3D modelling front-view of the prototype

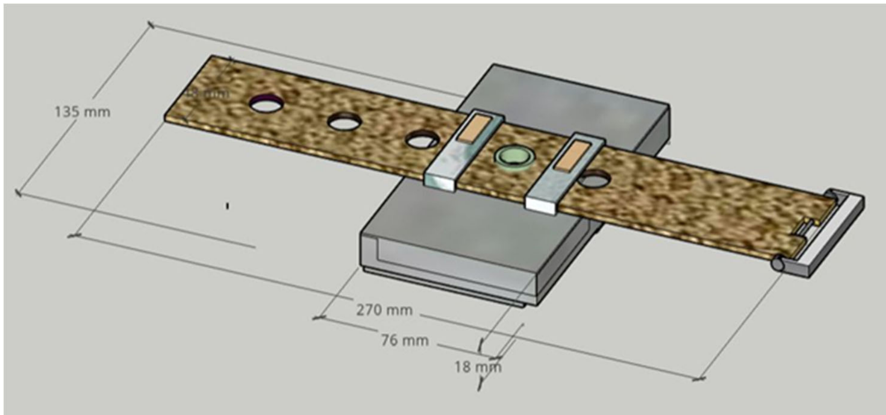

Figure 7: 3D modelling rear-view of the prototype

Based on this device's features, the circuitry for the device's prototype is constructed as in Figure 8. For the prototype, a strip board is used. Figure 9 shows the strip board schematics for the prototype.

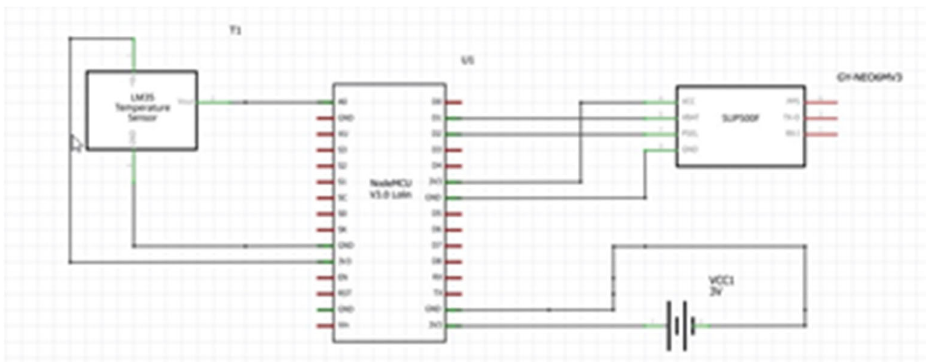

Figure 8: Schematic diagram of the microcontroller with dual sensors

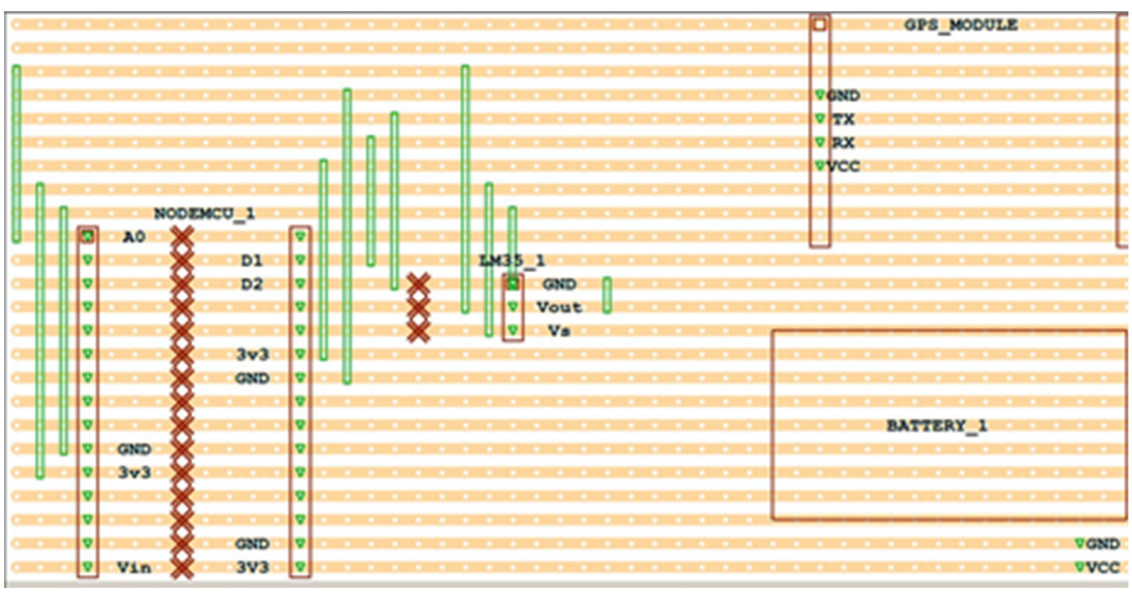

Figure 9: Schematic of the strip board with the microcontroller and sensors

As the product is wearable, the physical characteristics is very important. The product must be designed to be as comfortable and as reliable as it would. The prototype's physical specifications are listed in Table 3.

Table 3: Product physical specification

SIZE OF 3D PRINTED CASING	
Material	Polylactic Acid Filament (PLA-f)
Length	13.7 cm
Width	7.8 cm
Height	3.8 cm
Thickness of wall	4 mm
Strap Specification	
Material	Polyester (any other fabric or other material that have tensile strength are recommended)
Width	4.6 cm (maximum)
Length	27 cm (recommended)
Thickness	4 mm (maximum)
Strip Board Design	
Width (insulated nodes)	6.4 cm (24 nodes)
Length (connected nodes)	12.5 cm (48 nodes)

The size might look big, but this prototype is designed to be as small as possible. It should have 1/3 of the original size because PCB is used instead of stripboard. PCB would use less space. However, the implementation is not feasible due to limitation of the university laboratory access during pandemic. Another alternative is that the whole system can be implemented in ASIC (application specific integration circuit) instead of using microcontroller, but it requires loner time and higher cost to fabricate.

The casing material for the main module (hardware enclosure) is made of polylactic acid filament (PLA-F), which is derived from vegetables mostly corn starch. It is a thermoplastic aliphatic polyester that is mostly used in 3D printing for low-cost production. In large scale production, however, the industry can use other manufacturing methods and/or material as well. For the hand strap, polyester is used as the material. It is a piece of fabric that was cut up from an old decommissioned slack pants. Industry or individuals can use other materials as well, for example, they can use straw, rubber (like in most wristwatches) or straw/cotton (like most clothing nowadays). The strap is attached to the casing of the device through an opening (another name: flanges) that protrudes out at the bottom of the casing. Then, it is locked in place by hooking it with another flange (circular tube) with a hole that was cut out from the centre of the length of the strap as can be seen from the Figure 10.

As shown in Figure 11, the circuit and the components are soldered together. A regular soldering iron and tin wire are used to solder the circuit. Figure 12 shows the rear-view of the soldered strip board. Then, the circuit is assembled with the 3D casing to form the prototype as shown in Figure 13.

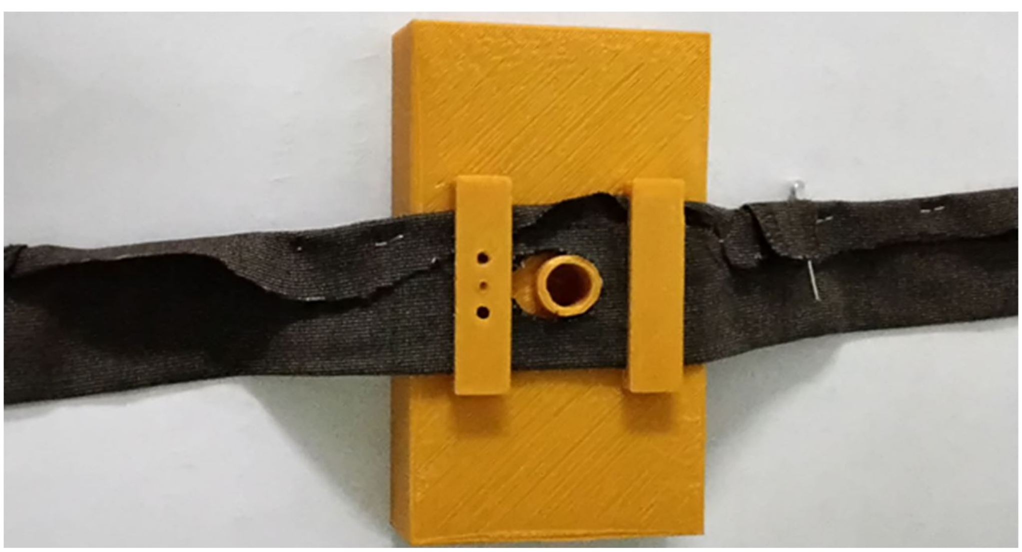

Figure 10: The 3D casing and the hand strap

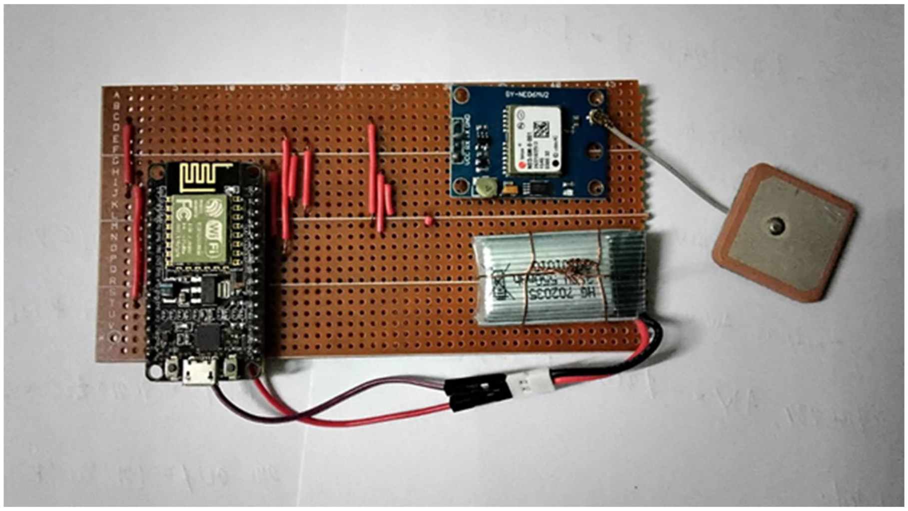

Figure 11: Soldered circuit on the strip board

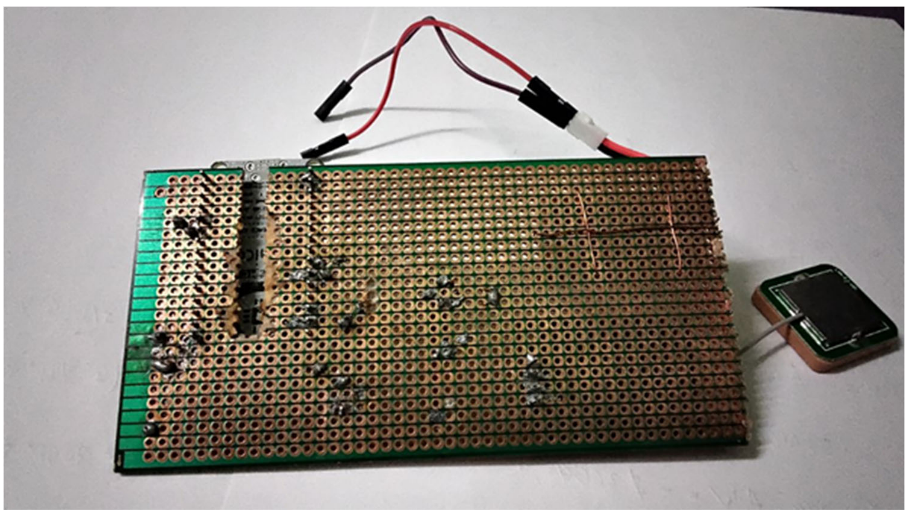

Figure 12: Rear-view of the soldered circuit on the strip board

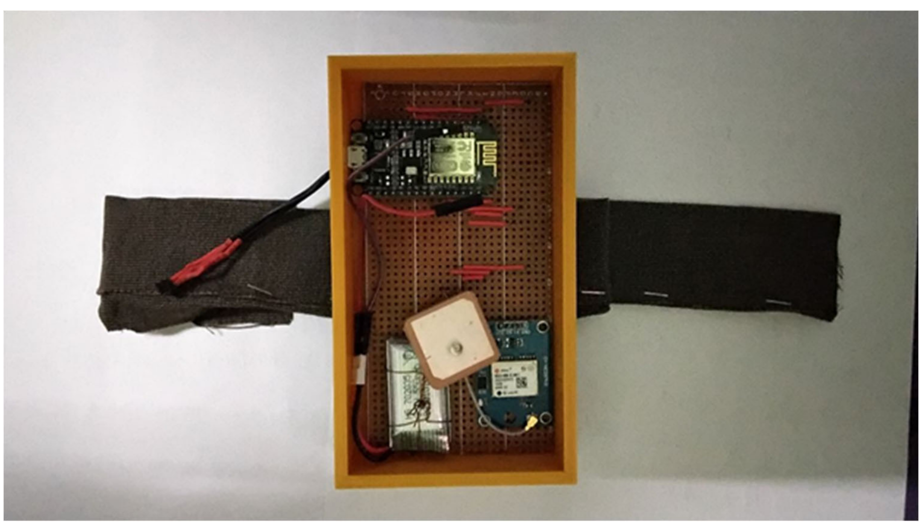

Figure 13: The complete figure of the prototype

For the electronic hardware, NodeMCU is chosen as the microcontroller because it already has a Wi-Fi-module that is built-in and embedded in the microcontroller. This save cost and space. For the temperature sensor, the LM35 temperature sensor is used. LM35 sensor is suitable for measuring the body temperature when is in contact with human skin. Otherwise, it will show the temperature of the surrounding air. The pin connection of NodeMCU is shown in Table 4.

Table 4: Pin connection for electronics components

NodeMCU	COMPONENTS	
GND	Ground	LM 35 Temperature Sensor
3V3	Vs	
A0	Vout	
D1	VCC	GY-NEO5MV3
D2	RX	
3V3	TX	
GND	GND	
3V3	VCC	3.8 V Li-Po Battery
GND	GND	

Product Development

The electronic components such as temperature sensor, GPS module, NODEMCU esp8266, breadboard and battery have been placed inside the 3D printed casing as shown in Figure 14.

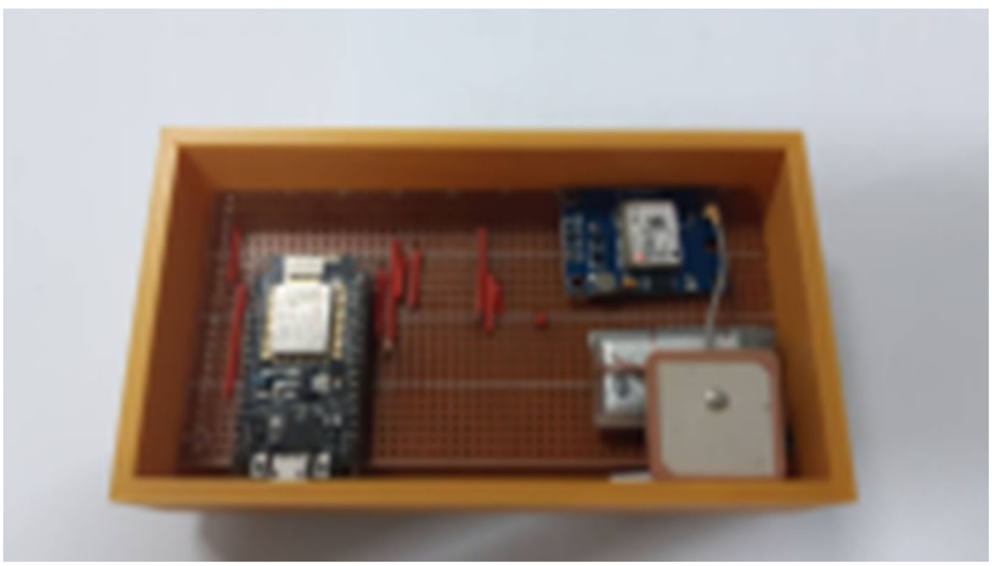

Figure 14: 3D printed casing for the electronic hardware

Once the microcontroller NODEMCU esp8266 is powered by the battery, it will collect the data from the sensors and the GPS module will detect the location. Then, these data are sent to the mobile application module. The mobile app receives the data directly from Blynk Cloud. The data can be displayed to the user's mobile phone and also to the monitoring personnel through a computer connected to the internet.

Discussion

As demonstrated in Figure 15, the user's temperature and location are displayed by the Blynk application on the phone. So, the data can be monitored frequently as it is sent every minute. The heart pulse sensor is considered to be integrated in the prototype but since the NODEMCU has only one analog input available, the additional feature of the prototype cannot be done at this point. However, the relevant authorities can monitor the temperature and the location of the patient, so the device still can help to provide information of the suspected covid-19 patient that under self-quarantine order.

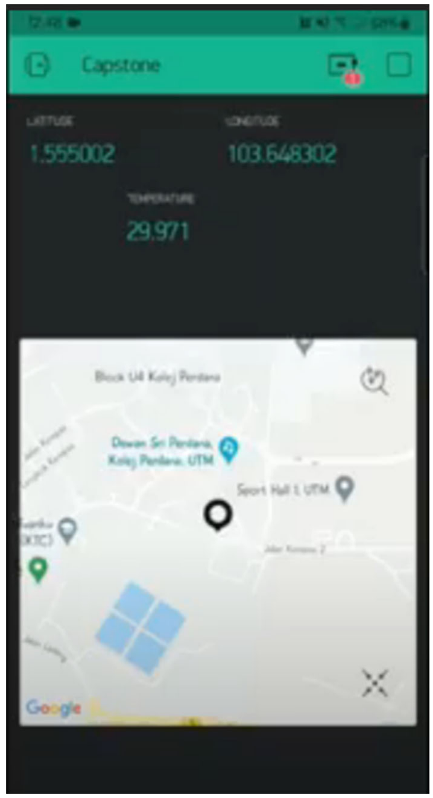

Figure 15: The application display screen for the data

Conclusion

The first step taken to realise this project is to conduct a survey to find out the target user and to find out their problems with existing solutions. With the collected data, ideas were brainstormed, and literature search was done to come up with a solution that fulfils STEEP analysis to predict future trends and impact to the surrounding in said areas. All parts of the prototype worked as intended and this included both the software parts and the hardware parts. The software used for the prototype include Arduino IDE, Blynk cloud, and Microsoft Excel, while the hardware used are the LM35 temperature sensor, NodeMCU ESP8266, and the GY-NEO6MV2 GPS Module.

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Smart Sleep Monitor

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Abstract: This project aims to create a wristband that can measure the user's heart rate, oxygen blood level, movement with surrounding temperature and humidity, have a sleep tracking feature and an algorithm that determines the user sleep quality. In this project, NodeMCU ESP8266 is used as the microcontroller for the hardware. The WIFI feature on the microcontroller is used as the wireless connection between hardware and software application. Blynk application is the platform used to display all the readings from the sensors and provides past readings for each sensor for up to 30 hours.

Keywords: Sleep monitor; MAX30100; ESP8266; DHT22; MPU6050; Blynk app

Introduction

Based on the survey done through questionnaire, respondents' main problem is not having enough sleep, curious about their sleeping patterns and curious body vitals during sleeping. The product is designed with various sensors and features such as heart rate and oximeter sensor, surrounding temperature and humidity sensor, gyro meter and accelerometer sensor, sleep duration tracker feature, and sleep rating feature to overcome their needs.

Due to the ever-challenging environment, everyone ranging from teenagers to adults, are studying and working hard around the clock. Without enough sleep, our bodies can feel exhausted and our brains have poor memory and performance. Therefore, having a sleep tracking feature user is informed of their sleeping duration and which helps in obtaining the optimum amount of sleep. Furthermore, the sleep rating feature motivates the user to continually improving their sleeping patterns.

The sleep rating features an algorithm that incorporates reading from each sensor to determine the user's sleep quality. This algorithm is unique to this project since it makes the data output from each sensor more functional and has dual purposes, instead of just displaying values.

The total budget used on the project is RM241.88, which is relatively affordable compare to other products in the market that provides a similar experience. The closest product that could compare with our project is called *realme Watch,* which is priced at RM299.00. However, this product is more of a fitness-focused oriented hence the sleep monitoring feature is basic.

In terms of the environmental aspect, the hardware used a relatively small amount of materials since making it as compact as possible was part of the design process. Due all of the data displayed digitally and the Blynk app can keep history data, users will no longer need to log their data on papers hence lessening the usage of paper and simultaneously saving the environment.

Description Analysis

For conceiving week, we developed a questionnaire based on our topic which was the Health and Wellbeing. After some brief discussion, 10 questions were developed through Google Form and the questionnaire were distributed through WhatsApp application. We stop collecting data after 5 days of distribution. The data that we obtain from the google form can be referred to appendix A. The question are as follows:

1. Range of age? (20-39, 40-59, 60 and above)
2. Did you have any medical history? (No, yes: please state)
3. How often do you get medical checkup? (Once a month, once every 6 months, once a year, when needed)
4. How do you keep healthy? (exercise, diet, eat healthy, other)
5. How often do you exercise? (everyday, a few times a week, a few times a month, a few times a year, none)
6. What prevents you from exercising? (lack of motivation, health conditions, no time, no fitness equipment, other)
7. How do you rate your health (1-5?)
8. Do you think that you have enough sleep? (yes, no, maybe)
9. What prevents you from getting enough sleep? (work, tv shows/movies, games, other)
10. Do you wish to have a smart device that keep you healthy? (yes, no, maybe)
11. What would like the device to monitor? (sleep track, heart rate monitor, exercise duration track, calories burned track, thermometer)

Next, to gather more data we need to interview 5 persons to help design the device. The question that was asked during the interview were almost same as above. All the interview we done in google meet and recorded. After that, make a personification based on the google form's data and make a problem statement.

After design statement from the personification are made, we came out with different design for our prototype. The designs were:

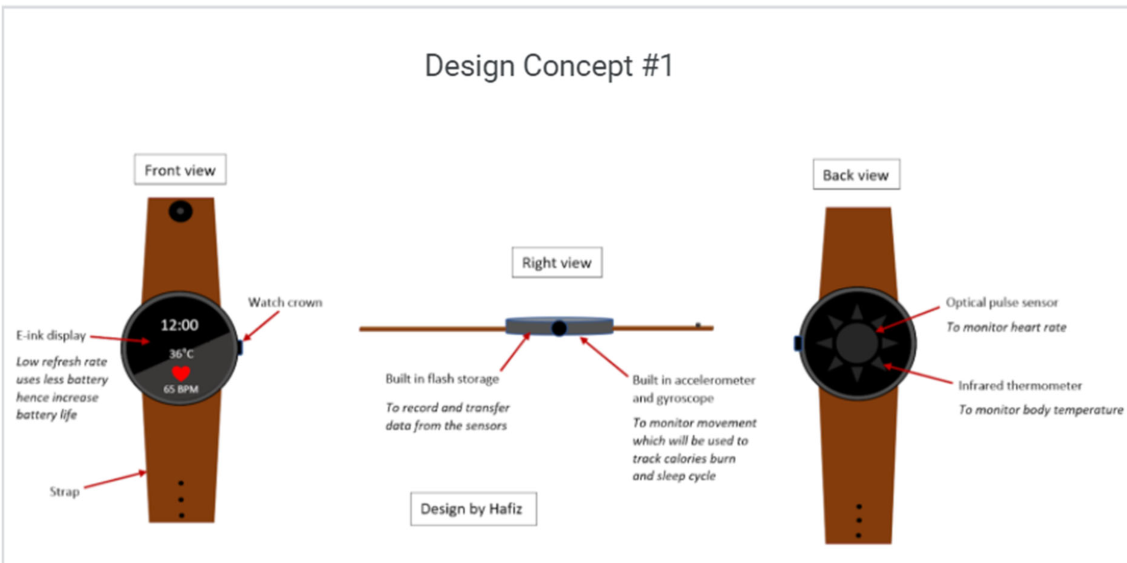


Figure 1: Design by M1

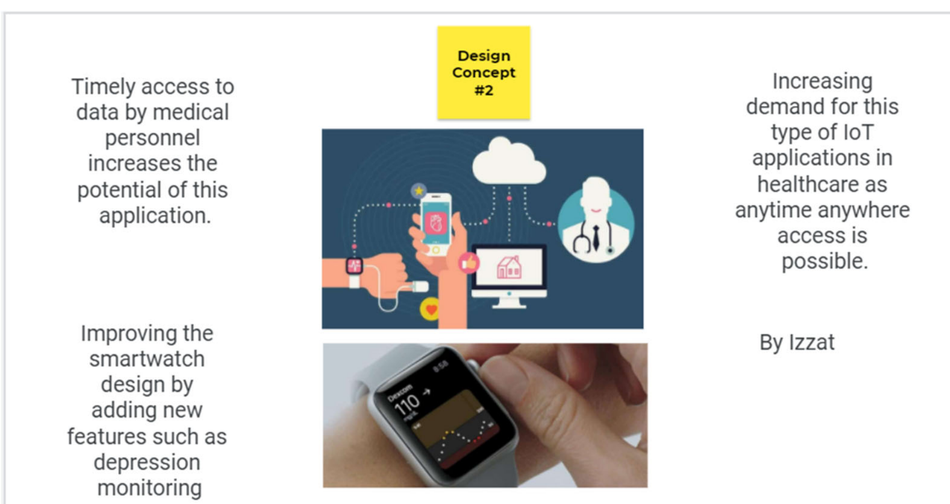


Figure 2: Design by M3

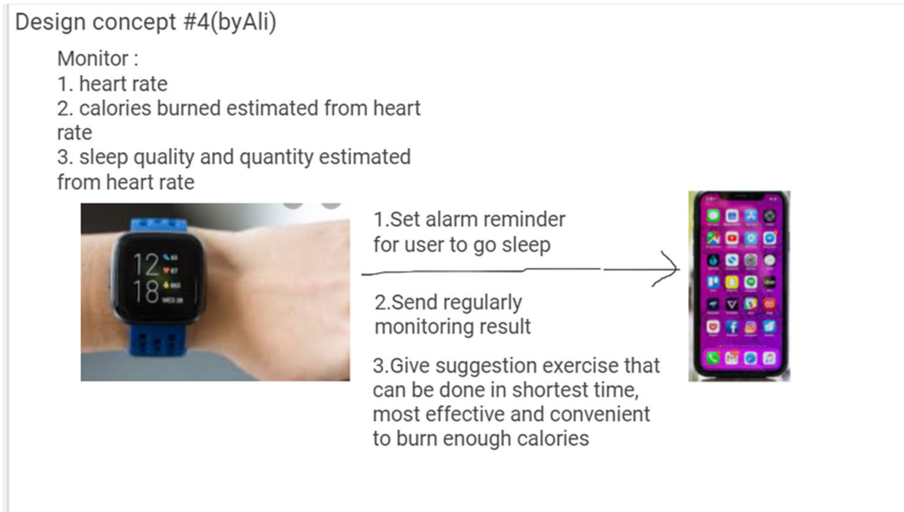


Figure 3: Design by M4

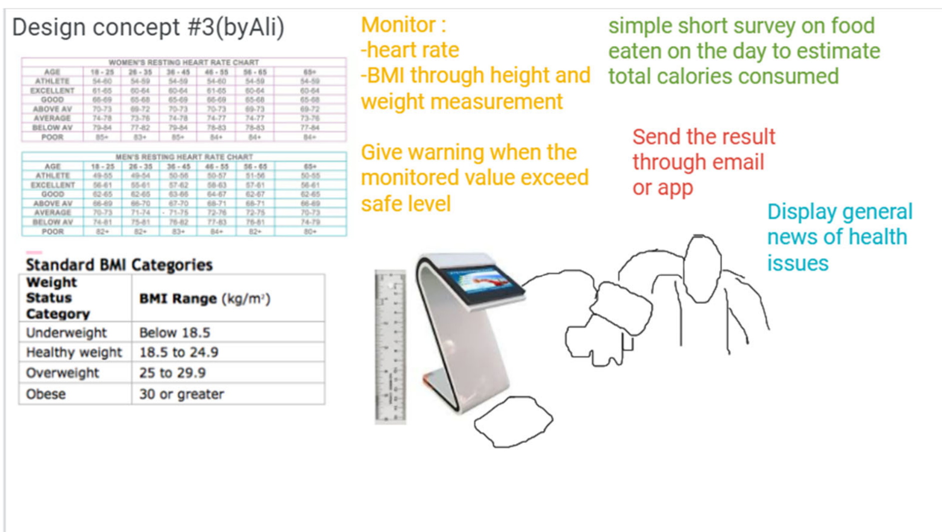


Figure 4: Design by M4

Design Statement

After a brief discussion about the design of the product, we come up with a design statement. The design statement is:

1) A smart wearable device that use can bring and wear during their sleep
2) Device that can monitor essential characteristic to have a good sleep
3) Device that can show to users the quality of their sleep through phone apps

Next, we agree on a design that suit our design statement. Unfortunately, our design was rejected by the panel during the prototype presentation due to discomfort.

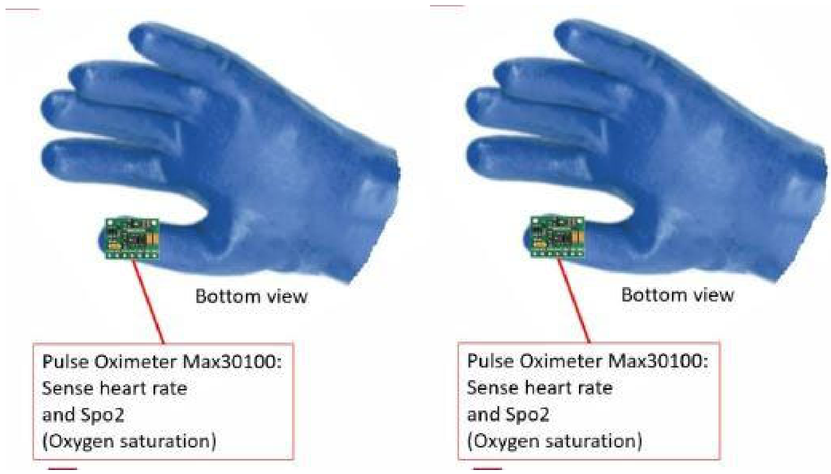


Figure 5: The early design

Finally, after discussion with our facilitator and our team member, we decided on a new device without using the gloves but still wearable, portable and comfortable during our sleep. The estimated design prototype is shown below.

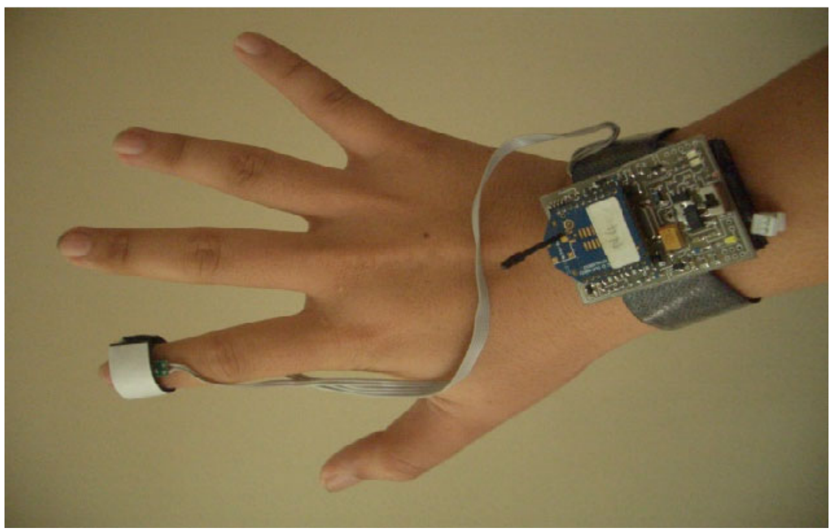


Figure 6: Final Estimated Design

STEEP analysis of the developed structure:

<u>Social</u>
- Many young Malaysians are becoming tech-savvy and are interested in using smart wearable devices.
- Smart wearable devices that focus on health and wellbeing may help in decreasing obesity rates in Malaysia.

<u>Technology</u>
- Rapid technology advancement may cause the product to be out of date.
- Low research and development due to budget constraints.

<u>Economical</u>
- Covid-19 pandemic has caused many unemployment and may result to lower sales.
- Sales of smart wearable devices will contribute to sales tax (SST).

<u>Ecology</u>
- Increasing in waste as consumers keeps upgrading to new smart devices.
- Electronics recycling facilities are not common.

<u>Political</u>
- Lifestyle income tax relief up to RM2500 on electronics by Malaysian government.
- Chinese gadgets have lower prices due to their cheap labor policies

Methodology

Hardware

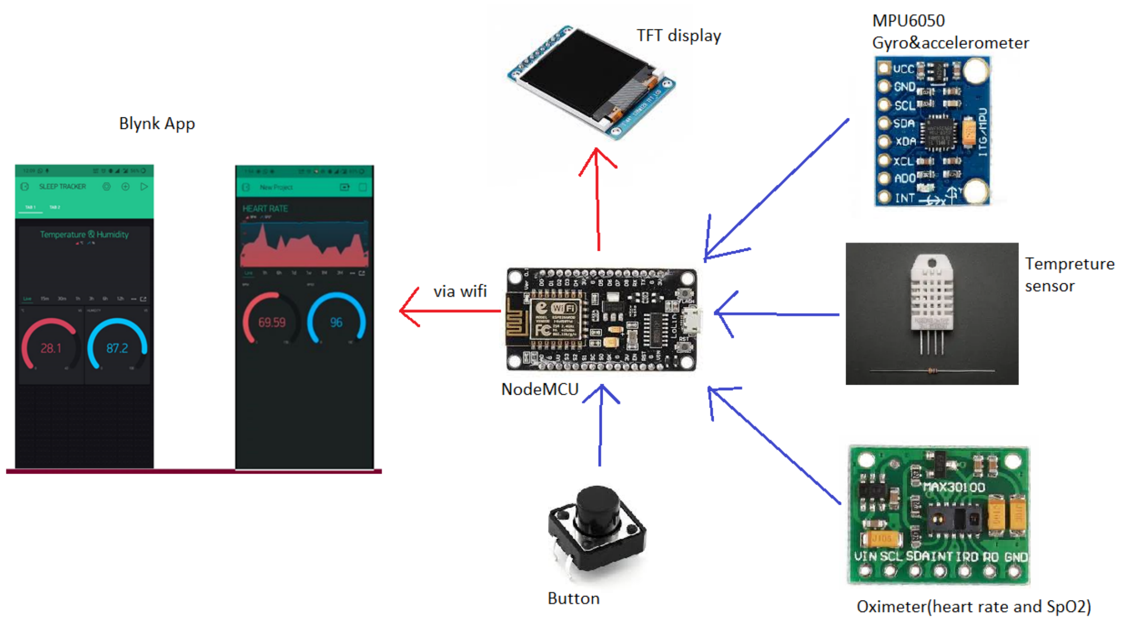


Figure 7: Block Diagram

Figure 7 shows the block diagram of our product. The microcontroller used is NodeMCU which have a built-in Wi-Fi module. The NodeMCU read the push button, the sensors' reading and control TFT display to display the user profile setting, time sleep and wake, and the sleep quality rating. The NodeMCU also sends sensor reading to the Blynk App for monitoring purposes, which is useful for parents and doctors.

Table 1: The pins connection of electronic components

NodeMCU Pin Number	**Component Pin**
D0	Push Button
D1	SCL
D2	SDA
D3	RES(TFT)
D4	DC(TFT)
D5	SCL(TFT)
D6	data(DHT22)
D7	SDA(TFT)
D8	CS(TFT)

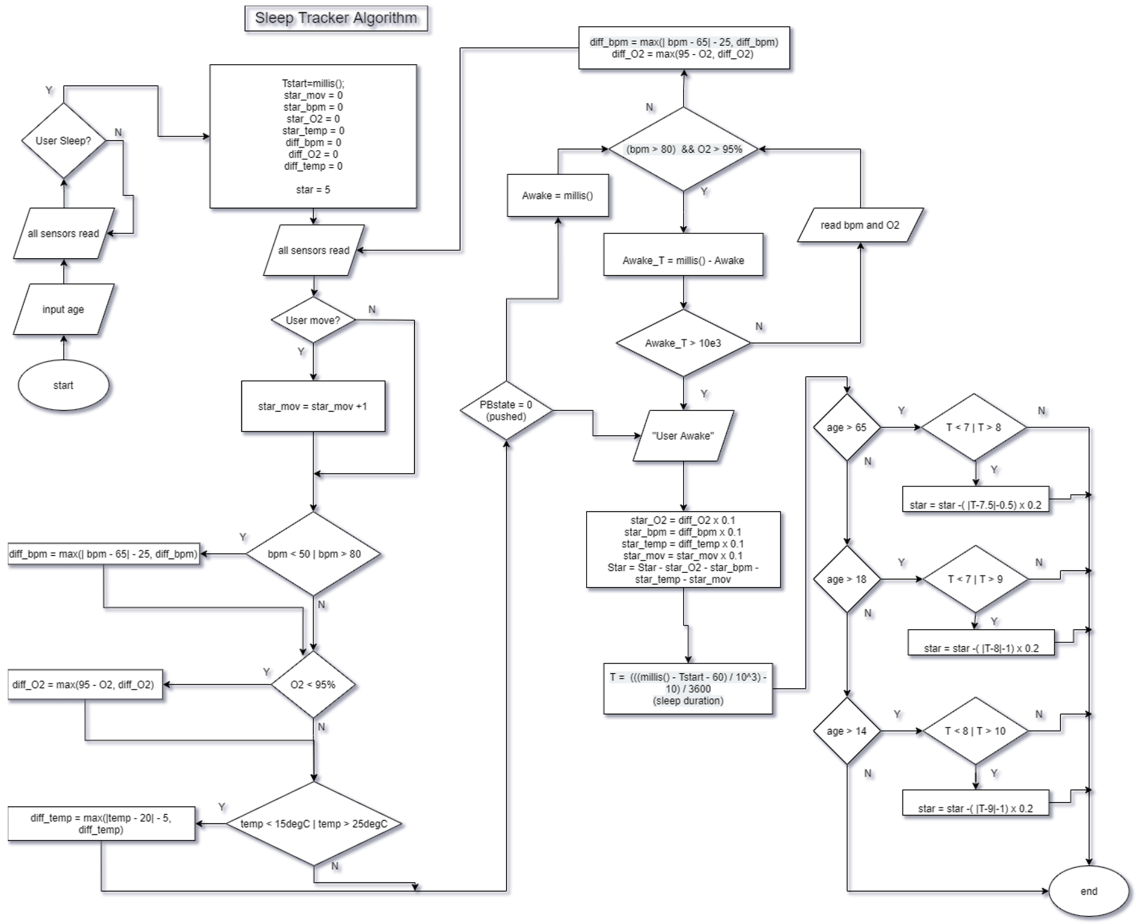


Figure 8: Flow chart

Figure 8 shows the flow chart of our algorithm. When the program start, user can key in his or her age. Then, NodeMCU read the sensors and check if user sleep. If not then, the program will reread sensors and check back user sleep or not. If yes then, the program starts declaring all parameters and start continuously reads sensors and calculates the offset of sensors' reading from the recommended boundary. After reading sensors, if button is pushed, the program assumes the user has awake. If not, it will check if the heart rate is higher than 80bpm and SpO2 higher than 95% which are the normal range of awake person for 10s. If the statement is false before reaching 10s, it will just go back to the usual reading sensors process and calculate offset. If the statement corrects for 10s meaning that the heart rate and SpO2 are in the standard range of awake persons for 10s, the program automatically assumes user has awake. When program assume user has awake, it will start deducting the rating which is initially full marks of 5 star with the offset value. Then, it computes the duration of the sleep and deducts the star again based on the user's age.

Software

A Blynk app is developed to monitor the sleep quality of the user. The widgets that are included in the user interface of Blynk are, gauges; to show the value of the data recorded from the hardware, and the supercharts; to display the real time data results. In the interface, there are two tabs which consist of the same widgets. The first tab is for the temperature and humidity data while the second tab is for the heart rate and oxygen saturation sensors. The superchart is used to display live and historical data that is streaming from the sensors. It also has a feature where it can be changed the mode between time ranges and live. All widget is linked through an Arduino IDE coding to connect with the Blynk and using the same hotspot connection.

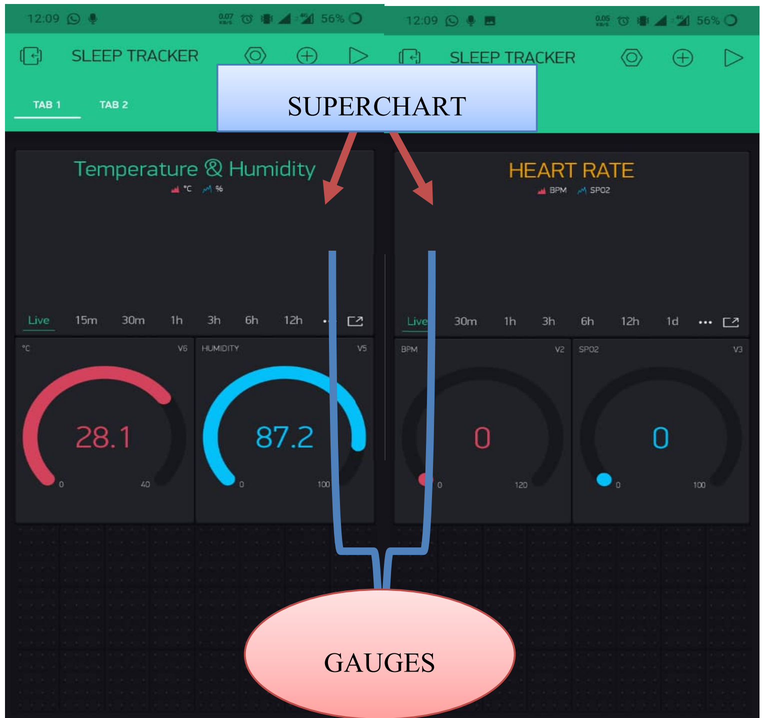


Figure 9: The tabs on the Blynk interface.

Product Development

Table 2 shows the Gantt Chart of our product development while Table 5.2 shows the billing of materials. Starting on week 5, after we decided on what product we will do we list the materials needed in the BOM list. The next week, we purchased all the materials and components. Then, on week 7 we draw all components' circuit connections by referring online tutorial and datasheet. On week 7 and 8, we researched the sleep tracker algorithm, make the flowchart and discuss with supervisor. On week 8 also, we assemble components on breadboard, coding and debug the program code of every sensor and component. On week 9, we fabricated a PCB board, complete and troubleshot the hardware. For week 10, we develop the software and user interface using Blynk. Week 11, we code the backend program for communicating to Blynk via Wi-Fi on NodeMCU. On week 12, we merge all the components program code and Blynk code in the main program that follow the complete flowchart to test and finalize our product. Then on week 13, we prepare for the project presentation. In the final week, we do the documentation and report.

Table 2: Gantt chart of the project.

NO	TASK	WEEK									
		5	6	7	8	9	10	11	12	13	14
1	Create billing of materials										
2	Purchasing components										
4	Draw circuit connections										
5	Sleep tracker algorithm research										
6	Assemble component										
8	Coding for the sensors										
9	Testing Hardware										
10	Software development										
11	User interface										
12	Backend programming for software										
13	Finalize hardware and software										
14	Finalize Project Presentation										
15	Report and documentation										

Table 3: Billing of materials.

No	Component	Estimated Cost		Actual Cost
		Unit Price (RM)	Qty.	Purchased Price (RM)
1	GY-521 MPU6050 6DOF Accelerometer + Gyro	9.50	1	9.50
2	NodeMCU Lua V3 ESP8266 WIFI with CH340C	14.90	1	14.90
3	1.44-inch 128x128 TFT LCD Breakout - ST7735	21.70	1	21.70
4	Grove - Temperature & Humidity Sensor (DHT11)	6.50	1	6.50
5	PCB 10x15cm Single Side Copper Laminate Circuit Board	3.30	2	11.64
6	MAX30100 Heart Rate Pulse Sensor & Oximeter Module	18.40	1	18.40
7	LiPo Rechargeable Battery 3.7V 1300mAH	20.00	1	20.00
8	22022 PCB Connector Header (R/A) 2 Ways	0.10	1	0.10
9	BX-4112 Round Hole Breadboard	28.00	1	28.00
10	Micro USB Data Cable	19.00	1	19.00
11	Mini RTC DS3231	12.00	1	12.00
12	Capacitor 10uF	0.20	2	0.40
13	Capacitor 470uF	0.45	1	0.4
14	1x18650 Battery holder	1.80	1	1.80
15	Voltage regulator 3.3V	2.00	1	2.0
16	3.7V 11000mAh Li-ion Battery	9.15	1	9.15
17	Straight Female Header 1x0 ways	1.20	2	2.40
18	DHT22 Temperature and humidity sensor	20.00	1	20.0
19	Push on/off button	2.00	1	2.00
20	NEW365 DC to DC Converter 3.7V 5V to 3.3V Step Down Module 18650 Li-ion battery	4.82	2	15.64
21	PCB Paper Heat Toner Transfer A4 for DIY PCB Electronic Prototype	2.00	6	20.00
22	Book strap 3in1	2.10	1	2.10
23	1A Lipo charger module with protection	4.00	1	4.00
24	Straight pin header 1x2 ways	0.05	4	0.20
			Total (RM)	241.88

Early Development

Figure 10 shows the early development of the product where we assemble components on breadboard for coding. Then, we do debug and modify the incorrect part of the circuit design. Some modification made is the circuit connection of TFT display due to misunderstanding of the communication protocol which we thought is I2C but SPI. Then, because of the same I2C address shared by RTC module and MPU6050 module, we had to change the MPU6050 address by connecting the AD0 pin to 3v3. Moreover, push-button was added to set the user profile on the board itself.

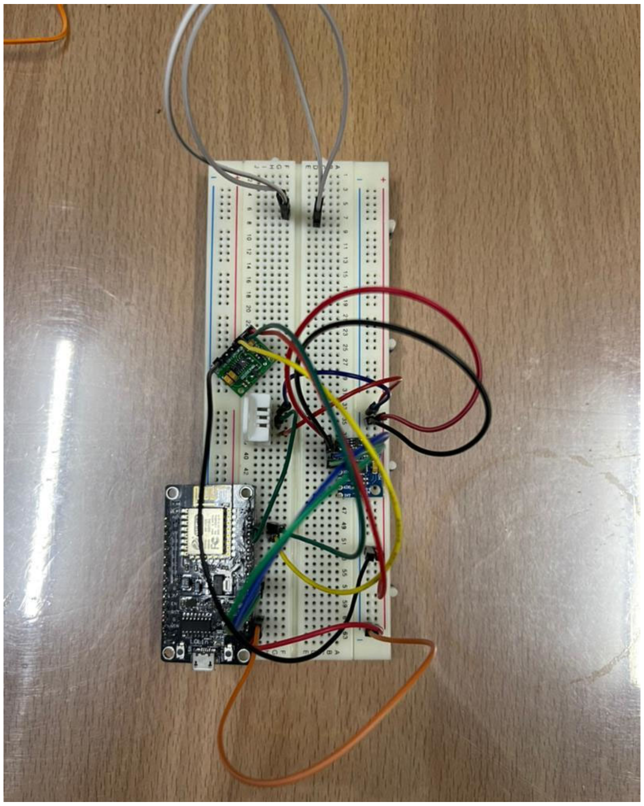


Figure 10: Early development using breadboard.

Middle Development

Figure 11 to 15 shows all the process of fabricating the PCB done on Lab PCB at P04. First is laminating process where we insert the heat transfer paper pasted on the PCB into the laminate machine. Second, the staff of the lab did etch process using acid. Next, we used the equipment to drill the holes and cut the PCB board's border edge.

Figure 16 shows the circuit schematic. Figure 17 shows our PCB design and Figure 18 shows the fabricated PCB board. Fortunately, the troubleshooting process went smoothly and no technical problem with the board.

Figure 11: Laminating PCB

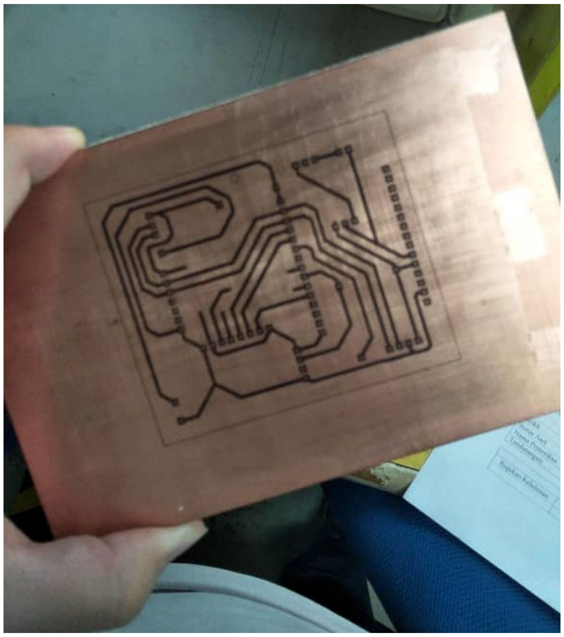


Figure 12: PCB after laminating process done

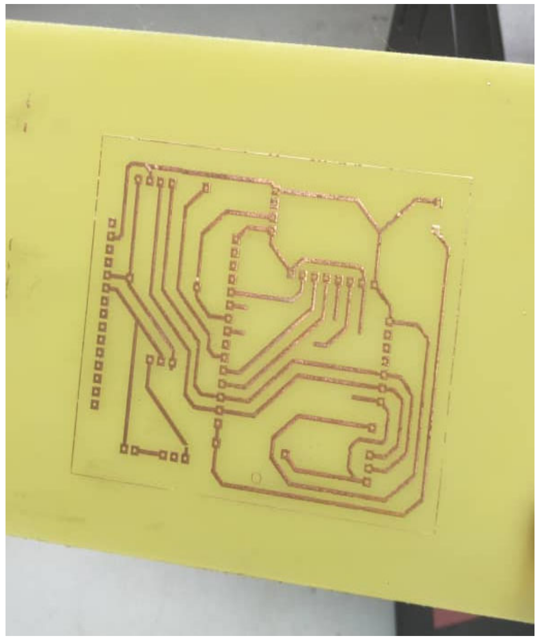


Figure 13: PCB after etching process done

Figure 14: Drilling PCB process

Figure 15: Cutting PCB process

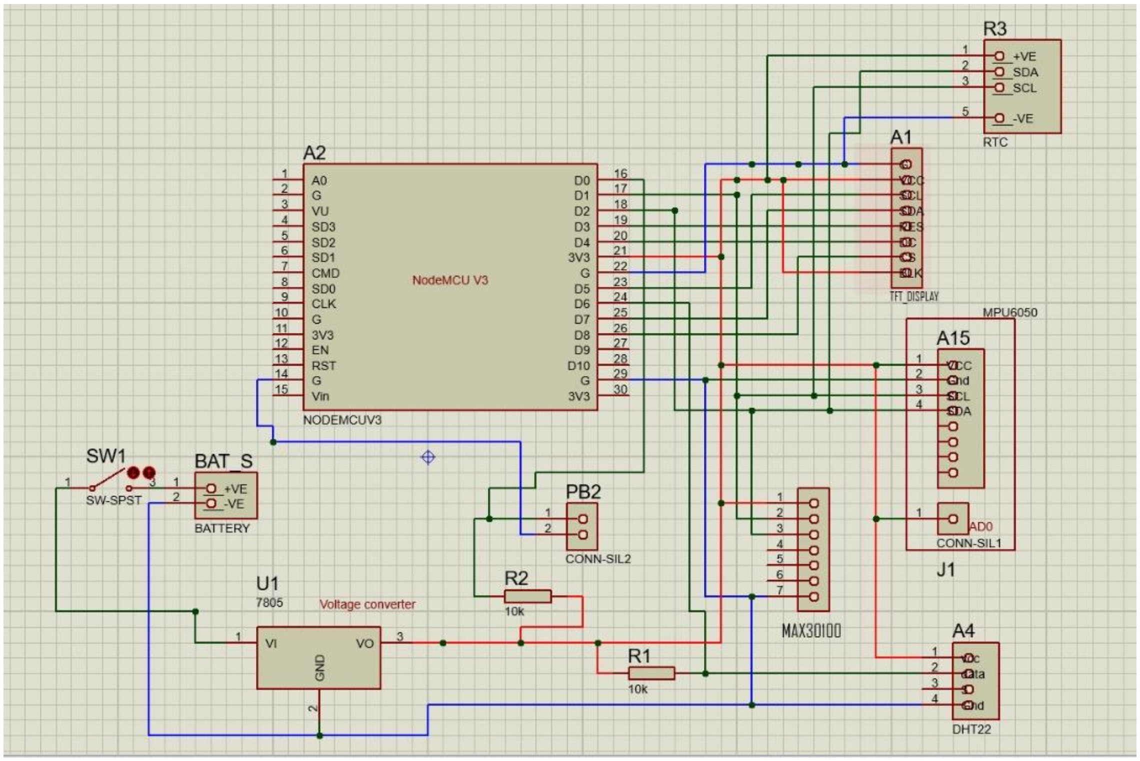
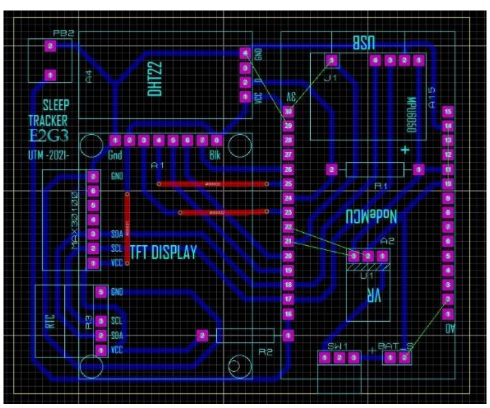


Figure 16: Schematic



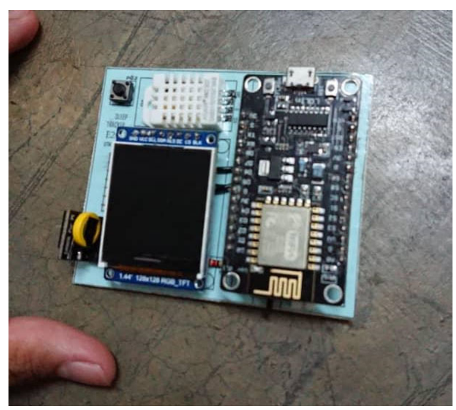


Figure 19 shows the developed user interface where user can monitor the graph of his heart rate and SpO2, surrounding temperature and humidity.

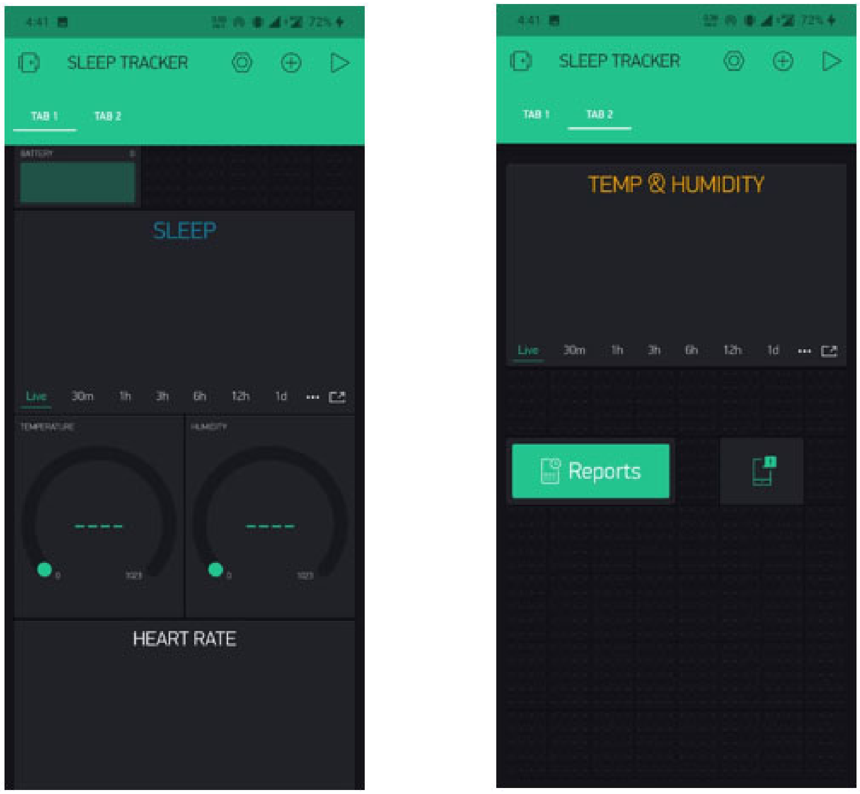


Figure 19: User interface

Late development

Figure 20 shows the top view of the complete product and figure 21 shows the side view. We used book strap to bind the product to hand wrist. A thin 3.7v 1300mAH LiPo Battery is used as power supply and placed right below the board. Figure 22 shows the oximeter sensor that is placed on the finger. Figure 23 shows the adapter used to charge the battery. During this stage, we completed the main program code that run the expected algorithm to set user profile, monitor sensor reading during sleep, and give rating of the sleep quality based on the comparison between sensors reading and recommended status. There was some challenge when debugging the main program. When the program run and enter a long loop in the code script, it automatically reset due to Watchdog timer called WDT. So, we had to include yield function to stop the WDT. Figure 24 shows the functioning user interface when running the main program.

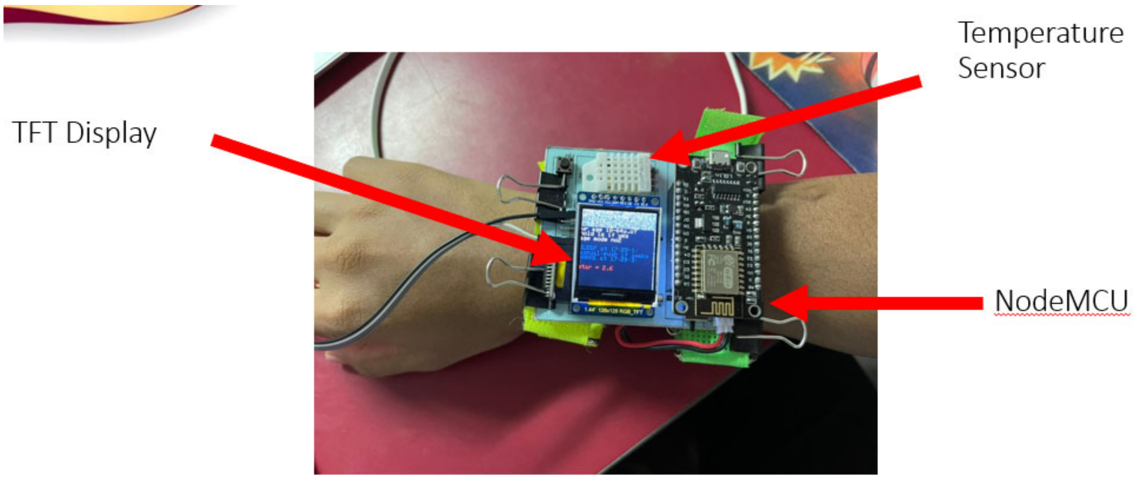


Figure 20: Complete product (top view)

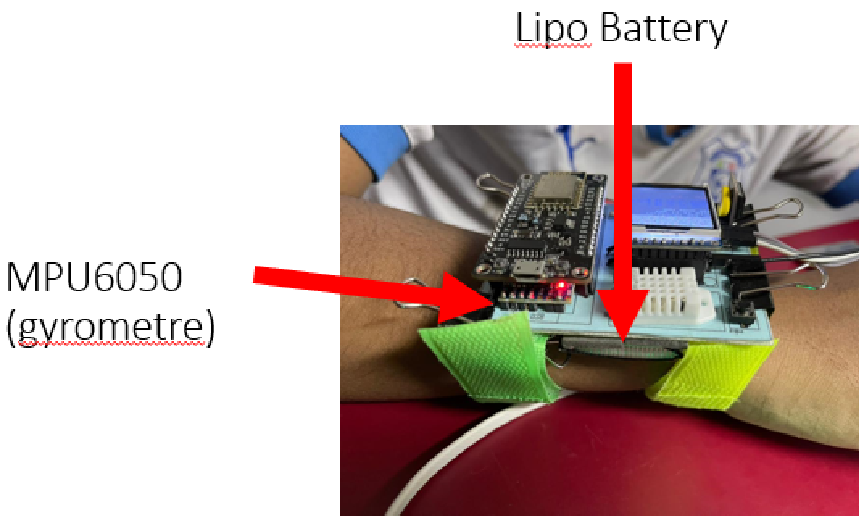


Figure 21 Complete product (side view)

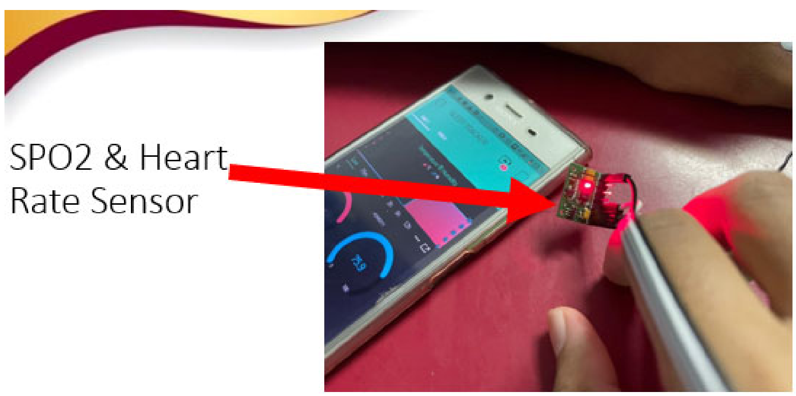


Figure 22: Oximeter sensor

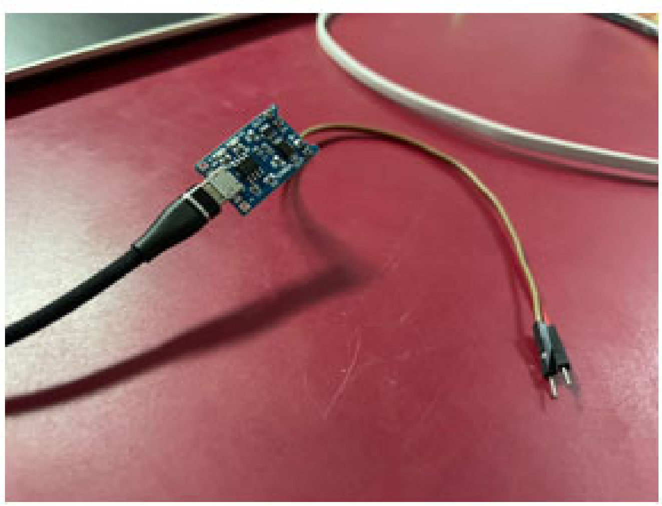


Figure 23: Battery charger

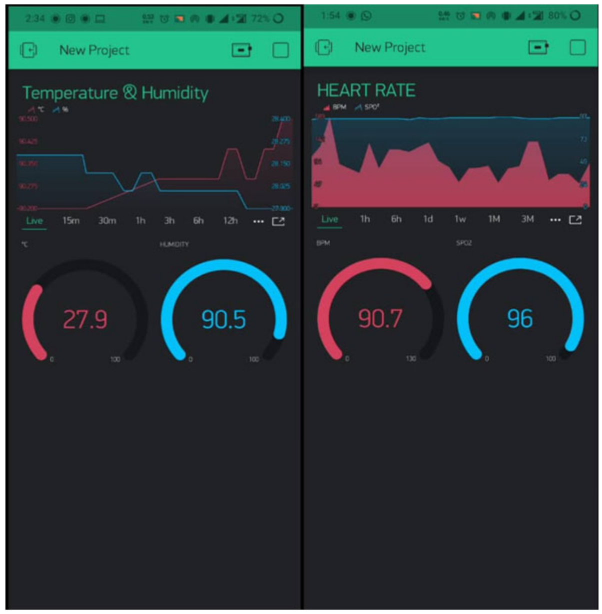


Figure 24: Functional user interface

Discussion

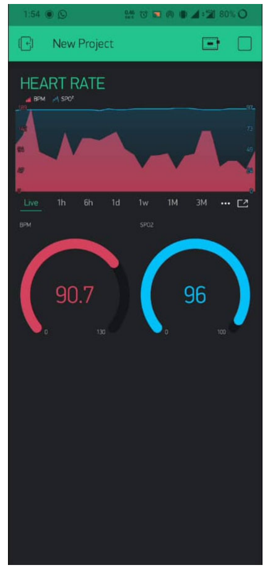
From the working operations, the sleep quality monitor is fully functioning. With some adjustments to be made on the features of the hardware and also the software, this product would be a great product to be promoted to the market. The Blynk app is used to monitor the sleep as it can show live and past data recorded from the sensor within the time range. Blynk is a paid to access app where the widgets require energy to be used. This energy can be obtained by purchasing it through the app.

As for getting a good sleep quality, some factors are included in the Blynk app which are the temperature and humidity in the room, heart rate and the oxygen saturation in the blood. The humidity is a vital parameter for human thermal comfort and also the sleep. If the temperature is too high above the ambient temperature and humidity, it will disrupt the sleep as this can wake us up immediately. The superchart in the humidity and temperature tab will provide the user about when the temperature will spike and the humidity decreases.

Besides, the other factors of getting a good sleep quality are the heart rate and the blood oxygen level. The blood oxygen level is needed to be monitored as this can diagnose sleep apnea if the SPO_2 in the blood is decreased below 90% because at this level, it can lead to fatal conditions for the human body. Moreover, sleep deprivation can lead to high blood pressure. People who tend to stay awake for 16-hours a day can exert energy, which brings them to unable to sleep due to anxiety or excitement. When sleeping, the heart rate is lower than regular heart rate, which is between 50 and 60 beats per minute. This feature of the Blynk's superchart allows the user to diagnose the pattern of his heartbeat when he is sleeping.

Lastly, one of the advantages of using this device is that it can provide us with our sleep pattern. As shown in Figure 25, the superchart in the Blynk helps the user observe any irregularities in their sleep to make a first diagnosis before they make an appointment with the doctor. However, from an end user's feedback, the app still needs enhancement and addition in the features to display the necessary actions to be taken by the user.

(a)



(b)

Figure 25 The results of recorded sensors. (a) Temperature and humidity (b) Heart rate which is consists of Heartbeat and SPO_2

Conclusion

In conclusion, the prototype worked successfully, although not achieving all of the targeted features due to time constraints and several other challenges. This includes one of the most critical features that provides summary and feedback to the user regarding their sleep. Further improvements are needed to make the prototype competitive in the market which include making the prototype more compact and comfortable to wear on the wrist. Next, by switching the software application platform from the Blynk app to MIT App Inventor, it could provide more functionalities in the software side.

Acknowledgment

The project was supported by the School of Electrical Engineering, Universiti Teknologi Malaysia. The authors would also like to convey our utmost appreciation and gratitude to the facilitator, Dr Usman Ullah Sheikh, who has sacrificed part of his precious time and given some of the brilliant ideas to the team in achieving the goal of the capstone project. A special thanks to Dr Musa bin Mohd Mokji, Capstone coordinator, who has prepared the Google Classroom and guidelines for us to do our project in this pandemic. In addition, we are thankful to our panels for their comments and advice towards improving our project.

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Smart Temperature Alert and Radar System

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Abstract: RFID tag is a piece of technology that is widely used in our society especially among the employees. It is easy to use and reliable at the same time making it very applicable in many sectors. The focus of this project is to maximize the usage of it and increase its potential by combining other technology in order to create a system that benefits the society. In the midst of pandemic, our project, the Smart Temperature Alert and Radar System also known as STARS Complex, is able to scan and show the body temperature, record the employees' temperature, and can alert authorities to provide them with reliable and necessary data. This system is a better version of the common equipment, normal infrared temperature scanner used in the society right now. It comes with features such as cloud storage and alert system at a low cost of production which will be a great help in reducing or stopping the transmission of the Covid-19 virus.

Keywords: Covid-19; Temperature; Alert; Radar; Smart System

Introduction

As the situation right now, the on-going pandemic has affected the lives of people, throughout the whole country. What is Covid-19? According to World Health Organization, WHO COVID-19 is a disease caused by a new strain of coronavirus. 'CO' stands for corona, 'VI' for virus, and 'D' for disease. Formerly, this disease was referred to as '2019 novel coronavirus' or '2019-nCoV'. Despite the dire situation, certain essential companies have to still carry-on work despite the pandemic. Thus, a strict standard operating procedure, SOP needs to be followed by the employees to avoid the spread of the virus even further. There are some preventive measurements that need to be obligated by the community. The first one is social distancing which is about 1 meter. After that, the people were asked to wash hands frequently especially after going out of the house as the virus might be transmitted through physical contact. Lastly, the people were asked to wear a mask in crowded place to prevent transmission of virus through the air.

One of the most common symptoms for this virus is fever. This shows that the body temperature is an especially important role in our society in reducing or stopping the transmission of the virus. There are much importance of body temperature checking during the on-going pandemic. First of all, to give confidence to employees in the working environment as the presence of the virus can lead to the decrease in performance or worse, panic among the colleagues. Then, it can aid in detecting one of the symptoms for Covid-19 which is the fever mentioned before and lastly, an early treatment and action can be taken when the suspected person is identified.

Conceive

We are given a task to design a system for health and wellbeing and the system should be able to cater the needs of end user. Hence, a study was carried out to identify the need of the end user and their opinion on our planned system. All needs and opinions of the end user have been listed out. Figure 1 shows the respondent's age and mostly are age 20 to 30 since our target market are workers or student.

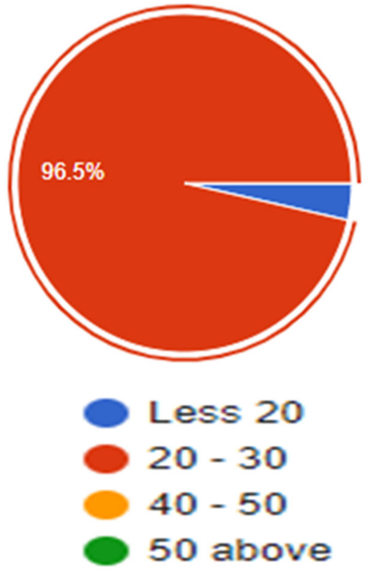

Figure 1: Gantt chart based on a respondent age.

Next question that we asked was their colour zone area in order to make sure that our survey cater all the people that in need. Figure 2 show the respondent colour zone and from that we know that our survey caters people from various places.

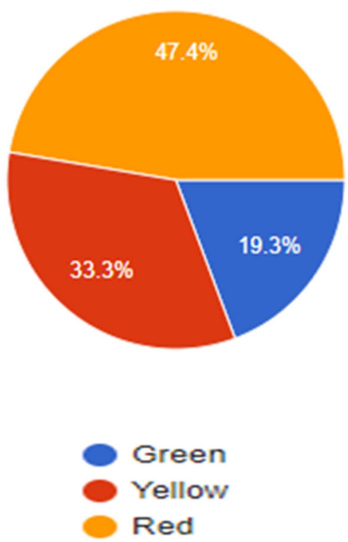

Figure 2: Gantt chart based on a respondent colour zone area.

Lastly, the most important part is that we also asked their opinion on our planned project so that we able to fulfil their need and whether our project will be impactful or not. Figure 3 show that the respondent agree that our project will be impactful to society.

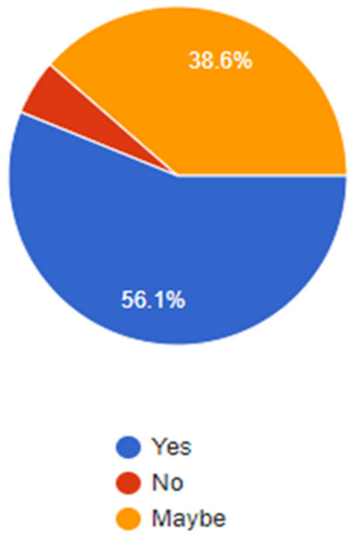

Figure 3: Gantt chart based on a respondent opinion of project impact.

Based on the problem given, we come out with a planned project and a google form was created and distribute to the target end user. The form also creates in order to collect their opinion and their face problem regarding Covid-19. All the opinion and problem of the end user was collected and analyse and finally we decide to develop a STARS complex system in order to cater the need of the end users.

A STEEP analysis together with an effective discussion among the team members and our facilitator were carried out to describe and explain the concept of this project. STEEP analysis has been listed below which shows the result of the discussion.

Table 1: STEEP of STARS Complex System

S-Social	• Ease user with development of advanced technology.
T-Technology	• Implementation of Internet of Thing (IOT).
E-Economy	• Offer product with multiple features at an affordable price
E-Ecological	• The product does not contribute to any pollution.
P-Politic	• Compliances with Ministry of Health.

Objective

The focus of this project is the group of employees with RFID tags that are present at small companies which lead to these objectives:

i. To create a reasonably priced device that would be able to aid smaller companies to create a controllable working environment.
ii. To alert when a person temperature is high, ensuring immediate action to be taken.
iii. To have data stored through cloud to reduce mishaps such as bugs and loss of data.

Design Statement

Nowadays, the number of active cases keeps on increasing day by day. Multiple efforts have been done by the Ministry of Health of Malaysia in reducing the transmission of the virus such as the restricting the movement of the people. The suspected people or people with symptoms were taken immediately for treatments and to prevent the virus from affecting other people. The common equipment or system used in the society right now is the normal infrared temperature which only provides the temperature reading and it also cannot hold any data for tracking and alerting purposes.

The development of this project, STARS Complex is able to solve the problems mentioned above. This project is able to scan and show the body temperature, record the employees' temperature, and can alert authorities to provide them with reliable and necessary data. All of these features were implemented in a single project to provide a better solution for the usage of society.

Methodology

This project includes proper flowchart to clearly view how the idea of the project came from and the project progression, two software used to code the program functions and to connect microcontroller to database, and hardware components to develop the device prototype.

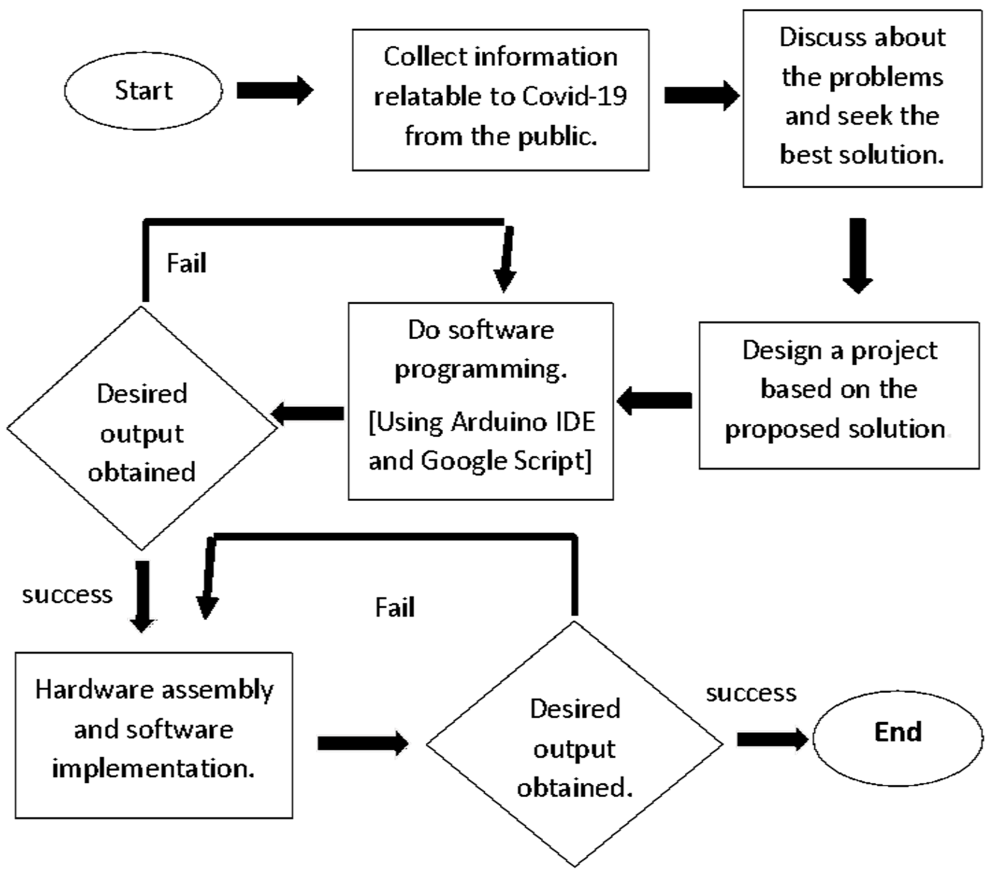

Figure 4: Process flow chart

No	Tasks	Start Week	End Week	Capstone Week 5	6	7	8	9	10	11	12	13	14	Remark upon Task Completion
1	Develope conceptual prototype	5	5	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	update user profile
2	Create checklist for items	6	6	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	
3	coding	7	10	☐	☐	☑	☑	☑	☑	☐	☐	☐	☐	
4	Set up database	10	10	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	
5	prepare prototype	11	12	☐	☐	☐	☐	☐	☐	☑	☑	☐	☐	
6	Test prototype	12	12	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	
7	troubleshooting & improvements	13	14	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	
8	presentation of product	14	14	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	

Figure 5: Gantt chart

Software

There were two programs used to achieve the project objectives. Arduino IDE program was used to write the coding of the project's functions. Which includes the temperature scanner, ID Card identifier, distance measurement, and connecting microcontroller to the internet. Another objective that was directly connected to the software is the database setup. For this google scripts editor was used. Google scripts is an application development platform that uses modern JavaScript. By connecting the microcontroller to google scripts and programming the google scripts editor to send all information to a sheet, the output temperature and ID were displayed in a google sheet that logs this information and the time and date they were taken.

Hardware

As a main component, the newly developed ESP32 chip was chosen as the microcontroller to the product. mainly due to the fact that it combines Wi-Fi and Bluetooth wireless capabilities and because of its cheap price. Also, it was chosen because it can be associated with NodeMCU firmware which can easily help develop an application for the product. This point was considered as part of the future plan for development.

An ultrasonic sensor was implemented to the product as an upgrade in order to control the distance at which distance the temperature reading is taken. In other words, the implementation of the ultrasonic sensor helps with the project's idea of the user not being too close to the product as to contaminate it and not too far to produce an inaccurate reading. As part of the future development plan, a further upgrade to the ultrasonic sensor is the implementation of a set of formulas that produce different readings based on the distance between the user and the device. Below is a full list of components procured for this project.

Table2: List of Components

DONE	Resistor 330 ohm	×	3
DONE	Resistor 4.75k ohm	×	2
DONE	Breadboard (generic)	×	3
DONE	Ultrasonic Sensor - HC-SR04 (Generic)	×	1
DONE	Buzzer	×	1
DONE	LED (generic)	×	2
DONE	MFRC-522	×	1
DONE	MLX90614	×	1
DONE	Jumper wires (generic)	×	1
DONE	Espressif ESP32-WROOM-32D Development Board	×	1

Table 3: Bill of material

COMPONENTS	QUANTITY	PRICE (RM)
Resistor 330 ohm	3	0.50
Resistor 4.75k ohm	2	0.50
Breadboard (generic)	3	14.17
Ultrasonic Sensor - HC-SR04 (Generic)	1	3.99
Buzzer	1	0.60
LED (generic)	2	0.80
MFRC-522	1	7.20
MLX90614	1	34.90
Jumper wires (generic)	1	5.17
Espressif ESP32-WROOM-32D Development Board	1	34.50
Tape 36 mm	1	2.90
Cutter knife	1	1.90
TOTAL		**RM 107.13**

Product Development

The COVID STARS Complex Project was developed at a few stages. The first stage of the project was to acquire the components needed to build the hardware. Due to the Movement control order, there were difficulties in obtaining hardware as many shops have closed down or are not operating. Therefore, this resulted us in purchasing the components through online platforms such as Shopee or Lazada. We made a list of items required, had it checked with our lecturer, and then proceeded. The items took around 1 week to be received. Having the items at hand, we had to test each component to ensure it was all working well. However, during testing, one of the problems faced was that the buzzer was not working. Therefore, we had to order a new buzzer again to help ensure we have all the required components for our project.

Next stage of our project was software development for the STARS Complex. We started first with the base code, whereby we used Arduino IDE to help program the ESP32 Board. The software consisted of various factors such as the wires that were assigned to each pin of the board, the code to tune the sound of the buzzer by adjusting its frequency, the code for the reading the temperature and the code for displaying data. Furthermore, our system had the ability to alert authorities. This was done by storing data and displaying them in real – time to ensure that temperature can be constantly monitored. If abnormalities were detected, there would also be a black and white proof as the data would be stored and shown on a google sheet. Moreover, we had to do adjustment to link the google sheet with the Arduino. This was done by using the google script and adjusting certain functions to enable syncing between Arduino and Google Cloud. Once done, the script had to be saved as developer option and then linked to the google sheet before syncing with the Arduino.

As soon as the software progressed well without any error, the next and final stage was to burn the software to the hardware. Here, we also faced difficulties as the first time we tried to burn, the hardware could not accept the software. After analysis, it was realized that the USB cable being used only had read capabilities. Therefore, we had to get another cable with read and write capability to ensure a hassle – free burning of the software. Once that was done, the project was set to undergo a trial run. We were happy with the results, as it was working as expected. However, there were still some bugs and error that had to be resolved, such as the data transfer process and alarm feature of the project.

At the end of the day, we managed to successfully complete the STARS Complex Project and it was working at full capability. To wrap things up, our project consisted of three stages, in which each stage was completed with proper timing and management that help led our project to be accomplished well.

The software team in this phase focused on the research and the study of the codes that can be used in the system. The codes will be used to realize the features implemented in the system. Various websites, blogs, and articles were used in the study such as the Arduino Project Hub and GitHub. Tutorials videos from YouTube also were used in the study. Each feature will require different functions and operations in the coding; thus, a clear understanding was needed in the development of the codes for the system. The software team also built a suggested circuit for the system which also will be used as the reference for the codes. The figure below shows some of the examples of the codes and the suggested circuit.

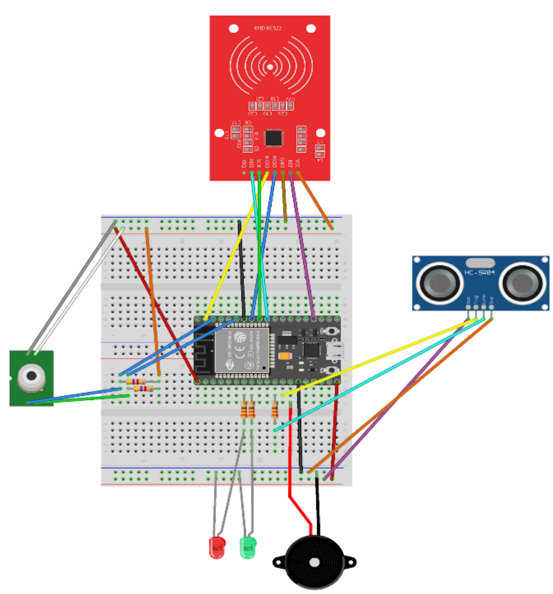

Figure 6: Prototype circuit

Figure 7: Final protoype

Discussion on the developed product

One of the key components that was used in this project is ESP32 microcontroller chips. Arduino is a microcontroller device that is quite popular among students and professionals as it has many benefits. Besides the cheap price of the component, the Arduino software also suitable in various kinds of other operation system such as Windows and Linux. However, external components are needed for the Arduino to use another feature like Wi-Fi and Bluetooth. For this project, using Wi-Fi is really important as the objective of the project is to be able to store the data in the cloud. So ESP32 microcontroller is used in our project as it also embedded with Bluetooth, Bluetooth Low Energy (BLE) and Wi-Fi. Coding for the ESP32 can be written in Micropython or C++ but as our project does not require some complex function, using Arduino IDE which it is an open-source Arduino software and already good enough to be used in the project.

During progress on the software, there are some difficulties we have to face. One of the problems is the google script and Arduino cannot be link together. Thus, the solution was by deleting the cache. Then try to reset the device files and finally made a new sheet. Other than that, when implementing the software to the hardware, the buzzer did not work. Hence to fix it, the pin assignment in the software was changed. After that, to used features like Radio Frequency Identification (RFID) and sensor, some external libraries have to be downloaded from GitHub. Next problem is the temperature sensor records inaccurate value of body temperature. As our main objective is to provide the authority with a reliable data, the thermal sensor must be as accurate as possible. The temperature reading for a normal body temperature would be between 36.5–37.5 °C. However, our device record body temperature much lower than the normal value as can be seen in Figure 5 below. For solution, the sensor was set to take three reading and then the values will be averaged to obtain much reliable result.

STARS COVID19 Saved to Drive
File Edit View Insert Format Data Tools Add-ons Help Last edit was seconds ago

fx 23/01/2021 00:34

	A	B	C
1	date	ID	TEMPERATURE
2	22/01/2021 05:1	199102234167	18.55
3	22/01/2021 05:2	199102234167	27.25
4	22/01/2021 05:2	199102234167	21.69
5	22/01/2021 05:2	199102234167	30.41
6	22/01/2021 05:2	199102234167	21.85
7	22/01/2021 05:2	199102234167	29.87
8	22/01/2021 05:2	199102234167	30.55
9	22/01/2021 05:2	4203240129	24.17
10	22/01/2021 05:2	4203240129	25.51
11	22/01/2021 05:3	4203240129	74.25
12	22/01/2021 05:3	4203240129	25.99
13	22/01/2021 05:3	4203240129	25.19
14	22/01/2021 05:3	4203240129	25.35
15	23/01/2021 00:0	199102234167	30.75
16	23/01/2021 00:0	199102234167	32.02
17	23/01/2021 00:0	199102234167	28.45
18	23/01/2021 00:1	199102234167	34.62
19	23/01/2021 00:1	199102234167	31.66
20	23/01/2021 00:3	199102234167	33.09
21	23/01/2021 00:3	199102234167	35.47

Figure 8: Inaccurate body temperature reading.

Troubleshooting not only done on the software part, but the hardware also has few problems that need to be fix. Firstly, the RFID and temperature sensor were not connected properly to the ESP32 chip. Without a proper connection, the components cannot function at all. So, we have to make sure the components was soldered carefully before try to connect them to the board. Then, problem also happened when some of pins on the ESP32 chip were not working. From some researched done, we found that there are many types of ESP32 like ESP32 Things, ESP320 and ESP32 N1. Thus, the one we bought is ESP32 Devkit-c, so the pin layout will be different which it has its own reference data sheet which shown as in Figure 6.

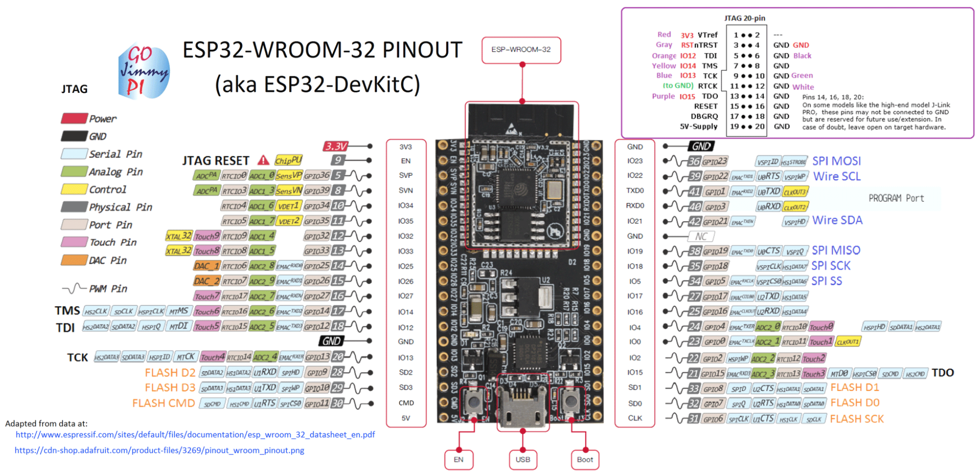

Figure 9: ESP32 DevkitC pin layout

For further work progress, we would like to add more features to our device like a face recognition and implement an app that will be linked to the device. Data of the temperature alone cannot provide enough reliable information for the authority. Other symptoms also have to be taken into measure as well. So, in future, person with a high temperature above than normal range, will not only able to enter any premises but they also have to answer few questions on the apps regarding to other symptoms. With that, much more reliable data could be collected and makes it easier for the authority to analyse the person based on their recorded history. The face recognition is also a good feature to be added to the device as Covid-19 may spread from a people touch. Hence the risk of cross infection could be reduced.

Conclusion

In conclusion, only the device prototype was developed and tested for every single test by considering the real uses of the device. However, the results of this project meet the specification of the real implementation of this system and need some adjustment in the future to satisfy the user requirement. The key goal of this project is to develop a stable temperature alert and radar system that able to detect distance of people and device and also able to alert the authorities if the temperature is above 37.5 Celsius. An opportunity is given during the system's development phase to locate the necessary sensors, program the microcontroller and interface the system's inputs and outputs. Besides, additional information is obtained regarding the use of applications.

This STARS complex system has given a great impact on learning and practical knowledge in hardware and software work. It also allows students the chance to develop a product based on end user needs and problems. In the nutshell, the main objectives of this system have been successfully achieved. This STARS complex system able to provides a system that able to alert the authorities hence able to provide a controllable working or study environment for the workers and students, respectively.

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