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جامعة بوليتكنك فلسطين

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Computer Engineering Department

Project Name:

Intelligent remote patient monitoring system

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26/12/2022

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ABSTRACT

Many members of society are exposed to various diseases that restrict their movement or make them need people to provide them with continuous care the patient may experience a change in his vital signs (such as a change in temperature, heart rate, lack of oxygen in the blood) or he may experience a loss of balance and then fall, as well as the caregiver finds it difficult to take care of the patient continuously and carry out his own activities at the same time.

It was our duty to provide a solution that helps both parties, whether the patient or the caregiver, by creating a system consisting of a group of sensors that sense the patient's vital signs, monitor his fall, and then send this data to the caregiver by sending a message to an application he carries or making a call to him.

Thus, the caregiver, while carrying out activities, was able to obtain the patient's data and provide him with appropriate assistance. Thus, we made it easier for both the patient and the health care provider to practice their lives with ease and safety.

يتعرض الكثير من أفراد المجتمع لأمراض مختلفة تقيد حركتهم أو تجعلهم بحاجة لوجود أشخاص يقدمون لهم الرعاية بشكل مستمر، فقد يتعرض المريض لتغير في علاماته الحيوية (كتغير درجة الحرارة، معدل نبضات القلب، نقص الاكسجين في الدم)، أو قد يتعرض لفقدان توازنه ثم السقوط، كذلك يجد مقدم الرعاية صعوبة في العناية بالمريض بشكل مستمر والقيام فكان بنشاطاته الخاصة بنفس الوقت.

من واجبنا تقديم حلاً يساعد الطرفين سواءً المريض أو مقدم الرعاية، من خلال عمل نظام مكون من مجموعة من المستشعرات التي تعمل على استشعار العلامات الحيوية للمريض، ومراقبة سقوطه وثم ارسال هذه البيانات لمقدم الرعاية، من خلال إرسال رسالة لتطبيق يحمله أو إجراء مكالمة

وبذلك استطاع مقدم الرعاية أثناء قيامه له.

بأنشطته الخاصة الحصول على بيانات المريض وتقديم المساعدة المناسبة له. وهكذا سهلنا على كل من المريض ومقدم الرعاية الصحية ممارسة حياتهم بكل سهولة وأمان.

Acknowledgements:

This project was not implemented without the help and support that was provided to all of us. The first thanks to God Almighty for giving us strength and success. Then we thank all the faculty members who helped us, especially our supervisor: Elayan Abu Gharbyeh, who used to provide us with the help and advice we needed to complete this project, we also do not forget to thank our families for providing us with psychological and moral support during our work on the project. finally, thank you all .

Table of Contents:

List of Figures:

List of Table:

Chapter 1: Introduction

1.1 Overview

Intelligent remote patient monitoring system is a system designed to monitor patients remotely, as it enables the caregiver to monitor the patient's vital signs (heart rate, temperature and blood oxygen level), as well as monitor the patient's fall down accident if it happens, and thus make a call or send a message to the caregiver, so the caregiver does not need to stay with the patient at all the time.

1.2 Motivations and Importance

The need to design this system was to facilitate life for caregivers of patients because they are busy in their daily work, which does not allow them to monitor the patient and stay next to him all the time, as well as speeding up the rescue of the patient, especially the elderly in the event of a change in his vital signs or loss of balance. His fall, which threatens his life and poses a danger to him, this system is designed to protect and provide care for them.

1.3 Objectives

The project aims to:

1. Develop an intelligent system that allows individuals to monitor the patient and perform work at the same time.
2. Ensure continuous monitoring of the patient's vital signs and notice any emergency and thus rescued.
3. Ensure monitoring of the person's fall condition and thus alerting the caregiver to provide the appropriate services as soon as possible.
4. Make a call or message to the person responsible for the patient in the event of any emergency for the patient.

1.4 Problem analysis and definition

The caregiver is always concerned about the patient, especially those who suffer from major health problems that greatly affect their movement and daily performance, as the patient faces problems during his day or changes in his health condition, so to take care of the patient and provide first aid to him, it is necessary to track his health condition continuously This is done by examining the vital signs and sensing the patient's falling state without the need for the patient's caregiver to stay next to him all the time, so our system provides continuous monitoring of the patient's vital signs and falls.

1.5 List of requirements

1- Designing an intelligent system for remote patient monitoring

2- Collecting patient data.

3- The system continuously updates the status and sends data to the mobile phone containing the application.

4- Create a simple mobile application so that caregivers can easily deal with it.

5- Connecting the system to the application on the caregiver’s phone, while ensuring that the information related to patient received correctly.

6- High accuracy in the components and sensors of the system.

1.6 Expected results

It is expected to build an integrated Intelligent monitoring system with the following specifications**:**

1- A small, lightweight and low-cost patient monitoring system.

2- This smart system should monitor vital signs (heart rate, temperature and blood oxygen level), and monitor the patient's fall status.

3- The system must deal with emergency situations facing the patient, by making a call and sending a message to the phone of the person responsible for providing care to the patient.

1.7 Short Description of the System

This smart system will measure the patient’s vital signs (heart rate, temperature and blood oxygen level), as well as sense the falling state of the sick person using special sensors, this system will be close to the patient, and as soon as it senses that any change has occurred in the case of the patient, the system makes a call or sends a message to the caregiver through a phone application that is installed on his smart phone.

1.8 Project Schedule

Tasks	Start date	End date
Buy sensors	25/8/2022	3/9/2022
Testing the sensor	3/9/2022	10/9/2022
Run of each sensor with code	11/9/2022	30/9/2022
Collect sensors together	1/10/2022	30/10/2022
Create the mobile application	1/11/2022	10/11/2022
Connect the firebase with Arduino	12/11/2022	15/11/2022
Connect the firebase with app inventor	16/11/2022	18/11/2022
Testing and modification errors and solve problem	15/11/2022	15/12/2022
Writing the report	16/12/2022	26/12/2022

Tasks table

1.9 Overview of the rest of report sections

The rest of the report is organized as follows: chapter 2 presents a theoretical background of the project, a description of the hardware and software components is discussed in addition to the system specification and design constraints. Chapter 3 detailed design, block diagrams, flowcharts. Chapter 4 contains an introduction to the software and the platform used for project programming. The last chapter contains a conclusion about our work.

Chapter 2: Theoretical background

2.1 Overview

This chapter introduces a theoretical background of the project, some description of hardware and software components used in the system. Finally, discussion of specification and design constraints are presented.

2.2 Theoretical background

This project aims to achieve interesting and useful changes in the medical environment, as the project urges the use of a smart system to monitor patients remotely. To achieve this goal, the project was understood by previous innovative and integrated projects with development.

The system relies on combining different electronic parts (sensors and ESP32 microcontroller). where the sensors help to detect any changes in the patient's condition, such as, heart rate, temperature and blood oxygen, such that MAX30102, and this is what will be referred to in the second part of this chapter. as for the ESP32 microcontroller, it is used to connect all sensors together and send the output from them to the app by firebase, as well as giving it codes and programming commands, because it is designed to facilitate the use of interactive electronics in various systems, the idea of the project was motivate when we saw the suffering of some patients due to the lack of continuous caregivers by their side because they are busy in other work far from patients, which makes the system highly acceptable, especially for those who suffer from this problem, and also it is related to the medical field so that it is easy to transfer patient information, finally, this intelligent system helps us identify motivation designed to be used in the medical environment, as the main motive is to enhance and facilitate the effective roles of patients and their caregivers.

2.3 Literature review

This system was developed as a development of a previous system entitled "Smart Elderly using Microcontroller". Monitors vital signs for chronically elderly patients using a Microcontroller.

Anaam, Tasneem, Rawand (2021), inside the laboratories of Palestine Polytechnic University, as part of a project entitled Smart Elderly using Microcontroller, which is a project that measures vital signs such as (temperature, blood pressure, blood oxygen) for the elderly through a watch consisting of sensors that sense It measures these vital signs and works to send that to an application that the caregiver has on his phone, so that he can provide assistance to the patient in any emergency.

In this project, we have added a fall sensor feature for patients in general, not just for the elderly. Therefore, our project senses the patient's vital signs and knows his location. If any defect occurs in these signs or the patient falls, a message is sent or a call is made to the caregiver. [1]

2.4 The summary

In this chapter, the theoretical background for this project was worked out, in which we explained the work of the project in a simplified manner, and as we mentioned, a literary review of a previous project, so our project is complementary to it.

Chapter 3: System design

3.1 Overview

This chapter includes an definition of the hardware and software components of the project, as well as a conceptual description of the system, i.e. the general block, and conceptual diagrams, and it will explain the algorithms and methodologies that were used in building the project , and the schematic diagrams

3.2 System components

3.2.1 Hardware system components:

This section describes all of the hardware used in our project. It presents a figure for each one with a short description about its work principle and why it is used in the system.

1. **Microcontroller (ESP32)**

We had two choices when choosing which microcontroller to use :

a) **ESP32** is created by Espressif Systems with a series of SoC (System on a Chip) and modules which are low cost with low power consumption. ESP32 not only has Built in WiFi but also has Bluetooth and Bluetooth Low Energy.
ESP32 chip ESP32-D0WDQ6 is based on a Tensilica Xtensa LX6 dual core microprocessor with an operating frequency of up to 240 MHz.
The small ESP32 package has a high level of integrations such as:

- Antenna switches
- Balun to control RF
- Power amplifier
- Low noise reception amplifier
- Filters and power management modules

On top of all that, it achieves very low power consumption through power saving features including clock synchronization and multiple modes of operation.
The ESP32 chip's quiescent current is less than 5 μA which makes it the ideal tool for our battery powered projects or IoT applications. [2]

And we will program this microcontroller so that it receives data from the sensors connected to it to display on the caregiver app screen.

b) **Arduino Mega2560** is a microcontroller board It contains everything needed to support the microcontroller, contain a ATmega2560 processor, a USB connection ,16 analog input, 54 digital IO and 15 PWM. [3]

__We chose to use the ESP32 because it supports the Wi-Fi that we need it in our project and it need low power.__

Figure3.1: ESP32 with functions of its bins [4]

2. MAX30102 sensor

MAX30102 is a biosensor module for pulse oximeter, heart rate and body temperature. It integrates a red LED, an infrared LED, a photodetector, optical components and a low-noise electronic circuit with ambient light suppression. We chose this sensor for its excellent performance where It will measure the body temperature, the percentage of oxygen in the blood, as well as the heart rate, when placed on the finger. [5]

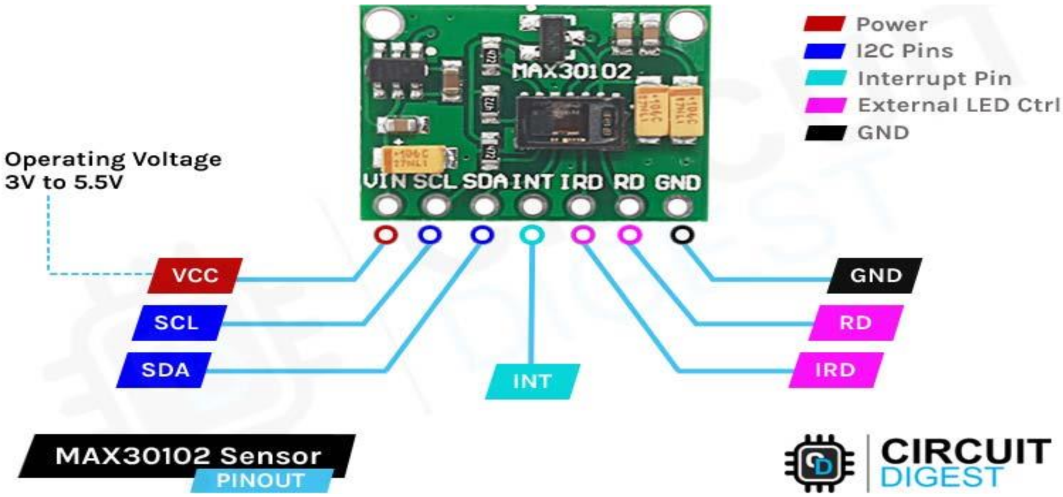


Figure3.2: MAX30102 sensor with functions of its bins [6]

3. NEO 6M GPS Module

is a complete GPS module that is based on the NEO 6M GPS. This unit uses to give the positioning information, it is accurate and can sense locations with NEO-6M GPS Module that can track up to 22 satellites and identifies locations anywhere in the world. and includes a larger built-in 25 x 25mm active GPS antenna with a UART TTL socket. A battery is also included so that you can obtain a GPS lock faster. The GPS module has serial TTL output, it has four pins: TX, RX, VCC, and GND. This module will accurately locate the patient to provide the caregiver with the exact location, we chose it because it is low power (suitable for battery powered devices), inexpensive, easy to interface with. [7]

Figure3.3: GPS sensor [8]

4. SIM800L GSM Module

SIM800L GSM/GPRS module is a miniature cellular GSM modem from Simcom, which can easily interface with any microcontroller to give the microcontroller GSM functionality, and allows for GPRS transmission. This module connects the microcontroller to the mobile network to make or receive phone calls, send or receive SMS (text messages), and connect to the internet using GPRS, TCP, or IP. Another advantage is It supports quad-band GSM/GPRS network, which means it can work anywhere in the world. These important functions, along with the low cost and small footprint, make this unit even more ideal to be used in our project and that require long range communication as well. [9]

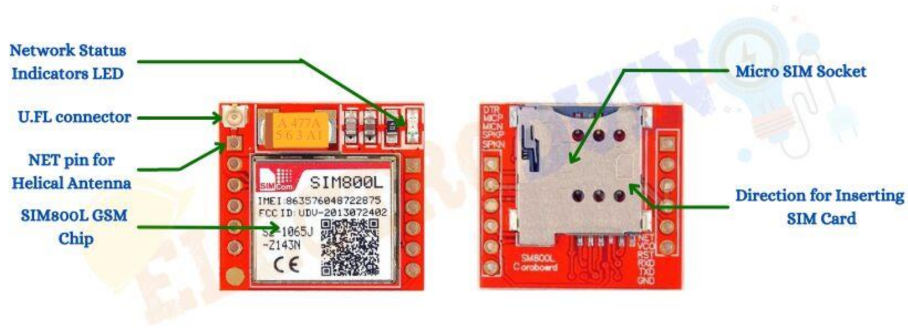


Figure3.4: SIM800L GSM Module [10]

5. MPU6050 IMU

MPU6050 is a Micro Electro-mechanical system, It helps us to measure velocity, orientation, acceleration, displacement and other motion, it captures three-dimension motion at the same time because it consists of a 16-bit analog to digital converter hardware. Featuring InvenSense MotionApps software, these devices combine a 3-axis gyroscope and 3-axis accelerometer on the same silicon mold, along with an integrated Digital Motion Processor (DMP) that processes complex 6-axis Motion Fusion algorithms which gives it the ability to solve complex arithmetic operations. This device can access other sensors through the I2C auxiliary bus, allowing the devices to collect sensor data without interference from the system processor. We will choose it to sense the patient's fall status by determining the patient's movement across the three axes where the main feature is that it can easily combine with accelerometer and gyro and it is one of the first motion tracking devices in the world, uses low power, low cost, high performance for wearable sensor, easily accessible. [11]

Figure3.5: MPU6050 IMU sensor [12]

3.2.2 Software system components:

1. Arduino IDE

Is an open-source computer programming language based on the wiring development platform, the Arduino IDE is based upon the Processing IDE, and it is available in several operating systems, which give us a programing editor with integrated libraries support and a way to easily compile and load our Arduino programs to a board connected to the computer. This language is a framework built on top of C++, the main difference from c/c++ is that you wrap all your code into two main functions, any Arduino program must provide at least two main functions.

2. Google firebase

Google Firebase is a Google-backed application development software that enables developers to develop iOS, Android and Web apps. Firebase provides tools for tracking analytics, reporting and fixing app crashes, creating marketing and product experiment.

Firebase offers a number of services, including:

- Analytics – Google Analytics for Firebase offers free, unlimited reporting on as many as 500 separate events. Analytics presents data about user behavior in iOS and Android apps, enabling better decision-making about improving performance and app marketing.

- Authentication – Firebase Authentication makes it easy for developers to build secure authentication systems and enhances the sign-in and onboarding experience for users. This feature offers a complete identity solution, supporting email and password accounts, phone auth, as well as Google, Facebook, GitHub, Twitter login and more.

- Cloud messaging – Firebase Cloud Messaging (FCM) is a cross-platform messaging tool that lets companies reliably receive and deliver messages on iOS, Android and the web at no cost.

- Realtime database – the Firebase Realtime Database is a cloud-hosted NoSQL database that enables data to be stored and synced between users in real time. The data is synced across all clients in real time and is still available when an app goes offline.

- Performance – Firebase Performance Monitoring service gives developers insight into the performance characteristics of their iOS and Android apps to help them determine where and when the performance of their apps can be improved.

- Test lab – Firebase Test Lab is a cloud-based app-testing infrastructure. With one operation, developers can test their iOS or Android apps across a variety of devices and device configurations. They can see the results, including videos, screenshots and logs, in the Firebase console. [13]

3. **MIT App inventor**

is an intuitive, visual programming environment that allows everyone to build fully functional apps for smartphones and tablets. And what's more, our blocks-based tool facilitates the creation of complex, high-impact apps in significantly less time than traditional programming environments. [14]

3.3 Detailed system description

This smart system is designed to monitor the patient's vital signs (heart rate, temperature, oxygen level in the blood) and sense his fall, the MAX30102 sensor is used to measure the patient's heart rate, blood oxygen level and temperature, and the MPU6050 IMU that will monitor the fall The patient, then the ESP32 will receive the data from these shards and then send it to the firebase which stores the data and sends it to the app that the caregiver has on his phone, then the caregiver will be able to monitor the patient constantly.
The NEO 6M GPS unit will also be used to locate the patient in order to quickly provide him with assistance. In addition, the process of informing the caregiver of any change in the patient's condition will be done by sending a message or making a call using SIM800L GSM Module.

3.3.1 General block diagram:

The general block diagram of the project shows how to connect the hardware and software parts of the system together, in order for it to work to perform the purpose of the system.

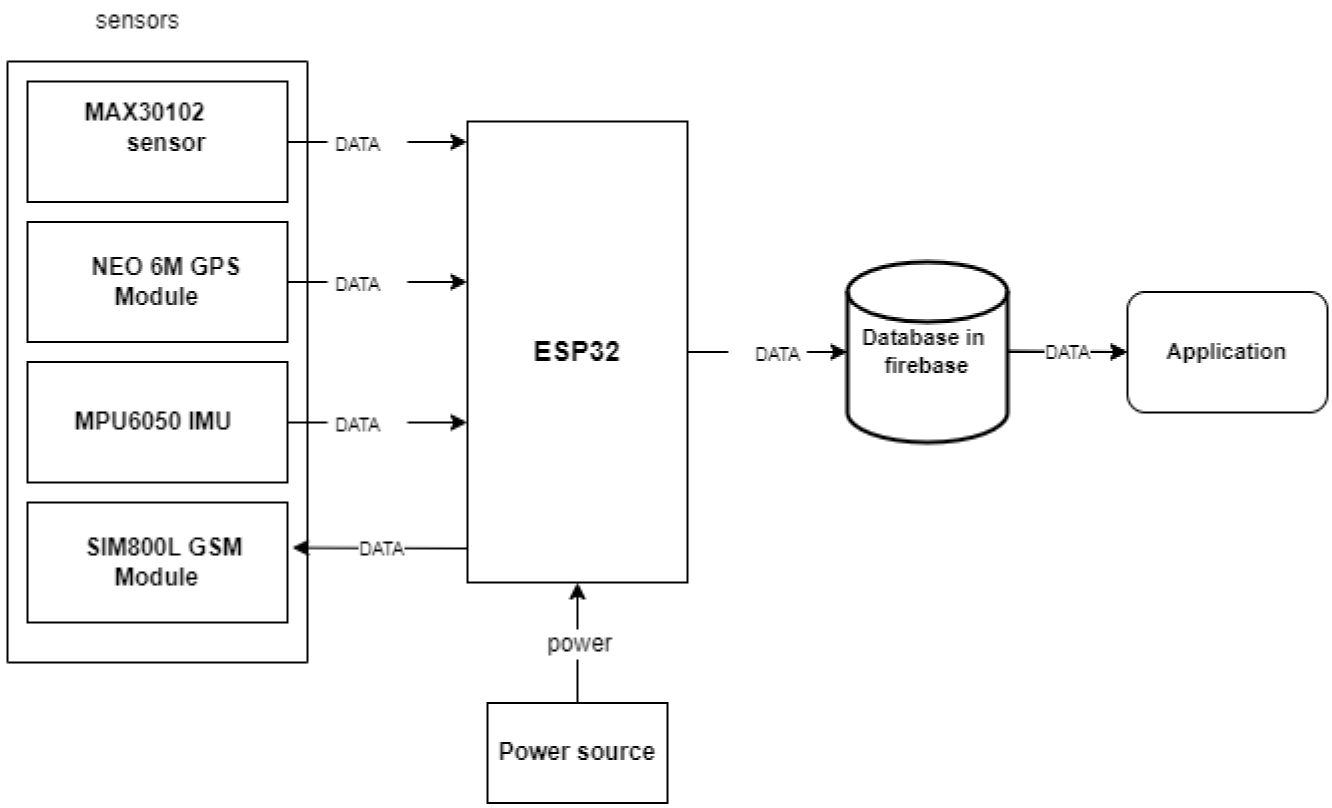


Figure3.6: General block diagram

3.3.2 Conceptual diagram:

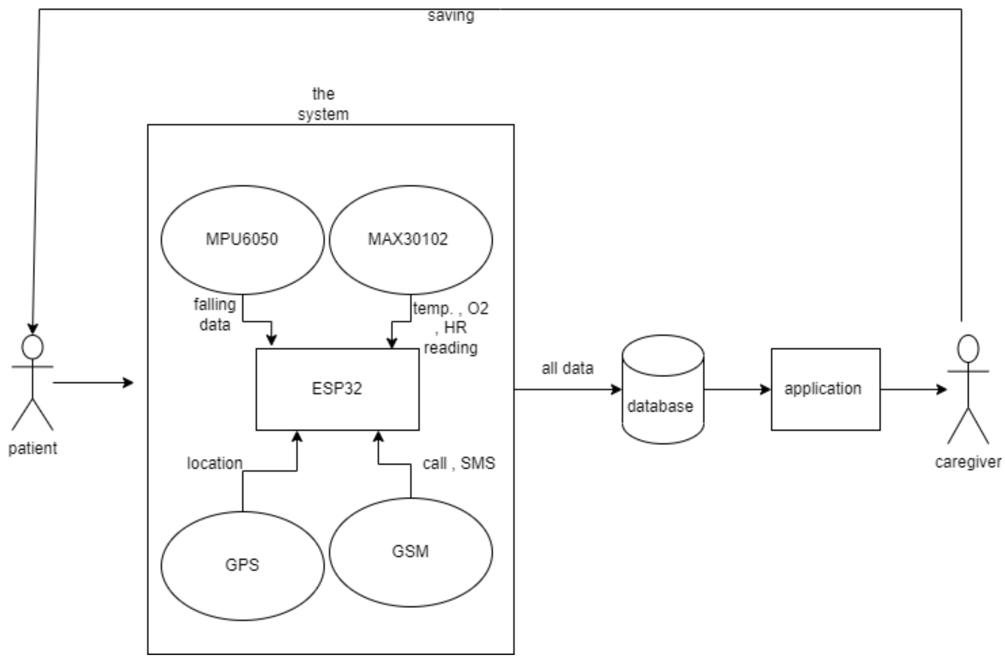


Figure3.7: Conceptual diagram

3.4 Algorithms and methodologies (flow charts)

In this part of the chapter, the methodology that was used to build the system will be clarified through flow charts.

This flowchart shows the temperate condition:

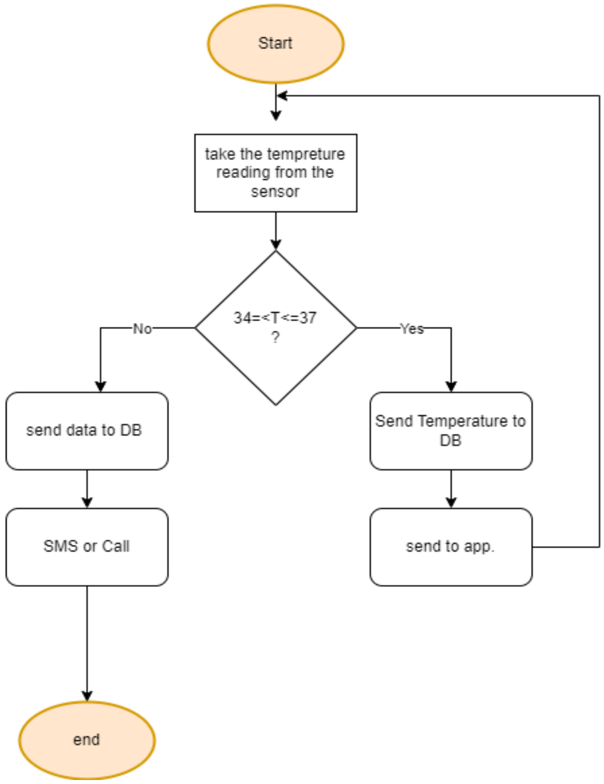


Figure3.8:Temperate flowchart

This flowchart shows the heartrate and oxygen condition:

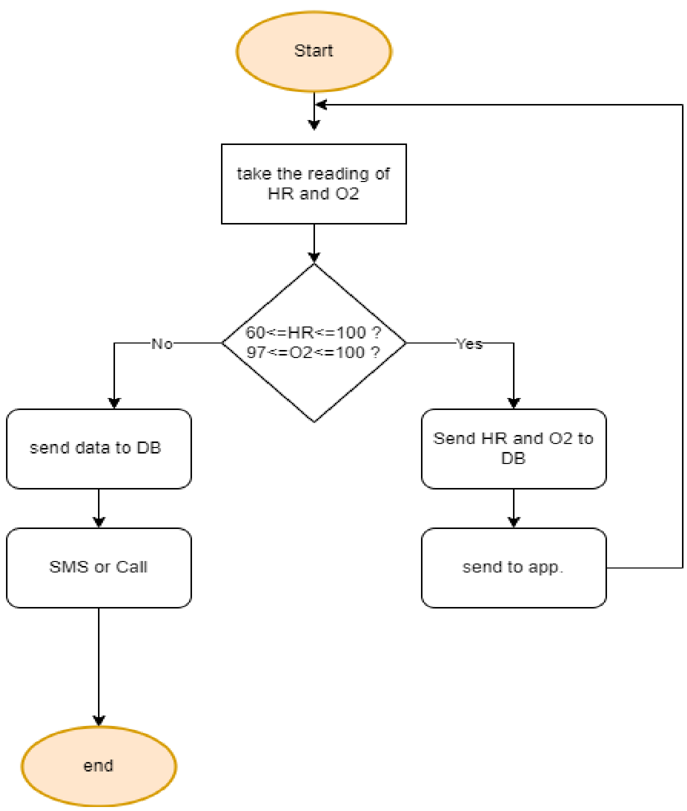


Figure3.9: heartrate and oxygen flowchart

the flowchart shows falling operation:

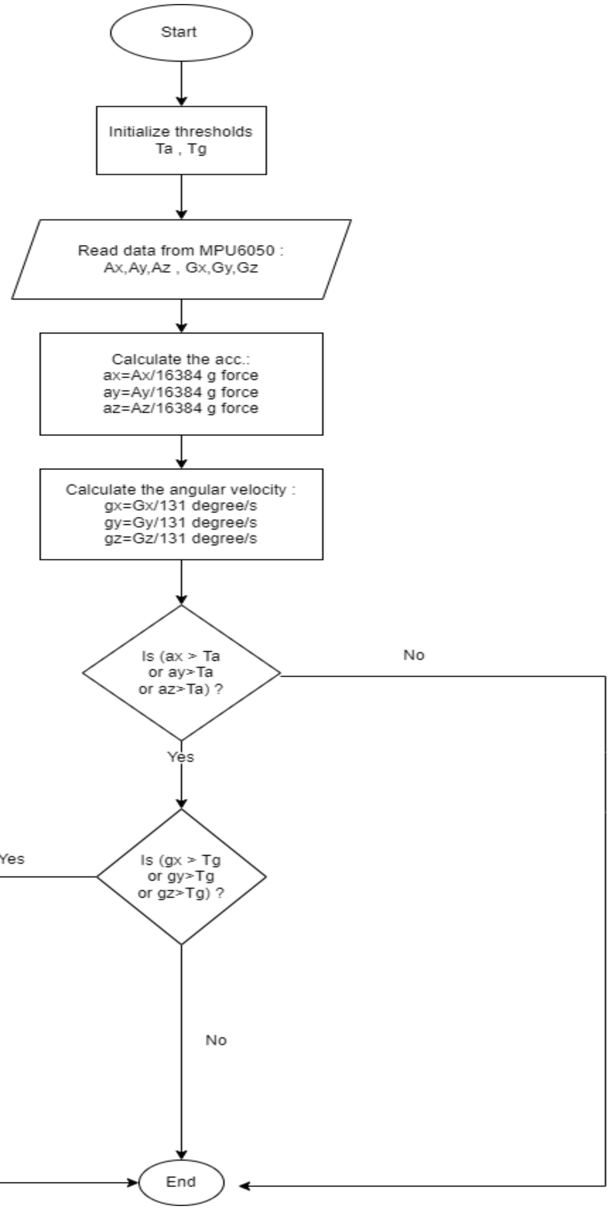


Figure3.10:Falling flowchart

3.5 Schematic diagrams

Figure shows the hardware components of the system and how them connect with ESP32.

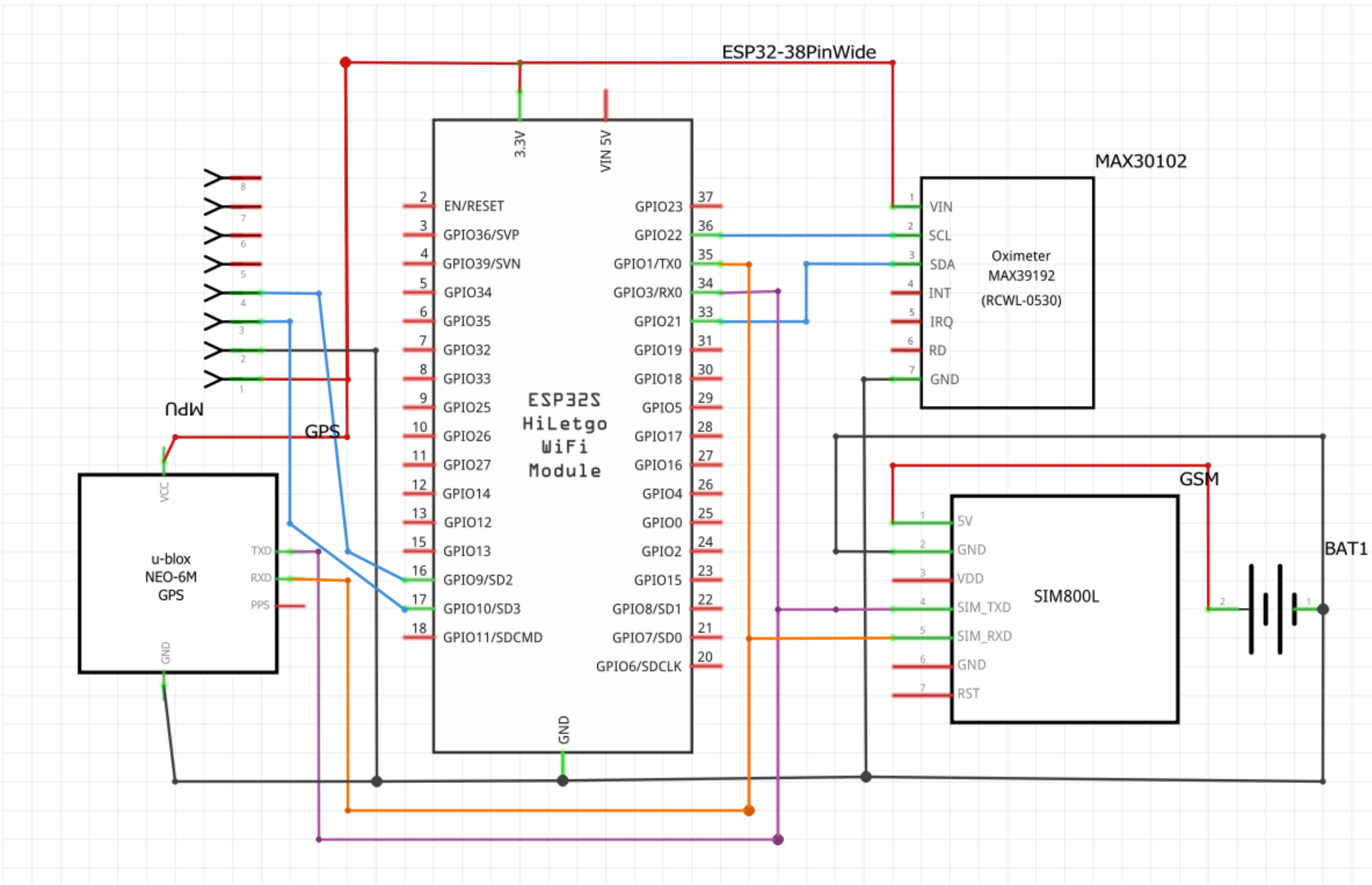


Figure3.11:Schematic diagram of intelligent remote patient system

Figure shows how the MAX30102 sensor connected to the ESP32.

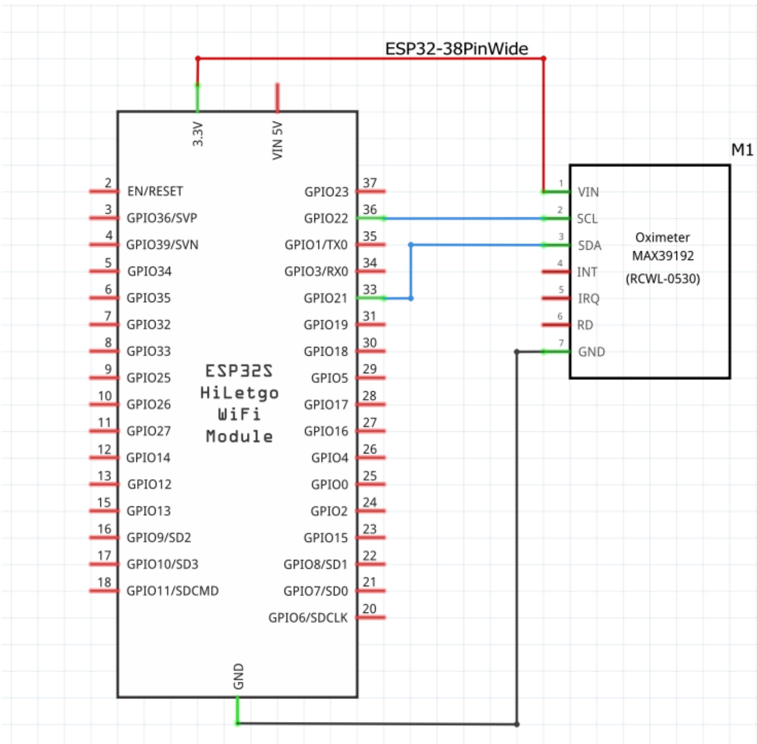


Figure3.12:MAX30102 sensor with ESP32

Figure shows how the MPU6050 IMU sensor connected to the ESP32.

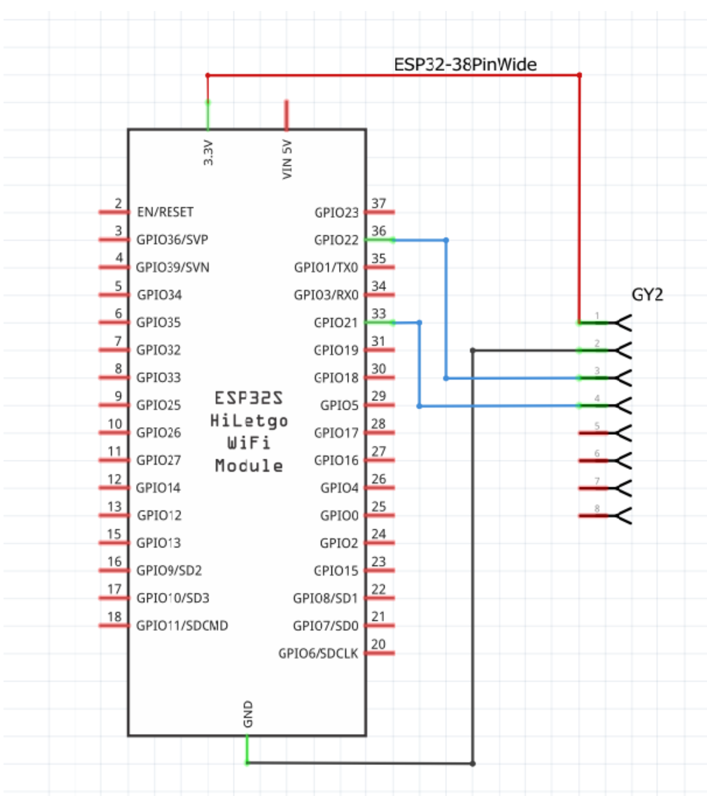


Figure3.13:MPU6050 IMU with ESP32

Figure shows how the SIM800L GSM Module connected to the ESP32.

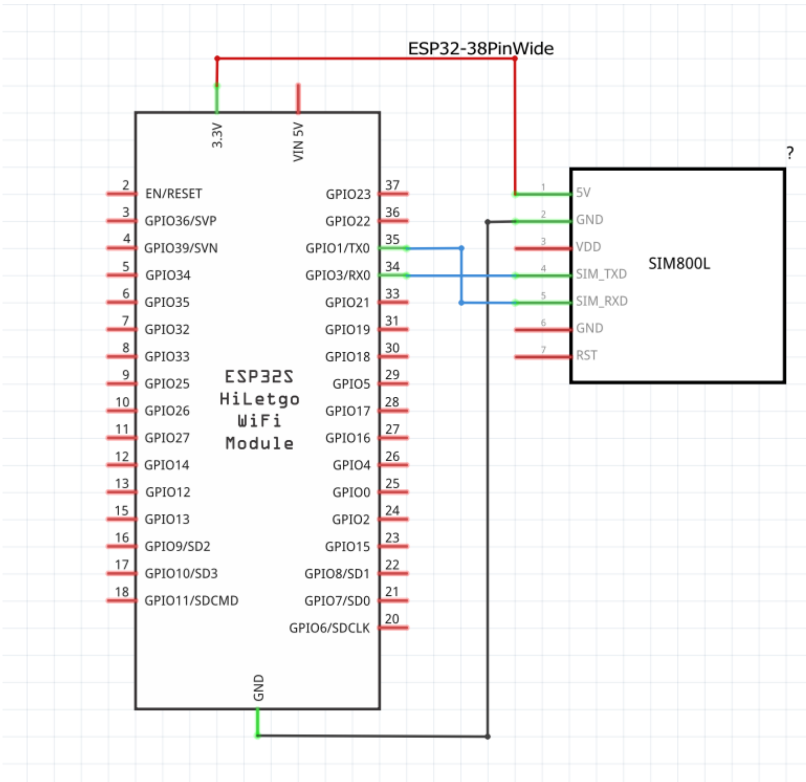


Figure3.14:SIM800L GSM with ESP32

Figure shows how the NEO 6M GPS Module connected to the ESP32.

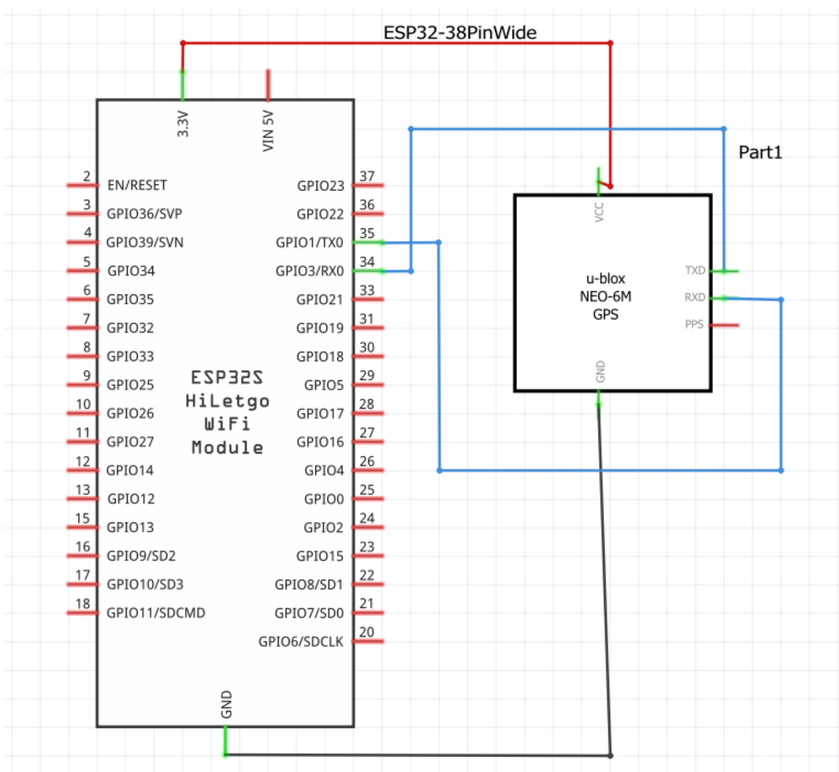


figure3.15;NEO 6M GPS with ESP32

3.6 The summary

In this chapter, all the hardware and software components of the system were defined, and The design of the system, how it works, and the connection of its parts were clarified through the use of illustrations of all kinds.

Chapter 4: Implementation and testing

4.1 Overview

This chapter explains and describes the problems we faced and the results of the implementation of the system of our project.

4.2 Description of the implementation

After designing the project and making all the plans, the implementation process came as follows:

- All the pieces were assembled together, where the MAX30102 sensor, the MPU6050 sensor, GSM, GPS and the ESP32 were connected, and work was done to install these components together by soldering the wires that connect them.
- The assembled parts were connected to the power source, which is the battery.
- The solderd parts, as well as the battery, are attached to a container with a strap to be attached to the wearer's hand.
- Then the system began to record the readings issued by the patient's body.
- Then the system worked to send these readings to firebase, where they appeared on the interface of the program, which in turn sent the data it received to the App Inventor application that was designed and included on the caregiver’s phone.

4.3 Implementation issues and challenges

We have been exposed, during our work on this system, to many issues and challenges, like any other project, perhaps because it is the first time that we have undertaken a project of this size and in this way, but success lies in facing these challenges and solving them.

Among these challenges were the following:

- The difficulty of finding all the component needed for our project, which made us have to replace them with other pieces that give the required results, but are not as good as the original pieces.
- Many of the pieces were quickly damaged while working on them, which made us have to buy one component more than once to complete our project.

- When using the GPS module, it was difficult to obtain a reading of the location inside the buildings, but this piece is considered the most used piece by university students, which made us use it too, as it gives us readings outside the buildings.
- In terms of programming, we had difficulty understanding and programming the MPU6050 IMU (fall sensor), but with continuous search for information about it, we were able to understand it well and program it correctly, which performs the required.

- When we put the pieces together, we encountered difficulty merging the codes of these separate pieces together, because each piece has a different data transmission speed, and therefore we could not get all the readings from all the sensors at the same time, and we solved that by changing some parts in the code.

4.4 Validation and testing

1. **MAX30102 sensor test:**

   When connecting a MAX30102 sensor with the ESP32, it was expected that the sensor would give us readings of body temperature, heart rate, and the percentage of oxygen in the blood, when it was placed on the patient's finger, and indeed these readings were obtained and the test succeeded.

2. **GPS module test:**

   When connecting the GPS piece, it was expected that it would determine the location of the patient, but when testing it inside the buildings, we did not get a reading from it, then we repeated the test outside the buildings (specifically on the roof of the building). A reading of the location was obtained. Therefore, the test outside the buildings succeeded, and this is the nature of the piece, as it was our best option for determining the location.

3. **GSM module test:**

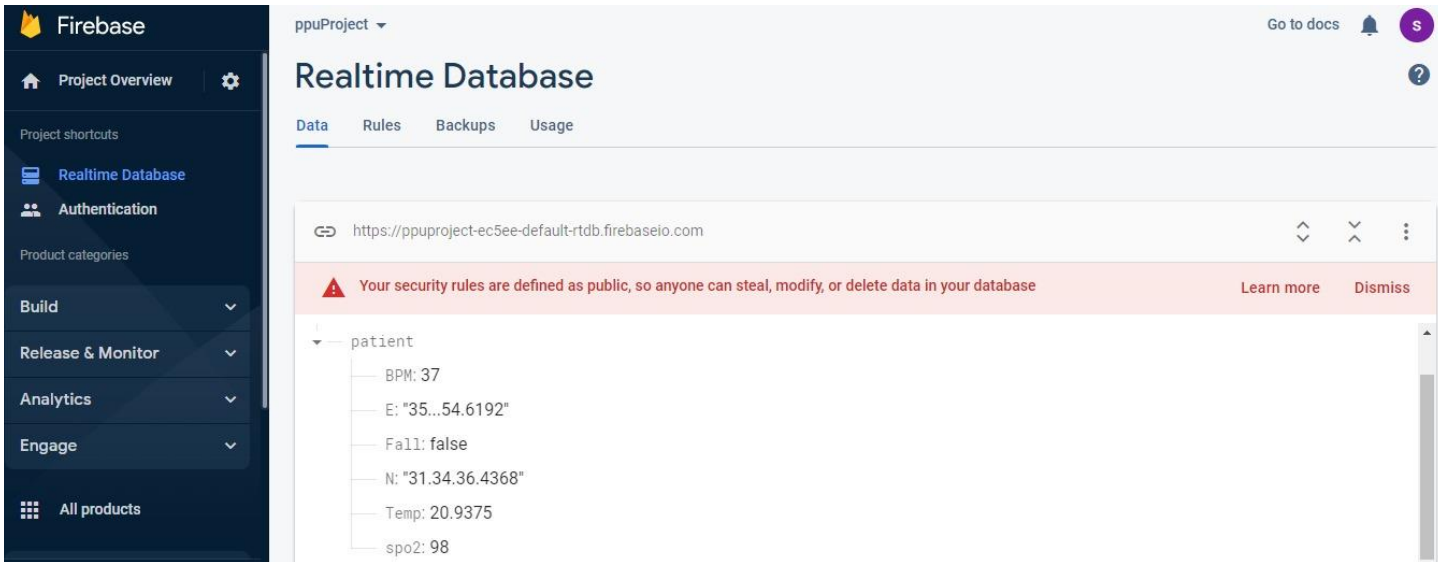
   When connecting the GSM, it was expected that it would make a call or send a message to the caregiver when an emergency occurred, and the GSM succeeded in this test when it was tested on the patient's body.

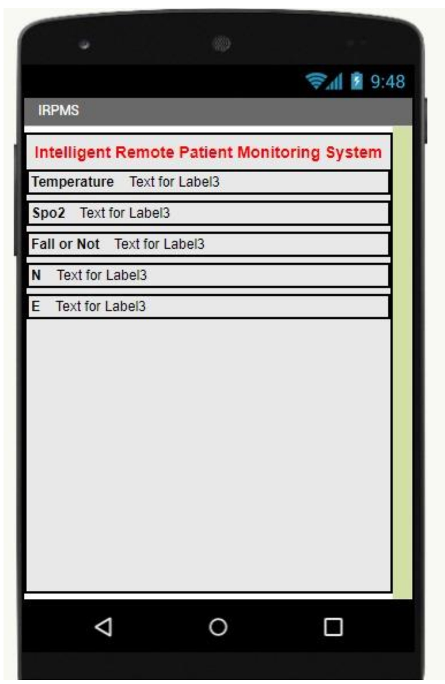
4. **MPU6050 IMU sensor test:**

   When connecting the fall sensor, it was expected that a logical value would indicate the patient's condition, whether he fell or not. And we did the test on the hand area because it was difficult to implement realistically (a person fell completely). Therefore, we reduced the threshold value until it was commensurate with the test on the hand, and the sensor succeeded in giving the required results.

5. MIT app inventor test:

As for the application that the caregiver has, he was expected to receive the results of the readings of the pieces from the Firebase and display them on his interface with its constant change as long as the pieces are reading.





4.5 The summary:

In this chapter, we have explained how the project issues and challenges we faced were implemented and how we solved and overcome them. We also explained how to properly check and test the project work.

Chapter 5: conclusion and future work:

5.1 Overview

In this chapter, we show the result from project and the expected future work.

5.2 Conclusion

The Remote Intelligent Patient Monitoring System is a very good system that helps to monitor and take care of the patient without the need for the caregiver to stay by his side all the time. With this system, the caregiver can carry out his various activities, monitor the patient's health condition, and assist him in the event of any emergency, all through his phone. We have worked on this system and tested its performance, and we are sure that it works as intended and performs all the tasks that need to be achieved from it.

5.3 Future work

- Call an ambulance immediately in case of any emergency.
- Connecting an alarm to remind the patient to take the medicine.

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