IOT HEALTH MONITORING SYSTEM FOR SELF QUARANTINED COVID-19 PATIENTS

VIKNESWARAN A/L BALAKRISHNAN

BACHELOR OF ELECTRICAL ENGINEERING (ELECTRONICS) WITH HONOURS

UNIVERSITI MALAYSIA PAHANG

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IOT HEALTH MONITORING SYSTEM FOR SELF QUARANTINED COVID-19 PATIENTS

VIKNESWARAN A/L BALAKRISHNAN

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ABSTRAK

Kajian ini memberi tumpuan sepenuhnya kepada pembangunan sistem pemantauan data kesihatan pesakit Covid-19 yang menjalani kuarantin sendiri melalui klasifikasi data. Dalam Covid-19 ini, kita sering mendengar dan melihat di pelbagai platform media serta media sosial tentang ramai orang yang mengalami kematian kritikal kerana tidak dapat memberitahu status kesihatan mereka kepada orang lain.. Bagi mengatasi masalah ini dalam masyarakat, penciptaan prototaip yang mampu mengesan data kesihatan tanda-tanda vital bagi pesakit yang dikuarantin sendiri Covid-19 adalah sangat penting. Cara menggunakan prototaip baru ini adalah seperti jam biasa yang dipakai di pergelangan tangan. Dalam ciptaan ini, sekiranya seseorang itu terjatuh, tindakan tersebut dapat dikesan kerana terdapat beberapa sensor untuk mengesan pergerakan. Dengan terciptanya prototaip ini, simptom Covid-19 yang teruk dapat dikesan dan memudahkan pesakit mendapat rawatan sewajarnya. Tujuan utama pembinaan prototaip ini adalah membina sistem pemantauan kesihatan untuk membaca data daripada tanda-tanda vital seperti kadar denyutan jantung, ketepuan oksigen dalam darah(SPO2), suhu, lokasi GPS dan pengesanan jatuh. Selepas itu tanda-tanda vital dan maklumat jatuh diklasifikasikan untuk menunjukkan keadaan berhati-hati. Kemudian bangunkan sistem IoT untuk memberitahu penjaga atau doktor tentang situasi kecemasan. Aliran projek ini akan memulakan sistem pada mulanya. Seterusnya, penderia menerima isyarat dan isyarat yang diklasifikasikan mengikut tanda-tanda vital untuk pesakit Covid-19. Selepas itu, data disimpan pada awan dengan bantuan IoT. Sebaliknya, jika data yang diklasifikasikan memenuhi situasi kecemasan, amaran akan dimaklumkan kepada doktor atau penjaga dan prosesnya akan tamat. Terdapat beberapa komponen utama yang perlu digunakan untuk mendapatkan tanda vital yang tepat dibaca. Pada mulanya Arduino Uno digunakan sebagai papan pembangun. Beberapa sensor juga digunakan untuk melengkapkan prototaip ini seperti sensor suhu LM35 yang mempunyai bacaan yang lebih tepat berbanding termistor, modul Wi-Fi ESP8266 untuk memindahkan data ke awan dan menyimpannya di awan, pecutan ADXL345, oksimeter nadi MAX30102 untuk mengira degupan jantung kadar dan ketepuan oksigen dalam darah dan U-Blox Neo-6m untuk pengesanan lokasi. Perisian yang digunakan untuk melakukan pengekodan ialah Arduino IDE yang sesuai untuk semua papan Arduino. Kemudian untuk mendapatkan bacaan suhu kami menggunakan beberapa algoritma untuk mengira bacaan suhu daripada sensor. Dalam perisian Arduino IDE kita boleh memantau dua jenis hasil satu adalah monitor bersiri dan satu lagi adalah plotter bersiri. Selain itu untuk melihat nilai keluaran kadar denyutan jantung, satu algoritma khas adalah perlu untuk mengira nadi. Bacaan keluaran akan mempunyai nilai BPM dan nilai purata. Seterusnya untuk melihat nilai keluaran ketepuan oksigen dalam darah, satu algoritma khas diperlukan untuk mengira SPO2. Bacaan keluaran akan mempunyai nilai peratusan dan nilai purata.

ABSTRACT

This study focuses fully on the development of a system of monitoring the health data of Covid-19 patients who undergoing self-quarantine by means of data classification. In this Covid-19, we often hear and see on various media platforms as well as social media about many people who suffer from critical dying due to not being able to tell their recent health status. To overcome this problem in society, the creation of prototypes that are able to track the health data of vital signs for Covid-19 self-quarantined patients is very important. How to use this new prototype is like a regular watch that is worn on the wrist. In this invention, if a person falls, the action can be detected because there are several sensors to detect movement. With the invention of this prototype, the symptoms of severe Covid-19 can be detected and make it easier for the patient to receive proper treatment. The main purpose on building this prototype is build a health monitoring system to read the data from vital signs such as heart beat rate, oxygen saturation in blood(SPO2), temperature, GPS location and falling detection. After that vital signs and falling information classified to show caution circumstances. Then develop an IoT system to notify guardian or doctor on emergency situation. The flow of this project will be initializing the system at the first place. Next, the sensors receive the signals and the signals the classified according to the vital signs for Covid-19 patients. After that, the data are saved on the cloud with the help of IoT. On the other hand, if the data classified meets the emergency situation an alert will be notified to doctor or guardian and the process end. There are some main components that have to be used in order to get the accurate vital sign read. At first place Arduino Uno is used as the developer board. Some sensors are also used to complete this prototype such as LM35 temperature sensor which has a more accurate reading than thermistor, ESP8266 Wi-Fi module to transfer data to cloud and save it on cloud, ADXL345 accelerometer, MAX30102 pulse oximeter to count the heart beat rate and oxygen saturation in blood and U-Blox Neo-6m for location tracking. The software used to do coding is Arduino IDE which is suitable for all Arduino boards. Then to get the temperature reading we use some algorithm to calculate the temperature reading from sensor. In Arduino IDE software we can monitor two types of result one is serial monitor and another one is serial plotter. Apart from that to see the output value of heart beat rate, one special algorithm is need to calculate the pulse. The output reading will have BPM value and average value.Next to see the output value of oxygen saturation in blood, one special algorithm is need to calculate SPO2. The output reading will have percentage value and average value.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

In this Covid-19 era, severe symptoms detection has become a major issue faced by self-quarantined Covid-19 patients. Health Monitoring System is a system that monitors health condition of patients by observing heart rate, oxygen saturation in blood and temperature with the aid of some sensors. The health status of user can be tracked without stop because this system will operate in real-time. Some serious issues can be prevented by getting the vital signs from the data observed by the system. Health Monitoring System can track the health status of user and store the data which is output of sensor. Even though the data obtained from the sensors are not accurate to find the actual status of Covid-19 patients, but it can provide some necessary details which the signs of the user suffers. The data obtained from sensors are kept by the system and uploaded to the database which contains the previous reading histories.

Wireless sensors and sensor networks have played a vital role for research, science and technology. In spite of the fact that sensor systems have been in put for over a couple of decades presently, entirety unused application space of sensors has been opened by the wireless domain. Wireless sensors and sensor systems different from routine wireless networks-fewer networks as well as computer systems and so display more issues to overcome, such as constrained vitality, shorter life span. Wireless detecting system combine wireless communication with transducers and mobile computing to supply a sensor framework that's cheap to construct in numerous applications. In any case, a particular perspective of remote detecting is the co-location of computing control and radio frequency (RF) communication inside the sensor system itself. Nowadays, improvements in science and innovation offer lower cost miniaturization, acceleration, intelligence, complexity and new materials, driving to the improvement of different high-performance smart detecting systems.

A Health Monitoring System have the ability to notify the client on their wellbeing status where they can check it as often as possible using their application which could be a item of Internet of Things system. The Health Monitoring System can be created in assist by including more features such as rehabilitations. This system will collect the information from sensors and it has it possess scoring strategy which is endorsed by the specialists. So essentially, the systems know what the health status of user by data classification method which obtained from sensors.

1.2 Problem Statement

As the world is growing rapidly towards Industrial Revolution 5.0, humans are busy chasing their enthusiasm and dreams. Few decades before, there are only one individual in a family go and do the work while others stay at home. But these days, everybody needs to find a job and work to overcome the financial problems. Even though this is a great advantage for the family, got some drawback which can brings a major impact. One of the drawbacks is, Covid-19 patients who undergoing self-quarantine tend to stay at their house without others observation.

Most of them passed away due to difficulty of breathing. When see the post mortem report of these Covid-19 patients who passed away because of shortness of breath, it states that they passed away after a few suffer. The bad thing is no one realize that they have the breath shortness. Self-quarantined Covid-19 patients also cannot be faulted in this issue because they have the breath shortness occasionally when they suffering from Covid-19 and it becomes a common thing for them until they recover from Covid-19. They also could not contact others when they having breathing difficulty. When the pain comes they think it is a normal pain. So if they use the device that keep tracking their health status, they can be saved.

These days, as the world is racing towards money, hospitals are not excluded from that. Hospitalization fees are expanding and also the rehabilitation fees increasing which need to be after a surgery. Hospitals also try to discharge patients and send them back to home as fast as they can to minimize the cost. The beds for Covid-19 patients also become limited in hospitals as many people affected by Covid-19. The significance and urgency of telemedicine and wireless monitoring of patients are growing. The patients are monitored by the aid of sensors. This is because a fall or stroke can cause injury to the person even death. People like that need to be monitored persistently and also medical help and care when essential.

When a patient becomes unconscious and suffering, health authority cannot identifying the current location of patients and it becomes a hard task to give them medical assist on time.

1.3 Project Scope

- This is a real-time health monitoring system prototype which user can wear it anywhere and anytime as a watch
- This prototype uses Arduino Uno developer board
- The data will be saved on cloud and can be accessed by doctor and guardian
- This system needs an internet network to operate.

1.4 Project Objectives

- To design an IoT Health Monitoring System that can observe vital signs for figure out the serious condition of covid-19 self-quarantined patients and classify an emergency situation.
- To build a health monitoring system prototype to extract data from vital signs (heart rate, oxygen saturation in blood, temperature and falling detection).
- To classify vital signs and falling information to show caution circumstance.
- To develop an IOT framework to notify guardian on emergency situation.
- To find out the current location of self-quarantined Covid-19 patients even if they become unconscious with the aid of GPS location service.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter examined about the researches related to the components that have involved in health monitoring system which are temperature, blood pressure, heart rate, and fall detection. With the reading of temperature we can know whether someone is ill or not. Heart rate is measured to induce information for the vital signs. From the measurement of blood pressure we can identify whether the individual gets adequate oxygenated blood cell or not. By getting the data from sensors, we can track the health status of an individual which is Health Monitoring System. Some chronic diseases has its own symptoms which we can find by the data collected from the sensors.

2.2 Temperature

For the measurement of temperature LM35 sensor can be used, which is an IC sensor to measure the temperature in proportion to the temperature using the analogue output. The LM35 sensor have a voltage output which is proportional to temperature reading of degree Celsius.[5] If compared to other linear temperature sensors with Kelvin and Fahrenheit calibration, LM35 is the best because don't need to carry out a big formula algorithm to remove large constant voltage from output values to get degree Celsius value. In an article by (Walker, Aroul, & Bhatia, 2009), they stated that LM35 sensor is extremely simple to interface with any sort of circuit because of it's salient features.

The LilyPad temperature sensor is the next sensor utilized within the band. It could be a small temperature sensor type of thermistor. At 0°C, the detector output is 0.5V while at 25°C the output voltage is 0.75V. In each degree Celsius, the sensor provides a 10mV energy for shift. The sensor must be in full contact with the body to get a constant body temperature. Leah Buechley and SparkFun are developing this wearable e-textile technology.[1] It was designed to make it possible to fit in garments by considering the needs. The sensor has the possible to be utilized freely all over because of it small size, thickness of 0.8mm and breadth of 0.2 cm. (Banka et al., 2018)

We used the BMA150 accelerometer, which has an integrated temperature sensor, to detect the bicycle rider's skin temperature and ambient temperature in RMMS. The accelerometer was essentially utilized to clarify the system for monitoring activity. For this gadget, we only used the accelerometer's integrated temperature sensor. To gather the ambient temperature and the skin temperature of the rider BioTE nodes are used in RMMS. The BioTE uses the SPI port which connected with temperature sensor. The bicycle coordinator node queries the ambient temperature sensor once every 5 seconds to gather the temperature information and forward this information to the base station along with other sensor information. (Malhi, Mukhopadhyay, Schnepper, Haefke, & Ewald, 2010)

The temperature sensor DS600 manufactured by MAXIM–Dallas Semiconductor to help the calculation skin temperature. The sensor produces an analogue output and the voltage must be calculated using a 12- bit analogue-to-digital-converter (ADC) by the microcontroller. The sensor is placed inside the wrist wrap, so it will be in contact with skin. With a rough estimate, the body temperature is normally 5.1 °C higher than the skin temperature.[1] The IC has a 0.5C precision and a 6.45mv/C linear output and a DS600 IC factory calibration offset of 509 mV, which is illustrated by the experimental transfer features. Normally for human, the sensors was used to take the reading of temperature of the body at wrist, forehead and armpit. For male and female the measurement of temperature is not same. (Kokalki et al., 2017)

2.3 Oxygen Saturation in Blood

Hypoxemia is referred as low blood oxygen and also known as hypoxia. This situation happens when oxygen saturation of blood is less than 94% in the absence of chronic lung disease and less than 88 with the chronic lung disease. The underlying pathology in covid-19 related hypoxia is probably a ventilation-perfusion mismatch, caused by a combination of intrapulmonary shunting, loss of lung perfusion regulation, intravascular microthrombi, and reduced lung compliance leading to alveolar collapse. Nowadays some people has buy pulse oximeter by their own for self-monitoring purpose.(Trisha Greenhalgh et al, 2021)

Pulse oximetry technology has transformed to use multiple wavelengths of light which can measure carboxyhemoglobin (SpCO), methemoglobin (SpMet), and total hemoglobin (SpHb). Total Hemoglobin (SpHb) is not so accurate to make transfusion decision. Respiratory waveform variability of the pulse oximeter can be useful to access pulsus paradoxus in patients with airway obstruction; To assess fluid responsiveness in mechanically ventilated patients, pulse pressure over the respiratory cycle can be used. There are some disadvantages for this method and recent technology is not good enough and need some major improvements.(Dean R Hess, 2016)

The noninvasive tool used to find patient with hypoxia is pulse oximetry. With the aid of microprocessor technology, light-emitting diodes and photoelectric sensors has improved. This improvement has made the reading of pulse oximetry more accurate and reliable. On the other hand, there are some limitations which is steps involved in interpret information received from pulse oximetry. The reading of pulse oximeter lag behind patient's condition because got response delay because got signal averaging in monitor. Normally pulse oximeter has a common setting of 8 seconds. This will cause an interval delay after the actual blood oxygen saturation in arterial starts to drop.(Susan DeMeulenaere, 2007)

Pulse oximetry is normally used for monitoring patients in critical care unit or intensive care unit. The latest signal processing techniques and reflectance technology used to improve performance of pulse oximeter for motion artifact and low perfusion conditions. Pulse oximeter measures oxygen saturation by illuminating the skin and measuring changes in light absorption of oxygenated (oxyhemoglobin) and deoxygenated blood (reduced hemoglobin) using two light wavelengths and this method is known as spectrophotometric method.[6] The ratio of light absorbance is calculated and calculated against direct measurements of oxygen saturation in arterial. (Amal Jubran, 2015)

2.4 Heart Beat Rate Detection

With the help of a pair of LEDs, LDRs and microcontroller, the heart beat rate is measured. IR LED emit the infrared radiation and reflected with infrared light by the ground. The radiation frequency created the pair of electrons which in turn generates the current of leakage. Then the current let to be pass by the resistors to get the voltage value.[2] Hence the higher the occurrence ray intensity, the voltage value obtained also will be higher. Our heart beat rate is measured when we put our forefinger tip on the sensor. To calculate the heart beat rate in BPM, the output is sent to the microcontroller for conversion. (Banka, Madan, & Saranya, 2018)

Heart Beat Rate is the count of pulse per minute and its unit is “bpm”. The Heart Beat Rate quality of each individual will be different due to some factors such as body movement, emotional level, appetite, strength and weakness, surrounding temperature and so many factors. The normal Heart Beat Rate are from 60 to 100 beats per minute or an ordinary person. The heartbeat is detected on the APDS9008 light sensor by reflecting the light emitted by the green LED. The sensor’s output voltage is converted into 1 512 ADC offset signal.[4] This type of sensor reacts to light intensity fluctuations and amount of light depends on the frequency of output signal. (Taştan, 2018)

The pulse sensor used in this design is a basic plug and play heart beat rate sensor for Arduino. The sensor consists of a standard optical heart sensor. Inside the circuit also got noise cancellation circuit to make sure the sensor more stable and efficient. The power requirement for this sensor is very low, just 4mA and 5V. The sensor’s working operation is simple which is made up of infrared led as transmitter while LDR as receiver. The tissues absorb some light from the transmitter and some other are reflected back which received by the receiver. The output of this sensor is in electrical signals. Then the electrical signals will be translated into heart beat rate.[1] .(Kokalki, Mali, Mundada, & Sontakke, 2017)

2.5 Fall Detection

Nowadays fall detection become a huge challenge in the field of healthcare, especially for the senior citizen as their physical wellness decrease. To overcome this problem a reliable monitoring system is needed to relieve the negative impact of falling. This paper creates a new mobile device-based drop detection system. The function of the system is to track body movement of human, detect a sudden fall from ordinary daily activities. It will automatically send command for help to their guardian or caretaker. The common injuries that an elderly individual face after a fall are fracture, coma and even paralysis. Most of the times high impact become the main cause of injury. But somehow, late medical help also can worsen the situation. Nowadays due to the technology growing fast, the fall detection have been identified and developed. First one is method based on computer vision which use camera in a limited space to supply pictures or videos of human activities. As the external support motion sensors can be used to improvise this method. This method is effective if its indoor because if its outdoor difficult to realize as cameras are always limited in deployment. Sensor-based on movement are mostly used now such as accelerometer and gyroscope. It provides data on linear and angular motion.[7] There are some methods to detect fall but different in composition of sensors and algorithm used for detection. The second method is by using accelerometer. A single triaxial accelerometer can provide the acceleration of an object in x-axis, y-axis and z-axis. The next method of fall detection is use accelerometer and gyroscope. Gyroscope provide the angular velocity and accelerometer provide linear motion details. Third method of fall detection is using magnetometer. A triaxial magnetometer can measure magnetic force in x-axis, y-axis, and z-axis. It also provides data on angular movement in horizontal plane. (Wu et al., 2015)

2.6 Internet Of Things

In the first stage, raw data collected and stored on the server from different IoT devices. This device includes many sensors such as vibration sensor, temperature sensor, heart beat sensors and so on. The output of the sensors will be in analogue which cannot be read by Raspberry Pi. So we must convert it to digital form. At stage two after sort, classify and categorize the data stored significant data is obtained.[4] The information will be utilized to predict that patient got what symptoms that related to which disease. For stage three prediction is made about the type and nature of disease by using data mining technique. The artificial intelligence can improvise the system.(Taştan, 2018)

As the world grow toward achievement, the usage of internet has become increased. IoT technology extends to incorporate many sectors and applications. Smart health sector is one of the example of IoT expansion to many sectors. Patients beneath healing center surveillance are dependent on bed, leaving patients uncomfortable. Numerous health issue that require early diagnosis will worsen patient's health problems because they cannot be tracked on time.[1](Kokalki et al., 2017)

Nowadays, the Internet of Things which is IoT is become an ordinary. Not as it were has the rising innovation driven the information / data trade on the web, but it has too done numerous other jobs. This new technology has made a difference individuals to form amazingly unpredictable use of the internet. We can use the internet with IoT to achieve any work a individual needs to do. In the field of sensors, microcontrollers and microprocessor, the use of internet has expanded quickly. A computer with more effective sensors and chips has increased its capability.[2] The proposed proposals for utilizing the Internet o Things in healthcare comprises of a smart health bracelet, included with heart beat rate and temperature scanner. This smart health bracelet helps to track health parameters recorded live. The status and live location of the patient will be made accessible through GPS navigation to the expecting individual, such as specialists or family members. After getting the patient's exact location, it is conceivable to require take necessary action for proper treatment.(Banka et al., 2018)

2.7 GPS Location Tracking

People nowadays able to track the place of someone with the aid of location based service which also known as Global Positioning System(GPS). Not only people can be tracked using GPS service but objects, machines, vehicles and resources can be tracked. The location can be accessed using some gadgets as smart phone, PDA's and others (Adusei, *et al,* 2004). Requesting location sensitive information is usually initiated by a user called the client or network provider. Most application nowadays uses Global Positioning System (GPS) to provide location information such as Facebook, Instagram, WhatsApp and so on. This location service not like previous tracking system and will give user to create a bookmark for current location and able to route back to that location from anywhere using Google Maps API's (Kolapo, 2015).

Over the last decade, GPS constellation has continuously increased the robustness of satellite positioning with some improvements on GPS. So the reliability and the possibilities of a GNSS-based structural health monitoring system has been improved. GPS receivers are more efficient with some simple hardware. It is used in an appropriate workflow such as relative positioning with short baselines. . Data from GPS sensor is analysed and correlated with traditional data, such as piers temperature (Nicolas Manzini et al, 2018).

Nowadays the system used to monitor health have transformed rapidly. Smart systems also introduced to monitor patient's health status. The recent monitoring system for health status of patients will try to track, trace and monitor their health, so that the medical service given in correct time. With the aid of some sensors, data will be obtained and classified with a configurable threshold via Microcontroller. The system will be able to bridge the gap between patients in dramatic health change occasions- and health entities who response and take actions in real time fashion.[10](Kahtan Aziz et al,2016

The Global Positioning System (GPS) is a space-based radio navigation system that provides reliable positioning, navigation, and timing services to users. Receivers receive information and use triangulation to calculate the user's exact location. GPS finds application in every realm of the world. GPS coordinates is possible to evaluate conservation efforts and assist in strategy planning(Swagata Upreti et al, 2015)

2.8 Covid-19

Recently, Covid-19 pandemic is one of the major global problem faced by health organizations. According to a statistic from reliable source, it is stated that as November 19, 2020, more than 56.4 million people confirmed infected with SARS-COV-2 worldwide. But for the Covid-19 fatalities, it exceeds 1.35 million. It is concluded that Covid-19 cases are surging worldwide. Normally a Covid-19 patient will have some similar symptoms.[9] The symptoms are shortness of breath, fever, headache, decrease in oxygen saturation level, diarrhea, sore throat, dry cough, loss of taste, vomiting and smell, body pain, and abnormal pulse rate.(Safia Mehnaz et al, 2021).

The COVID-19 pandemic has brought into sharp focus the need to harness and leverage our digital infrastructure for remote patient monitoring. Current tests and vaccines take time to emerge, so for detect disease and monitor health status can be helped by wearable sensors. This technology used to correlate physiological metrics in daily live. The translation of this technology can predict Covid-19 incidence. Identifiable data, for example remote monitoring of cohorts (family, businesses, and facilities) associated with individuals diagnosed with COVID-19, can provide valuable data such as acceleration of transmission and symptom onset. (Dhruv R. Seshadri et al, 2020)

Nowadays, the Covid-19 has made a huge change in everyday life of human population. The main dominations of this Covid-19 pandemic in everyday life are work from home, social distancing and so on. Univariate and multivariate regression was used to examine differences in quality of life between different groups of people during the COVID-19 pandemic and their associations with selected predictors. This Covd-19 also has make some negative impacts to human such as fear of infection, concern about the health of family members and stress, for example due to the dual burden of working from home and childcare. (Robert Koch, 2021)

Severe Acute Respiratory Syndrome coronavirus type 2 (SARS-CoV-2) has threaten public health system in many countries. In some developed countries, positive patients normally placed in home isolation immediately after diagnosis. This type of home isolation will develop a severe course of the disease mainly for patients with risk factors. The example of those factors are cardiovascular, metabolic diseases, pulmonary and advanced age. Successful self-monitoring in residential separation is or maybe unfeasible. Some health authorities recommend that affected patients take their temperature reading at least three times a day. (David Wurzer et al, 2021)

CHAPTER 3

METHODOLOGY

3.1 Flowchart

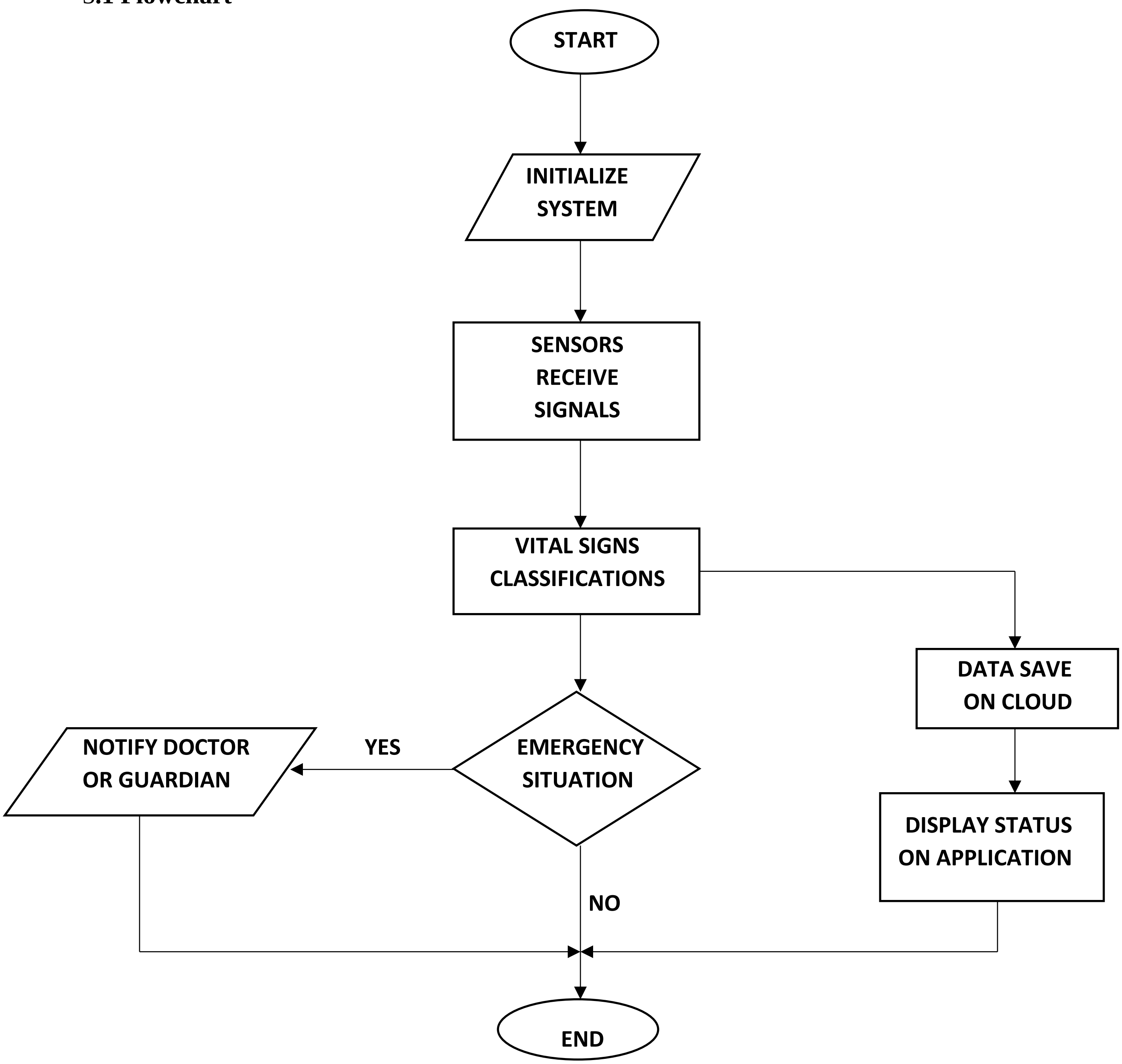


FIGURE 3.1.1 Flowchart Of The System

The workflow of the study is outlined in the form of flowchart above. The flow starts with the study of past equipment and technologies utilized for the health monitoring system. On the first place, system will be initialized. After that, the sensors start to get signals reading about the vital signs to find the health condition of self-quarantined Covid-19 patients. Then, the signal will be translated by controller board which is Arduino Uno. The analogue electrical signals translated into digital output. In the system got some data classification with respect to the heartbeat reading, oxygen saturation in blood arterial, temperature reading, fall detection and GPS location . In the event that the classification has reached dangerous level, it will alert doctor or guardian by notify them. If the classification didn't reach dangerous level, the system will keep tracking the health status. The data will be stored on cloud and it can viewed by user via an application.

3.2 Block Diagram

3.2.1 Hardware

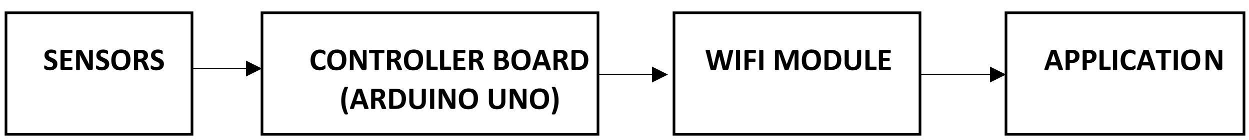


FIGURE 3.2.1 Block Diagram Of Hardware

For hardware, the output from the sensors will be detect by controller board which is Arduino Uno. The signals received will be transformed to digital form because the raw data from sensor is analogue signal. Arduino Uno will also classify the information according to the vital signs for chronic disease. It also will send health status to the user's application via Wi-Fi.

3.2.2 Software

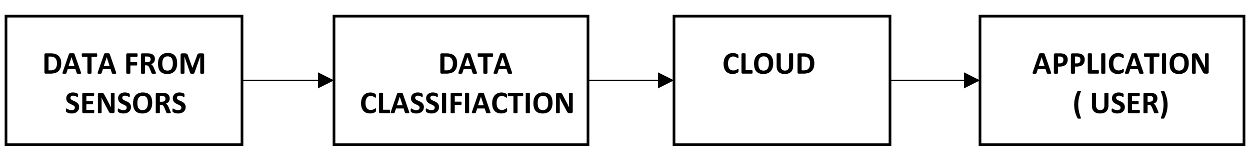


FIGURE 3.2.2 Block Diagram Of Software

When the data is obtained from the sensors, the data will be classified in respect to the vital signs. Then the classified data will be saved on Cloud. The status of health can be viewed by user via an application. In emergency situation, the doctor or guardian will be alerted with a notification message.

3.3 Vital Signs Of The System

3.3.1 Body Temperature

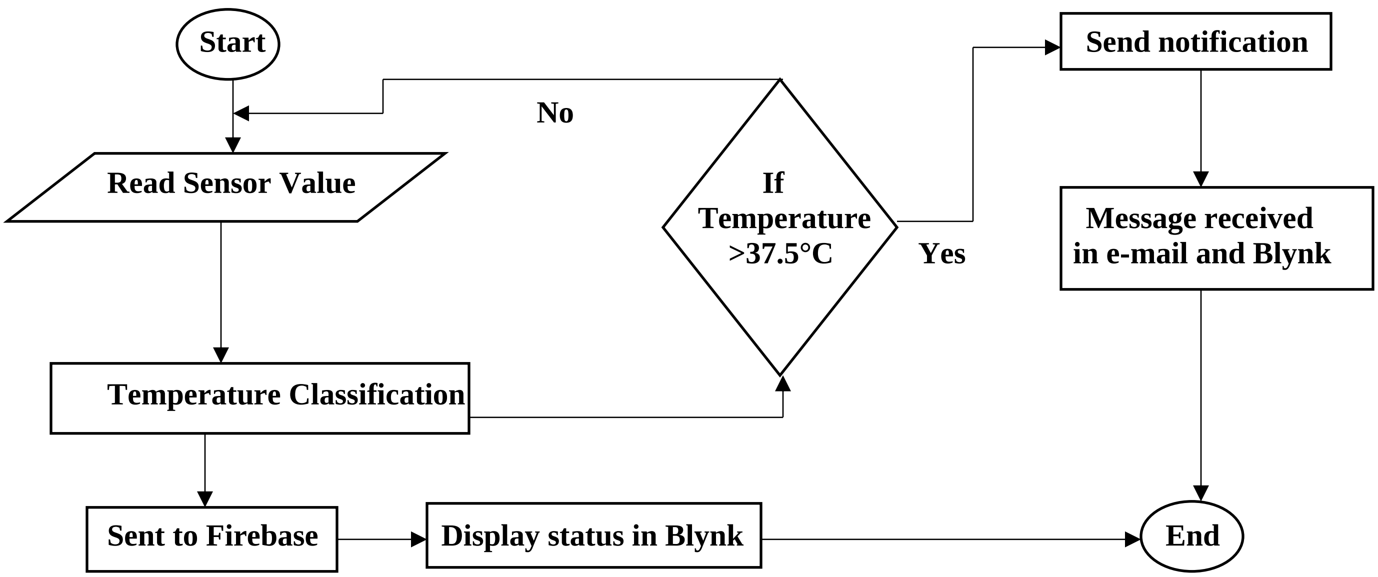


FIGURE 3.3.1.1 Flowchart For Temperature Sensor

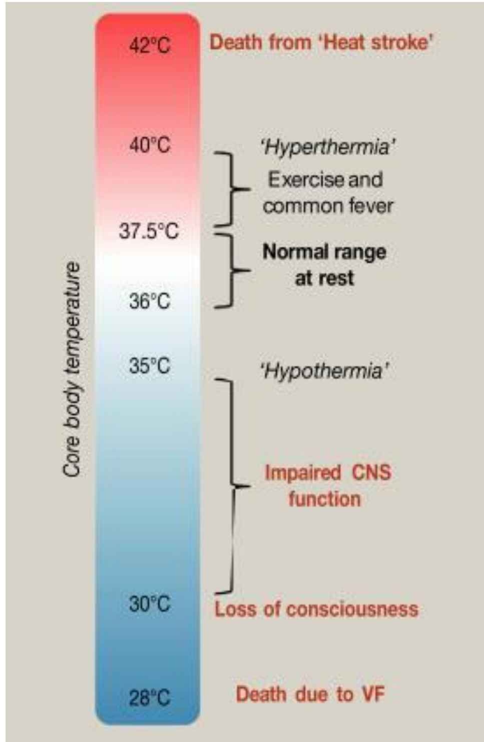


FIGURE 3.3.1.2 Graphical Presentation Of Human Body Temperature

Classification	Temperature
Hypothermia	<35‘C
Normal	36.5’C – 37.5’C
Fever/Hyperthermia	>37.5’C – 38.3’C
Hyperpyrexia	>40.0’C

TABLE 3.3.1.1 Classification Table For Body Temperature

From the table above, we can know that the temperature human mainly lies from 25°C to 42°C. The classification on the table above is for the temperature reading on forehead. The temperature varies depend on the place we taking measurement. Taking temperature measurement on the forehead is recommended by most medical authority as it can give accurate body temperature. For this project, we set 36.5°C – 37.5°C as normal body temperature. If it is lesser than or more than the normal range, a notification will be send to mobile application. The temperature reading is taken with the aid of LM35 as it is more accurate than thermistor.

3.3.2 Heart Rate

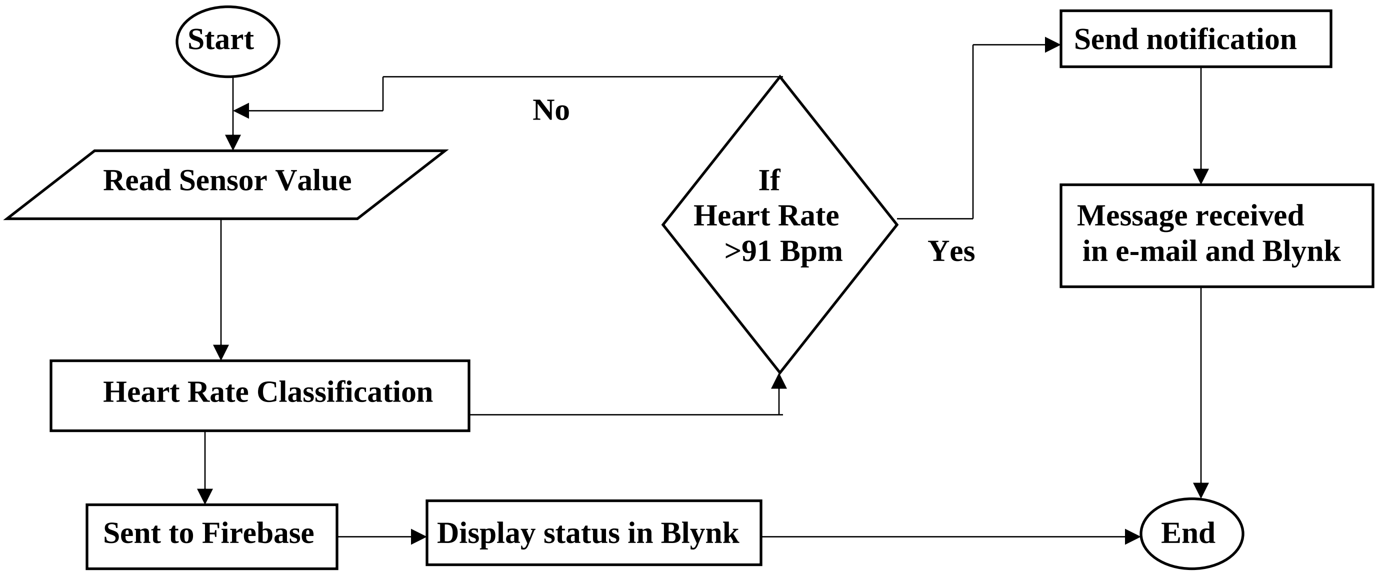


FIGURE 3.3.2.1 Flowchart For Heart Rate Detection

FIGURE 3.3.2.2 Graphical Representation Of Heart Rate

Age	18-25	26-35	36-45	46-55	56-65	65+
Athlete	49-55	49-54	50-56	50-57	51-56	50-55
Excellent	56-61	55-61	57-62	58-63	57-61	56-61
Good	62-88	62-90	63-90	64-92	62-94	62-95
Average	89-93	91-93	91-94	93-96	95-96	95-96
Poor	≥94	≥94	≥94	≥9	≥97	7≥97

TABLE 3.3.2.1 Classification Table For Heart Rate According Age

Referring to the table of heart rate classification above, we can conclude that the range of heart rate varies with age. The heart rate is about how many times the heart pump the blood in one minute. Heart rate also known as pulse. The unit for heart rate is BPM(beats per minute). For teen with the range age of 18 to 25, the normal heart rate count is 62 to 88 BPM. For adult from age 26-35, the nominal heart beat is 62-90, for adult aged 36-45, the normal heart beat rate is 63-90, for elder people aged 46-55, normal heart beat rate is 64-92, for senior citizenship aged 56-65, the normal heart beat rate is 62-94 and for senior citizen aged more than 65 years old, the nominal heart beat rate is 62-95. A higher heart beat rate higher than the normal reading maybe caused by weakness of heart muscles due to some virus infection or other problems that force heart to beat more vigorously to pump blood to the full body.

3.3.3 Oxygen Saturation in Blood (SPO2)

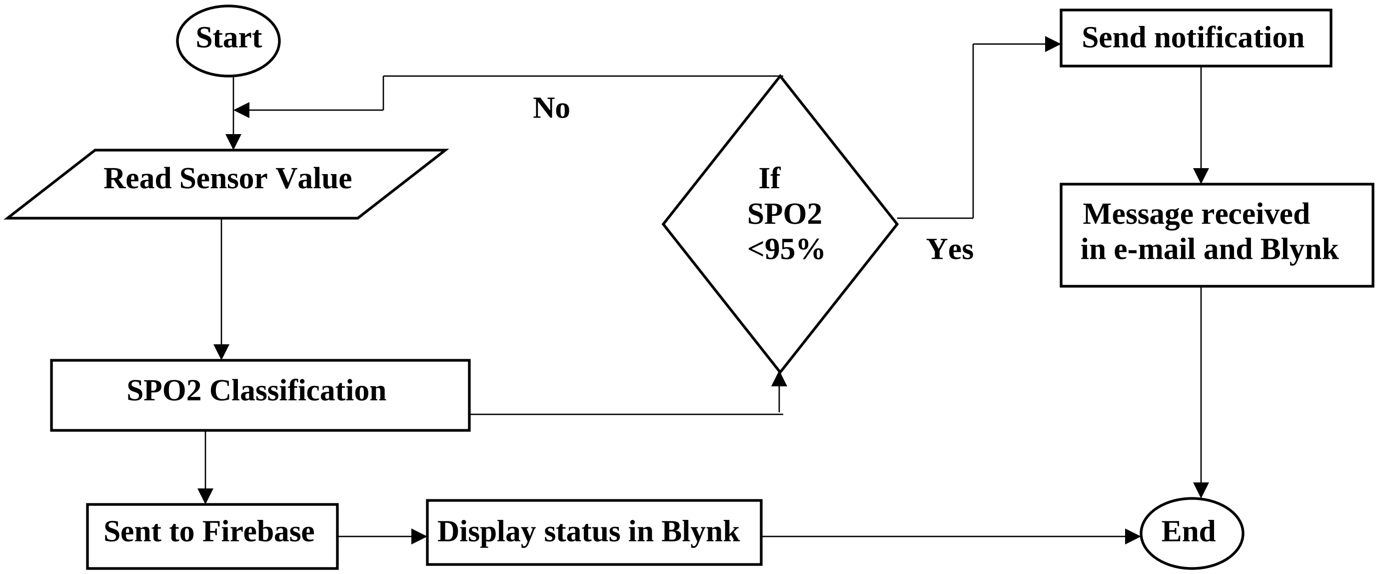


FIGURE 3.3.3.1 Flowchart For Oxygen Saturation In Blood (SPO2)

FIGURE 3.3.3.2 Graphical Representation Of Oxygen Saturation In Blood (SPO2)

Classification	SP02 (%)
Normal	95 - 100
Mild Hypoxemia	91 - 94
Moderate Hypoxemia	86 – 90
Severe Hypoxemia	<85

TABLE 3.3.3.1 Table Of Classification For Oxygen Saturation In Blood (SPO2)

As seen in classification table of oxygen saturation in blood (SPO2) above we can say that normal level of oxygen saturation in blood is 95%. 91% to 94% is considered as mild hypoxemia. 85% to 90% is considered as moderate hypoxemia. The severe hypoxemia is when the of oxygen saturation in blood (SPO2) is less than 85%. In this Covid-19 pandemic if a patient less than 95% they need to given oxygen. In this project we use MAX30102 to detect the oxygen saturation in blood (SPO2). This type sensor is accurate than other pulse oximeters.

3.3.4 Medical Verification

The classification table of body temperature, heart beat rate and oxygen saturation in blood is verified by the health authority.

Classification of Vital Signs for Covid-19 patients

Oxygen Saturation in Blood (SPO2)

Classification	SP02
Normal	95 - 100
Mild Hypoxemia	91 - 94
Moderate Hypoxemia	86 – 90
Severe Hypoxemia	<85

Heart Rate

Age	18-25	26-35	36-45	46-55	56-65	65+
Athlete	49-55	49-54	50-56	50-57	51-56	50-55
Excellent	56-61	55-61	57-62	58-63	57-61	56-61
Good	62-88	62-90	63-90	64-92	62-94	62-95
Average	89-93	91-93	91-94	93-96	95-96	95-96
Poor	≥94	≥94	≥94	≥9	≥97	7≥97

Body Temperature

Classification	Temperature
Hypothermia	<35‘C
Normal	36.5 – 37.5’C
Fever/Hyperthermia	>37.5 – 38.3’C
Hyperpyrexia	>40.0’C

Score / Vital Signs	0	1	2	3
Heart Rate	Excellent	Good	Average	Poor
SPO2	Normal	Mild Hypoxemia	Moderate Hypoxemia	Severe Hypoxemia
Temperature	Normal	Hypothermia	Fever / Hyperthermia	Hyperpyrexia

If sum of score > 5 = System will start alert

Prepared by,

....

VIKNESWARAN BALAKRISHNAN

EA18064

Verified & Approved by,

DR. JAYALACHUMY A/P BALAKRISHNAN
MB. BCH. BAO
(IRELAND-PENANG MEDICAL COLLEGE)
Pegawai Perubatan
Hospital Sultanah Maliha
No. Pendaftaran MPM - 78611

Figure 3.3.4.1 Evidence Of Data Classification Table Verified By Health Authority.

3.4 Components

There are some main components including sensors which playing a vital role in get the vital signs for chronic disease. The sensors are very important because each sensor manufactured with their special working principle and its vey helpful in monitor the health status.

3.4.1 Arduino Uno

Figure 3.4.1.1 Arduino Uno

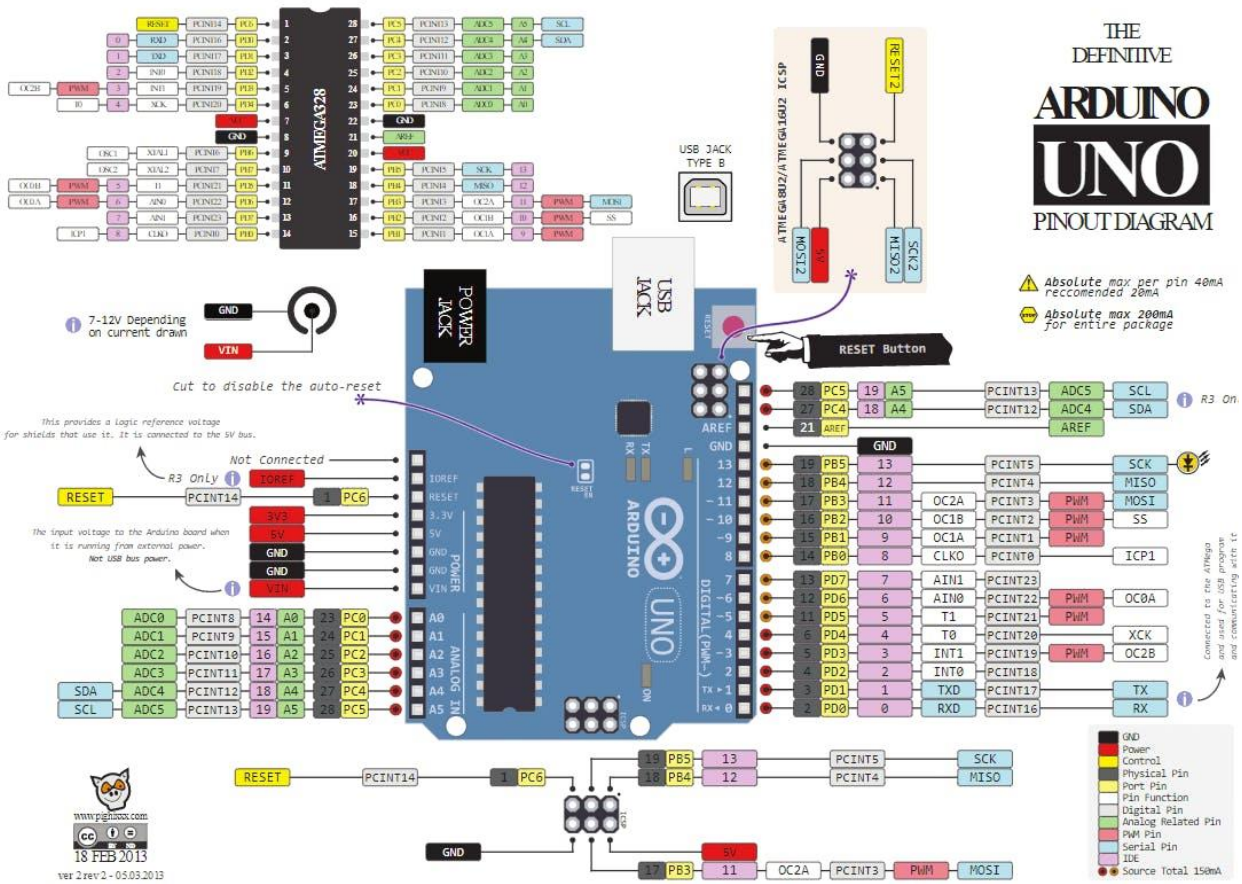


Figure 3.4.1.2 Schematic Diagram Of Arduino Uno.

Arduino Uno is a microcontroller board based on ATmega328P IC. It has 14 digital pins which includes digital inputs and digital outputs. The pins are 6 analog inputs pins, one USB connection, one power jack, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), one ICSP header, 6 PWM output pins header and a reset button. It can be connected to the computer by just using USB cable or with an AC-DC adapter or dry cell. The CPU used is Microchip AVR which is 8-bits and memory is SRAM. Static Random Access Memory (SRAM) only requires a minimal power requirement, 5 voltage to 12 voltage but can have the fast processing speed. The advantage of this developer board is we can program and repogram it because the storage used is EEPROM. When we enter the program to the board it will overwrite the previous coding.

3.4.2 LM-35 Temperature Sensor

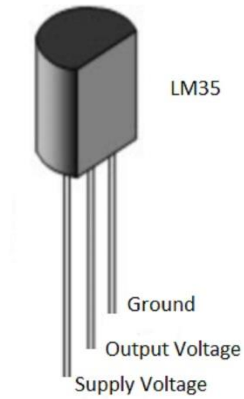


Figure 3.4.2.1 LM-35 Temperature Sensor

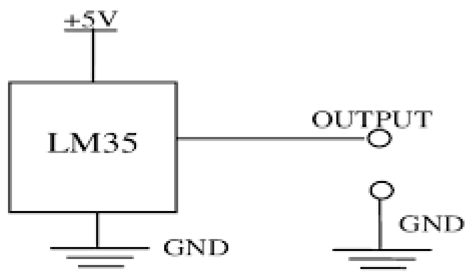


Figure 3.4.2.2 Schematic Diagram Of LM-35 Temperature Sensor

LM35 is one of the commonly used sensors for measure temperature. LM35 has three pins which are input voltage (Vcc), analog output and ground. This sensor only requires a small input voltage to operate and it is 4 volts. This device has an analog output voltage which proportional to temperature. The output of this device is in Degree Celsius and it does not require any external calibration circuitry. Reading of LM35 is more accurate than a thermistor. LM35 has a sensitivity of 10 mV/degree Celsius. When the temperature inclines, the output voltage also inclines. LM35 temperature sensor can read the temperature from -55°C to 150°C.

3.4.3 ESP8266 Wi-Fi Module

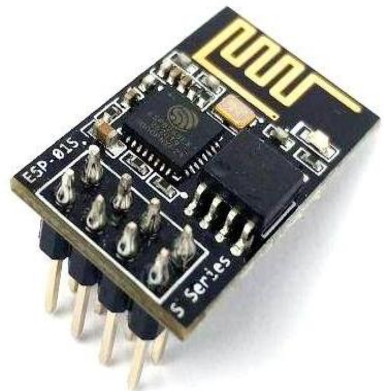


Figure 3.4.3.1 ESP8266 Wi-Fi Module

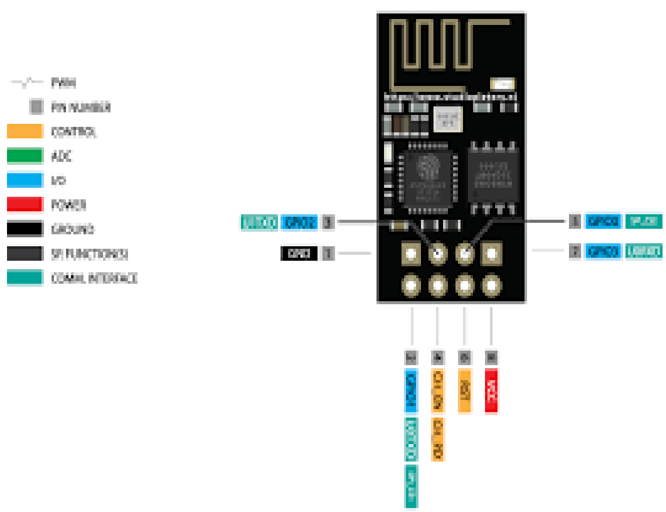


Figure 3.4.3.2 ESP8266 Wi-Fi Module Pinout

For this project ESP8266 Wi-Fi Module is needed because data obtained will be stored in Cloud. This microchip is a self-contained SOC with TCP/IP protocol stack, so that any microcontroller can access to Wi-Fi network. ESP8266 has 8 pins which are input voltage pin (Vcc), ground pin (Gnd), reset pin (Rst), transfer receiver pins (RX TX) and GPIO pins for outputs and inputs. This Wi-Fi module can host application or offloading all Wi-Fi networking functions from another processor. ESP8266 is pre-programmed with AT command set firmware. The cost of this microchip also not expensive.

Label	GPIO	Input	Output
D0	GPIO16	no interrupt	no PWM or I2C support
D1	GPIO5	OK	OK
D2	GPIO4	OK	OK
D3	GPIO0	pulled up	OK
D4	GPIO2	pulled up	OK
D5	GPIO14	OK	OK
D6	GPIO12	OK	OK
D7	GPIO13	OK	OK
D8	GPIO15	pulled to GND	OK
RX	GPIO3	OK	RX pin
TX	GPIO1	TX pin	OK
A0	ADC0	Analog Input	X

Table 3.4.3.1 Table Of Esp8266 Wi-Fi Module Pins

3.4.4 ADXL345 Accelerometer

Figure 3.4.4.1 ADXL345 Accelerometer

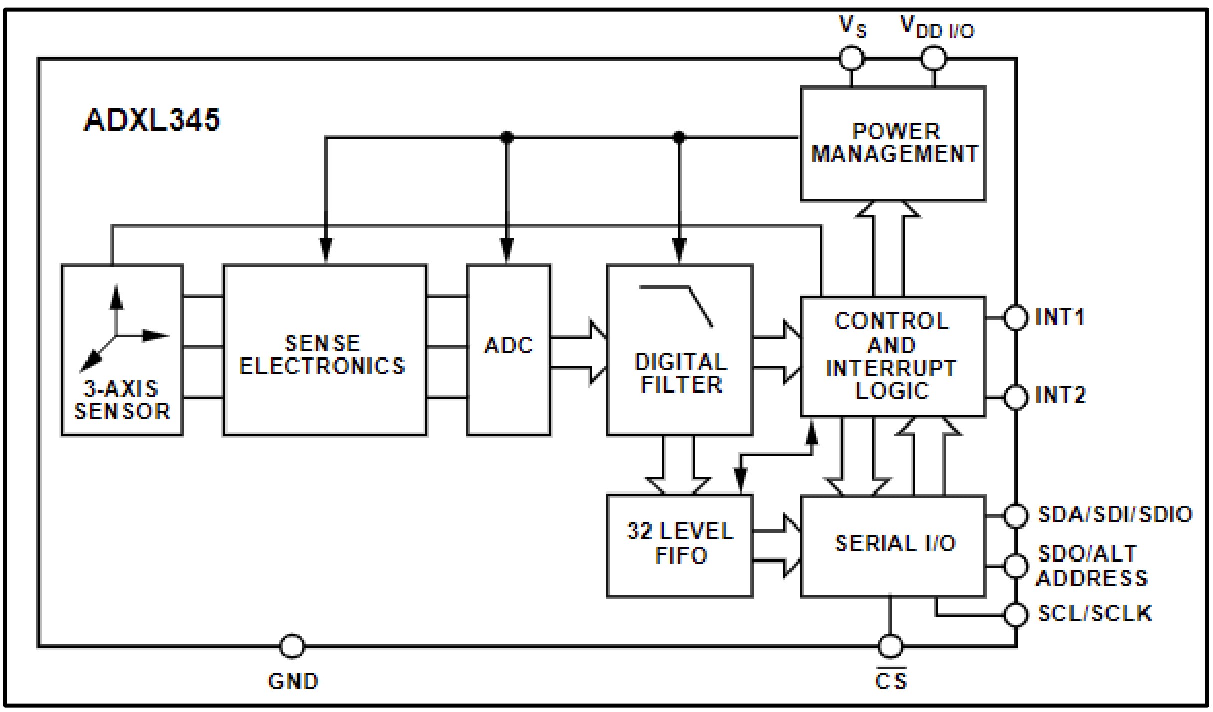


Figure 3.4.4.2 Block Diagram Of ADXL345 Accelerometer

The sensor named ADXL345 is used in mobile devices to measure static acceleration of gravity. We also can detect the axis such as x-axis, y-axis and z-axis. This sensor is very light in weight, thin and uses low power consumption. Power consumption of ADXL345 automatically scales with bandwidth. Output of this sensor is complemented by 16-bit twos and can be accessed through virtual SPI or I2C interface. This sensor has 10 fixed bit resolution. This sensor only needs a low input voltage of 2 volt until 3.6 volt. There are 8 pins for ADXL345 sensor which are GND pin, Vcc pin, CS pin, INT1, INT2, SDO pin, SDA/SDI/SDIO pin and SCL/SCLK pin. The pin description can be referred in table below.

Mnemonic	Description
GND	This pin must be connected to ground
VCC	Supply Voltage
CS	Chip Select
INT1	Interrupt 1 Output
INT2	Interrupt 2 Output
SDO	Serial Data Output (SPI 4-Wire) / I2C Address Select
SDA / SDI / SDIO	Serial Data I2C / Serial Data Input (SPI 4-WIRE) / Serial Data Input and Output (SPI 3-Wire)
SCL/SCLK	Serial Communications Clock

Table 3.4.4.1 ADXL345 Accelerometer Pins And Description

3.4.5 MAX30102

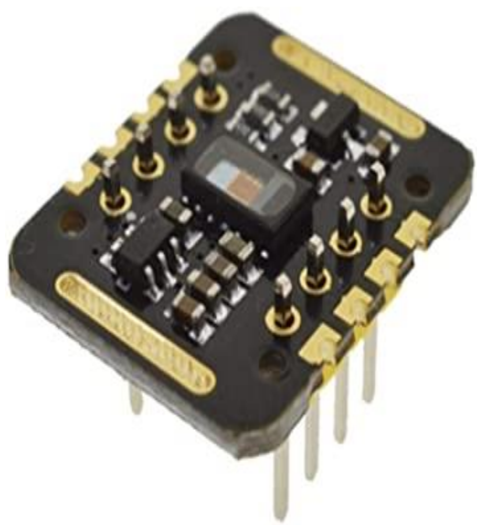


Figure 3.4.5.1 MAX30102

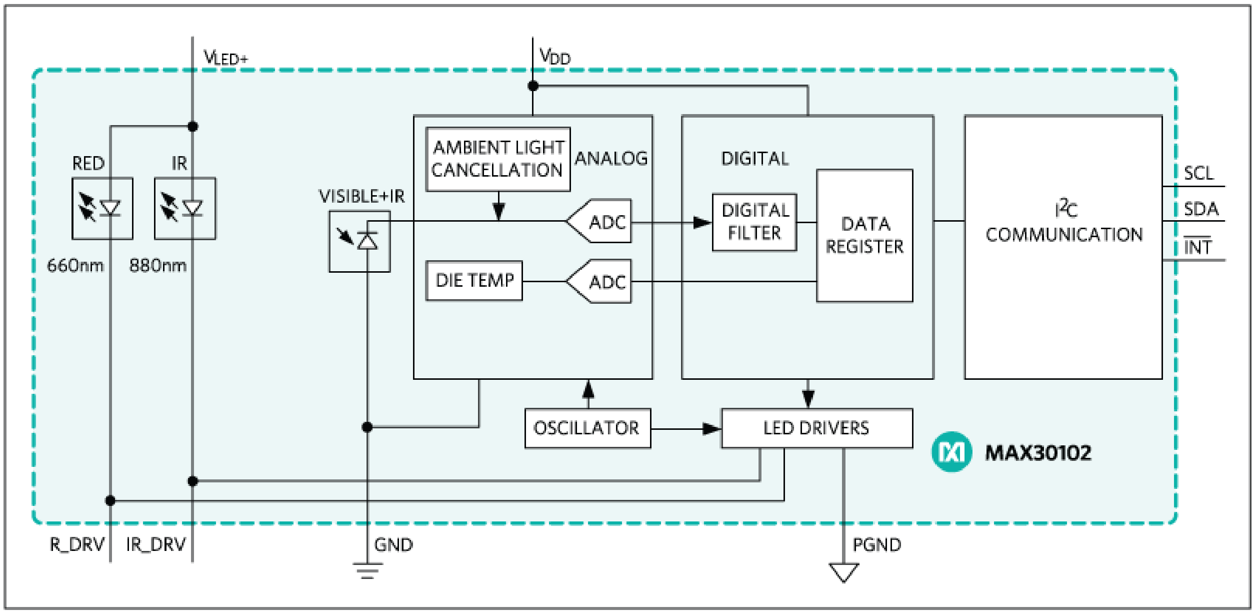


Figure 3.4.5.2 Block Diagram Of MAX30102

In this project our purpose is to monitor health status of user. Heart rate is one of the elements that we measure. The next element we measure is oxygen saturation in blood arterial (SPO2). For this we use MAX30102 because it is an integrated electrocardiogram and pulse oximeter sensor. This circuit built in with internal LEDs, photodetectors, optical elements, noise cancellation circuit and so on. MAX30102 also has ambient light rejection. This model is wearable type sensor. This sensor operates with small power supply of 1.8 voltage and separate 3.3 voltage power supply for LEDs. This sensor communicate via standard I2C-compatible interface.

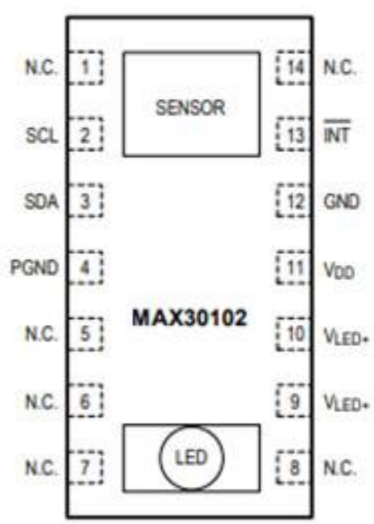


Figure 3.4.5.3 MAX30102 Pinout Configuration

PIN	NAME	FUNCTION
1, 5, 6, 7, 8, 14	N.C.	No Connection. Connect to PCB pad for mechanical stability.
2	SCL	I^2C Clock Input
3	SDA	I^2C Data, Bidirectional (Open-Drain)
4	PGND	Power Ground of the LED Driver Blocks
9	V_{LED+}	LED Power Supply (anode connection). Use a bypass capacitor to PGND for best performance.
10	V_{LED+}	
11	V_{DD}	Analog Power Supply Input. Use a bypass capacitor to GND for best performance.
12	GND	Analog Ground
13	$\overline{INT}$	Active-Low Interrupt (Open-Drain). Connect to an external voltage with a pullup resistor.

Table 3.4.5.1 MAX30102 Pinout Configuration and Functions

3.4.6 Ublox GPS NEO 6M

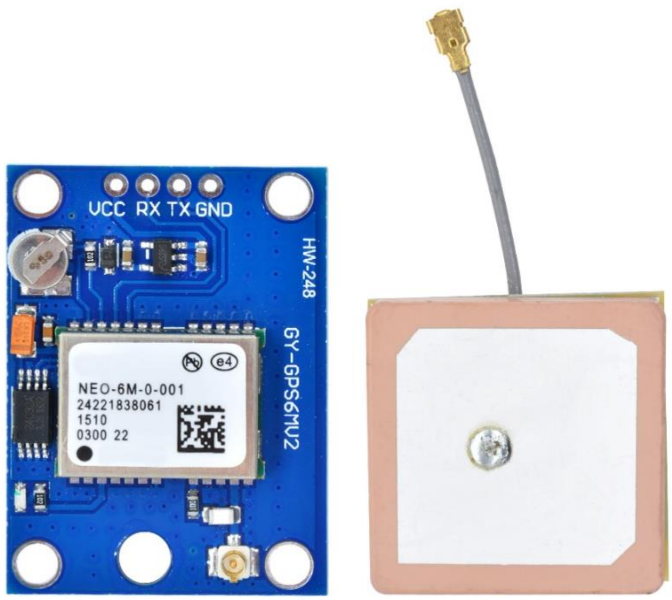


Figure 3.4.6.1 Ublox Gps Neo 6m

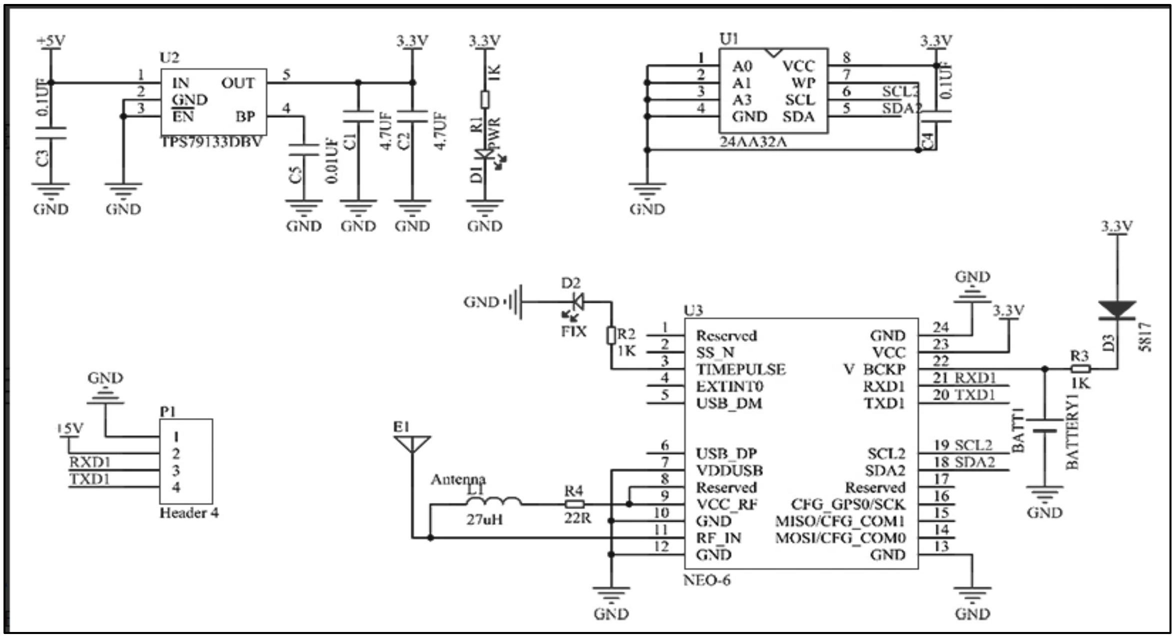


Figure 3.4.6.2 Block Diagram Of Ublox GPS NEO 6M

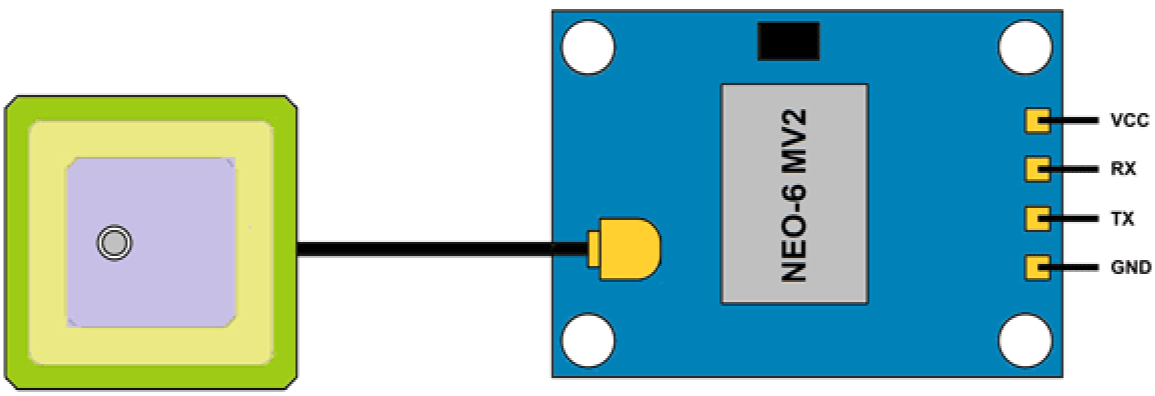


Figure 3.4.6.3 Ublox GPS NEO 6M GPS Tracker Pinout

For this project, we use Ublox Neo 6M GPS tracker and receiver to know the exact location of patient. This type of GPS tracker and receiver chosen because it has a navigation update rate of 1Hz to 5Hz. Its horizontal position accuracy is 2.5m. Next, the serial baud rate for GPS Neo 6M is from 4800 to 230400 and it only require small amount of voltage to operate which in between the range of 2.7V and 3.6V. Ublox Neo 6M GPS has 4 pins. The pins are Vcc pin for input voltage, RX pin for UART receive pin, TX pin for UART transmit pin and Gnd pin for ground.

3.5 Software

3.5.1 Arduino IDE

For software, we develop the project using Arduino Uno because we want to do a prototype. The software used for this project is Arduino IDE.

Figure 3.5.1.1 Arduino IDE Software

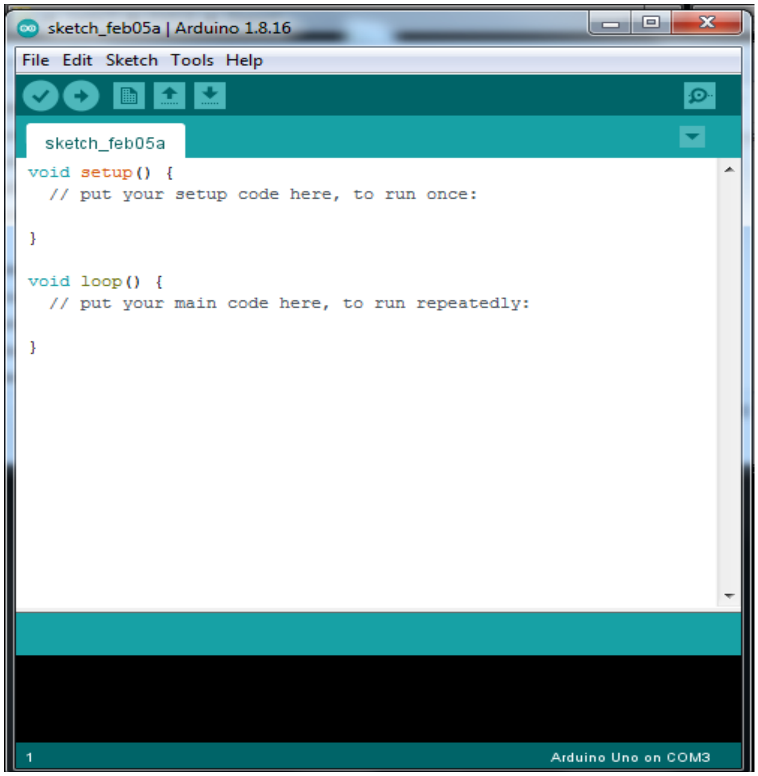


Figure 3.5.1.2 Arduino IDE Software Coding Page

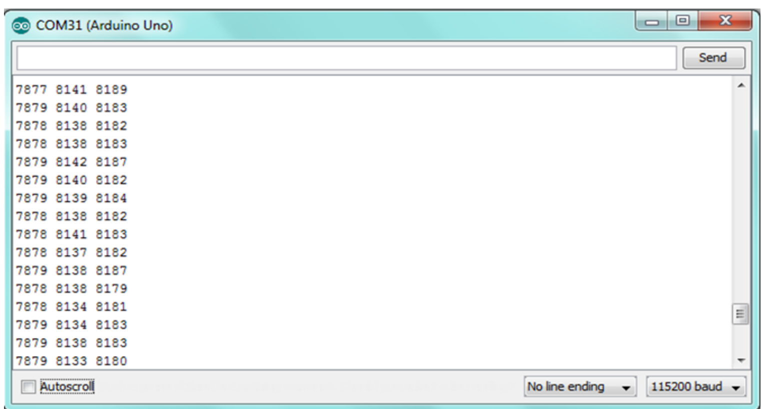


Figure 3.5.1.3 Example Of Serial Monitor In Arduino IDE

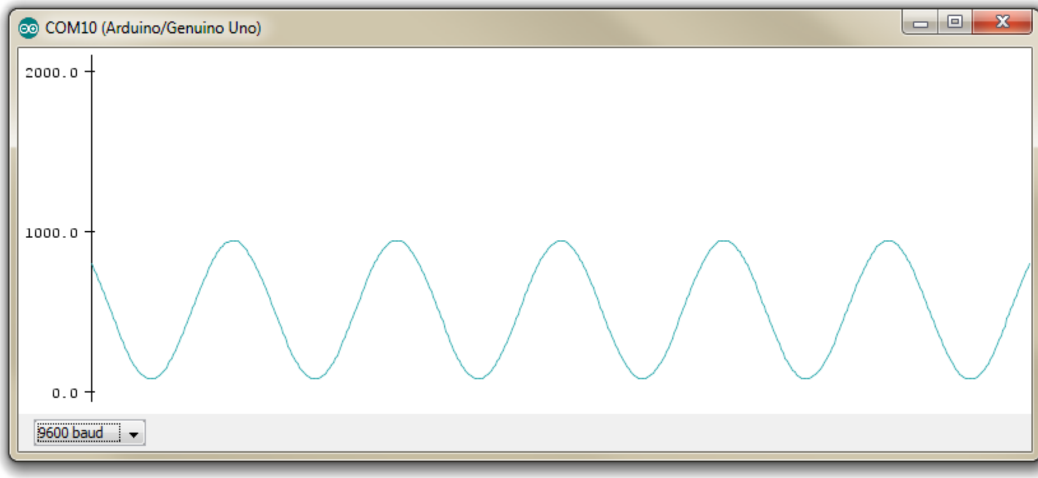


Figure 3.5.1.4 Example Of Serial Plotter In Arduino IDE

Arduino IDE is one of software that is free to use. We can write a program for microcontroller board in this software. Using this software we can do coding for all type of Arduino boards. Internet of Things (IoT) related project also can be done in this software. In this Arduino IDE software, it has void setup, void loop and void function. Void setup commands are for declare and define variables for the project. Void loop command is for coding part which will repeat in loop until we stop it. Void function command is for function return type. It will indicate that function not return a value. We also need to select the correct port and board type to export to microcontroller board after the coding is verified and contain zero error.

3.5.2 Firebase

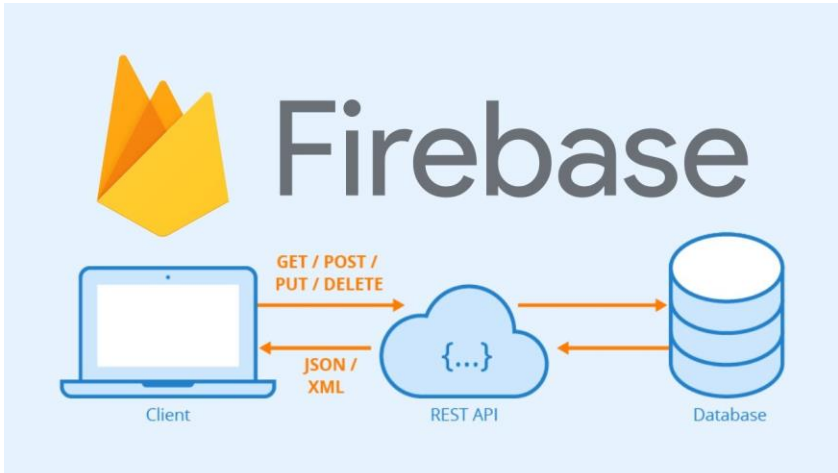


Figure 3.5.2.1 Firebase Online Cloud

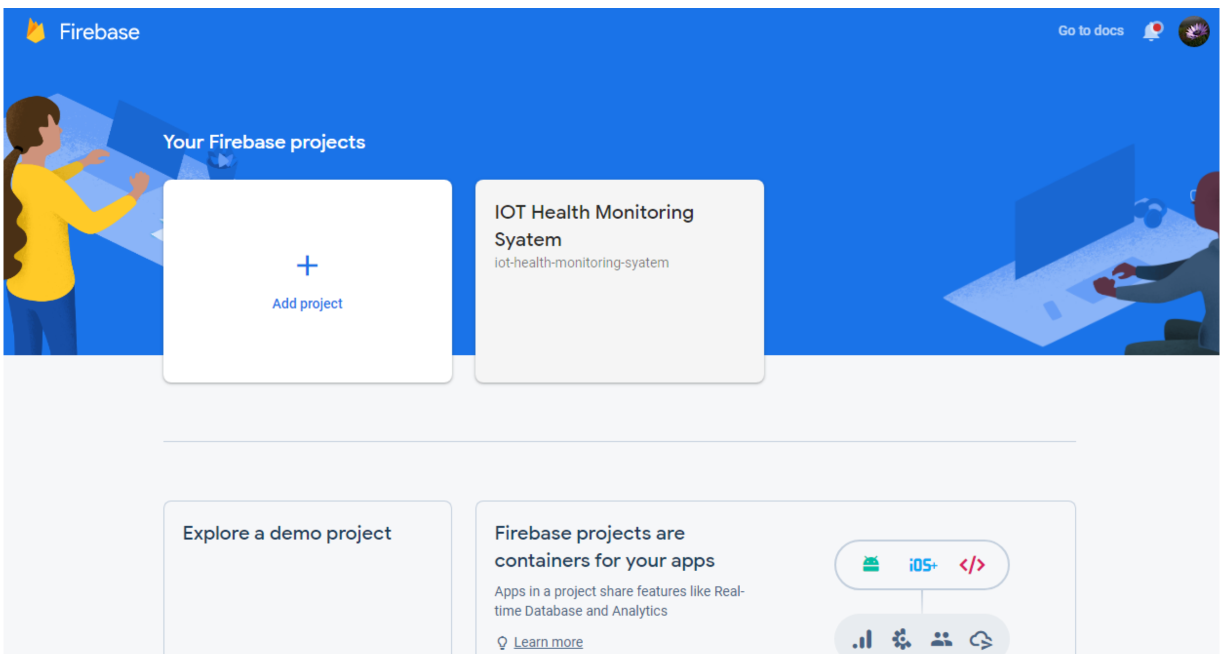


Figure 3.5.2.2 Firebase online cloud Main Page

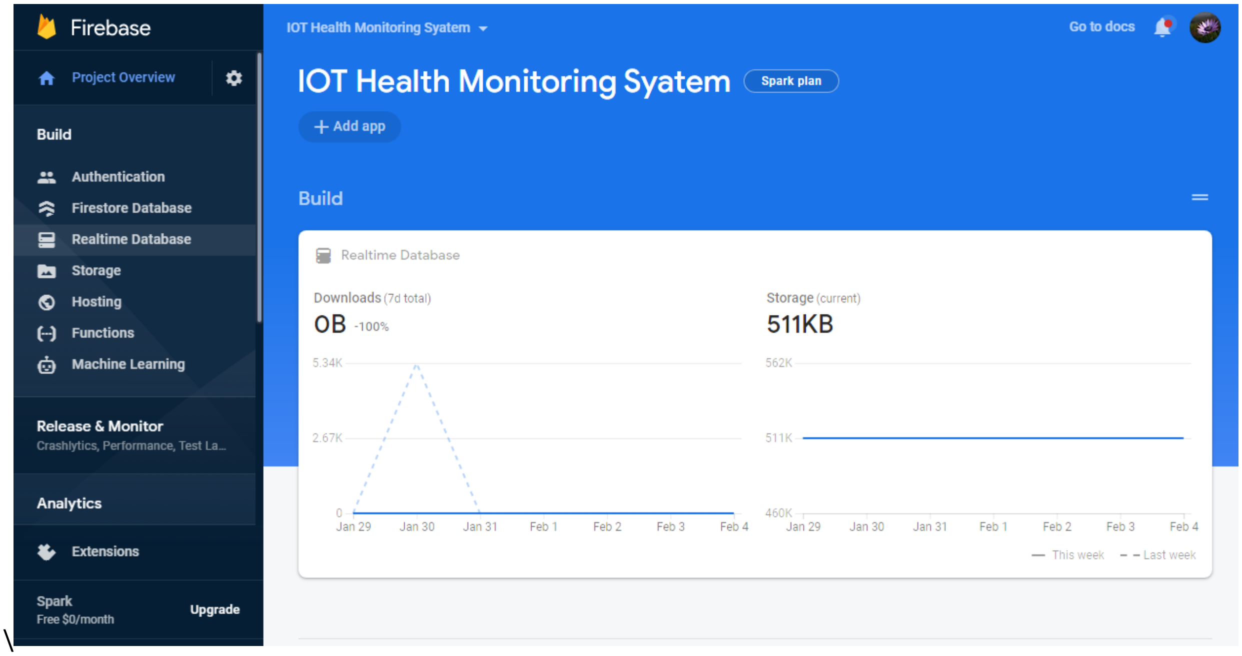


Figure 3.5.2.3 Firebase Online Cloud Realtime Monitor

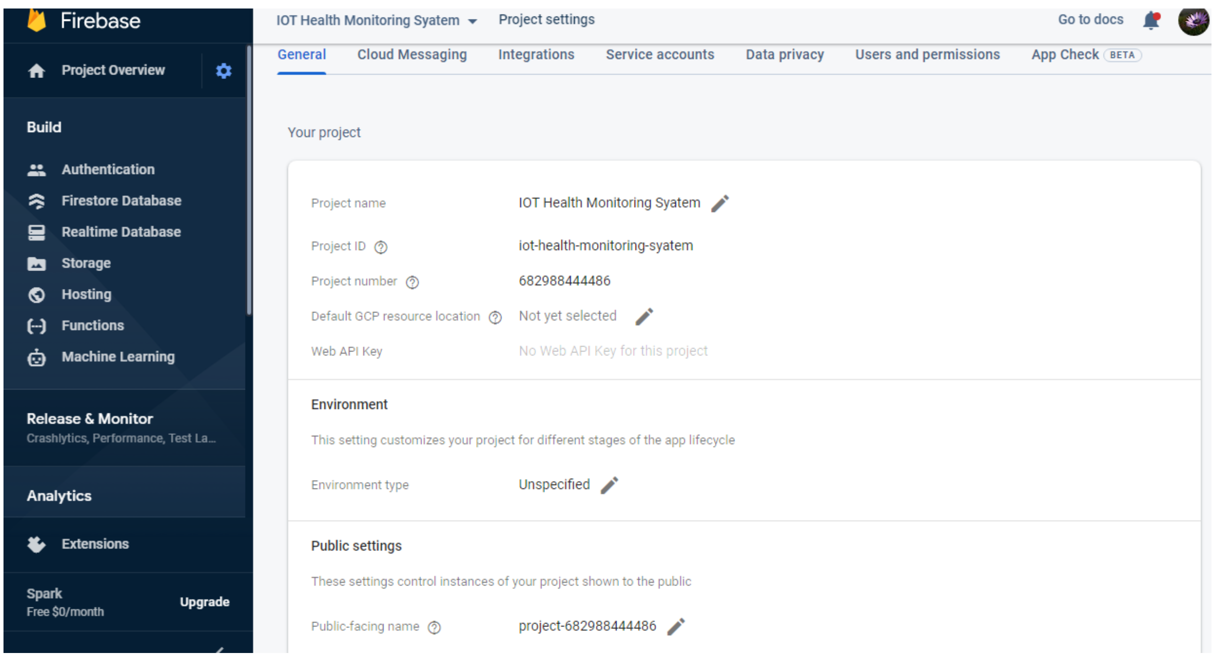


Figure 3.5.2.4 Channel ID And API Key For Firebase

Firebase is an application of Google. It is a Google backed application development software that enables to develop Internet of Things(IoT) apps. Firebase is an online cloud to collect, save, analyze, visualize data from microcontroller board such as Arduino boards, Raspberry Po board, Nodemcu boards and so on. This cloud is free to use but with limited storage.

If we need a large space to save data we need to purchase monthly pack. Firebase also provide tools to track analysis, report and fixing app crash. Firebase is a cloud-hosted NoSQL which can store and sync data in real time. After a channel is created in Firebase, we can write data and view data via the API key of channel. Every channel has a specific API key value. There are two types of API keys which are Write API and Read API. Write API is for wrote data in Firebase. Read API is to allow people to see results in Firebase online cloud.

3.5.3 Blynk

Figure 3.5.3.1 Blynk Mobile Application

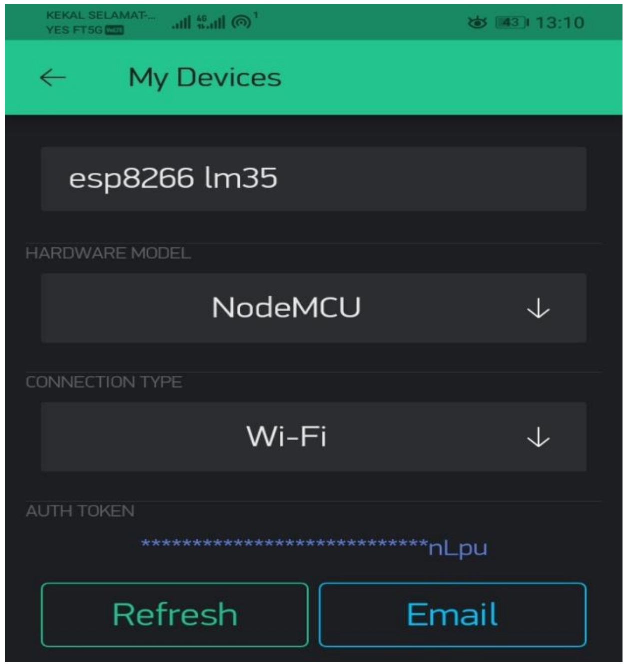


Figure 3.5.3.2 Channel name and Auth Key For Blynk.

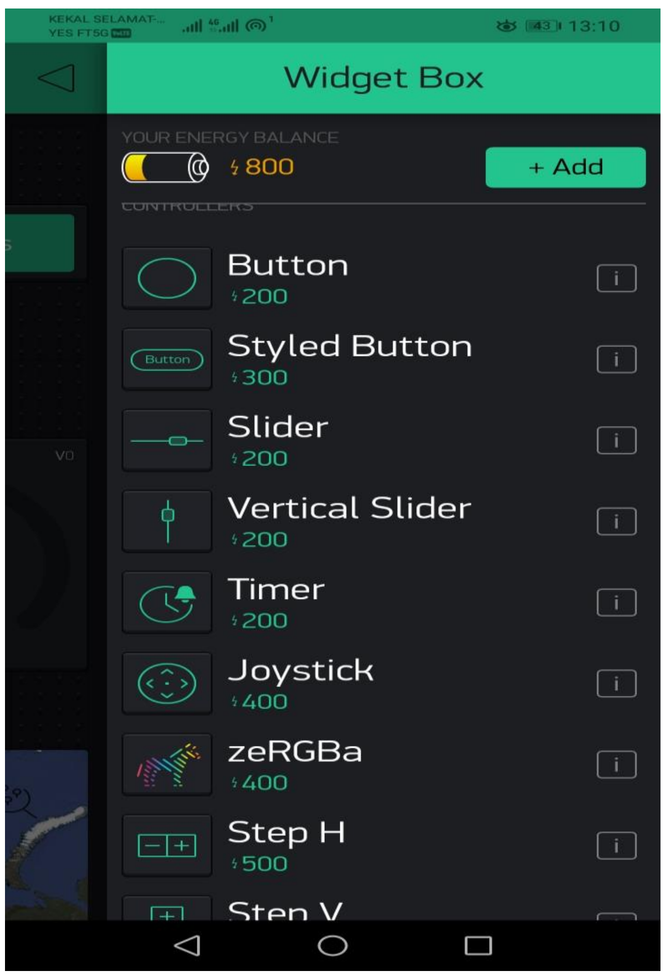


Figure 3.5.3.3 Widget Box in Blynk for add on option

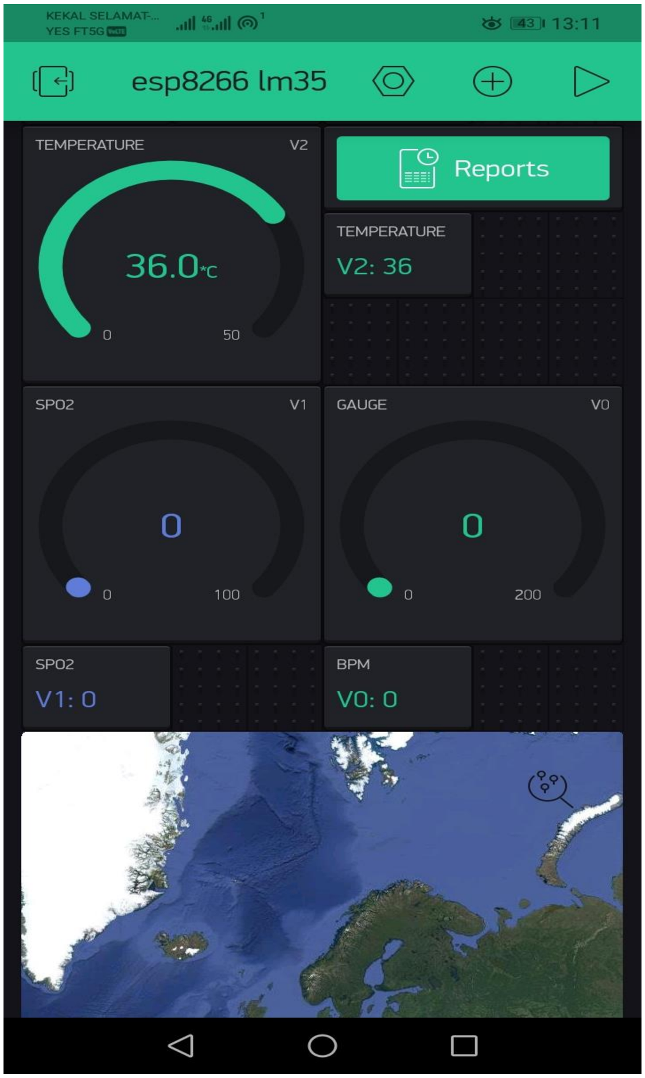


Figure 3.5.3.4 Main Page of Blynk Mobile Application

Blynk is a mobile application which can be downloaded directly from Google Play Store or Huawei Play Store. Blynk also can be used in IOS phones. Blynk is used to create a graphical interference or human machine interface (HMI). This process is done by compile and provide appropriate address on widget. In blynk we build interfaces to control and monitor the hardware projects with just Android or IOS smartphones. Blynk mobile application is free to use. They give some coins as we registered as new use and the coins we will use to create dashboard and select elements we need. The examples of elements are button, graphs, slider, labelled value display, Google Maps and others.

3.5.4 Circuit,io

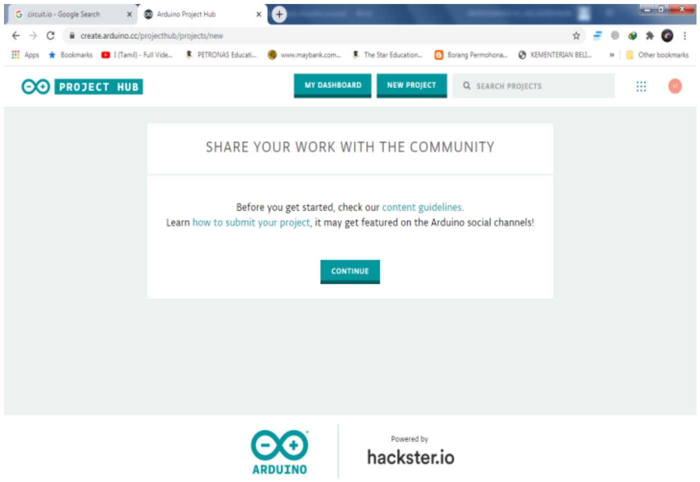


Figure 3.5.4.1 Main Page Circuit.io

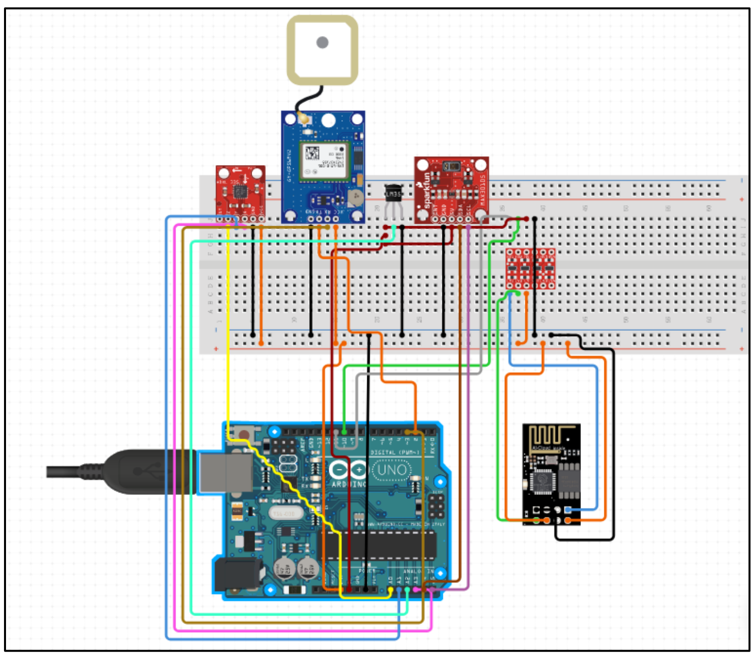


Figure 3.5.4.2 Circuit Drawn in Circuit.io

Circuit.io is an online platform to design electronic circuits. In this circuit designing app, we can auto generate the schematics with accurate and less time. We select the electronic components, major building blocks we need and the application will make a connection for the schematic.

3.6 Resource and Financial Planning

Components	Quantity	Price
Arduino Uno	1	RM 35.00
LM35	1	RM 30.00
MAX30102	1	RM 45.00
ESP8266	1	RM 25.00
ADXL345	1	RM 45.00
Ublox GPS NEO 6M	1	RM 35.00
Breadboard	1	RM 12.00
Jumpers	1 packet	RM 8.00
Watch Strip	1	RM 10.00
	Total	RM 245.00

Table 3.6.1 Table of Components with Price

Table above shows the items used for project and its quantity and price. The total price for this project is Ringgit Malaysia 245.00.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Sample of Demographic

Name : Vikneswaran A/L Balakrishnan

Gender : Male

Age : 25

Number of Data : 5

Name : Magilan A/L Muniandy

Gender : Male

Age : 23

Number of Data : 5

Name : Elijah Ezzran Blase

Gender : Male

Age : 27

Number of Data : 5

Name : Chandrathevan A/L Sathiamurthy

Gender : Male

Age : 25

Number of Data : 5

Name : Dharswini A/P Ponnalagu

Gender : Female

Age : 25

Number of Data : 5

Name : Harvin A/L Krishnan

Gender : Male

Age : 25

Number of Data : 5

Name : Anbananthan Pillai A/L Munanday

Gender : Male

Age : 25

Number of Data : 5

For this project, I have taken data of seven people consisting of male and female with different age as can be seen the data above. Six male and one female helped me to carry out this project. Four male and one female are 25 years old while one person with 23 years old and one person with 27 years old are tested in this project. The value of temperature and heart beat rate differs from each other because of their lifestyle as some are physical active also known as athletes. In order to check the accuracy and precision value, the data taken is 3 times on first day with the minimal interval of 30 minutes and the remaining two data taken the next day. We need to wait at least 10 - 20 seconds once the device is wear in wrist. This is to stabilize the readings. For example, the temperature needs some time to get correct reading as it will be affected by surrounding temperature. The same process applied to take the reading of heart beat rate as it must detect the blood vessels in wrist and for oxygen saturation in blood also need some time to get actual reading. For GPS location tracking, it also needs some time to connect with satellite and give exact location detail as GPS location tracking device only refresh 15 seconds once. After a few minutes, the data values are recorded for classification and measure accuracy and precision value. To find accuracy and precision four possibility are used. The possibilities are true positive (TP), true negative (TN), false positive (FP) and false negative (FN). True positive (TP) is when disease is present and test result also show positive. True negative (TN) is when disease is absent and test result also show negative. False positive (FP) is when disease is absent but test result show positive. False negative (FN) is when disease is present but test result show negative. Accuracy is also known as how close the reading of measured value towards the expected value. Precision is how close the reading of measured value to each other.

4.2 Temperature (LM35)

With the help of temperature sensor LM35 body temperature can be obtained. This sensor first calibrated and tested using Arduino IDE. The reading we got from sensors is recorded through serial plotter and serial monitor. To get the temperature reading some algorithm has been use. The algorithm is **:**

```
temp_adc_val = analogRead(lm35_pin)
temperature = (temp_adc_val * input voltage)
temperature = ((temp_val/output voltage)
```

Thermometer Reading	Condition	My Project Temperature Reading	Condition	Possibility
37.8	Fever/Hyperthermia	37.5	Normal	FN
37.5	Normal	37.5	Normal	TN
37.3	Normal	37.8	Fever/ Hyperthermia	FP
36.8	Normal	37.0	Normal	TN
37.1	Normal	37.1	Normal	TN
36.1	Normal	36.4	Normal	TN
36.5	Normal	36.6	Normal	TN
36.6	Normal	36.6	Normal	TN
37.3	Normal	37.2	Normal	TN
37.5	Normal	37.5	Normal	TN
37.3	Normal	37.3	Normal	TN
37.3	Normal	37.2	Normal	TN
36.8	Normal	36.7	Normal	TN
37.7	Fever/Hyperthermia	37.5	Normal	FN
36.6	Normal	36.7	Normal	TN
37.3	Normal	37.5	Normal	TN
36.4	Normal	36.6	Normal	TN
35.8	Hypothermia	35.7	Hypothermia	TP
36.3	Normal	36.3	Normal	TN
36.8	Normal	36.7	Normal	TN
36.7	Normal	36.8	Normal	TN
36.6	Normal	36.6	Normal	TN
36.7	Normal	36.7	Normal	TN
37.2	Normal	37.3	Normal	TN
36.6	Normal	36.7	Normal	TN
37.3	Normal	37.3	Normal	TN
36.6	Normal	36.5	Normal	TN
35.8	Hypothermia	35.9	Hypothermia	TP
37.0	Normal	36.9	Normal	TN
37.5	Normal	37.5	Normal	TN
36.3	Normal	36.4	Normal	TN
37.0	Normal	36.8	Normal	TN
36.4	Normal	36.0	Normal	TN
37.4	Normal	37.5	Normal	TN
36.9	Normal	37.0	Normal	TN

Table 4.2.1 Data of Temperature

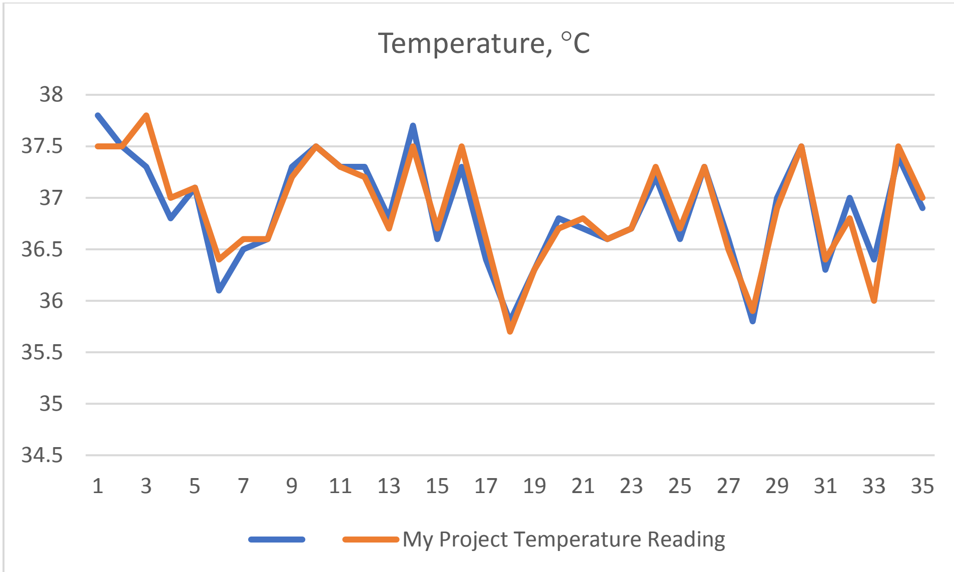


Figure 4.2.1 Comparison Graph Between My Device and Temperature Scanner for Temperature

True Positive (TP)	True Negative (TN)	False Positive (FP)	False Negative (FN)
2	30	1	2

Table 4.2.2 Data of Temperature for Accuracy and Precision

Accuracy = (TP+TN)/ (TP+FP+FN+TN)

= (2+30)/(2+1+2+30)

= 0.91

Accuracy = 0.91

Precision = TP/ (TP+FP)

= 2/(2+1)

= 0.67

Precision = 0.67

For temperature 35 data collected, one with device and another one with temperature scanner. The value of LM35 and temperature scanner differs a little bit due to the sensitivity of equipment. The normal range of temperature is from 36.0°C to 37.5°C. LM35 temperature sensor has an accuracy of 0.91 and 0.67 precise.

4.3 Heart Beat Rate (MAX30102)

MAX30102 is an integrated electrocardiogram, oximeter, heart rate monitor sensor pulse module. Inside this sensor got LEDs, photodetector noise cancellation circuitry. The sensors calibrated using Arduino IDE. The microcontroller receive analogue signals. So to convert it to digital form we use an algorithm. The algorithm is :

long delta = millis() - lastBeat

lastBeat = millis()

beatsPerMinute = 60 / (delta / 1000.0)

By applying this algorithm, the BPM can be obtained.

Automatic Omron Reading	Condition	My Project Reading	Condition	Possibility
72	Good	73	Good	TN
95	Poor	97	Poor	TP
94	Average	93	Average	TP
88	Good	88	Good	TN
67	Good	66	Good	TN
70	Good	73	Good	TN
75	Good	75	Good	TN
95	Poor	96	Poor	TP
93	Average	92	Average	TP
90	Good	90	Good	TN
89	Good	90	Good	TN
88	Good	90	Good	TN
94	Average	90	Good	FN
64	Good	66	Good	TN
80	Good	80	Good	TN
68	Good	73	Good	TN
63	Good	65	Good	TN
65	Good	65	Good	TN

78	Good	79	Good	TN
90	Good	88	Good	TN
88	Good	88	Good	TN
73	Good	74	Good	TN
76	Good	76	Good	TN
66	Good	68	Good	TN
68	Good	73	Good	TN
63	Good	65	Good	TN
65	Good	65	Good	TN
78	Good	79	Good	TN
85	Good	87	Good	TN
91	Average	90	Good	FN
88	Good	88	Good	TN
75	Good	75	Good	TN
83	Good	80	Good	TN
94	Average	93	Average	TP
89	Good	90	Good	TN

Table 4.3.1 Data for Heart Beat Rate

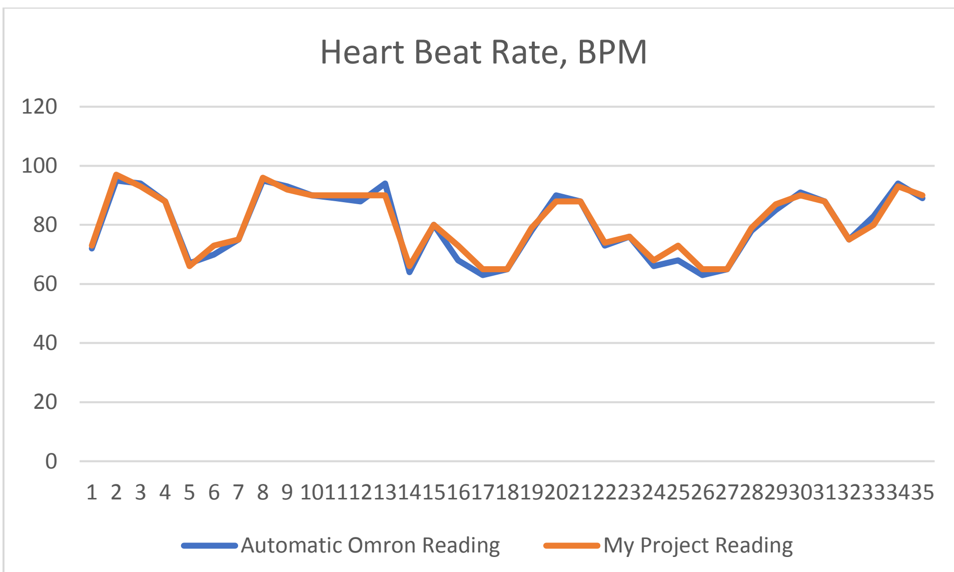


Figure 4.3.1 Comparison Graph Between My Device and Automatic Omron Device for Heart Beat Rate.

True Positive (TP)	True Negative (TN)	False Positive (FP)	False Negative (FN)
5	28	0	2

Table 4.3.2 Data of Heart Beat Rate for Accuracy and Precision

Accuracy = (TP+TN)/ (TP+FP+FN+TN)

= (5+28)/(5+0+2+28)

= 0.94

Accuracy = 0.94

Precision = TP/ (TP+FP)

= 5/(5+0)

= 1

Precision = 1

35 data have taken to find the accuracy and precision of MAX30102 for heart beat rate. The data is obtained with device and automatic omron machine. The value of MAX30102 and automatic omron machine differs a little bit due to the sensitivity of equipment. The normal range of heart beat for all type of ages are from 55bpm to 94bpm. MAX30102 pulse oximeter sensor has an accuracy of 0.94 and precision of 1.

4.4 Oxygen Saturation in Blood SPO2 (MAX30102)

R = (AC RMS of Red / DC of Red)/ (AC RMS of IR / DC of IR)

SpO2= 110 – 25 × R

SpO2 = SpO2 + offsetSpO2;

By applying this algorithm, the oxygen saturation in blood, SPO2 can be obtained.

Pulse Oximeter Reading	Condition	My Project Reading	Condition	Possibility
99	Normal	100	Normal	TN
95	Normal	96	Normal	TN
98	Normal	97	Normal	TN
100	Normal	100	Normal	TN
100	Normal	99	Normal	TN
94	Mild Hypoxemia	95	Normal	FN
96	Normal	97	Normal	TN
98	Normal	98	Normal	TN
99	Normal	99	Normal	TN

100	Normal	100	Normal	TN
95	Normal	96	Normal	TN
97	Normal	96	Normal	TN
98	Normal	98	Normal	TN
99	Normal	99	Normal	TN
100	Normal	99	Normal	TN
99	Normal	99	Normal	TN
97	Normal	99	Normal	TN
99	Normal	99	Normal	TN
100	Normal	100	Normal	TN
99	Normal	100	Normal	TN
93	Mild Hypoxemia	94	Mild Hypoxemia	TP
98	Normal	97	Normal	TN
99	Normal	99	Normal	TN
99	Normal	100	Normal	TN
99	Normal	99	Normal	TN
97	Normal	99	Normal	TN
99	Normal	99	Normal	TN
99	Normal	99	Normal	TN
97	Normal	99	Normal	TN
94	Mild Hypoxemia	92	Mild Hypoxemia	TP
98	Normal	97	Normal	TN
97	Normal	99	Normal	TN
99	Normal	99	Normal	TN
100	Normal	98	Normal	TN
100	Normal	100	Normal	TN

Table 4.4.1 Data for Oxygen Saturation in Blood, SPO2

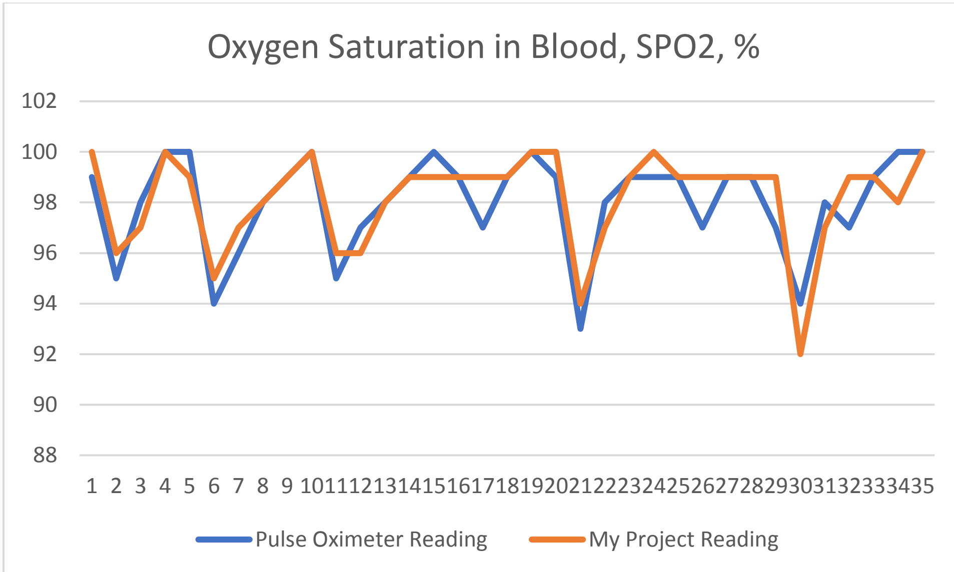


Figure 4.4.1 Comparison Graph Between My Device and Pulse Oximeter for Oxygen Saturation in Blood, SPO2.

True Positive (TP)	True Negative (TN)	False Positive (FP)	False Negative (FN)
2	32	0	1

Table 4.4.2 Data for Oxygen Saturation in Blood, SPO2 for Accuracy and Precision

Accuracy = (TP+TN)/ (TP+FP+FN+TN)

= (2+32)/(2+0+1+32)

= 0.97

Accuracy = 0.97

Precision = TP/ (TP+FP)

= 2/(2+0)

= 1

Precision = 1

35 data have taken to find the accuracy and precision of MAX30102 oxygen saturation in blood, SPO2. The data is obtained with device and pulse oximeter. The value of MAX30102 and

pulse oximeter differs a little bit due to the sensitivity of equipment. The normal range of oxygen saturation in blood must be more than 95 percent. MAX30102 pulse oximeter sensor has an accuracy of 0.97 and precision of 1 for oxygen saturation in blood, SPO2.

4.5 Falling Detection (ADXL345)

ADXL345 is a 3-axis accelerometer which is small and thin. The main function of this sensor is measure static acceleration of gravity and also dynamic acceleration. The sensors calibrated using Arduino IDE. The microcontroller receives analogue signals. So to convert it to digital form we use an algorithm. The algorithm is :

```
ax = (AcX - 2050) / 16384.00;
ay = (AcY - 77) / 16384.00;
az = (AcZ - 1947) / 16384.00;
gx = (GyX + 270) / 131.07;
gy = (GyY - 351) / 131.07;
gz = (GyZ + 136) / 131.07;
byte trigger1count = 0;
byte trigger2count = 0;
byte trigger3count = 0;
int angleChange = 0;
```

By applying this algorithm, the acceleration of static gravity can be obtained and falling will be detected.

4.6 GPS Location Service (Ublox GPS Neo 6m)

Ublox GPS Neo 6m is a location tracking sensor. This sensor will send the data of current location and this sensor will refresh every 15 seconds interval. The sensor calibrated using Arduino IDE. The microcontroller receives analogue signals. So to convert it to digital form we use an algorithm. The algorithm is :

```
gps.location.isUpdated()) {
 latitude = gps.location.lat();
 longitude = gps.location.lng();
 link = "location = " + String(latitude, 6) + "," + String(longitude, 6);
myMap.location(2,  latitude, longitude, "User");
```

By applying this algorithm, the current location can be obtained.

4.7 Overall Performance Analysis

Accuracy = (0.91+0.94+0.97 / 3) x 100%

Accuracy of device is 94%

Precision = (0.63+1+1 / 3) x 100%

Precision of device is 87%

From the above calculation it is clear that the device accurate and less precise.

4.8 Arduino IDE

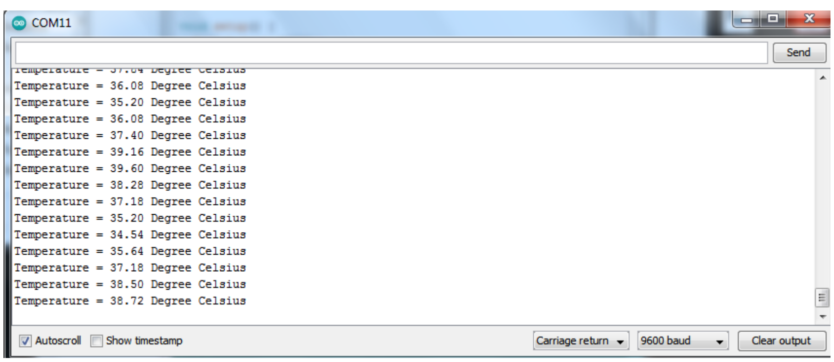


Figure 4.8.1 Serial Monitor for Temperature

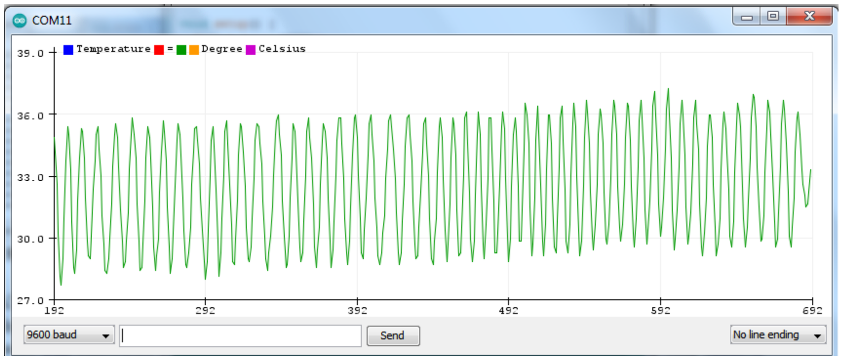


Figure 4.8.2 Serial Plotter for Temperature

Figures above show that the result of LM35 temperature sensor when connected to Arduino IDE via a usb cable. The figure 4.8.1 is serial monitor displayed in Arduino software. In that serial monitor it show the temperature value in degree Celsius after the analog output voltage from LM35 is changed with some algorithm. The figure 4.8.2 is result of serial plotter in Arduino IDE. The serial plotter shows the value of temperature in graph form. The graph is temperature vs time.

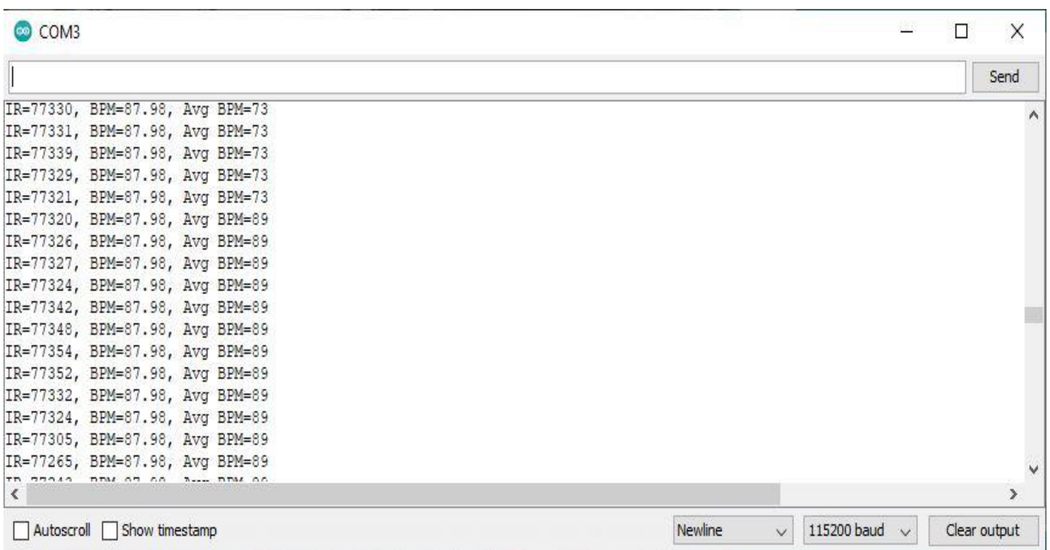


Figure 4.8.3 Serial Monitor for Heart Beat Rate

The figure 4.8.3 shows the serial monitor for heart rate beat in Arduino software. The serial monitor shows the infrared (IR) value, heart rate value in bpm and average value after some calculation. The average value obtain by plus previous heart rate value and divide it with number of heart rate values being plus.

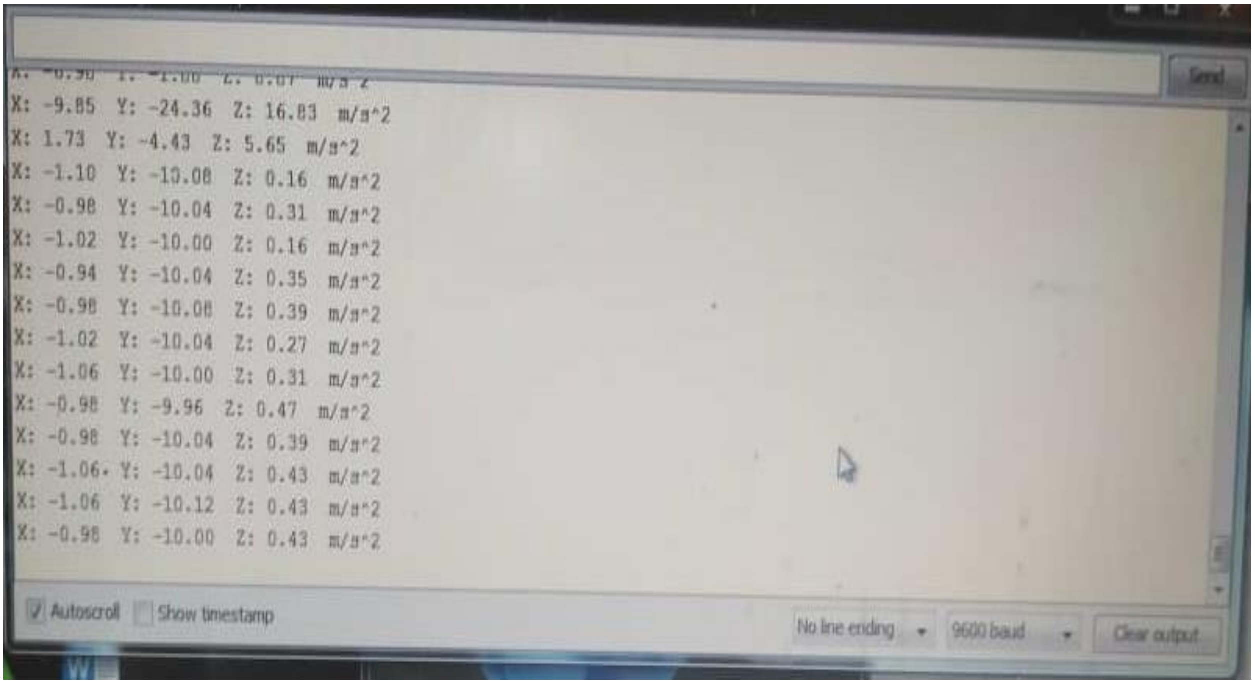


Figure 4.8.4 Serial Monitor For Accelerometer

The figure 4.8.4 shows the result of ADXL345 accelerometer sensor in serial monitor. In this serial monitor value of x-axis, y-axis and z-axis are shown. This three axis are for static gravitational acceleration. Using this three axis we can detect fall.

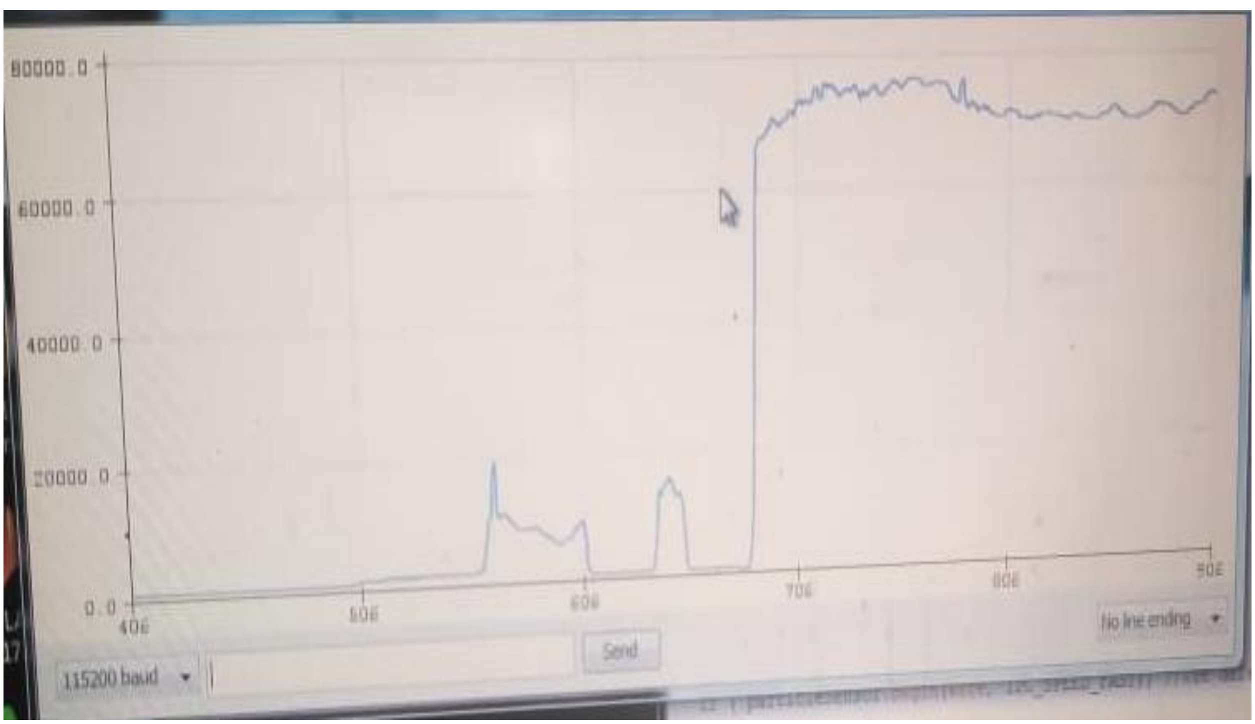


Figure 4.8.5 Serial Plotter for Oxygen Saturation in Blood, SPO2

The graph for oxygen saturation in blood can be seen from figure 4.8.5 which is serial plotter in Arduino IDE software. It show the result of oxygen saturation in blood in graph form. It will refresh every 1 second.

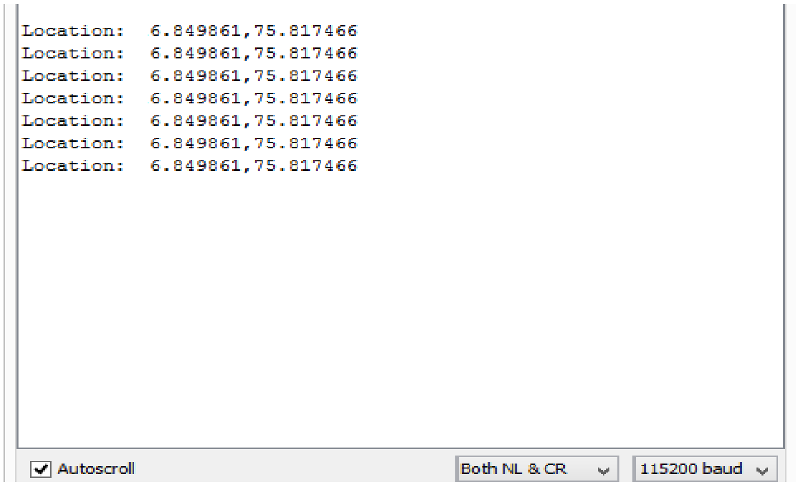


Figure 4.8.6 Serial Monitor for Location Detection

The figure 4.8.6 shows the result of location tracking in serial monitor. In this serial monitor, it will show the latitude value and longitude value.

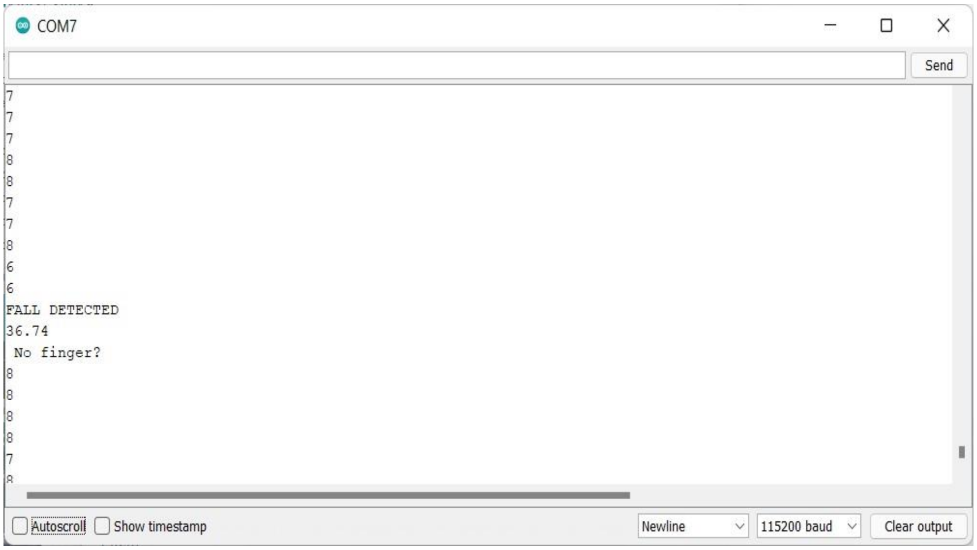


Figure 4.8.7 Serial Monitor for Fall Detection

For fall detection it will count for trigger 1 and if trigger 1 is true then it will continue to count to trigger 3 and if trigger 3 also true it will display fall detected in serial monitor as can be seen from figure 4.8.7.

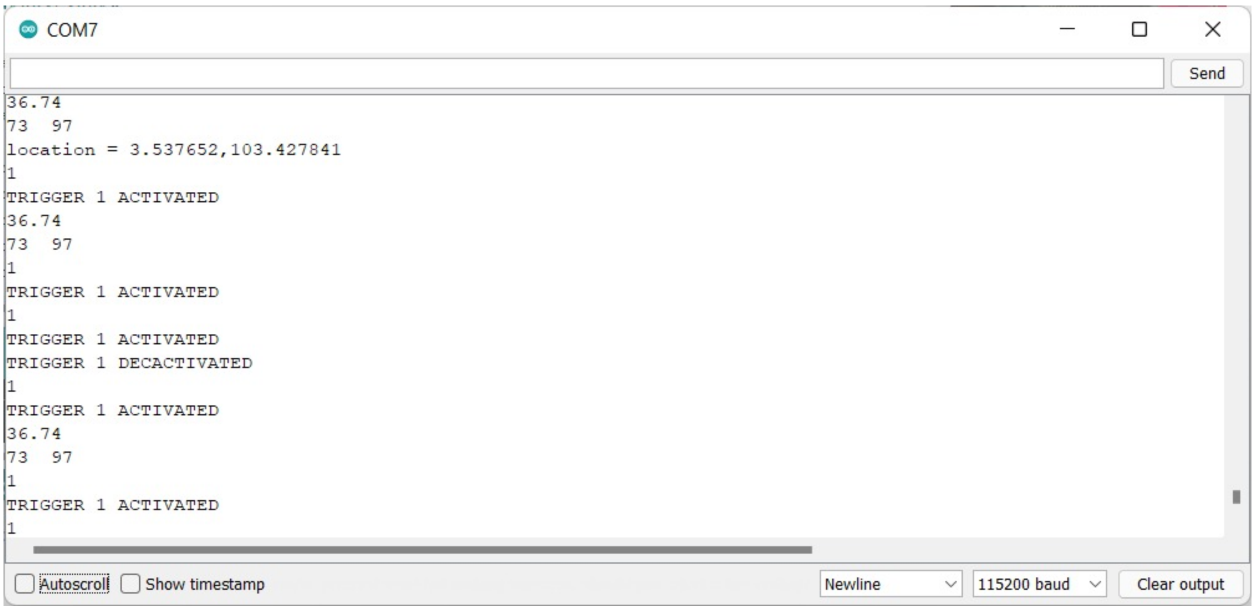
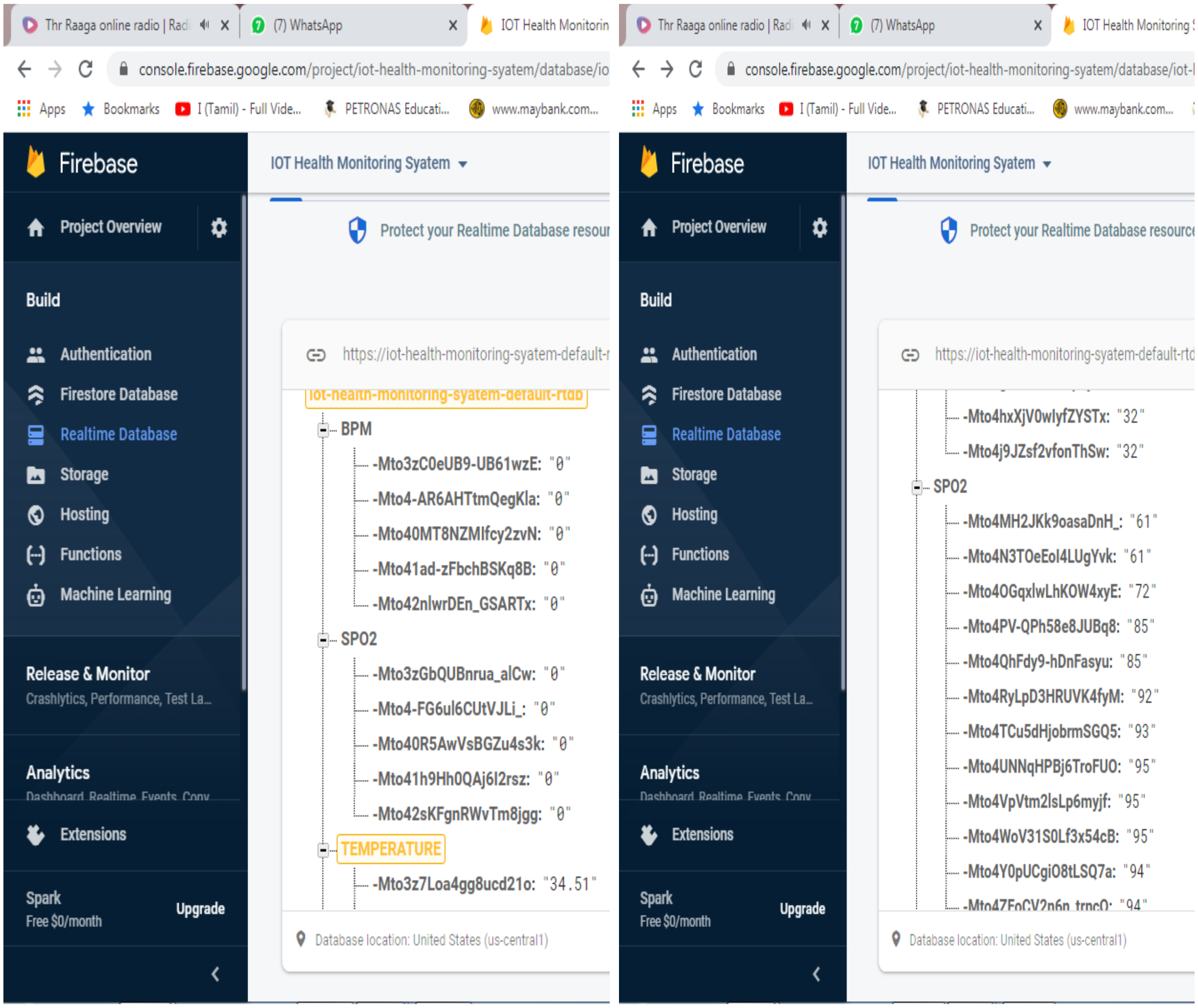


Figure 4.8.8 Overall Result in Arduino IDE for This Project

The figure 4.8.8 shows the overall result for my project in serial monitor of Arduino IDE software. In this serial monitor we can see the temperature value, heart rate, oxygen saturation level, latitude and longitude for location tracking and falling detection information.

4.9 Firebase (Cloud Storage)



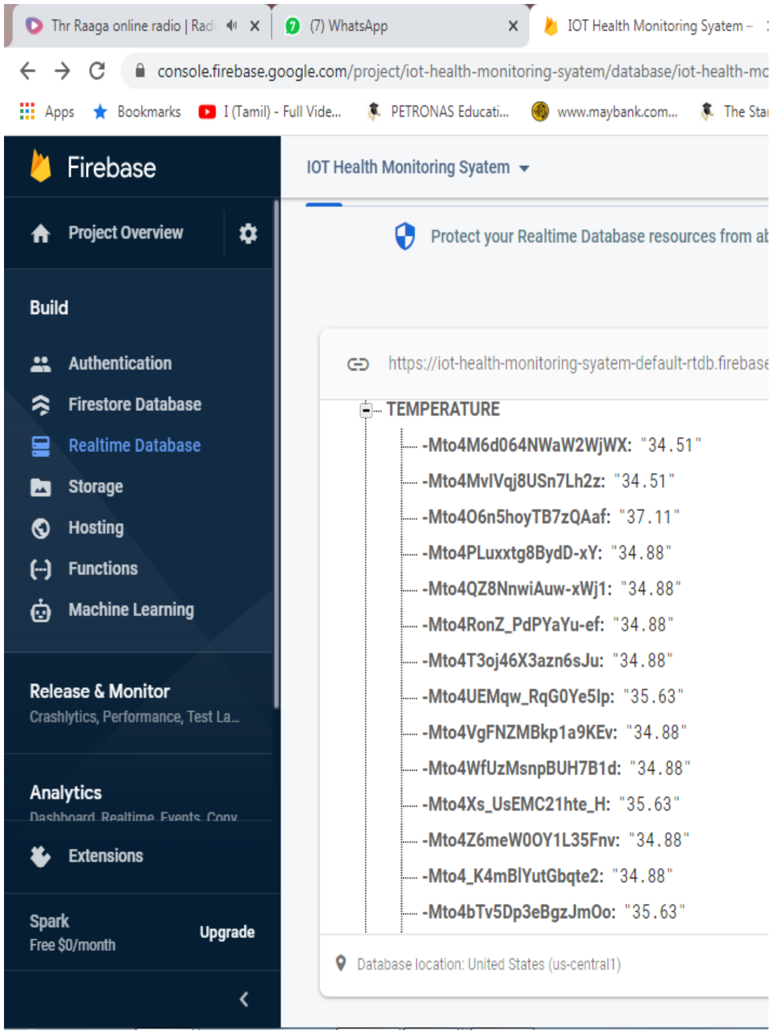


Figure 4.9.1 Data Stored in Online Cloud Storage Firebase

The figure 4.9.1 show the data recorded in online cloud storage which is Firebase. The data recorded are temperature, heart rate, oxygen saturation in blood and location. The data recorded are in realtime. When the main title in yellow colour it means that the data are added. If the data colour in green it means the data are changes.

4.10 Blynk (Mobile Application)

Figure 4.10.1 The Blynk Mobile Application.

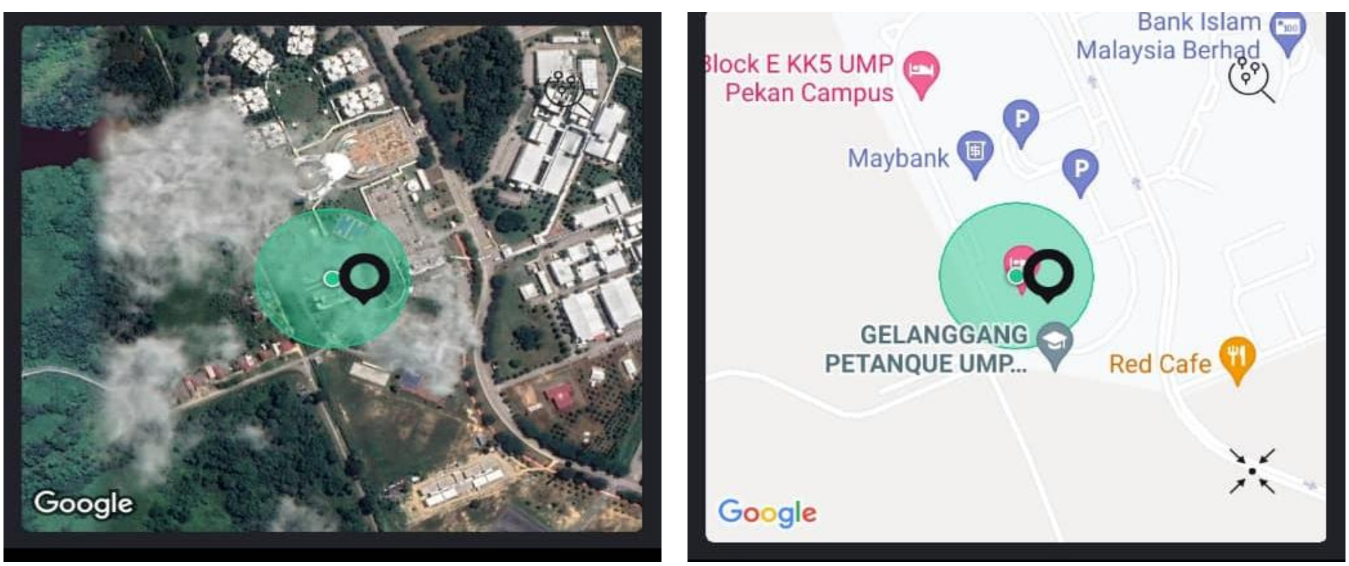
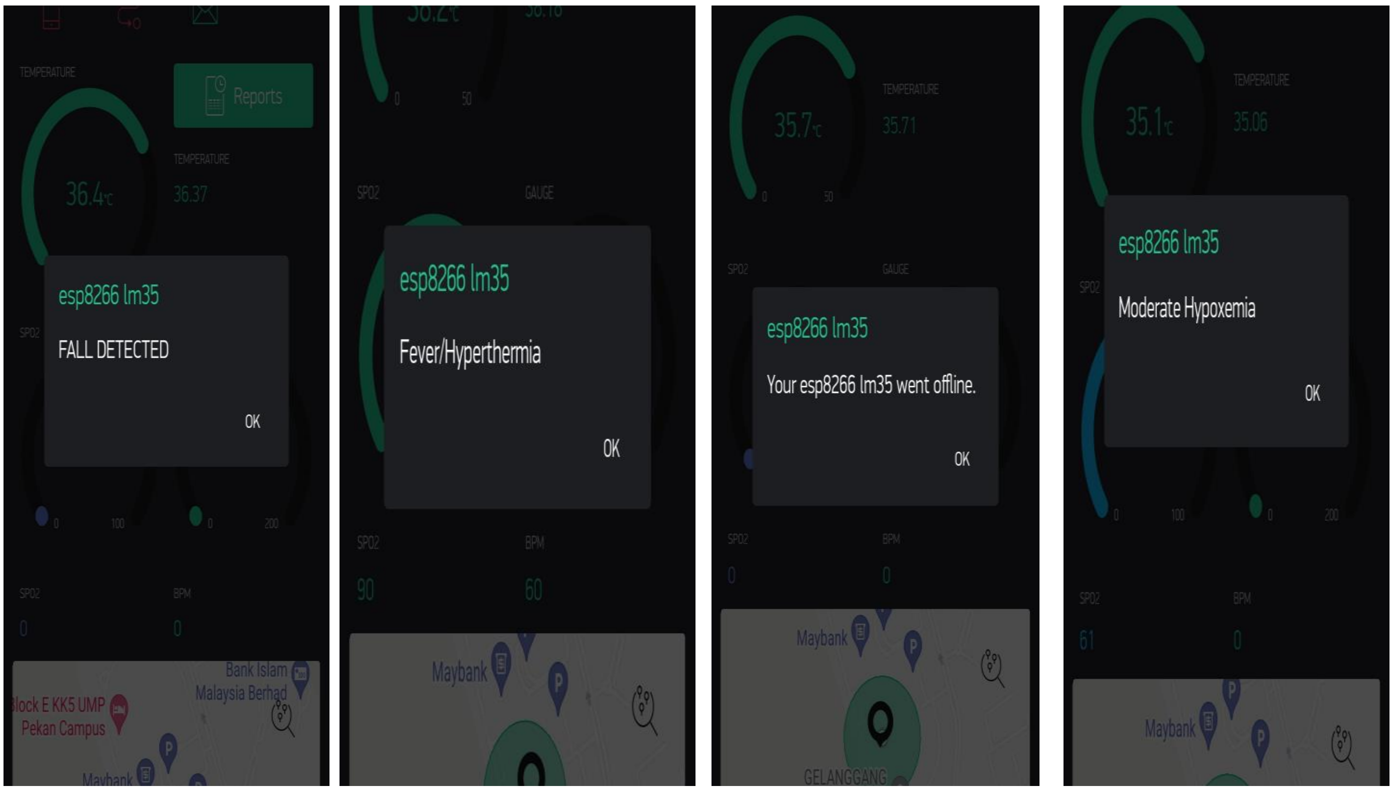


Figure 4.10.2 Satellite View and Normal View Location Service in Blynk.

The figure 4.10.2 show the Blynk mobile application. In that mobile application when the project start operating we can see the temperature value and its demographic view. For oxygen saturation in blood and heart beat rate its same like the temperature which will run in real time. For Google Maps got two view which are normal view and satellite view. The green circle in maps show our phone location and the black circle shows the exact location of device.



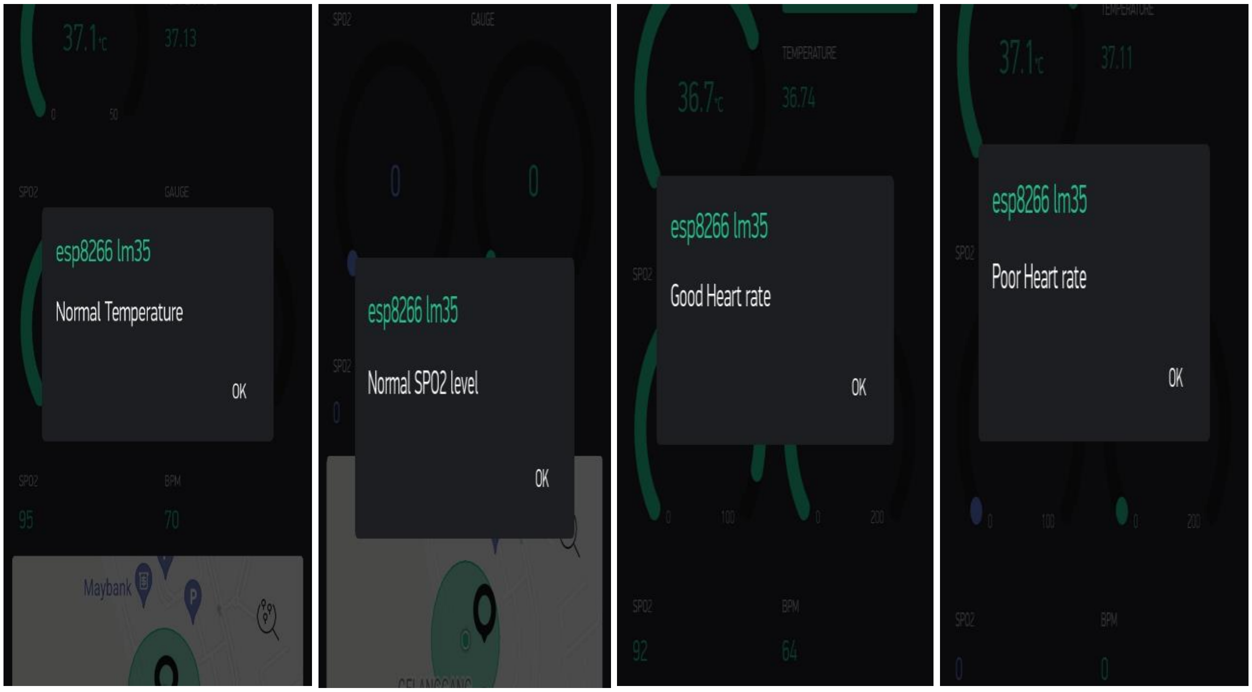


Figure 4.10.3 Some Notifications Shown in Blynk Mobile Application

The figure 4.10.3 show some notification that will pop up in Blynk mobile application. The examples are fever, normal SPO2 level, fall detected, your esp8266 went offline, poor heart rate and so on. For the notification pop up we need to classify the condition and declare what notification will pop up.

4.11 E-mail

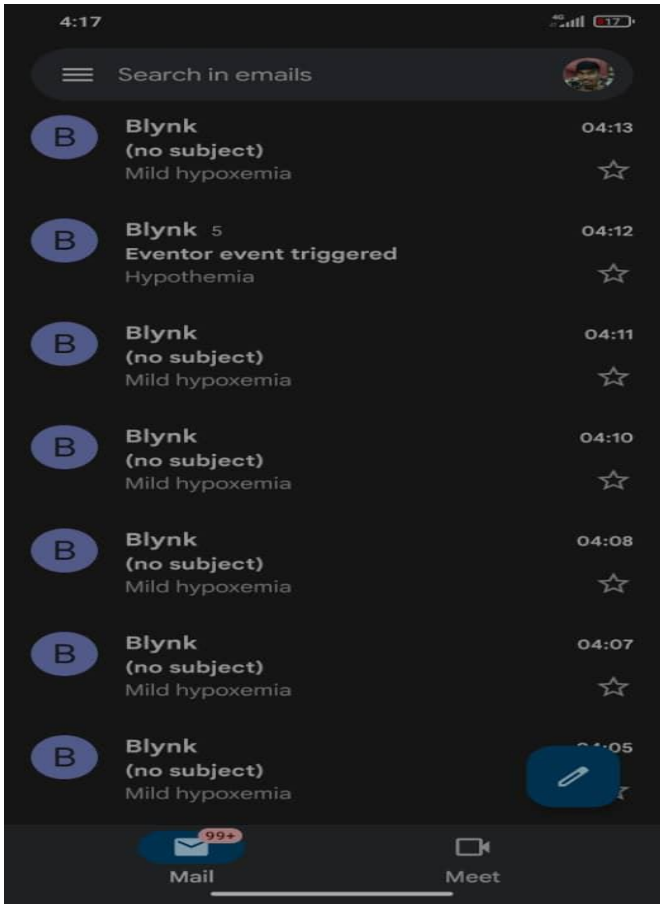


Figure 4.11.1 Notification Sent to Guardian via E-mail on Emergency Situation.

The figure 4.11.1 shows the e-mail of the guardian. When the self-quarantined Covid-19 patients in emergency situation Blynk will send emergency alert to the guardian. We need to set guardian’s e-mail address in Blynk and what type of message must be sent.

4.12 Comparison of My Project with Health Equipment

Figure 4.12.1 Comparison of Temperature with Device and Temperature Scanner

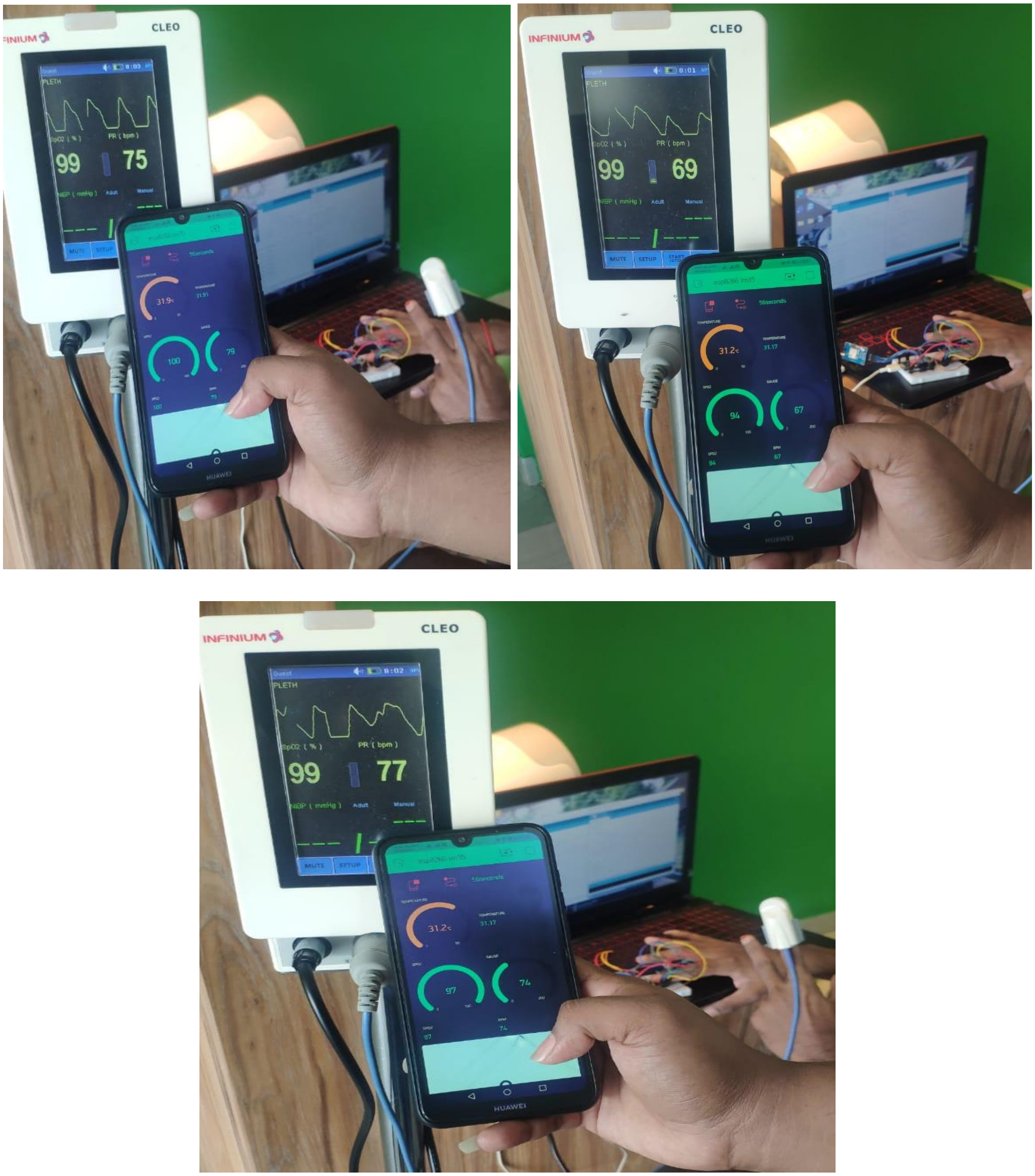


Figure 4.12.2 Comparison of SPO2 and Heart Rate of Device With Automatic Omron Machine

The figures above show the proof of my device readings and real health equipment readings which taken during data taking process. The figure 4.12.1 show the temperature reading with using my project device (LM35) and temperature scanner. The figure 4.12.2 show the measurement of oxygen saturation in blood, SPO2 and heart beat rate. For my device MAX30102 is used and for health equipment we used Automatic Omron Machine. The values differs a little bit due to the sensitivity of equipment.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In a nutshell, a group of sensors detecting and sending data obtained to show the vital signs of chronic disease is very important because we can monitor the health status of an individual and take preventive actions early. A real time health monitoring system will help to track the health status of user, even if the user become fainted. When we identify the vital signs for chronic diseases, we have the chance to start the early treatment and chance to cure is high compared to who has been detected for their chronic disease at last stage. This can make health status of an individual improved, reduce the healthcare cost and be independent and have a great life quality. This project has achieved the objectives. An IOT health monitoring system has been designed for self-quarantined Covid-19 patients to monitor their vital signs as heart rate, body temperature, oxygen saturation in blood, falling detection and notify emergency situation. The location of Covid-19 patients can be tracked with the aid of GPS location service. I only allowed to test with normal patients and Covid-19 second generation close contacts only. Health authorities didn’t recommend me to test my project on Covid-19 patients as it is more risk as I exposed to Covid-19. Then there is no proper sanitization method to sanitize my project.

5.2 Recommendation

In the first place, the improvement needed for this project is add on blood pressure reading. Blood pressure measurement is important to detect the pressure in blood vessels. It can show the reading systolic blood pressure which is the maximal arterial pressure when left ventricle of the heart is contracting and diastolic blood pressure which is the arterial pressure when heart is relaxing.

Last but not least, another additional feature that can be added to this self-quarantined Covid-19 patients IOT health monitoring system is blood glucose level detection. The sensor that can be used is continuous glucose sensor. The function of this sensor is to detect blood glucose level in bloodstream whether the patient have sudden fall of glucose level in blood which known as hypoglycemia. Some Covid-19 patients are at risk of hypoglycemia due to poor oral intake and lethargy. Hypoglycemia without proper treatment on time can cause be life threatening.

APPENDICES

Coding for the IOT Health Monitoring System for Self-Quarantined Covid-19 Patients

```
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <Wire.h>
#include "MAX30105.h"
#include "heartRate.h"
#include "FirebaseESP8266.h"
#include <TinyGPS++.h>
#include <SoftwareSerial.h>

#define FIREBASE_HOST "iot-health-monitoring-syatem-default-rtdb.firebaseio.com"
//Without http:// or https:// schemes
#define FIREBASE_AUTH "dhjuYvToNpd6gqqpT2HhrP5Viwf452LFrjyE2cmp"
char auth[] = "HGK5R7iNbESqsm111HnC1MOnFhYxnLpu";//Blynk
char ssid[] = "SLEET ELECTRONICS@unifi";
char pass[] = "abcdefghijk36";

const int MPU_addr = 0x68; // I2C address of the MPU-6050
int16_t AcX, AcY, AcZ, Tmp, GyX, GyY, GyZ;
float ax = 0, ay = 0, az = 0, gx = 0, gy = 0, gz = 0;
boolean fall = false; //stores if a fall has occurred
boolean trigger1 = false; //stores if first trigger (lower threshold) has occurred
boolean trigger2 = false; //stores if second trigger (upper threshold) has occurred
boolean trigger3 = false; //stores if third trigger (orientation change) has occurred
byte trigger1count = 0; //stores the counts past since trigger 1 was set true
byte trigger2count = 0; //stores the counts past since trigger 2 was set true
byte trigger3count = 0; //stores the counts past since trigger 3 was set true
int angleChange = 0;
const int sensor = A0;
float tempc;
float tempf;
float vout;
BlynkTimer timer;
MAX30105 particleSensor;
WidgetMap myMap(V4);
FirebaseData firebaseData;
static const int RXPin = 14, TXPin = 12;
static const uint32_t GPSBaud = 9600;
TinyGPSPlus gps;
SoftwareSerial ss(RXPin, TXPin);
int offsetSpo2 = 30;
```

```
double latitude, longitude;
String link;
const byte RATE_SIZE = 4; //Increase this for more averaging. 4 is good.
byte rates[RATE_SIZE]; //Array of heart rates
byte rateSpot = 0;
long lastBeat = 0; //Time at which the last beat occurred
float beatsPerMinute;
int beatAvg;
int confinger = 0;
long irValue;
int spo2;

void myTimerEvent()
{
  vout = analogRead(sensor);
  vout = (vout / 1024.0) * 3300;
  tempc = vout / 10;
  tempc = tempc + 30;
  Serial.println(tempc);
  spo2 = map(beatAvg, 60, 100, 60, 80);
  spo2 = spo2 + offsetSpo2;
  if (spo2 > 100) {
    spo2 = 100;
  }

  if (irValue < 50000) {
    spo2 = 0;
    beatAvg = 0;
    Serial.println(" No finger?");
    confinger = 0;
    Blynk.virtualWrite(V0, "0");
    Blynk.virtualWrite(V1, "0");

  }
  else {
    Serial.print(beatAvg);
    Serial.print("  ");
    Serial.println(spo2);
    Blynk.virtualWrite(V0, beatAvg);
    Blynk.virtualWrite(V1, spo2);
  }
  Blynk.virtualWrite(V2, tempc);
}

void gps1()
{
```

```
  if (gps.location.isUpdated()) {
    latitude = gps.location.lat();
    longitude = gps.location.lng();
    link = "location = " + String(latitude, 6) + "," + String(longitude, 6);
    Serial.println(link);
  }
  myMap.location(2,  latitude, longitude, "User");
}

void senddata()
{
  Firebase.setString(firebaseData, "TEMPERATURE" , String(tempc));
  Firebase.setString(firebaseData, "BPM" , String(beatAvg));
  Firebase.setString(firebaseData, "SPO2" , String(spo2));
  Firebase.setString(firebaseData, "latitude" , String(latitude));
  Firebase.setString(firebaseData, "longitude" , String(longitude));
}

void setup()
{
  Serial.begin(115200);
  pinMode(sensor, INPUT);
  Wire.beginTransmission(MPU_addr);
  Wire.write(0x6B);  // PWR_MGMT_1 register
  Wire.write(0);     // set to zero (wakes up the MPU-6050)
  Wire.endTransmission(true);
  Serial.println("Initializing...");
  ss.begin(GPSBaud);
  Wire.begin();
  // Initialize sensor
  if (!particleSensor.begin(Wire, I2C_SPEED_FAST)) //Use default I2C port, 400kHz speed
  {
    Serial.println("MAX30105 was not found. Please check wiring/power. ");
    while (1);
  }
  Serial.println("Place your index finger on the sensor with steady pressure.");
  //

  particleSensor.setup(); //Configure sensor with default settings
  particleSensor.setPulseAmplitudeRed(0x0A); //Turn Red LED to low to indicate sensor is
running
  particleSensor.setPulseAmplitudeGreen(0); //Turn off Green LED
  Blynk.begin(auth, ssid, pass);
  Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);
  timer.setInterval(1000L, myTimerEvent);
  timer.setInterval(2000L, gps1);
```

```
  timer.setInterval(5000L, senddata);
  timer.setInterval(100L, falling);
}

void loop()
{
  Blynk.run();
  timer.run(); // Initiates BlynkTimer
  while (ss.available() > 0) {
    gps.encode(ss.read());
  }
  irValue = particleSensor.getIR();

  if (checkForBeat(irValue) == true)
  {
    //We sensed a beat!
    long delta = millis() - lastBeat;
    lastBeat = millis();

    beatsPerMinute = 60 / (delta / 1000.0);

    if (beatsPerMinute < 255 && beatsPerMinute > 20)
    {
      rates[rateSpot++] = (byte)beatsPerMinute; //Store this reading in the array
      rateSpot %= RATE_SIZE; //Wrap variable

      //Take average of readings
      beatAvg = 0;
      for (byte x = 0 ; x < RATE_SIZE ; x++)
        beatAvg += rates[x];
      beatAvg /= RATE_SIZE;
    }
  }

}

void falling() {
  mpu_read();
  ax = (AcX - 2050) / 16384.00;
  ay = (AcY - 77) / 16384.00;
  az = (AcZ - 1947) / 16384.00;
  gx = (GyX + 270) / 131.07;
  gy = (GyY - 351) / 131.07;
  gz = (GyZ + 136) / 131.07;
  // calculating Amplitute vactor for 3 axis
  float Raw_Amp = pow(pow(ax, 2) + pow(ay, 2) + pow(az, 2), 0.5);
```

```
  int Amp = Raw_Amp * 10;  // Mulitiplied by 10 bcz values are between 0 to 1
  Serial.println(Amp);
  if (Amp <= 2 && trigger2 == false) { //if AM breaks lower threshold (0.4g)
    trigger1 = true;
    Serial.println("TRIGGER 1 ACTIVATED");
  }
  if (trigger1 == true) {
    trigger1count++;
    if (Amp >= 12) { //if AM breaks upper threshold (3g)
      trigger2 = true;
      Serial.println("TRIGGER 2 ACTIVATED");
      trigger1 = false; trigger1count = 0;
    }
  }
  if (trigger2 == true) {
    trigger2count++;
    angleChange = pow(pow(gx, 2) + pow(gy, 2) + pow(gz, 2), 0.5); Serial.println(angleChange);
    if (angleChange >= 30 && angleChange <= 400) { //if orientation changes by between 80-100
degrees
      trigger3 = true; trigger2 = false; trigger2count = 0;
      Serial.println(angleChange);
      Serial.println("TRIGGER 3 ACTIVATED");
      Blynk.notify("FALL DETECTED");
    }
  }
  if (trigger3 == true) {
    trigger3count++;
    if (trigger3count >= 10) {
      angleChange = pow(pow(gx, 2) + pow(gy, 2) + pow(gz, 2), 0.5);
      //delay(10);
      Serial.println(angleChange);
      if ((angleChange >= 0) && (angleChange <= 10)) { //if orientation changes remains between
0-10 degrees
        fall = true; trigger3 = false; trigger3count = 0;
        Serial.println(angleChange);
      }
      else { //user regained normal orientation
        trigger3 = false; trigger3count = 0;
        Serial.println("TRIGGER 3 DEACTIVATED");
      }
    }
  }
  if (fall == true) { //in event of a fall detection
    Serial.println("FALL DETECTED");
    Blynk.notify("FALL DETECTED");
    //delay(3000);
```

```
    fall = false;
  }
  if (trigger2count >= 6) { //allow 0.5s for orientation change
    trigger2 = false; trigger2count = 0;
    Serial.println("TRIGGER 2 DECACTIVATED");
  }
  if (trigger1count >= 6) { //allow 0.5s for AM to break upper threshold
    trigger1 = false; trigger1count = 0;
    Serial.println("TRIGGER 1 DECACTIVATED");
  }
}

void mpu_read() {
  Wire.beginTransmission(MPU_addr);
  Wire.write(0x3B);  // starting with register 0x3B (ACCEL_XOUT_H)
  Wire.endTransmission(false);
  Wire.requestFrom(MPU_addr, 14, true); // request a total of 14 registers
  AcX = Wire.read() << 8 | Wire.read(); // 0x3B (ACCEL_XOUT_H) & 0x3C
(ACCEL_XOUT_L)
  AcY = Wire.read() << 8 | Wire.read(); // 0x3D (ACCEL_YOUT_H) & 0x3E
(ACCEL_YOUT_L)
  AcZ = Wire.read() << 8 | Wire.read(); // 0x3F (ACCEL_ZOUT_H) & 0x40
(ACCEL_ZOUT_L)
  Tmp = Wire.read() << 8 | Wire.read(); // 0x41 (TEMP_OUT_H) & 0x42 (TEMP_OUT_L)
  GyX = Wire.read() << 8 | Wire.read(); // 0x43 (GYRO_XOUT_H) & 0x44 (GYRO_XOUT_L)
  GyY = Wire.read() << 8 | Wire.read(); // 0x45 (GYRO_YOUT_H) & 0x46 (GYRO_YOUT_L)
  GyZ = Wire.read() << 8 | Wire.read(); // 0x47 (GYRO_ZOUT_H) & 0x48 (GYRO_ZOUT_L)
}
```

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