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Fingertip Heartbeat Monitor

Muhammad Afiq Zakaria[1], Amirul Syafiq Sadun[1]*

[1]Department of Electrical Engineering, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, 84600 Pagoh, Johor, MALAYSIA

*Corresponding Author Designation

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Abstract: In preventing cardiac-related disorders, heart rate monitoring is very important. Early diagnosis of heart attacks will lead to death. This problem is caused by the lack of instruments to quickly detect cardiac problems and the warning of anxiety patients. A MAX 30100 connected to a smartphone via Bluetooth will be used as the proposed system. The processed signals are transmitted to your mobile phone. This will allow patients to receive early treatment and prevention and hopes to reduce the rate of death from heart problems.

Keywords: MAX30100, Arduino, MIT App Inventor, Heart Rate Monitor, OLED Display, Bluetooth

1. Introduction

The heart usually beat around 60 to 100 bits per minute (BPM) in a normal adult person [1]. One of the determinants of cardiac rate is individual fitness. A person with a heart rate higher and lower than the normal heart speed is affected by tachycardia and bradycardia respectively [2]. During tachycardia and bradycardia, blood flow efficiency in the body decreases. Vital parameters like cardiovascular, blood pressure monitoring, recognition of dangerous situations and the prevention of health diseases plays an important role. The pulse oximeter is an approach to monitor heart rate. The photoplethysmography (PPG) is a small tool use to record changes in blood flow, by illuminating the finger with LED and measuring alterations in the skin with the illustrated light with a photodiode. Although it is easy to put on the finger, pulse oximeters are somewhat overwhelming and impractical for intermittent use throughout the day. In this study, the approach of real-time PPG signal processing application on Android smartphone is presented. Recent advancement in this filed has led to automatic non-contact inexpensive methods for continuous monitoring of the heart rate using nothing but ambient light. Figure 1 shows example of an PPG signal.

*Corresponding author: amirul@uthm.edu.my

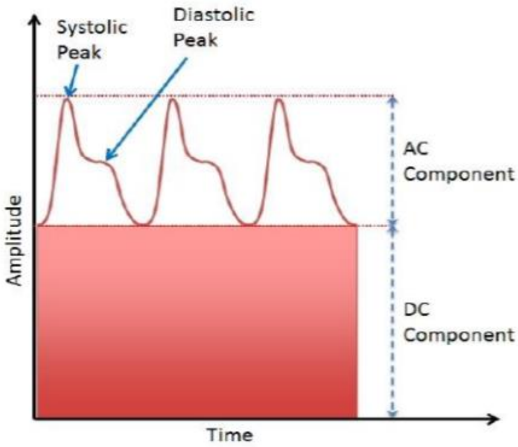

Figure 1: Example of PPG signal

1.2 Problem Statement

The most serious health problem among people is cardiovascular disease [1]. The lack of immediate action by people was the main reason people were faced with curing difficulties. Lack of mobile devices to immediately detect heart rate abnormalities and to alert patients to emergencies.

1.3 Objectives

Several objectives must be achieved to complete this project. The system design consists of:

i. To develop the device for heart rate measurement
ii. To monitor the heart rate with a suitable sensor that capable of alert user for Tachycardia and Bradycardia
iii. To analyse the device performance for on different age.

1.4 Scope

The scope and limitations that need to be considered for completing this project are as follows:

i. Analysing the PPG signal.
ii. Learn MIT Application Inventor or Android Studio programming skills.
iii. Use MIT Application as a platform to develop and mobile application.

2. Literature Review

To understand the scope of the subject, several research papers were examined and studied. The study was conducted by analyzing the heart rate signals and developing the android application. Use of Body Sensor Network (BSN) as the basis of the 2014 Android Base Heart Surveillance system to develop cardio frequency monitoring and reporting systems [3]. In case of heart attack, a warning is sent to contacts in cases of an emergency. The sensor data is transmitted via Bluetooth to the mobile app.

It is understood that wireless sensors were used to facilitate the hardware connection to the mobile app. The tools installed in the proposed project are PCB hardware. The devices proposed by the author in his research paper are ULN Darlington as a voltage regulator. MAX232 IC for serial communication with 10-bit ANC (similar to a digital converter). The project will send detected sensor values via Bluetooth to Android mobile phone, and the user signal ECG will also be dispatched on the phone.

The system of the patient should be simple and easy to use Peter Leijdekkers suggested. The designed application consists of words with larger fonts and clearer images, making it easier for the patient to be used in emergencies. The ECG sensor can be used to detect blood pressure and blood glucose. If a 12-lead ECG sensor were correct in the detection of cardiac attack, it would have been difficult to put electrodes without assistance [4].

The proposed system shows an ECG-smartphone-based monitoring system which transmits the ECG signal via an Android telephone and then to a remote server. Within this system, an ECG signal is sent throughout the system by the Android telephone [5].

An application for android-based mobile devices has been developed which allows ECG monitoring and automatic rhythms detection in real time through an analysis of ECG parameters, and which is able to monitor the use of android-based mobile devices for the detection [6]. For the detection of the ECG signal, a Wireless ECG sensor is used, and the data collected will be forwarded via Bluetooth to the mobile phone.

There is also a system called CUEDATA [7]. The ECG monitoring system includes data from a biosensor, such as heartbeat. The Mobile Heart Monitoring Solution developed consists of the PDA version of PHIMS as well as an integrated electrocardiogram bathing detector (ECG). It was mainly because the authors decided to make early detection of cardiovascular disease using the mobile computing technologies.

In addition, the author explained that the existing system that implements the ECG system on mobile phones does not have an automatic method. The system is designed so that the patient must press a button and the ECG is read. For further analysis and treatment, these readings should be taken to the cardiologist.

It is a system called the heterogeneous HWNS [8]. This system was proposed. The ECG sensor data will be transmitted to the physician via HWNS. It also includes the position of the patient via the GPS sensor. The summary of the research carried out is shown in Table 1.

Table 1: Summary of proposed projects

Year	Title	Explanation
2008	A self-test to detect a Heart Attack using a mobile phone and wearable sensors.	• Show the customer several questions. • Call immediately for emergency contact if symptoms have been detected. • No symptom - ECG recording continues
2010	A novel method to detect a real time heart monitoring system using android smart phone.	• The heart rate can be estimated with a mobile phone camera
2011	Development of the Irregular Pulse Detection Method in Daily Life using Wearable Photoplethysmography Sensor	• PPG sensor used to measure the arrhythmic pulse • Analyse the correlation between the PPG and ECG data
2012	ECG monitoring and Alarming system based on Android smartphone	• ECG data sent to an android phone to be processed • Delivers an alarm message to the doctor and emergency contact
2012	Cue date: A real time heart monitoring system using android smartphone	• ECG monitoring using ECG sensor • Personal Information Management (PHIMS) data can be saved in a PDA version via wireless network.

2012	Real time ECG monitoring and arrhythmia detection using android based mobile device	• CG sensor used for ECG signal collection • Data transmitted via Bluetooth to mobile phones
2012	A mobile ECG healthcare platform	• ECG sensor for ECG signal collection • Signals can be transmitted and sent to a remote server to android phones.
2014	Android Base Heart monitoring and reporting system	• Using Body sensor network • Sensors used to detect temperature and heart rate • Data sent vis Bluetooth
2014	Android Based body area network for the evaluation parameter	• Data collection platform based on Android OS. Keep and send data to the clinical server in an internal memory

3. Methodology

This project presents the concept and system design of this project. The project deals with the development of the software design program. The planning has been done in the MIT. This work describes a method to estimate the heart rate of smartphones by using a PPG signal. That is to say, in order to record video fingertip data which PPG acquires signals, the photodiode and the light source in pulse oximeters is replacing the integrated application monitor and the LED. The project workflow for the completion of the project is shown in Figure 2.

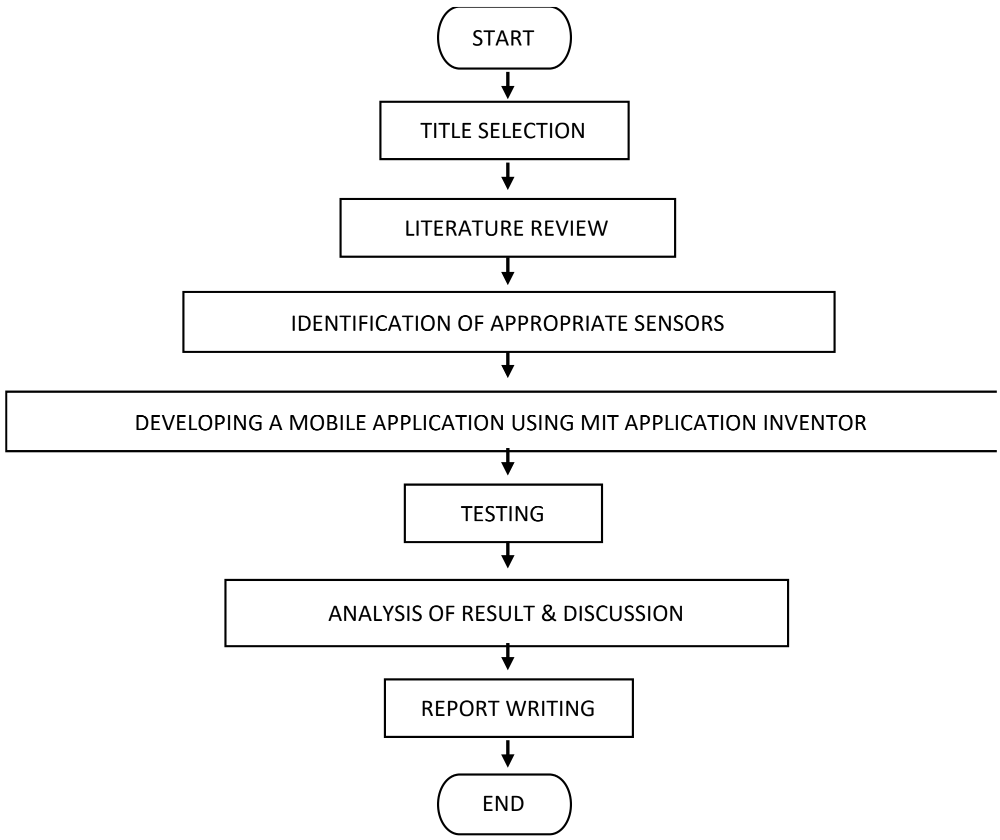

Figure 2: Project Workflow

3.1 Detailed Project Design

This section contains all details on the design of software and hardware. The project design consists of software design, as illustrated in the Figure 3.

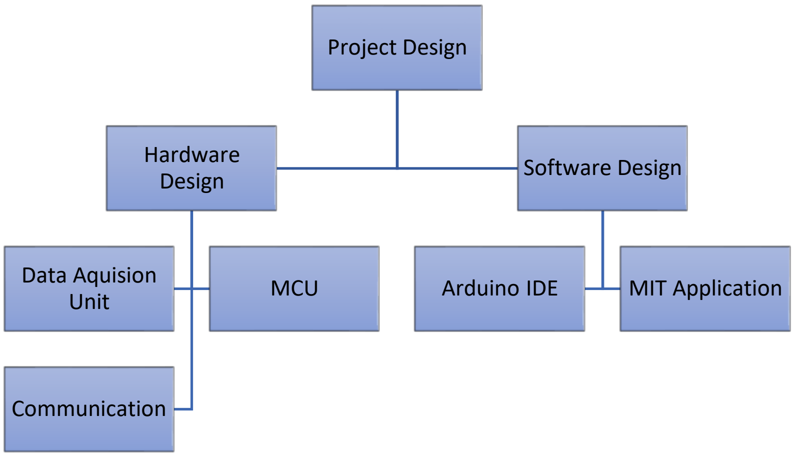

Figure 3: Project Design Divisions

3.1.1 Electrical Design

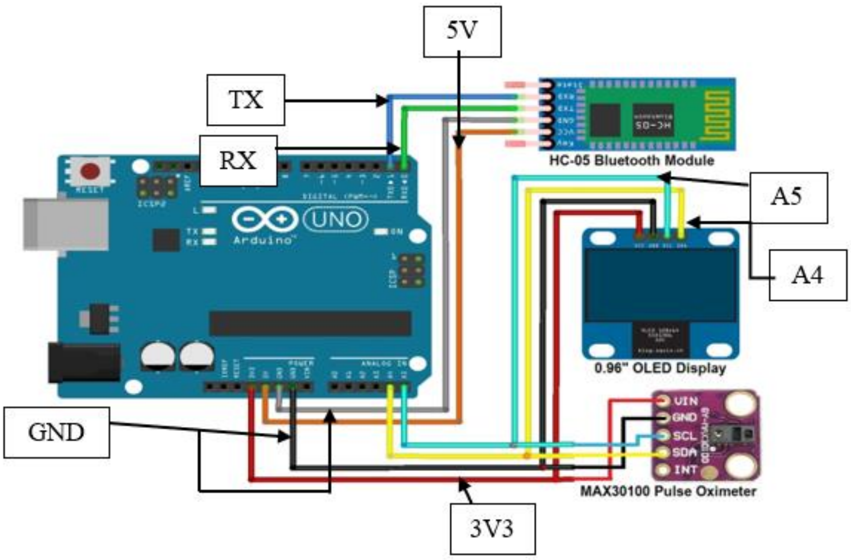

Figure 4: Connection Design

MAX30100 and OLED Display is operating on the I2C protocol of communication. Therefore, the SDA and SCL are attached to the Arduino I2C screw, respectively A4 and A5. The Bluetooth module is also a UART module that needs to be wired to Arduino's Tx and Rx pins.

3.1.2 System Design

Real time concepts for home and training people to prevent Tachycardia and Bradycardia. The user may well be wearing the MAX 30100 based on the concept of heart rate detection. The data is sent to a smartphone for Android. The best way is for Bluetooth data to be transmitted. The application is programmed to receive the data every one second from the heart rate monitoring equipment foe using Android Studio and MIT Application Inventor. As data is transferred in real time to the device, the data about the user's cardiac rate is shown on the smartphone accordingly. Smart sampling has also been programmed in order to trigger the user to understand the condition of Tachycardia and Bradycardia and also to send the user alert. The system flow suggested is shown in Figure 5.

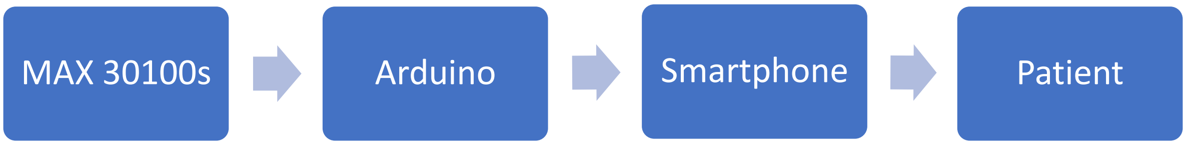

Figure 5: Flow of the system

With wireless Bluetooth, the developed app communicates with the device. When available, developed apps are still going to look for devices. The Bluetooth module HC-05 used during this project for the research and connection of the device. If you want to connect to your app, use the HC-05 Bluetooth module to create a socket. Now that the socket is built, the application can receive and send data via Bluetooth transmission.

Arduino will notify the command size once the device is connected to the server. Arduino uses serial communications when it receives its size to send Arduino commands. In response to the "send" command, Arduino will continuously send pulse data to the mobile phone. This will be managed by the connection manager based on the message size and message. Figure 6 shows the transfer flow. The pulse data will be sent to mobile phone with the microcontroller. The microcontroller instructions are sent via the on-phone connection manager. The connection manager processes the initialization to receive and send the order. The extension is sent when a 'Send' command is sent.

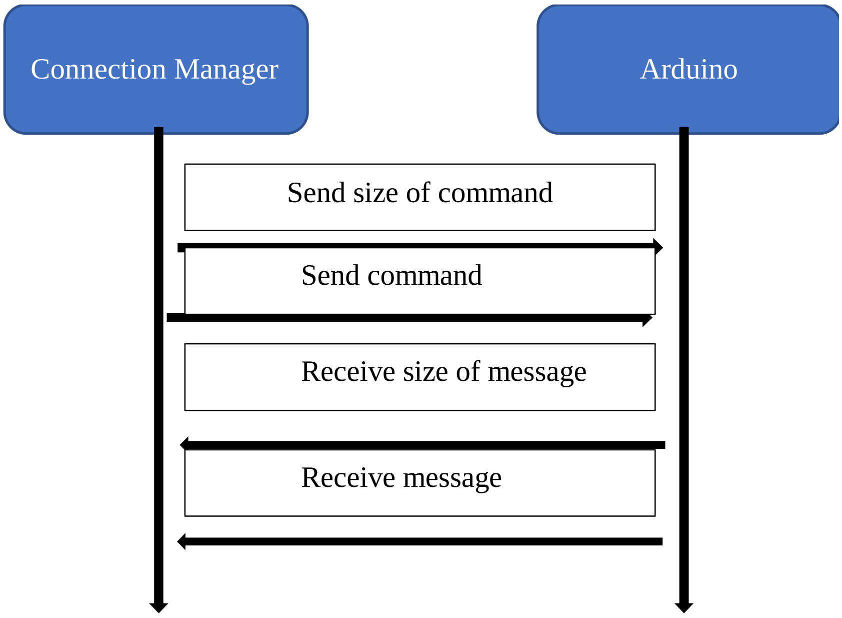

Figure 6: Flow of Data transmission

In order to receive incoming pulses data and analyse them using threshold sets, mobile apps have been developed on the phone. Mobile applications analysis can determine if users have Tachycardia or Bradycardia experiences. If so, the application will automatically send and warn users of delayed medical advice and of the treatment for heart failure.

3.2 Programming Flowchart

The Final Year Project (FYP) project process is identified to design the fingertip heart rate monitor. It can be divided into several phases. The main theme is the concept of electronics for the Fingertip Heart Rate Monitor. The other part is to develop the internal and external electronic design of the Fingertip Heart Rate Monitor. Testing, examining and other minor task conclude the final stage.

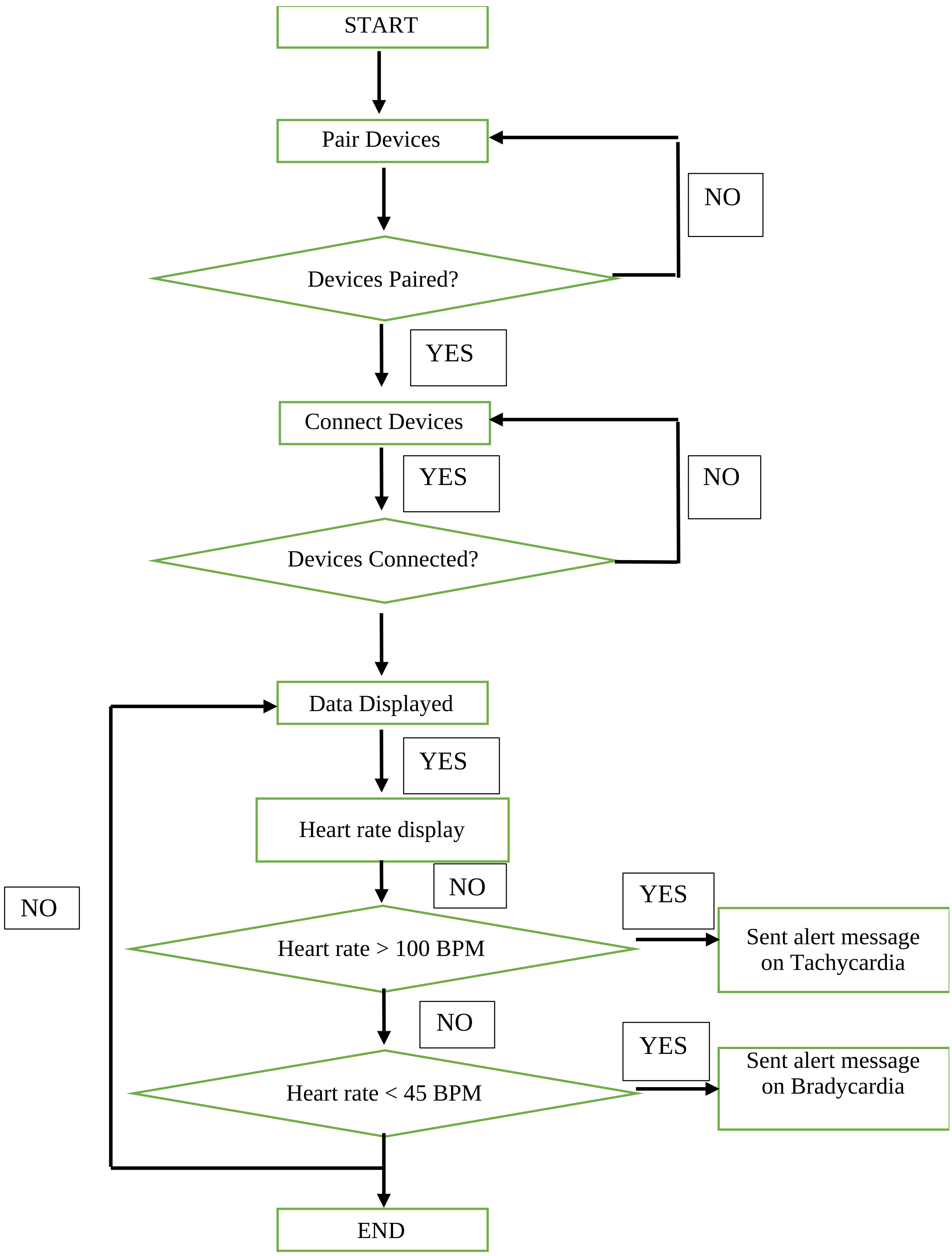

Figure 7: Flowchart of the project

3.3 Mechanical Design

3.3.1 Project Design Using SOLIDWORK

The SolidWorks software will be used in Figure 8 for the design of the project hardware, which focuses on the project's shape and total volume. Furthermore, this software helps to make a draft and assemble the part before the actual part and components are decided and assembled. The ideal project sketching in Solidwork. The actual project structure that refers to this Solidwork design in order to prevent an error when constructing a prototype for each component.

- 2D Design

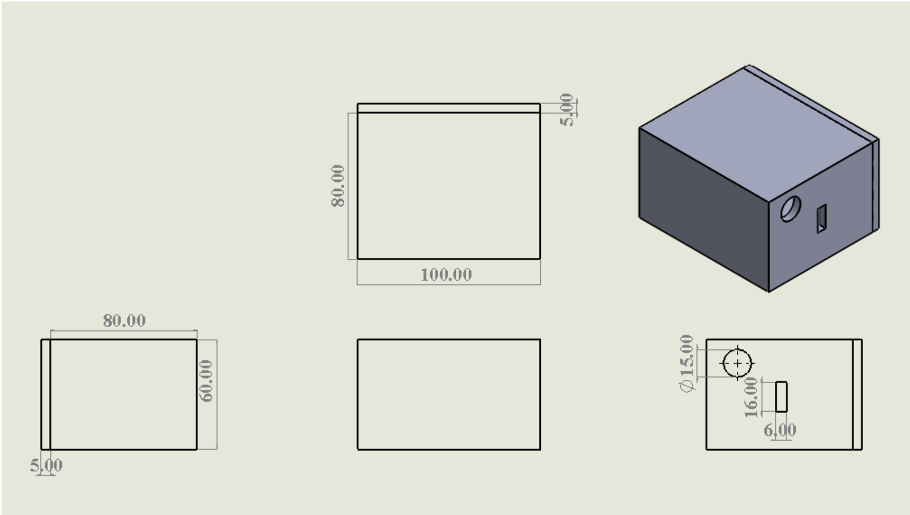

Figure 8: 2D Design

- LEFT

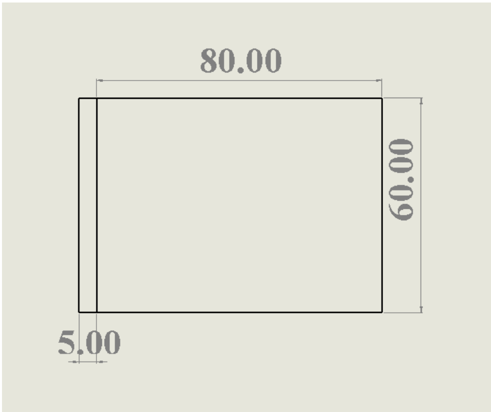

Figure 9: 2D Left

For Figure 9 width is 60 mm and height is 80 mm. Value for 5 mm is height for cover

- RIGHT

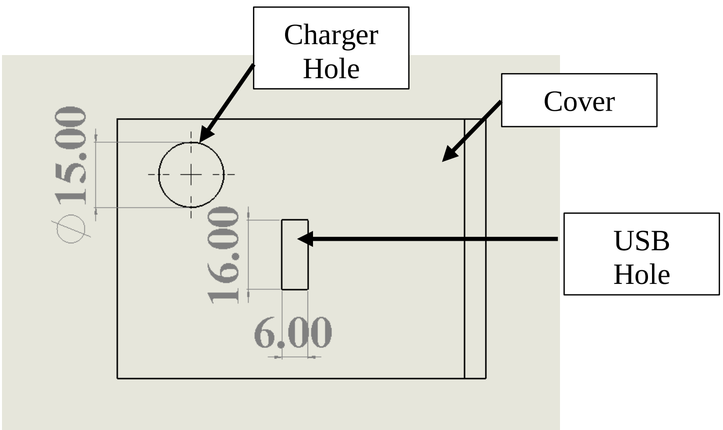

Figure 10: 2D Right

From the right side the circle diameter is 15 mm for the charging port and for the rectangle width is 16 mm and height is 6 mm for USB connection Arduino.

- TOP

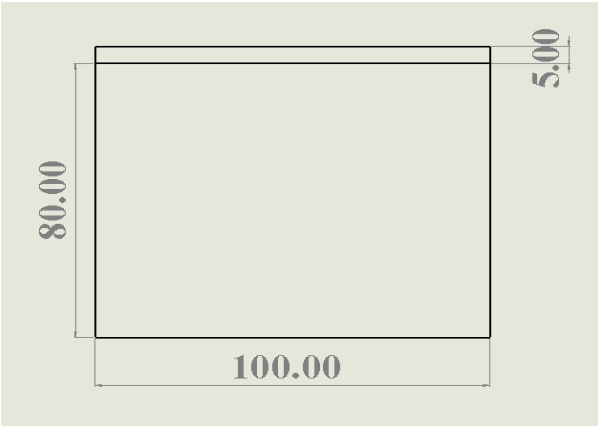

Figure 11: 2D Top

From the top view length 100 mm and width 80 mm for body, the cover value 5 mm

3D Design

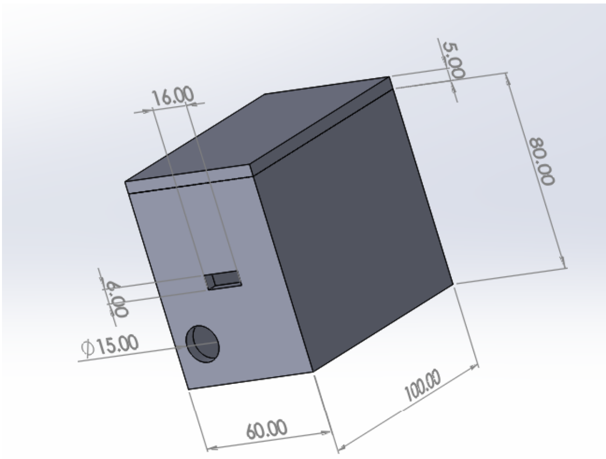

Figure 12: 3D Design

- FRONT

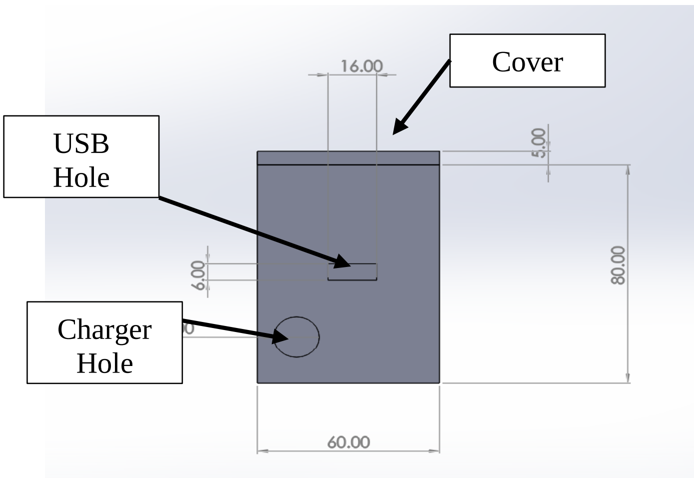

Figure 13: 3D Front

3.4 Component

Material	Function
Arduino Nano 	To control pulse sensor and Bluetooth Module
MAX 30100 	Red light and infra – red light are also used for calculating blood oxygen levels.
HC-05 Bluetooth Module 	To Communicate with Arduino or to communicate with any device with Bluetooth functions such as Phones or Laptops
I2C OLED 	OLED displays can generate large contrasting texts/images and even under the bright light are easily readable.

3.5 Testing and Analysis

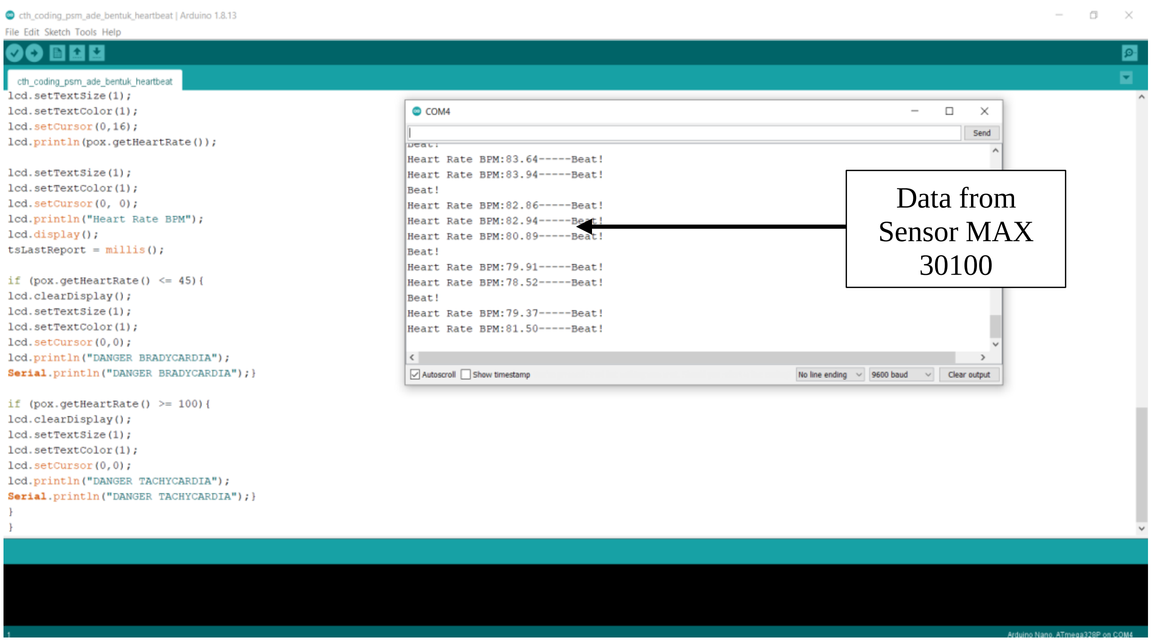

Figure 14: Testing sensor MAX 30100

From Figure 14 testing coding sensor MAX 30100 with serial monitor to check the sensor MAX 30100 fully function before making any real connection with another component.

4. Result and Discussion

4.1 Circuit Diagram and connection

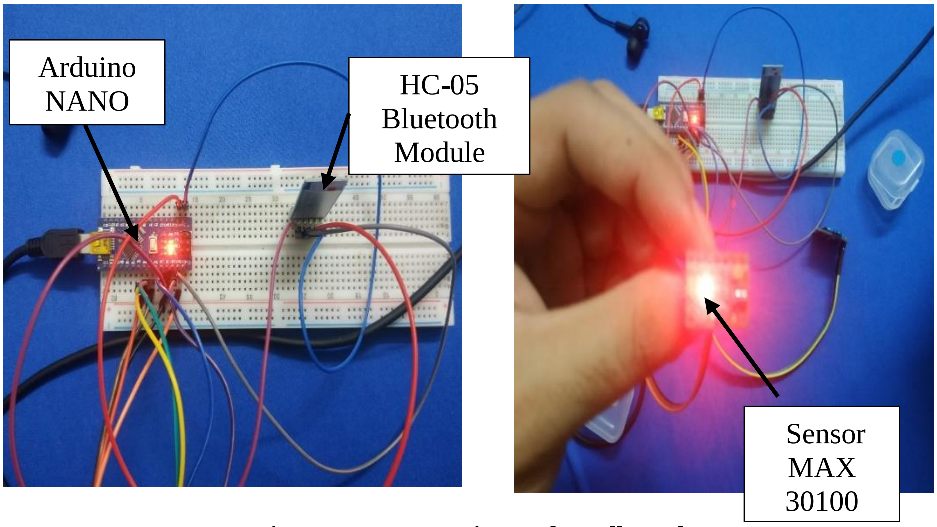

Figure 15: Connection on breadboard

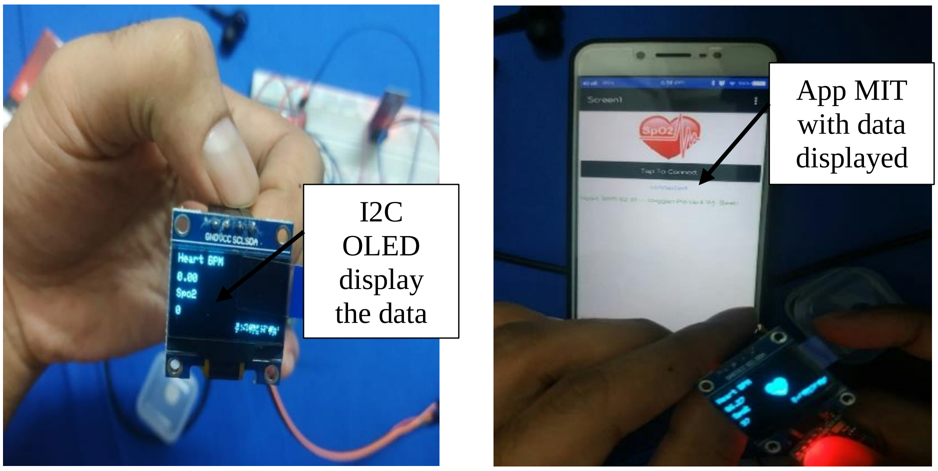

Figure 16: Result after connection with breadboard

Figure 15 show MAX 30100 is Arduino-compatible. This allows the Arduino to record the PPG signal used to detect an individual's heartbeat per minute. Figure 16 show OLED displays can be mounted wirelessly to Android via the Android App via a Bluetooth connection, with pulse rate and Blood Oxygen concentration. Device on the Breadboard is tested for the project. Initially, the BPM values are zero if the finger is not placed over MAX30100. The BPM values are displayed when the finger is placed. But the displayed value is not correct at the outset, then the OLED display starts to show the right value after a few seconds.

4.2 Heart Rate Prototype

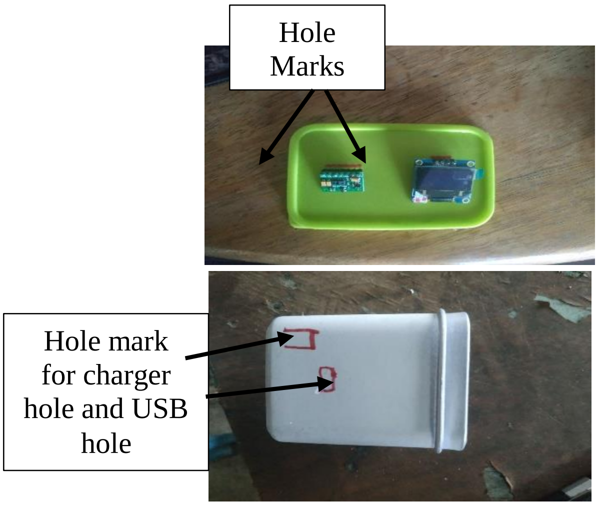

Figure 17: Make the MAX 30100 and OLED hole marks

Figure 18: Holes for MAX 30100 and OLED after already made

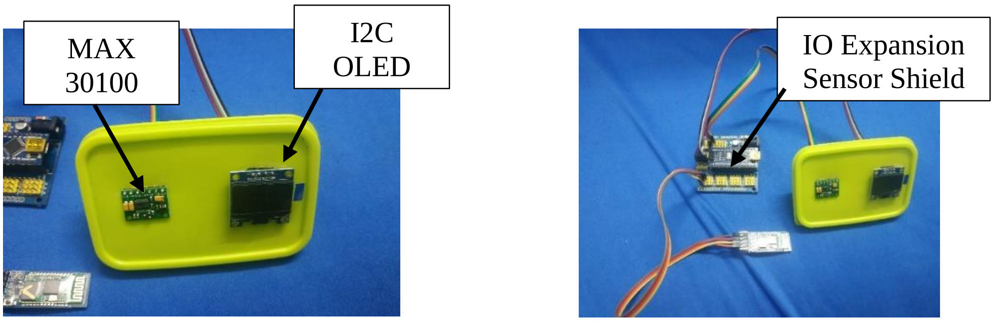

Figure 19: make installation on NANO IO Expansion Sensor Shield

A mark must be made as a guide as in Figure 17 before a hole is created on the cover surface. After a mark has been made for MAX 30100 as well as for OLED parts, a hole is drawn as in Figure 18 On Figure 19 do installation on IO Expansion Sensor Shield

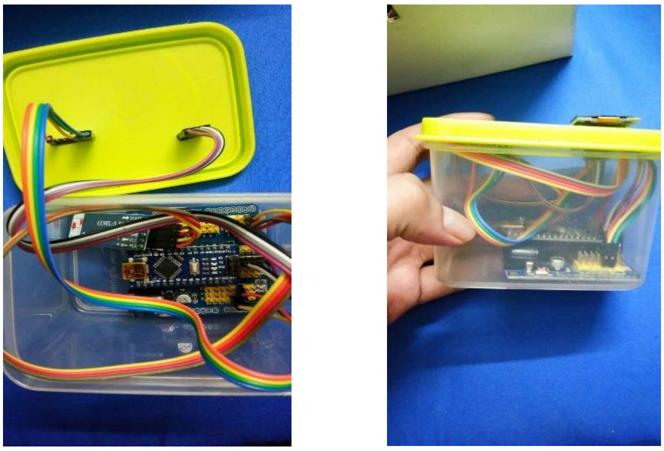

Figure 20: Insert Arduino into food storage containers

Figure 21: Prototype Fingertip Monitoring

For Figure 20 shows all the connection Arduino get insert into the food storage container and the Figure 21 shows all system in good condition.

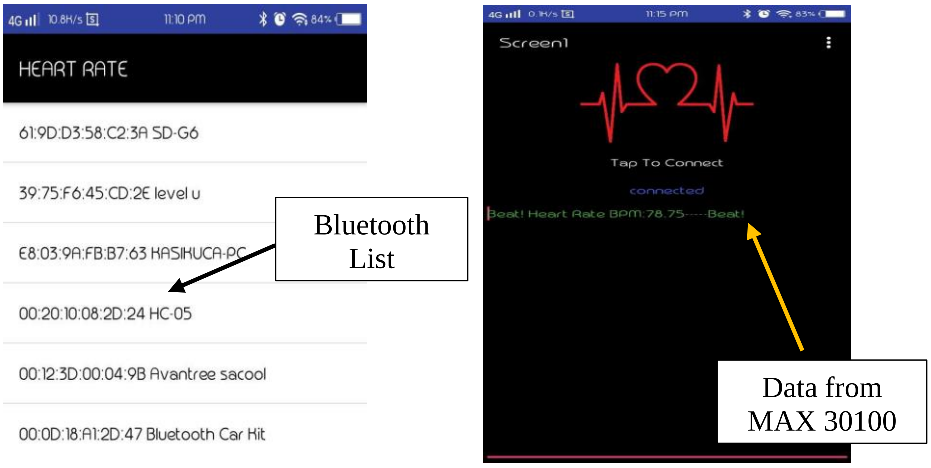

Figure 21: Bluetooth List

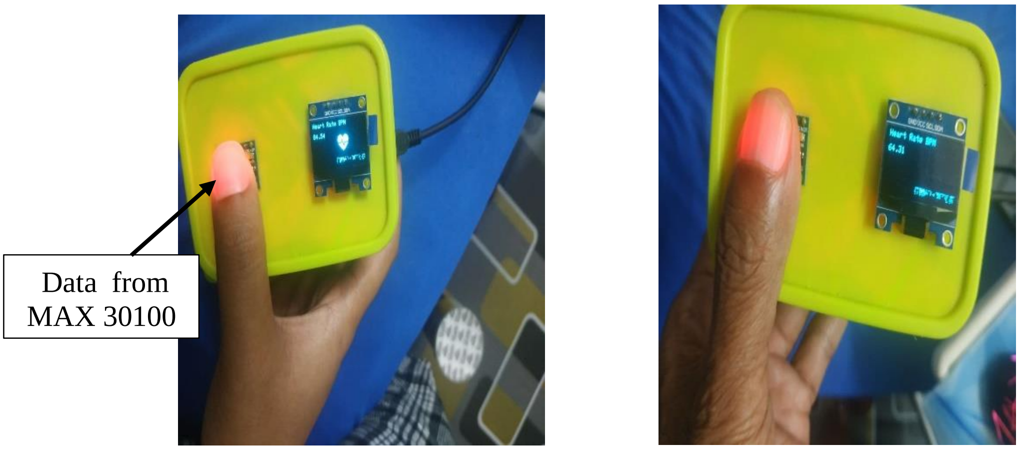

Figure 22: User holds MAX 30100

The user must select the HC-O5 that is the name of the device. This is now connected to the application and the sensor circuit. When the user holds the MAX 30100 as shown in Figure 22 the pulse rate data transmission from the Arduino to the application begins.

The results are shown in Figure 22. The graph is synced with the user to display the Beats every 1seconds. The nice beat is generated and displayed when the pulsed sensor touches the fingertip of your user. From Figure 22, you can detect the heart rate range from 78.27 BPM to 85.53 BPM in a cardiac rate monitoring device. The nominal cardiac rate is from BPM 60 to 100BPM for a person over the age of 25 who exercises. BPM is called bradycardia when the heart rate drops below 45, while the situation is called tachycardia if its heart rate drops below 100 BPM.

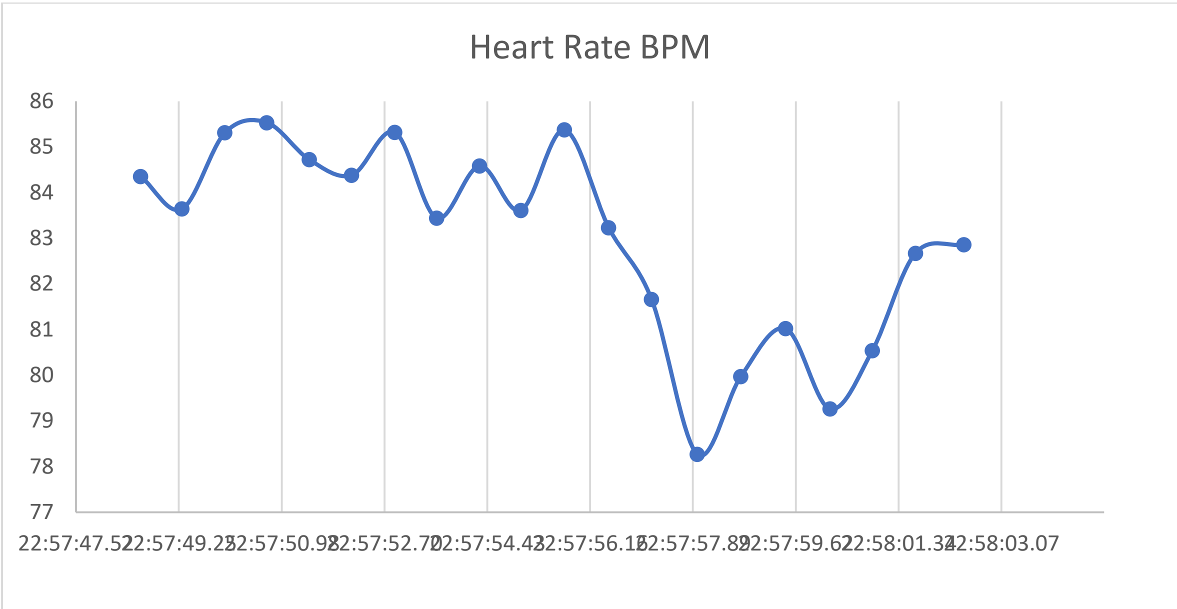

Figure 23: Data of BPM for Man with age 27 from serial monitor

The results are shown in Figure 23. The graph is synced with the user to display the Beats every 1seconds. The nice beat is generated and displayed when the pulsed sensor touches the fingertip of your user. From Figure 23 you can detect the heart rate range from 51.5 BPM to 67.67 BPM in a cardiac rate monitoring device. A slight difference in BPM is found between men 27 years of age and parents 65 years of age.

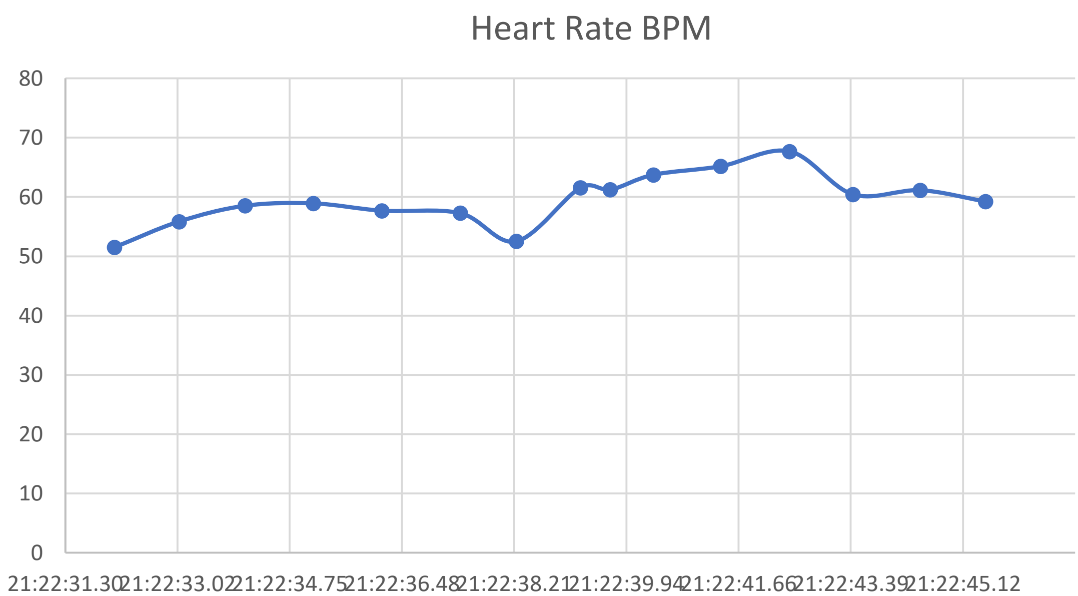

Figure 24: Data of BPM for Parents with age 65 from serial monitor

The results are shown in Figure 24 The graph is synced with the user to display the Beats every

1seconds. The nice beat is generated and displayed when the pulsed sensor touches the fingertip of your user. From Figure 24, you can detect the heart rate range from 82.58 BPM to 87.34 BPM in a cardiac rate monitoring device. BPM is roughly the same for men aged 27 as for women aged 30 years

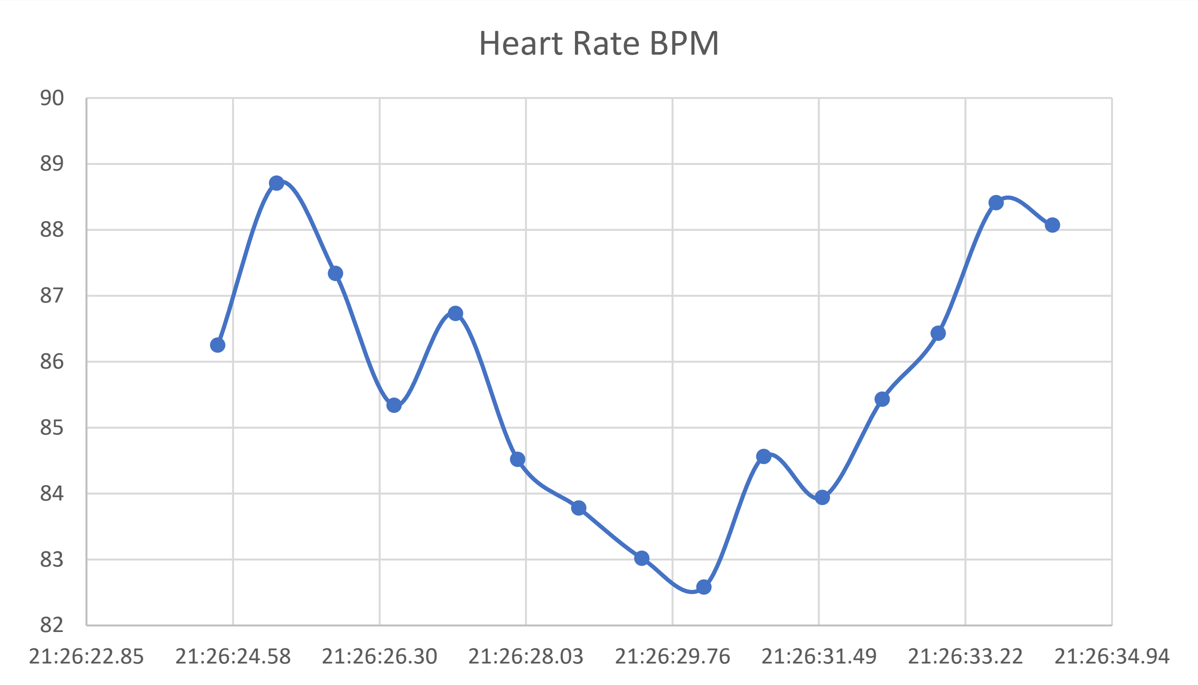

Table 25: Data of BPM for Woman with age 30 from serial monitor

5. Conclusion

In addition, an Android app for the smartphone has been developed as part of the Android platform to cater for input from the Heart Rate tracking devices. Data were successfully collected from the tracking system via the android platform. The Android app reads and shows the cardiovascular value. Where the data collected is incompatible with the threshold range, the user will be notified of the user's emergency.

Acknowledgement

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