IoT Based Maternal Health Risk Detection System

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A Final Year Design Project (FYDP) submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirements for the degree of B.Sc. in Electrical and Electronic Engineering

Department of Electrical and Electronic Engineering
Brac University
December 2022

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Declaration

It is hereby declared that

1. The Final Year Design Project (FYDP) submitted is our own original work while completing degree at Brac University.
2. The Final Year Design Project (FYDP) does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The Final Year Design Project (FYDP) does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. We have acknowledged all main sources of help.

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of Fall, 2022 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of B.Sc. in Electrical and Electronic Engineering on 15th December, 2022.

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Ethics Statement

We hereby confirm that this project “IoT Based Maternal Health Risk Detection System” has matched the criteria of the Final Year Design Project (FYDP). It has been written and completed with our own efforts. In the event that any supplementary resources from other sources have been correctly cited, though. With the help of our supervisor and the institution, we put the project's contents into practice.

Abstract/ Executive Summary

Bangladesh has a high Maternal Mortality Rate (MMR) which means a lot of women die every year due to pregnancy related health risks and complications. This is a serious problem in the world today and with the help of IoT we can connect doctors to patients more efficiently and reduce the risk of death in an emergency. In this project we developed an IoT based health monitoring system that tracks the patients' vital health parameters and connects her to the doctor via a mobile application.

Keywords: MMR; IoT; Maternal Health; Maternal Health Risk.

Acknowledgement

We would like to express our immense gratitude to Professor Dr. Mohammad Belal Bhuiyan, the chair of our committee, for his continuous assistance and guidance which has helped us to finish our project gracefully. Additionally, we are appreciative of Abdullah Hil Kafi and Md. Mahmudul Islam, lecturers at Brac University, who offered advice and suggested many conventions to improve the project.

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List of Acronyms

ADC	Analog to Digital Converter
AI	Artificial Intelligence
BP	Blood Pressure
BPM	Beats Per Minute
BPT	Blood Pressure Trend
BPM	Beats Per Minute
CNN	Convolutional Neural Network
CPU	Central Processing Unit
DAC	Digital to Analog Converter
DBP	Diastolic Blood Pressure
DC	Direct Current
DMP	Digital Motion Processor
EDA	Electronic Design Automation
EEPROM	Electrically Erasable Programmable Read Only Memory
FLIR	Forward Looking Infrared
FPS	Frames Per Second
GPIO	General Purpose Input/Output
GPS	Global Positioning System

HR	Heart Rate
ID	Identification
IDE	Integrated Development Environment
IoT	Internet of Things
IR	Infrared
IT	Information Technology
JST	Japan Solderless Terminal
LED	Light Emitting Diode
MEMS	Micro Electro-Mechanical System
MMR	Maternal Mortality Rate
NIR	Near-infrared
NGO	Non-Government Organization
NodeMCU	Node Microcontroller Unit
OS	Operating System
PCB	Printed Circuit Board
RAM	Random-Access Memory
RF	Radio Frequency
RFID	Radio-frequency identification
SBP	Systolic Blood Pressure

SCL	Serial Clock
SDA	Serial Data
SPI	Serial Peripheral Interface
SpO2	Saturation of Peripheral Oxygen
TSMC	Taiwan Semiconductor Manufacturing Company
UART	Universal Asynchronous Receiver/Transmitter
UI	User Interface
Wi-Fi	Wireless Fidelity

Chapter 1

Introduction- [CO1, CO2, CO3, CO10]

1.1 Introduction

Pregnancy is the time of a woman's life which is full of joy and anticipation. Yet there are some major health risks attached to it. The health risks tied to pregnancy can be dangerous and often life threatening. Therefore, doctors recommend a regular health checkup for the pregnant mother. In this project, the proposed system aims to develop and implement a smart health monitoring system based on vital health parameters of a pregnant woman and forming useful predictions on her health status as well as set up an effective notification system for any pregnancy related health emergency.

1.1.1 Problem Statement

Many women die every year during childbirth, or they experience lifelong health complications due to it. According to World Bank figures, 62 percent of Bangladesh's population lives in rural regions. Most developing countries' rural populations face a lack of hospitals and medical facilities, and Bangladesh is no exception. According to the World Bank, Bangladesh has 0.8 hospital beds for every 1000 inhabitants. This has an influence on the lives of everyone who lives in rural regions. Pregnant women, in particular experience several difficulties as a result of this. In truth, Bangladesh has a high mortality rate due to a lack of effective infrastructure in the nation to frequently check the health conditions of pregnant women. To be precise, the MMR (Maternal Mortality Ratio) shows 173 deaths per 100,000 live births in Bangladesh in the year 2017. To improve this dire condition several systems have been developed. From our survey, which has been conducted through google forms 84.6% of participants have shown positive interest in a maternal health monitoring kit.

1.1.2 Background Study

Marques et al. [1] designed a smart health system for both fetal and maternal monitoring. In the system, health parameters of the patient are measured using sensors and transferred to the IoT layer of their design, it is then taken to the emergency subsystem where data is compared to threshold values, after that it is processed using a deep learning classifier. The health parameters that were addressed in this system are heart rate, oxygen saturation, blood pressure and temperature.

In the system proposed by Priyanka et al. [2] the data is shared to IoT using a Wi-Fi module and the results of abnormal health data triggered an alarm system in the mobile application of the patient.

Lyu et al. [11] proposed a multi-communication-fusion based mobile monitoring system to monitor the vital signs of a pregnant mother. In the system they included data collectors to collect health data from patient’s homes and upload them to a central database server. Remote doctors then accessed the patients’ data and provided diagnosis and advice based on the data. The information provided by the doctor is then transferred to the patients’ side.

Ahmed et al. [3] proposed an IoT based prediction model in the context of Bangladesh. This model is collected through sensor devices that are wearable. It was also collected from hospitals and clinics in Dhaka. The data had been fed to a cloud system where machine learning had been applied to figure out the state of the patient. The collected data had been stored in both a cloud and a local server. The system allowed the doctor-patient interaction through a website portal as well. Moreover, the patient could insert her information to the website manually and a risk analyzer developed from the training data set could give her risk prediction results.

From our survey we observe that 92.3% of patients prefer a mobile application to view their health data. Moreover, in our questionnaire we asked the participants if they would prefer wearable or environmentally integrated systems, most of them preferred a wearable device.

1.1.3 Literature Gap

The demerit of the system proposed by Marques et al. [1] lies in the fact that vital parameters like blood glucose and fetal movement are missing. The system proposed by Priyanka et al. [2] also missed the blood glucose measurement. It used a temperature sensor, blood pressure sensor, heart rate sensor and accelerometer. There was no indication of a doctor's mobile application interface in the system. Therefore, communication between patient and doctor was not set up in the system. There are some problems with this proposed system of Lyu et al. [11]. Firstly, the data collection procedure included an invasive blood glucose measuring meter which the patient might not be comfortable in. According to their system a few of the health data was to be manually transferred to the database using speech. The blood glucose level has to be one of them. This leads to the next problem and that is the issue of noise in the data. The system proposed a way of reducing the noise in the input data which ensures maximum possible accuracy but there is still a chance of inaccuracy which may prove to be risky for the patients' diagnosis. Moreover, the doctors' advice is also collected through a speech module which faces the same issue. Lastly, the whole system architecture was slow and more time consuming than expected as it depends on the manual diagnosis of available remote doctors. The system proposed by Ahmed et al. [3] had no alarm or notification system set in place.

1.1.4 Relevance to Current and Future Industry

There has not been implementation of this sort of system currently. Prototype work has been done but no sign of mass production of such a system has been noticed.

1.2 Objectives, Requirements, Specification and Constraint

On one hand every design has some specifications and requirements that it has to fulfill to make the design as flawless as possible and on the other hand since no design is ever perfect every design regardless of its efficiency and effectiveness comes with some constraints. Here we have discussed all the specifications, requirements and constraints that our designs have.

1.2.1 Objectives

Therefore, to approach the problem we have aimed to develop this project. The major objective of this project is to develop a smart system that enables a pregnant lady to track her health data on a regular basis in five stages:

- Measure the vital health parameters that indicate risk level of pregnancy.
- Take non invasive measurements that can be done at home by the patient
- Store health information in both doctor and patient interface in a mobile application and communicate it to the app's doctor interface.
- Determine the patient's degree of risk and display via the app.
- When the patient is in a serious condition, set up an emergency notification system to notify the doctor.

1.2.2 Functional and Nonfunctional Requirements

Requirements are the items we require in order for our design to operate and achieve the desired outcomes. There are two kinds of requirements. Which are Functional and Non-Functional. Certain parameters that the system must monitor are included in the functional criteria. Furthermore, functional requirements define the whole system. On the other hand, Non-functional requirements are the components that ensure the system's quality. This includes the decisions our system will make to improve the quality and reliability of our systems. Here, the Functional and Non-Functional requirements for our system are given below:

Functional requirements

Sl.	Functional Requirements	Reason
1	Temperature (37°F)	It is vital to monitor the temperature since high temperatures can affect the growth of the fetus's brain and spinal column, potentially resulting in birth defects.
2	Blood Sugar (3.5 mmol/L - 5.0 mmol/L)	Some pregnant women are unable to produce enough additional insulin, resulting in high blood sugar levels. Gestational diabetes is the medical term for this illness. Again, falling below the range might indicate Hypoglycemia, a condition in which glucose or blood sugar levels fall.
3	Heart Rate (60-110 b/m)	During pregnancy, blood volume increases by 30 to 50% to nourish the growing baby, the heart pumps more blood per minute, and heart rate rises, which can lead to cardiac irregularities. The pulse rate must be examined to detect any irregularities.
4	Oxygen Saturation (95-100%)	Shortness of breath can be a diagnostic problem for the patient because it can potentially be a symptom of serious heart or respiratory illness. These situations can lead to hypoxia, which has a negative impact on both the mother and the fetus.
5	Fetal Kick count (after 37 weeks; 10 kick/h)	During the last trimester of pregnancy, the doctor may instruct the patient to keep note of the baby's movement every day. This is generally known as "kick count." Counting the baby's kicks may assist physicians in learning about the baby's movement patterns and identifying any changes. A change might indicate an issue.
6	Fall Detection	If the patient falls due to any health abnormalities, the doctor will get the alarm and notification for that fall immediately and the health provider can send help as soon as possible.
7	Blood Pressure	It is one of the health parameters that indicate risk level.

Table 1. Functional Requirements

Non-functional requirements

Sl.	Non-Functional Requirement	Reason
1	Nylon	Since the main system is a wearable device, it would be more preferable to use comfortable materials as the sensors would be attached to the patient's body. For this reason, it is decided to use nylon material as the band, which is a very durable, and easy to clean material.
2	Using multiple ADXL335 sensors	For monitoring the baby's position by counting the fetal kicks. Since baby's position is not fixed so we need more than one ADXL335 sensor to sense the kicks on different position.

Table 2. Non-Functional Requirements

1.2.3 Specifications

Specifications are the elements that we are considering in order to determine the operating principles of our designs. These are the basic thresholds that we require in order for our design to operate.

- Take non invasive measurements that can be done at home by patients.
- Store health information in cloud database.
- Display patient health information in doctor and patient app interface.
- Give alarm notification for abnormal health data results or when pregnant woman suddenly falls down.

In chapter 2, we have mentioned 3 design approaches which are intended to fulfill the above specifications.

1.2.4 Technical and Non-technical Consideration and Constraint in Design Process

Constraints are the limitations in designing and executing the systems. We also have come across a few limiting factors that are going to affect the execution of our designs. Constraints are of two types: Technical constraints and Non-Technical constraints. Here, technical constraints are the limitations that are technology related and prevent the project from delivering the desired result. Other limitations that are not related to the technology are called non-technical constraints. Here, some of the technical and non-technical constraints of the project is given below:

Constraints

Constraints From User's end	Criteria	Reason
Technical Constraint	Internet Issue	Since our primary goal is to assist people wo live in remote areas. As a result, our biggest drawback is the internet problem. According to a poll conducted by The Daily Star, 54% of Bangladeshi rural homes do not have access to the internet. 16% of families have "no skill" with digital access. However, Bangladesh is making progress in this area and has achieved significant improvements in recent years. We still have faith that rural people will use the Internet for useful reasons and to get actual benefits.
	Risk of damaging sensors	Since our main system requires sensors to be placed on the patient's body. There is a high chance of sensor damage due to movements or any other reason. However, the main system has the flexibility of replacing the damaged component at any time. It will not affect the other working components.
Non-Technical Constraint	Discomfort	Having to wear a body kit all day as our design-1 is a wearable body kit. Which might be cumbersome for some patients but to ensure better quality we will be using Nylon as the body kit's material which is durable and easy to clean material which means less hassle. This issue has been addressed to be resolved in our nonfunctional requirements.
	Acceptance	Since we aim to help the rural people, our system is wearable technology. So, there might be a problem of

		unacceptance to modern IT tools during pregnancy time. Although, our main stakeholders are medical centers and NGOs that work for women's and children's' health. So, the doctors can help them to deal with this limitation by guiding them properly.

Table 3. Constraints

1.2.5 Applicable Compliance, Standards, and Codes

Our system designs are based on the sensor-cloud dependency. Data will be collected from the sensors and then, the cloud will process the data and determine if the output is normal or abnormal. After that, the mobile application will display the result accordingly. Hardware and software interfacing will be done by a microcontroller and with the help of internet access. Since we are working with all the medical sensors and monitoring is IoT based, so, the applicable compliance, standards and codes that relates to our project aim are given below:

- **IEEE 1451-99:** This standard specifies a way for data exchange, interoperability, and message security across a network in which sensors, actuators, and other devices can communicate with one another independent of the underlying communication technology.

- **CEN ISO/IEEE 11073 Health informatics:** Medical / health device communication standards allow medical, health care, and wellness devices to communicate with external computer systems. They record client-related and vital signs data, as well as device operating data, in an automated and thorough manner.

1.3 Systematic Overview/Summary of The Proposed Project

Every year, many women die or suffer life-long health complications due to childbirth. As a result, doctors advise pregnant women to get frequent health checks. Rural people in most developing nations, including Bangladesh, suffer a lack of hospitals and medical facilities. According to the World Bank, Bangladesh has 0.8 hospital beds per 1000 people. For this reason, the proposed system in this project intends to create and implement a smart health monitoring system based on key health metrics of a pregnant woman, creating helpful predictions on her health status, and setting up an effective alerting system for any pregnancy-related health emergency. So, the doctors can get notified every time the patient faces risk and can take immediate action to help the patient.

1.4 Conclusion

To sum up this chapter, we have described our motivation and objective for doing the project on "IOT based Maternal Health Risk Detection System". Our project aims to reduce maternal health risks to some extent. We have discussed the risks linked with many health parameters, which create a basic understanding of health concerns. We have also discussed the project's constraints and also mentioned ways to overcome them.

Chapter 2

Project Design Approach [CO5, CO6]

2.1 Introduction

Our aim consists of developing a monitoring system for pregnant women which will keep track of all our pre-set parameters and will notify the doctor and the patient when the value of a parameter drops or rises over a predefined threshold. We have set the parameters upon consulting with a health specialist, and we have done the same along with surfing through papers to set up the threshold values.

2.2 Identify Multiple Design Approach

2.2.1 Design Approach 1

We will create wearable technology to track the patient's overall maternal health using a variety of sensors, such as a MEMS-based accelerometer for detecting fetal kicks, a pulse sensor for counting heartbeats, a temperature sensor, a near-infrared sensor for counting blood sugar, and a few other sensors. In accordance with the study "Non-invasive Blood Glucose Determination using Near Infrared LED in Diffused Reflectance Method," we will build the near infrared sensor [19].

All of these analog signals from these sensors will be received by the ESP-32. Data will be translated into its ADC values before being sent to a cloud server, where it will be processed. Depending on a predetermined threshold, the system will determine if the patient is in immediate danger or not.

A mobile application with two interfaces is being developed. The patient should use one, and the treating physician should use the other. While the doctor's side of the app displays all the detailed readings from all the various sensors along with the patient's GPS location, the patient side of the app provides various pre-inserted guidelines for the patient under specific scenarios.

This is the only one of the three designs that is solely focused on a wearable object, and as of right now, we have decided that it will be our main design. We are going to use this.

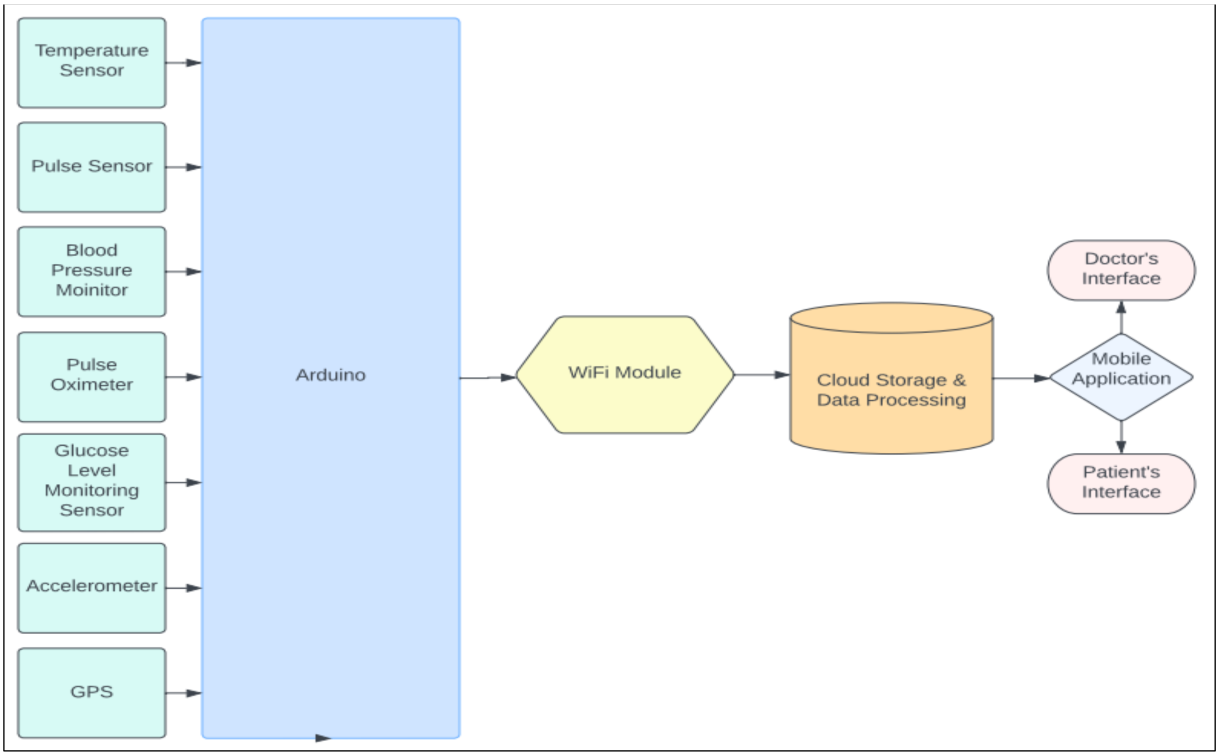

Figure 1. Flowchart of Design 1

2.2.2 Design Approach 2

The goal of this technique is to develop a surveillance-based health monitoring system rather than depending exclusively on physical outputs. This system primarily relies on the resolution of the camera's fast processing capacity paired with Convoluted Neural Network algorithm and deep learning-based computer vision to reach a quick conclusion based on even the tiniest signal on the pretrained parameters. Thermal imaging will help with temperature readings and fetal monitoring, improve the depth of AI-based outputs, and do both.

This model will be built on a network of several cameras positioned all around the patient. The question is how the camera would track the patient in this scenario as we are not placing it on any mobile devices. We therefore developed the idea of mounting passive RFID tags on patients and inserting RFID readers on camera modules to overcome this problem. In this way, all the other cameras will be off and only the one nearest to the patient will turn on. In doing so, we'll save electricity and make sure our cameras are working properly.

The patient will see one perspective of the output via the mobile app, similar to the prior model. This model has one advantage over the other two despite being more expensive: unlike the other two, it can evaluate multiple patients at once. So even though this model is expensive for single-user monitoring, it can be a deal for monitoring a large patient population.

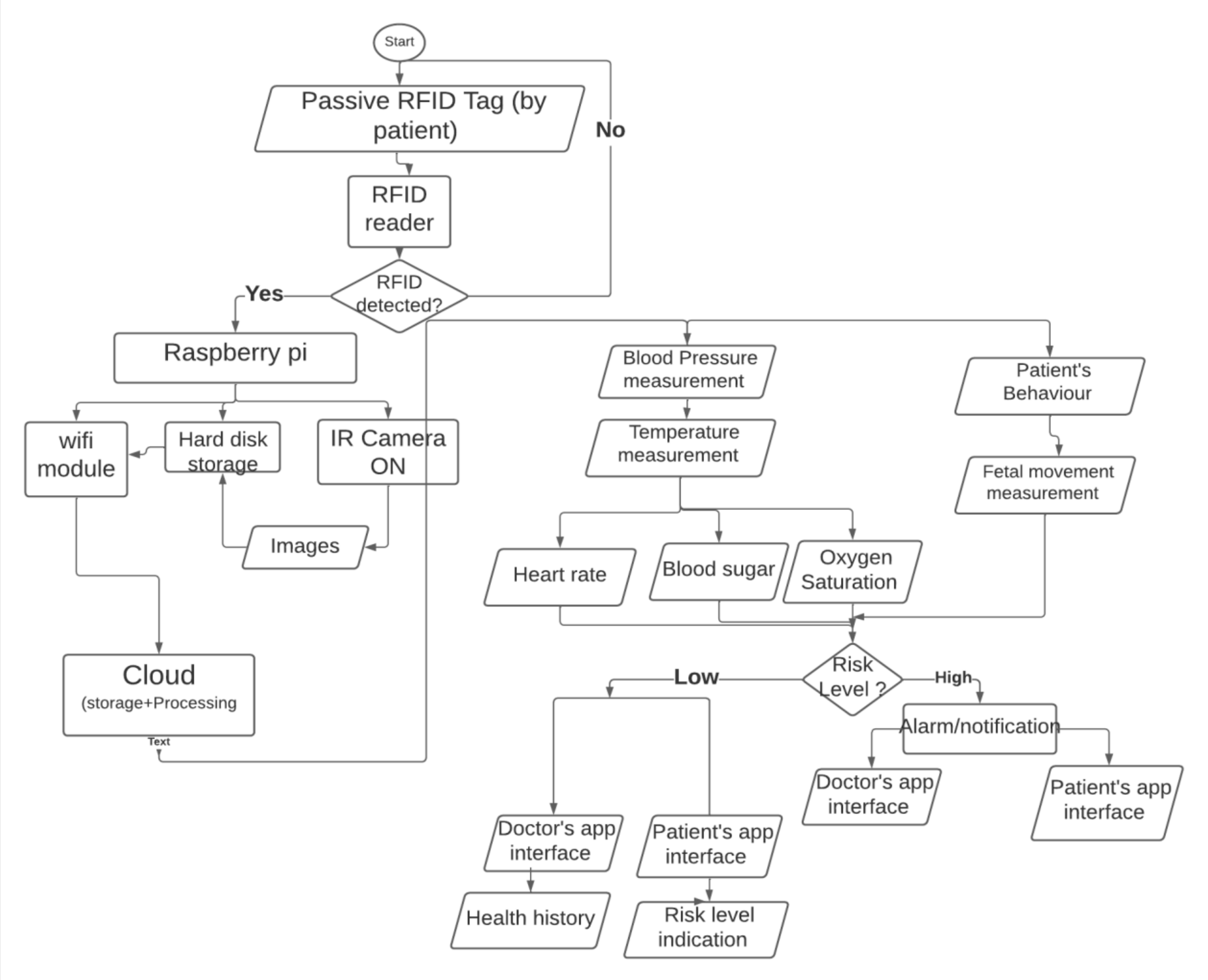

Figure 2. Flowchart of Design 2

2.2.3 Design Approach 3

This design strategy was driven by the desire to integrate multiple health metrics measuring sensors into everyday things in order to create a non-wearable health monitoring system. However, unlike our previous design, this one intends to integrate such sensors into everyday things so that the patient won't have to worry about wearing a device for most of the day. It is built on the usage of physical sensors to monitor several specified metrics, just like our first design.

For instance, we could create a kit and offer it to the patient, who would then place it, say, in a part of her bed or another location where she would spend a lot of time lying down. We also refer to this system as a "night time monitoring system" because most of the monitoring will take place at night while the patient is sleeping because the sensors are largely built into her bed. This design is primarily recommended as an alternative to the wearable technology we created in Model 1.

The patient can view a filtered version of the outputs, similar to the prior model, while the doctor receives the detailed version of the output.

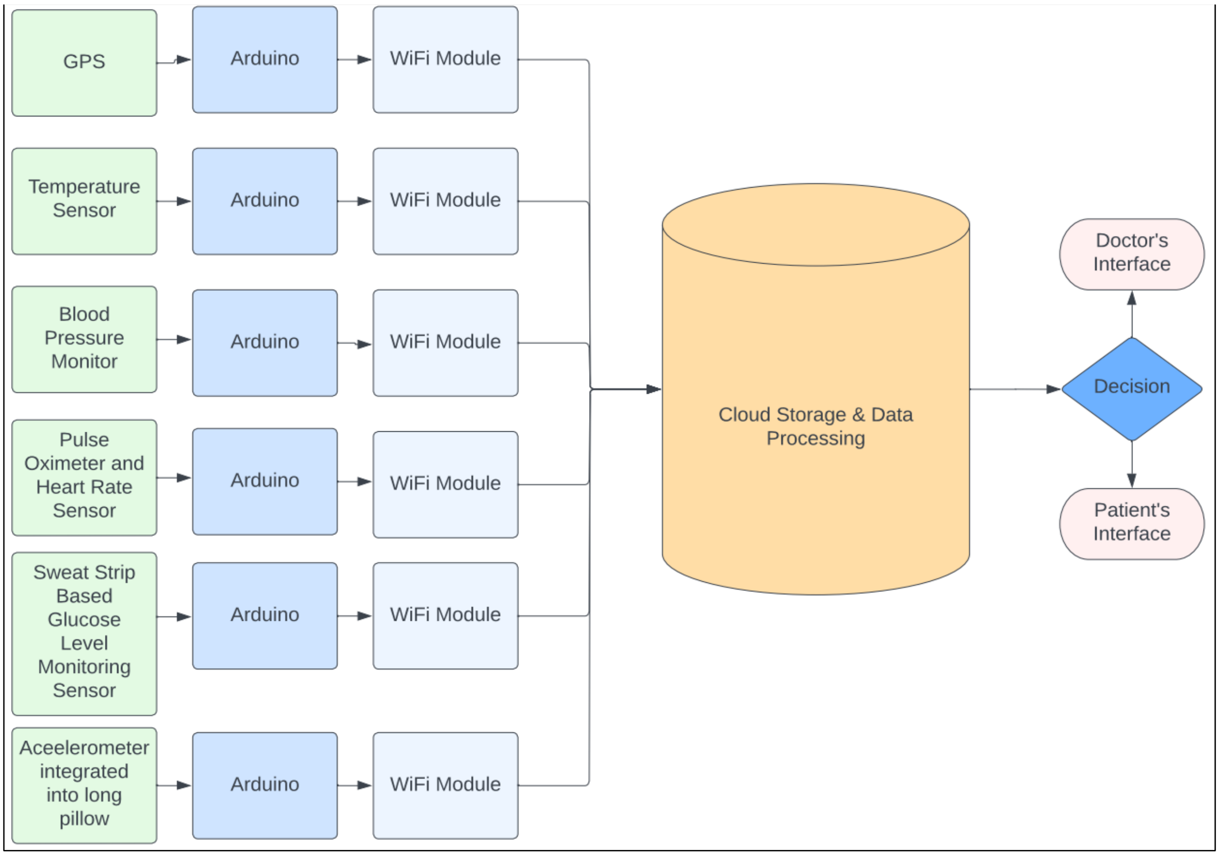

Figure 3. Flowchart of Design 3

2.3 Describe Multiple Design Approach

2.3.1 First Approach

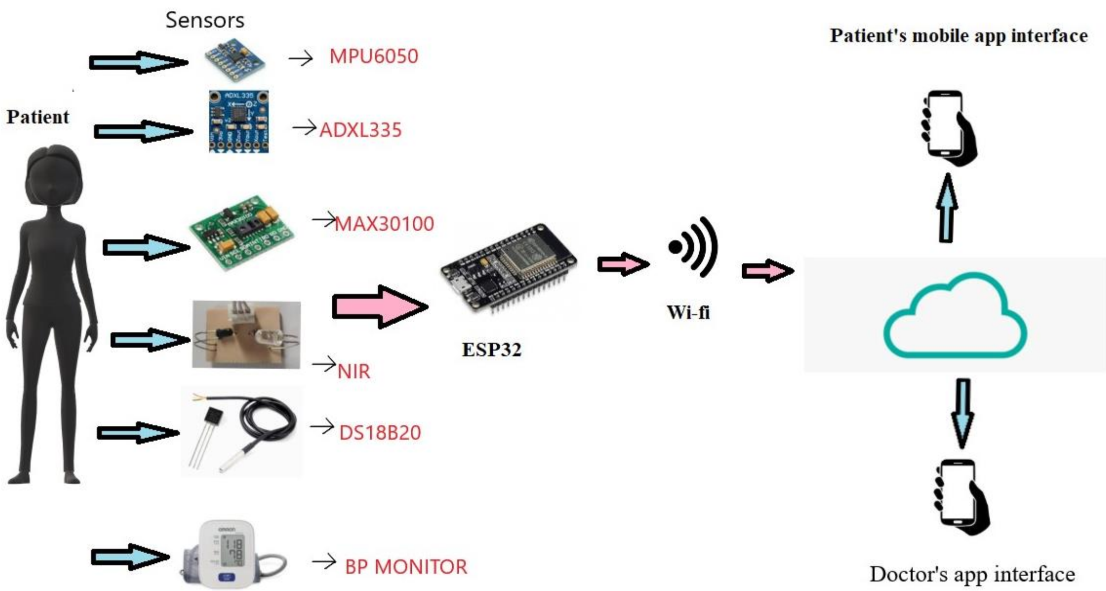

Figure 4. Design Overview of Design 1

- Microcontroller for receiving all the data from the sensors spread around.
- Sensors for measuring the specified parameters.
- The data from the microcontroller will be sent through the internet to the cloud.
- The received data will be matched with the pre-set threshold to determine danger level.
- The app will have two interfaces. One for the doctor and one for the patient.
- The doctor's side of the interface will have details of the all the measured parameters.

Design approach 1 is based on a sensor-based monitoring system. Here the sensors are integrated into a single PCB making it a small, compact and wearable device. This device is designed to monitor the patient 24/7 and so we had to keep in mind the type of power supply we would use along with the freedom to change a sensor whenever necessary. Our design here mainly consists of a central microcontroller that takes in all the inputs and has all the data, and the sensors will be placed into their pre-registered places.

2.3.2 Second Approach

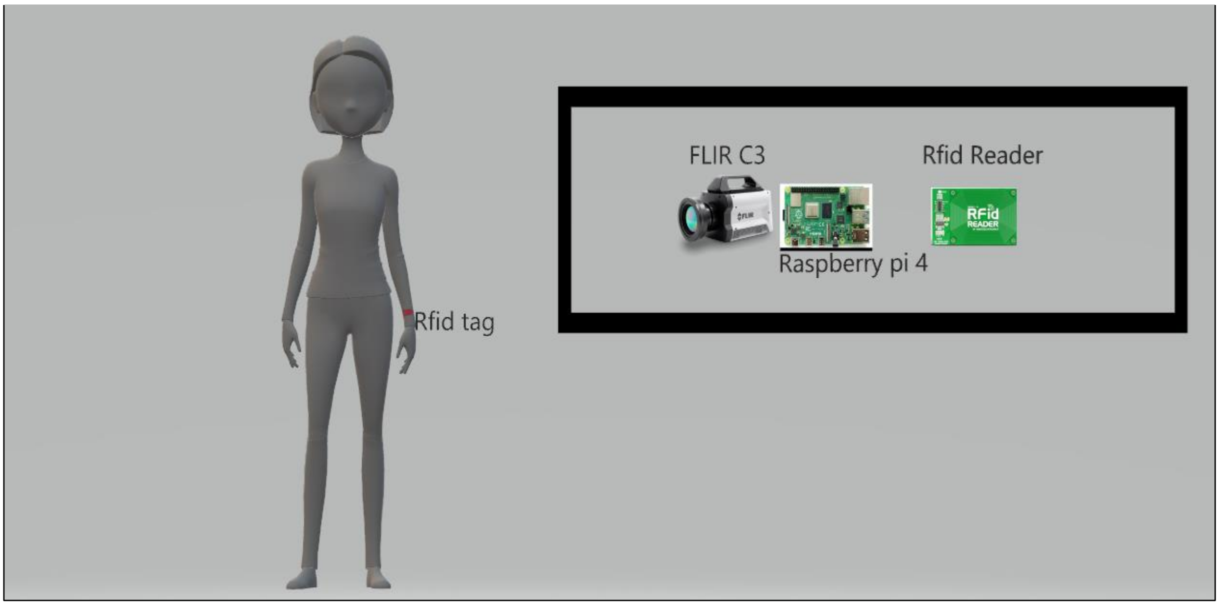

Figure 5. Design Overview of Design 2

- This system is based on IR cameras and image processing.
- IR thermal cameras are set all around the house with RFID readers.

- An RFID tag is attached with the patient.
- The RFID system works as a way to notify the position of the patient within a house.
- The images are sent to cloud where they are processed, and the health parameters are identified.

Design approach 2 is based on IR cameras and image processing. Here the images are taken using IR cameras and then sent to cloud where the data from the images are taken apart and then processed to determine certain health parameters which are then matched against a predefined threshold and risk level is determined accordingly. In this design there is also an app-based system to keep the doctor and the patient updated with the readings from the image processing.

2.3.2 Second Approach

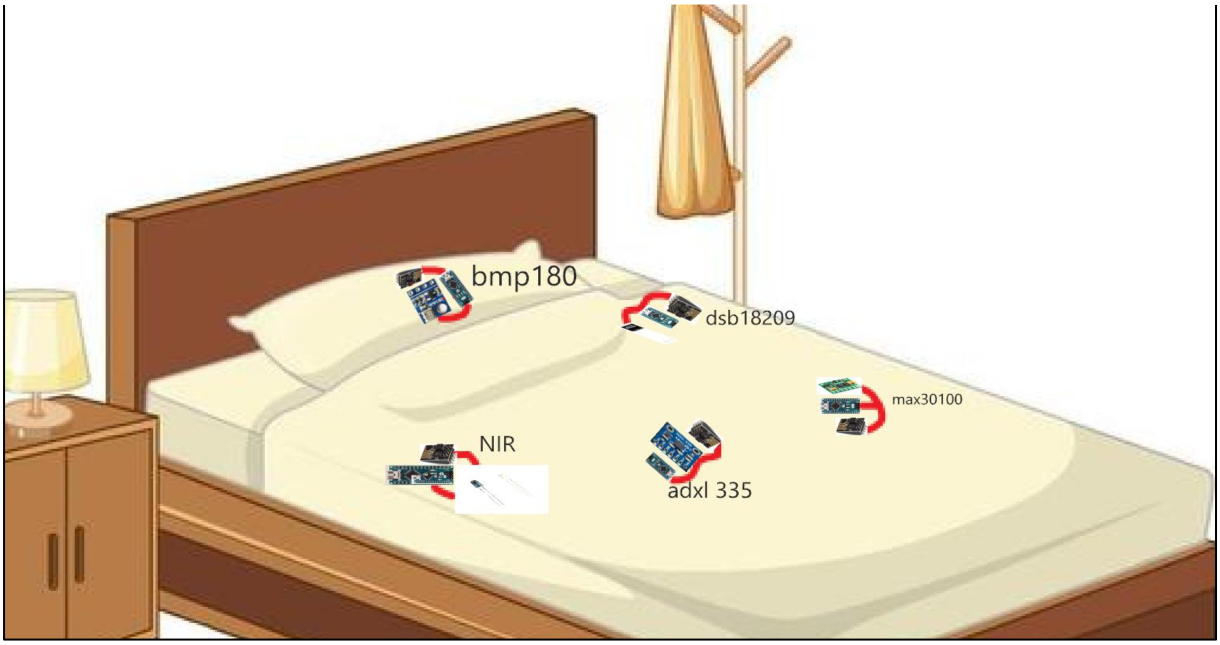

Figure 6. Design Overview of Design 3

- Here all the sensors are separated and are integrated into different house appliances.
- The main goal of this design is to implement a design without the help of a wearable device.
- This is not a 24/7 monitoring system. Rather it is 12 hours monitoring system.

- Expect the fact that it is not a wearable 24/7 monitoring system and that we will be using a different microcontroller for every sensor, the rest of this design is same as the design 1.
- Like design 1 this will also have an app with the previous specifications.

This design strategy was driven by the desire to integrate multiple health metrics measuring sensors into everyday things in order to create a non-wearable health monitoring system. However, unlike our previous design, this one intends to integrate such sensors into everyday things so that the patient won't have to worry about wearing a device for most of the day. It is built on the usage of physical sensors to monitor several specified metrics, just like our first design.

2.4 Analysis of Multiple Design Approach

In order to compare the three design strategies, we evaluated them based on a number of criteria, and the findings are shown in the table below.

Criteria	**Design 1**	**Design 2**	**Design 3**
Design flow	To measure health metrics, it makes use of several sensors.	The system uses thermal camera image to determine health parameters	Is based on data collected by sensors built into common household furniture and objects.
Wearability	Wearable device	Non wearable and the system is stationed at particular place	Non-wearable, packaged as a system, and used in the patient's surroundings
Monitoring Window	24-hour surveillance	To determine health parameters, the system uses thermal camera images. The system is stationary at a certain location and is not wearable. monitoring at specific time intervals (only monitors when patient is detected in the nearby range)	8-to-12-hour observation

Dependency on hardware/software	The sensor readings are what determine its design.	The effectiveness of the thermal picture, as well as the subsequent color mapping and image processing, are the foundations of this concept.	Like design 1, this design is heavily dependent on sensors.
Dataflow	Provide continuous values	provides ongoing results of calculations	Delivers measurements based on the sensors being used rather than a streamlining of information like designs 1 and 2
Accuracy	Provides the most precise statistics of the three designs.	Accuracy depends on long-term data training. Moreover, environmental differences have a significant impact on data accuracy.	Accurate but intermittent
Cost	Is the most affordable	Is the most expensive	Because more sensors of the same type are used, design 2 is more expensive than design 1.
Versatility	Can only be applied to one person at once	Can be used to watch numerous people's parameters at once. Ideal for monitoring at home or even in a hospital ward	Only one person at a time may utilize it
Monitoring area	Ideal for monitoring at home	Ideal for in home or even in hospital ward monitoring	Ideal for monitoring at home
User preference	User preference for wearable designs is highest	Some people favor non-wearable alternative	Some people favor non-wearable alternative
Mass Production ability	Can be bulk made using components found nearby.	Components are quite difficult to find.	Indigenous components that cannot be bulk produced.
Initial Setup	No need for setup	Arduous to set up	A user manual is necessary for setup. Quite simple to set up.

Table 4. Comparison Between The Multiple Designs

2.5 Conclusion

We have covered a variety of mathematical reasoning, analytical thinking, and complicated engineering problem-solving difficulties. We compared the functionality phases of the 3 distinct design approaches we came up with after finishing these tasks in order to select the optimal design approach (Design Approach-1) for our system.

Chapter 3

Use of Modern Engineering and IT Tool [CO9]

3.1 Introduction

The phrase "contemporary Engineering Tools" is frequently used in the engineering world. A "current" engineering tool should be chosen using the best approaches, which include research, analysis, and comparison. Before employing a modern engineering tool, the user must perform extensive study in order to select the appropriate one for the task. Therefore, we carried out a wide range of research, literature reviews, and comparisons in order to choose the Modern Engineering tools (i.e., Hardware, Software, Simulation software, etc.) for our project.

3.2 Select Appropriate Engineering and IT Tools

Model	**Component**	**Technical Specification**	**Component Description**
Doit Devkit	ESP32	Architecture: 32 bits Flash Memory:16 Mb RAM:512 KB Clock Speed: 160 MHz	Esp32 works faster than Arduino and is more powerful for a lower price. It is 32-bit architecture with integrated Wi-Fi and dual-mode Bluetooth
DS18B20	Temperature Sensor	Operating voltage: 3V to 5V Temperature Range: -55°C to +125°C Accuracy: ±0.5°C	A temperature sensor detects and measures heat and cold, then converts the data into an electrical signal.
MAX30100	Oxygen Saturation Sensor	Operating Voltage: 1.8-3.3V Input Current - 20mA 12C pinout	It's a system that combines pulse oximetry and a heart rate monitor. It is complete pulse oximeter and heart rate sensor solution, simplifies design, integrated LEDs, photo sensor, and. high-performance analog front. Ultra-low power operation increases battery life for wearable devices.
MPU6050	Accelerometer and Gyroscope Sensor	16-bit analog to digital converter	The Micro Electro-Mechanical System (MEMS) MPU6050 contains an accelerometer and a three-axis gyroscope

NIR LED (940nm)	NIR LED (940nm)	Transmitting Wavelength: 940nm i.e., in the near infrared region	Transmits 940nm wavelength which lies in the near infrared region
NIR Photodiode Receiver (940nm|)	NIR Photodiode Receiver (940nm|)	Receiving wavelength: 940 nm i.e., in the near infrared region	Receives the transmitted wavelength of 940 nm i.e., in the near infrared region
Resistor	Resistor	1K ohm 5K ohm 4.7K ohm	Used to manipulate the flow of current and hence the voltage applied to nodes
Capacitor	Capacitor	2.2uF 50V	Maximum voltage that can be applied across both ends is 50V
ADXL335	Accelerometer Sensor	Single-supply operation 1.8 V to 3.6 V 3-axis sensing 10,000 *g* shock survival	The ADXL335 is a 3-axis analog-output accelerometer with ±3 g measurement range.
1A Glass Fuse	Glass Fuse	1A	Breaks the circuit when higher current than required rating enters.
CR43-4R7	DC to DC step down buck converter	12-24 V step down to 5V	This steps down voltage in a circuit.
MAX32664 (Pulse Express)	Pulse Express Pulse-Ox & Heart Rate Sensor	I2C Interface 35 mm x 17 mm in size	Easy to use. Requires ultra-low power. I2C interface for connecting with any host microcontroller. incorporates a high-sensitivity pulse oximeter as well as a heart rate sensor.
18650 Rechargeable Batteries	Rechargeable Battery	Nominal 3.7V, Full Charge: 4.2V ± 0.05V	Rechargeable Battery
Two Tank Battery Holder	Battery Tank	For 18650 batteries	For mounting and dismounting batteries

Table 5. Hardware Tools

Tool Name	Reason
Visual Studio Code	Front End Coding for App Development
ReactNative	For Backend development of Application
Firebase	To develop app and interface software and hardware

EasyEDA	To design printed circuit board
ArduinoIDE	To run and test hardware components
Proteus	For software simulation of total design

Table 6. Software Tools

3.2.1 Software and comparison

A comparison table between different software those were initially selected is shown below:

Software Name	Portable	Runs on Moderate PC Specs	Import facilities	Free	Crash issue	Graphs	Visualization	Component Naming	Capability of Conne-cting to Cloud	Image processing
Proteus	✓	✓	✓	X	✓	✓	✓	✓	X	X
Sci-lab	X	X	X	X	X	✓	✓	✓	X	X
MATLAB	✓	X	X	X	X	✓	✓	X	✓	✓
TINKERCAD	X	✓	✓	✓	X	X	X	✓	X	X
Pspice	X	✓	X	X	X	X	X	✓	X	X

Table 7. Software Comparison

By comparing several factors, we can find that Proteus has the most online forums and resources available and a very user-friendly UI. Therefore, for the simulation portion, we have chosen to use Proteus 8 Professional (v8.13).

3.3 Use of Modern Engineering and IT Tools

ESP32: The ESP32 family of system on a chip microcontroller is low-cost and has integrated Wi-Fi and dual-mode Bluetooth. The ESP32 series includes integrated antenna switches, RF baluns, power amplifiers, low-noise receive amplifiers, filters, and power-management modules in addition to the Tensilica Xtensa LX6 dual-core or single-core microprocessor, Tensilica Xtensa LX7 dual-core, or a single-core RISC-V microprocessor. The ESP32 was created and built by the Shanghai-based Chinese company Espressif Systems, and it is manufactured by TSMC using their 40 nm process. It is a substitute for the ESP8266 microcontroller. This is our choice of microcontroller for the optimal design as it has a built-in Wi-Fi module, so it reduces complexity. Moreover, it has an adequate number of digital and analog pins to support our designs.

DS18B20 Temperature sensor: The DS18B20 is a small temperature sensor with a built-in 12-bit ADC. Connecting to an Arduino digital input is easy. The sensor uses a one-wire bus for communication and only needs a few additional components. The sensor operates in two different ways: normally and parasitically. In standard mode, a 3-wire connection is necessary. When a sensor is working in parasitic mode, the data line supplies electricity to the sensor. Only two wires are required: one for data and one for ground. In normal mode, each sensor is coupled to a power line (Vdd pin 3) and ground (GND pin 1) as well as the data output (DQ pin 2), which is connected to a third data line. The DQ pin 2 (data output port) is a 3-state port. This is our choice of temperature sensor as it is water resistant.

MAX30100 Pulse Oximeter and Heart Rate Sensor: A sensor system called the MAX30100 features integrated pulse oximetry and heart rate monitoring. It features two LEDs, a photodetector, better optics, low-noise analog data processing, and pulse oximetry and heart rate signal detection. We chose this sensor as it can give two health parameters using one sensor so reduces circuit complexity as well as power requirement.

Blood Pressure Monitor: With serial out, blood pressure and pulse readings are displayed on the display for external integrated circuit processing and display projects. displays the pulse, systolic, and diastolic readings. A little design that fits like a watch over your wrist. Pumping is eliminated by the simple wrist design. This was initially our choice of blood pressure measurement but due to lack of datasheet it couldn't be integrated in the circuit. Therefore, we proposed the use of MPU32664.

MAX32664: The MAX32664 Ultralow Power Biometric Sensor Hub from Maxim Integrated has wearables-specific embedded firmware and algorithms that enable smooth customer-requested sensor functionality. This feature includes sending raw or computed data to the outside world as well as communication with Maxim's optical sensor solutions. This is accomplished while limiting the system's overall power usage. It is a sensor that can locate a blood pressure trend (BPT) when attached to the finger of a patient.

MPU6050: The Micro Electro-Mechanical System (MEMS) MPU6050 contains an accelerometer and a three-axis gyroscope. It facilitates the measurement of motion-related properties like displacement, acceleration, and direction.

The MPU6050's Digital Motion Processor (DMP) is capable of handling challenging calculations. The MPU6050 includes a hardware 16-bit analog to digital converter. It can concurrently capture three-dimensional motion thanks to this feature. Due to its widespread availability and well-known features, this module can be utilized with popular microcontrollers like Arduino. This module communicates with Arduino via the I2C module. In addition to being less priced, the MPU6050 has the benefit of being easy to pair with an accelerometer and gyro. This sensor has been the choice to detect sudden fall in patient as it is a source of vital health risk in patient.

ADXL335: A 3-axis analog-output accelerometer with a measurement range of about 3 g is called the ADXL335. The breakout board's tiny size (1" x 1") makes it simple to mount the accelerometer to an existing system without the need for extra hardware and with no impact on the system's and accelerometer's performance. This sensor has been used to monitor the fetal kick in patient’s abdomen.

Proteus: It is a collection of tools for automating electronic design in design software. The program is primarily used by electronic design professionals to create schematics for system simulation and PCB design (Printed Circuit Boards). For developing and putting it into practice physically, Proteus's 2D design of electrical and electronic circuits and its simulation can be quite beneficial. Before the circuit is really built, we can examine any potential flaws and issues with it using the circuit simulation. Since testing certain types of equipment in real life might be expensive, simulation is required.

Arduino IDE: In addition to a text editor for writing code, a message area, a text console, a toolbar with buttons for frequently used operations, and a number of menus, the Arduino Integrated Development Environment, sometimes known as the Arduino Software (IDE), is also available. In order to upload programs and communicate with them, it connects to the Arduino hardware.

Visual Studio Code: You may get started coding right now with the help of the free coding editor Visual Studio Code. Without changing editors, use it to code in any programming language. Python, Java, C++, JavaScript, and many other languages are supported by Visual Studio Code.

ReactNative: Meta platform built React Native, an open-source UI framework for building mobile applications. This gives a framework for almost any general task that may be completed and maintained. Because it is a reusable software environment, we do not need to build code from the start for each application. This framework helps to reduce the probability of introducing errors into the code. React native can be used for both Android and iOS.

Firebase: Google has established the Firebase platform for developing mobile and web applications. Firebase Realtime Database supports the building of complex, collaborative apps by allowing safe access to the database from client-side code. Data is stored locally and may even be seen when not connected to the internet. Furthermore, the database is constantly updated with real-time events, ensuring a dynamic user experience. Firebase is utilized in our project to collect device-level information, assess it, and guarantee that our mobile application has simple access to parameters. This enables us to make sound decisions.

EasyEDA: EasyEDA is a web-based EDA tool package that allows hardware engineers to publicly and privately generate, model, exchange, and evaluate schematics, simulations, and printed circuit boards.

3.4 Conclusion

To choose the best cutting-edge technical techniques for the hardware and software components of our project, we ultimately read through a number of research articles and assessments. We chose the sensors and other tools that were offered on the regional market. We also had to keep a major point in our head while planning for the whole project and that is our main design has to be very cost efficient as we have a plan to mass produce the product and spread it across the nation. In conclusion we tried to make the best use of hardware and software tools available to facilitate our design.

Chapter 4

Optimization of Multiple Design and Finding The Optimal Solution [CO7]

4.1 Introduction

We have selected a few criteria to help us select the best design approach from among the several design approaches for our project. In this case, our main goal was to find the offered design that would best meet our goals, criteria, and specifications.

4.2 Optimization of Multiple Design Approach

In order to optimize the various design approaches, we have gone through some test cases. We have tried to measure the usual human body reading through these designs and see which design makes the most of the resources it has got. A brief of all these is given below:

4.2.1 Design 1

Here we can see a schematic diagram of our design 1 laid out in proteus. This design is heavily based on sensors and usually has the error rate that is given in the data sheet of the specified sensors. But here are two sensors, one of which is our own made experimental one based on IEEE papers.

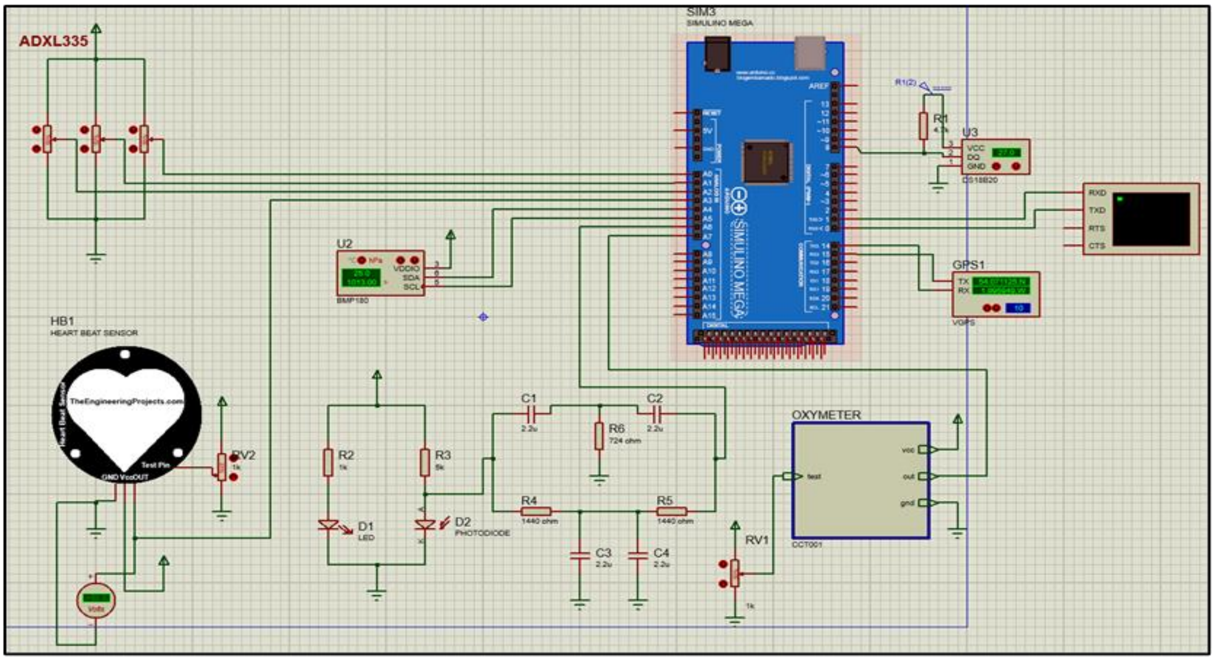

Figure 7. Proteus implementation of Design 1

Of the two sensors mentioned above one is an accelerometer used for the detection of fetal kicks and another is an NIR based system used for the measurement of blood glucose. We implemented this in the hardware as proteus simulation of it was not possible.

1. ADXL335 for fetal kick monitoring

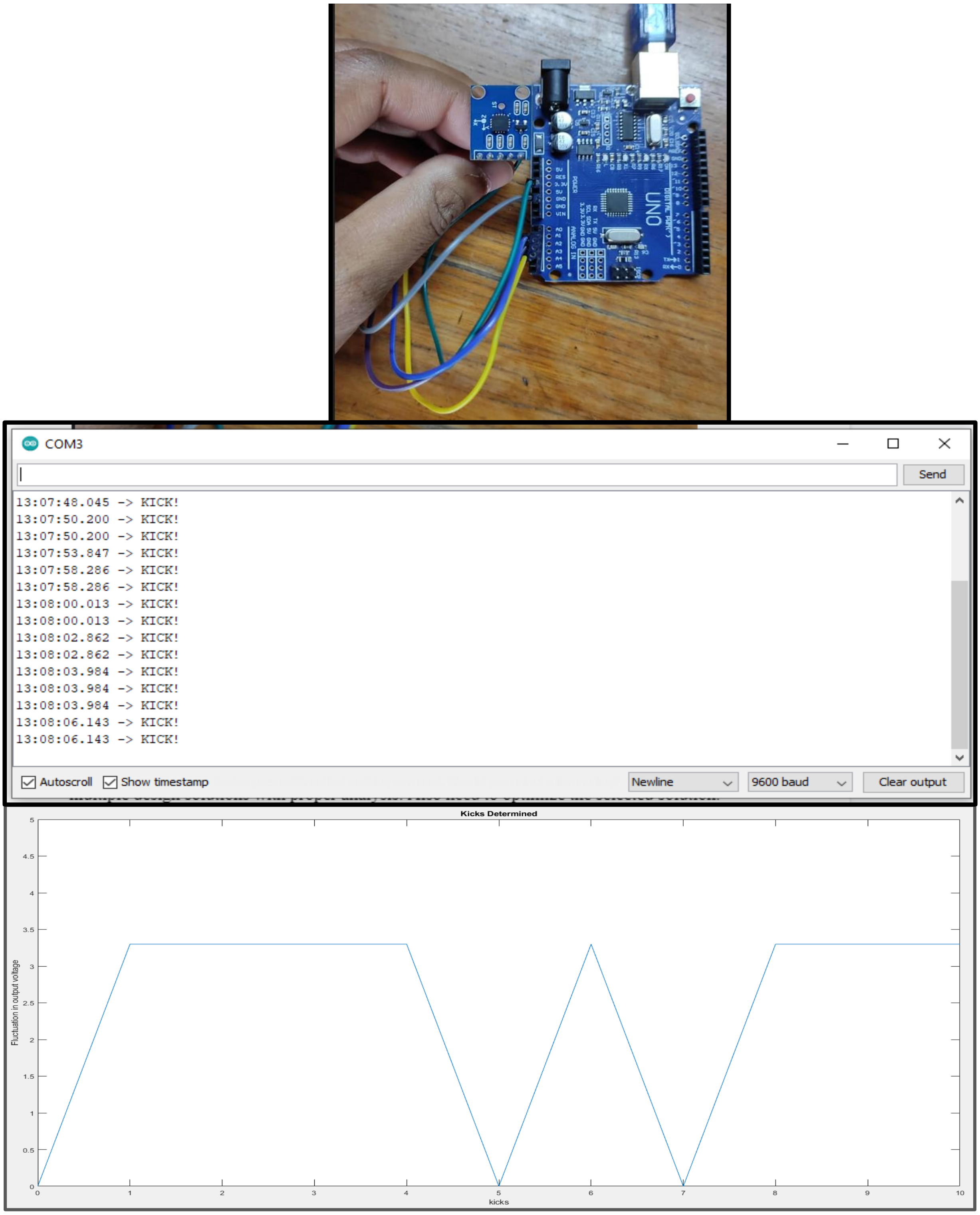

Figure 8. ADXL335 Sensor interface and result

2. NIR for blood glucose monitoring

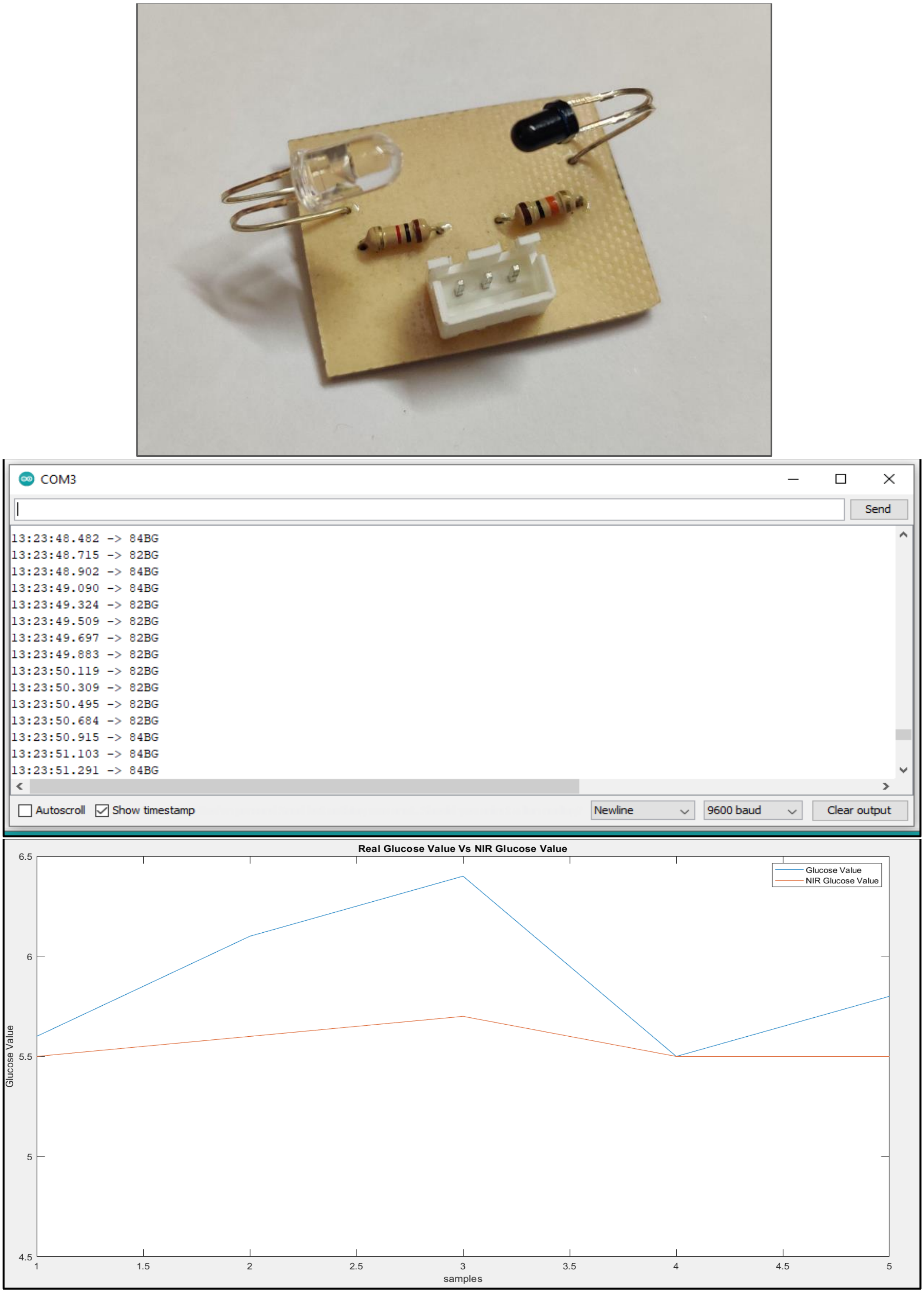

Figure 9. NIR Sensor interface and result

4.2.2 Design 2

Now since the design 2 is based mainly on image processing, so there is no schematic diagram for it but here is a diagram to best demonstrate the purpose:

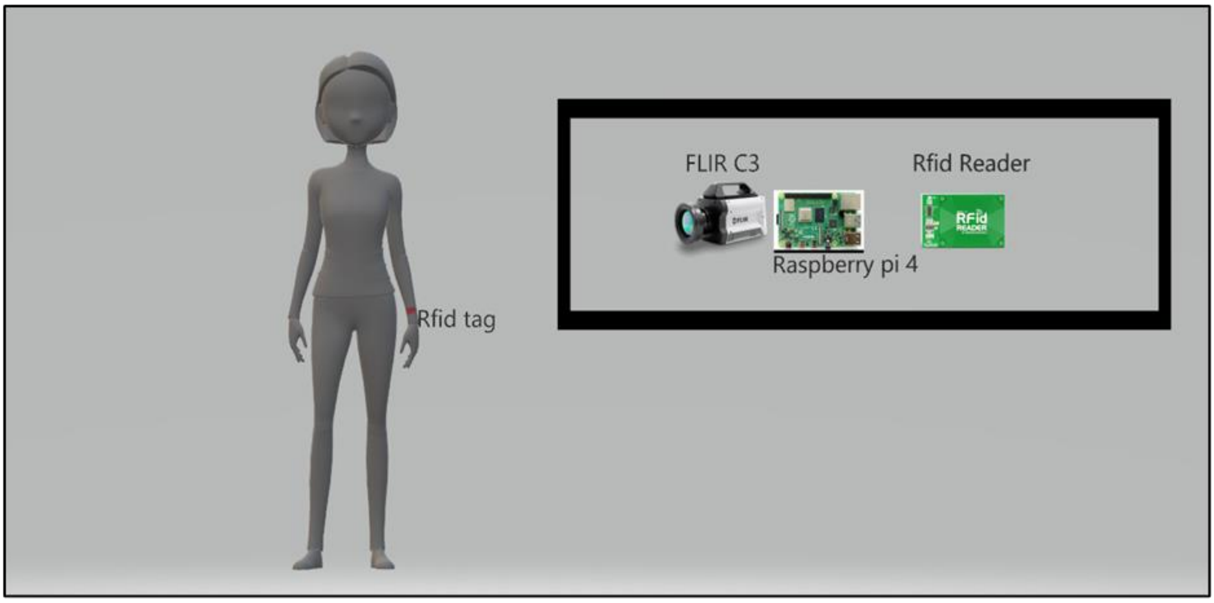

Figure 10. Design Overview of Design 2

An industry-grade FLIR camera was not easily available, therefore we were forced to improvise by using the AMG8833 thermal camera module. The quantity of sensors used in thermal cameras affects image resolution. The measurement range of the AMG8833 thermal camera is 0 to 80 degrees Celsius, with a 2.5 degree accuracy. It can detect objects at a distance of up to 7 meters. The highest frame rate of this camera is 10 Hz, or 10 frames per second, and it has an 8x8 (or 64 pixel) image resolution. The sensor's field of view is 60 degrees. A thermal camera can detect the heat that is spread throughout the item. The AMG 8833 is a low-resolution thermal camera.

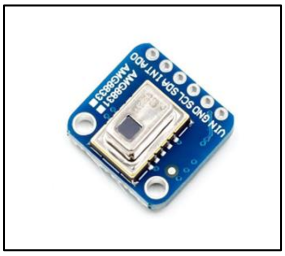

Figure 11. AMG8833 Sensor

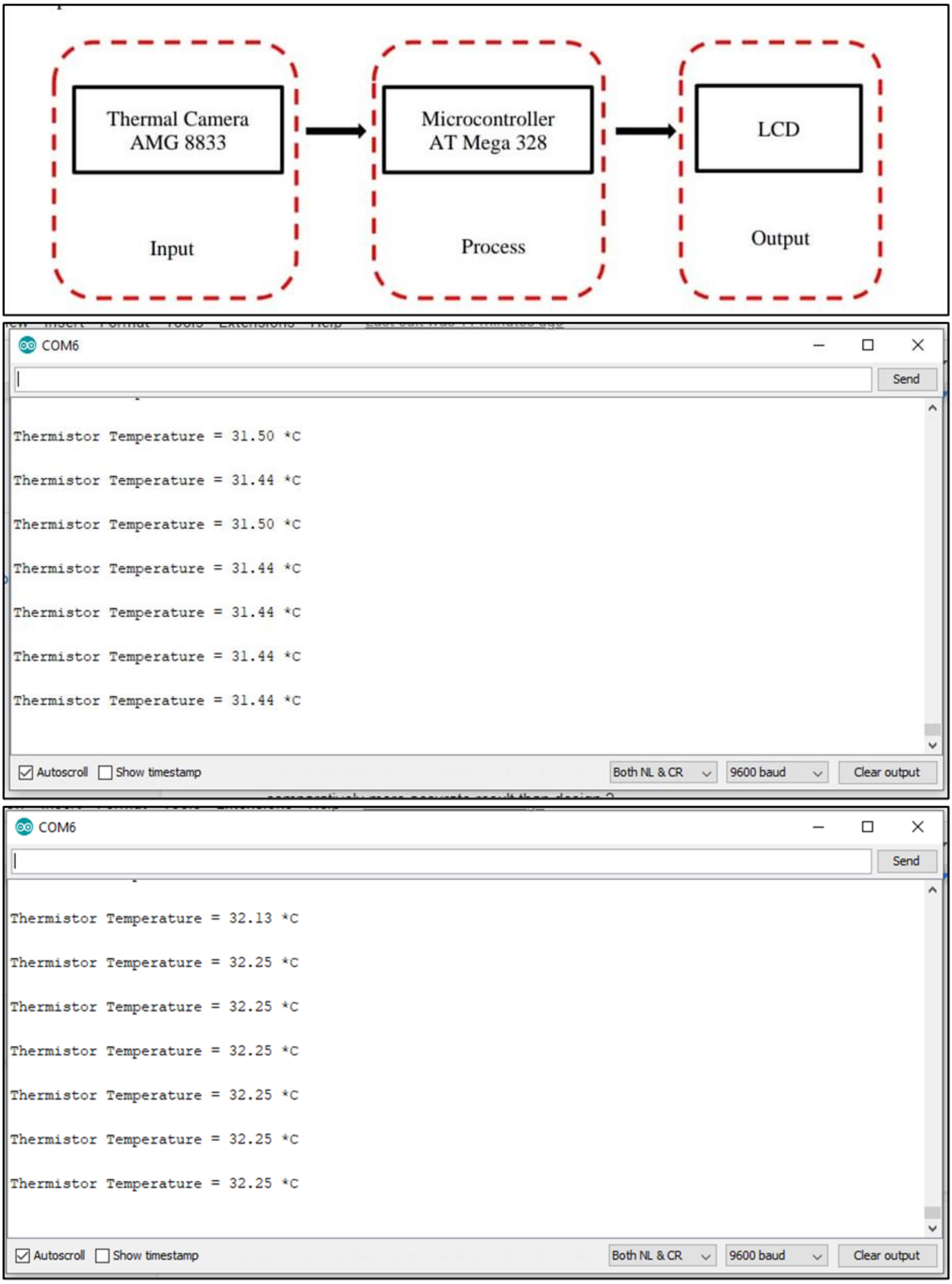

Figure 12. AMG8833 Sensor interface and result

Now the only thing that we were getting accurate from this sensor was the temperature. The other parameters needed to be derived from the actual thermal image provided by a high-end

IR camera which was not readily available to us. So, we had to rely heavily on literature review to assert the possibilities of this model. From literature review we found:

- Fetal Kick count: Done via maternal perception which is proven to be less accurate compared to use of accelerometer sensor [22].
- Pulse Rate Measurement: Absolute errors are 2.003 bpm and 3.823 bpm [23].
- Blood sugar level detection: Measurement accuracy is low due to disturbance from environment and lack of stability in the environment.
- Heart rate measurement: Compared with the finger pulse oximeter, the HR measurement obtained from the proposed infrared video has quite accurate performance [24].

4.2.3 Design 3

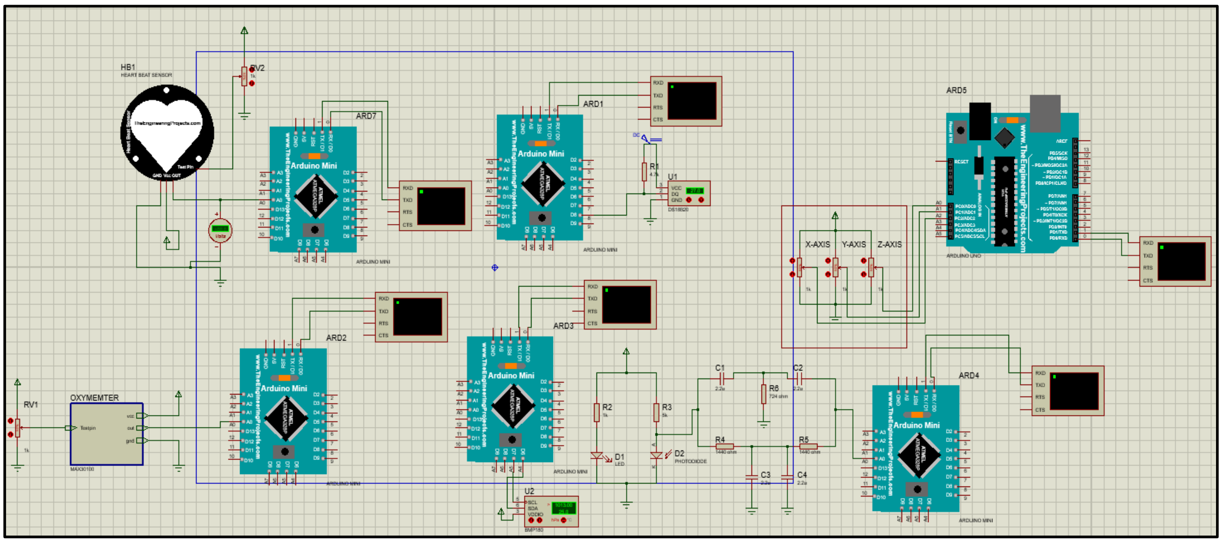

Figure 13. Proteus implementation of Design 3

Here we can see the schematic diagram of design 3. Design 3 is basically a redesign of design 1 to bypass the need of a wearable device. Other than that, everything else is basically the same as design 1. For better understanding a table comparing the difference between design 1 and design 3 is given below:

	Design 1	**Design 3**
Efficiency	The wearable device is the most effective of the three since it can continuously and continuously read data from the patient throughout the day.	Since it makes use of the same sensors as design 1, this model's efficiency is comparable to that of design 1. The sole distinction is that this model's output is greatly influenced by how much of the time the patient uses the furniture and accessories because it cannot read data as continuously as design 1 can.
Usability	It is very usable because it is simple to set up and can be turned on or off with the push of a button.	more usable than design 1 primarily due to the fact that it is not a wearable device and can thus be utilized by the patient very easily.
Portability	Since all the sensors and the microcontroller are integrated into a small wearable device, it is incredibly portable.	The least portable of the three models
Manufacturability	Since the availability of the sensors is what determines how easily anything can be manufactured and installing the sensors is rather simple	The manufacturing process is more difficult than it was for designs 1 and 2 primarily because each sensor needs its own Wi-Fi module and power supply in addition to being seamlessly integrated into everyday objects, which calls for skill and craftsmanship. Manufacturability also depends on the availability of the sensors.
Maintainability	Since the sensors are reasonably priced and easily replaceable, they are simple to maintain.	easier to maintain than design 2 due to the ease of replacing the sensors and the less complex nature of the components utilized in design 2.
Costing	Less expensive of the two	More expensive of the two

Table 8. Design Comparison Between Design 1 And Design 3

The design differences of the 3 designs are given below.

Design 1	**Design 2**	**Design 3**
It uses a number of sensors to measure health parameters	The system uses thermal camera image to determine health parameters	Is based on readings from sensors integrated into everyday household furniture's and objects
Wearable system	Non wearable and the system is stationed at particular place	Non wearable, comes as a kit system and integrated into the patient environment
24-hour monitoring	Specific time interval monitoring (only monitors when patient is detected in the nearby range)	8–12-hour monitoring
This design is dependent on the readings from the sensors	This design is based on the quality of the thermal image as well as the consecutive color mapping and image processing	Like design 1, this design in very much sensor dependent
Gives continuous values	Gives continuous calculated outputs	Doesn't give a streamline of information like design 1 and 2 but gives readings based on which sensors are being used
Gives the most accurate data among all 3 designs	Accuracy depends on data training over time. Moreover, data accuracy is massively affected by environmental discrepancies	Accurate but not continuous
Is the least expensive	Is the most expensive	More expensive than design 1 due to use of multiple sensors of same type
Can be used on one person at a time	Can be used to observe the parameters of multiple people at a time	Can be used for only one person at a time
Ideal for in home monitoring	Ideal for in home or even in hospital ward monitoring	Ideal for in home monitoring
Highest User preference for wearable design	Some users preferable non wearable	Some users prefer non wearable
Can be mass produced with locally available components.	Components are very unavailable.	Components locally available but cannot be mass produced
No need to set up	Difficult to set up	Set up requires a user manual. Moderately easy to set up

Table 9. Design Comparison Between Three Designs

4.3 Identify Optimal Design Approach

After simulating all the 3 proposed designs, we have come to a conclusion that the design best fit for our purpose is design 1. Below a brief comparison of all the three models is shown:

Criteria	**Design 1**	**Design 2**	**Design 3**
Wearability	✓	X	X
Monitoring Window	✓	✓	X
Dependency on hardware	✓	X	✓
Dataflow	✓	✓	X
Accuracy	✓	X	✓
Cost	✓	X	X
Versatility	✓	X	X
Monitoring area	X	✓	X
User preference	✓	X	X
Mass Production ability	✓	X	✓
Initial Setup	✓	X	X

Table 10. Brief Design Comparison Between Three Designs

So, from the table above we can see that Design-1 holds the most favorable position of the three designs that we have proposed. And after giving scores on certain criteria, we can see that the design-1 holds the most score:

	Design 1	**Design 2**	**Design 3**
System Design (5)	5	4	3
Accuracy of Performance (5)	4	2	3
Price (5)	5	1	3
Availability of Components (5)	5	2	5

User Preference (5)	5	3	4
Social and Environmental Impact (5)	5	3	4
Total Score (30)	29	15	22

Table 11. Scores of Different Designs

4.3.1 Swot Analysis

Design-1:

Strengths:

- Wearability
- Monitoring Window
- Dependency on hardware
- Consistent Dataflow
- Most Accuracy
- Cost-effective
- Versatility
- User preference
- Simple Initial Setup

Weaknesses:

1. Monitoring area
2. Mobile Application may be hacked

Opportunities:

1. Mass Production ability
2. Medical data can be used in research
3. Inspire Government to integrate in existing medical infrastructure

Threats:

- Chip Shortage

Design-2:

Strengths:

- Monitoring Window
- Dataflow
- Monitoring area

Weaknesses:

- Wearability
- Expensive
- No Versatility
- Least User preference
- Complex Initial Setup

Opportunities:

1. Multiple Patients surveillance in hospitals
2. Medical thermography is popularized

Threats:

1. Difficult for Mass Production ability

Design-3:

Strengths:

1. Dependency on hardware
2. Accuracy

Weaknesses:

1. Wearability
2. Shorter monitoring window (half duration)
3. Dependency on hardware
4. Inconsistent Dataflow
5. Expensive
6. No Versatility
7. Least User preference
8. No Initial Setup

Opportunities:

3. Mass Production ability

Threats:

2. Chip Shortage

After Performing all the simulations and critically observing all the criteria of using SWOT analysis, we can state that Design-1 shows the superlative results.

4.4 Performance Evaluation of Developed Solution

In this section we breakdown the performance of each hardware component of our total optimal Design -1 as well as give an overall analysis of the total system working.

4.4.1 Sensor Performance Evaluation

1. **Temperature Sensor (DS18b20):**

<u>Experiment:</u>

A digital thermometer is used to measure human body temperature. Simultaneously, data is taken from the sensor by placing it on patients' fingers.

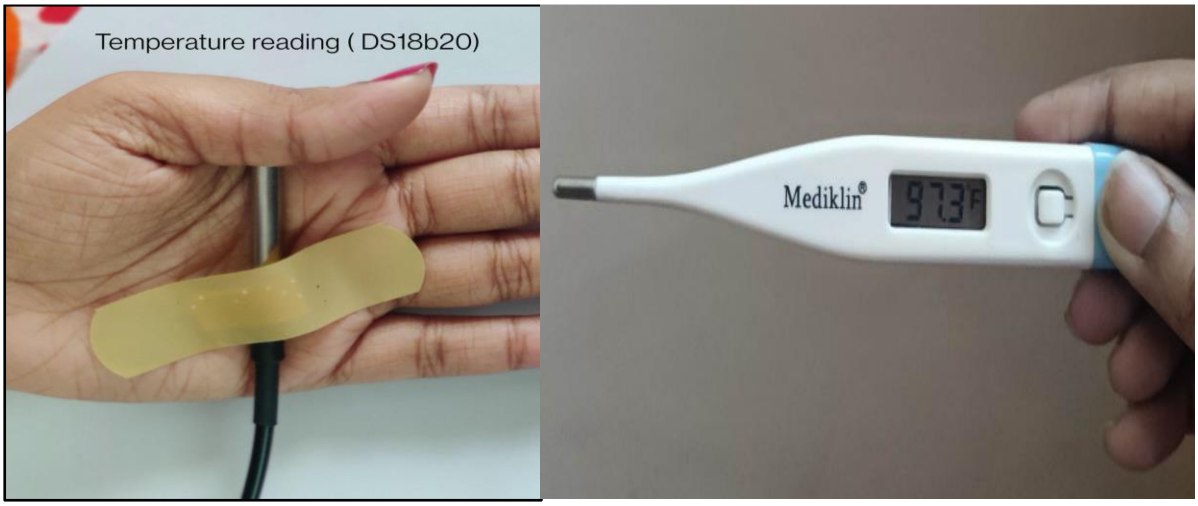

Figure 14. Temperature Sensor Measurement using sensor and digital thermometer for reference values

To calibrate the sensor, we have used the readings from a commercial medical grade digital thermometer as a reference. To take the values, put them in a table and then determined the difference between the sensor value and the thermometer value. We did this with 10 different sample readings and figured out the percentage deviation between them each time and then taking the average of them we celebrated our sensors.

Analysis:

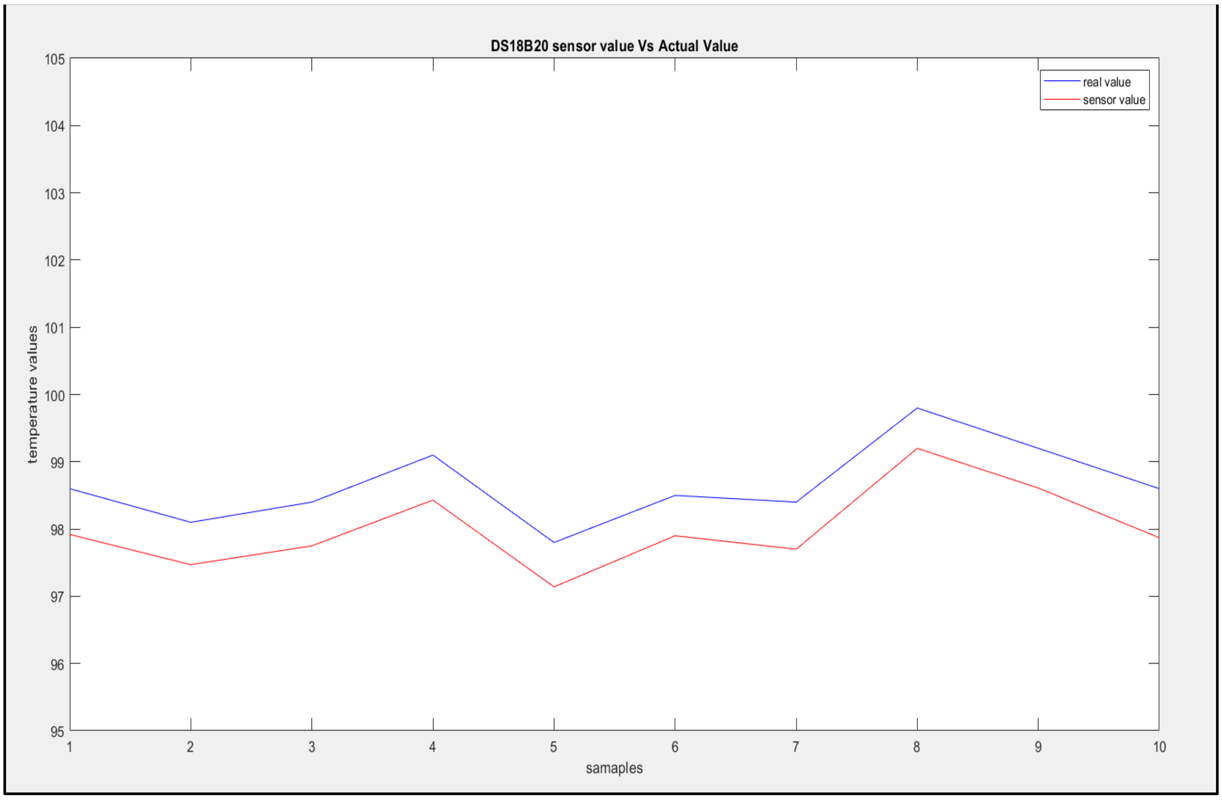

Figure 15. Comparison between real and sensor value

Here, the graph is plotted where y axis is the temperature values and x axis is the number of samples. Here we can see that the values from the sensor were lower than the actual values but there was a linear relationship between the actual value and the reading from the sensor. Looking at the table will give a better insight into the real vs sensor value and the difference between them. Below is a table showing the deviation between real and sensor values.

Real Value	Sensor Value	%Deviation
98.6	97.92	0.68
98.1	97.47	0.64
98.4	97.75	0.66
99.1	98.43	0.67
97.8	97.14	0.65
98.5	97.9	0.61

98.4	97.7	0.71
99.8	99.2	0.6
99.2	98.61	0.59
98.6	97.87	0.74
Average Real Value = 98.65	Average Sensor Reading = 97.99	Average Deviation = 0.655

Table 12. Deviation Between Thermometer and Sensor Values

Calibration Amount	+0.66

Here we can see that only a +0.66 change in the sensor value could yield us a value that is in accordance with the actual value.

2. Heart rate and Oxygen Saturation Sensor (MAX30100):

<u>Experiment</u>:

Human Heart rate and Oxygen Saturation values are taken using a pulse oximeter in real time. Simultaneously, the values are taken from the sensor by attaching it to a finger.

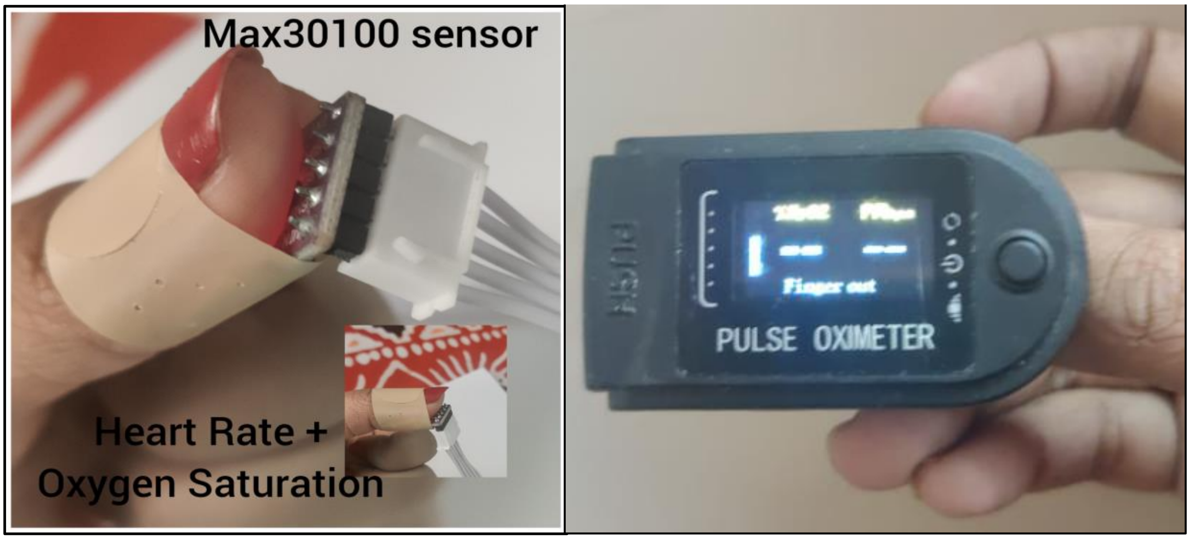

Figure 16. Heart Rate and SpO2 Measurement using sensor and pulse oximeter for reference values

We have done similar calibration for calibrating this sensor as we have done for our temperature sensor. We have taken readings from a medical grade oximeter and then compared those values to the readings from our MAX30100 sensor. We then have calculated the difference in values for both heart rate and oxygen saturation percentage individually and then from the average of those values we have figured out the calibration amount.

Analysis:

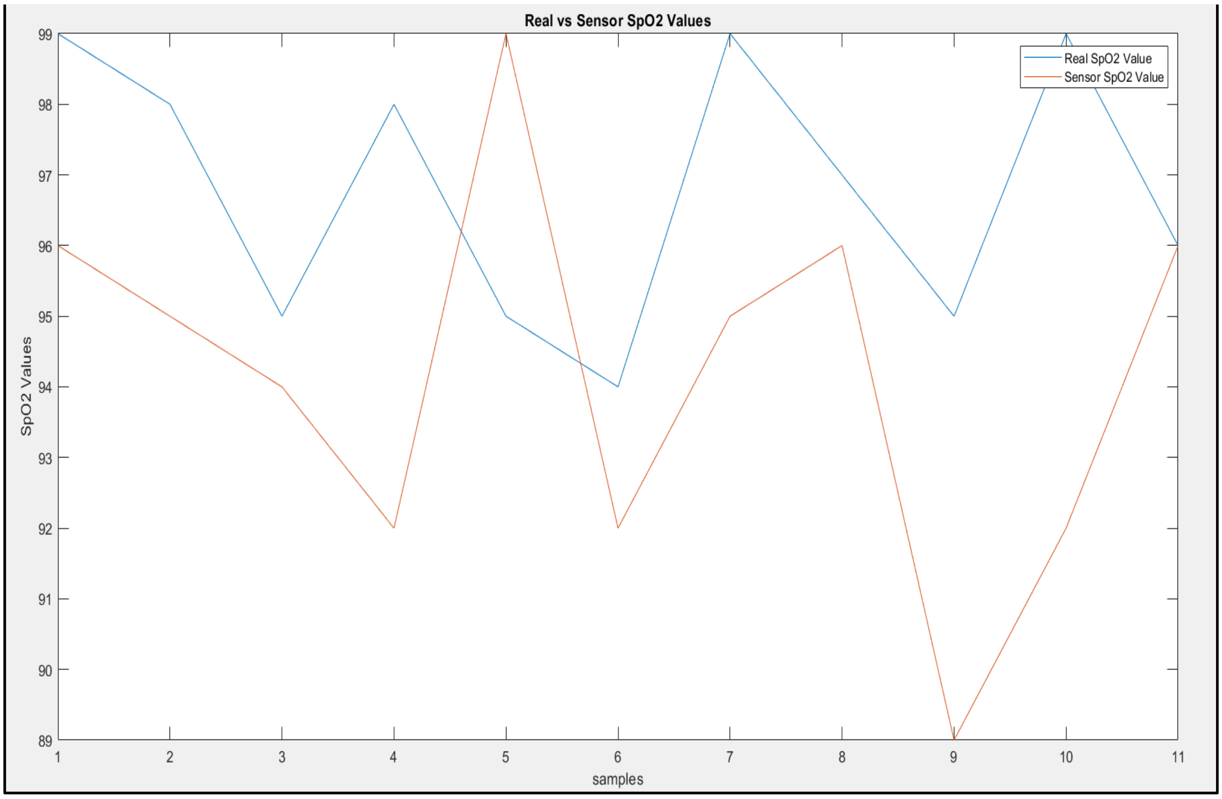

Figure 17. Comparison between sensor and actual SpO2 values

Here in the above graph, we can see the relationship between the real and the sensor reading value for oxygen saturation. We can see that except for one instance of the 11 readings we took, the value from the sensor remained lower than the actual value and maintained a similar difference in value. We can look at the table below for a better understanding:

Reading No:	Real Value (SpO2)	Sensor Value (SpO2)	%Deviation (SpO2)
1	99	96	3.03
2	98	95	3.06
3	95	94	1.05
4	98	92	6.12
5	95	99	-4.21

6	94	92	2.12
7	99	95	4.04
8	97	96	1.03
9	95	89	6.32
10	99	92	7.07
11	96	96	0.00
	Average SpO2 = 96.81	Average Sensor SpO2 = 94.18	Average SpO2 value deviation =2.70

Table 13. Deviation Between Pulse Oximeter and Sensor SpO2 Values

Here we can see that except for one value all the other values of the sensors were below the actual values and except for one value of the sensor all the other values were different than the actual values.

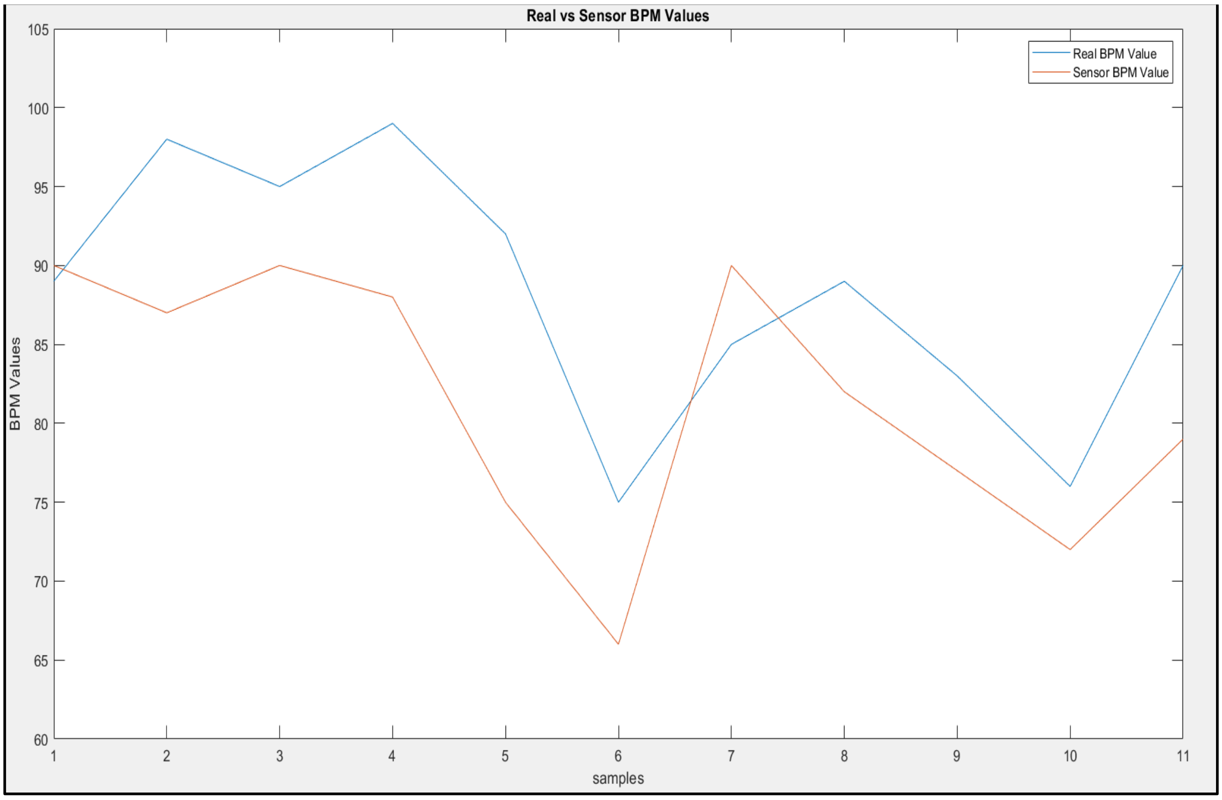

Figure 18. Comparison between Heart rate values of sensor and actual

Here we can also see that except for two values all the other from the sensor was below the actual value. The reason the two values spiked over the actual value has something to do with the interference from the surrounding light. The interference is probably what caused the values to spike over the actual values twice in this case and once in case of the oxygen saturation. The table below gives a better representation of the differences in the values:

Reading No:	Real value (BPM)	Sensor Value (BPM)	%Deviation (BPM)
1	89	90	-1.12
2	98	87	11.22
3	95	90	5.26
4	99	88	11.11
5	92	75	18.47
6	75	66	12.00
7	85	90	-5.88
8	89	82	7.86
9	83	77	7.23
10	76	72	5.26
11	90	79	12.22
	Average BPM =88.27	Average Sensor BPM =81.45	Average BPM value deviation =7.60

Table 14. Deviation Between Pulse Oximeter and Sensor BPM Values

3. NIR Blood Glucose Sensor (Custom/Experimental):

This is an experimental sensor that was custom made by us from the reference paper Non-invasive Blood Glucose Determination using Near Infrared LED in Diffused Reflectance Method' [19]. To put a theory into action and see the effects of NIR (940-960 nm) for detecting the glucose in blood. This system works in a very intricate way and the wavelength has to be precise to make this system work otherwise the light will get reflected off of other particles in the blood and will not do the work as it was supposed to do. The graph below shows the relationship between the actual vs NIR readings in determining the blood glucose:

Experiment:

Glucose level reading is taken from a glucometer. Simultaneously, reading is checked from the NIR sensor.

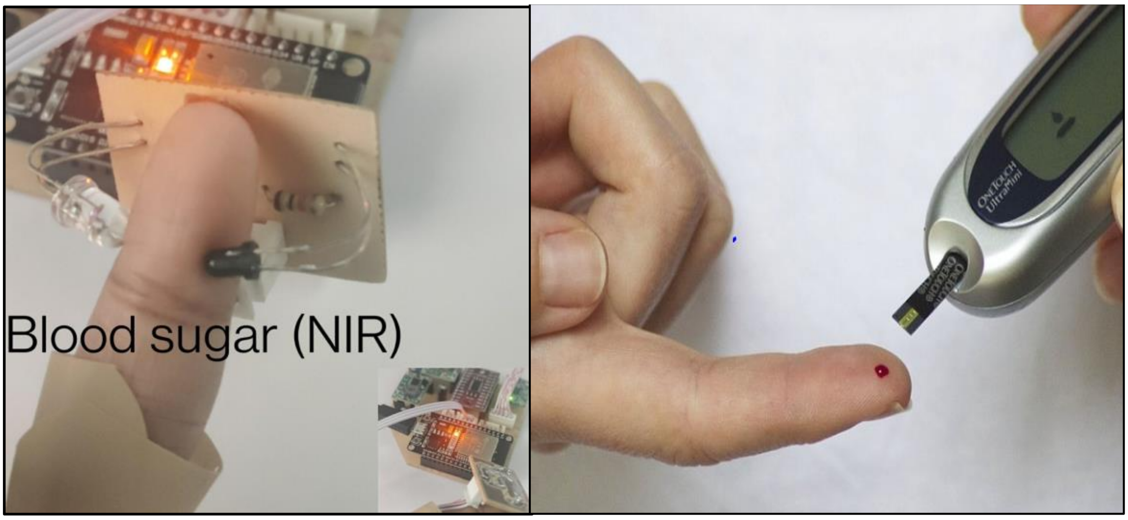

Figure 19. Blood Glucose Measurement using sensor and commercial glucometer for reference values

Analysis:

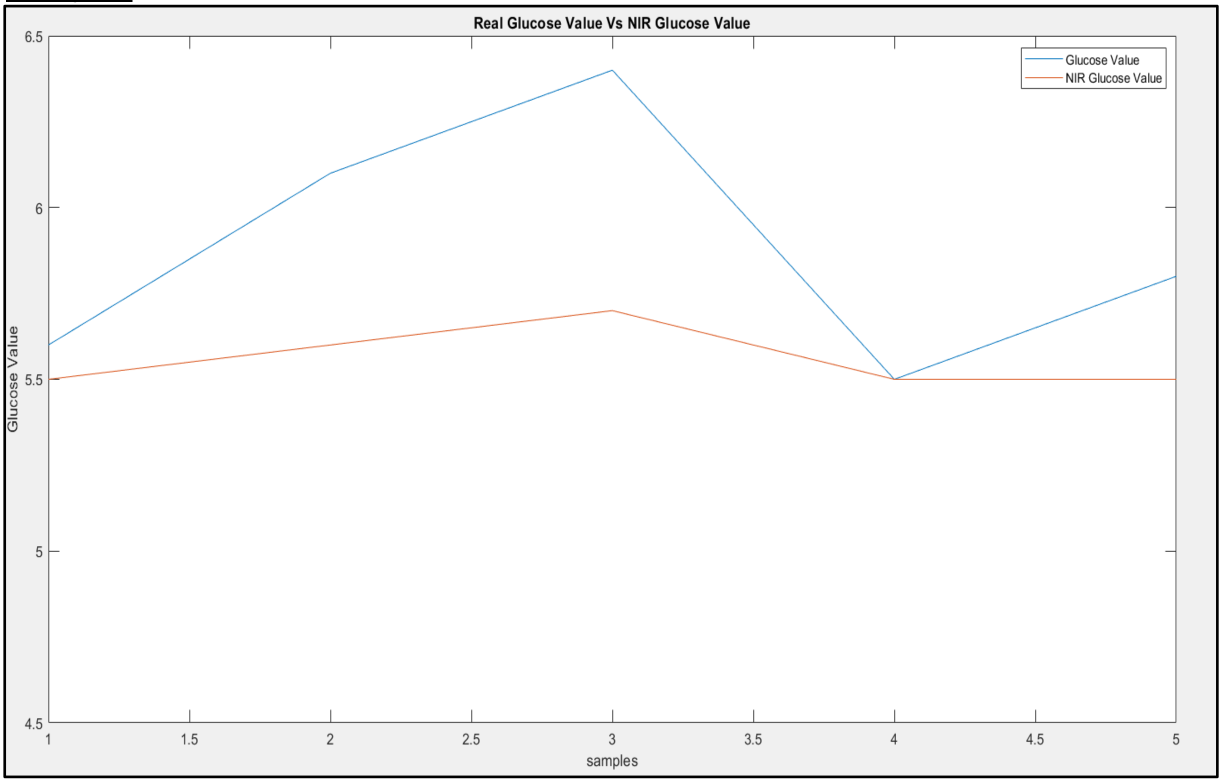

Figure 20. Comparison between blood glucose values of sensor and actual

Here we can see that the actual value is typically higher than the NIR sensor value. The NIR sensor value in fact doesn't fluctuate much and except for one instance its always lower than the actual value. The table below will be of a better understanding:

Real Glucose Value	**NIR Glucose Value**	**%Deviation**
5.6	5.5	1.79
6.1	5.6	8.20
6.4	5.7	10.93
5.5	5.5	0.00
5.8	5.5	5.17
Average Glucose Value = 5.88	Average NIR Glucose Value = 5.56	Average Deviation = 5.218

Table 15. Deviation Between Glucometer and NIR Sensor Values

Here we can see that in the second last reading of the 5 readings the NIR value coincided with the actual value and other than that it always remained below the actual value.

4. Fetal Kick Count (ADXL335):

We have used this sensor to determine fetal kicks and in order to do that we first had to acquire knowledge about the different axes of the sensor and the values it usually gives while being on an axis and up or against the force of gravity. We had to code the system accordingly. We then fixed an axis on which the sensor will be laid while being attached to the belly and made adjustments around the axis. Taking two values at a delay of 10ms and then taking the difference of those to readings and then comparing them against a lower and a higher threshold we can detect a kick. That's what we have done in our system.

Experiment 1:

We tapped the sensor with the intensity and sudden time duration of a fetal kick. We have checked with a doctor about the kind of intensity and pressure felt during a fetal kick. In this way we mimicked a 'fetal kick'.

Experiment 2:

We gave bigger and longer motions on the sensor simultaneously with short random taps mimicking fetal kicks.

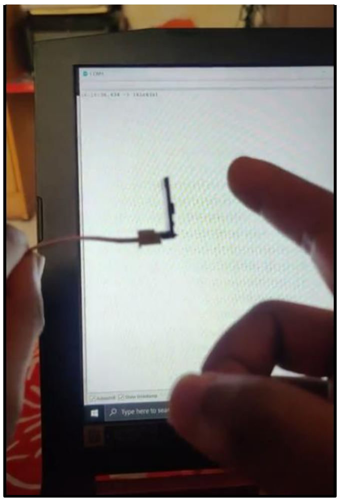

Figure 21. Tapping on the Sensor mimicking 'Fetal Kick'

Analysis:

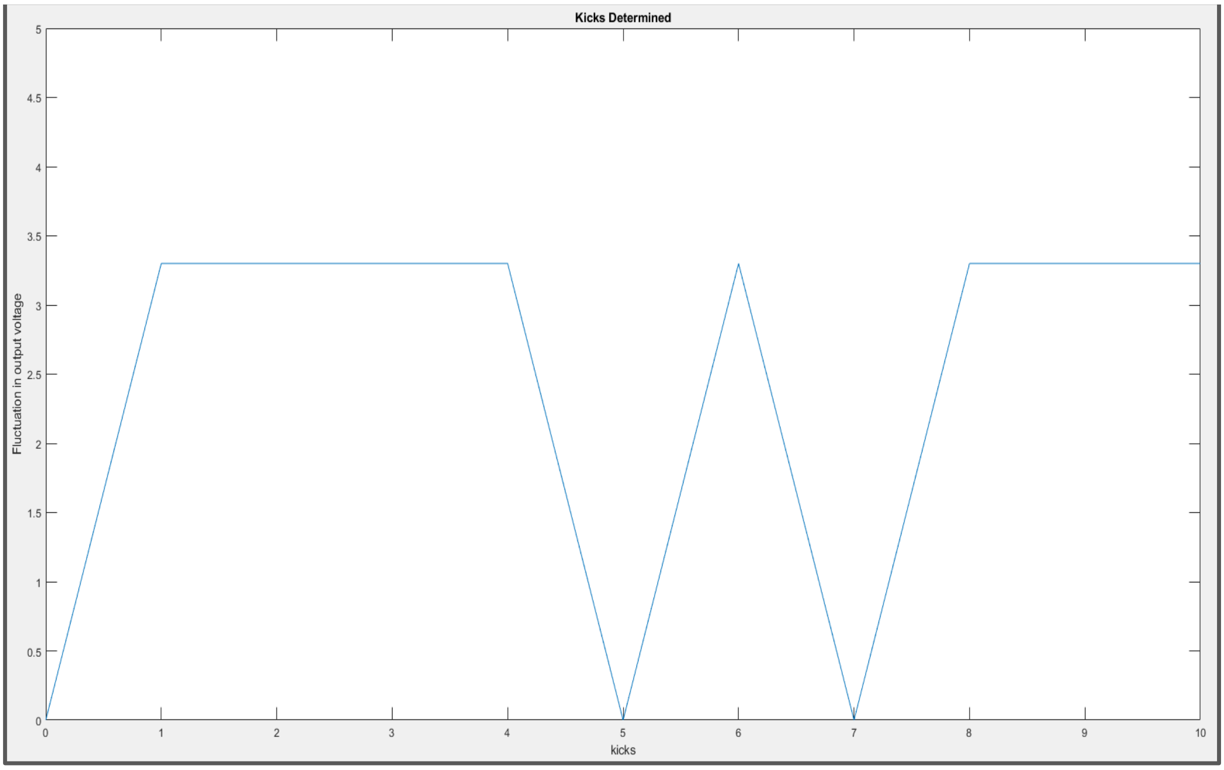

Figure 22. Output voltage vs number of kicks

Below is the screenshot of the serial monitor we can see that of the 10 kicks we have simulated, the sensor was successful in picking up 8 of them. So that gives the sensor a success rating of 80%. Here the sensor gives an output of 3.3V every time a kick is detected, and we can see that the sensor gives a 3.3V output 8/10 times.

And again, when we wanted to see if the sensor could detect consecutive kicks, we could see that the sensor could in fact detect consecutive kicks Here we can see that between 9 and 10 seconds 4 consecutive kicks were given, and the sensor was able to pick them all up.

From Experiment 2 we have found that the sensor filters out longer and bigger motions and only detects the short and sudden motions, proving that the sensor can filter out environmental motions and only detect the kicks.

```
12:39:01.908 -> 3kick(s)
12:39:02.131 -> 4kick(s)
12:39:04.253 -> 5kick(s)
12:39:06.854 -> 6kick(s)
12:39:08.749 -> 7kick(s)
12:39:09.710 -> 8kick(s)
12:39:09.752 -> 9kick(s)
12:39:10.804 -> 10kick(s)
12:39:10.981 -> 11kick(s)
```

Figure 23. Kick results

5. Sudden Fall Detection (MPU6050):

<u>Experiment:</u>

We dropped the sensor from a height.

Figure 24. Dropping MPU6050 sensor from a height

Analysis:

```
12:19:21.391 -> TRIGGER 1 ACTIVATED
12:19:21.480 -> 1
12:19:21.480 -> TRIGGER 1 ACTIVATED
12:19:21.611 -> 14
12:19:21.611 -> TRIGGER 2 ACTIVATED
12:19:21.611 -> 99
12:19:21.611 -> 99
12:19:21.611 -> TRIGGER 3 ACTIVATED
12:19:21.695 -> 19
12:19:21.811 -> 8
12:19:21.891 -> 12
12:19:22.000 -> 10
12:19:22.087 -> 10
12:19:22.211 -> 10
12:19:22.330 -> 10
12:19:22.406 -> 9
12:19:22.521 -> 10
12:19:22.521 -> 10
12:19:22.521 -> 10
12:19:22.521 -> FALL DETECTED
```

Figure 25. Drop results

Here we can see that the sensor works on the basis of a tri trigger system. Only after the third trigger is triggered will the sensor detect a kick. In order to trigger all the triggers, the change in angles and acceleration needs to be right. Here in the above screenshot of a serial monitor we can see that the fall physically started happening at 21 second and the fall was detected at 22 second. So, we can see that from the moment of the initiation of the fall to the detection of fall there is a delay of 1.2 seconds which was within our preset limit and so we didn't have to do any calibration in case of this sensor. We kept it as it is.

4.4.2 Overall System Performance

- The system is quite effective in detecting the risk level of a patient.
- Our primary goal is to detect risk level not 100% accuracy of health parameters.
- In our app interface we have adjusted the calibration of sensor data so it can effectively detect risk level.
- The calibration has been done with the doctor's guidance.

- Due to use of multiple analog sensors, the system is a bit slow. This can be improved in the future by using a higher budget microcontroller.

4.5 Conclusion

To sum it up, we have covered our three multiple design approaches and found the optimal one. We have made some changes according to the component availability by analyzing the market and also some changes are made to the final design for the betterment of the system. Sensor data were calibrated and compared to the actual value to ensure the accurate data for our system.

Chapter 5

Completion of Final Design and Validation [CO8]

5.1 Introduction

Here we implemented our optimal design which is Design-1: Wearable System. To make the final design, first the sensors were tested and calibrated according to their performance which has been discussed in detail in section 4.4. Then all the sensors were implemented in hardware by constructing an electrical power system in a breadboard model. Simultaneously a mobile application had been developed and interfaced with our microcontroller ESP32. When the sensor data has been successfully displayed in the app interface, we proceed to design a final printed board circuit for a compact design.

5.2 Completion of Final Design

Design 1: Wearable IoT based Maternal Health Risk Detection System:

We completed the prototype development of Design 1 in the following stages.

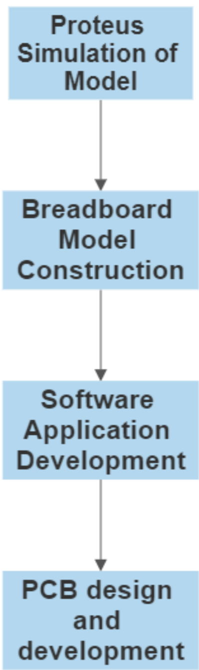

Figure 26. Workflow of Design 1

5.2.1 Software Simulation

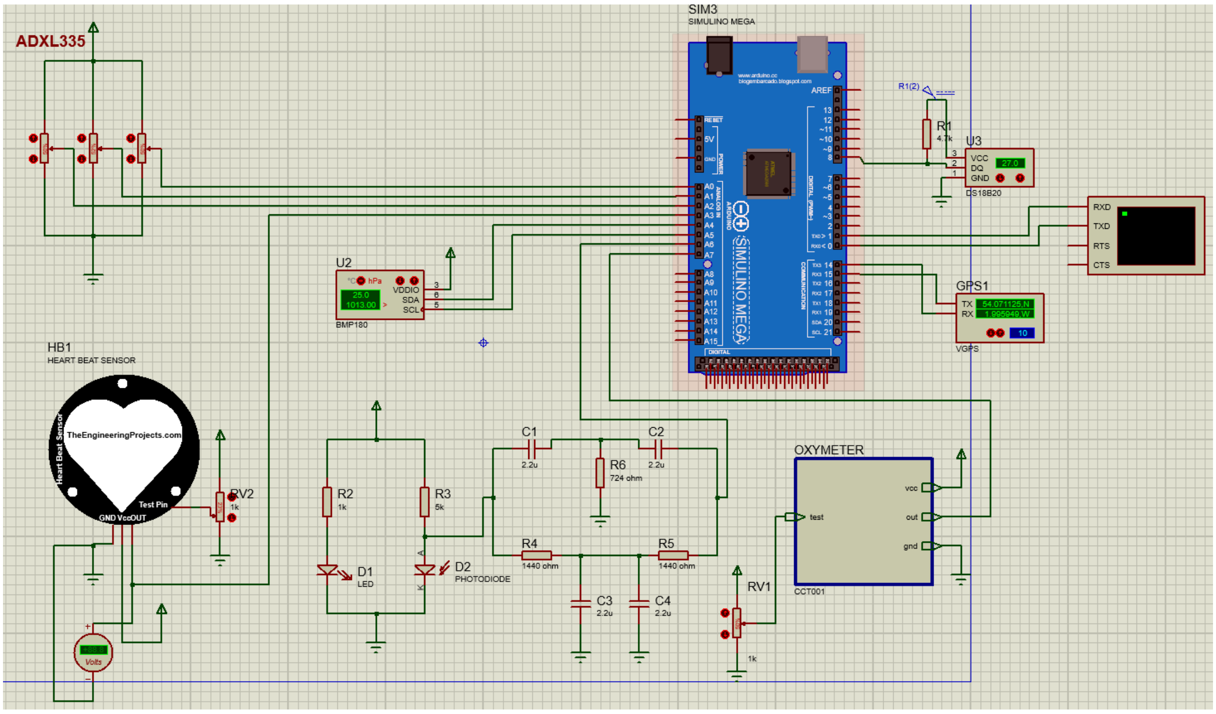

Figure 27. Proteus Simulation of Design 1

All the components are displayed in a Proteus software file as done in EEE-400D.

5.2.2 Breadboard Model Development

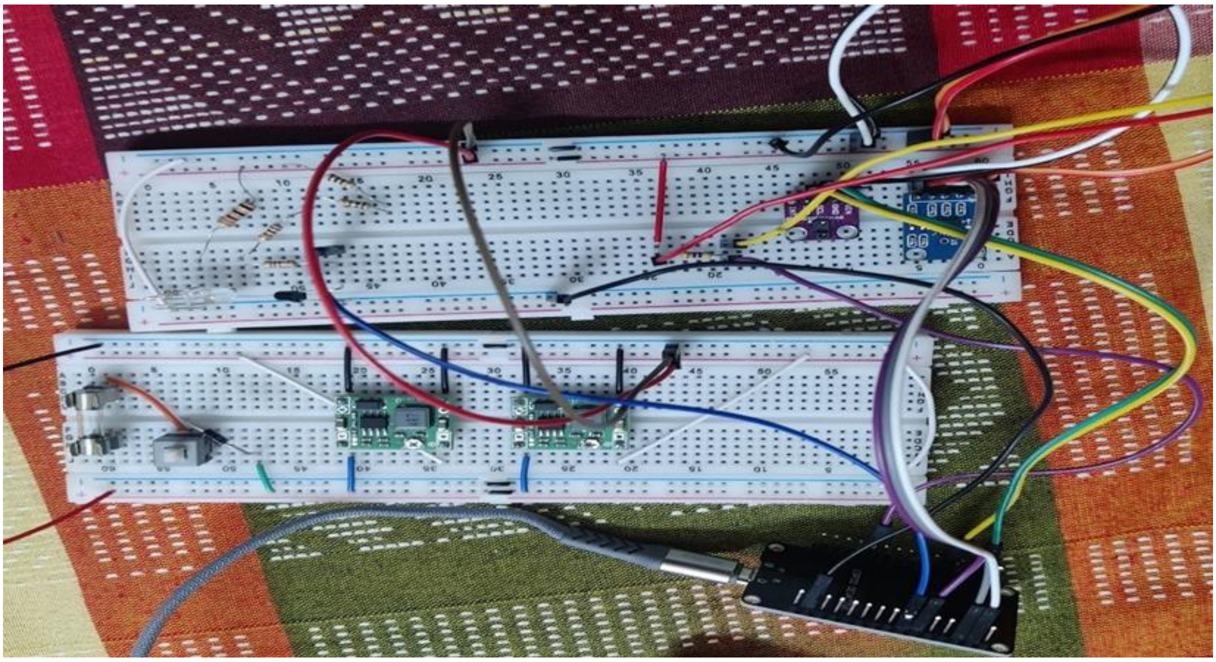

Figure 28.Breadboard model containing all sensors and ESP32

The breadboard model has been developed after designing an electrical power system using 2 3.7V batteries which has been divided into two parallel circuits of 3.3V and 7V. The 3.3V part of the circuit connects all the sensors and the 7V part powers the ESP32 microcontroller. Additionally, two buck converters and a 1A glass fuse has been added to regulate the voltage and current across the components. Below is a visualization of how our circuit has been designed.

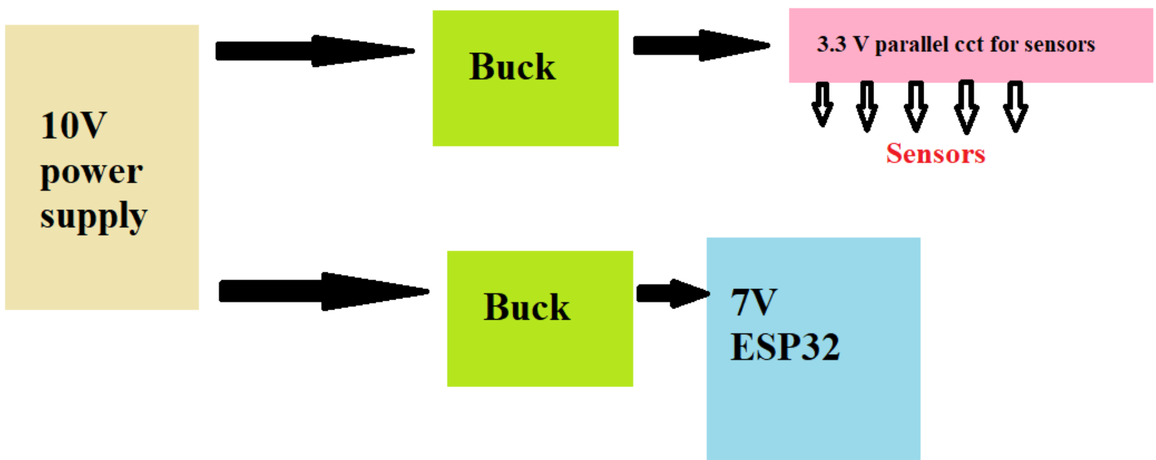

Figure 29. Power Division between sensor and microcontroller

5.2.3 Mobile Application Development

Requirement For Mobile Application: The primary requirements for the Health Monitoring App are –

- There will be a signup and login page.

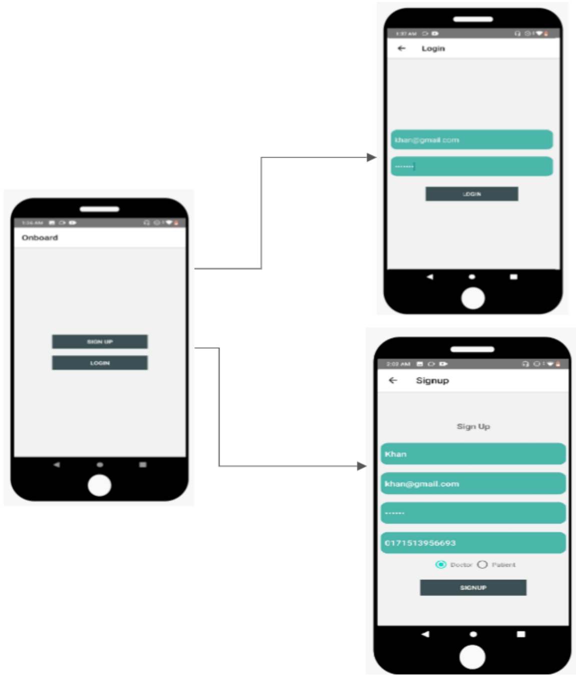

Figure 30. Signup and Login page

- Two interfaces for Doctor and Patient. Doctor and Patient id can be created by signing up. The ID's can be fetched from Firebase Database.

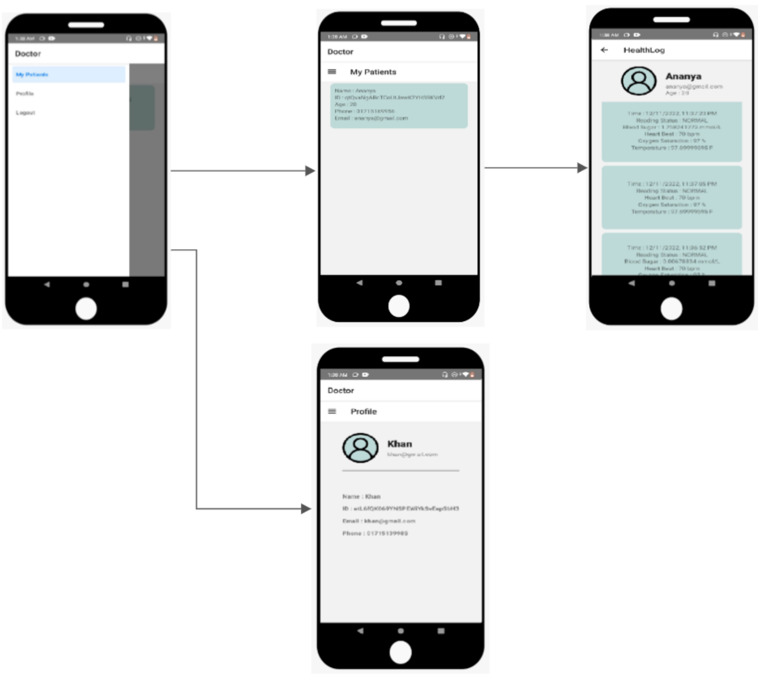

Figure 31. Doctor Interface

Figure 32. Patient Interface

- Both Doctor and Patient interfaces will have the health log page to see the health records.

Figure 33. Health log page

- Another feature of the app is the doctor will get notification and alarm whenever there is any detection of risk or abnormal data.

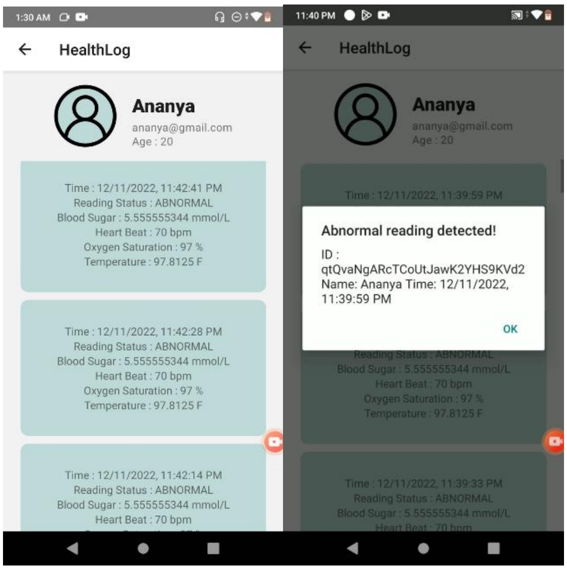

Figure 34.Push notification for Abnormal reading in Doctor interface

5.2.4 PCB and prototype designing:

We have mainly designed two parts of PCB:

- Main board containing MPU6050 sensor, buck converters, capacitors, resistors, SDA SCL port, Battery port and JST cable port for the rest of the sensors.
- NIR based glucose monitoring sensor.

After implementing the integrated circuit into the breadboard, we proceeded towards PCB designing. We mounted the MPU6050 sensor on the PCB and it is the only sensor that is mounted on the PCB. All the other sensors are connected to the main board using jst cables. We designed our PCB based on figure 15. After designing the PCB in software, the layout looked like the following:

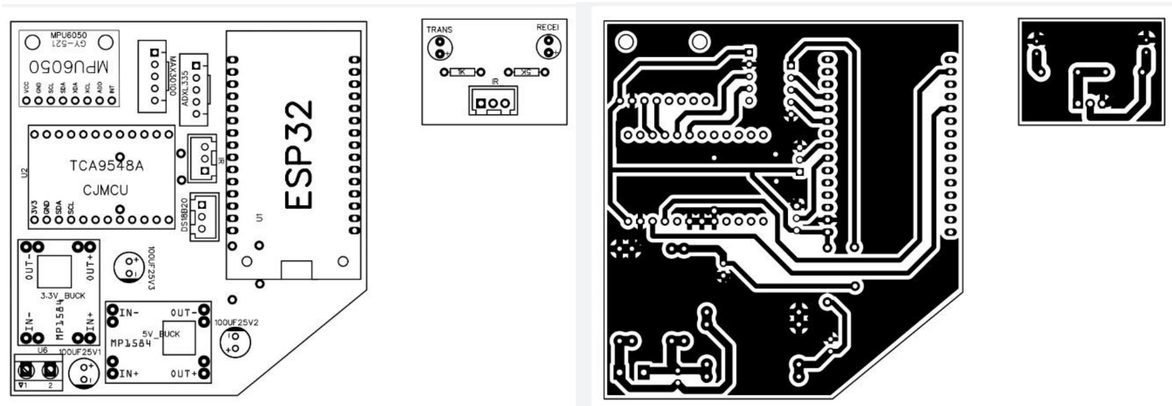

Figure 35. PCB layout schematic (on the left the main board on the right the NIR sensor)

The final physical PCB looked like the following:

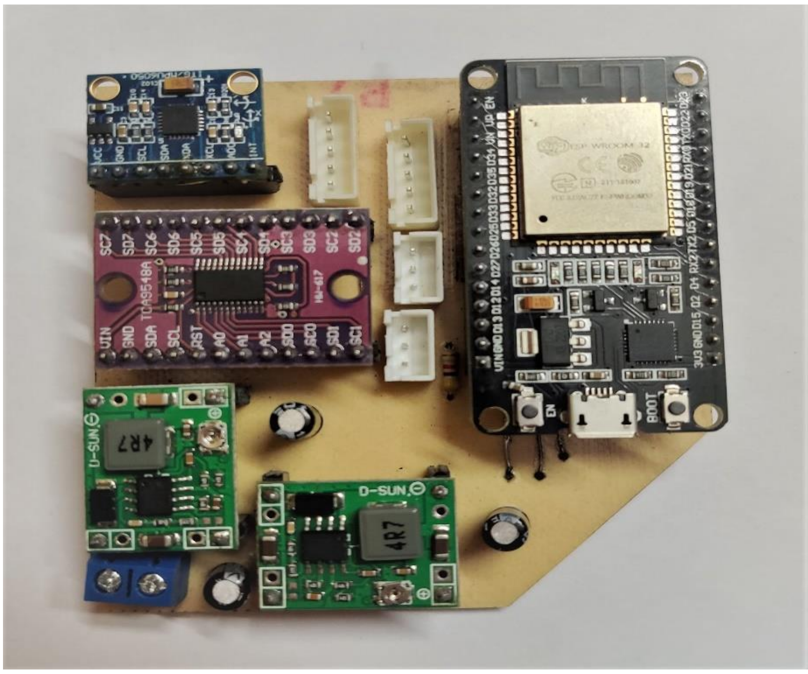

Figure 36.Front view of PCB

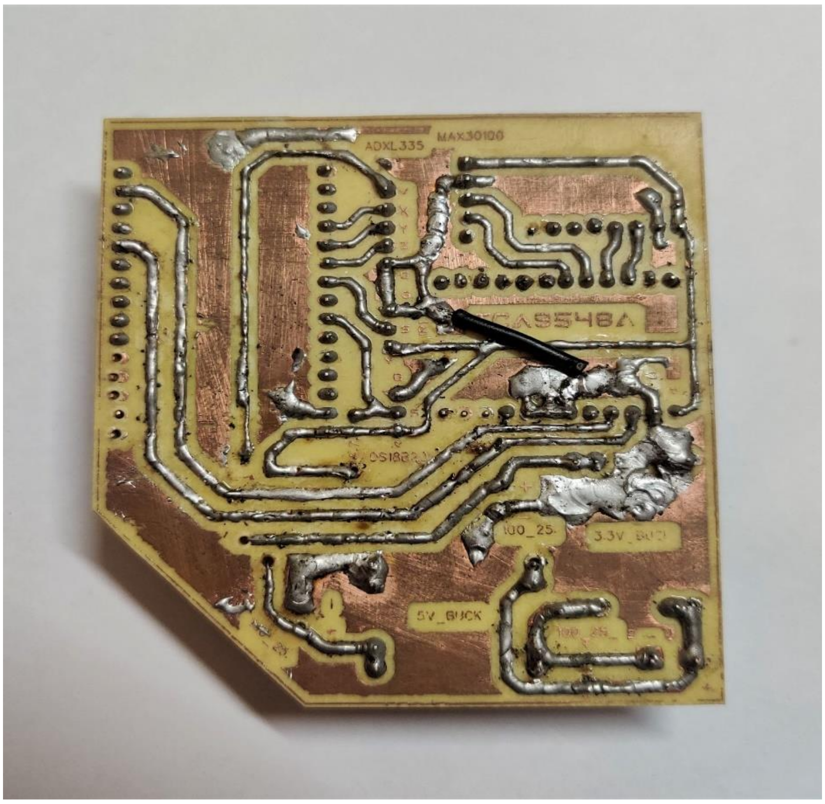

Figure 37. Back view of the PCB

And for our custom made NIR sensor for determining blood glucose we had to design a PCB as well so that it can be as compact as humanly possible and so that it can be integrated into the wearable system.

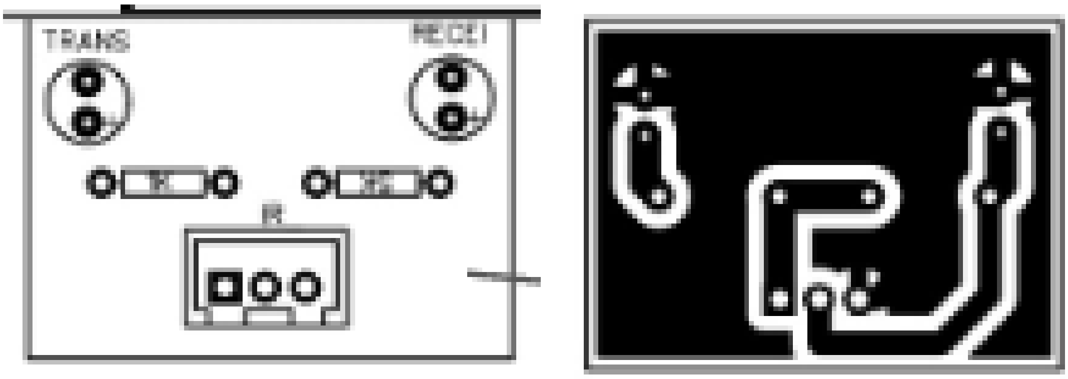

Figure 38. PCB layout schematic for the NIR sensor

And the final physical product of the PCB looks like the following:

Figure 39. Front and back view of the NIR blood glucose monitoring sensor PCB

Complete PCB Outcome

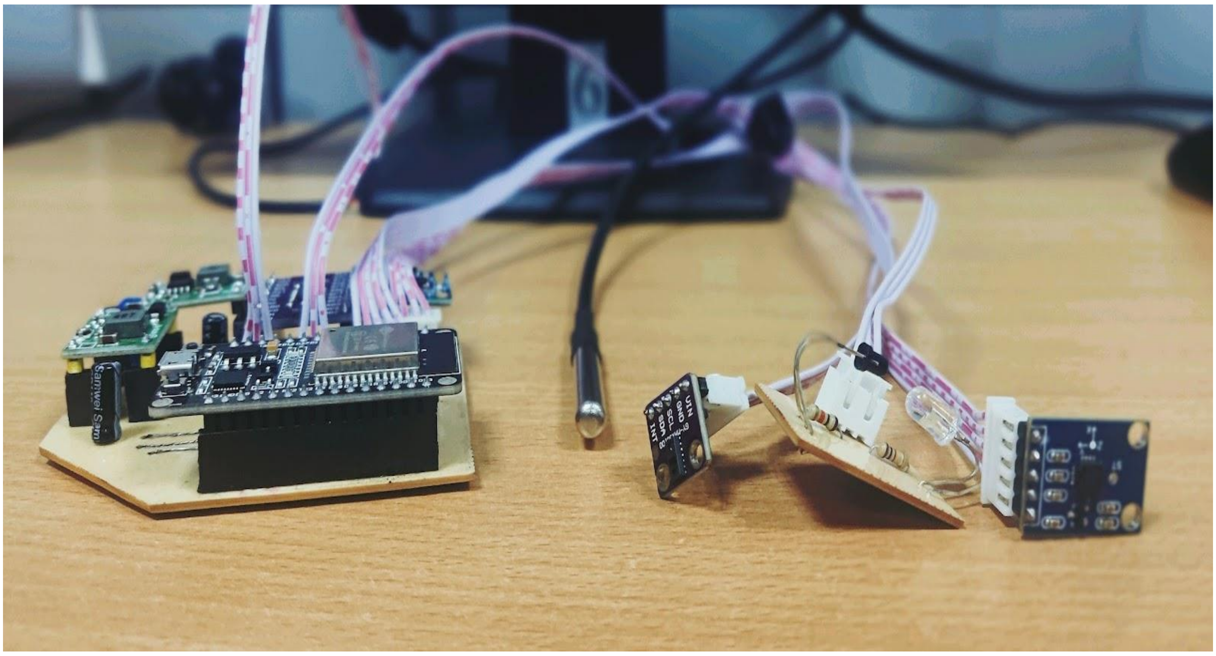

Figure 40. Complete PCB outcome (from left to right main board, temperature sensor, NIR sensor, adxl335 sensor)

Final Prototype Visualization

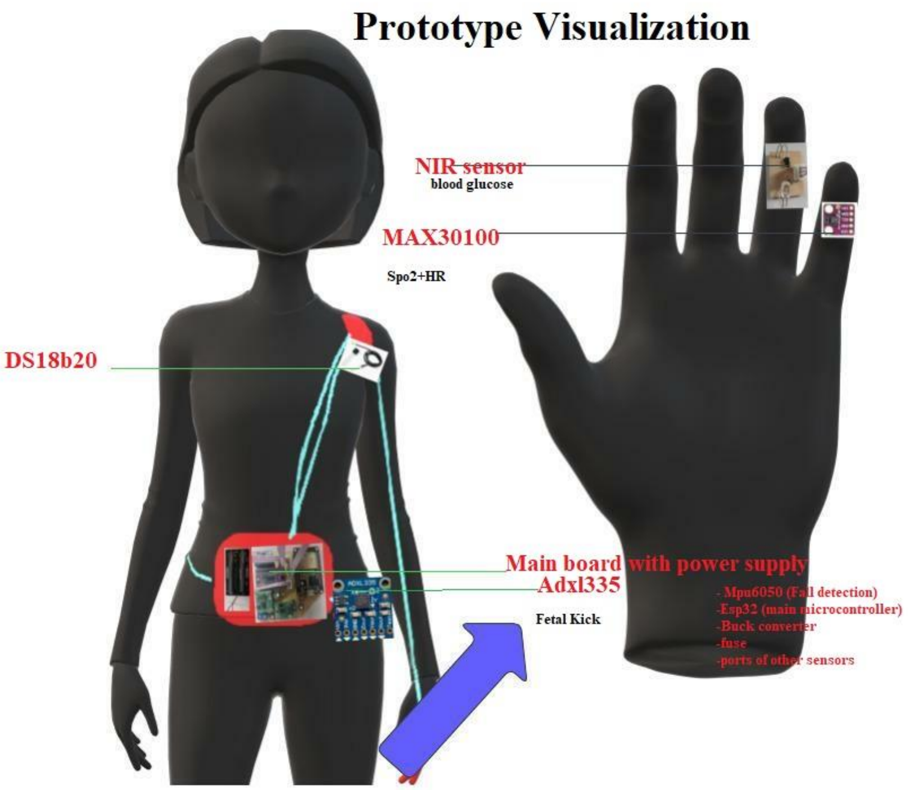

Figure 41. Prototype Visualization of Wearable System

5.3 Evaluate The Solution to Meet Desired Need

In our solution we addressed all 4 of our specifications, which in short are:

1. Measure Vital Health Parameters.
2. Data stored in cloud /Data history.
3. Mobile Application Interface (Doctor & Patient).
4. Alarm System for Abnormal Values.

5.3.1 Measuring Vital Health Parameters

Figure 42. Readings of Health Parameters

Here we can see that the readings from the sensors are being constantly updated in the doctor's app interface at an interval of 10 seconds. If anything goes wrong within this time period, an alarm will be triggered which will let the doctor know that there is something wrong with the patient and he/she can immediately check up on the patient. In the screenshot above we can see that the 5 different parameters from the 4 sensors to be attached on various parts of the body as planned are being displayed here at a time. The status says normal since there were no abnormal values being picked up at that moment. It also shows the time and date so that anytime an abnormal reading is detected and even if the doctor misses the notification, he/she can still scroll down and check when the abnormal reading was detected.

5.3.2 Alarm notification for Abnormal values

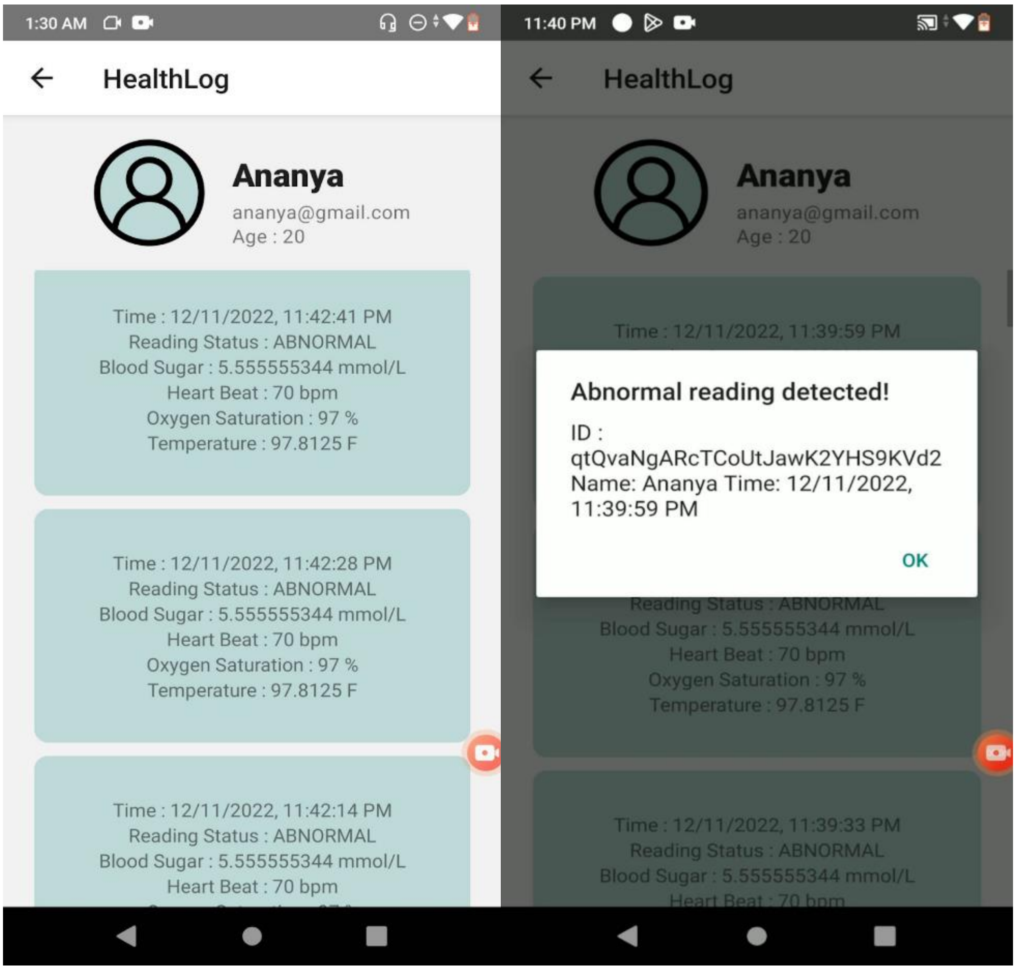

Figure 43. Notification for Abnormal Data

One of our vital requirements was the alarm system for our app to notify the doctor in charge if there is anything wrong with the patient at any given moment. Here in the above screenshot, we can see that the notification system for the app went off along with the alarm so that the doctor can be notified about a discrepancy in the values against the presetted thresholds. We set the threshold based on the following table:

Heart Rate	**Min**	**Max**
Risk - (101-110) (low) - > 110 (high)	60 bpm	100 bpm
Temperature	**Min**	**Max**
Risk - temp < 36.1°C - temp > 37.2°C	90°F (36.1°C)	99°F (37.2°C)
Oxygen Saturation	**Min**	**Max**

Risk - 85% - 94% (low) - < 84% (high)	95%	100%
Blood Pressure (normal SBP <130 & DBP <85)	**Systolic**	**Diastolic**
High BP (risk)	130 -139 mmHg	85 – 89 mmHg
Low BP (risk)	90 mmHg	60 mmHg
Blood Sugar (normal ≤ 99 mg/dL)	**High**	**Low**
	1000 – 125 mg/dL	70 mg/dL
	Risk – ≥ 126 mg/dL	Risk < 70 mg/dL

Table 16. Selected Threshold Values For Health Parameters

Based on the values above we have run an if/else loop inside our code following the following logic:

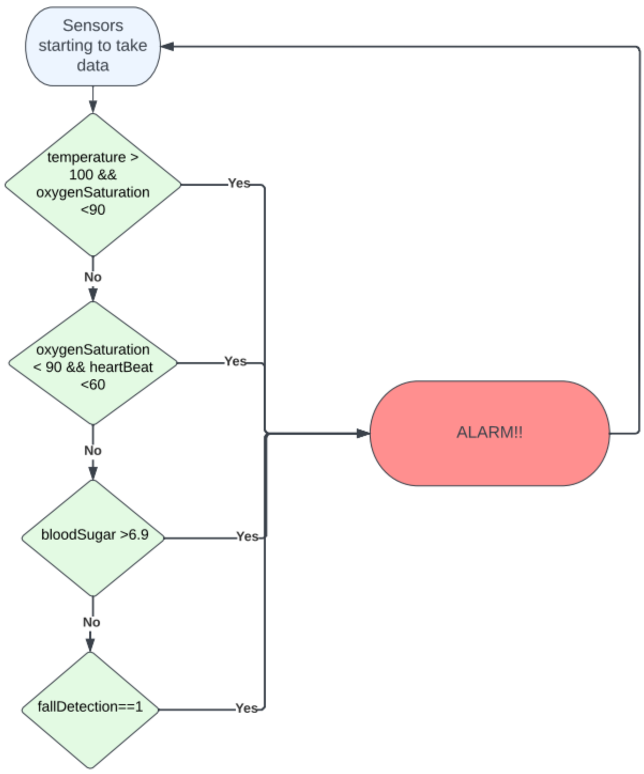

Figure 44. Flowchart of alarm system

Here in the above flowchart, we can have a clear depiction of the logic used inside our code to make this alarm system work. Every time the values go up or down the presetted threshold the alarm will go off notifying the doctor about the risk. Then the system will go back again towards reading data. This system will go on until the values come under control.

5.3.3 Alarm notification for Fall Detection

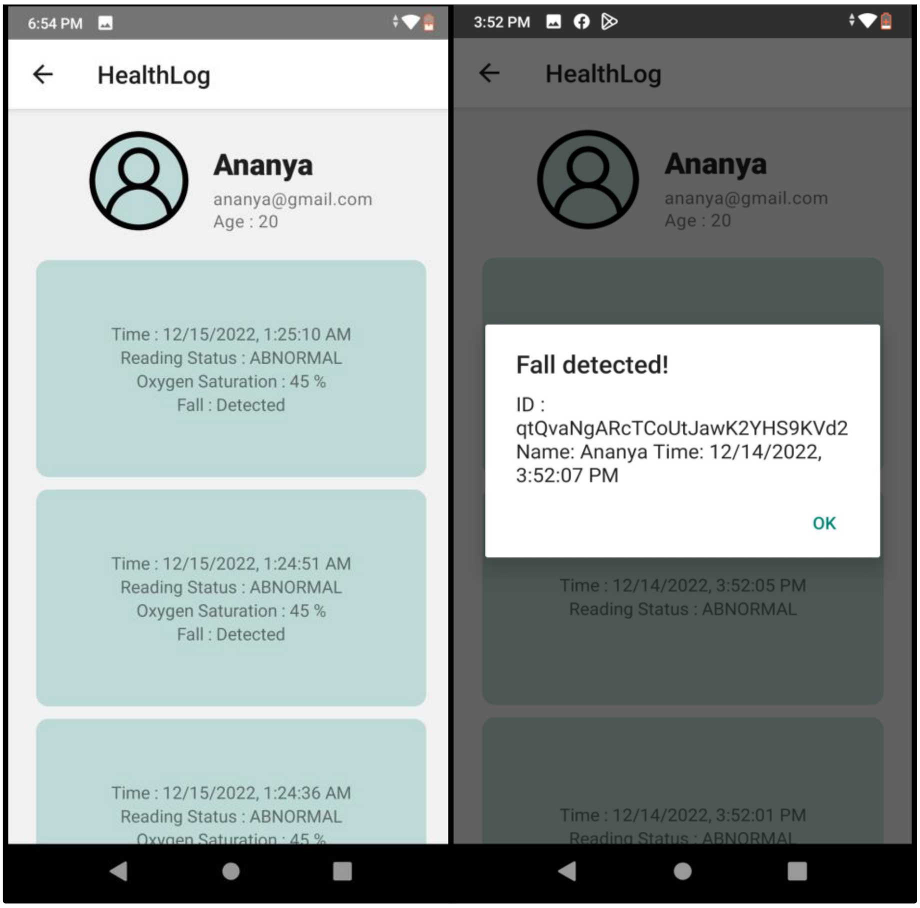

Figure 45. Notification for Fall Detection

This is an un updated specification of our system. We realized that suddenly falling down is a cause of great and widespread emergency among mothers, therefore, to instantly give an alarm when the mother accidentally slips or falls down, we have made use of an accelerometer plus gyroscope sensor called the mpu6050. In our application interface, an alarm is set into place whenever there is a fall detection. In this above figure, we can see that due to a sudden fall an alarm rings and the application gives a notification saying, “Fall detected”.

5.3.4: Adjustment to Final Design as per performance evaluation

We have discussed in section 4.4 the changes that needed to be made according to analysis. In the table below we have listed the adjustments below:

Factor	**Type of Adjustment**
Temperature sensor	The sensor value was added with a constant of +0.66
Heart rate and Oxygen Saturation Sensor	Sensor HR reading +7.60 and Sensor SpO2 reading +2.70
NIR sensor	Sensor value calibrated by a factor of 1.06
Microcontroller	EPS32 used instead of previously proposed Arduino
Mobile Application Front End	Threshold values adjusted to calibrated values

Table 17. Adjustment to Final Design as per Performance Evaluation

5.3.5: Updates made in Final Design

We have made 3 major changes while developing our final project compared to the proposed project:

1. Using ESP32 instead of Arduino MEGA 2560 REV3:

The table below gives a comparison between Arduino UNO (proposed microcontroller) and ESP32 (Implemented microcontroller).

Specification	Arduino UNO	ESP32
Number of Cores	1	2
Architecture	8 bits	32 bits
CPU Frequency	16 MHz	160 MHz
Wi-Fi	No Wi-Fi	Built-in Wi-Fi
Bluetooth	No	Yes
RAM	2 Kb	512 Kb
FLASH	32 Kb	16 Mb
GPIO Pins	14	36
Busses	SPI,12C, UART	SPI,12C, UART,12S, CAN
ADC Pins	6	18
DAC Pins	0	2

Table 18. Comparison Between Arduino UNO vs ESP32

The main reason for this change was to make our system more compact and to remove the necessity of any external Wi-Fi shield for internet connectivity. Since our main design is a wearable system and we were determined to make it as compact as possible we had to opt towards using an ESP32 because it was much smaller in size and didn't require an external Wi-Fi shield to connect to the internet.

2. Using MPU6050 for fall detection:

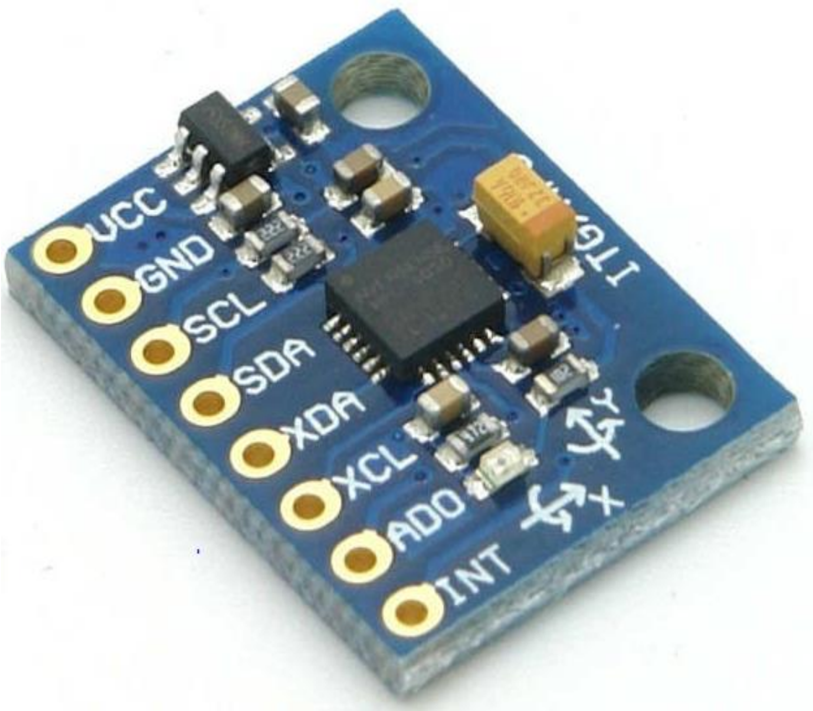

Figure 46. MPU6050 Sensor

We have added a vital parameter to our design and that is fall detection. We have used an MPU6050 sensor to determine fall detection. As from our experiment in 4.4.1 we can see that within 1 second of a fall the sensor was able to detect the fall and was successful in sending an alarm to the doctor.

5.4 Conclusion

To provide a seamless workflow, we divided the duties for the wearable system's completion into many categories. Prior to adjusting each sensor and system components, we read over some pertinent literature and looked through the datasheets of the ones we are using. We eventually worked to integrate the system completely and connect it to an app so that users could view the house model from a distance. We had to repeatedly go over the readings for sensor calibration in order to remove any system noise before utilizing the final results to determine the actual health parameters. We created the app's user interface to make the wearable system.

Chapter 6

Impact Analysis and Project Sustainability [CO3, CO4]

6.1 Introduction

It is crucial to consider a project's sustainability and the influence it will have on numerous factors while it is being built. The talk that follows gives a quick overview of the patient effect we want to have and the sustainability we hope to achieve after project implementation.

6.2 Assess The Impact of Solution

The following list includes many categories of the effects of our endeavor.

Societal impact:

Because it is a smart monitoring system, the user won't have any trouble using the tool because it will automatically monitor all the necessary information. We want to design our machine such that everyone living in our society may use it without any prior knowledge or having to retain a lot of information. Additionally, because of the home-based monitoring system, the patient doesn't have to travel far.

Health impact:

The most prized possession a person can possess is both a healthy body and mind. The device's small size and lightweight ensure that the mother won't feel any strain while wearing it. It will make home health monitoring more accessible and inform patients' health awareness. It can be used by pregnant women to continuously monitor their bodies while they are having a risky pregnancy. Many women constantly worry about the risks of getting pregnant. Continuous observation can reduce their anxiety about their health. Our product has no side effects, making the environment safer for both the mother and the fetus. Early detection of alarming health issues allows for quick action before the problems worsen.

Safety impact:

The biggest concern with an unexpected product will be how safe it is to use. Any product that is available to consumers on the market must adhere to a certain level of product safety standards.

When it comes to keeping track of the pregnant woman's health, safety is of utmost importance. Systems with immediate warnings reduce the possibility of negative outcomes. The system enables pregnant women from all over the nation who might not have otherwise had access to health monitoring to do so. It can be used by women who are carrying a high-risk pregnancy to continuously monitor their bodies. Given all the potential harm an electronic device could do to the body, we made sure that our project was safe to use. There won't be any possibility of the mother unintentionally receiving electrical charge from the machine.

Legal impact:

Before attaching the device to the mother, a consent note will be given to her outlining all of its features and explaining how it will be applied. Regarding the crucial information gathered from the patient throughout the pregnancy, complete transparency will be upheld. The data will be kept private, we guarantee.

Cultural impact:

This project will have a positive cultural impact by assisting in the eradication of some pregnancy-related taboos and superstitions that are pervasive in our society. Because there is little awareness of the risks of maternal death in our culture, making pregnancy monitoring kits more common will help.

6.3 Evaluate The Sustainability

The capacity to continue at a certain rate or level is known as sustainability. A product must be created and/or used in a way that does not harm or destroy the environment in order to be deemed sustainable. If a product's manufacturing uses nonrenewable resources, damages the environment, or has a negative impact on people or society, it is unlikely to be regarded as environmentally sustainable. Used components are recyclable and cost effective.

To ensure that our project is sustainable, we have taken a few environmental, social, and economic factors into account. We strive to obtain patient data with the least amount of error.

Environmental:

The components used in our project are recyclable, this minimizes landfill pollution. We will be using Li-po batteries to power the devices so there is no risk of radiation or carbon emission. The components that are being used are recyclable and cost effective.

Economic:

Because of its compact size and lightweight, the device will be produced at a reasonable cost. If any components are found to be defective or malfunctioning, they will be changed.

Social:

Along with other things, factors to take into account include community development, social support, social responsibility, cultural competence, community resilience, and human adaptation, as well as the effects of any specific machinery or new innovative ideas/technologies that will improve quality of life.

6.4 Conclusion

An important impact and sustainability analysis of the design project is given to us by the investigation and discussion in this chapter. In this section, we've looked at how our project might affect the environment, society, user safety, and their health. The economic and environmental aspects of sustainability have also been covered in our discussions. Finally, while keeping an eye on the financial viability of the design and manufacturing, we evaluated the sustainability factor by comparing various surveys that took into account the condition and requirements of the patient.

Chapter 7

Engineering Project Management [CO11, CO14]

7.1 Introduction

The main goal of engineering project management is to keep the project on schedule, under budget, and in compliance with all pertinent standards. Here, we investigated and examined a number of engineering project management-related issues, created a Gantt chart, fairly distributed the group's tasks, and evaluated the project's accomplishments using a set of standards.

7.2 Define, Plan, and Manage Engineering Project

Every engineering project has a management section where the tasks, allocation of resources, and allocation of time have all been planned out. The management of our FYDP (final year design project) has been handled in the same way here.

7.2.1 Definition of project management

As it entails identifying project objectives, needs, and specifications, engineering project management also includes project planning and communication with stakeholders. Engineering project management's primary goal is to safeguard and complete the project on schedule, within budget, and in accordance with client requirements. Here, the fundamental requirements and abilities required to finish the project on schedule are listed as follows: Risk management, Stakeholder management, Process integration, Timing, cost, and scope of the project, Communications.

7.2.2 Planning of the Engineering project:

The project plan indicates the timelines of our projects and our expected time to finish the project. Our overall project total can be broken down into three sections. The three phases of our project plan are broken out in the flowcharts below.

Flowchart of the phase 1:

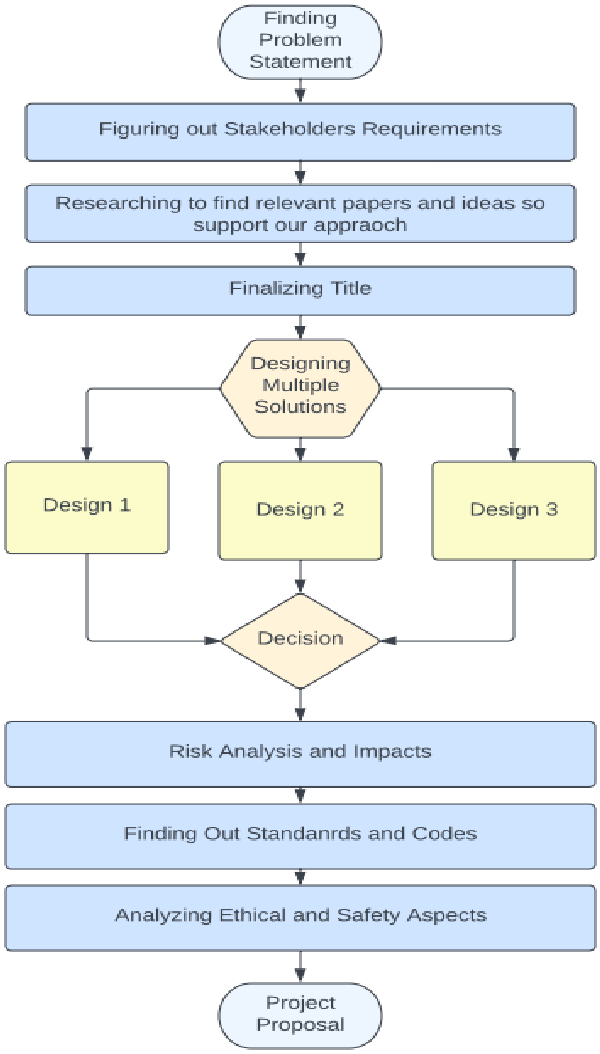

Figure 47. Workflow Diagram of EEE400P

We had to be careful about our ethical and safety aspects as we were working in the health sector. We contacted a gynecologist to come up with the metrics and their threshold. After that came risk analysis and impacts, followed by standards and codes and analyzing the ethical aspects of our design.

Flowchart of phase 2:

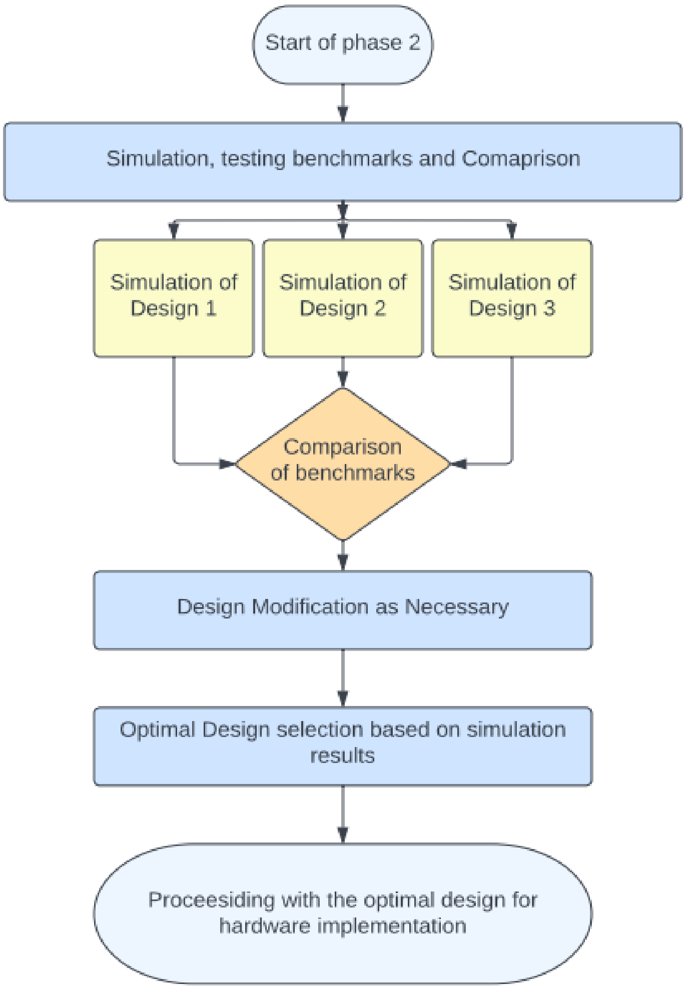

Figure 48. Workflow Diagram of EEE400D

The primary goal of this phase is to establish some benchmarks for the designs we have provided, replicate those designs using software, and assess how well they function in terms of speed, accuracy, and simplicity. The best design will then be chosen, and we'll work to overcome all of its flaws and restrictions so that we can execute it flawlessly in the next hardware implementation.

Flowchart of phase 3:

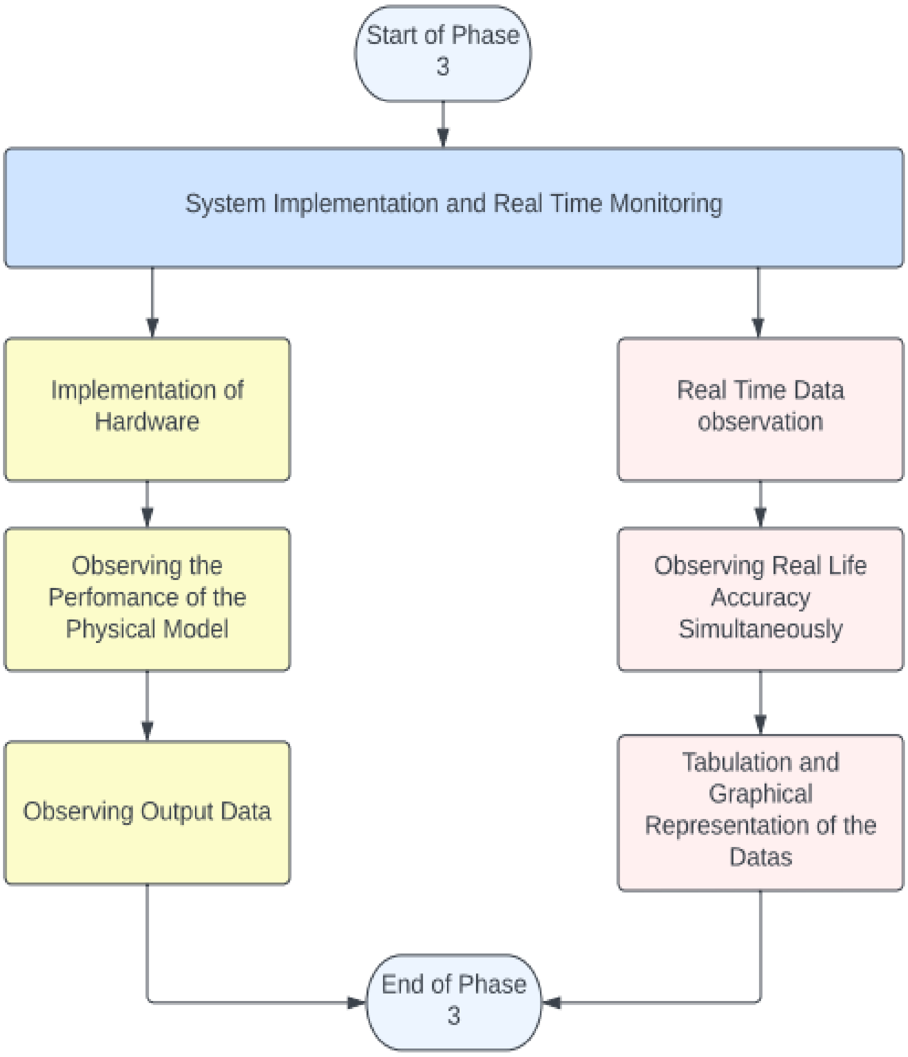

Figure 49. Workflow Diagram of EEE400C

Phase 3 is the physical manifestation of what we have worked to accomplish throughout the previous two phases. This completes the project's implementation. Here, we primarily give our project the much-anticipated physical form it now needs and assess the outcomes to see if they live up to our expectations. We will set up the system and keep an eye on the data in real time. The data will then be compared between before and after the system was put into place.

7.2.3 Project Planning/ Gantt chart

❖ **EEE400P**

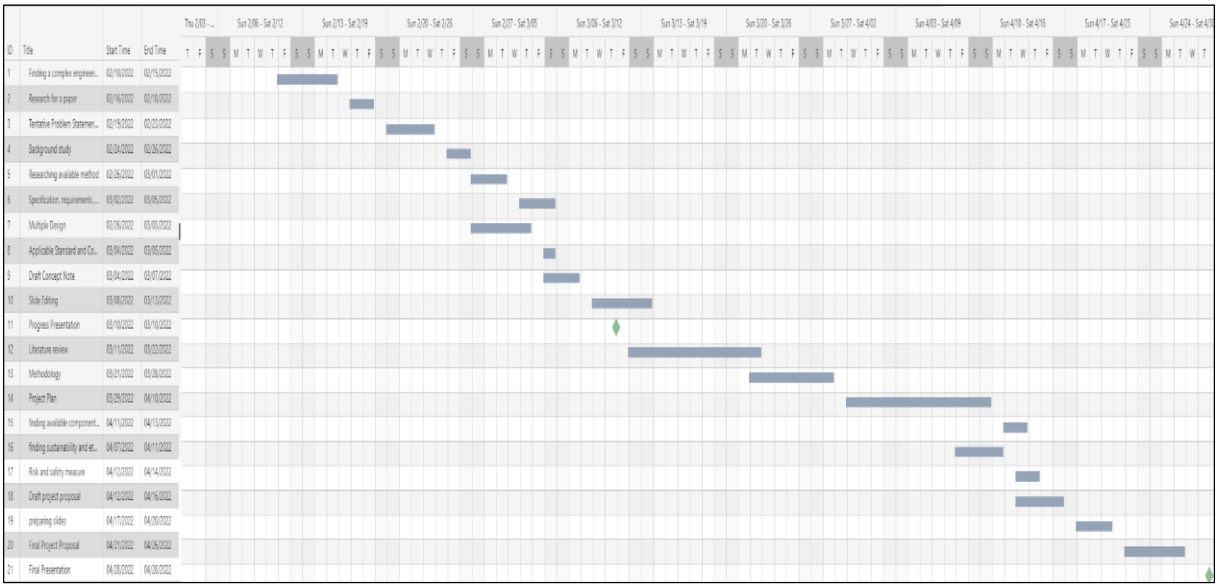

Figure 50. Gantt chart of EEE400P

❖ **EEE400D**

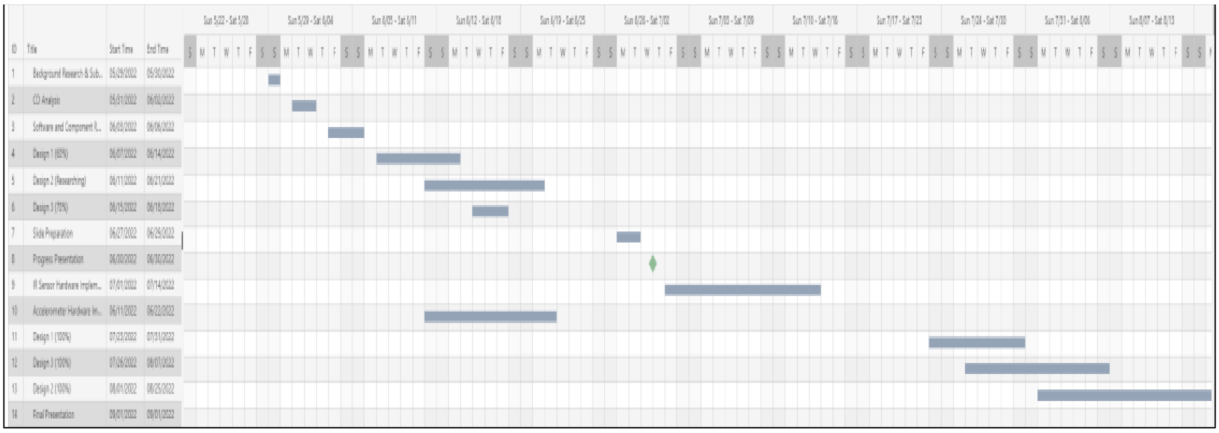

Figure 51. Gantt chart of EEE400D

<u>Task distribution</u>

Task	Starting Date	End Date	Duration
Background Research and Subsystem planning	29/05/2022	30/05/2022	1
CO Analysis	31/05/2022	02/06/2022	3
Software and Component Research	03/06/2022	06/06/2022	4

Analysis of Design approach 1	07/06/2022	14/06/2022	8
Design Approach 2 (Researching)	11/06/2022	21/06/2022	11
Analysis of Design Approach 3	15/06/2022	18/06/2022	4
Slide Preparation	27/06/2022	29/06/2022	3
Progress Presentation	30/06/2022	30/06/2022	1
IR sensor Hardware Implementation	01/07/2022	14/07/2022	15
Accelerometer Hardware implementation	11/07/2022	22/07/2022	12
Design 1 Completed	23/07/2022	31/07/2022	9
Design 3 Completed	26/07/2022	07/08/2022	14
Design 2 Completed	01/08/2022	25/08/2022	26
Slide Preparation and Report Submission	26/08/2022	31/08/2022	6
Final Presentation	01/09/20222	01/09/20222	1

Table 19. Task Distribution Table

❖ **EEE400C**

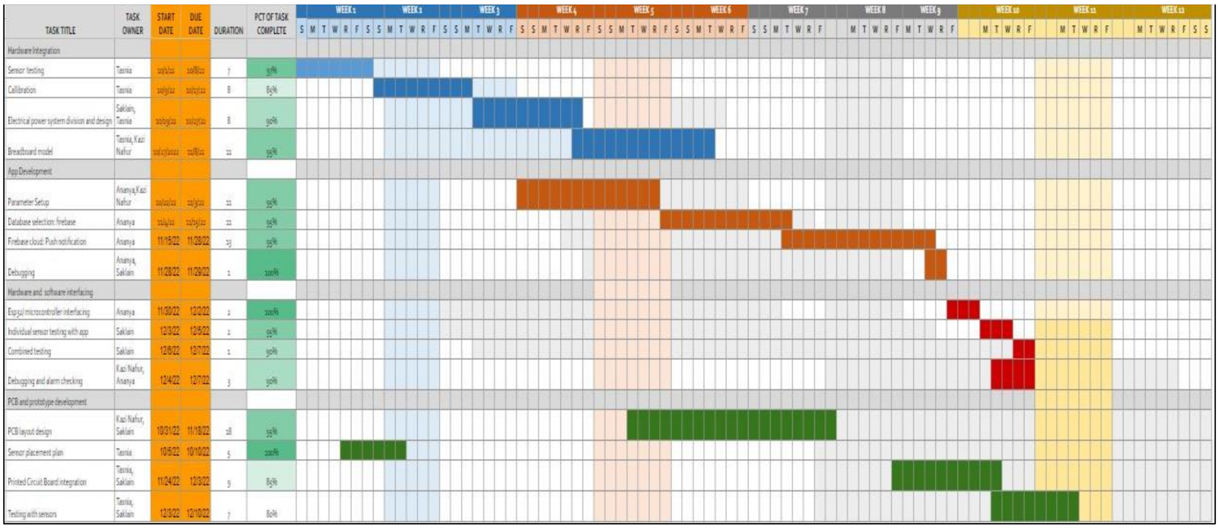

Figure 52. Gantt chart of EEE400C

7.3 Evaluate Project Progress

To create the project, we completed a number of activities. Here, throughout the course of the three semesters, we divided up the project work among the various group members. As a result, we organized the project work using numerous strategies such as: Gantt Chart to complete work in due time, keeping a logbook to record members' activity, Each semester, peer evaluation forms are used to assess how well each group member contributed to the project.

Task Title	Task Owner	Start Date	Due Date	Duration
Hardware Integration				
Sensor testing	Tasnia	10/1/2022	10/06/2022	7
Calibration	Tasnia	10/9/2022	10/17/2022	8
Electrical power system division and design	Saklain, Tasnia	10/19/2022	10/27/2022	8
Breadboard model	Tasnia, Kazi Nafiur	10/19/2022	11/08/2022	11
App Development				
Parameter Setup	Ananya, Kazi Nafiur	10/22/2022	11/03/2022	11
Database section: Firebase	Ananya	11/04/2022	11/15/2022	11
Firebase cloud: Push notification	Ananya	11/15/2022	11/28/2022	13
Debugging	Ananya, Saklain	11/28/2022	11/29/2022	1
Hardware and Software Interfacing				
ESP32/ microcontroller interfacing	Ananya	11/30/2022	12/03/2022	2
Individual sensor testing with app	Saklain	12/03/2022	12/05/2022	2
Combined testing	Saklain	12/06/2022	12/07/2022	1
Debugging and alarm checking	Kazi Nafiur, Ananya	12/04/2022	12/07/2022	3
PCB and Prototype Development				
PAB layout design	Kazi Nafiur, Saklain	10/31/2022	11/18/2022	18
Sensor placement plan	Tasnia	10/0520222	10/10/20222	5
PCB integration	Tasnia, Saklain	11/24/2022	12/3/2022	9
Testing with sensor	Tasnia, Saklain	12/3/2022	12/10/2022	7

Table 20. Project Progress and Duration

7.4 Conclusion

As a result of our analysis, we have included the words of project management abilities and criteria to our FYDP (Final Year Design Project). Therefore, by keeping a logbook, a Gantt chart, and a peer review form, we have equitably dispersed our project's work in order to finish it on schedule and within budget.

Chapter 8

Economical Analysis [CO12]

8.1 Introduction

The field of engineering economics investigates the value of a project. e. An engineering project must comply with a certain set of economic analysis standards in order to be finished. Therefore, by examining and assessing such aspects, a project developer may be able to determine the economic impact on his project.

8.2 Economic Analysis

Economic analysis gives us suggestions on how to improve resource allocation in order to create more profit from any product. We can determine how effective a product or business is by applying economic analysis to acquire a better grasp of how much profit it is making.

Remote maternal health monitoring is not currently possible with any available products on the market. We created a product that automatically tracks maternal health. Additionally, by using the applications, patients and doctors can monitor their health conditions and receive emergency notifications. The product's total price is around 5000 BDT, making it affordable for the majority of people. So, if we want to create bulk production it can be easily done. Therefore, it is simple to build a large-scale production. Additionally, it may be said that the price of individual sensors drops when we buy them in large quantities, according to market research. Thus, the product's price might be reduced.

Our developed system can help certain people who can afford it with their financial problems, compared to the routine health checkup in a hospital. Additionally, it may be useful for those who reside in remote locations and are unable to travel for routine checkups.

8.3 Cost Benefit Analysis

We have tried to minimize our pricing as much as possible. Moreover, the project was developed with all readily available parts present in our country which are cheap and easily replaceable. Moreover, the technology and resources needed to commercialize this product is quite achievable and easy. To add to that, according to our survey results a good percentage of people are interested in this kind of product as more and more people are inclined to monitor their pregnancy. Therefore, as demand is higher and overall resource, costing and pricing all are in achievable and convenient range the cost benefit of this product is quite high.:

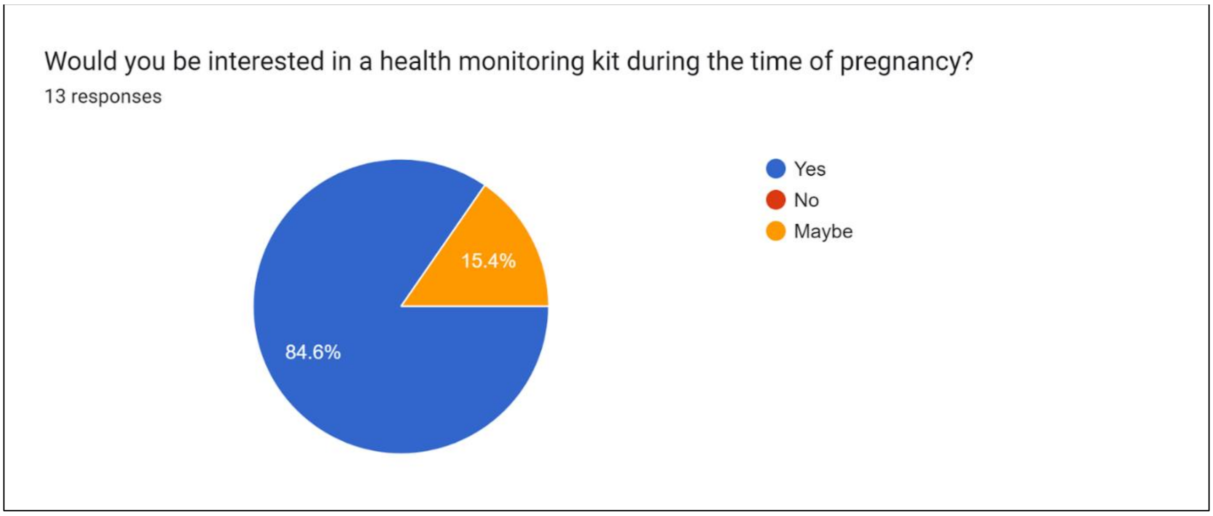

Figure 53. Survey of health monitoring kit

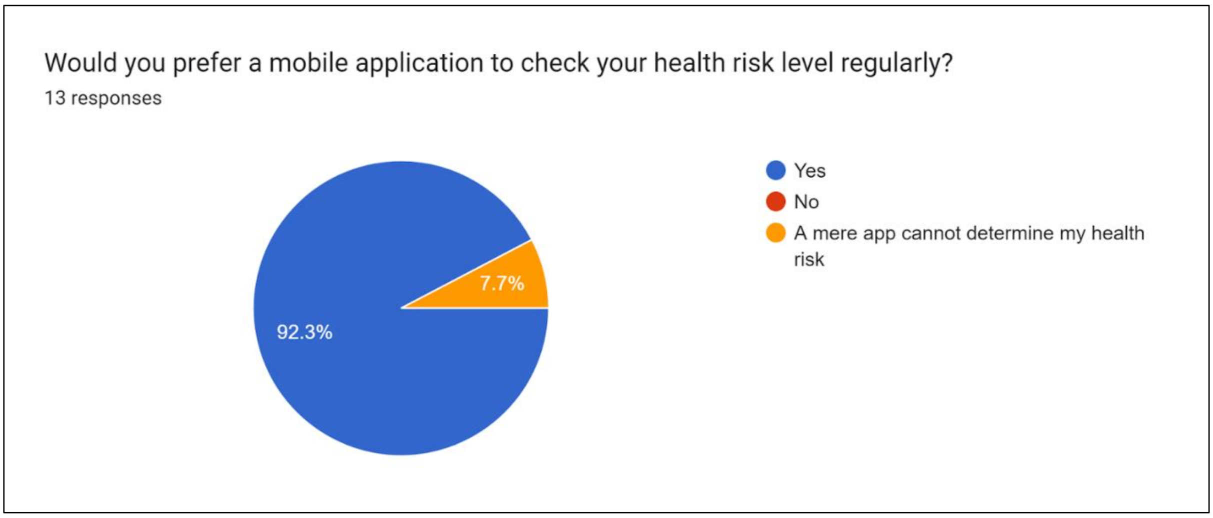

Figure 54. Survey of mobile application

These are the survey results which indicate high demand for this product.

8.4 Evaluate Economic and Financial Aspects

Given that we created the system in consultation with experts in the field, this project will be profitable from an economic and financial standpoint. Doctors assisted us in choosing the appropriate module so that they could obtain the precise data that they required. In addition, we made a point of designing a system that would be both affordable and convenient for the patients while keeping their needs in mind. The stakeholders can use this system pretty easily because it is an IoT-based device. Last but not least, mass manufacturing of this technology is fairly simple and advantageous for the community. The budget for prototype implementation is as follows:

Component name	Unit	Price (BDT)	Links
NodeMCU ESP32	1	740	Purchasing link
DS18B20 Temperature Sensor	1	270	Purchasing link
MAX30100 Oxygen Saturation & Heartbeat sensor	1	500	Purchasing link
ADXL335 3-Axis Accelerometer	1	445	Purchasing link
NIR Photodiode & Receiver	1	150	Purchasing link
MPU6050 3-Axis Gyro	1	290	Purchasing link
DC to DC Buck Converter	2	240	Purchasing link
18650 Battery	2	400	Purchasing link
PCB	2	1100	
Miscellaneous Cost	-	1091	
Total Budget		**5226**	

Table 21. Budget For Prototype Design

8.5 Conclusion

To make our pricing range as cost-effective as feasible for our sustainability plan, we have made every effort to keep it to a minimum. Our final design costs are a bit higher than the initial cost but after extensive analysis we have concluded with this price. The overall analysis suggests that there is quite a bit of demand for this sort of product which outweighs the research and labour costs of prototype development.

Chapter 9

Ethics and Professional Responsibilities [CO2, CO13]

9.1 Introduction

The ethical and professional duties of the project must be taken into account in order to build a sustainable and helpful engineering project for people. By concentrating on these moral and professional obligations, we can better comprehend the potential social, economic, and environmental effects of our undertaking. Our ethical considerations can direct us to create projects while upholding morality and social responsibility. On the other side, our obligations as professionals will direct us in how best to use our engineering expertise when designing the project.

9.2 Identify Ethical Issues and Professional Responsibility

When assessing the ethical issues that are pertinent to the stakeholder's expectations, every engineering project should consider a few key factors. The developer should consider user privacy and security, sustainability, and safety issues when building an engineering project.

Any engineering project's developer should take into account a few characteristics in the professional responsibility area to satisfy the needs of the stakeholders. The manufacturer must adhere to all essential standards, professional codes, and legal criteria to make sure the project complies with the appropriate authorities.

9.3 Apply Ethical Issues and Professional Responsibility

When addressing issues relating to people, one should adhere to a set of moral principles. No one engages in behavior that is detrimental to society or an individual because of moral obligations. We have considered some of the following factors:

1. **Consent:** All participants in the evaluation have given their full knowledge and informed consent. Participants must be made aware of the purpose of the experiment, who is funding it, how the results will be used, any risks associated with their involvement, and who will have access to the results.

2. **No health hazard:** A pregnant woman being vulnerable to any external radiation and sharp object is a serious matter of concern. Keeping this in mind we have used sensors which are medical grade and have refrained from using materials with sharp edges and hard coatings with any exposed sharp metal objects.

3. **Privacy of information:** The information of a patient as well as her health log will be solely visible to the doctor alone and no other person will have access to it. Only an authorized person will be allowed to see the elaborate health data and the health log history will be accessible upon logging into the app using a password set by the user.

4. **Environmental safety:** We have used sensors which are very small in size and durable so that there is no need of replacing them often and we have used jst cables to make the sensors replaceable and so that each sensor remains as an individual replaceable component, and we have also used rechargeable batteries thus minimizing waste.

5. **Maintaining quality:** We have ensured to place rechargeable batteries so that it can be easily charged back if quality falters as well as used JST cables to mount and dismount sensors if they falter in efficiency or degrade over time.

6. **Maintaining relationship between clients and stakeholders**: To ensure that patients could use this method without experiencing any hardship, we made every effort to reduce costs to a minimum while maintaining the high quality of the product. As a result, we would be able to keep the public's trust in our ability to implement the project in practical settings.

9.4 Conclusion

As a new and innovative project, it is only our duty to make sure that safety and ethical considerations are taken into account during project implementation. We have taken into consideration every conceivable code of behavior an engineer must adhere to in accordance with identification and application. Engineers must be encouraged to develop projects in this field, and stakeholders must be driven to show interest in the project, by its ethical features.

Chapter 10

Conclusion and Future Work

10.1 Project Summary/Conclusion

During the period of pregnancy several health risks are faced by women which pose a threat to the life of the mother. By analyzing these health factors, we developed and implemented a smart health monitoring system for reducing maternal health risk based on a pregnant woman's vital health parameters, creating meaningful predictions about her overall health, and establishing an effective notification system for any pregnancy-related health emergency. At first, we proposed 3 designs to face this challenge then we ran an intricate analysis to select an optimal design method. In our optimal design, we considered parameters such as Blood sugar, Temperature, Fetal Kick, Heart Rate, Oxygen Saturation as well as Fall Detection. We have set threshold values for risk detection during pregnancy for each parameter. We have done this by carefully selecting cost-effective and budget friendly sensors which give optimal results. If any of these parameters goes below or above that certain range, our system will consider this as an abnormal value and send notification to the doctor. If the system detects a fall, it also sends an alarm. It also stores the number of fetal kicks the patient is experiencing per day for the doctor to see and analyze the health of the fetus.

10.2 Future work

As science is always progressing and expanding, the term "future work" is closely associated with any complex engineering challenge. As a consequence, any complex engineering project may include Future Works, in which the hardware and software may be upgraded and modified. Our Project is not different from that. Since we are working on an IOT based Maternal Health Risk Detection System, we have considered some future scopes where our system will be more updated and beneficial to the consumers.

10.2.1 Introduce the Project's Future Work Possibilities

For Hardware System:

- Initially we planned to use I2CEEPROM from any digital blood pressure machine for blood pressure monitoring. However, we could not find any data sheet for I2CEEPORM and for this plan we need to modify the pressure machine and Arduino which is a very complex process. So, we have come up with an alternative plan that we can consider as future work for blood pressure monitoring by using MAX32664 sensor which is also known as pulse sensor. It estimates BPT (Blood Pressure Trend) using Arduino. The sensor has low availability in Bangladesh and is quite expensive (approximately 4000 INR in India) for our FYDP budget, but we can definitely make it work for our further research.

Figure 55. MAX32664 Sensor

- Development and integration of a system that alerts the manufacturer when a sensor quality falters.

For Health Monitoring App

- **Show metrics/graph for each sensor:** Show time series graph for each sensor to demonstrate how each sensor data changes over a period of time in a mobile app.

- **Support multiple Doctors and Patients:** Add support for multiple doctors and patients by providing an option for a patient to be assigned to a doctor. A doctor can have multiple patients, but a patient can be assigned to only one doctor at a time. Doctor and patient ID can be created by signing up and the ID's can be fetched from the database to sync with multiple hardware setups.

- **Chatbot in mobile app:** Adding chatbot to patient's interface where the patients can communicate with chatbot. Here, the bot will ask some common questions and patients can add their responses to the bot questions. This feature can be added to know the patient's mental state to some extent by asking some related questions.

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Chapter 11

Identification of Complex Engineering Problems and Activities

11.1 Identify The Attribute of Complex Engineering Problem (EP)

A. Attributes of Complex Engineering Problems (EP)

	Attributes	**Put tick (√) as appropriate**
P1	Depth of knowledge required	√
P2	Range of conflicting requirements	√
P3	Depth of analysis required	√
P4	Familiarity of issues	√
P5	Extent of applicable codes	√
P6	Extent of stakeholder involvement and needs	
P7	Interdependence	√

Table 22. Attributes of Complex Engineering Problems (EP)

11.2 Provide Reasoning How The Project Address Selected Attribute (EP)

- **P1: Depth of knowledge required:**

  Depth of knowledge is necessary when putting together a model with so many parameters that must be seamlessly integrated into one cohesive body to get the best potential result.

- **P2: Range of conflicting requirements:**

  We had to integrate both the MAX30100 sensor as well as the MPU6050 sensor which both required the I2C pins of our microcontroller which we had to tackle. Moreover, we had to design a system which is least uncomfortable while being made to use multiple sensors which are difficult to place without sacrificing a bit of comfort. So, we design a system as compact as possible to minimize discomfort as much as possible.

- **P3: Depth of analysis required:**

  Studying the integration of so many components and the possibility of them working effectively when combined required extensive study and secondary research.

- **P4: Familiarity of issues:**

  As Electrical Engineers, we are unfamiliar with a pregnant woman's medical characteristics and the extent to which a body function or level may be assessed utilizing various technologies. We had to become well acquainted with every aspect of a pregnant patient in order to provide the best answer for every result.

- **P5: Extent of applicable codes:**

  Because our solutions are built on the interdependence of sensors and cloud processing, the IEEE code EEE 1451-99 applies here. There is also data sharing between the microcontroller and the internet, as well as the engagement of a mobile application, therefore CEN ISO 11073 Health Informatics applies here.

- **P7: Interdependence:**

  This project includes subsystems such as a temperature detection system, an oxygen level detection system, a blood sugar detection system, and so on. These are interconnected.

11.3 Identify The Attribute of Complex Engineering Activities (EA)

B. Attributes of Complex Engineering Activities (EA)

	Attributes	Put tick (√) as appropriate
A1	Range of resource	√
A2	Level of interaction	√
A3	Innovation	√
A4	Consequences for society and the environment	√
A5	Familiarity	√

Table 23. Attributes of Complex Engineering Activities (EA)

11.4 Provide Reasoning How The Project Address Selected Attribute (EA)

- **A1: Range of resource:**

  To put the system together, we'll need microcontrollers, several sensors, a GPS module, a Wi-Fi module, and other components readily available in local marketplaces.

- **A2: Level of interaction:**

  There will be several sensors in this system. Controlling and maintaining these components is difficult. In such instances, the microcontroller must manage many sensors. As a result, the system may pull multiple currents, and we must develop an effective method to make everything smooth.

- **A3: Innovation:**

  Introduction of fetal kick detection and implementation of non-invasive blood glucose measurement are the innovations of our project.

- **A4: Consequences for society and the environment:**

  In our project, we will employ many environmentally friendly components. Furthermore, with the assistance of this health monitoring system, the patient will visit the doctor less frequently, reducing the carbon footprint she would have otherwise left.

- **A5: Familiarity:**

  We will use microcontrollers and sensors in this project. We have had prior experience dealing with a few of these components.

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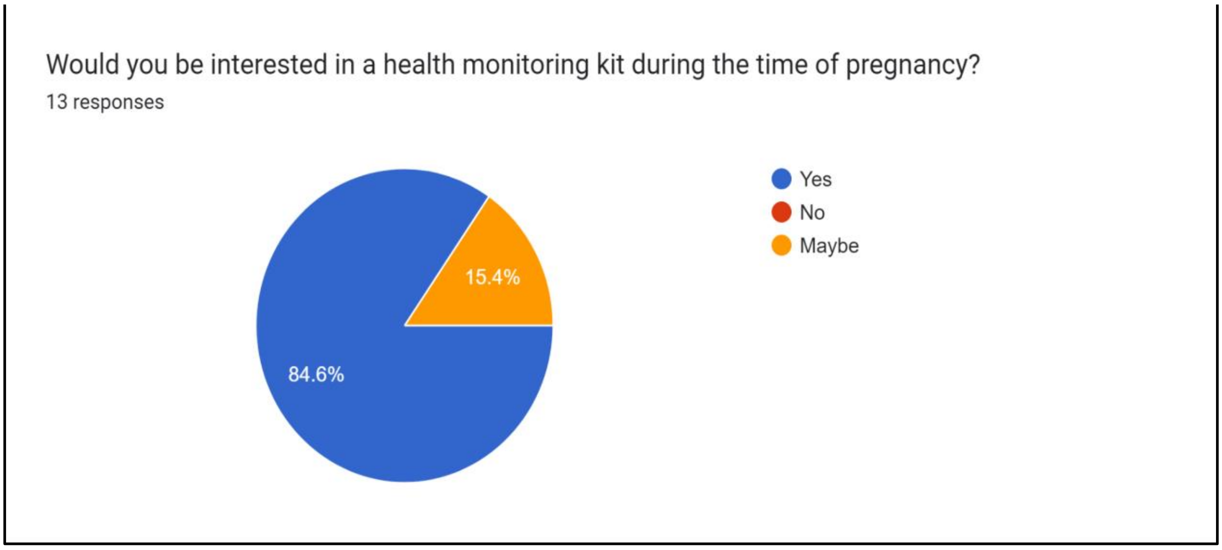
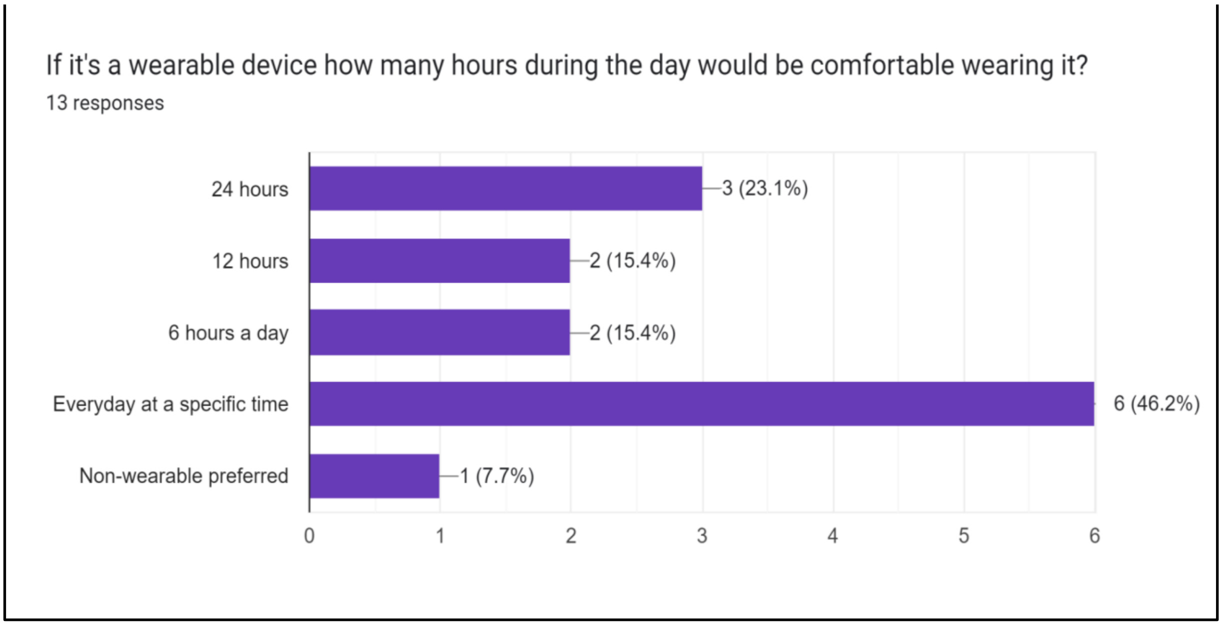
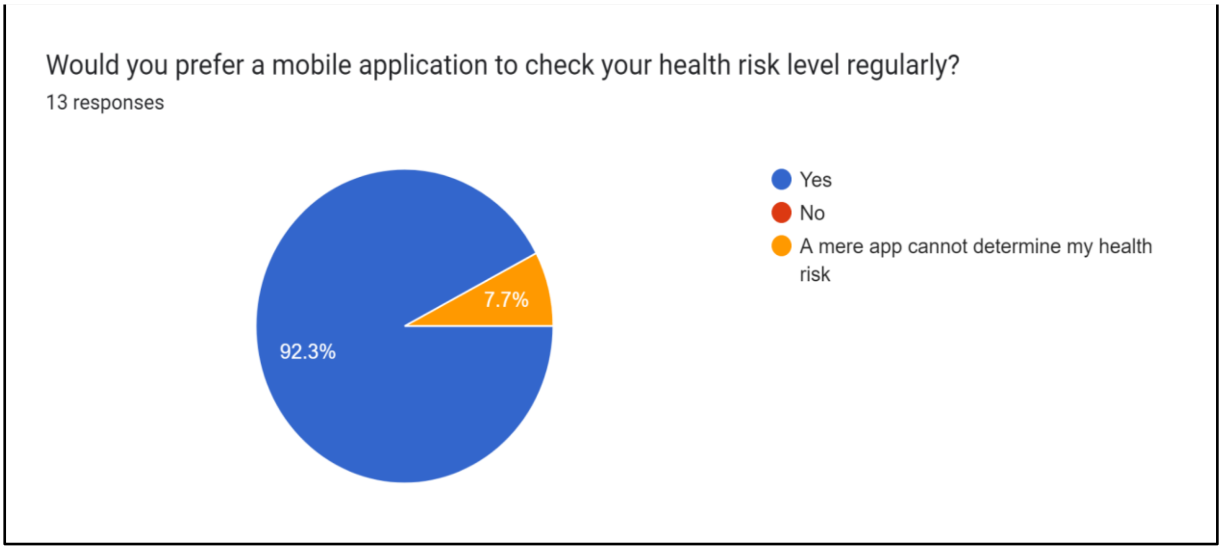
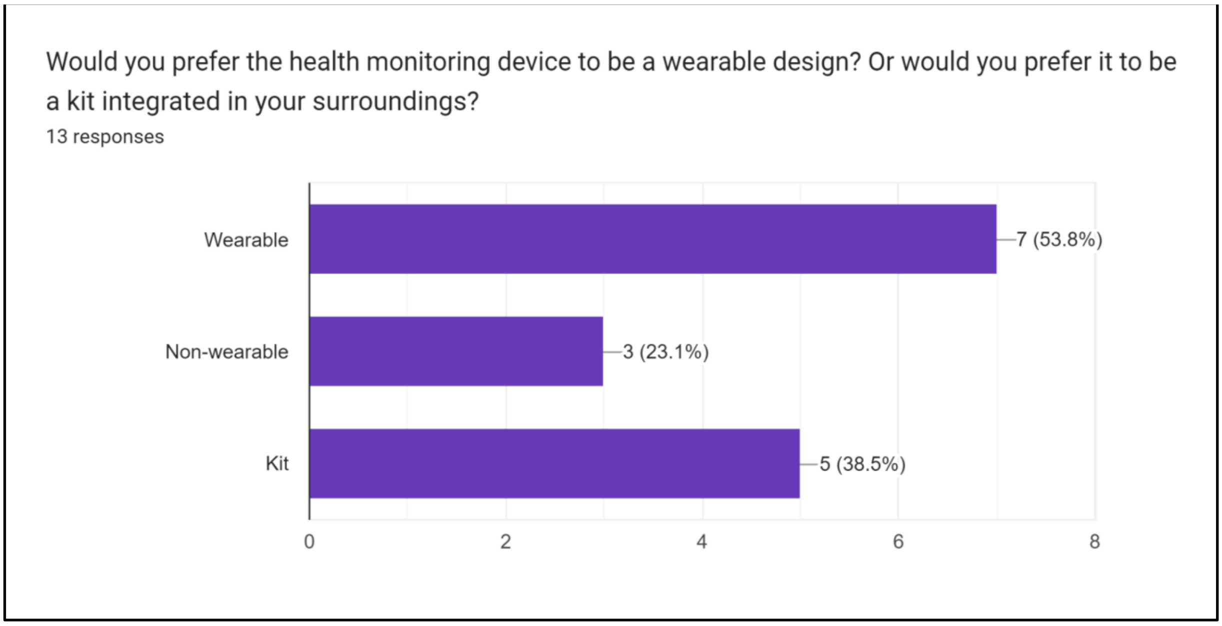
Appendix A.

Survey Results:









Survey form link: https://forms.gle/hRJYKUGdLsJ9Sn8d7

Code:

Hardware code:

```
#include <WiFi.h>
#include <Wire.h>
#include <OneWire.h>

const String doctorId = "etL6fQK069YJNSPEWiYkSvJEepSbH3"; //fixed
const String patientId = "qtQvaNgARcJTCoUtJawK2YJHS9KVd2"; //fixed

String type = "NORMAL";
double oxygenSaturation = 90;
int kickCount = 0;
int heartBeat = 70;
double bloodSugar = 0;
int fallDetection = 0;
double temperature = 0;

const String firebaseUrl = "https://firestore.googleapis.com/v1/projects/healthmonitoring-
1eeb7/databases/(default)/documents/HealthLog?key=AIzaSyCB1X8dOLNPmKSzpLncrC2QUkCIU9jmFiI"
; //fixed

//DS18B20 Temperature sensor variables//
// GPIO where the DS18B20 is connected to
const int oneWireBus = 26;

// Setup a oneWire instance to communicate with any OneWire devices
OneWire oneWire(oneWireBus);

// Pass our oneWire reference to Dallas Temperature sensor
DallasTemperature temperatureSensor(&oneWire);

//ADXL335 sensor variables//
const int xpin = A0; // x-axis of the accelerometer
const int ypin = A3; // y-axis
const int zpin = A4; // z-axis
int x1,a1,z1;
int x2,a2,z2;
int s1,s2,s3;
//int kickCount=0;
const int threshold1=50;
const int threshold2=500;

//NIR variables//
int const readpin=A5;
float reading;
float reading1;
//float reading2;

//MAX30100//
#define REPORTING_PERIOD_MS 1000
PulseOximeter pox;
uint32_t tsLastReport = 0;

//MPU6050
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;

#define TCAADDR 0x70
void tcaselect(uint8_t i) {
  if (i > 7) return;

  Wire.beginTransmission(TCAADDR);
  Wire.write(1 << i);
  Wire.endTransmission();
}


void postToFirebaseDB(){
  HTTPClient http;
  http.begin(firebaseUrl);
  http.addHeader("Content-Type", "application/json");

  String json;
  StaticJsonDocument<400> doc;

  JsonObject fields = doc.createNestedObject("fields");
  fields["doctorId"]["stringValue"] = doctorId;//fixed
  fields["patientId"]["stringValue"] = patientId;//fixed
  fields["type"]["stringValue"] = type;//fixed
  fields["oxygenSaturation"]["doubleValue"] = oxygenSaturation;
  fields["kickCount"]["integerValue"] = kickCount;
  fields["heartBeat"]["integerValue"] = heartBeat;
  fields["bloodSugar"]["doubleValue"] = bloodSugar;
  fields["fallDetection"]["integerValue"] = fallDetection;
  fields["temperature"]["doubleValue"] = temperature;
  serializeJson(doc, json);

  Serial.print("Posting sensor data to databse " + firebaseUrl + "... ");
  int httpResponseCode = http.POST(json);
  if (httpResponseCode == 200) {
    Serial.print("HTTP ");
    Serial.println(httpResponseCode);
    Serial.println("Successfully posted to database!");
    String payload = http.getString();
    Serial.println();
    Serial.println(payload);
  }
  else {
    Serial.print("Could not post data to databse. Error code: ");
    Serial.println(httpResponseCode);
  }
}

void onBeatDetected()
{
  Serial.println("Beat!");
}

void setup() {
```

```
  Serial.begin(115200);
  WiFi.begin(ssid, password );

  Serial.print("Connecting to WiFi");
  while (WiFi.status() != WL_CONNECTED) {
  delay(100);
  Serial.print(".");
  }
  Serial.print("OK! IP=");
  Serial.println(WiFi.localIP());


  // Start the DS18B20 sensor
  temperatureSensor.begin();

  //MAX30100
  Serial.print("Initializing pulse oximeter..");
  Wire.begin();
  tcaselect(5);
  if (!pox.begin()) {
  Serial.println("FAILED");
  for(;;);
  }
  else {
  Serial.println("SUCCESS");
  }
  pox.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);
  pox.setOnBeatDetectedCallback(onBeatDetected);

  //MPU6050
  Wire.begin();
  tcaselect(6);

void loop() {
  //pox.update();
  calculateSensorReading();
  calculate_BPM_SpO2();
  calculateKicks();
  determineFall();
    delay(10000);

}

void calculateType(){
  if (( temperature > 100)&& (oxygenSaturation <90)) {
    type="ABNORMAL";
   }
  else if ((oxygenSaturation < 90) && (heartBeat <60)){
    type="ABNORMAL";
  }
  else if (6.9 < bloodSugar ){
    type="ABNORMAL";
  }
  else if (fallDetection==1){
    type="ABNORMAL";
  }

}

void calculateSensorReading(){
```

```
  //NIR
  reading=analogRead(readpin);
  reading1=reading/40.95;

  //DS8B120
  analogReadResolution(12);
  temperatureSensor.requestTemperatures();
}

void calculate_BPM_SpO2(){
  //MAX30100
  pox.update();
  if (millis() - tsLastReport > REPORTING_PERIOD_MS) {
}
}
void calculateKicks(){
  //ADXL 335
  analogReadResolution(10);

  if(s3>threshold1 && s3>threshold2){
    kickCount++;
  }
}

void determineFall(){
 mpu_read();
 ax = (AcX-2050)/1634.00;
 ay = (AcY-77)/1684.00;
 az = (AcZ-1947)/1634.00;
 gx = (GyX+270)/13.07;

 // calculating Amplitute vactor for 3 axis
if (amplitude<=2 && trigger2==false){ //if AM breaks lower threshold (0.4g)
   trigger1=true;
   Serial.println("TRIGGER 1 ACTIVATED");
   }
 if (trigger1==true){
   trigger1count++;
   if (amplitude>=12){ //if AM breaks upper threshold (3g)
     }
 }
 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

   }
 if (trigger3==true){
    trigger3count++;
    if (trigger3count>=10){
       angleChange = pow(pow(gx,2)+pow(gy,2)+pow(gz,2),0.5);
       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
  // bloodPressure=1;
   Serial.println("FALL DETECTED");
   //send_event("FALL DETECTION");
   fallDetection=1;
   }
 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 mOpu_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)
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)
 }
```

FYDP (C) Summer 2022 Summary of Team Log Book/ Journal

Group No: 15

Final Year Design Project (C) Summer 2022			
Student Details	**NAME & ID**	**EMAIL ADDRESS**	**PHONE**
Member 1	Ananya Khan - 18121087	ananya.khan@g.bracu.ac.bd	01715139985
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ATC Details:			
ATC 4			
Chair	Dr. Mohammed Belal Hossain Bhuian	belal.bhuian@bracu.ac.bd	
Member 1	Abdullah Hil Kafi	abdulla.kafi@bracu.ac.bd	
Member 2	Md. Mahmudul Islam	mahmudul.islam@bracu.ac.bd	

FYDP (C) Summer 2022 Summary of Team Log Book/ Journal

Date/Time /Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
29.09.2022	1.Ananya 2.Tasnia 3.Saklain 4.Nafi	1. Selecting the sensors based on research 2. ordering the components	Task 1: Saklain,Tasnia,Nafi,Ananya Task 2 : Saklain,Tasnia,Nafi,Ananya	
2.10.2022	1.Dr. Mohammed Belal Hossain Bhuian 2. Ananya 3.Tasnia 4.Saklain 5.Nafi	1.Presented the finalized design 2. Discussion on selected components 3. Brief discussion on COs,POs	All	
6.10.2022	1.Ananya 2.Tasnia 3.Saklain 4.Nafi	1.Individual Sensor Testing : Temperature sensor, NIR Sensor, Heartbeat sensor 2. research on I2C EEPROM for blood pressure monitoring	Task 1: Saklain,Tasnia Task 2 : Ananya,Nafi	
11.10.2022	1.Dr. Mohammed Belal Hossain Bhuian 2.Md. Mahmudul Islam 3. Ananya 4.Tasnia 5.Saklain 6.Nafi	1. Temperature sensor, NIR Sensor, Heartbeat sensor testing result 2. Findings and drawbacks of I2C EEPROM	Task 1: Tasnia, Saklain Task 2 : Ananya, Nafi	
15.10.2022	1.Ananya 2.Tasnia 3.Saklain 4.Nafi	1.Calibration - Temperature sensor, NIR Sensor, Heartbeat sensor 2. Sensor Testing - Accelerometer,MPU6050 3. Learn react native and initiate project for app	Task 1: Tasnia,Saklain Task 2 : Saklain,Tasnia Task 3 : Ananya	
18.10.2022	1.Dr. Mohammed Belal Hossain Bhuian 2.Md. Mahmudul Islam 3. Ananya 4.Saklain 3. Nafi	1.presented the sensor output on serial monitor	All	

25.10.2022	1.Ananya 2.Tasnia 3.Saklain 4.Nafi	1.selecting firebase and initiate project for cloud and setup database configuration 2. Setting up the requirements for mobile application 2. Calibration for Temperature sensor, Max30100,Accelerometer, NIR sensor	Task 1 : Ananya Task 2 : Nafi, Ananya Task 3. Saklain,Tasnia	
29.10.2022	1. Saklain 2. Tasnia	1.Individual sensor testing and taking outputs after calibration	Saklain, Tasnia	
01.11.2022	1.Dr. Mohammed Belal Hossain Bhuian 2. Abdullah Hil Kafi 3.Md. Mahmudul Islam 4. Ananya 5.Tasnia 6.Saklain 7.Nafi	1. Update for our progress presentation 2. presented the sensor results individually	All	find alternative for blood pressure monitoring
1.11.2022	1. Ananya 2.Tasnia 4.Saklain 4.Nafi	1.Prepare the slides for Progress presentation	All	
3.11.2022	1.Ananya 2.Tasnia 3.Saklain 4.Nafi 5. ATC Panel	Progress Presentation	Tasnia,Ananya,Saklain,Nafi	1. need to work on video quality 2. Start integrating the sensors
4.11.2022	1.Ananya 2.Tasnia 3.Saklain 4.Nafi	1. implement sign up, login and doctor screen with static data without implementation with backend 2. Sensor Integration Trial-1 3. Electrical power system division and design 4. learn PCB design layout	Task 1 : Ananya Task 2 : Tasnia Task 3 : Saklain Task 4 : Nafi, Saklain	
07.11.2022	1.Ananya 2.Tasnia 3.Saklain 4.Nafi	1. integrate signup and login page with firebase 2.Circuit Integration Trial-2 3. PCB layout Trial -1	Task1: Ananya Task 2: Tasnia Task 3: Saklain,Nafi	
08.11.2022	1.Dr. Mohammed Belal Hossain	1. Presented the integrated signup and login page with firebase	All	1. start working on software and

	Bhuian 2. Abdullah Hil Kafi 3.Md. Mahmudul Islam 4. Ananya 5.Tasnia 6.Saklain 7.Nafi	2. Circuit integration update		hardware integration 2. try to add Chatbot feature on app 3. recalculate current-voltage for circuit integration
13.11.2022	1.Ananya 2.Tasnia 3.Saklain 4.Nafi	1. Work on app and backend project to implement push notification 2. circuit calculation with recalculated current voltage (trial-3)	task 1 : Ananya task : Saklain,Tasnia	
15.11.2022	1.Dr. Mohammed Belal Hossain Bhuian 2. Abdullah Hil Kafi 3.Md. Mahmudul Islam 4. Ananya 5.Tasnia 6.Saklain 7.Nafi	1. presented the full circuit integration and hardware output	All	
20.11.2022	1.Ananya 2.Tasnia 3.Saklain 4.Nafi	1.Complete Breadboard model 2.Implement patient and doctor screen with static data 3. Sensor placement plan	Task 1 : Nafi,Tasnia Task 2 : Ananya Task 3 : Saklain,Tasnia	
23.11.2022	1.Ananya 2.Tasnia 3.Saklain 4.Nafi	1.PCB layout design 2.Integrate all remaining screens with actual data from firebase 3.Sensor placement plan (Final)	Task 1 : Saklain,Nafi Task 2 : Ananya Task 3: Tasnia	
29.11.2022	1.Ananya 2.Tasnia 3.Saklain 4.Nafi	1. Printed Circuit Board Integration 2.Integrate all remaining screens with actual data from firebase	Task 1 : Tasnia,Saklain Task 2 : Ananya,Nafi	
04.12.2022	1.Ananya 2.Tasnia 3.Saklain 4.Nafi	1. Testing with sensors (PCB) 2. Mobile app and hardware prototype integration	Task 1 : Tasnia,Nafi Task 2 : Ananya,Saklain	

06.12.2022	1.Dr. Mohammed Belal Hossain Bhuian 2.Md. Mahmudul Islam 3. Ananya 4.Tasnia 5.Saklain 6.Nafi	1. Presented the prototype 2. Discussion on finding alternative for blood pressure monitoring	All	• use cover band on prototype if possible
08.12.2022	1.Ananya 2.Tasnia 3.Saklain 4.Nafi	Testing the whole system (hardware and software) and recording outputs	All	
11.12.2022	1.Ananya 2.Tasnia 3.Saklain 4.Nafi	1. Slide preparing 2. Draft report preparing	All	
13.12.2022	1.Dr. Mohammed Belal Hossain Bhuian 2.Md. Mahmudul Islam 3. Ananya 4.Tasnia 5.Saklain 6.Nafi	presented the slides	All	• use graphical representation for results • add economical analysis • add validation of the project in slide
15.12.2022	1.Ananya 2.Tasnia 3.Saklain 4.Nafi 5. ATC Panel	FYDP-C Final Presentation and Showcasing	All	