Development of a Brain Computer Interface (BCI) for Person with Disabilities to Control Their Wheelchair using Brain Waves along with Health Monitoring System

By

Sk Tahmed Salim Rafid
19121028
Redwan Ahmed Miazee
19121033
Md. Kutubuddin Byzid
19121127
Afsana Anjum Anika
19121034

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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Academic Technical Committee (ATC) Panel Member:

Dr. AKM Abdul Malek Azad (Chair)
Professor, Department of EEE, Brac University
Afrida Malik (Member)
Lecturer, Department of EEE, Brac University
Mohammed Thushar Imran (Member)
Lecturer, Department of EEE, Brac University

Department of Electrical and Electronic Engineering
Brac University
December 2022

Declaration

It is hereby declared that

1. The Final Year Design Project submitted is my/our own original work while completing a degree at Brac University.
2. The Final Year Design Project 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 does not contain material that 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.

Student's Full Name & Signature:

SK Tahmed Salim Rafid 19121028	**Redwan Ahmed Miazee** 19121033
Md. Kutubuddin Byzid 19121127	**Afsana Anjum Anika** 19121034

Approval

The Final Year Design Project titled "Development of a Brain-Computer Interface (BCI) for Person with Disabilities to Control Their Wheelchair using Brain Waves along with Health Monitoring System" submitted by

1. Sk Tahmed Salim Rafid (19121028)
2. Redwan Ahmed Miazee (19121033)
3. Md. Kutubuddin Byzid (19121127)
4. Afsana Anjum Anika (19121034)

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 15^{th} December, 2022.

Examining Committee:

Academic Technical Committee:
(Chair)

____
AKM Abdul Malek Azad, Ph.D.
Professor, Department of EEE,
Brac University

Final Year Design Project Coordination Committee:
(Chair)

____
Abu S.M. Mohsin, Ph.D.
Associate Professor, Department of EEE,
Brac University

Department Chair:

____
Md. Mosaddequr Rahman, Ph.D.
Professor, and Chairperson, Department of EEE,
Brac University

Ethics Statement

We hereby declare and confirm that this project "Development of a Brain-Computer Interface (BCI) for Person with Disabilities to Control Their Wheelchair using Brain Waves along with Health Monitoring System" has met the requirements of the Final Year Design Project (FYDP). It has been written through the collective efforts of our group members. In the case of supporting materials used for analysis, literature review, and data collection - have all been cited properly. The plagiarism report from the library of Brac University has determined that this report has a similarity score of 3%. We have implemented the contents of this project through support from our supervisors and the university.

Abstract/ Executive Summary

Humanity's endeavor to learn the way the human brain works has been exponentially fastened through the means of Brain Computer Interface (BCI) technology. It has helped in mapping different electrical activities in the brain to different actions thus giving us a simplistic view of understanding human thoughts. Interacting with electric and mechanical systems utilizing such technology is one of its practical applications. This project is an amalgamation of the aforementioned BCI coupled with a motor driver to drive a wheelchair. It additionally provides features to ensure the safety of the patients during movement, and to monitor a patient's health data remotely through the usage of a mobile application.

Keywords: BCI; Biomedical Engineering; Wheelchair; IoT.

Acknowledgment

We would like to extend our gratitude to Professor Dr. AKM Abdul Malek Azad, the chair of our committee, for his tremendous assistance and thorough examination of the project. Additionally, we are appreciative of Afrida Malik and Mohammad Tushar Imran, lecturers at Brac University, who offered advice and suggested many conventions to improve the project. Last but not least, we want to thank Md. Nahid Haque Shazon for helping us out in the initial stage of the project.

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List of Acronyms

BCI	Brain Computer Interface
EEG	Electroencephalogram
A/D	Analog to Digital
GUI	Graphical User Interface
FIR	Finite Impulse Response
DC	Direct Current
EMG	Electromyography.
SMS	Short Message Service
GPS	Global Positioning System
API	Application Program Interface
IoT	Internet of Things
CRP	Center for Rehabilitation of the Paralyzed
MPH	Miles Per Hour
GSM	Global System for Mobile communication
GPRS	General Packet Radio Service
UART	Universal Asynchronous Receiver Transmitter
SOC	System On Chip
TCP	Transmission Control protocol
LCD	Liquid Crystal Display
LED	Light Emitting Diode
IC	Integrated Circuit
ECG	Electrocardiogram
MCU	Microcontroller Unit

SoC	State of Charge
PCB	Printed Circuit Board
COMPIM	Communication Physical Interface Model
CAD	Computer-Aided Design
CAE	Computer-Aided Engineering
GPIO	General-Purpose Input/Output
VSPE	Virtual Serial Port Emulator
BPM	Beats Per Minute
EEPROM	Electrically Erasable Programmable Read-Only Memory
RPM	Rounds Per Minute
IMU	Inertial Measurement Unit
CPU	Central Processing Unit
FIFO	First In First Out
PWM	Pulse Width Modulation
I2C	Inter-Integrated Circuit
LiDAR	Light Detection and Ranging
MSE	Mean Squared Error
MAPE	Mean Absolute Percentage Error

Chapter 1

Introduction- [CO1, CO2, CO3, CO10]

1.1 Introduction

Paralysis is a state of temporary or permanent obstruction of movement in a single limb (Monoplegia) or multiple sections of the body (Quadriplegia). The growing development of paralysis can make the victim unwantedly and increasingly dependent on others while perceiving themselves as a burden to their family and friends [1]. Customized wheelchairs for such patients have been designed and manufactured commercially at large scales. However, the scope for customizing a wheelchair for patients who have almost complete physical inactivity (tetra patients) has been found to be minimal.

The Brain Computer Interface (BCI) is a system that determines functional intent - the desire to control or interact with something in our environment directly from our brain activity [2]. It is important for humans to properly interpret and translate thoughts to external electrical signals that can be manipulated to carry out different functions. BCI, coupled with a driving motor and a wheelchair can translate the patient's desires of movement from the plane of imagination to one of reality, in other words, convert a patient's brain signals to electrical signals to drive a motor.

This project delves deeply into investigating methods and wheelchair enhancements to cater to aforementioned tetra patients through the usage of BCI technology, while keeping in mind the safety of the patients, need for independent movement, and ease of communication between patients and caretakers as a priority for the design

1.1.1 Problem Statement

Paralysis can limit a person's regular activity opportunities in more than a few ways. It can emotionally drain a patient, making rehabilitation essential. One form of strong rehabilitation can be seen through the sense of accomplishment from an unaided self-driven movement. Since quadriplegic/tetra patients do not always have the opportunity for self-driven movement compared to other patients, the need for rehabilitation is a mandatory factor. Paralysis can make its way to a patient's face as well, making it extremely hard for proper communication between a patient and a caretaker. Non-verbal communication cues are necessary for this case. The patients also need constant surveillance to ensure life-threatening events are less likely to occur [3]. Hence the addition of a non-invasive, easy-to-wear, health monitoring system with remotely accessible data is integral for organizations catering to such patients. Subsequently, the pressure of constantly monitoring multiple patients can be overcome [4]. Paralyzed patients with the opportunity to self-driving their wheelchairs may be victims of unforeseen accidents and damages, hence a system should also feature dedicated safety protocols for avoiding such events and further reducing the need for external physical involvement (nurse).

There is a lack of research done on a system that combines the attributes and mechanisms from different sectors together into one wheelchair - driven by methods that do not require external aid, thus overcoming the need for physical labor completely, with an integrated health monitoring and safety system, thus catering to the needs of a patient victim to paralysis.

1.1.2 Background Study

It is evident that much work has been done on the individual crucial elements of this project. Lei Zhang et al devised a low-cost device to acquire EEG signals [5]. They used bipolar AgCl electrodes to read the microvolt level signals from the brain, which are fed to a Radio Frequency Interference filter to filter out the radio frequencies. Then the signal passes through a Protection circuit to ensure that no damage is done to the user or the circuit. An Instrumentation Amplifier amplifies the signal by 13.5 times. A common Mode Rejection circuit is also added to overcome line noises like the 50 Hz interference. The signal then passes a high-pass filter, followed by the main amplifier, and a Band-Pass Filter to reduce distortions. Lastly, a 50 Hz Notch Filter is also added to reduce further noises along with an isolation circuit. After which the signal is converted to digital form using an A/D circuit. Regardless of the measures taken to reduce noise, the accuracy of the device dwindled as noise interference was great in magnitude. As for the assistive wheelchair itself, a few models have been seen throughout the world similar in approach but differentiable by control mechanism and devices used. The OpenBCI Cyton + Daisy board, with additional channels along with the 8 already present ones, was used in conjunction with a motor to emulate a brainwave-controlled wheelchair by Monowara et al [6]. Gold Cup electrodes along with Ten20 Conductive Paste were placed on the scalp using the 10-20 system (globalized). The data is processed in the Cyton board and sent to the GUI in the laptop through the WiFi shield used for faster transmission. To reduce noise, they have used an FIR Butterworth Band Pass Filter for 0.5 - 60 Hz filtering along with a Notch Filter to reduce 50 Hz noise. The data is processed using Fast Fourier Transform and Root Mean Square method, and the Nyquist Sampling theory is also applied. Serial communication is maintained between the Arduino and the OpenBCI, and the Lab Streaming Layer is used to send the data to MATLAB for further processing. These readings are then processed and logic circuitry is set up using the Arduino and DC motors driven by the L298 Motor Driver to make the wheelchair model. However, when noiseless results vs cost analysis were done it was evident that the system was relatively expensive compared to the result.

Dev et al came up with a similar model [7], they used the Neurosky MindWave headset to acquire the attention level and double eye blink confirmation from the patients to control the movements of the wheelchair. Graphics-based fuzzy images have been added in the design for assisting the patients with varying their attention level if needed. In reference [8], Neurosky Mindwave Mobile 2 was used to acquire the blink affirmation for direction choosing and attention level to confirm movement in the chosen direction. A threshold was set for the EEG signal to be considered as a confirmation for movement. The Neurosky MindWave headset has the possibility of being used directly with a microcontroller. So the need to use a computer can be eliminated. Furthermore, according to the authors, a relaxed state ensures an attention magnitude ranging from 0-40, a strong blink gives a value greater than 50, and focusing on something gives an output of 55-70. These ensure thresholding mechanisms.

Cheng et al devised a control mechanism that only used eye blinks, not coupled with attention level, to control the movement of the wheelchair [9]. It was proposed that the wheelchair would keep moving forward by default, and based on the speed of blinking, the wheelchair 3 would move left or right. This showed a considerable increase in the rate of change/usability of the wheelchair. Francis et al used a laptop with an interactive GUI [10], to present illuminated directions to a user. Each direction is highlighted for 3 seconds and a forced blink is used for locking on the option.

Most of the work mentioned above does not have an integrated/dedicated Health Monitoring system or safety-ensuring mechanisms for the patients. Sathya et al used various wearable sensors [11], to attain the ECG, EMG, temperature, blood glucose level, and respiratory rate of the patient. These data are transmitted through a low-power digital radio - Zigbee to the Cloudlet where all of it is stored. Different devices can be used to attain the data of the patients through mobile phones, computers, tablets, etc. The data of the patients are analyzed using a pattern recognition architecture of a machine learning system to better classify and predict abnormal health trends.

Reference [12] introduces the idea of the Internet of Things to the wheelchair, it uses a Fall Detection system using sensors to alert concerned authorities via a buzzer and an SMS alert system while using GPS to track the patient. Kumar et al used an accelerometer and gyroscope to map sudden changes in sensors to a “fall’ in the fall detection system [13]. However, this system could not distinguish whether the patient is on or off the wheelchair. Al-Sawaai used a similar approach to [13] in [14] but also added a simple button to alert concerned authorities about the user still positioned in the wheelchair. References [15], [16] introduced a specialized camera and 24 sonar sensors individually respectively to set up an obstacle detection system for the wheelchair. Both projects assumed that the wheelchair moved at low velocities. It was noted that the usage of specialized cameras greatly increased the cost of the project, however, the sonar array showed relatively great accuracy with respect to its cost.

Simulating such a complex system would require the authors to carefully decide on the software needed. It has to be simple to use, accurate and effective. Reference [17] simulates a game to investigate the viability of connecting 2 EEG acquisition devices on a single computer. Here, they have used a custom-made Application Program Interface (API) using python based coding to interact and process the raw EEG data. They created a class (ThinkGearPy) and connected it to 2 serial ports to attain and store unreadable data. The data is then filtered to reduce high-frequency noise. After this, to evaluate the translation of brain signals to command, they made a game using C# language. This would take the values of attention, blinking, and meditation as commands for different things in the game. This approach used python based coding to simulate a system. Lim, Alfred & Chia, and Wai took a different approach in reference [18] by using MATLAB software as the simulation environment. MATLAB receives raw EEG data from the application program interface (API) provided by Neurosky. Scripts are used to read and write on the aforementioned data. Discrete Cosine Transform is performed to change from time to frequency domain. The discovered high-frequency components are discarded using MATLAB filtering algorithms (noise filtering). Then, 3 classifiers - Artificial Neural Network, Linear Discriminant Analysis, and K-Nearest Neighbor are used to classify the EEG signals. These readings were used to analyze stress in patients. Sasikumar et al also investigated EEG data analysis in a MATLAB environment [19]. The authors have used BCI's in-house API to take the raw EEG data and store the dataset in MATLAB first. Next, processing of the data occurs, followed by classification from extracted features. The categories for classification include montages, sensitivity, filtering, and sweeping. First, a category is selected, then the placement of the electrodes is selected. The left montage means the electrodes are connected on the left side of the user's head. After this, a channel is selected for detailed viewing. These waveforms are filtered with high freq (50 to 70) and low freq (0.1 to 1), giving the final readable EEG signal. The previously mentioned reference [8] shows work on a similar project. When simulation-based testing was to be done, the authors decided on modeling the entire wheelchair in Proteus' environment. This is done by assembling Arduino along with voltage regulators, optocouplers, transformers, motor drivers, and other essential components in proteus. Our design utilizes simulation software mechanisms from the research mentioned above. Raw EEG data is saved in an excel sheet to create a database. Python coding is used to create a class containing the dataset. Processing of the signal is done using Python, when essential. The data is then imported to proteus using the COMPIM method, which provides a virtual serial port in the environment.

1.1.3 Literature Gap

The background research for this field shows the extensive need for advancement in such a sector, not only in one particular subsystem but in entire systems consisting of different customizable features. The accuracy of a brainwave acquisition device is very crucial. Researchers have used both commercially available devices and privately designed ones, but a thorough analysis of cost-effectiveness vs noise interference is absent. IoT in the health monitoring sector has played a crucial role not only in remotely communicating data but in non-verbal communication as well. Control mechanisms derived from the usage of brain activity have been kept to simple actions in most of the research done, these actions may include imagination of simple motor actions. Utilizing each of the nodes of the 10-20 system, along with individual Fourier analysis for pattern recognition is yet to be explored. This would result in more customizable and accurate prediction of thoughts by a device, used later to drive the wheelchair.

The aforementioned research done in the “background study” section addresses individual issues at hand such as a cost-effective and accurate brainwave acquisition device, different control mechanisms for a physical labourless wheelchair, an easily accessible health monitoring system, and lastly safety mechanisms for self-driven wheelchairs. However, the task of putting all the different subsystems together and working in harmony as one whole product is yet to be unveiled.

1.1.4 Relevance to Current and Future Industry

A survey was conducted at the Center for Rehabilitation of the Paralyzed (CRP), Bangladesh, regarding different wheelchair designs catering to patients with varying degrees of paralysis. There were motorized wheelchairs designed for indoor usage, these could be used by patients with minimal physical activity allowance. There were semi-motorized wheelchairs used for outdoor activities and travel over long distances, these were used by patients with relatively stronger physical capabilities. Other wheelchairs included ones that were designed to be hand-driven or be pushed by someone else, these were for all patients regardless of their status. It was evident that patients with absolutely no physical movement abilities did not have methods catered to them for self-driven movement. The union of BCI technology with biomedical projects has had interest grown extensively over the past few years. According to the World Health Organization, around 10% of the people of Bangladesh are disabled in some form or another. Hence, research in this field is relevant and extensively needed to cater to not just a large demography of completely paralyzed people but also to the comfort and safety of all the patients.

1.2 Objectives, Requirements, Specification, and Constraint

1.2.1 Objectives

To mitigate the issues, we need to create a system that satisfies the following requirements in various sectors:

- Acquiring accurate EEG data, followed by proper data processing used to categorize different actions.
- Creation of a motorized wheelchair with collision avoidance and obstacle detection capabilities that responds to distinct action classes obtained from the processed EEG data.
- Establish a system to monitor the patient's oxygen level, pulse rate, body temperature, and blood pressure for Health Monitoring.
- Develop a system for fall detection from the wheelchair.
- Design an IoT-based wheelchair battery monitoring system.
- Implementing IoT features in all the sub-systems needed for remote monitoring.

1.2.2 Functional and Nonfunctional Requirements

Functional requirements:

- Proper EEG signal processing to extract needed parameters and development of the wheelchair control system

- Data monitoring in real-time through a smartphone.
- Developing a suitable Obstacle Detection system-based braking mechanism for the wheelchair that meets all of the requirements.
- Connecting all of the sensors to the processing unit and sending data to the server.
- Control over the wheelchair's pace, ensuring patient safety.

Non-Functional requirements:

- Obtaining approval and recommendations from the proper bodies that work with paralyzed people.
- Configuring the database in a manner such that it can save all of the patient's information on the cloud server.
- Making the system sturdy enough to withstand normal day-to-day patient usage.
- Obtaining permission from the competent authorities for the accuracy of the biomedical sensors.
- Following the system-level requirements of the stakeholders.

1.2.3 Specifications

System level:

All design projects are universally required to satisfy requirements and needs addressed by the user or stakeholders. Reference [8] sheds light on some of the requirements of such aforementioned classes of people. These requirements dictate that the maximum speed of the wheelchair is below 5 MPH and that the wheelchair be sustainable through the usage of replaceable components. On the user end, foot support is added along with adjustable restraints to make sure the user does not sway too much. Gokul E. puts importance on the trajectory taken by a system, in [20], taking into consideration the interferences from multiple sensors. Therefore, a modification should be set up in a way to overcome complex situations, such as safety protocols for wheelchairs in front of stairs and not normal objects like a wall. Lastly, it is evident that accurate biomedical sensors, EEG acquisitors, and robust processing units are also essential. These sought-after features are listed below in a tabulated manner:

System Level	Specifications
Wheelchair speed limit	It is advised to maintain a speed limit below 5 miles per hour
Wheelchair repair feasibility	Readily available parts should be used to design the wheelchair
Wheelchair orientation	Foot support and additional restraints Should be present to ensure the patient does not move unintentionally
Safety features	Usage of accurate trajectory related And biomedical sensors should be used

Table 01: System level requirements from existing work done in this area.

Industry-oriented system-level requirements must also be taken into consideration. For our project, after a thorough assessment, it was determined that the Center for the Rehabilitation of the Paralyzed (CRP) plays a crucial role in this field. In a premeditated meeting with CRP, the feedback session lead to a few useful insights, also tabulated below:

System Level	Specifications
Wheelchair orientation	It should be lightweight (~ 60 kg), and contain smaller wheels for indoor usage. It should also be engineered to enhance the posture of tetra/quadriplegic patients and maintain protocols set by World Health Organization (WHO)
Wireless communication	GSM module with GPRS functionality should be used while ensuring adequate encryption for safety

Motorized wheelchair	Sturdy wheelchair with a carrying capacity of ~ 140 kg and has configurable DC motor driver and a speed limit of 0.3 to 0.5 m/s
Biomedical sensors	Accurate signal acquisition with noiseless transmission
Battery output	Allowable movement radius should be around 20 km per charge session

Table 02: System-level requirements from the stakeholder (CRP) technical team.

Based on the requirements of CRP, a small scale prototype was designed for demonstration. In the second meeting arranged, the prototype was showcased to and tested by CRP physicians and consultants. Further feedback were given in the meeting, which have been tabulated below:

System Level	Specifications
Wheelchair modification	It should have a mirror on the wheelchair oriented in a manner that allows backside view, along with back movement options
Wheelchair modification	Addition of alternate movement option for patients able to move their wrists in the form of a joystick system
Safety enhancement	Upon obstacle detection, slow the speed down gradually instead of instantaneous stoppage
Speed control	There should be variable speed control to ensure smoother ramp movement.
Further system level requirements will be sent from the technician team of CRP at a later date.	

Table 03: Updated system-level requirements from the stakeholder (CRP) technical team.

Component level:

Component	Model	Component Description	Specifications
EEG headset	Brainsense-BCI	Brainsense is a Brain-Computer Interface (BCI) gadget designed for students, researchers, and members of the wellness community. A stylish, single-channel wireless headgear that analyzes your brain activity and converts EEG data into relevant information.	Electrodes: Main Electrode & Ear clip electrode (Ground) Type of Electrode: Non-Invasive Battery: 3 AAA Battery Standup Time: 6 Hours run time Connectivity: Bluetooth v2.1 class
Processing unit	Arduino MEGA 2560	The Arduino Mega 2560 is a microcontroller board based on the ATmega2560.Capable to process data with digital I/O and analog data reading capability	Microcontroller: ATmega2560 Operating Voltage: 5V Input Voltage (recommended): 7-12 V Input Voltage (limits): 6 - 20 V Digital I/O Pins: 54 (of which 14 provide PWM output) Analog Input Pins: 16 DC Current per I/O Pin: 40 mA DC Current for 3.3V Pin: 50 mA Flash Memory: 256 KB of which 8 KB used by bootloader SRAM: 8 KB EEPROM: 4 KB Clock Speed: 16 MHz
Bluetooth module	HC-05	The HC05 Bluetooth module is a UART serial converter module that can simply send UART data over wireless Bluetooth.	Frequency Range: 2.4 GHz ISM band Operating Voltage: 3.3 V Operating Current: 50 mA Speed: Speed: Asynchronous: 2.1Mbps(Max) / 160 kbps, Synchronous: 1Mbps/1Mbps
GSM module	UART A6 GSM & GPRS Module	GPS module with GPRS functionality. The A6 functionalities are enabled over GSM rather than Wi-Fi.	Operating Voltage: 5V Working Temperature: -30℃ ~ +80℃ GSM/GPRS band: 850/900/1800/1900 MHz Sensitivity: < 105 dBm Download rate: 85.6Kbps Upload rate: 42.8Kbps Support SMS Support GPRS data communication,
Gyroscope and accelerometer	MPU6050	The MPU6050 is a Micro Electro-mechanical System that includes a three-axis accelerometer and a three-axis gyroscope. It assists us in	Supply voltage: 2.3–3.4 V Consumption: 3.9 mA max. Accelerometer: Measuring ranges: ±2 g ±4 g ±8 g ±16 g Calibration tolerance: ±3%

		measuring velocity, direction, acceleration, displacement, and other motion-related characteristics.	Gyroscope: Measuring ranges: ±250/500/1000/2000° /sar Calibration tolerance: ±3% Communication protocol: I2C interface Operating temperature: -40°C to +85°C
Wireless receiver	ESP-01	The ESP 01 ESP8266 Serial WIFI Wireless Transceiver Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network.	Serial/UART baud rate: 115200 bps Integrated TCP/IP protocol stack Input power: 3.3V I/O voltage tolerance: 3.6V Max Regular operation current draw: ~70mA Peak operating current draw: ~300mA Power down leakage current: <10µA +19.5dBm output in 802.11b mode Flash Memory Size: 1MB (8Mbit) WiFi security modes: WPA, WPA2 Module's dimensions: 24.75mm x 14.5mm (0.974" x 0.571")
Blood pressure device	Mini Digital Automatic Wrist Pulse Monitor Heart Beat Meter.	Measure your blood pressure and pulse rate at the same. LCD displays Blood Pressure (Systolic and Diastolic), Pulse, Date, Low battery Icon, Heart Icon, and Memory Record Number. Easy to operate. Memorize measuring data and of the most recent 60 s. The portable design allows you to monitor your blood pressure anywhere. Large backlight LCD screen for easy reading. A perfect tool to understand your body condition.	Material: plastic Color: white Case size: 65*60*25mm Wrist band width: 72 mm Wrist circumference: about 275mm Pressure range: 40-280mmHg Pulse range: 30-160 s/minute Pressure accuracy: ±5mmHg Pulse accuracy: ±5% Battery life: 300 s (180mmHg, 1 /day) Storage capacity: 60 memories
Sonar sensor	HC-SR05 Ultrasonic Ranging Module	The HC-SR05 ultrasonic sensor measures the distance to an object using sonar. Furthermore, this module includes an ultrasonic transmitter and receiver module.	Working Voltage: DC 5 V Working Current: 15mA Working Frequency: 40Hz Range: 2 cm - 4m Measuring Angle: 15-degree Trigger Input Signal: 10uS TTL pulse Dimension: 45*20*15 mm
Heart rate and blood oxygen sensor	MAX30100 Pulse Oximeter & Heart Rate Sensor IC	The MAX30100 is a sensor package that combines pulse oximetry with a heart rate monitor. It detects pulse oximetry and heart rate signals by combining two LEDs, a	Power Supply Voltage: 1.7 - 2.0 V Supply Current: 1200 µA ADC Resolution: 14 bits

		photodetector, improved optics, and low-noise analog signal processing.	
Temperature sensor	DS18B20 Single-Channel Digital Thermometer	The DS18B20 connects with a central CPU through a 1-Wire bus, which by definition requires just one data line (and ground).	Supply Voltage: 3.0 - 5.5 V Thermometer Error: ±0.5 ℃ Temperature Range: -55°C to +125°C
ECG sensor	AD8232 ECG module	The AD8232 is a signal conditioning block that is incorporated for ECG and other biopotential measuring applications. It's intended to collect, amplify, and filter tiny biopotential signals in the presence of noisy situations like mobility or distant electrode placement.	Operating voltage: 2V to 3.5V Electrode: 3 electrodes (Including reference electrode) Minimum current supply: 170 μA
Display	LCD2004	The LCD2004 20x4 I2C Blue LCD Display provides a 20 character x 4 line LCD with I2C interface for easy control by a uC.	20 character x 4 line Blue LCD 4-bit and 8-bit parallel interface 5V operation
Adapter	I2c	I2C LCD adapter is a device containing a micro-controller PCF8574 chip. This microcontroller is an I/O expander, which communicates with other microcontroller chips with two wire communication protocols.	Operating Voltage: 2.5V to 6V Size: 41.5 mm x 19 mm x 15.3 mm Weight: 5g PCB color: Black

Buck converter	Mk161-5	Compact step-down DC-DC power supply module features a fixed output of 5V. The module is capable of delivering output currents of up to 3A with additional cooling. The current outputs of 2A are practical without any additional cooling or heatsink.	Input voltage: 7V-40V(do not input over 40V) Output voltage: 5V Output current: 3A(Max) Working temperature: -40°C to +85°C Size: 32mm X 32mm

Table 04: Component level specification and descriptions.

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

<u>Technical consideration</u>

- Proper EEG signal processing to extract needed parameters and development of the wheelchair control system
- Data monitoring in real time through smartphone.
- Developing a suitable Obstacle Detection system-based braking mechanism for the wheelchair that meets all of the requirements.
- Connecting all of the sensors to the processing unit and sending data to the server.
- Control over the wheelchair's pace, ensuring patient safety.

<u>Non-technical consideration</u>

- Obtaining approval and recommendations from the proper bodies that work with paralyzed people.
- Configuring the database in a manner such that it can save all of the patients' information on the cloud server.
- Making the system sturdy enough to withstand normal day-to-day patient usage.

- Obtaining permission from the competent authorities for the accuracy of the biomedical sensors.
- Following the system level requirements by the stakeholders.

Constraints:

- The EEG signal contains a great deal of information. As a result, obtaining accurate noiseless EEG data is a difficult task. EEG headsets with finer data acquisition channels are costly.
- The patients will require external assistance for a while to get used to the system.
- The system will require a continuous power supply to operate.
- This system might be a little bit costly because of the unavailability of brain sensors in the current market due to the global COVID-19 pandemic, hence we have to import them from another country.
- We must deal with the correctness of EEG signals. We may need to test alternative headsets for this, however, most of them are not currently accessible on the market owing to the COVID situation.
- Patients' mental states must be steady at all times while utilizing the wheelchair.

1.2.5 Applicable Compliance, Standards, and Codes

Name	Standard No.	Definition	How it affects the solution
International Organization for Standardization	ISO 7176-1 2014	Part 1: Determination of static stability of wheelchair	These provide methods to measure the tipping angles for both motorized and manual wheelchairs. This would be helpful in setting up a threshold for the fall detection sub-system
International Organization for Standardization	ISO 7176-2 2017	Part 2: Determination of dynamic stability of electrically powered wheelchairs	

Standard for Harmonization of Internet of Things (IoT) Devices and Systems	IEEE 1451-99	This standard defines a method for data sharing, interoperability, and security of messages over a network, where sensors, actuators, and other devices can interoperate, regardless of underlying communication technology.	Security is absolutely integral to be ensured when it comes to medical data. Since our system allows remote health monitoring features, proper encryption and a secure, reliable line for data transmission must be ensured
IEEE Standard Association	IEEE 802.15.1-2002	Part 15: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Wireless Personal Area Networks (WPANs) and Bluetooth technologies	

Table 05: Applicable Compliances, Standards, and Codes

1.3 Systematic Overview/Summary of The Proposed Project

The proposed model was developed primarily to provide paralyzed individuals at some degree of self-driven mobility. The system will also eliminate the time-consuming task of manually monitoring multiple patients' health attributes. It can be further categorized into four sub-systems: measuring, classifying, controlling, and monitoring.

A. Data acquisition

A brain acquisition device is used in the acquisition part to determine brain wave parameters such as attention level, blink force, and so on. These are relayed to the microcontroller through Bluetooth connectivity. The proposed system will use headsets capable of reading the user's EEG data for this purpose.

B. Data classification

The microcontroller will do the classification in order to forecast the user's desire to go in a specific direction. We will classify the user's intention to move based on the properties of the obtained EEG data. For example, whenever the user blinks forcefully with a high enough blink strength, the system will be ready to take commands to move, and subsequent blinks assist the user in giving commands to move in a certain direction.

C. System control mechanism

The controlling mechanism will be based on the classifying part. Once the user's EEG signal is classified the microcontroller will give commands to the actuators through the motor driver to turn on or off based on the classification. Safety features such as obstacle detection will also be employed to control interrupt actions in the control mechanism for safety purposes.

D. Monitoring

The monitoring portion would be utilized to keep track of the system and the numerous data pertaining to the patient's health. We shall employ a variety of non-invasive sensors for this. Various sensors will also be used to monitor the system's status, the wheelchair's orientation, and the obstacles in front of it. This information will be relayed to the monitor through means of IoT technology.

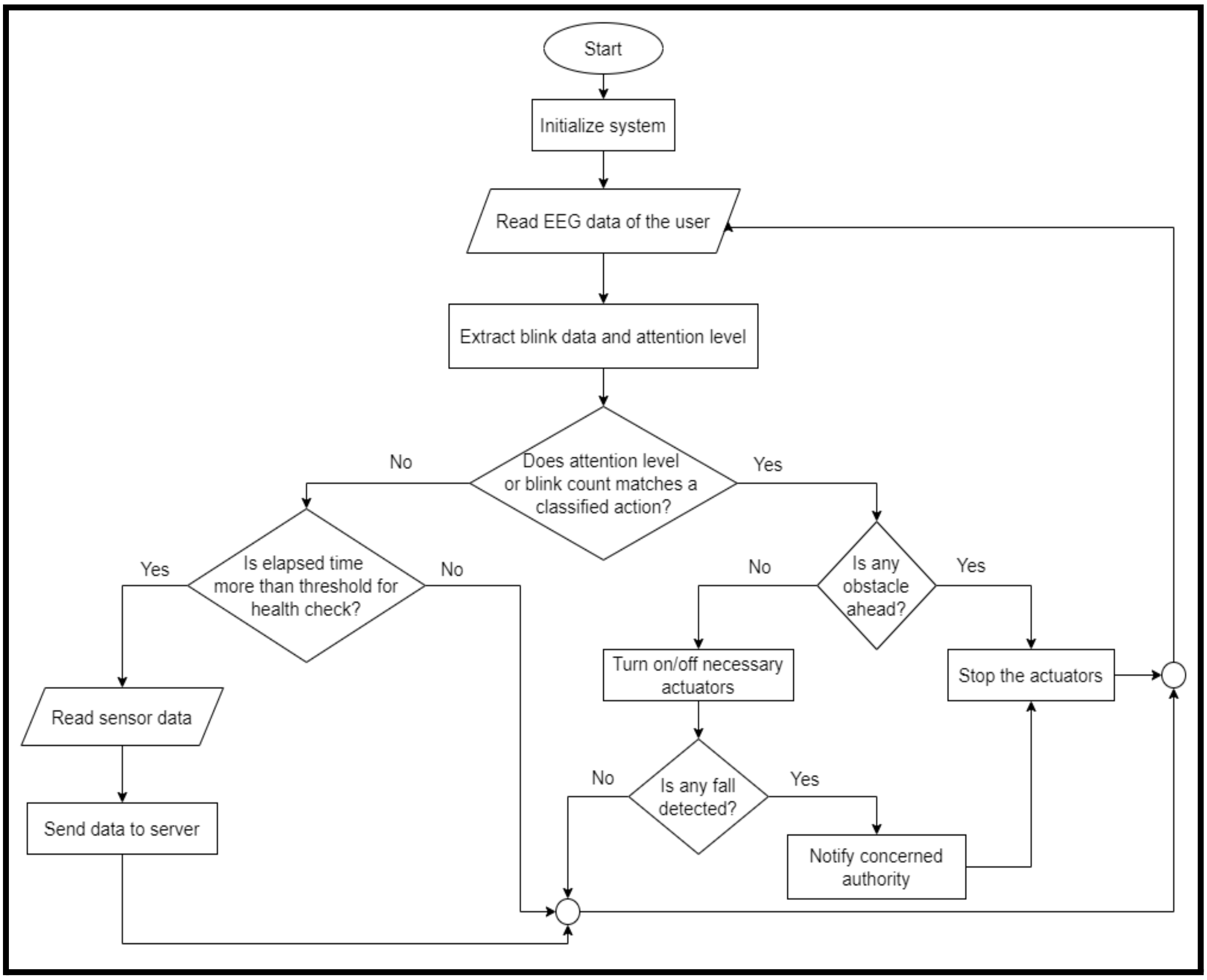

Figure 1: Methodology Flow Chart of Proposed Project

The system's flowchart in figure 1 can be explained as follows: EEG data will be collected using a headband. Various metrics, such as attention level and eye blink count, will be derived from the data. Based on the input, the processing unit will classify the action and determine if the user intends to move in a specific direction. If there is no obstacle ahead, the onboard obstacle detection system will identify it and the actuators will turn on to move the wheelchair. This process will be repeated, and the system will check whether the wheelchair has fallen or not as part of the process. According to the flowchart of figure 3, if the user sits motionless and no movement commands are sent to the system, the system checks to see if a particular period of time has passed. If the time elapsed crosses the threshold, the system will read the data from the non-invasive health monitoring sensors and send it to a server.

1.4 Conclusion

Self-driven movement is a key factor and the first step towards rehabilitation of patients suffering from complete paralysis. This project investigates and attempts to build a wheelchair catered to such patients that move through the usage of non-physical means. It also provides additional features as part of the system to ensure safety from movement operations, immediate response in dire times, and non-verbal communication means.

Chapter 2

Project Design Approach [CO5, CO6]

2.1 Introduction

Two distinct and individual models were designed by us to achieve the set objectives. For proper parallel comparison both the designs have had minimal changes in component level, however, a few alternative components were used for each model. While designing both approaches we made sure to only use components that meet and maintain proper standards for consumer usage. Through both of our designs, we have obtained the aforementioned objectives.

2.2 Identify Multiple Design Approach

Design approach 1:

The first design approach utilizes two processing units. One MCU is solely used for the control mechanism, obstacle detection, and fall detection. It collects the classified action data and relays the information to the drivers while keeping track of other trajectory factors. Another MCU is used for the health monitoring portion of this project. The second MCU collects necessary health vitals and sends them to a predefined server in order to visualize them in the mobile application. Figure 2 shows a systemic overview of the first design while figure 3 shows the component level overview.

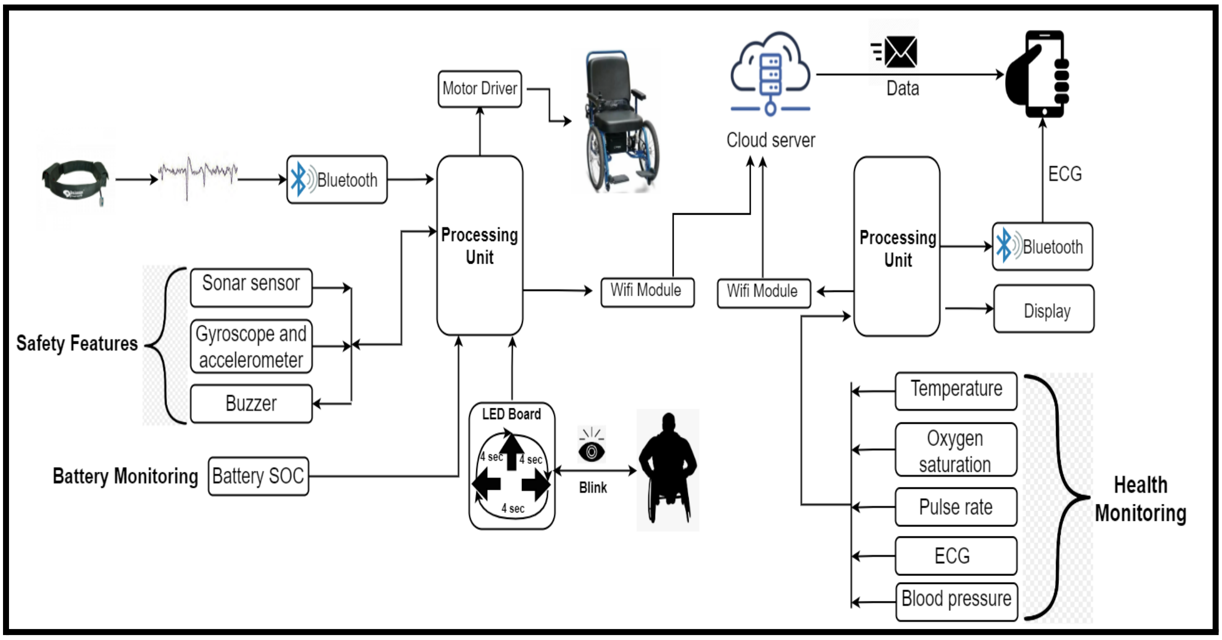

Figure 2: Design Approach 1

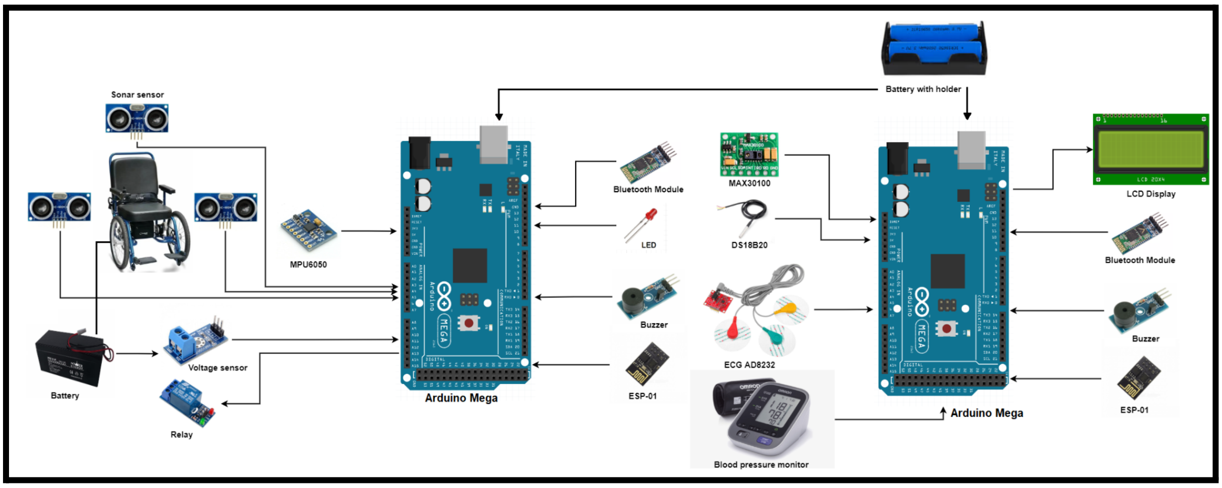

Figure 3: Component-wise schematic diagram of design 1

<u>Design approach-2:</u>

The second design approach utilizes a single processing unit. A single MCU classifies the brain signal for the control mechanism, and detects obstacles, falls and also the same MCU is used for the health monitoring portion of this project. The MCU collects necessary health vitals and sends them to a predefined server in order to visualize them in the mobile application. Figure 4 shows the systemic overview of the second design. The highlighted parts are the differences between both designs. Figure 5 gives the component level architecture.

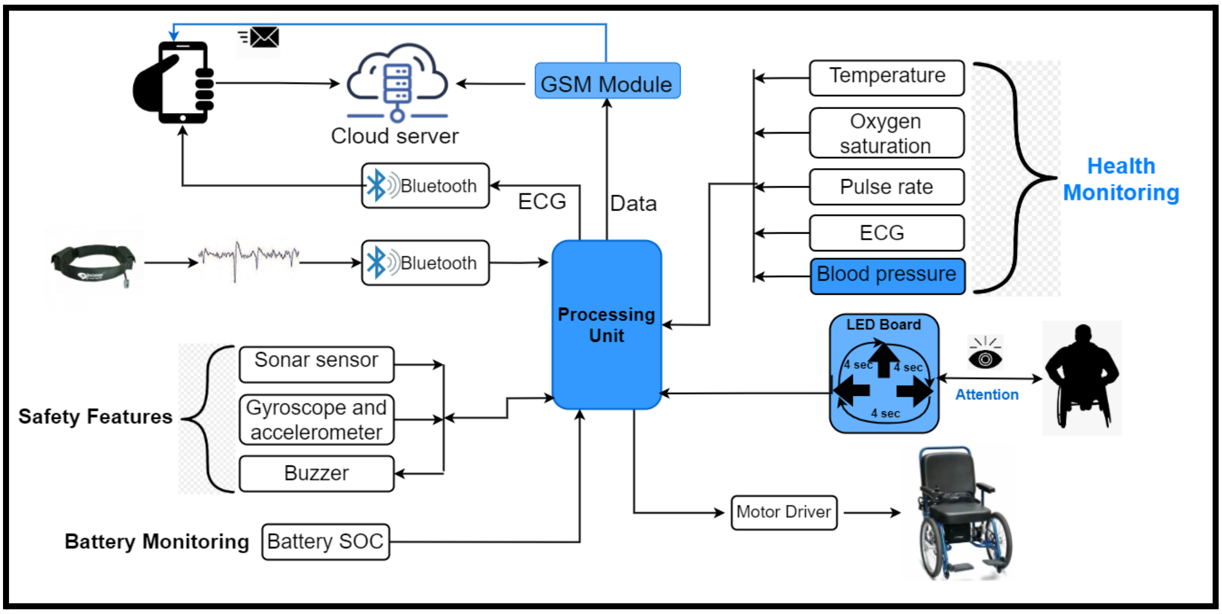

Figure 4: Design Approach 2

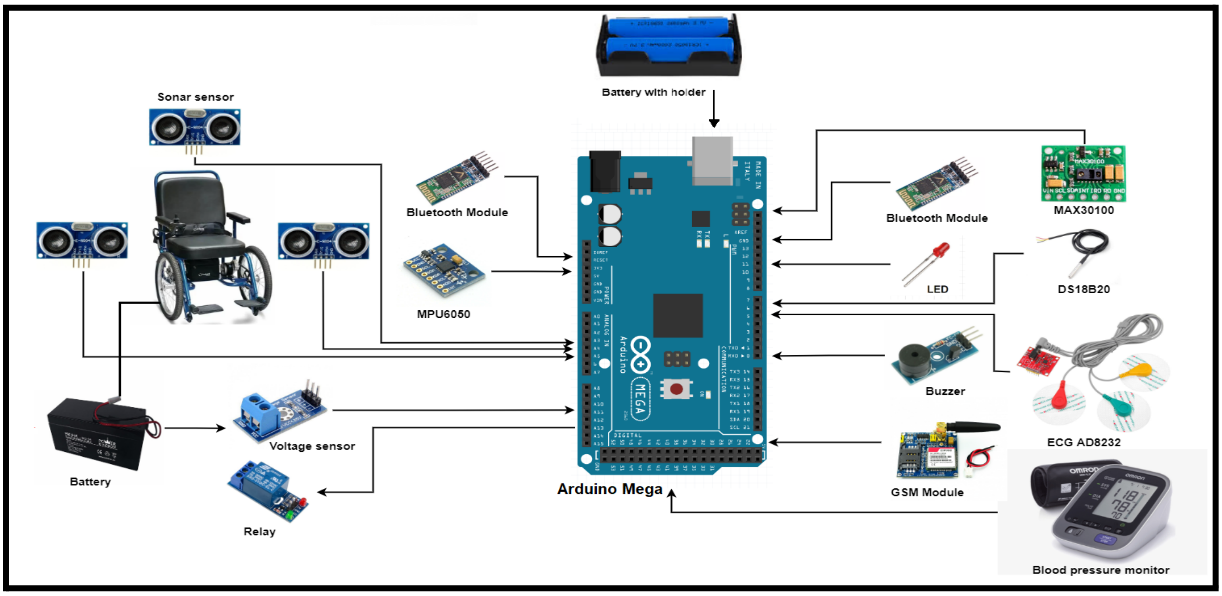

Figure 5: Component-wise schematic diagram of design 2

2.3 Describe Multiple Design Approach

Design approach 1:

The first design employs a Bluetooth Module and an EEG headband - Brainsense to transfer EEG data straight to our first processing unit for data collecting and processing. Figure 2 shows that the data will be processed, and the number of forced blinks from the user will be categorized and tallied. There is a "Direction Control LED" panel with three LEDs pointing in forward, left, and right directions. When the user blinks twice, the system gets activated and a single LED is lit; after every 4 seconds, the next direction LED in the cycle is lit. If the user wishes to choose a direction, he or she simply forcefully blinks once, and the wheelchair begins movement in the last illuminated direction. If the patient blinks once during the movement, the wheelchair comes to a halt.

Figure 2 depicts several non-invasive sensors connected to the patient's body for data gathering in the context of health monitoring as well as a second processing unit is introduced to make the system modular and portable. These data include the patient's oxygen saturation, ECG data, temperature, blood pressure and pulse rate. Using 2 WiFi Modules, these data are transferred to a database. If suspicious patterns are noticed, the database server will send a warning SMS to authorized staff (such as a nurse). As for the ECG data, the data is taken only when requested from the server and the data is sent directly to the mobile phone bypassing the need for the server.

The suggested design would include an Obstacle Detection system based on an array of sonar sensors for user safety. It would also include a Fall Detection system that would rely on data from a specialized Gyroscope and Accelerometer module [21].

The wheelchair's battery will be continually checked using a few sensors, the extracted voltage data will be used to give an estimation of the State of Charge (SoC) of the battery which would be forwarded to the server for monitoring. All the aforementioned data will be displayed on an LCD for the local attendant (nurse) to monitor.

Design approach 2:

The second design employs the EEG headband - Brainsense to deliver EEG data to the processing unit for data collection. In figure 4, following processing, a digital signal comprising a movement order for the wheelchair is transferred to the motor driver. The "Direction Control LED" panel in this design will have the same configuration, with four LEDs pointing in three directions. The LEDs would light up one after the other for 4 seconds. If the patient's attention level is high enough during this time, the system will pick the lit direction as the direction of motion. During the motion, if the patient's attention level again becomes higher than the threshold, the system comes to a halt.

In order to gather data for Health Monitoring, several non-invasive sensors will be mounted to the patient's body, as shown in Figure 4 (Design 2). These data are forwarded to the processing unit, then to a database server, and if dangerous patterns are recognized, a cautionary SMS is sent straight from the processing unit through a linked GSM/GPRS Module to an authorized individual (such as a nurse).

This suggested design would have the same Obstacle Detection system that uses an array of sonar sensors for User Safety. It would also have a Fall Detection system that would use data from the specialized Gyroscope and Accelerometer sensors. Finally, a buzzer must be supplied for manual communication if needed.

The wheelchair's Battery Monitoring system will have the same characteristics as Design 1 (figure 2). All of the aforementioned metrics, from Health Monitoring to Battery Monitoring, will be shown on the IoT platform.

2.4 Analysis of Multiple Design Approach

	Design 1	Design 2
Data Acquisition and Processing	The processing unit will process the users' blink force from the EEG input.	The processing unit will extract the user's attention level from the EEG input and process it.
Direction Control Mechanism	The control method is reliant on the user's eye blink, which gives the system additional control.	It will take some time to choose the right path as maintaining a certain level of attention might prove to be difficult to do.
Number of Processing Units	2 separate processing units would be used.	1 processing unit would be used.
Cautionary SMS system	Notification SMS will be transmitted through a server. Monitoring the server's available SMS will suffice.	The notification SMS will be delivered to the authorized individual using the onboard GSM module in this way. As a result, regular checks of available SMS balances will be necessary, increasing maintenance labor.
Data visualization	All data will be transferred to an IoT server, which will be accessible from anywhere in the globe. The LCD display can be utilized to monitor the vitals without using the phone.	All health data will be presented solely in the IoT server. Without a phone no data can monitored..
Data connectivity means	2 WiFi modules would be used.	A single GSM module would be used.

Table 06: Comparison table between design 1 & 2

2.5 Conclusion

Based on the analysis done in table 5 it can be concluded that design approach 1 seems to have few advantages over design approach 2. Though design approach 2 has a few advantages over design approach 1, the advantages of design approach 2 like the usage of one processing unit might prove to be its disadvantage as design approach 1's multiple processing units will provide the system with additional processing power. But without any simulation exact performance of both the systems can not be estimated. But from the analytical points presented in table 5, we can conclude that design approach 1 might be the most feasible approach and implementing it will be well grounded.

Chapter 3

Use of Modern Engineering and IT Tool [CO9]

3.1 Introduction

Various modern engineering and IT tools were used for this project to visualize and perform preliminary analysis on the different approaches towards the objective. The following tools have been selected catering to the needs of our prototype.

3.2 Select Appropriate Engineering and IT Tools

Hardware Tools	Software Tools
Arduino Mega	Arduino IDE
Esp 32	Proteus 8.12 Professional
BMS (battery management system)	Python
IMU (inertial measurement unit)	Solidworks
Vibration Detector	Blynk 1.0
DC Motor (12v 100rpm)	
Motor driver	
Blood Pressure sensor	
ECG sensor	
EEG headband sensor	
Sonar sensor	
Obstacle sensor	
Temperature sensor	
O_2 saturation sensor	

Table 07: Appropriate Engineering and It Tools

3.3 Use of Modern Engineering and IT Tools

Python

It is a robust high level language with general-purpose attributes. Python is attractive due to its easy to comprehend syntax and increased productivity compared to other languages. Dynamic typing ensures that the assembled programmes are much shorter in magnitude compared to programmes assembled using other languages. Dynamic typing and dynamic binding also make python effective as a scripting language or glue language. For simulation purposes, we have loaded an excel datasheet containing EEG data into python using scripting. Afterwards this data is sent to a virtual serial port in Proteus through python scripting.

Arduino

It is an open source platform that focuses its resources on the development of different hardwares and softwares. It consists of a microcontroller and an Integrated Development Environment (IDE) to write computer codes into the microcontroller. These codes are written in C/C++ language. Arduino is versatile for the compatibility of its programmable microcontroller with different sensors, motor drivers, integrated circuits, modules and other types of system technologies. We shall be using Arduino Mega 2560 for our project. The Mega 2560 set has 16 analog input pins along with 54 digital I/O pins. It contains CH340 programmer, 256 KB of Flash memory, 8 KB of SRAM and 4 KB of EEPROM, along with the aforementioned multiple General Purpose Input/Output (GPIOs) pins allowing versatile and reprogrammable microcontroller board. We have used the Mega 2560 to translate the EEG data from the headset into commands to control the motor driver of the wheelchair. It also takes other sensor inputs and determines further course of action based on the received data.

Proteus

The proteus design suite is a software tools primarily used to simulate embedded systems, create schematics and design PCB layouts. It has a huge library of multiple integrated circuits (ICs) from different major manufacturers, along with multiple sensors, motors, motor drivers and other essential components needed to set up an electronic system. These make sure that proteus can successfully simulate a system much before its physical assembling, thus allowing cost-effective, easily tunable and versatile troubleshooting. We have simulated our entire system containing all necessary sensors, drivers and motors using proteus' existing library of components. EEG data is sent to proteus using python's scripting to send the data to proteus' virtual serial port - COMPIM. This data is processed to select an action course in the arduino board set up in proteus' environment. This method allows us to minimize the number of physical components needed to troubleshoot such a system.

Blynk 1.0

Blynk is a platform that specializes in carrying out the different operations of "Internet of Things" systems. It can be used to connect different devices through IoT technology for ensuring interconnectivity in the environment. Blynk has vast libraries that are compatible with multiple coding languages and we have determined it to be a perfect fit for bringing our system to the consumers. We have used Blynk 1.0 to create an online server that takes care of the different notifications sent from the system, it also stores the health data of the patient which can be accessed through a mobile phone.

Solidworks - SolidWorks is a solid modeling computer aided design (CAD) and computer aided engineering (CAE) application used to design different mechanical systems for evaluation and testing before the model is manufactured realistically. It allows users to change different parameters with ease to tune the system. We have used the solidworks software to design the initial model of the pilot prototype of our project. Based on the design done in the software environment, we have manufactured the actual real life prototype.

3.4 Conclusion

All the various engineering tools used for this prototype have been a standard in research and recommended by IEEE for their easy to use interface, vast libraries and incredible versatility. This chapter summarizes the different engineering tools that were used along with their assigned individual tasks.

Chapter 4

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

4.1 Introduction

To accomplish the intended outcome, two design strategies have been developed. Although the two designs operate in distinct ways, they both achieve the same outcome. The first design is based on two processors. One unit handles all the control logic of the project and the second processing unit is used to monitor health vitals. In the case of the second design, we have used a single processing unit for both the control and health monitoring part. Subsequently analyzing a set of data and simulations we found the ideal design strategy we were looking for the foremost results

4.2 Optimization of Multiple Design Approach

<u>Design 1:</u>

The configuration of design - 1, as demonstrated in figure 6 below, includes Arduino boards due to its processing power, available GPIO pins, low power consumption and overall user-friendly environment. For the communication protocol, the cloud server is represented using COMPIM for serial communication. It is a substitute for the WiFi module. There are 2 Arduino boards - one is used for handling the control mechanisms, fall and obstacle detection, battery condition monitoring, the other is used to make the health monitoring system modular. ESP-01 is used for WiFi connectivity.

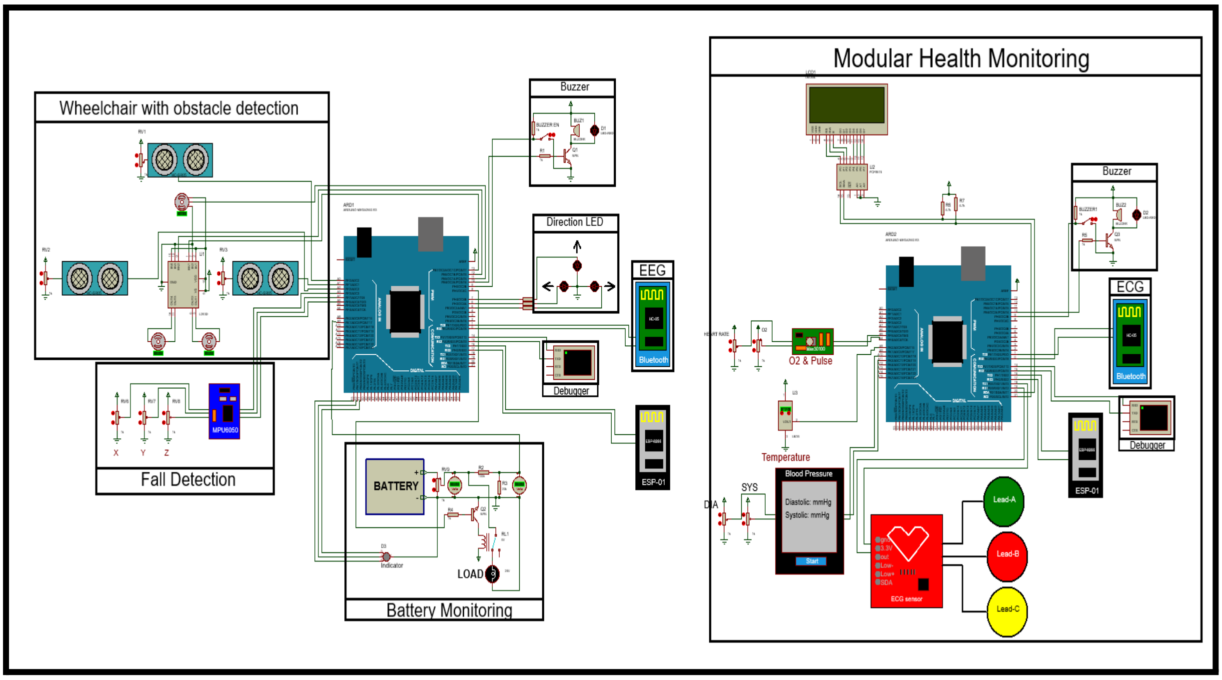

Figure 6: Simulation schematic of design 1

Control mechanism:

To control the wheelchair a brain signal based control mechanism is implemented in the system. The brain sensor we have simulated is the Brainsense. Data from the sensor is sent to the processing unit through a bluetooth module. We have used Python to develop a software which utilizes collected brain wave datasets to simulate brain signals. The direction LED board includes LEDs corresponding to each choice of movement. We have used the L293D motor driver to correspond to movement commands from the processing unit.

We are using the “NeuroskyBlinkControl” dataset [22] which we found from Kaggle. The dataset has various brain signal parameters tabulated down. The approach for design 1 is mainly concerned with the blink strength. A small portion of the dataset is attached in table 05. The table only contains the information needed for the brain signal simulation.

Data	Time	Blink_Strength	Attention_Level	Action	Attention_Type
1	0	0	67	0	L
2	1006	0	75	0	L
3	1986	0	81	0	L
4	2995	0	66	0	L
5	3990	50	66	1	L
6	4984	24	66	1	L
7	5969	0	35	0	H
8	6984	0	42	0	H
9	7958	0	37	0	H
10	8946	0	62	0	H
11	9948	0	66	0	H

Table 08: Subset of the "Neurosky Blink Control" dataset from Kaggle

In the collected dataset, the owner classified single forced blink and double forced blink with 1 and 2 respectively in the action column.

We used "Virtual Serial Port Emulator" to emulate the bluetooth communication. Furthermore, our developed software uses serial communication to send data to the simulation environment. This developed software and "VSPE" have been demonstrated below in figure 7.

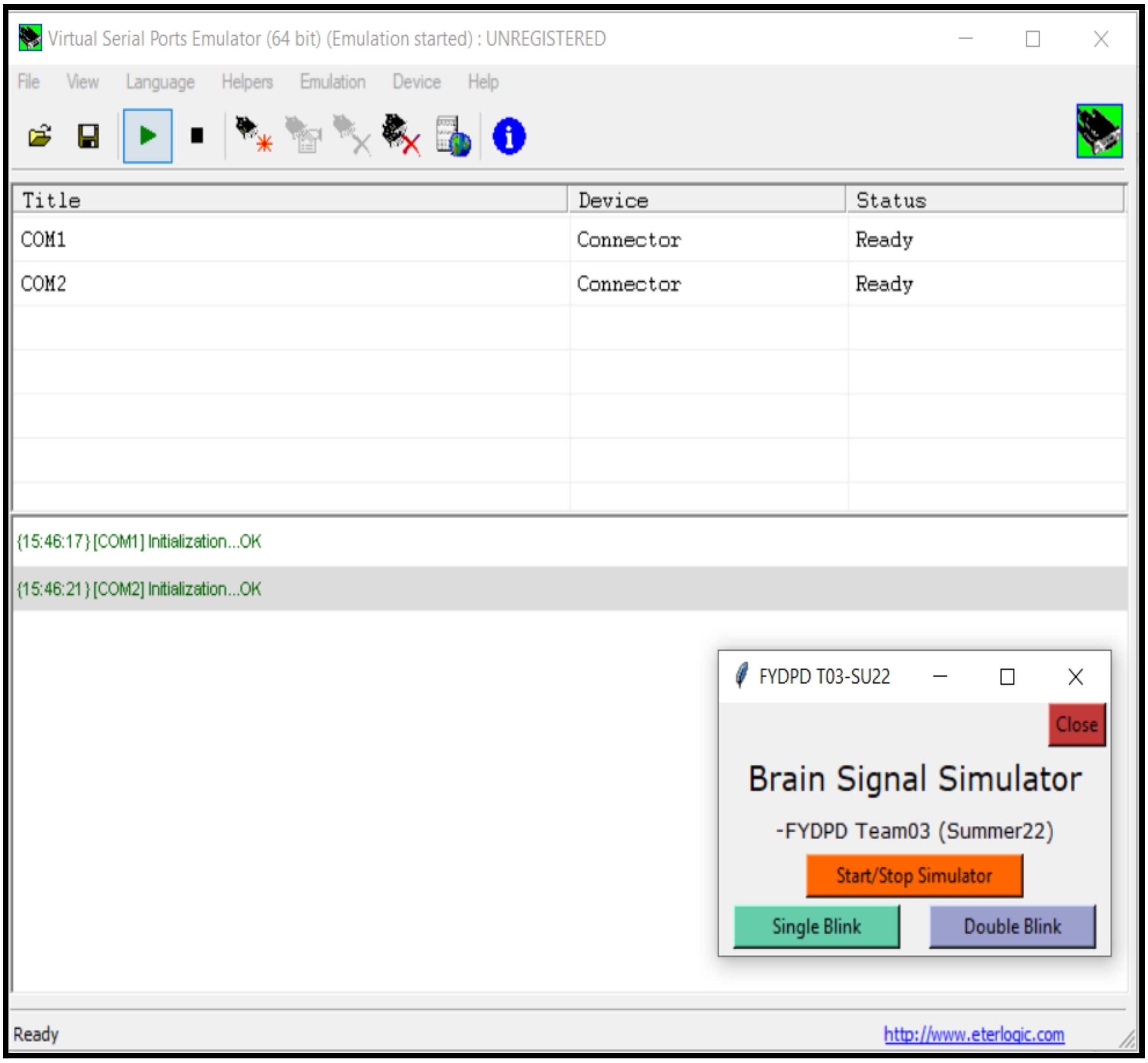

Figure 7: Developed software along with Virtual Serial Port Emulator (VSPE)

Initially the wheelchair is in a halt position. Figure 8 shows that the direction led is deactivated and all the motors are also in 0。 position denoting no motion.

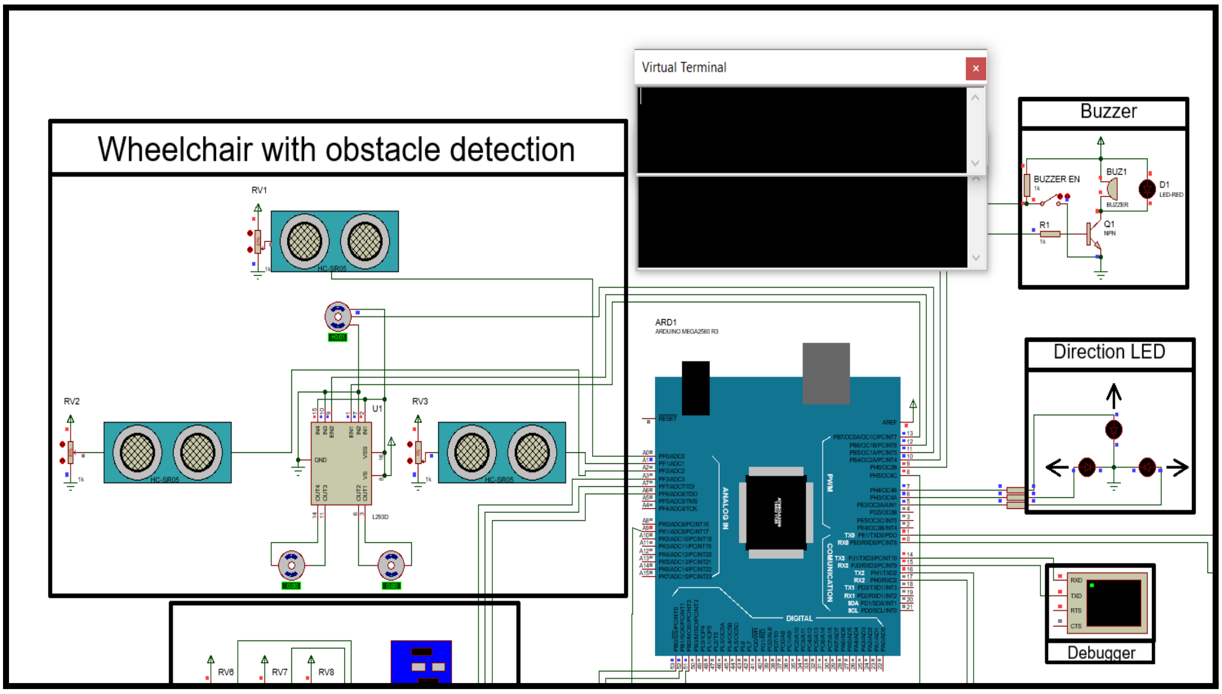

Figure 8: LED deactivated, all motors deactivated (halt position)

Using the developed software when we sent double blink in the system the system got activated. Figure 9 shows that even though there is no motor rotation, the direction led panel's forward LED is turned on denoting forward direction.

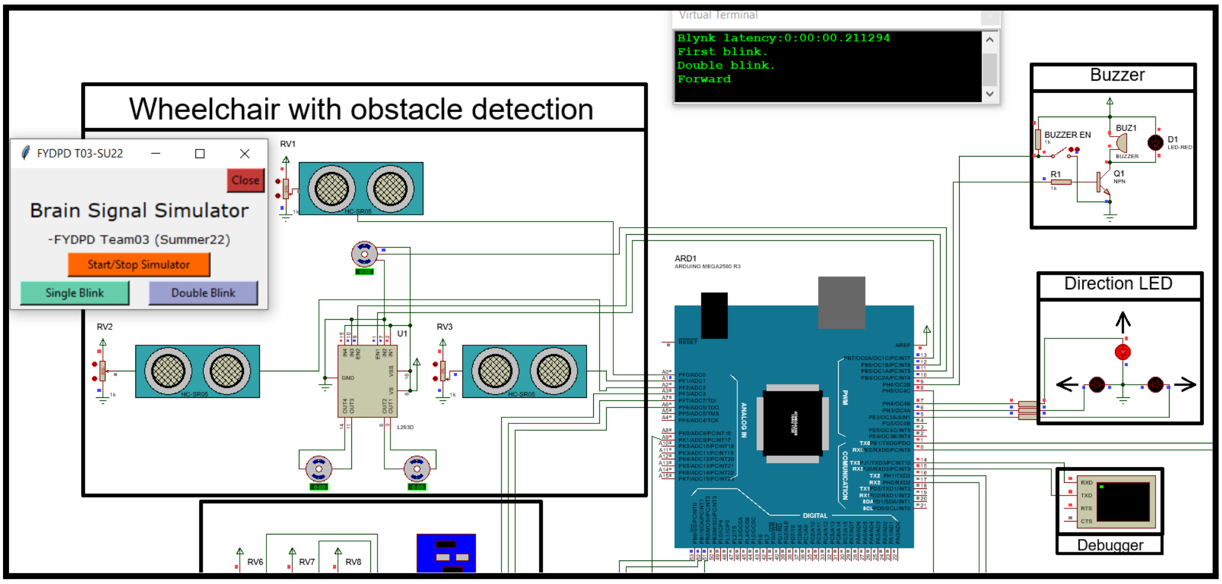

Figure 9: Forward LED activated, all motors deactivated (halt position)

With every four second interval the direction LED changes. After a certain time when the forward direction led is illuminated again, we sent a single blink command. With the detection of a single blink the motors started rotating as seen from the figure 10 attached below. Furthermore, the forward wheel is in 0。 degree position denoting forward direction movement. In the serial monitor we can also see the system status showing “Going Forward”. During this period the control system gets deactivated thus all leds are on indicating no further direction command input for the time being.

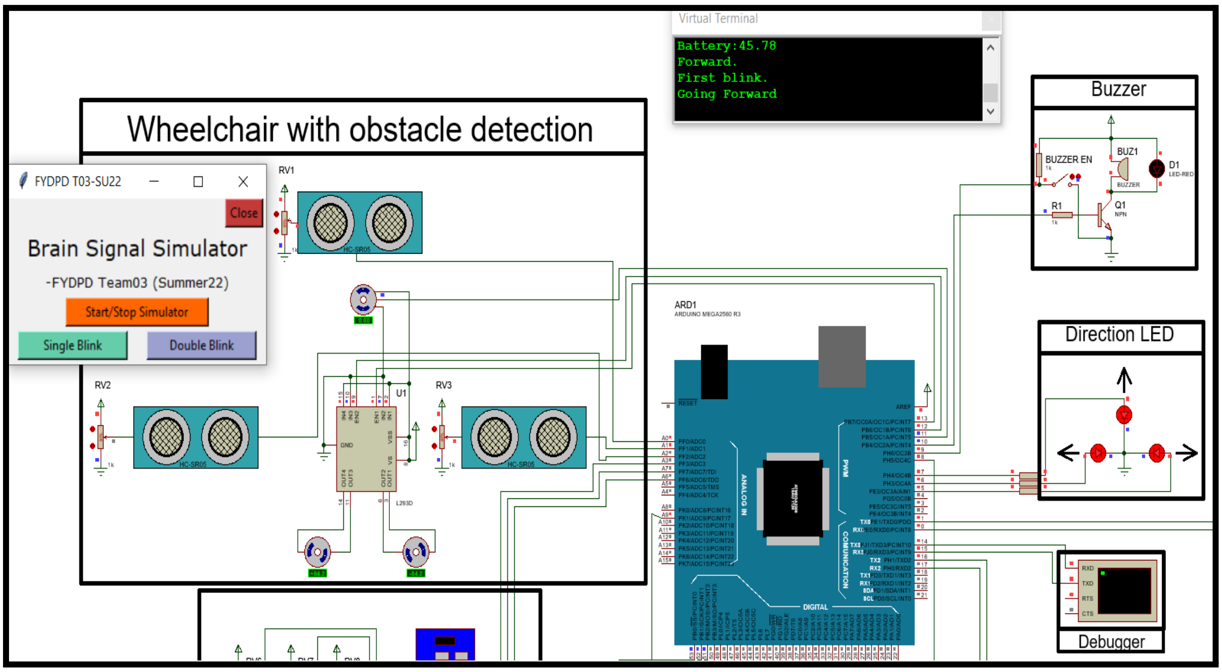

Figure 10: Forward LED activated, back motors activated (forward movement)

When the system moves in any direction, a single forced blink will command the system to stop immediately. So, in our simulation we sent a single blink command and the system stopped immediately. This is demonstrated in figure 11. The motors speed came down to 0 and the direction LED got activated again to take further commands.

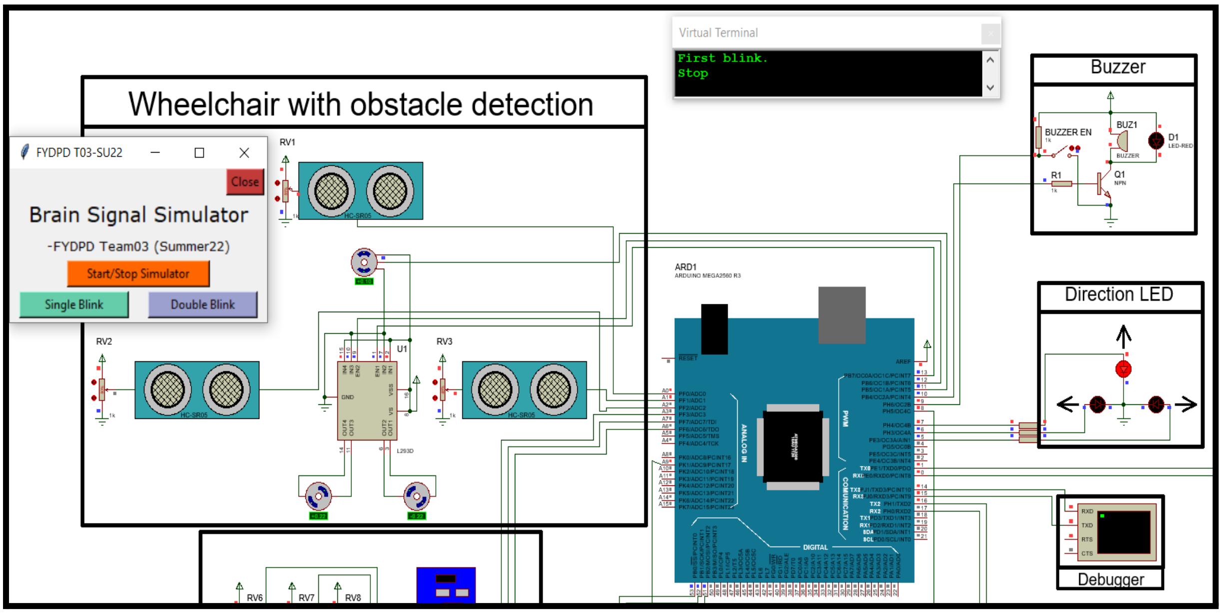

Figure 11: Forward LED activated, all motors deactivated (halt position)

Similarly, when the right direction is illuminated, sending a single blink will start the system's movement in the right direction. The system will stop taking commands during this period as mentioned earlier. The motors will start rotating, however the servo will rotate to +90◦ to move in the right direction. "Going Right" is displayed in the debugger window and the simulated output can be seen in figure 12 below.

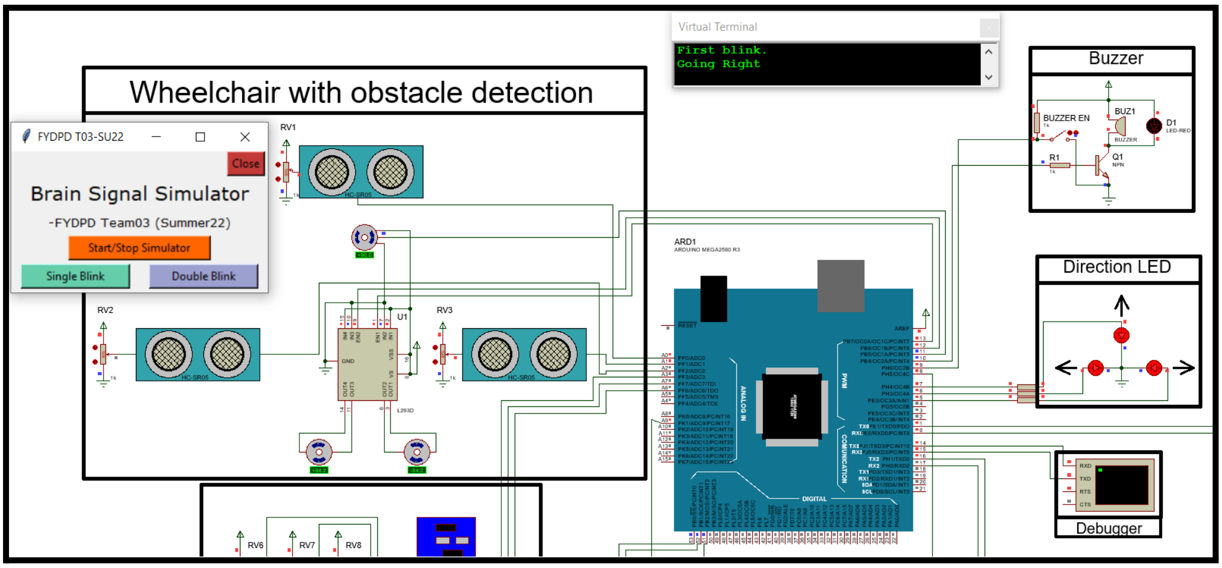

Figure 12: Right LED activated, back motors activated, servo in +90◦ (right movement)

Figure 13 shows the case for left direction movement. However during the left direction movement, the servo will rotate to -90◦ and the debugging window also shows "Going Left".

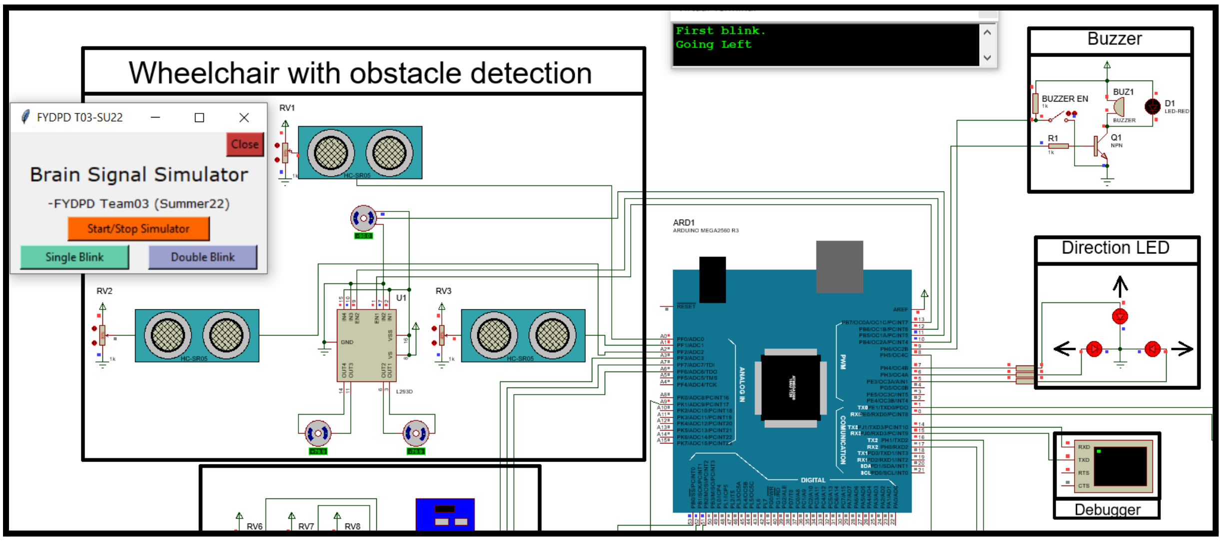

Figure 13: Left LED activated, back motors activated, servo in -90◦ (left movement)

After activating the system using forced double blink, the system takes command for 20 seconds. During this interval if no movement command is given to the system, the system automatically deactivates itself. This is evident in figure 14.

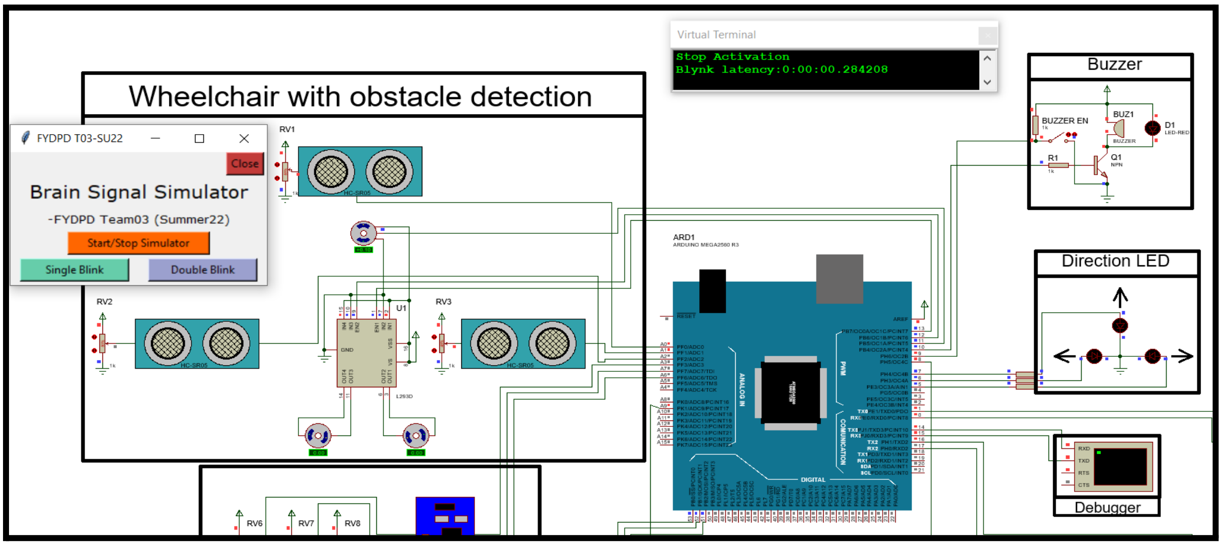

Figure 14: LED deactivated, all motors deactivated (halt position)

Obstacle detection system:

For obstacle detection, the distance of different objects from the front, left and right sides of the wheelchair are measured using the HC-SR04 sonar sensor. For the front detection, if the measured distance is below 100 cm (initial model condition), then the processing unit sends information to the motor driver to stop the wheels. For both left and right sides, the acceptable distance is 50 cm. During the movement of the wheelchair the implemented obstacle detection system continuously checks for any obstacle in the moving direction using the sonar sensors. If any obstacle is detected in the range of the moving direction then the system applies a brake to stop itself. Figure 15, 16 and 17 show the system response to objects detected in front, to the right and to the left of the wheelchair respectively.

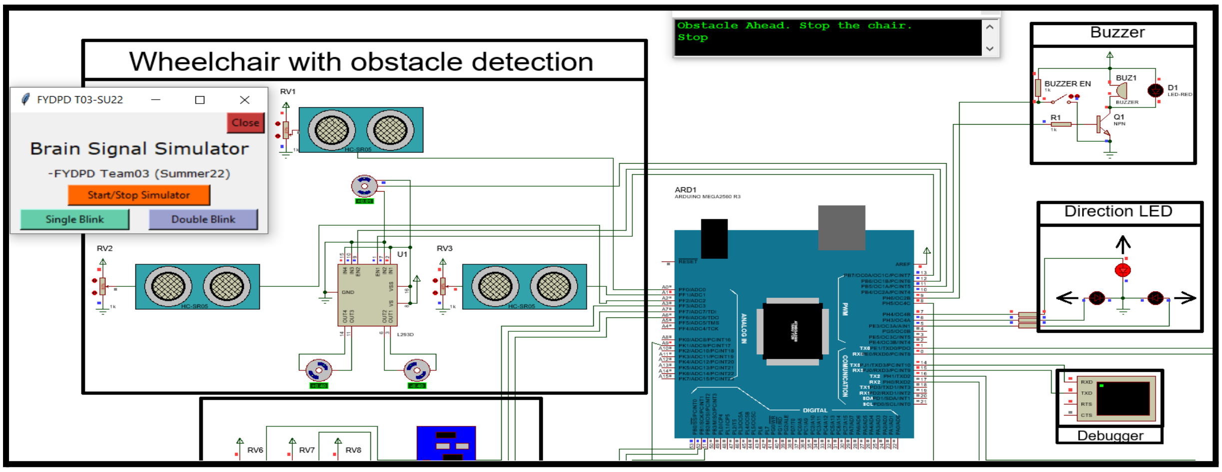

Figure 15: Obstacle detected in front, all motors deactivated (halt position)

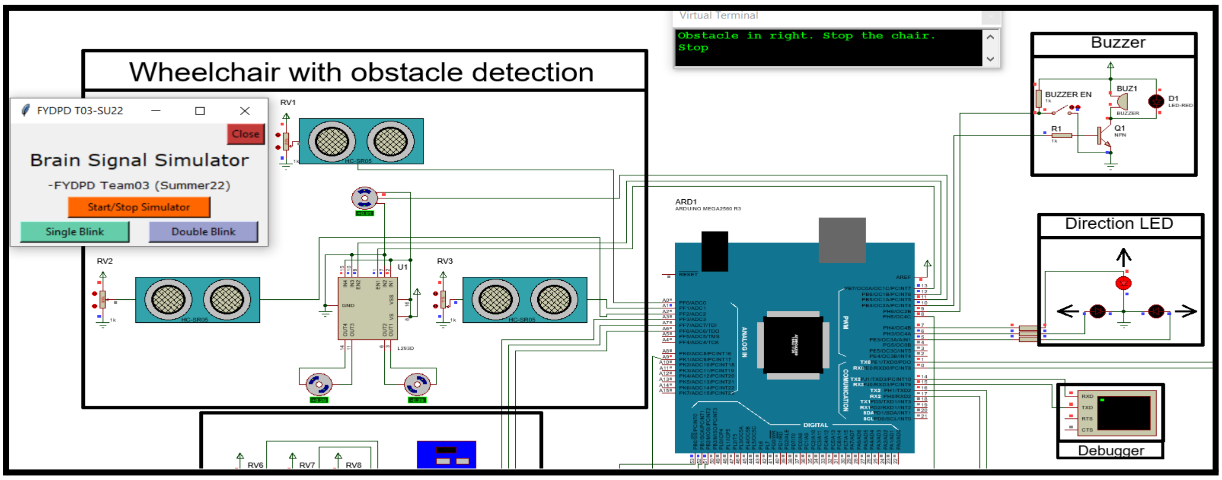

Figure 16: Obstacle detected to right, all motors deactivated (halt position)

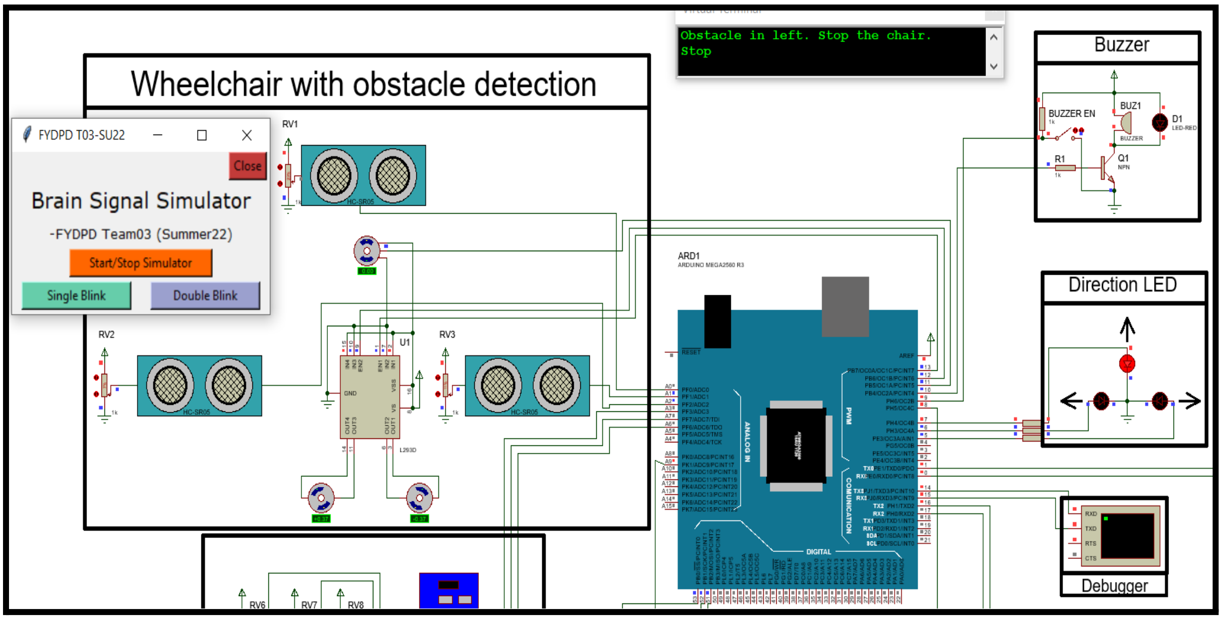

Figure 17: Obstacle detected in left, all motors deactivated (halt position)

Fall detection system:

For fall detection, a means to sense the change in angle with respect to the vertical axis needs to be found. We have used the MPU6050 module to sense the change in angle. For both the x and y axis, the acceptable threshold is 10°. No change is detected in the z-axis due to the orientation of the wheelchair. In the case of fall detection, the gyroscope's X or Y axis angle is changed. During this time, the buzzer will keep buzzing until the wheelchair's position is recovered. In the meantime the system will also notify the persons in charge about the incident through a sms notification. This can be seen in figure 18.

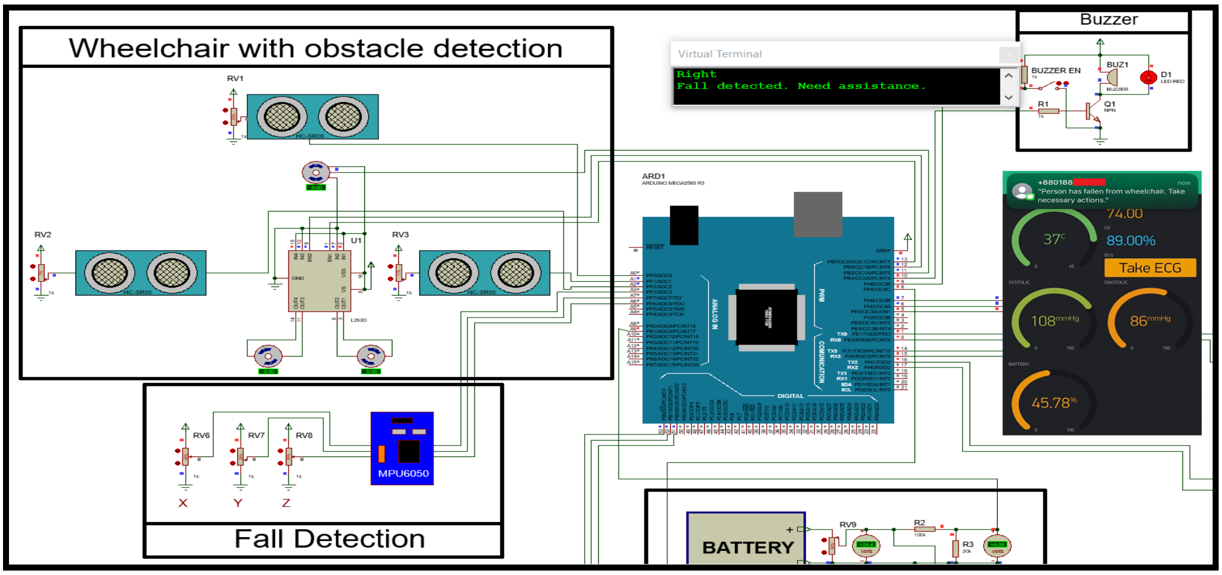

Figure 18: Fall detected, sms sent, system deactivated (halt position)

Figure 19 shows the wheelchair's position restored, the buzzer will stop and the system again starts to function normally.

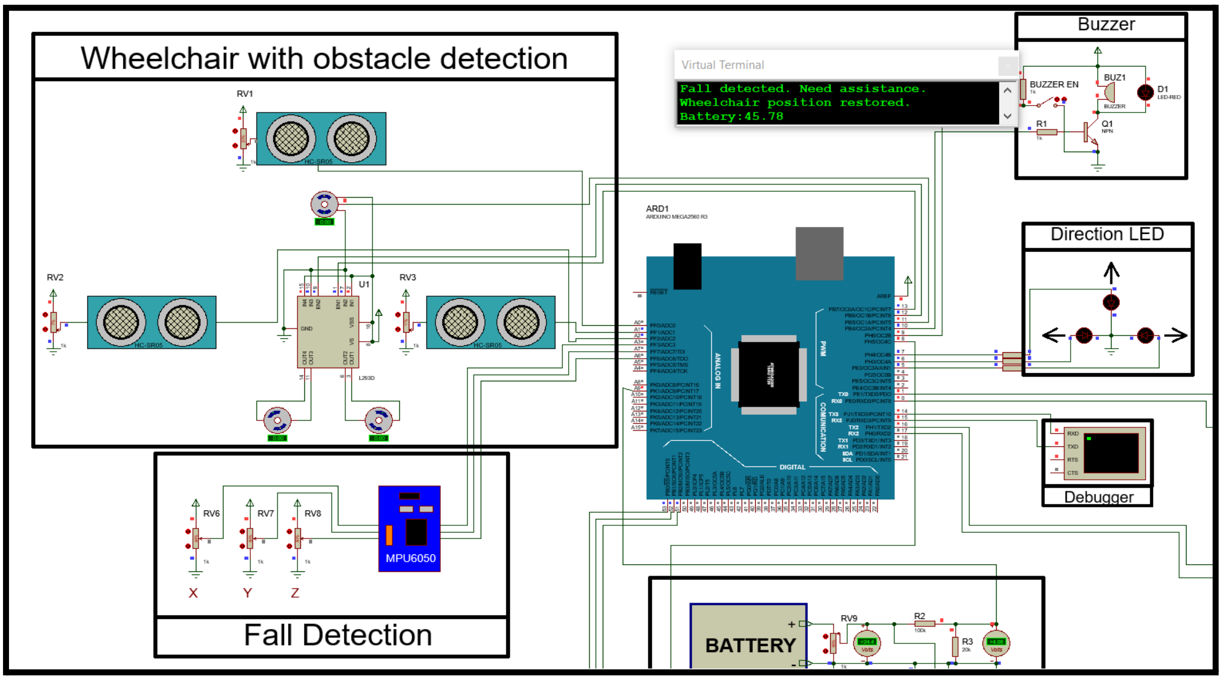

Figure 19: Position restored, system activated (halt position)

Battery monitoring:

A 24V lead acid battery is used for the wheelchair. We have taken the State of Charge (SoC) curve of a lead acid battery, and with regression a straight-line function was produced. When given a voltage, taken from the sensor, the capacity percentage can be mapped using the aforementioned function. For battery safety purposes, when the discharge percentage is at

50%, the relay disconnects the load from the battery to prevent damage. An indicator is also simulated, which shows green when percentage is over 75%, blue when 60 - 75% and red when below 60%. Information about the battery is sent to the server using the WiFi setup.

A sealed lead acid battery's voltage and capacity is shown in table 06. Using this data, a graph is plotted and it is deduced that a linear relationship exists between voltage and capacity. This linear relationship is demonstrated in figure 20 attached below.

Voltage	Capacity
25.77	100
25.56	90
25.31	80
25.02	70
24.81	60
24.45	50
24.21	40
23.91	30
23.61	20
23.4	10
23.25	0

Table 09: Tabular relation of Voltage - Capacity for a sealed lead acid battery

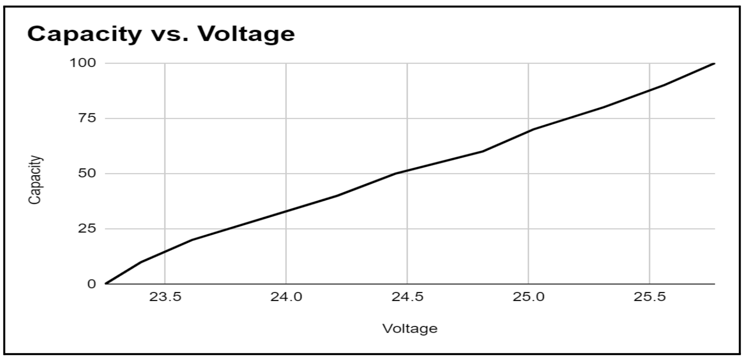

Figure 20: Capacity vs. Voltage graphical relation

From the given voltage and capacity in table 07, we have used linear regression to approximate the capacity of the battery.

Using the data above, we formulated an equation to estimate the battery capacity as a function of voltage (V) for our simulation. The formula is given below.

$$f(V) = -870.5823048+37.60269348V$$

When charge is greater than 50% the battery protection circuit will allow the system to draw current from the battery. In figure 21 the charge percentage shown in the IoT platform is 88.79% so the relay is on and the battery is supplying power to the load. During this time the battery percentage is more than 75% so green led is also indicating that.

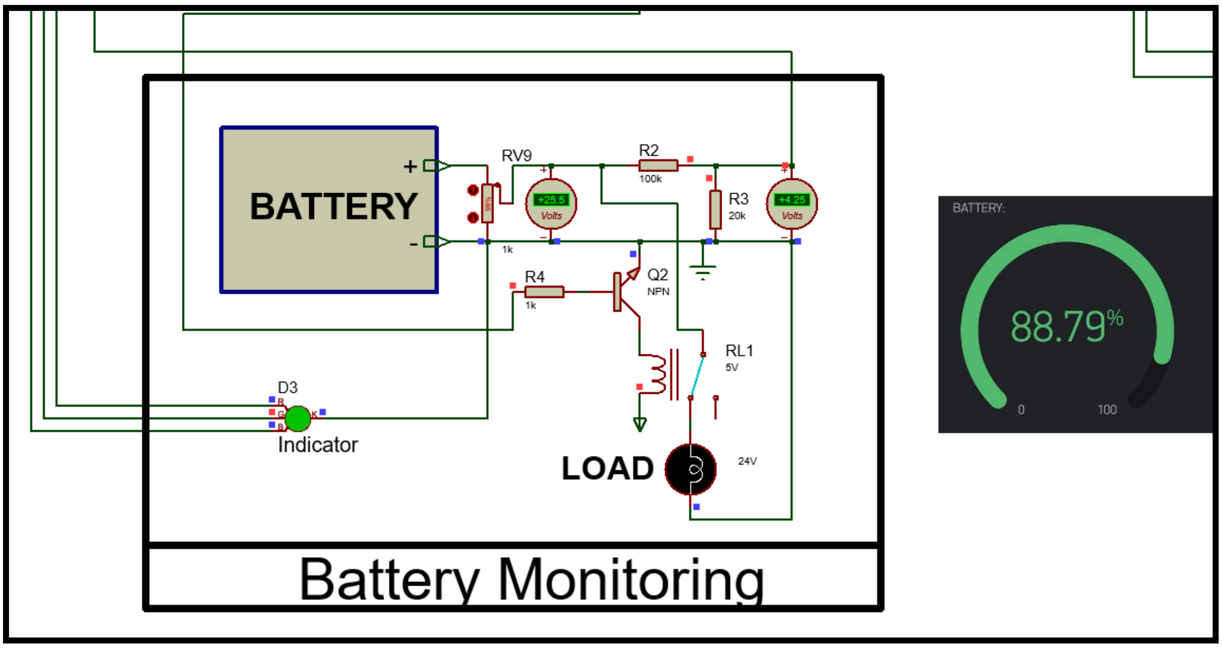

Figure 21: Charge percentage greater than 70%, green indicator, relay on (system active)

Furthermore when the percentage falls below 50%, the battery protection relay comes into action and the load is disconnected from the battery by turning off the relay. Successful operation of this feature is shown in figure 22.

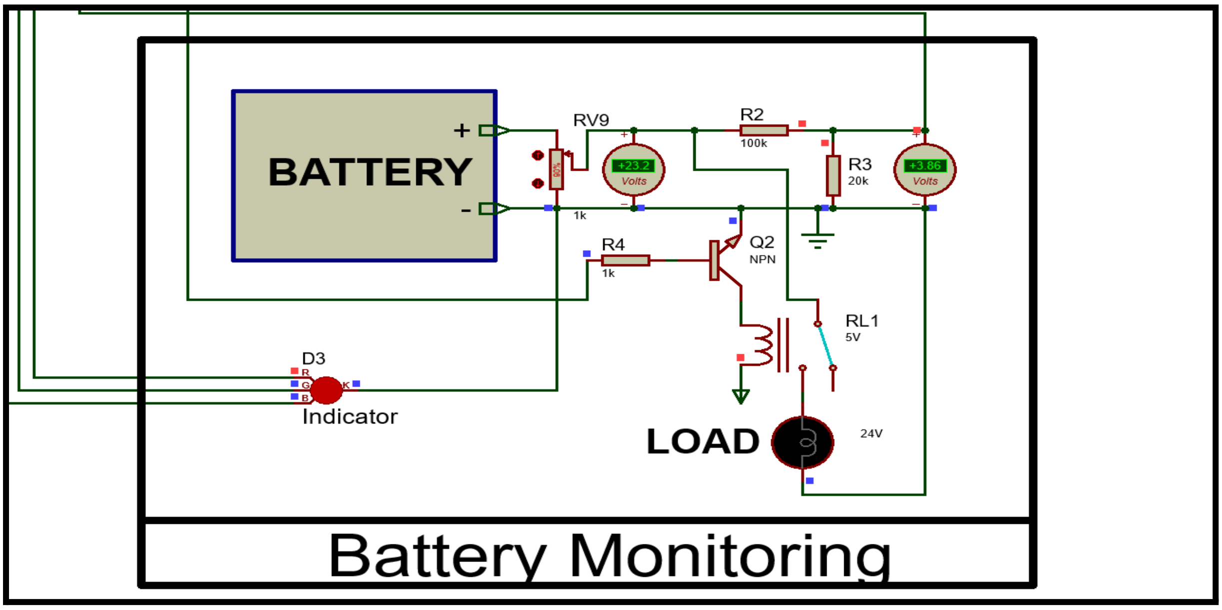

Figure 22: Charge percentage less than 50%, red indicator, relay off (system inactive).

Health monitoring system:

A modular approach is used for the health monitoring system, hence the additional Arduino board. We have provided a LCD screen for viewing data locally instead of mobile phones. The oxygen concentration and pulse rate is measured using the MAX30100 sensor. If the oxygen level drops below 95%, or if the pulse rate is either less than 60 bpm or greater than 100 bpm then the buzzer attached to the system is activated. Body temperature is measured using the LM35 sensor with an acceptable range from 36 - 38℃. Cheap dedicated devices are available to check the blood pressure of a patient, we have modified such a device to take data directly from the EEPROM of such devices. The ECG sensor is simulated to take ECG data only when requested by the server. The data is sent to the mobile phone using the bluetooth module dedicated to ECG.

Figure 23 shows the dedicated modular health monitoring system's display, which displays the measured health vitals. The same information is sent to the IoT server and displayed in the user interface.

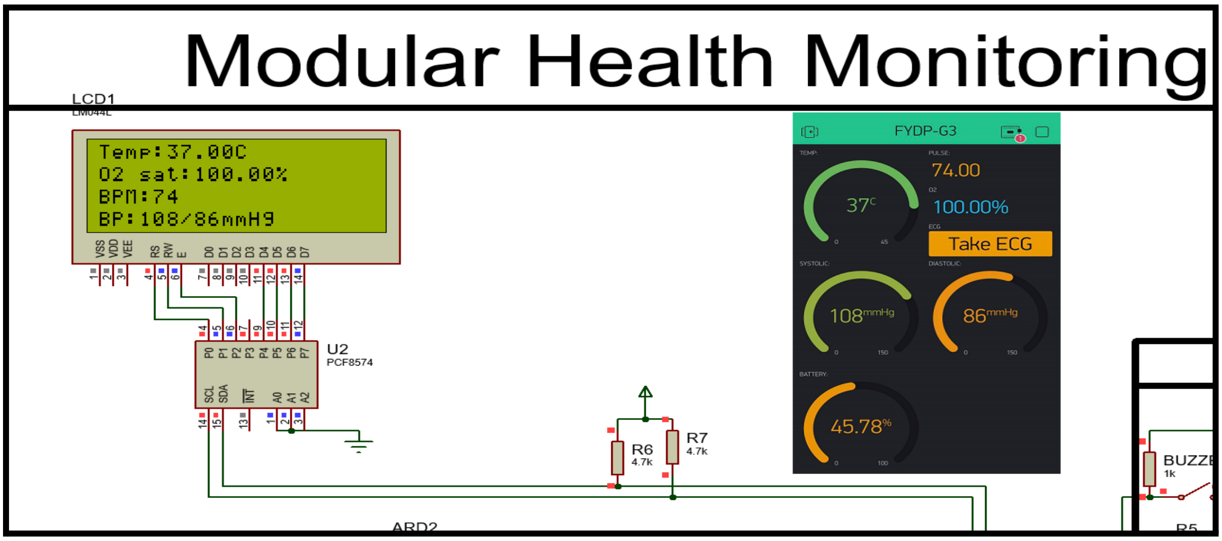

Figure 23: Health parameters displayed locally and in mobile application

The system will alert the user with the buzzer and also a SMS notification if the oxygen saturation falls below 95%. Figure 24 shows the response of the system when the oxygen saturation is 94%.

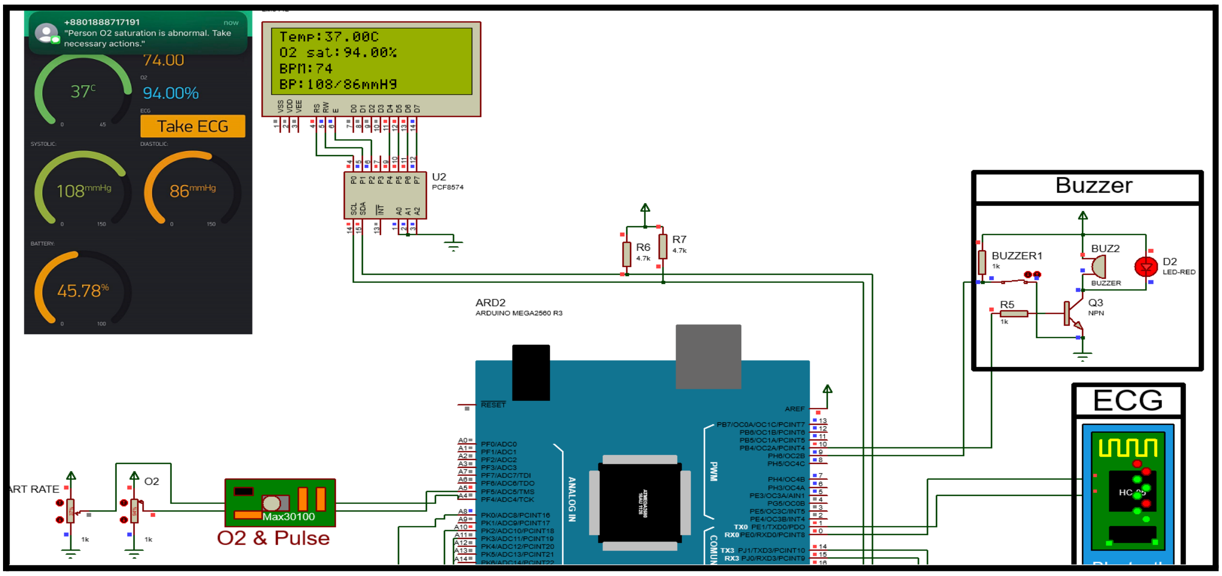

Figure 24: Oxygen percentage below 95%, buzzer active, sms notification sent

If the heart rate is less than 60 or greater than 100, then the system's buzzer will notify and also the system will send a SMS about abnormal heart rate. Figure 25 shows the response of the system when the heart rate is 58 bpm.

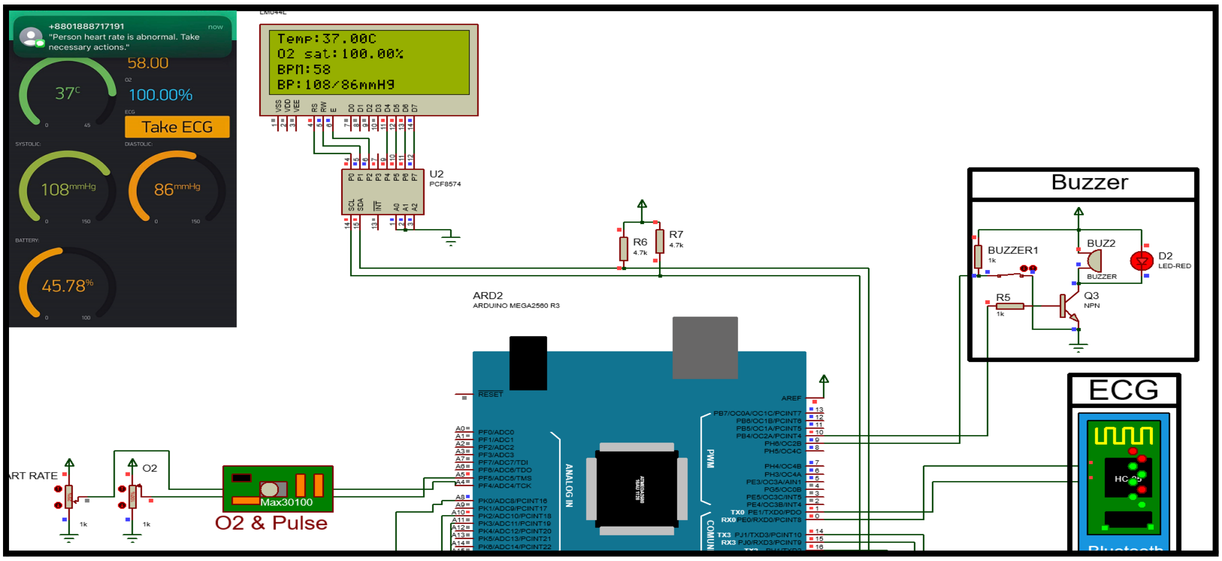

Figure 25: Heart rate below 60 bpm, buzzer active, sms notification sent

Similarly, when the systolic blood pressure becomes more than 120mmHg or diastolic blood pressure becomes more than 90mmHg, the system will notify the concerned personnels by buzzer and SMS. Figure 26 shows the system response when the diastolic pressure is 126mmHg.

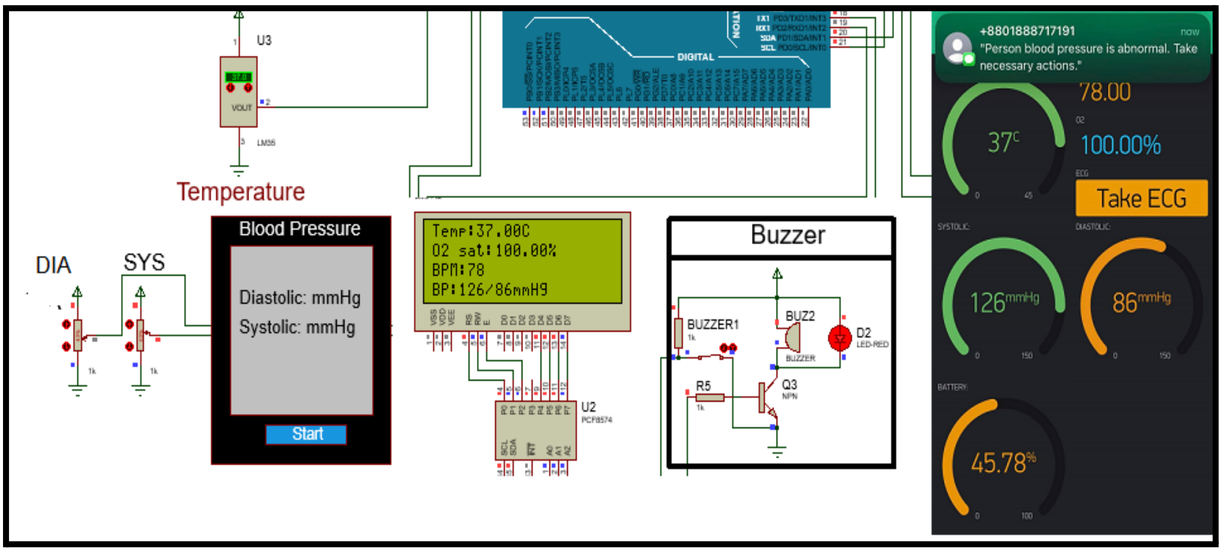

Figure 26: Systolic BP over 120mmHg, buzzer active, sms notification sent

Furthermore, the system is equipped with an ECG monitoring subsystem. However, the ECG will not be monitored continuously. Whenever ECG data is requested through the IoT platform, the system will take the ECG and send it to a connected mobile device via bluetooth. The simulated output of ECG data request, complete acquisition and bluetooth transfer of the concerned data is shown below in figure 27.

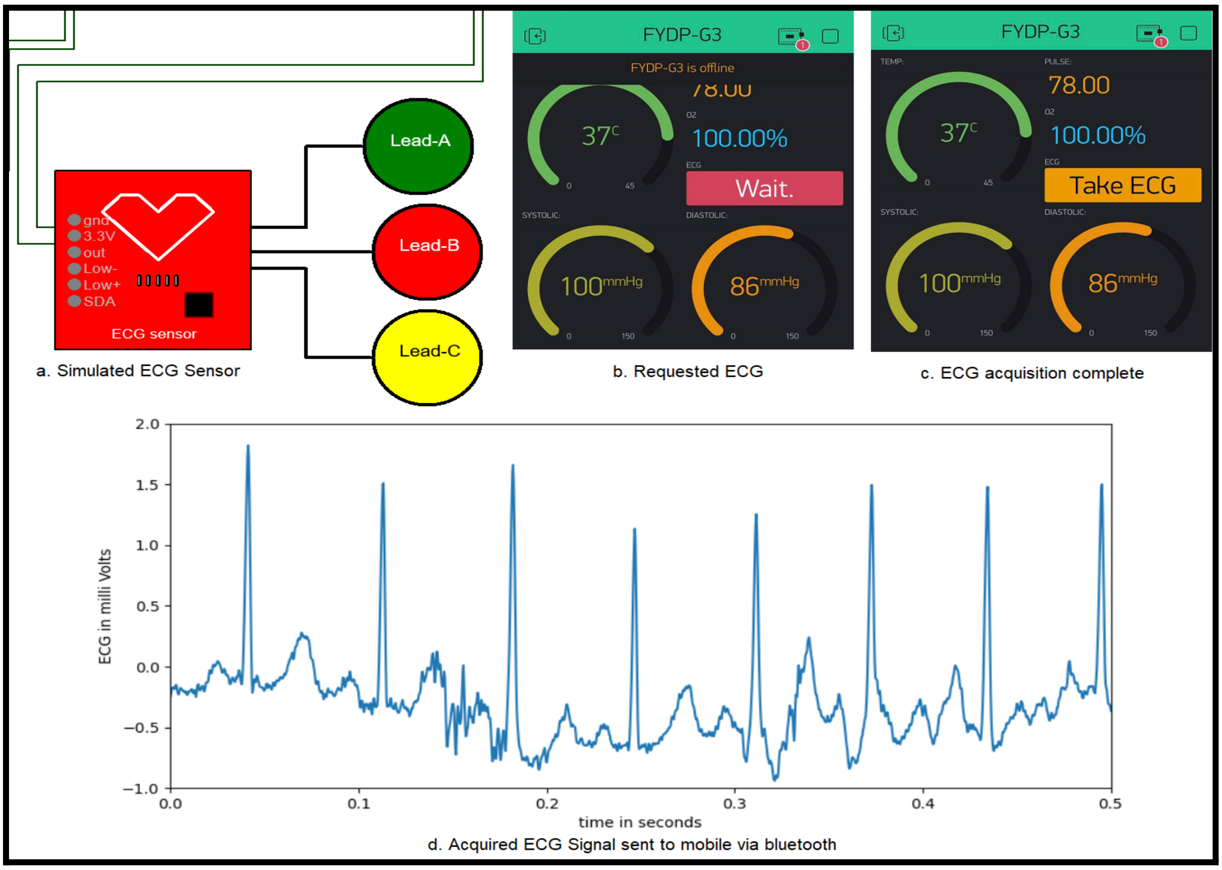

Figure 27: Requested ECG data sent through bluetooth

<u>Design - 2</u>

The design in figure 28 includes a single processing unit used both for the control mechanism and the health monitoring system as well. The ECG data is sent from the processing unit and EEG data is sent to the same unit. A GSM module is attached to the processing unit to be used for data connectivity means. The health monitoring system is integrated to the whole system thus disregarding the portability factor.

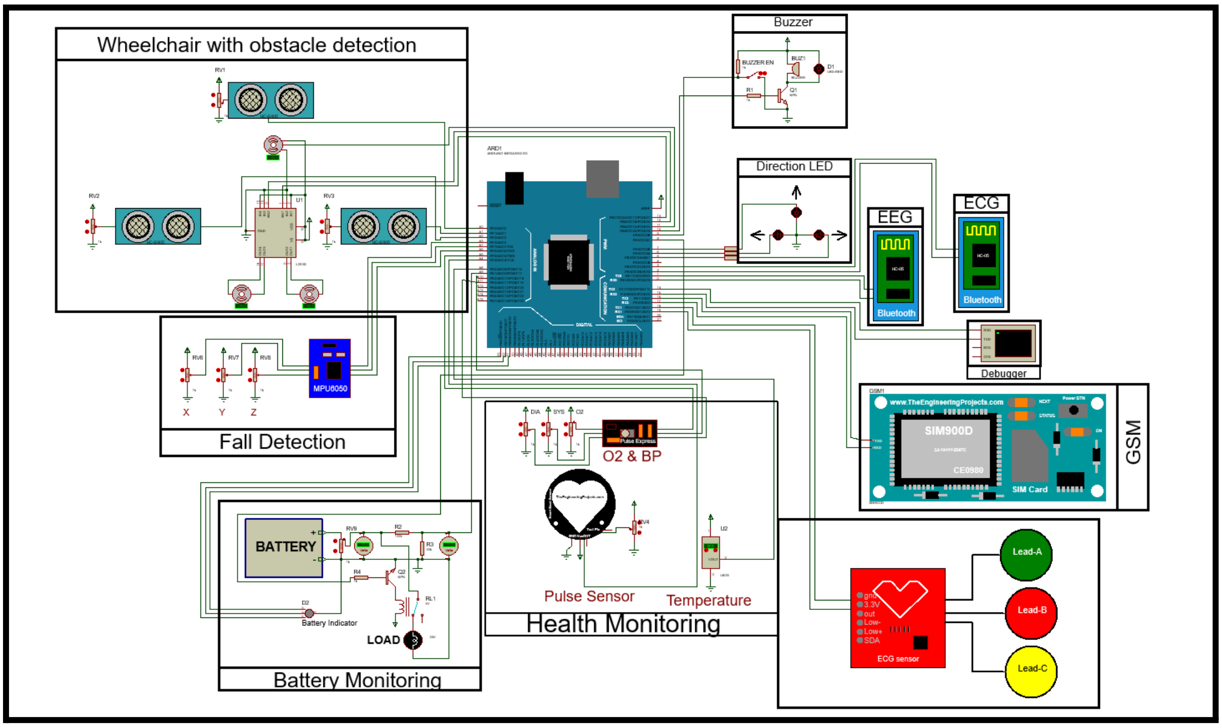

Figure 28: Simulation schematic of design 2

Control mechanism:

The wheelchair is controlled using the attention level data processed in the Arduino board from data sent from the EEG sensor through the bluetooth module. The EEG sensor - brainsense is simulated using the python setup as mentioned earlier for design 1. Data is sent to the processing unit through a bluetooth module. The attention level of the user is extracted from the data and then commands are given. This setup includes the same direction LED board along with the L293D motor driver.

The way in "Design Approach 1" we simulated the brain signal, in "Design Approach 2" we did the same thing. The same dataset mentioned earlier is used to simulate the attention level of the user.

Similar to "Design Approach 1" the system is activated, as shown in figure 29, once the user forcefully blinks twice in a short period of time. The same direction control LED is activated in that case.

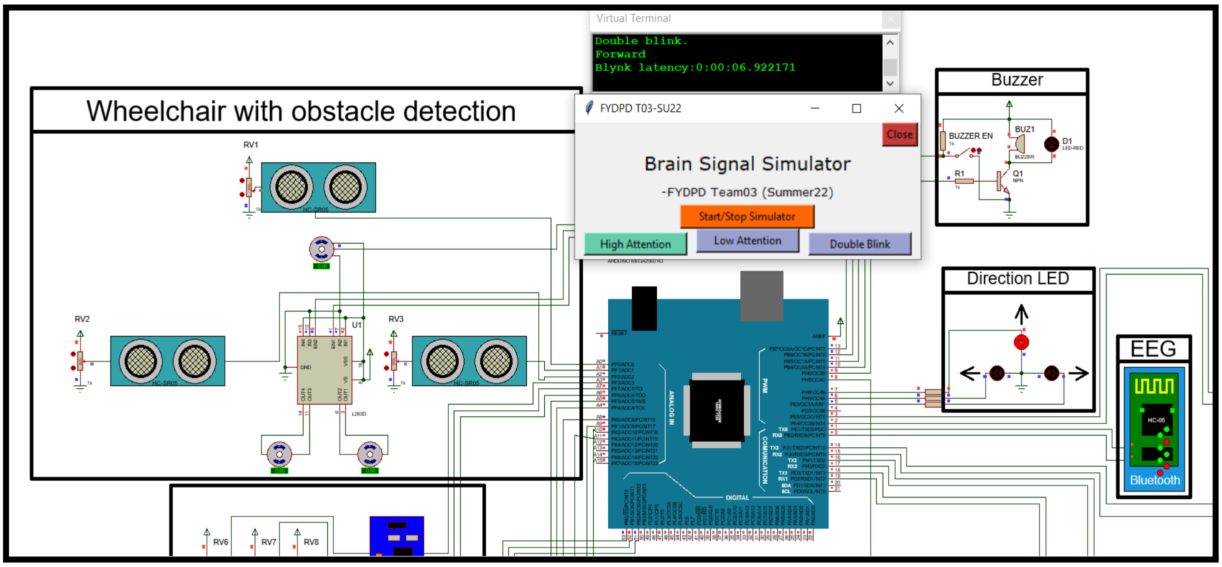

Figure 29: LED activated, all motors deactivated (halt position)

Once the system is activated in this approach, movement command is given by increasing the attention level. When a direction LED is active, attention level is increased to verify or affirmate the decision. In figure 30, attention level is increased for forward direction. Though the system was given command to move in forward direction, due to time taken to increase the attention level, the system classified high attention rate when the control LED was in the right direction. Thus the wheelchair started moving in the right direction.

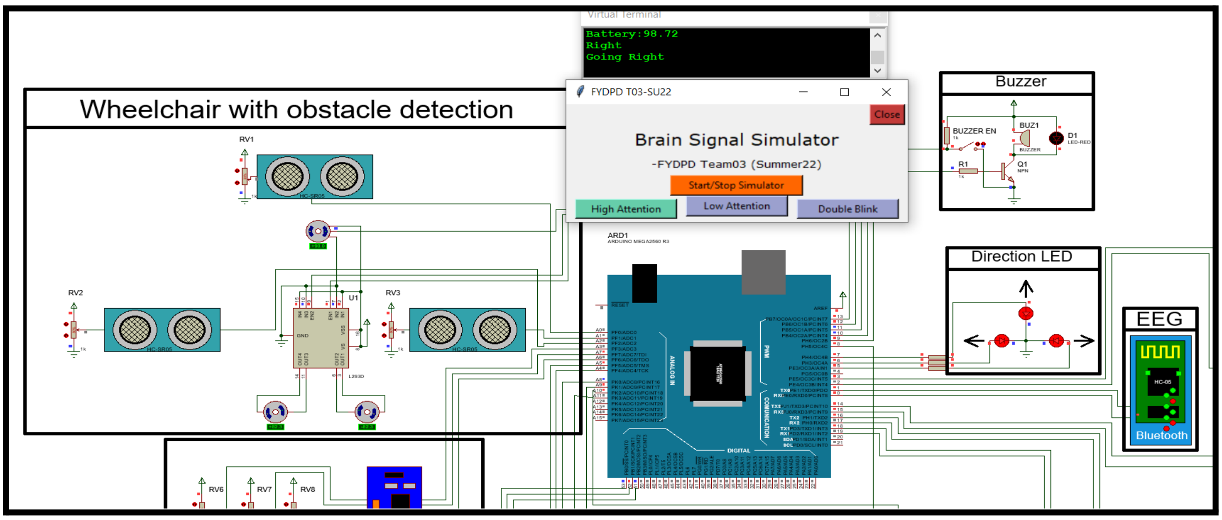

Figure 30: Forward LED activated, back motors activated, servo in +90∘ (right movement)

From Table 05's data 7-11, we can notice that even though the user was asked to increase the attention at 7th second, it took that user more than 4 seconds to increase the attention level beyond the threshold, set at 50. Therefore, the system is not performing as expected.

To stop the wheelchair, the user needs to increase his/her attention level. When a high attention signal is sent to the processing unit, the system successfully stops itself. However, due to the previously mentioned delay and due to the complexity of controlling attention level, the system took longer than “Design Approach 1” by approximately 3 seconds. The simulated output is attached below in figure 31.

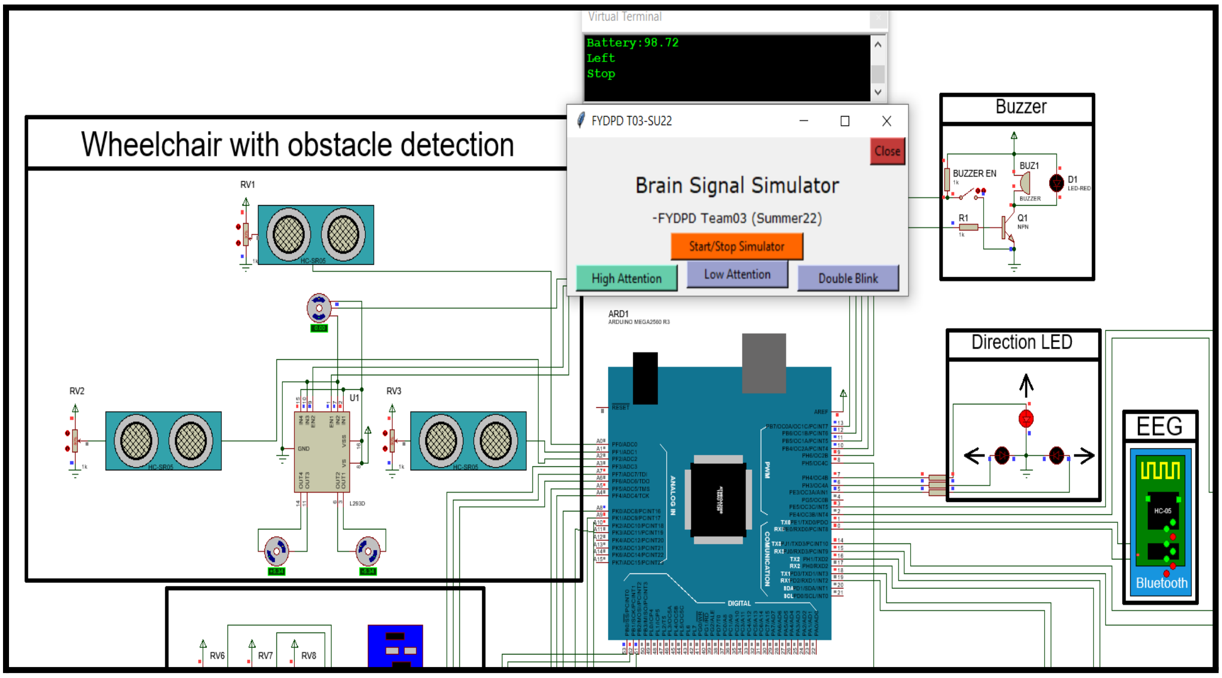

Figure 31: Forward LED activated, back motors deactivated, servo in 0° (halt position)

Further, during idle time the attention level of the user is low. But when a low attention signal is sent to the system, the system acts in a strange way. From Table 05’s data it is evident that during the low attention level period, the user’s attention level increased significantly, more than the threshold level. Thus the system received movement commands unintentionally. The false or unwanted movement is simulated and shown in figure 32.

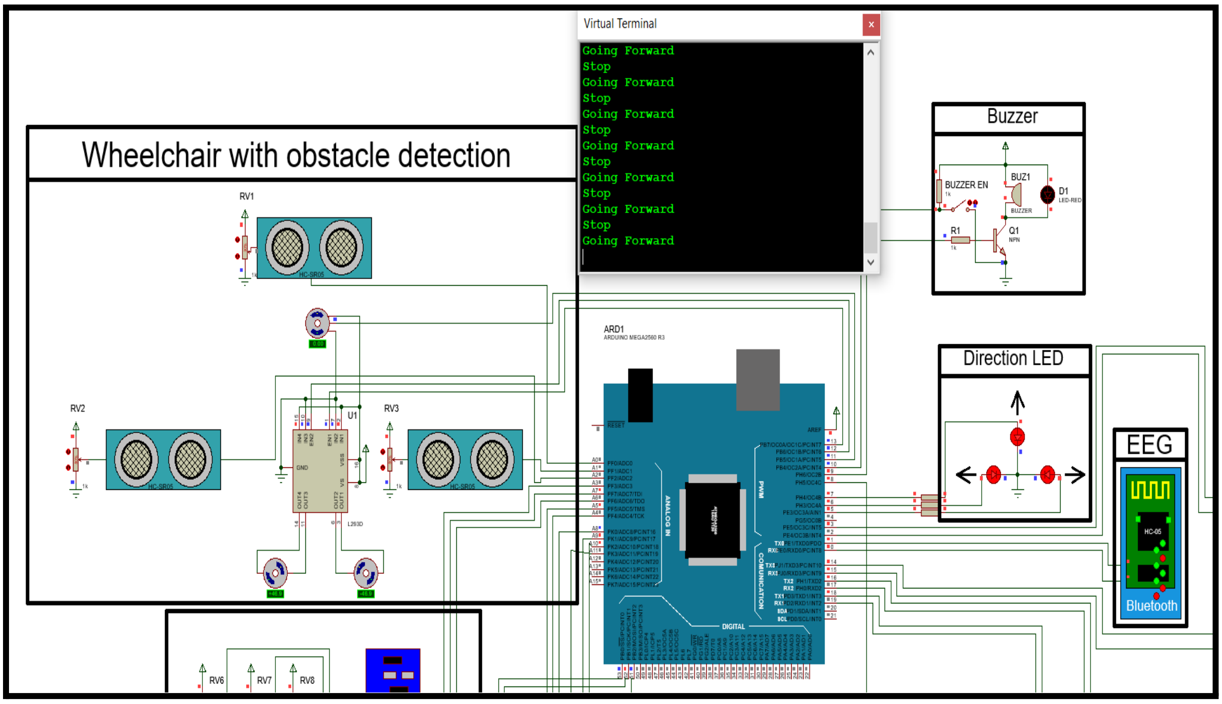

Figure 32: Forward LED activated, back motors activated, servo in 0◦ (unwanted direction movement)

As "Design Approach 2" performed badly with the attention level, so other cases are not shown in the report. However, for the other direction movement too, the system had moved unintentionally and gave erroneous output. The simulated result is tabulated in a later portion of this chapter.

Obstacle detection:

This configuration uses 3 HC-SR04 sensors in three separate directions for obstacle detection. The acceptable range is 50 cm for both left and right directions and 100 cm for front direction. If such thresholds are crossed then the L293D driver would stop the motors from rotating.

For obstacle detection the system was able to detect obstacles in all the three directions. However, it took some time for the system to stop the wheelchair as it was busy processing other things. Figure 33 and 34 shows system response to objects detected in right and left direction respectively.

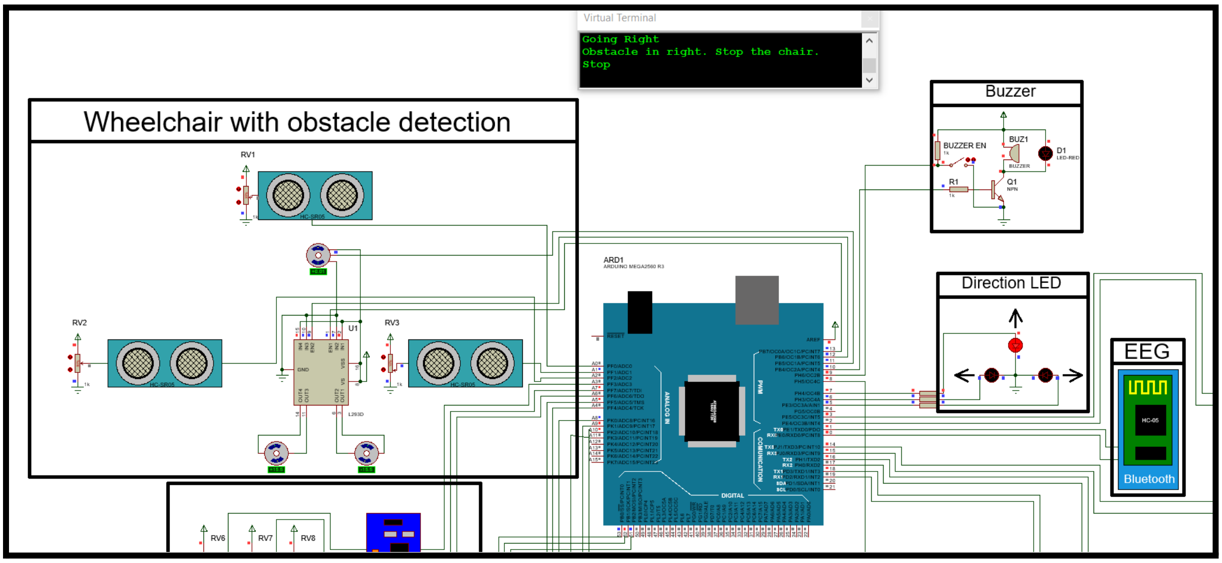

Figure 33: Obstacle detected to right, all motors deactivated (halt position)

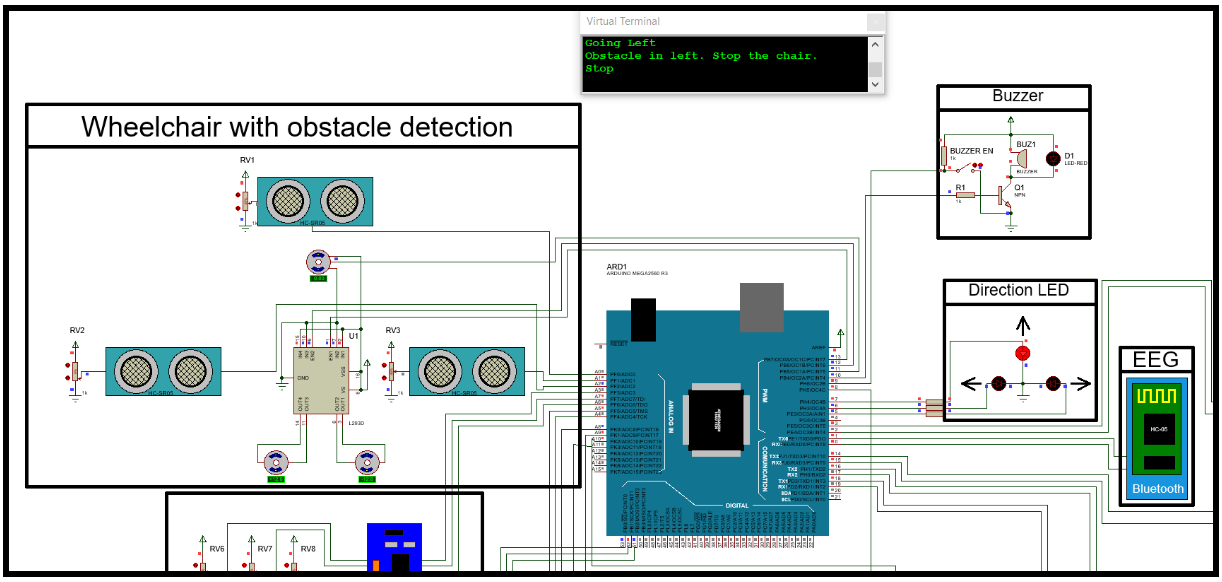

Figure 34: Obstacle detected to left, all motors deactivated (halt position)

Fall detection:

For fall detection, the MPU6050 module is used to determine if the wheelchair has crossed the 10° threshold in the x and y directions only.

In the case of fall detection, the system buzzer will be on and a SMS will be sent to the authorized person's mobile phone. Figure 35 shows the system response when fall has been detected.

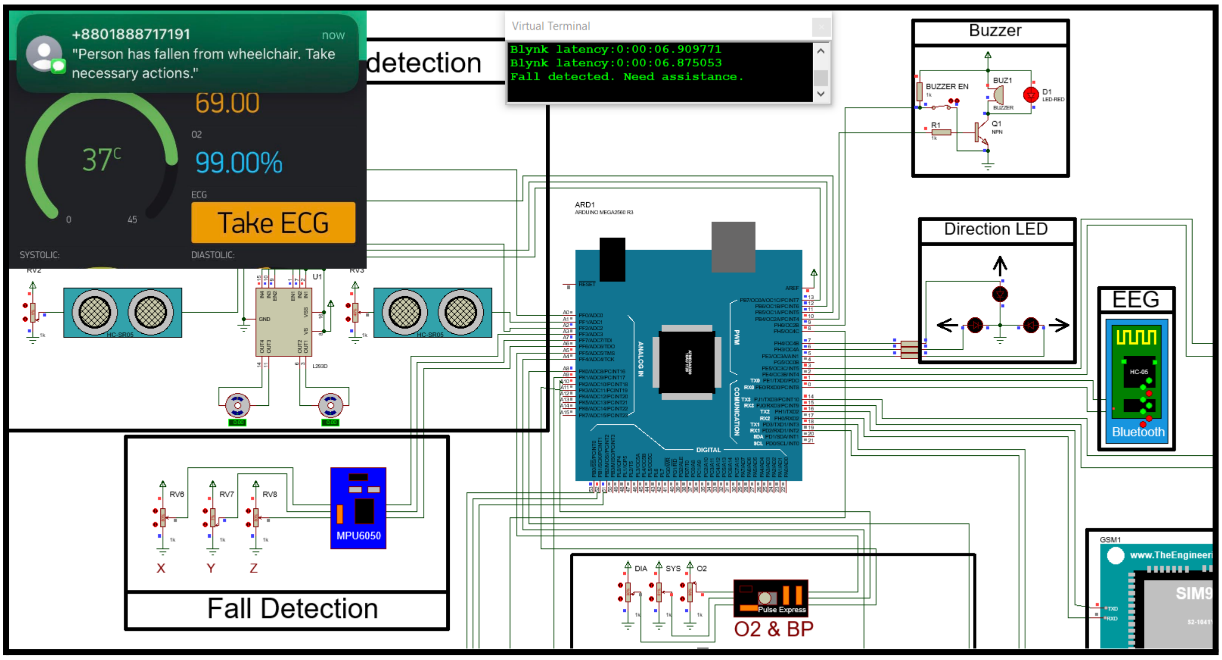

Figure 35: Fall detected, sms sent, system deactivated (halt position)

Once the wheelchair is restored, the buzzer turns off. Figure 36 shows the system response when fall issue has been mitigated and the system has been restored.

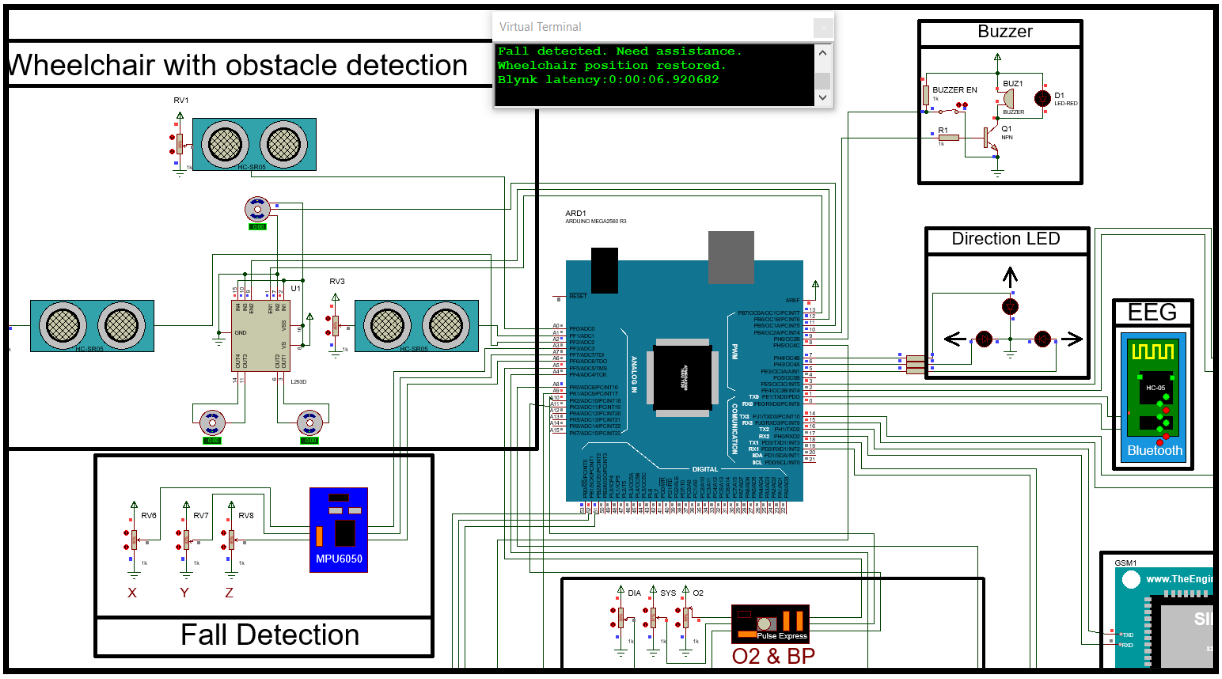

Figure 36: Position restored, system activated (halt position)

Battery monitoring system:

The entire setup is connected to the battery through a relay used for safety purposes. The SoC curve of lead acid battery is regressed to give a function that can map voltage levels to charge percentage. If the charge is above 75%, then the indicator shows green, it shows blue for 60 - 75% range and it shows red for below 60% charge. The information of the battery is sent to the server using the GSM module. Here the same data and linear regression model is used which is used in "Approach 1".

When the battery percentage is more than 75%, the green led is on and the same data is sent to the IoT server. Figure 37 shows the system response at battery percentage = 98.72%.

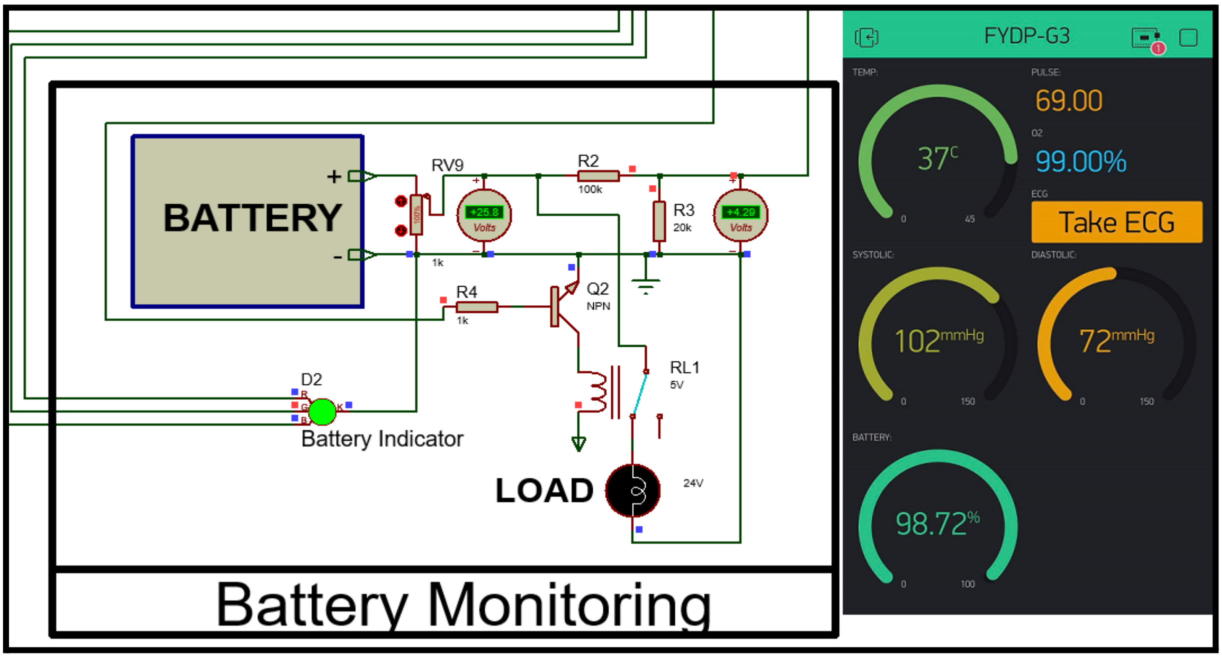

Figure 37: Charge percentage greater than 75%, green indicator, relay on (system active)

When the battery percentage is less than 60% the buzzer is on to notify and once the battery's charge goes below 50% the battery protection circuit automatically disconnects the battery from the system. Figure 38 shows the system response at battery percentage less than 50%.

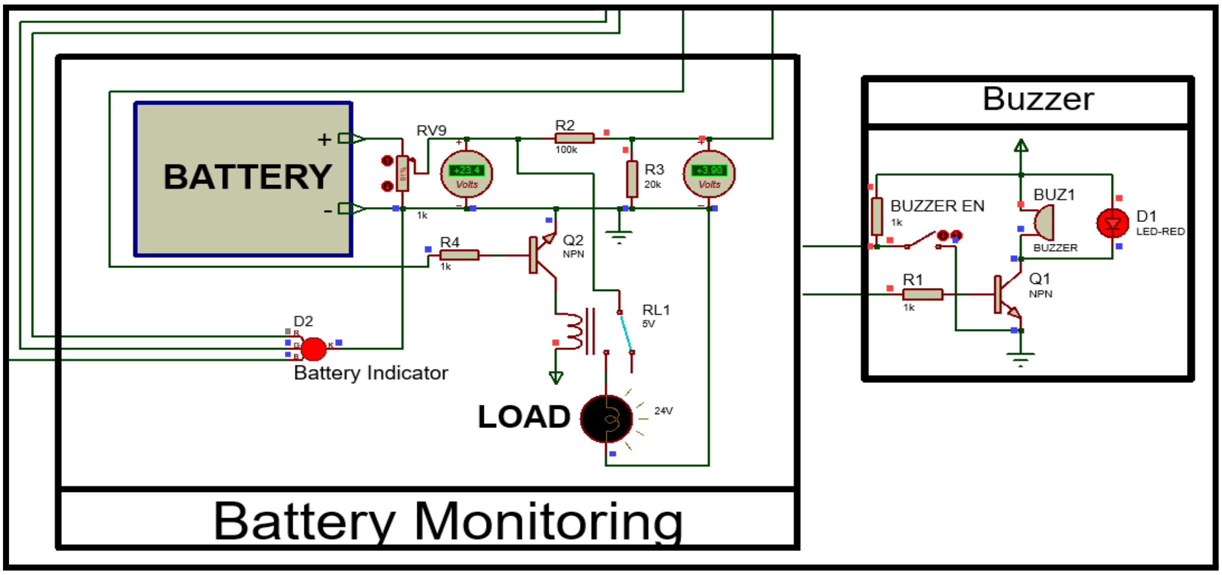

Figure 38: Charge percentage less than 50%, red indicator, relay off (system inactive)

Health monitoring system:

The health monitoring system uses the same processing unit as the control mechanism system. This means that the system is not portable outside the wheelchair perimeter. The pulse express is an expensive sensor dedicated to measuring oxygen concentration and blood pressure. If the concentration is below 95% then the buzzer is activated. A pulse sensor can also be seen in figure 39, if the rate is below 60 bpm or above 100 bpm then the buzzer is activated. The LM35 sensor is used to measure temperature, an abnormal flag is seen if the temperature is not within the 36 - 38℃ range. The ECG sensor sends data through the bluetooth module to a mobile phone only when requested through the server.

The health monitoring system attached in the control mechanism, measures various vitals and continuously sends the data to the server. Time taken to send data to the server is also shown in the virtual terminal.

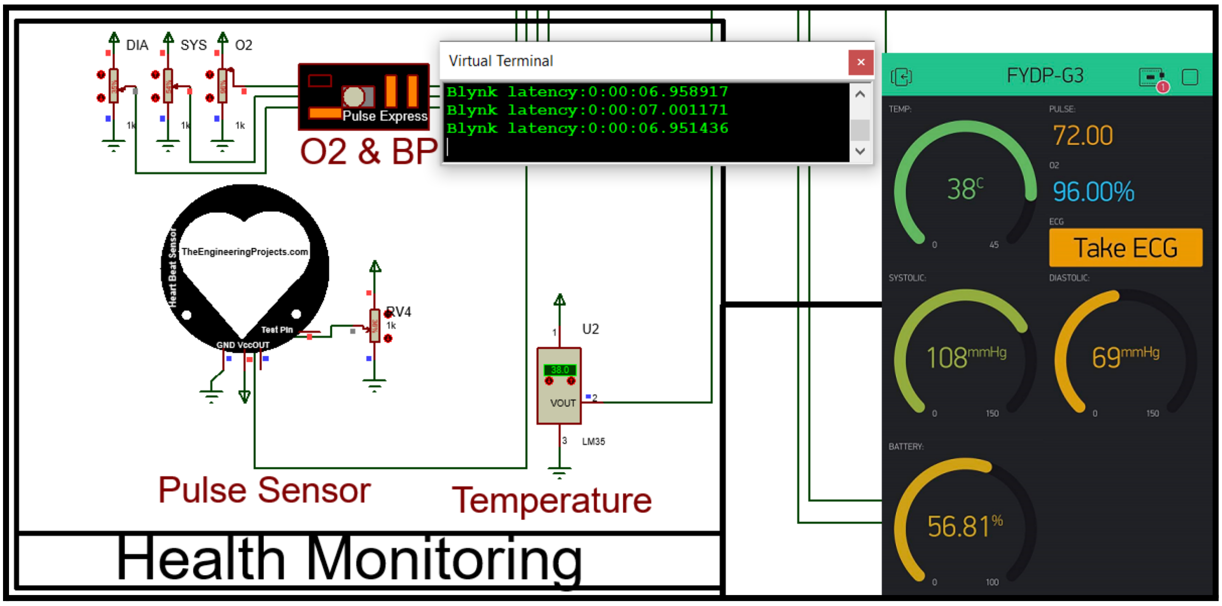

Figure 39: Health parameters displayed locally and in mobile application

In case of any abnormality, the system sends SMS and the buzzer is also on, to notify people around. In case of abnormal health vital's pattern the simulated output is shown below. Figure 40 shows the system response when systolic BP is 124 mmHg and when the oxygen saturation is at 93%.

Figure 40: Systolic pressure above 120 mmHg, Oxygen percentage below 95%, buzzer active, sms notification

The system has the ability to monitor ECG if requested from the server. The ECG data is then sent to a connected bluetooth device. The simulated output of ECG data request, complete acquisition and bluetooth transfer of the concerned data is shown below in figure 41.

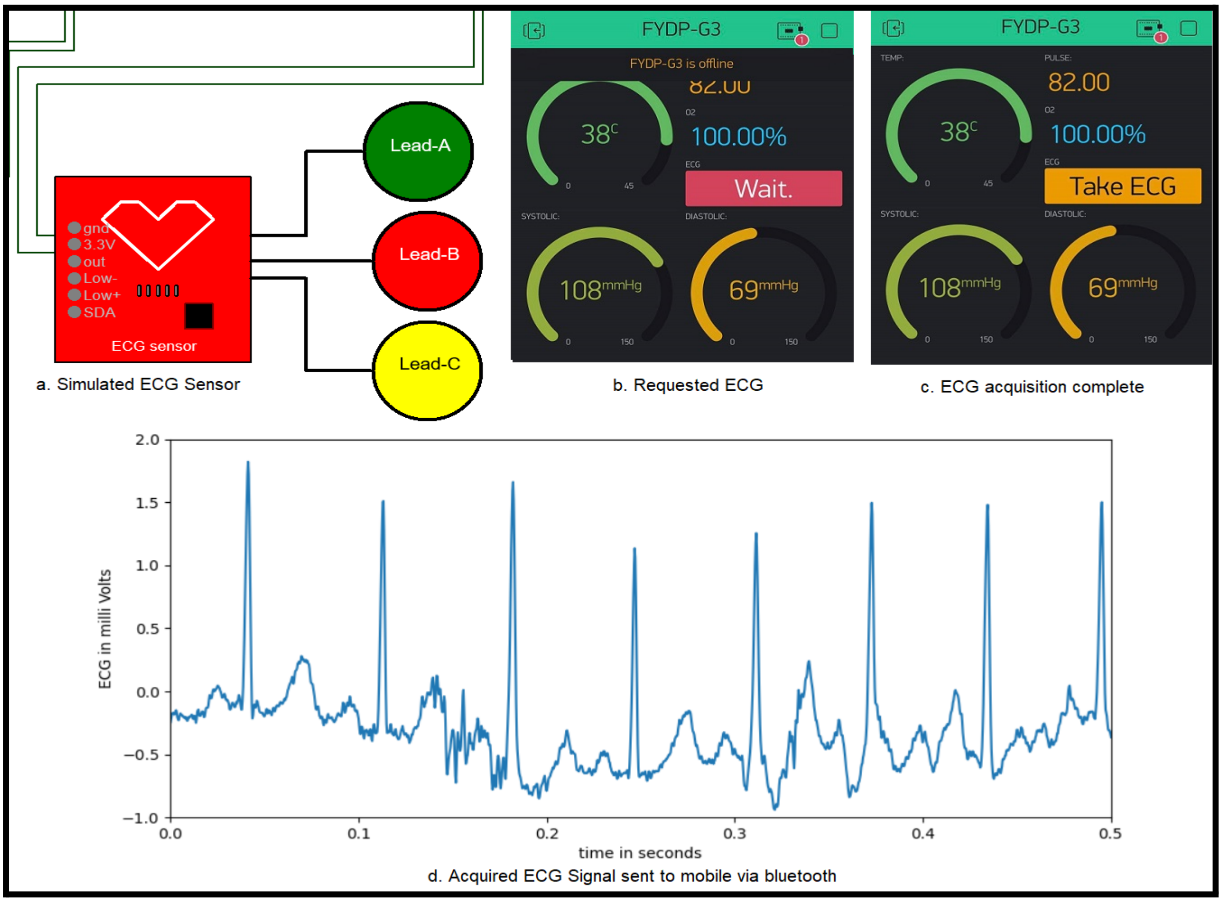

Figure 41: Requested ECG data sent through bluetooth

4.3 Identify Optimal Design Approach

In order to choose the best design strategy for the project, we have performed SWOT analysis and design simulation comparison in this part. The full disclosure is shown below along with the required justification:

	Comments		Decision	
Criteria	Design Approach 1	Design Approach 2	Design Approach 1	Design Approach 2
Control Mechanism	Blink	Blink and Attention	✓	╳
Health Monitoring	Temperature, Heart Rate, O2 Saturation, ECG and Blood Pressure	Temperature, Heart Rate, O2 Saturation, ECG and Blood Pressure	✓	✓
Fall Detection	Instantaneous	Delayed due to processor being busy	✓	╳
Communication System	Wifi	2g GSM	✓	╳
Number of Processing Units	2	1	╳	✓
Processing Unit Block Time	Average time 0.260 seconds	Average time 4.897	✓	╳
Data Visualization	On board display and app	Only the app	✓	╳
Portability	Portable health monitoring system	Limited portability	✓	╳
Battery Monitoring	SoC	SoC	✓	✓
Cost	Approximately cheaper	More expensive than other approach	✓	╳

Table 10: Overall comparative analysis for design 1 and design 2.

SWOT Analysis for Design 1:

Strengths:

1. Control mechanism accuracy: This design uses blink data only, it has been established already that this parameter can be translated into movement commands with accuracy over 95%.
2. Sub-system processing speed: Design 1 poses the least latency among both the designs due to usage of 2 processing units for control mechanism and health monitoring system respectively.
3. Communication bandwidth: Approach 1 has greater bandwidth due to usage of WiFi technology in place of GSM technology.

Weaknesses:

1. Modular complexity: The segmented design approach means that separate resources have to be allocated for configuring, troubleshooting and setting up each of the modules.
2. Continuous internet connectivity required: Since WiFi shields are used, internet connectivity must be ensured at all times for the system to work properly and efficiently.

Opportunities:

1. All-round health monitoring: Since the health monitoring system is detachable due to a separate processing unit, one can reap the benefits of the system even when not on the wheelchair.
2. Product for uncatered demography: This project aims to provide independent self-realized movement for quadriplegic patients, a class which has not been provided such opportunities before in Bangladesh.

Threats:

1. User data security: Soft analysis of health data shall be done from all of the user data sent to the server, therefore it is absolutely integral that the safety of the aforementioned data is ensured.
2. Unavailability of sensor: The global pandemic has created massive problems when it comes to importing specialized sensors from abroad. Such is the case with our EEG signal acquisitor. Therefore, availability of the sensor plays a crucial role in the manufacturing side.

SWOT Analysis for Design 2:

Strengths:

1. System design complexity: Since only one processing unit is used, it is much easier to set up, configure and troubleshoot compared to the other design.
2. Ease of interfacing: This system uses Arduino, widely recognised for being very easy to work with and interface.

Weaknesses:

1. Data latency: It is evident that this design has a much higher block time for processes, therefore real-time responses of safety features may not take place when it is essential.
2. Cost: It was established that the cost for this design exceeded the cost for the other design.

3. Control mechanism accuracy: From experimental data it was seen that when “attention level” data was coupled with “blink” data for control commands, there was an unprecedented increase in the error rate.
4. Communication bandwidth: The GSM module used provides a much lower data transmission rate compared to the ESP-01 WiFi shield.

Opportunities:

1. Installability on existing wheelchairs: The cost of a wheelchair is much greater compared to the cost of the entire system to be installed upon. Hence to cut down costs further, this system has been designed to be installable on existing wheelchairs.
2. No physical labor required for movement: This design relies solely upon the attention level of the user along with the forced blink strength to drive the motor drivers of the wheelchair thus disregarding the need for physical labor.

Threats:

1. Inaccurate surface analysis of health data: Due to block time, since real-time health data is not sent for monitoring by authorized personnel, it is possible that judgement would be made on the basis of malicious data.
2. Unintended movement commands: Data latency in the system along with routined change of direction in the direction LED board can sometimes result in malicious and unwanted movement commands as elaborated in previous sections.

The aforementioned SWOT analysis for both the designs have been summarized and tabulated down below in table 11 and table 12.

Strengths	Weaknesses
● Higher control mechanism accuracy ● Lower processing latency ● Higher communication bandwidth	● Increased sub-system complexity ● Uninterrupted internet connectivity required
Opportunities	Threats
● Health monitoring privileges available at all times ● Uninitiated target demography	● Unavailability of sensors ● User data security

Table 11: SWOT analysis for design 1

Strengths	Weaknesses
● Lower sub-system complexity ● Interfacing is user-friendly	● Higher data latency ● Higher set-up expense ● Lower control mechanism accuracy ● Lower communication bandwidth
Opportunities	Threats
● System can be installed on existing wheelchairs ● Minimum physical labor required	● Inaccuracy in health data acquired ● Unwanted movement of wheelchair may take place

Table 12: SWOT analysis for design 2

Finally, to conclude, from our simulated results, SWOT analysis and table 08, based on almost all criteria mentioned above it can be inferred that “Design Approach 1” is better than “Design Approach 2”.

4.4 Performance Evaluation of Developed Solution

Control mechanism:

In design approach 1 and 2, both the implemented control mechanisms have a total possible 5 types of commands. Therefore, in both of our designs we gave each command 5 times and noted down whether the system was successful or not in executing aforementioned commands. We have also recorded the time taken to execute each of these commands. The simulated result is tabulated in table 13 attached below.

Design Approach 1				Design Approach 2			
Desired Action	Executed	Success	Time taken(s)	Desired Action	Executed	Success	Time taken(s)
Actuate	Actuate	Y	2.85	Actuate	Actuate	Y	2.85
Left	Left	Y	1.2	Left	Left	Y	3.1
Forward	Forward	Y	1.1	Forward	Right	N	4.35
Right	Right	Y	1.15	Right	Left	N	3.67
Left	Left	Y	1.25	Left	Right	N	3.17
Forward	Forward	Y	1	Forward	Right	N	4.52
Right	Right	Y	0.95	Right	Right	Y	2.86
Actuate	Actuate	Y	2.9	Actuate	Actuate	Y	2.9
Right	Right	Y	1.06	Right	Left	N	4.7
Forward	Forward	Y	1.13	Forward	Forward	Y	2.37
Stop	Stop	Y	1.03	Stop	Stop	Y	3.1
Right	Right	Y	0.96	Right	Left	N	4.12
Actuate	Actuate	Y	3.1	Actuate	Actuate	Y	3.1
Forward	Forward	Y	0.8	Forward	Forward	Y	2.3
Left	Left	Y	1.3	Left	Forward	N	3.54
Stop	Stop	Y	1	Stop	Stop	Y	3.14
Actuate	X	N	3.35	Actuate	Actuate	Y	3.35
Left	Left	Y	0.95	Left	Forward	N	3.92
Stop	Stop	Y	1.15	Stop	Stop	Y	2.58
Actuate	Actuate	Y	3.1	Actuate	Actuate	Y	3.1
Forward	Forward	Y	1.1	Forward	Right	N	4.53
Right	Right	Y	1.3	Right	Left	N	3.21
Left	Left	Y	0.85	Left	Forward	N	3.98
Stop	Stop	Y	1.2	Stop	Stop	Y	3.08
Stop	Stop	Y	0.8	Stop	Stop	Y	4.54

Table 13: Control mechanism comparative analysis for design 1 and design 2.

From the simulated results, we further calculated the average time taken by each type of commands and also determined the success rate of executing the desired command. This data is then tabulated in table 14.

Execution time analysis				Accuracy analysis			
Design Approach 1		Design Approach 2		Design Approach 1		Design Approach 2	
Command	Time (s)	Command	Time (s)	Command	Accuracy (%)	Command	Accuracy (%)
Actuate	2.9875	Actuate	3.06	Actuate	80	Actuate	100
Forward	1.026	Forward	2.33	Forward	100	Forward	40
Right	1.084	Right	2.86	Right	100	Right	20
Left	1.11	Left	3.1	Left	100	Left	20
Stop	1.036	Stop	3.288	Stop	100	Stop	100
				Average	96	Average	56

Table 14: Execution time and accuracy comparative analysis for design 1 and design 2.

A barchart to visualize the successful execution of the different desired action for each of the design approaches is provided below:

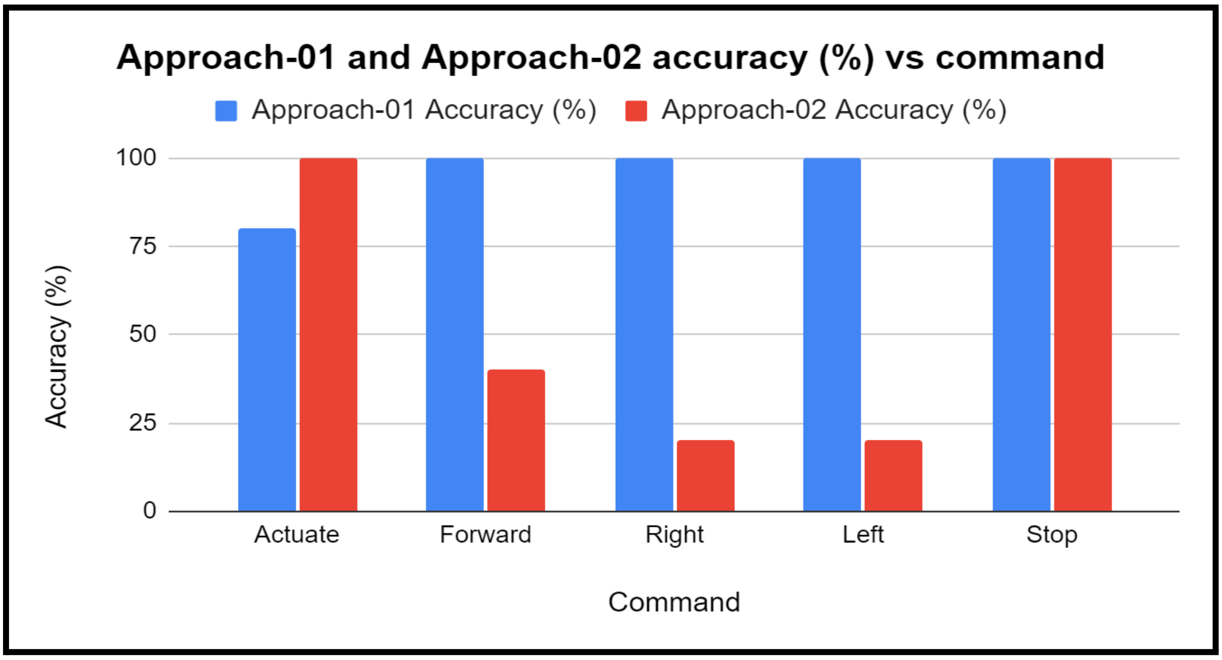

Figure 42 : Accuracy vs command graph for both the designs

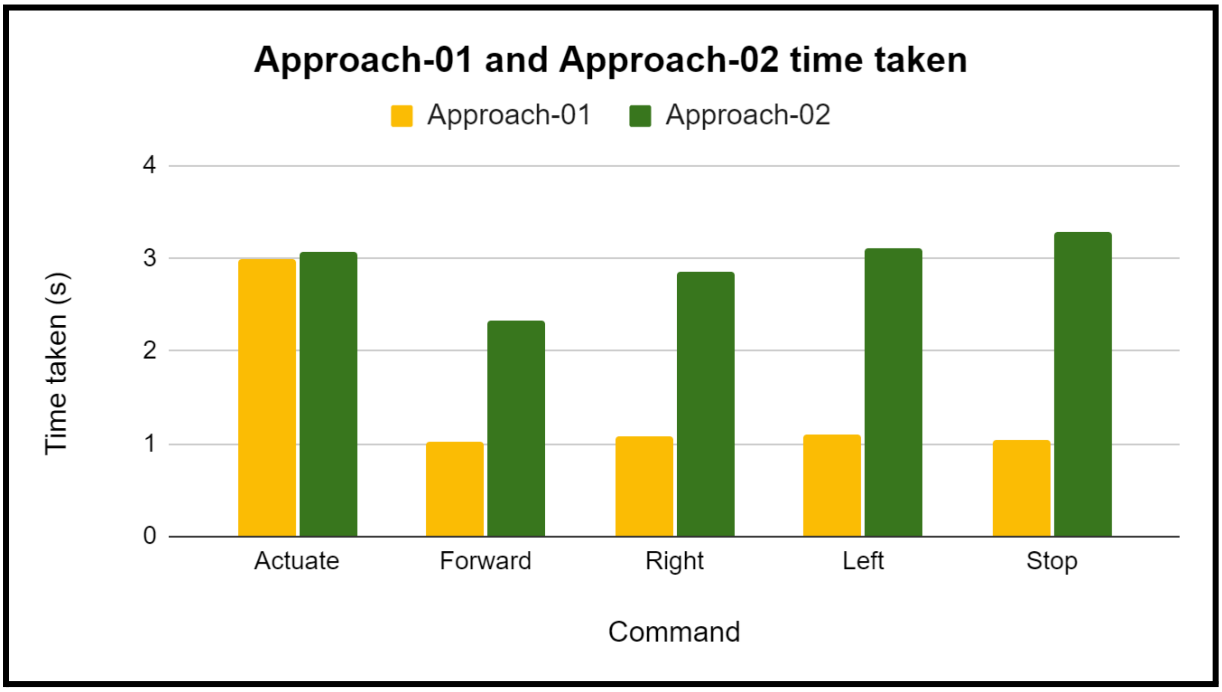

Figure 43 : Time taken to execute a command for both the design

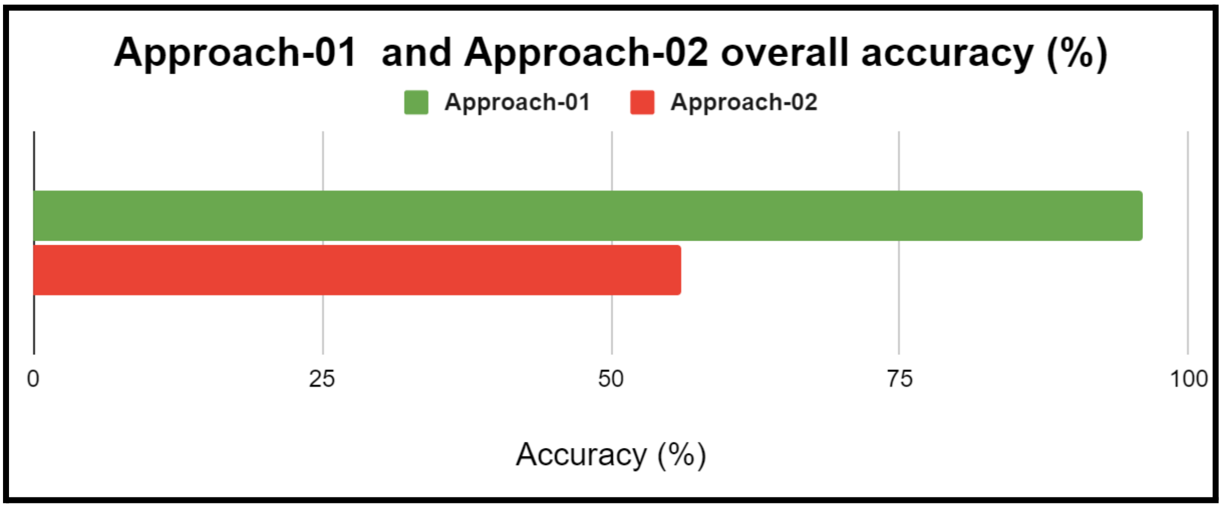

Figure 44: Overall execution accuracy of both the design

From both the simulation provided in above tables and the relevant graphs provided after that we can see "Design Approach 1" is faster regarding execution of any desired command than "Design Approach 2". Furthermore, when both the designs are evaluated on the basis of accuracy, it can be seen that "Design Approach 1" showed an average accuracy of 96%, whereas "Design Approach 2" showed an accuracy of only 56%.

From this analysis, we can come to a conclusion that regarding the control mechanism, "Design Approach 1" is better than "Design Approach 2" regarding execution time and execution accuracy of the control mechanism.

Fall detection:

As discussed earlier, the fall detection system is designed in such a way that only the changes in the x and y axis angle is used as parameters of fall detection. Hence, we changed the x and y axis angles and recorded whether a fall has occurred or not. Then, we noted down the buzzer's notification success rate and also the SMS notification's success rate. The simulated results are presented in table 15.

Design Approach 1					Design Approach 2				
Axis	Fall	Buzzer	SMS	Success	Axis	Fall	Buzzer	SMS	Success
X	1	1	1	1	X	1	1	1	1
Y	1	1	1	1	Y	1	1	1	1
X	0	0	0	1	X	0	0	0	1
X	1	1	1	1	X	1	1	1	1
Y	0	0	0	1	Y	0	0	0	1
Y	0	0	0	1	Y	0	0	0	1
X	1	1	1	1	X	1	1	1	1
Y	1	1	1	1	Y	1	1	1	1
Y	1	1	1	1	Y	1	1	1	1
X	0	0	0	1	X	0	0	0	1

Table 15: Fall detection response comparative analysis for design 1 and design 2.

The table's result can be summarized in a bar graph provided below:

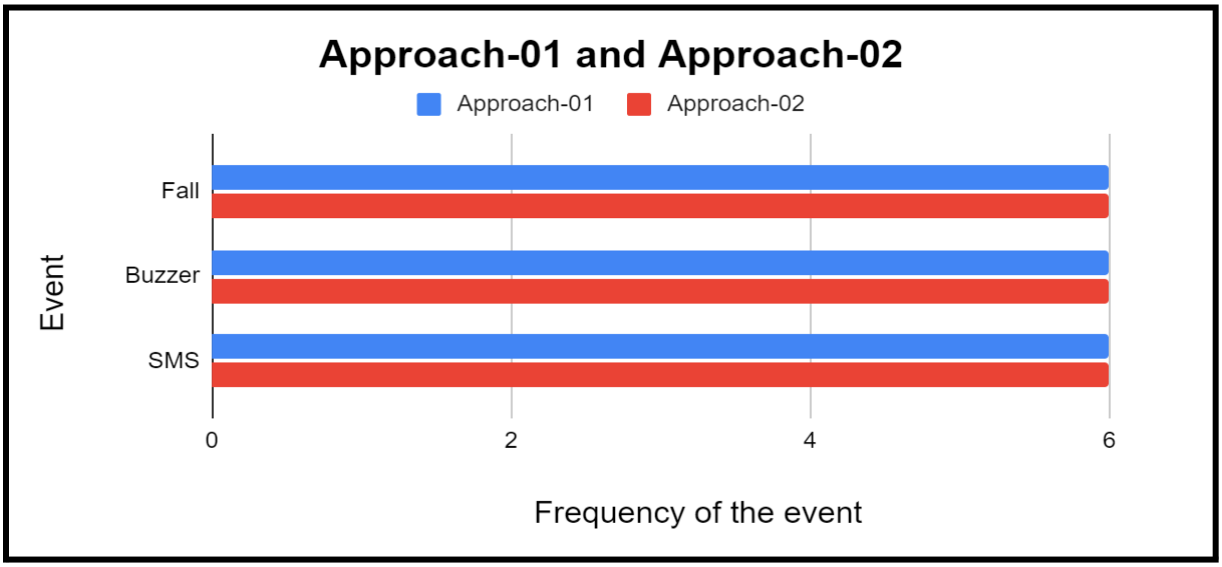

Figure 45: Fall detection response analysis graph

From the simulated results and the table, we can see that in both the designs the buzzer has given a notification when it is desired and at the same time the SMS notification was also sent to the desired number. So in this criteria both the design's have a success rate of 100%.

Therefore it can be concluded that the fall detection and notification mechanism of both the designs are on par with each other.

Obstacle detection:

In both the designs, we have implemented a sonar sensor based obstacle detection system. For both the systems, the allowed obstacle's distance during movement in forward direction is 100cm, left and right is 50cm. Both the design approaches were successful to detect any obstacle in the range. However, due to the processor being busy, obstacle detection in "Design Approach 1" is faster than that of "Design Approach 2".

Therefore, it can be concluded that "Design Approach 1" is better regarding the obstacle detection due to its faster execution time advantage.

Health monitoring:

In both approaches, we monitored various health vitals. Our system is designed in such a way that, if there is any abnormality in the vitals, the system will use a buzzer and send a SMS notification to alert the designated personnel. Therefore, we varied the different vital parameters of the user and recorded how the system reacted in such scenarios. The system response along with the desired responses for both the designs are tabulated in table 16.

Design Approach 1					Design Approach 2				
Criteria	Measured	Buzzer	SMS	Success	Criteria	Measured	Buzzer	SMS	Success
Temperature	37	0	0	1	Temperature	37	0	0	1
Heart Rate	68	0	0	1	Heart Rate	78	0	0	1
O2 Saturation	98	0	0	1	O2 Saturation	96	0	0	1
Temperature	39	1	1	1	Temperature	40	1	1	1
Heart Rate	102	1	1	1	Heart Rate	107	1	1	1
O2 Saturation	92	1	1	1	O2 Saturation	90	1	1	1
Temperature	37	0	0	1	Temperature	37	0	0	1
Heart Rate	50	1	1	1	Heart Rate	56	1	1	1
O2 Saturation	99	0	0	1	O2 Saturation	100	0	0	1
Systolic Pressure	110	0	0	1	Systolic Pressure	105	0	0	1
Diastolic Pressure	82	0	0	1	Diastolic Pressure	75	0	0	1
Systolic Pressure	142	1	1	1	Systolic Pressure	136	1	1	1
Diastolic Pressure	95	1	1	1	Diastolic Pressure	92	1	1	1

Table 16: Health monitoring response comparative analysis for design 1 and design 2.

Apart from all these, the system is also able to take ECG if requested by the server. In our simulation both the systems were successfully able to acquire the ECG data and send it over bluetooth to a connected device. The successful acquisition of ECG data is already demonstrated in previous sections.

From the above simulated results we can conclude that the health monitoring system implemented in both the designs is capable of successfully monitoring health vitals and notify the desired personnel in case of abnormality.

Therefore, the health monitoring and notifying part of both the designs can be concluded as on par with each other.

IoT simulation:

In both of our design approaches we have implemented IoT functionality to monitor the health parameters and also the battery condition remotely. However, the key differentiating factor here is the usage of WiFi connectivity in “Design Approach 1” and the usage of 2g GSM connectivity in “Design Approach 2”. In our simulation we noted down the latency to update the data in the server.

Design Approach 1		Design Approach 2	
Trial	Time Taken (sec)	Trial	Time Taken (sec)
1	0.303	1	4.57
2	0.223	2	4.98
3	0.312	3	5.32
4	0.35	4	6.12
5	0.203	5	4.12
6	0.233	6	4.53
7	0.157	7	3.65
8	0.289	8	5.89
9	0.193	9	6.52
10	0.332	10	4.23
11	0.266	11	5.63
12	0.311	12	7.82
13	0.192	13	6.56
14	0.312	14	3.98
15	0.226	15	4.59

16	0.216	16	4.32
17	0.306	17	5.12
18	0.344	18	3.65
19	0.305	19	4.12
20	0.366	20	4.36
21	0.241	21	5.56
22	0.215	22	4.25
23	0.187	23	3.79
24	0.264	24	3.45
25	0.168	25	5.3
Average	0.26056	Average	4.89736

Table 17: Data transmission comparative analysis for design 1 and design 2.

A visual depiction of the latency between each of the approaches is given below in the following figure.

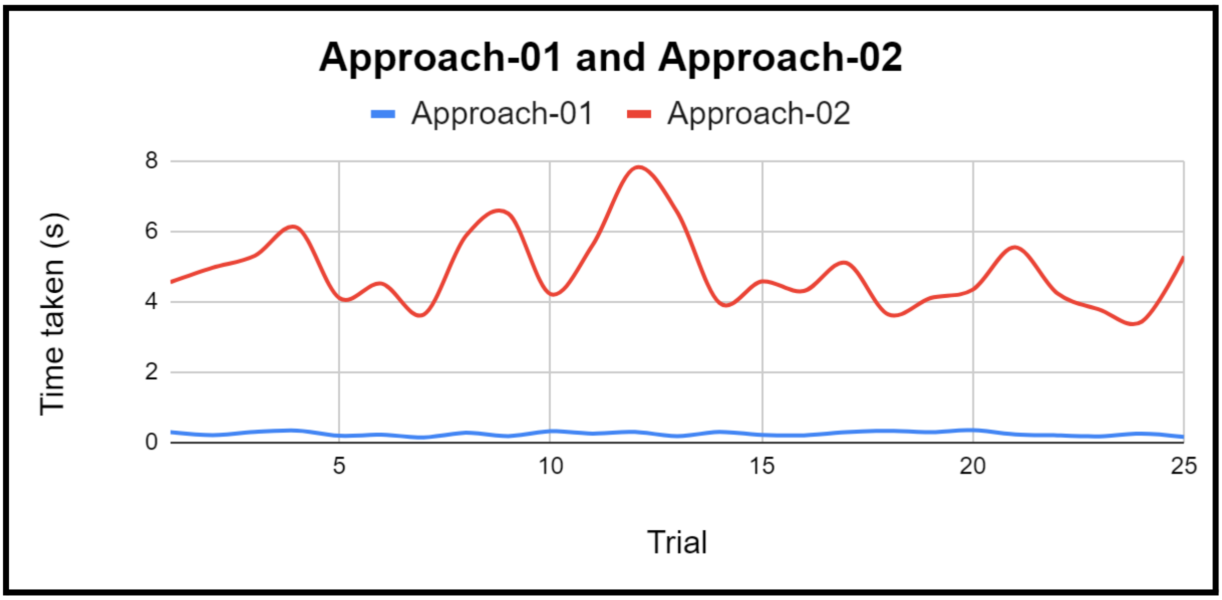

Figure 46: Data transmission latency analysis

From table 17 of the results, we can see that "Design Approach 1" takes only 0.26056 seconds to send the data to the IoT server, whereas " Design Approach 2" takes around 4.89736 seconds to send the data to the server. Ki As the "Design Approach 2" uses a 2g GSM module for internet connectivity, there is this huge latency. In "Design Approach 1" the WiFi connectivity we are using is assumed to be a stable 4g connection. The difference in magnitude of latency between both the models has been illustrated in the figure attached above.

Therefore, from the average time it can be concluded that the “Design Approach 1” is better than “Design Approach 2” in case of IoT data transmission.

Processing:

In “Design Approach 1” we used two individual processing units. One for the control mechanism and the other for the modular health monitoring. However in “Design Approach 2” only one processing unit is used. From our simulated results presented in the previous “IoT Data Transmission Latency” section we have already seen that in “Design Approach 2” the system gets blocked for around 4.89 seconds while the data is transmitted to the IoT server. During this interval the control mechanism is disabled and the health monitoring system is also halted. If we put this problem in another perspective it is noteworthy that when the server requests ECG data the system will not react to any brain signal nor will the other parts function. But in “Design Approach 1” the health monitoring is executed in another processing unit, therefore neither the control mechanism will not be blocked due to the monitoring process, nor will the system’s control mechanism disable the monitoring process. Furthermore in “Design Approach 2” the fall detection happens sometimes with a latency due to the blocking of the processing unit. But in “Design Approach 1” we did not face such issues.

Therefore, from the above mentioned analysis we can say that the use of multiple processors is a better solution than using one processor to complete all the tasks. However using multiple processors adds up to the cost of the design and also power consumption.

Data visualization:

In “Design Approach 1” we have used a local display in the “Modular Health Monitoring” part. This offers the nearby persons to monitor the health vitals, without accessing a mobile phone. But in “Design Approach 2” there is no such functionality. So, it’s not possible to monitor the vitals without using an internet connected device.

Therefore, we can conclude that in regards to “Data Visualization”, “Design Approach 1” is better than “Design Approach 2” as it shows data locally while also having remote data transmission capabilities.

Battery Monitoring:

In the simulation shown in chapter 4, for both the designs we have used a linear regression model to estimate the State of Charge of the battery. The model’s predicted value and error is shown in the following table.

Voltage	Capacity	Predicted Capacity	Error	Error (%)
25.77	100	99.76312643	0.23687357	0.23687357
25.56	90	90.54254055	-0.5425405488	-0.602822832
25.31	80	81.14186718	-1.141867179	-1.427333974
25.02	70	70.23708607	-0.2370860696	-0.3386943851
24.81	60	61.4897236	-1.4897236	-2.482872667
24.45	50	48.80355079	1.196449214	2.392898428
24.21	40	39.77890435	0.2210956492	0.552739123
23.91	30	29.6513987	0.3486013	1.162004333
23.61	20	19.87136549	0.12863451	0.64317255
23.4	10	9.9314567	0.0685433	0.685433
23.25	0	0.0002	-0.0002	0.0002
			MSE	1.545580378

Table 18: Battery monitoring system comparative analysis for predicted vs actual values

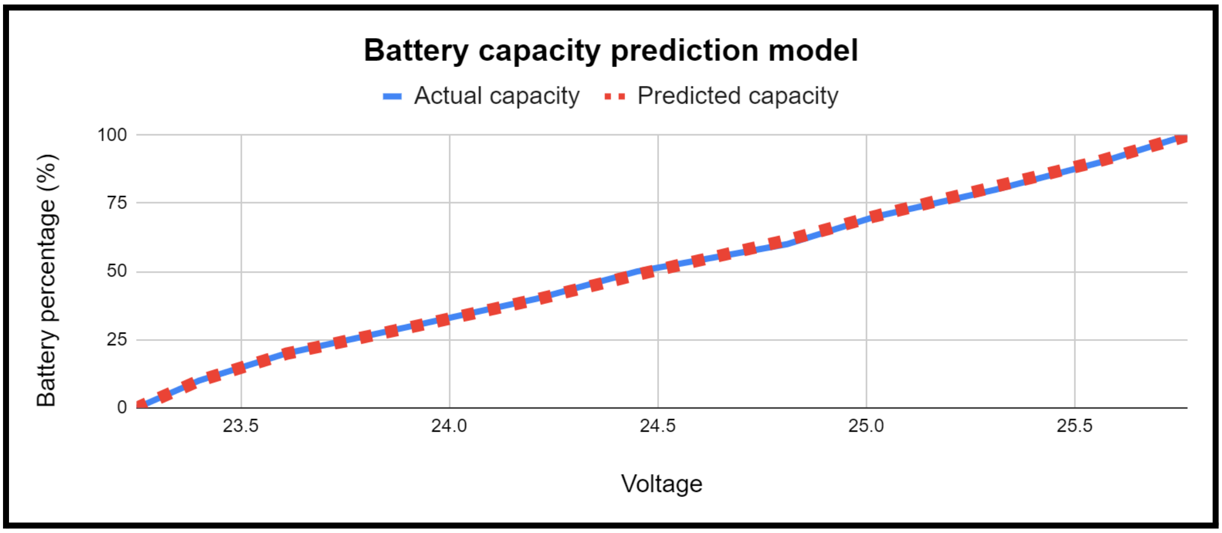

Figure 47: Error analysis of predicted battery capacity

From table 18, it is evident that the linear regression model used in both the design approaches has a mean squared error percentage of only 1.55%. The figure attached above also shows that the absolute percentage of the error is within 2.5%. The error percentage is very low. Thus, we can conclude that both the design's battery monitoring model is appropriate.

Portability:

In “Design Approach 1” the health monitoring part is done on a seperate processing unit. So, the health monitoring system of “Design Approach 1” can be used even when the person is not in the wheelchair. Thus allowing continuous soft analysis of health data regardless of position. But in case of “Design Approach 2” the person must be in the wheelchair as “Design Approach 2’s” health monitoring is connected to its processing unit.

Therefore, in terms of portability “Design Approach 1” is better than “Design Approach 2”.

Cost:

The total cost for “Design Approach 1” is seen to be approximately 65000 taka whereas for “Design Approach 2” the cost is around 70000 taka. From an economical perspective “Design Approach 1” costs 5000 taka less than the “Design Approach 2”.

Therefore, from an economical perspective we can say that the “Design Approach 1” is more optimal than “Design Approach 2”.

4.5 Conclusion

From Table 6 and SWOT analysis, we have found that Design-1 is the optimal solution, which meets all the objectives of our project by keeping the system efficient. Hence, based on our stated analysis and simulated results, we have come to the conclusion that “Design Approach 1” out-performs “Design Approach 2” in almost all aspects. However, one thing which is a drawback of “Design Approach 1” is the use of multiple processing units. But in 4.4’s “Processing” section we have already discussed the simulated result, that using multiple processors is more beneficial than using only a single processing unit. So, this minor drawback of “Design Approach 1”can be considered as a tradeoff to get better performance from the system.

Therefore, we have analyzed all the factors to determine the optimal design as Design-1 to proceed with.

Chapter 5

Completion of Final Design and Validation [CO8]

5.1 Introduction

The previous chapter included an extensive comparison between the implementations of the multiple designs proposed. This was done through software simulation of the systems. Different troubleshooting opportunities were presented to further tune the system. The identified optimal solution has been used to design a hardware prototype for further evaluation. This chapter includes a detailed overview and analysis of the optimal design.

5.2 Completion of Final Design

In Figure 48, we can see the simulation schematic of the system. Based on this simulated design we tried to implement the small scale prototype as a proof that the wheelchair can be controlled by brain signal.

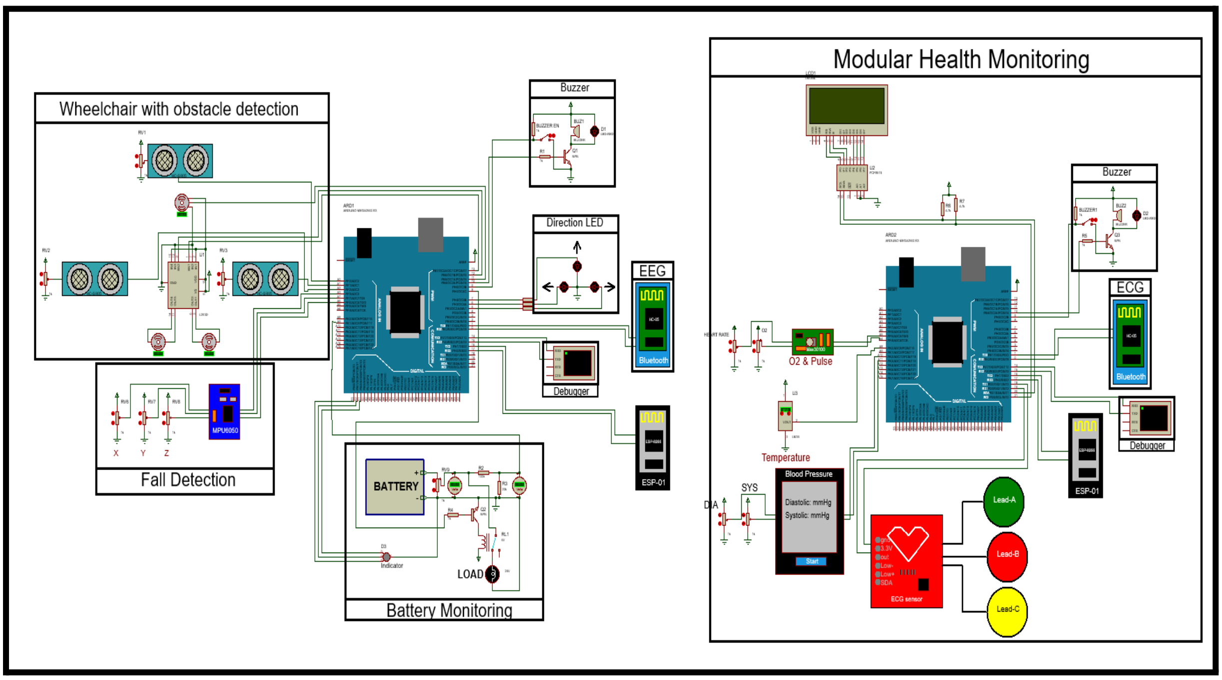

Figure 48: Simulation of the total system

Before the implementation of the small scale prototype we arranged a meeting with the stakeholders and gathered their suggestions and required specifications, which have been tabulated in chapter 1 section 1.2.3's table 02. We proposed to show them a small scale prototype with the new control mechanism.

Before the implementation we tried to visualize how the small scale prototype will look. To put the idea into perspective we developed a 3D model of the prototype which made the building of the prototype a bit easier as we could visualize how the final product would look. The small scale prototype's 3D design has been illustrated in figure 49.

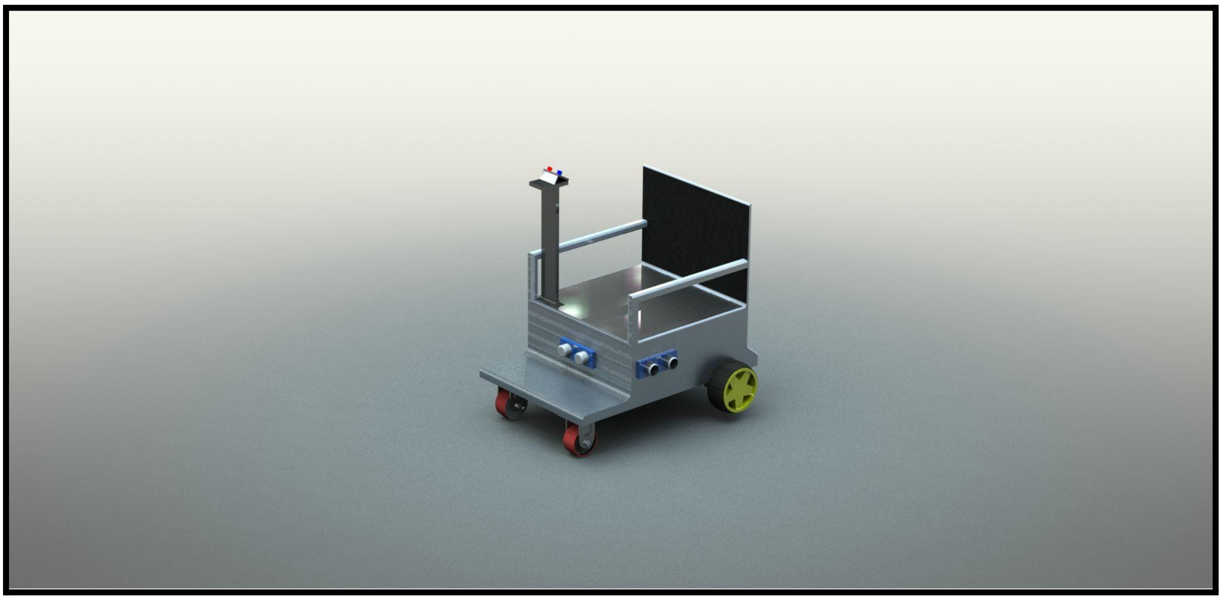

Figure 49: 3D model of the prototype

Following the design and simulation we started the implementation of the prototype. The prototype has a scale ratio of 1:4. The standard wheelchair can have a maximum length of 42 inches and a width of 30 inches, as shown in figure 50. So according to that the small scale prototype is adjusted, resulting in a length of 10 inches and width of 8 inches.

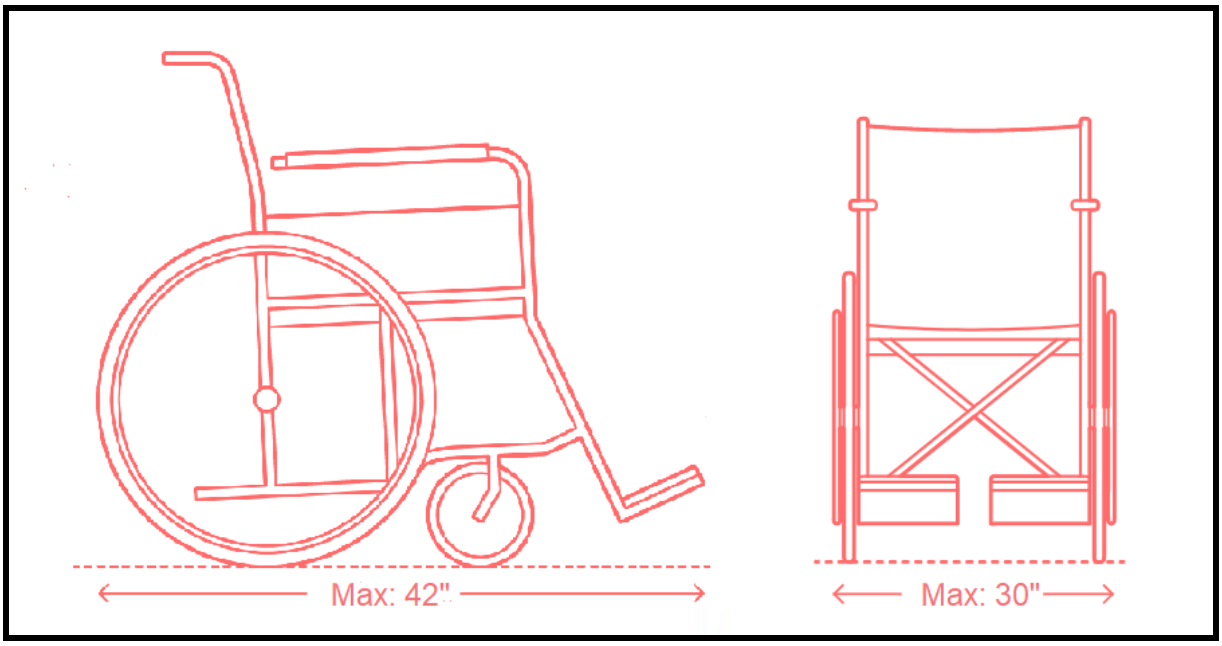

Figure 50: Standard wheelchair dimensions

According to the stakeholder's suggestion we planned to keep the full-scale model's speed limited to 2 km/h. For the 1:4 scale prototype the speed comes down to 500 m/h. For the prototype we chose wheels with a diameter of 2.5 inches.

With a wheel diameter of 65 mm (~ 2.5 inches), for each rotation of the wheel the wheelchair will move the same distance as its circumference. Circumference, $C = 2\pi r$, where 'r' is the radius of the wheel. And with a wheel diameter of 65mm or 0.065m the circumference comes to be $C = 0.19634m$. To achieve the predetermined 500 m/h, the motor should have a minimum RPM = $\frac{500}{0.19634*60} = 42.44$. So, for the prototype we chose a motor with a RPM of 50.

Then we built the prototype where the MCU received the brain signal via bluetooth connection and based on the threshold, actions were extracted and translated into movement commands. The same MCU was also processing the IMU data and the sonar sensor data. During the development phase we noticed false and delayed execution of the commands. After a thorough investigation we found out that the delay was happening due to the time taken by IMU and sonar sensors to provide the data. In figure 51 the working principle of the sonar sensor is provided.

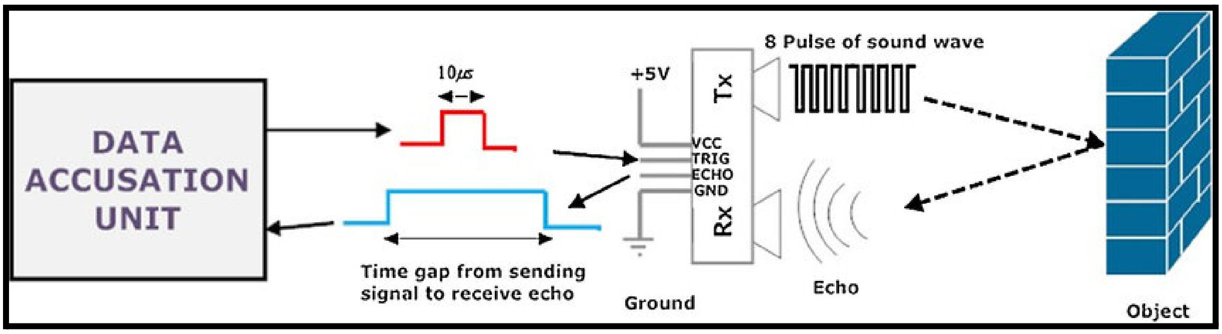

Figure 51: Working principle of sonar sensors

From figure 51 we can see that to detect an obstacle the sonar needs a certain amount of time and during that time the MCU can't process other data. In the development we polled all the three sonar sensors at the same time, resulting in a noticeable blocking time for the processing unit and thus the MCU was skipping a few brain signals. To overcome this limitation we revised the obstacle detection methodology. Rather than polling all the sensors at the same time, we polled only one direction's sensor and the sensor selected for polling was the sensor that was detecting obstacles in the moving direction. This modification in the obstacle detection methodology improved the prototype's accuracy significantly. To further reduce the latency in recognizing commands, the fall detection's methodology was revised. Rather than using ESP-01 only as a communication device, we replaced it with the ESP-32 and shifted the total fall detection algorithm to this MCU. So, the previous problem due to the IMU polling continuously was solved. For the safety of the users, we also implemented a collision detection system. But to stop the control mechanism from flooding with data we shifted the collision detection system to the ESP-32 as well. But the problem we faced here was that the collision detection system was falsely triggered while the wheelchair was moving. It was due to the shaking of the wheelchair during its mobility. To overcome the issue we bridged both the MCUs, so that they can communicate with each other and when the wheelchair is moving, the Arduino Mega can command the ESP-32 to stop running the collision detection algorithm. The system is equipped with a buzzer to notify the people around about any unexpected events and at the same time the ESP-32 handles the process of sending SMS notifications. After all the modifications we came up with the initial prototype of the wheelchair shown in figure 52 and 53.

Figure 52: Front view of the initial prototype

Figure 53: Side view of the initial prototype

After the implementation of the initial prototype, we arranged another meeting with the stakeholders and demonstrated the prototype in front of them. One of their representatives also used the prototype. They have provided us with some additional feedback and requirements, which have been tabulated in chapter 1 section 1.2.3's table 03. Few of the major suggestions provided to us in the second meeting with the stakeholders are to incorporate a joystick in order to provide the option of controlling the wheelchair using both brain signals and with the patient's wrist. Next, regarding the movement direction of the wheelchair the stakeholder's delegates suggested to provide the option of going backwards as well. Finally, they suggested incorporating an option to control the speed of the wheelchair. After the feedback we modified the prototype according to the suggestions provided by the stakeholders. For the joystick control we implemented a switching mechanism. If the joystick's center button is pressed and held for more than 3 seconds then the control mechanism will switch between brain control and joystick control. Next to implement the speed control feature, we used a rotary input device. All the data regarding control methodology and speed is displayed in an OLED display attached to the system. The final implemented prototype can be seen in the following figure 54.

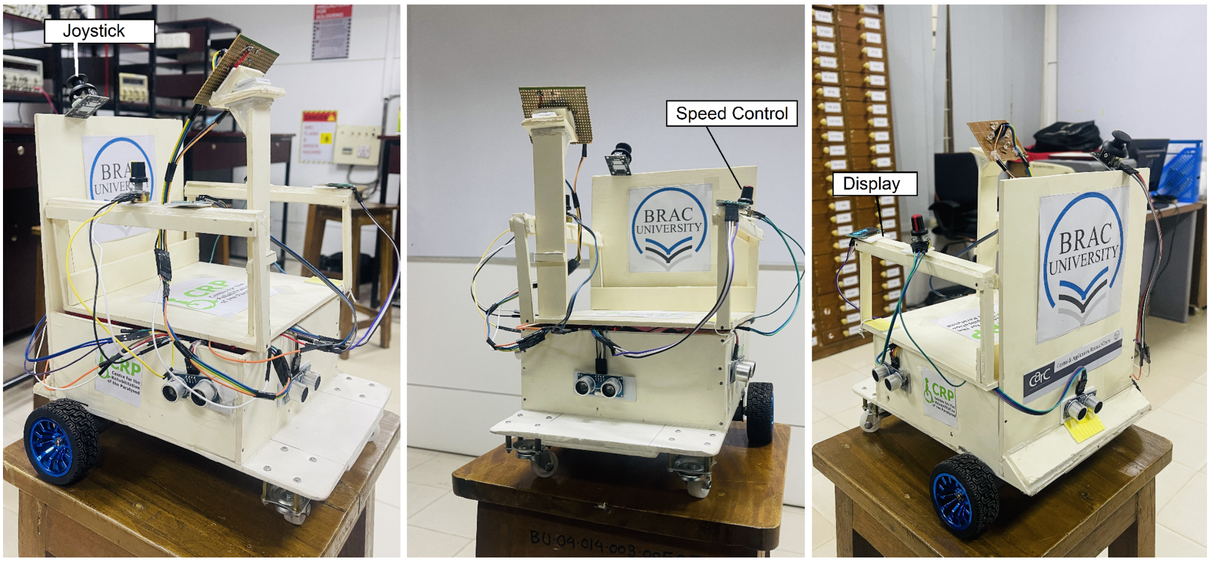

Figure 54: Final prototype of the wheelchair incorporating stakeholder feedback

For the health monitoring we had chosen a total of 5 vitals - temperature, oxygen saturation, blood pressure, heart rate, and ECG. For the body temperature measurement, we chose DS18b20 with a probe. For the oxygen saturation, we used a MAX30100 sensor. Apart from oxygen saturation, the sensor is also capable of measuring heart rate. During the implementation phase, when we incorporated the MAX30100 with DS18b20, the system was not able to measure the value of oxygen saturation and heart rate, however, the temperature sensor was giving appropriate readings. After proper investigation of the MAX30100 datasheet and its library for interfacing with MCU, we found out that the MAX30100 incorporates a 16 sample memory bank which is practically a FIFO buffer. In order to get the values from the buffer of MAX30100, in the MCU we need to sample the update function at a 10 ms interval. This is due to the sampling rate of MAX30100 which is 100 Hz. In other words, the MCU can not process any other tasks that take more than 10 ms to execute in order to stop the FIFO buffer from filling out and stopping the sensor from providing measurements. To overcome this issue we revised the methodology of how frequently the system will measure oxygen saturation. We will be measuring the temperature of the body and then for 10 seconds the system will stop measuring temperature and activate the MAX30100 and after 10 seconds of continuous reading, the system will deactivate the MAX30100 and measure other vitals and then reactivate the MAX30100. Thus, the problem of the overflow of FIFO buffer memory will be solved and the system will be able to measure all the vitals simultaneously.

For the acquisition of blood pressure, we took a commercially available wrist blood pressure monitoring machine (CK101S), and using the I2C sniffing technique, we read the values by the MCU of the health monitoring portion. The key point here is the blood pressure monitoring machine has an on-board EEPROM and is used to store the last few measured data. For this, the data had to be transmitted to the EEPROM chip over the I2C protocol, which is basically a serial communication technique. It uses two wires to transmit data between devices with a specific I2C address. The methodology of how I2C protocol works is graphically represented below.

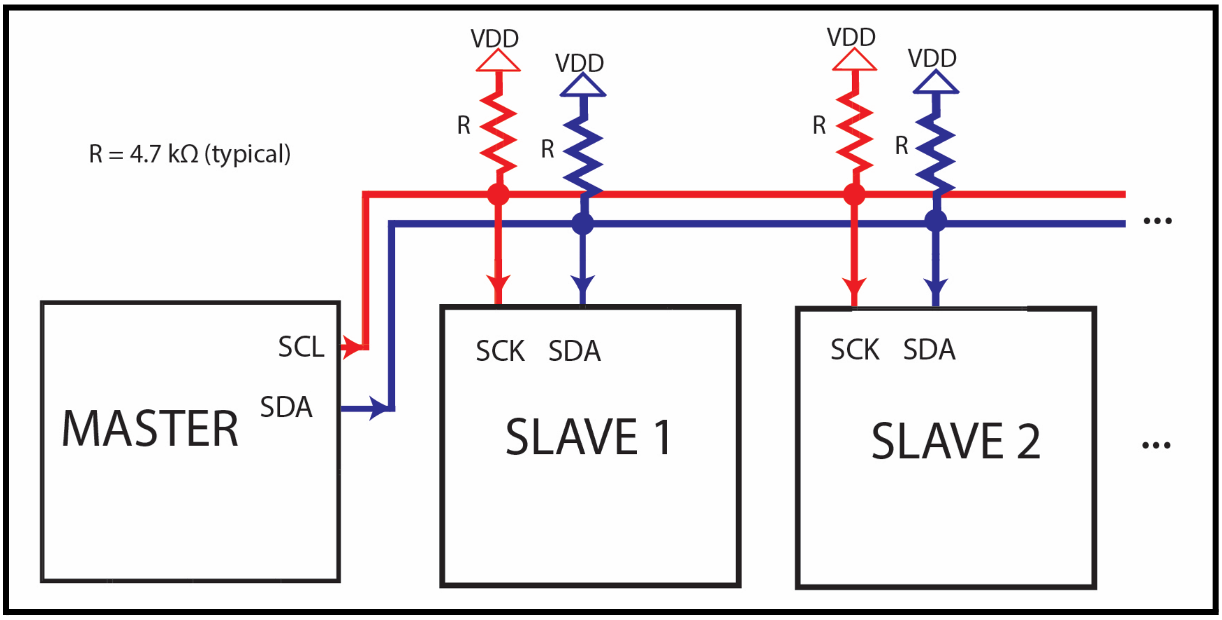

Figure 55: EEPROM chip over I2C Protocol mechanism

We used this functionality of the blood pressure machine in order to acquire the data in the MCU. For this the MCU had to act as a slave with specific addtress in the transmission bus, which was not possible with the ESP-32, as ESP-32 can't work as a slave device. For this we had to revise the methodology of acquiring blood pressure and introduced a 3.3V arduino pro mini to the system. The purpose of this device was to act as a slave in the data transmission bus and acquire the transmitted data by the blood pressure machine. The data was transmitted once the measurement was fully complete. To check the completion of taking the measurement we used the logical state of the valve of the blood pressure machine. After the completion of the measurement we have seen the device transmits exactly 35 values and from which the 28th is the systolic blood pressure, 29th diastolic blood pressure and 30th is the heart rate measurement. So, we extracted those values once 35 values were received from the blood pressure machine. The blood pressure measurement is not continuous. The user can set a specific time interval for taking blood pressure measurement or set a specific time of the day to take the blood pressure measurement. In the implemented system the user also has the option to manually activate blood pressure measurement. The communication between arduino pro mini and ESP-32 is established via serial communication. Once the measurement is done the arduino pro mini sends the acquired data to the ESP-32 via serial communication and the ESP-32 sends the received data to the IoT cloud.

The ECG data is acquired using the arduino pro mini. The reason behind this revised methodology is the non-linear nature of the ESP-32's ADC and the non-trivial requirement of calibration of the ESP-32's ADC. According to [23] minimum sampling frequency of 500Hz or more is considered to be optimal for the ECG signal acquisition. According to [24] the IoT server can handle at max 100 requests per second offering at max 100 samples per second. This limitation raises another concern and that's why the acquired ECG signal is transmitted via bluetooth to a connected device and not sent to the IoT server. The ECG is not continuously done. Whenever ECG is requested from the mobile application the system takes ECG for 1 minute and during this period all the ECG data is sent to the connected mobile device. For the ECG we used AD8232 3 lead ECG module. ECG is prone to noise present in the household ac line. So, during the implementation phase we had to make sure that while taking ECG the device is not powered from the mains of the household. Further while taking ECG the person should be at rest and body movement should be avoided as much as possible. During the period of ECG data acquisition it also needs to be ensured that the person is wearing insulating material and none of the body parts are directly in contact with ground. The implemented ECG system can measure ECG from the following two electrode placement options provided below. However number 2 (Placement option provided in the right most) of the provided image is more preferable for ECG data collection.

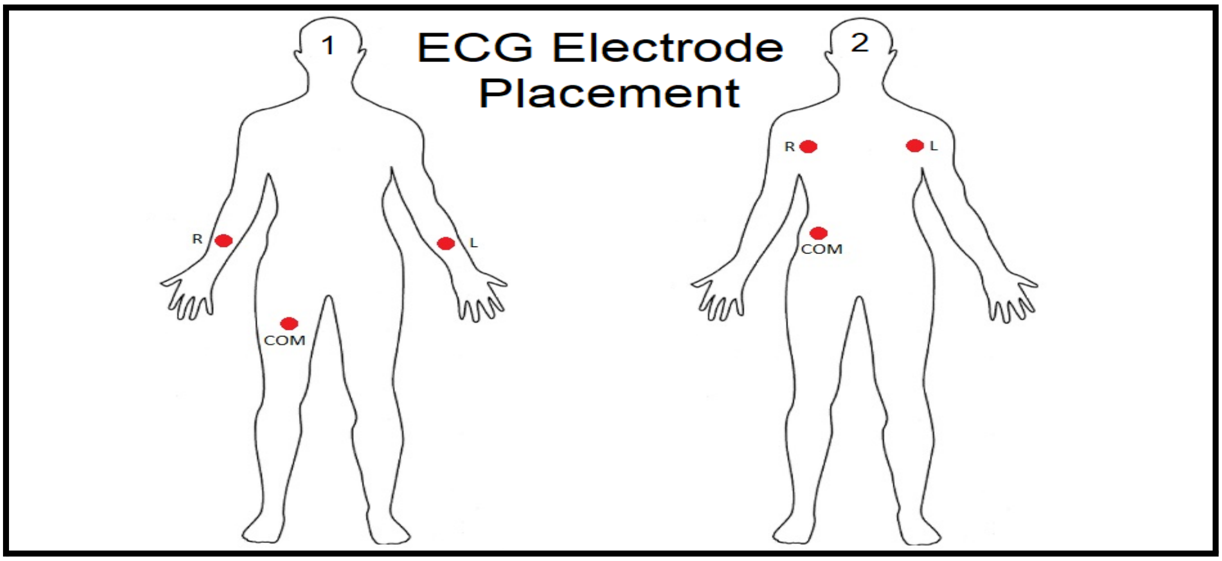

Figure 56: ECG Electrode placement direction in Human body.

In case of any abnormality in health vitals like high temperature, fast heart rate or low oxygen saturation, the system will immediately send a notification SMS to the authorized person's mobile number. For the locally data visualization we attached an OLED display with the implemented system. The implemented system is shown in the following figure.

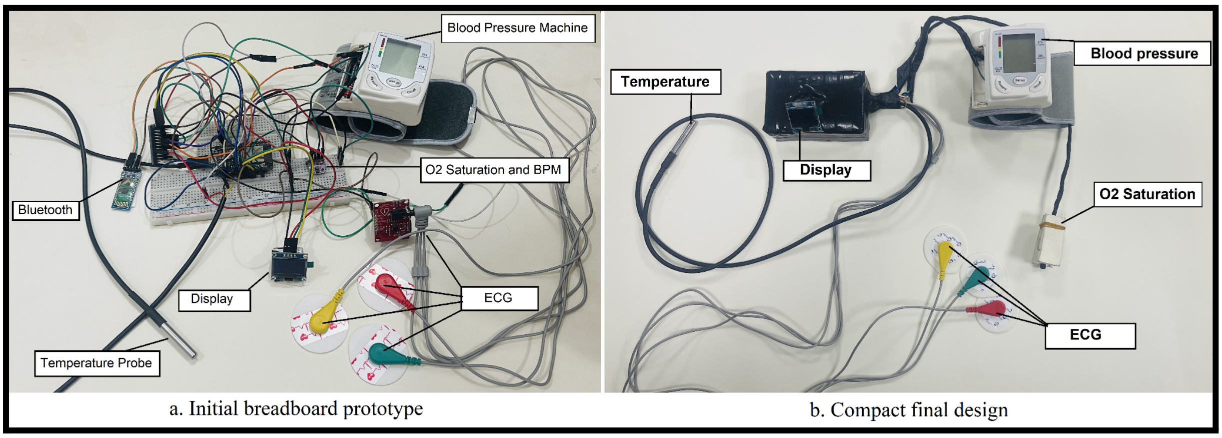

Figure 57: Final viewpoint of the Health Monitoring system.

The IoT application for health monitoring can be seen from the following figure.

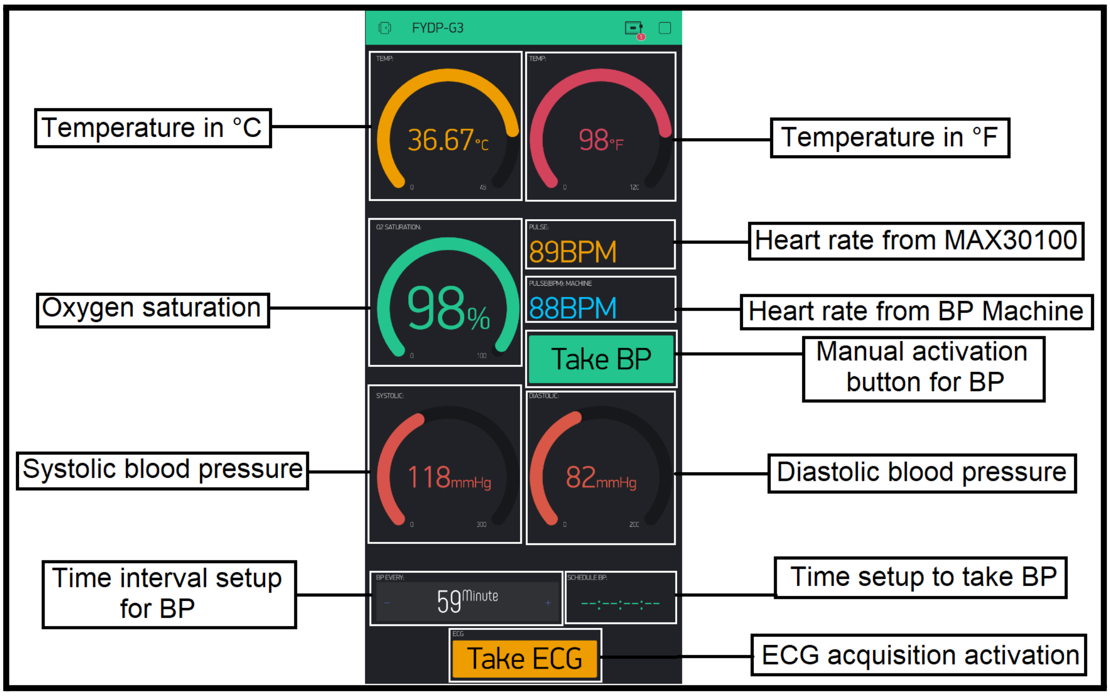

Figure 58: Mobile application of Health Monitoring system.

5.3 Evaluate The Solution to Meet Desired Need

The developed system has two subsystems, one for the control mechanism of the wheelchair and another for health monitoring. In the control mechanism the main concern is the accuracy of the control mechanism. To evaluate the control mechanism we have collected data of a total of 6 users while using the small scale prototype equipped with the developed control mechanism and recorded the time and executed the command simultaneously. For the experimental data collection we have tested the prototype with no training, with 15 minutes of training and finally with 30 minutes of training on the subject. After the experiment, data of individual subjects are tabulated below.

In the table following notations are used:

CET	Command execution time
MCDE	Misfire count during the experiment

Volunteer - 1 data:

Command to execute	No training			After 15 minutes of training			After 30 minutes of training		
	Executed command	CET (s)	MCDE	Executed command	CET (s)	MCDE	Executed command	CET(s)	MCDE
Activation	Activation	2.34	5	Activation	1.87	2	Activation	2.35	2
Activation	Activation	2.14		Nothing	2.16		Activation	1.82	
Forward	Forward	1.23		Forward	1.42		Forward	1.42	
Forward	Forward	1.41		Forward	1.26		Forward	1.37	
Right	Backward	4.58		Right	1.41		Right	1.39	
Right	Right	1.45		Right	1.54		Right	1.04	
Left	Left	1.38		Left	1.71		Left	1.25	
Left	Left	1.29		Left	1.48		Left	1.61	
Backward	Left	4.62		Backward	1.26		Backward	1.06	
Backward	Backward	1.04		Backward	1.38		Backward	1.41	
Stop	Stop	0.93		Stop	0.81		Stop	0.94	
Stop	Stop	1.02		Stop	0.87		Stop	0.69	
Successful	**10**			**12**			**12**		

Table 19: Control mechanism verification volunteer 1.

Volunteer - 2 data:

Command to execute	No training			After 15 minutes of training			After 30 minutes of training		
	Executed command	CET (s)	MCDE	Executed command	CET (s)	MCDE	Executed command	CET(s)	MCDE
Activation	Nothing	-	7	Activation	2.47	4	Activation	1.53	2
Activation	Activation	1.48		Nothing	-		Activation	2.23	
Forward	Forward	1.26		Forward	1.23		Forward	1.58	
Forward	Forward	1.88		Forward	1.1		Forward	1.26	
Right	Right	1.03		Right	1.08		Right	1.15	
Right	Right	1.46		Right	1.25		Right	1.28	
Left	Left	1.79		Left	1.08		Left	1.47	
Left	Left	1.33		Left	1.26		Left	1.16	
Backward	Backward	1.38		Backward	1.38		Backward	1.23	
Backward	Backward	1.06		Backward	1.12		Backward	1.66	
Stop	Stop	0.9		Stop	0.66		Stop	0.89	
Stop	Stop	0.68		Stop	0.65		Stop	1.13	
Successful	**11**			**11**			**12**		

Table 20: Control mechanism verification volunteer 2.

Volunteer - 3 data:

Command to execute	No training			After 15 minutes of training			After 30 minutes of training		
	Executed command	CET (s)	MCDE	Executed command	CET (s)	MCDE	Executed command	CET(s)	MCDE
Activation	Activation	1.96	6	Activation	1.93	2	Activation	2.58	1
Activation	Activation	1.46		Activation	2.15		Activation	2.14	
Forward	Forward	1.32		Forward	1.43		Forward	1.62	
Forward	Forward	1.68		Forward	1.22		Forward	1.37	
Right	Right	1.14		Right	1.03		Right	1.31	
Right	Right	1.52		Right	1.32		Right	1.48	
Left	Left	1.67		Left	1.26		Left	-	
Left	Left	1.24		Left	1.65		Left	1.15	
Backward	Backward	1.53		Backward	1.42		Backward	1.07	
Backward	Backward	1.03		Backward	1.59		Backward	1.57	
Stop	Stop	0.66		Stop	0.78		Stop	0.93	
Stop	Stop	0.87		Stop	0.92		Stop	1.26	
Successful	**12**			**12**			**11**		

Table 21: Control mechanism verification volunteer 3.

Volunteer - 4 data:

Command to execute	No training			After 15 minutes of training			After 30 minutes of training		
	Executed command	CET (s)	MCDE	Executed command	CET (s)	MCDE	Executed command	CET(s)	MCDE
Activation	Activation	2.08	5	Activation	1.94	5	Activation	2.13	2
Activation	Activation	1.73		Nothing	2.12		Activation	2.17	
Forward	Forward	1.57		Forward	1.3		Forward	1.43	
Forward	Forward	1.61		Forward	1.23		Forward	1.45	
Right	Right	1.45		Backward	4.37		Right	1.28	
Right	Right	1.68		Right	1.52		Right	1.34	
Left	Left	1.36		Left	1.74		Left	1.56	
Left	Forward	4.68		Left	1.14		Left	1.38	
Backward	Backward	1.14		Backward	1.25		Backward	1.39	
Backward	Left	4.93		Backward	1.31		Backward	1.71	
Stop	Stop	0.74		Stop	0.91		Stop	1.34	
Stop	Stop	0.82		Stop	0.84		Stop	1.11	
Successful	**10**			**11**			**12**		

Table 22: Control mechanism verification volunteer 4.

Volunteer - 5 data:

Command to execute	No training			After 15 minutes of training			After 30 minutes of training		
	Executed command	CET (s)	MCDE	Executed command	CET (s)	MCDE	Executed command	CET(s)	MCDE
Activation	Nothing	-	8	Activation	1.87	7	Activation	2.19	3
Activation	Activation	2.18		Nothing	-		Activation	1.95	
Forward	Right	4.16		Forward	1.47		Forward	4.06	
Forward	Right	4.43		Forward	1.03		Forward	1.27	
Right	Right	1.67		Right	1.27		Right	1.89	
Right	Right	1.39		Right	1.87		Right	1.54	
Left	Left	1.26		Forward	4.63		Left	1.32	
Left	Left	1.25		Left	1.52		Left	1.74	
Backward	Backward	1.53		Backward	1.38		Backward	1.32	
Backward	Backward	1.08		Backward	1.24		Backward	1.66	
Stop	Stop	0.85		Stop	0.78		Stop	1.01	
Stop	Stop	1.21		Stop	0.92		Stop	0.78	
Successful	**10**			**10**			**11**		

Table 23: Control mechanism verification volunteer 5.

Volunteer - 6 data:

Command to execute	No training			After 15 minutes of training			After 30 minutes of training		
	Executed command	CET (s)	MCDE	Executed command	CET (s)	MCDE	Executed command	CET(s)	MCDE
Activation	Activation	2.34	5	Activation	1.87	2	Activation	2.35	2
Activation	Activation	2.14		Nothing	2.16		Activation	1.82	
Forward	Forward	1.23		Forward	1.42		Forward	1.42	
Forward	Forward	1.41		Forward	1.26		Forward	1.37	
Right	Backward	4.58		Right	1.41		Right	1.39	
Right	Right	1.45		Right	1.54		Right	1.04	
Left	Left	1.38		Left	1.71		Left	1.25	
Left	Left	1.29		Left	1.48		Left	1.61	
Backward	Left	4.62		Backward	1.26		Backward	1.06	
Backward	Backward	1.04		Backward	1.38		Backward	1.41	
Stop	Stop	0.93		Stop	0.81		Stop	0.94	
Stop	Stop	1.02		Stop	0.87		Stop	0.69	
Successful	**10**			**12**			**12**		

Table 24: Control mechanism verification volunteer 6.

From the above given tables, we summarized the results. The first data that is tabulated is the misfire count during the execution. While using the prototype few unintentional commands were executed. The results have been tabulated below:

Subject	Without training	After 15 minutes training	After 30 minutes training
Volunteer - 1	5	3	1
Volunteer - 2	7	4	2
Volunteer - 3	6	2	1
Volunteer - 4	5	5	2
Volunteer - 5	8	7	3
Volunteer - 6	5	2	2

Table 25: Misfire count during the data collection

The acquired results can be visualized by the following graphical representation:

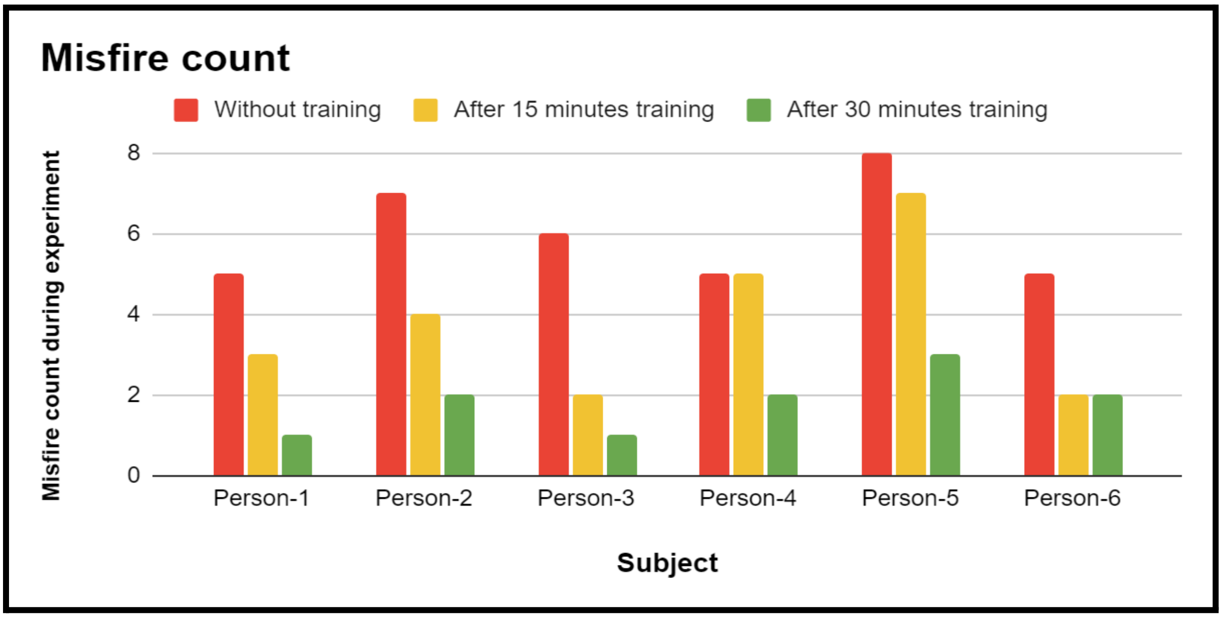

Figure 59: Graphical representation of misfire counts.

From the graph we can observe that with the increasing time period of training the misfire count was reduced significantly for all the participants. Also the above graph shows that with around 30 minutes of training the misfire count was reduced significantly, to less than 2.

In the data collection experiment, we have given each participant a total of 12 commands and recorded the succession of executing the commands. Based on that data the average accuracy can be measured with the variation of usage of the system. The table below shows the accuracy of the developed control mechanism.

Subject	Without training	After 15 minutes training	After 30 minutes training
Volunteer - 1	11	11	12
Volunteer - 2	11	11	12
Volunteer - 3	12	12	11
Volunteer - 4	10	11	12
Volunteer - 5	10	10	11
Volunteer - 6	10	12	12
Accuracy	88.89%	93.06%	97.22%

Table 26: Accuracy data analysis of developed control mechanism

The data presented in the above table can be graphically presented using the following graph:

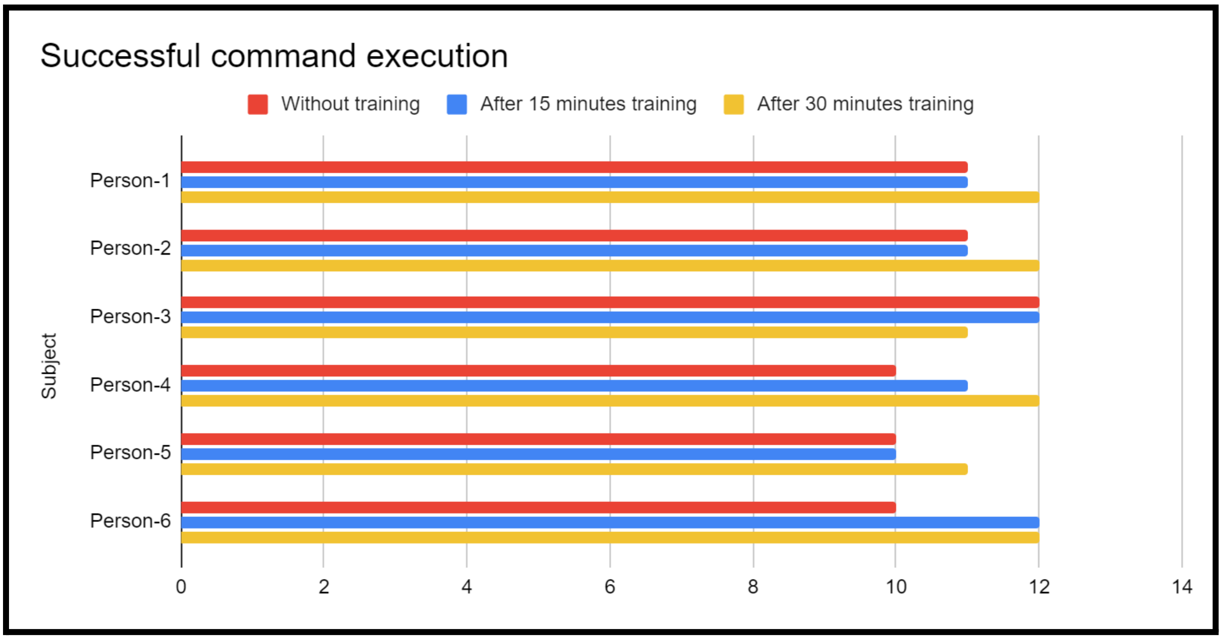

Figure 60: Graphical representation of successful command execution.

From the above graph it's evident that as the training period increases, the number of successfully executed commands also increases. The same result also reflects in the accuracy graph given below.

Figure 61: Graphical representation of accuracy before and after training.

From the graph we can see that without any training the system had an overall accuracy of 88.89%, but with only 15 minutes of training the accuracy increased to 93.06% and with further training which is 30 minutes in this case, we observe an accuracy of 97.22% of the developed system.

It is evident that with the increased time period for training, the participants get more accustomed to the system, resulting in a better accuracy of the control mechanism. Furthermore each of the participant's accuracy over the training period has been noted down in the following table:

Subject	Without training	After 15 minutes training	After 30 minutes training
Volunteer - 1	91.67%	91.67%	100.00%
Volunteer - 2	91.67%	91.67%	100.00%
Volunteer - 3	100.00%	100.00%	91.67%
Volunteer - 4	83.33%	91.67%	100.00%
Volunteer - 5	83.33%	83.33%	91.67%
Volunteer - 6	83.33%	100.00%	100.00%

Table 27: Accuracy of control mechanism of different subjects

The same data can visualized by the following graph:

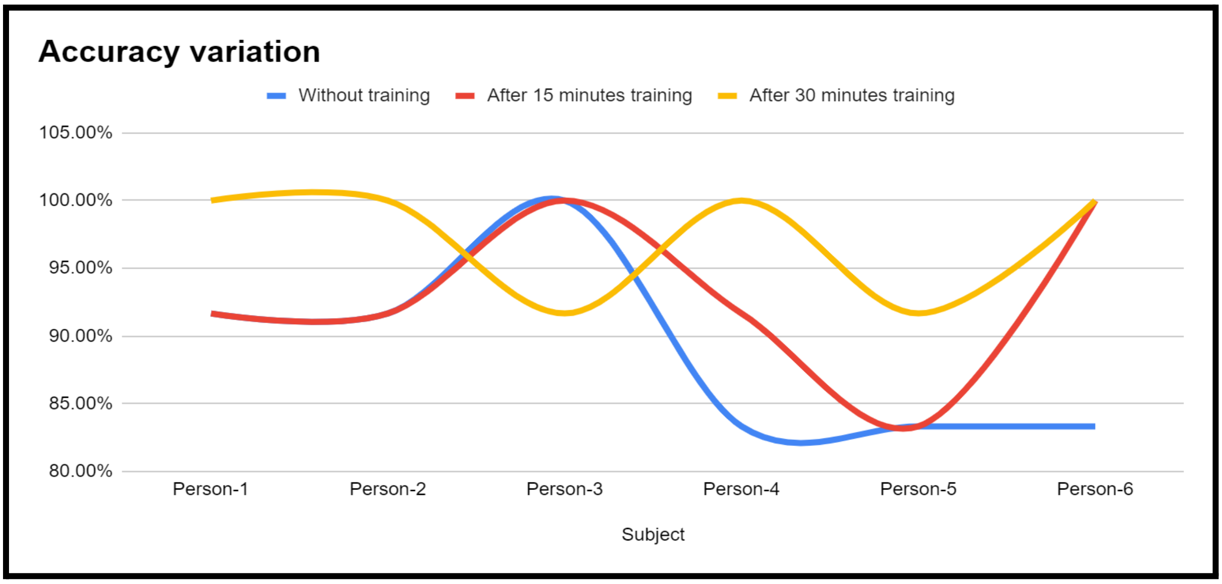

Figure 62: Accuracy variations of different persons regarding control mechanism

The next point of concern for the control mechanism is the response time. So, during the data collection phase we also recorded the time period from when the participant was asked to move to a direction to the successful execution of that specific command. In a few cases we have seen some malfunction of the control mechanism. During the calculation of the average execution time of the commands, we excluded those timings. The execution time has been tabulated below:

Command	Execution time (s)
Activation	1.931
Forward	1.402727273
Right	1.393235294
Left	1.421212121
Backward	1.345588235
Stop	0.895

Table 28: execution time vs command tabulated data

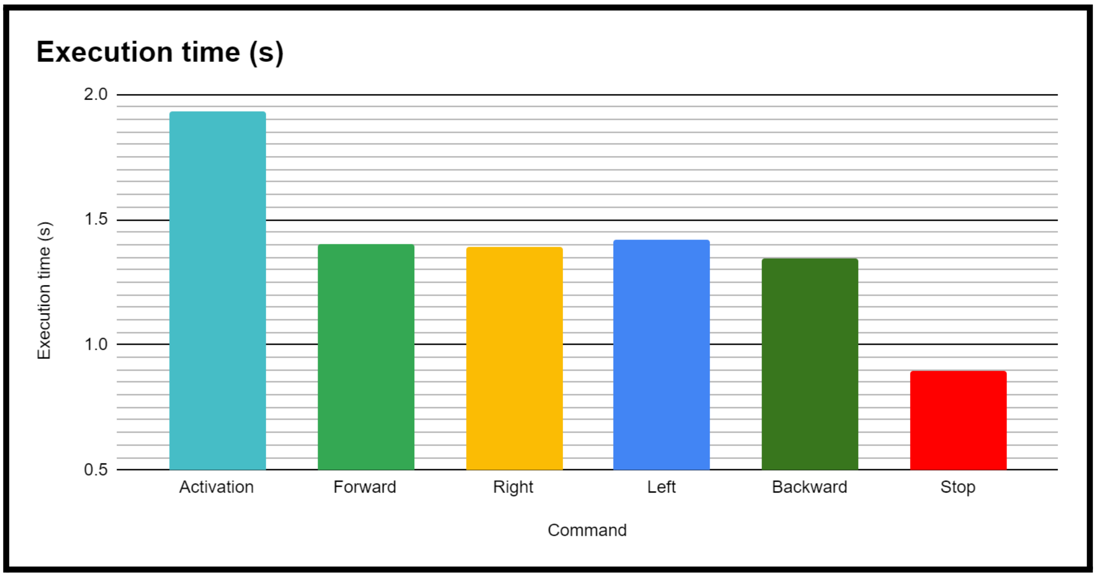

Figure 63: Graphical representation of execution time vs command

According to the stakeholder's requirement, after the modification, we incorporated a joystick in the prototype. The joystick's performance regarding the movement commands was another point of concern for the control mechanism. We gave commands to move in various directions using the joystick and recorded whether it was successfully executed or not. The tabulated results are as follows:

Command Direction	Executed Command	Misfire
Forward	Forward	NO
Forward	Forward	NO
Forward	Forward	NO
Right	Right	NO
Right	Right	NO
Right	Right	NO
Left	Left	NO
Left	Left	NO
Left	Left	NO
Backward	Backward	NO
Backward	Backward	NO
Backward	Backward	NO
Stop	Stop	NO
Stop	Stop	NO
Stop	Stop	NO

Table 29: Joystick execution time vs command tabulated data

From the above tabulated data, we can conclude that the implemented joystick control system performed all the commands with 100% accuracy.

Another functionality that was implemented was the speed control mechanism. For the validation, we set up a testing area of 1 meter in length and recorded the time period for moving a displacement of 1 m. The recorded data are as follows:

PWM (%)	Time for 1m (s)	Speed (m/s)	Speed (km/h)
10%	36.23	0.028	0.099
20%	29.32	0.034	0.123
30%	24.56	0.041	0.147
40%	20.26	0.049	0.178
50%	16.7	0.060	0.216
60%	14.21	0.070	0.253
70%	12.57	0.080	0.286
80%	11.32	0.088	0.318
90%	10.05	0.100	0.358
100%	9.32	0.107	0.386

Table 30: Variable Speed control mechanism data

The graphical representation of the tabulated data are as follows:

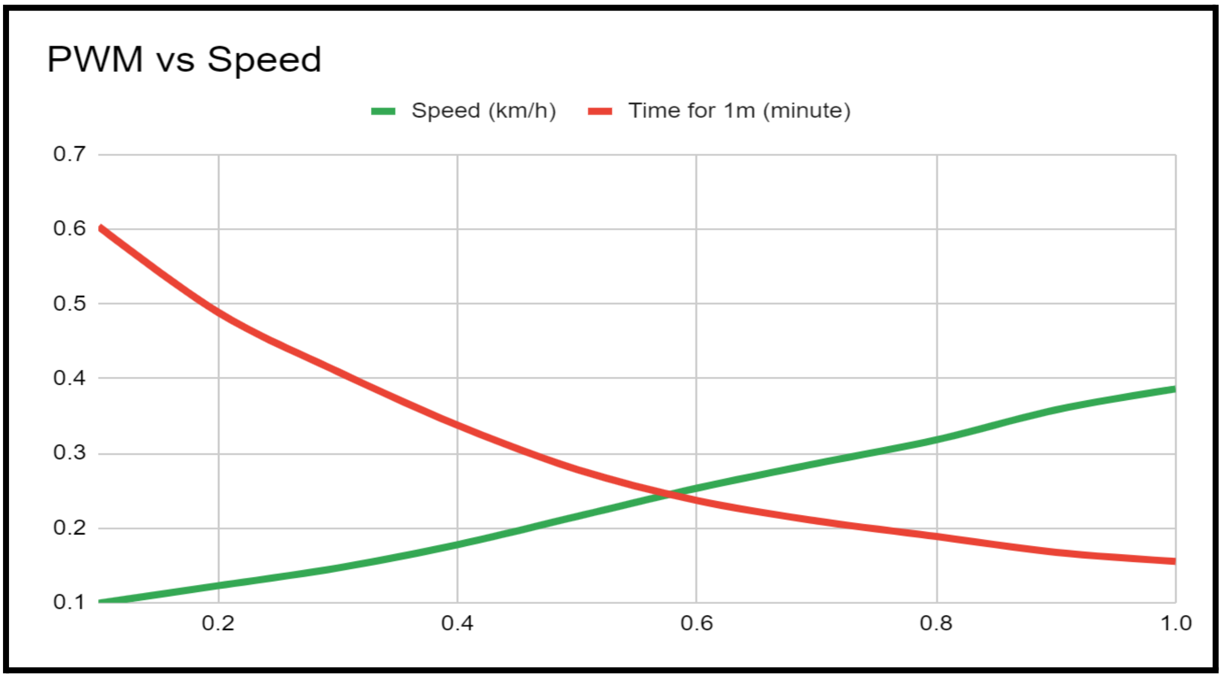

Figure 64: Variable speed control Graphical representation

From the graph we can see that as the PWM signal's percentage increases, the speed also increases and subsequently the required time to move 1 meter distance decreases. This validates that the system's implemented speed control mechanism is performing perfectly.

A major concern while developing a control mechanism for the wheelchairs is safety of the users. In the small scale prototype the implemented obstacle detection system had a forward direction threshold of 25 cm, in backward direction 20 cm and 15 cm in both the left and right directions. The systems obstacle detection was tested for both static and moving/dynamic obstacles and the distance between the prototype automatically stopping itself and the obstacle after detection is tabulated below:

Direction	Obstacle type	Detection	Stop Distance (cm)
Forward	Static	Yes	24.2
Forward	Static	Yes	23.95
Right	Static	Yes	13.6
Right	Static	Yes	13.1
Left	Static	Yes	13.3
Left	Static	Yes	13.2
Backward	Static	Yes	18.3
Backward	Static	Yes	17.8
Forward	Dynamic	Yes	22.3
Forward	Dynamic	Yes	23.1
Right	Dynamic	Yes	12.35
Right	Dynamic	Yes	12.55
Left	Dynamic	Yes	11.95
Left	Dynamic	Yes	12.2
Backward	Dynamic	Yes	17.55
Backward	Dynamic	Yes	17.9

Table 31: Obstacle detection according to command detection

Furthermore, the table is summarized in the following table with 2 types of categories, one for the detection direction and another for the type of obstacle the system detected.

Direction	Static obstacle	Dynamic obstacle
Forward	24.075	22.7
Right	13.35	12.45
Left	13.25	12.075
Backward	18.05	17.725

Table 32: Different obstacle detection

The graphical representation of the acquired data is as follows:

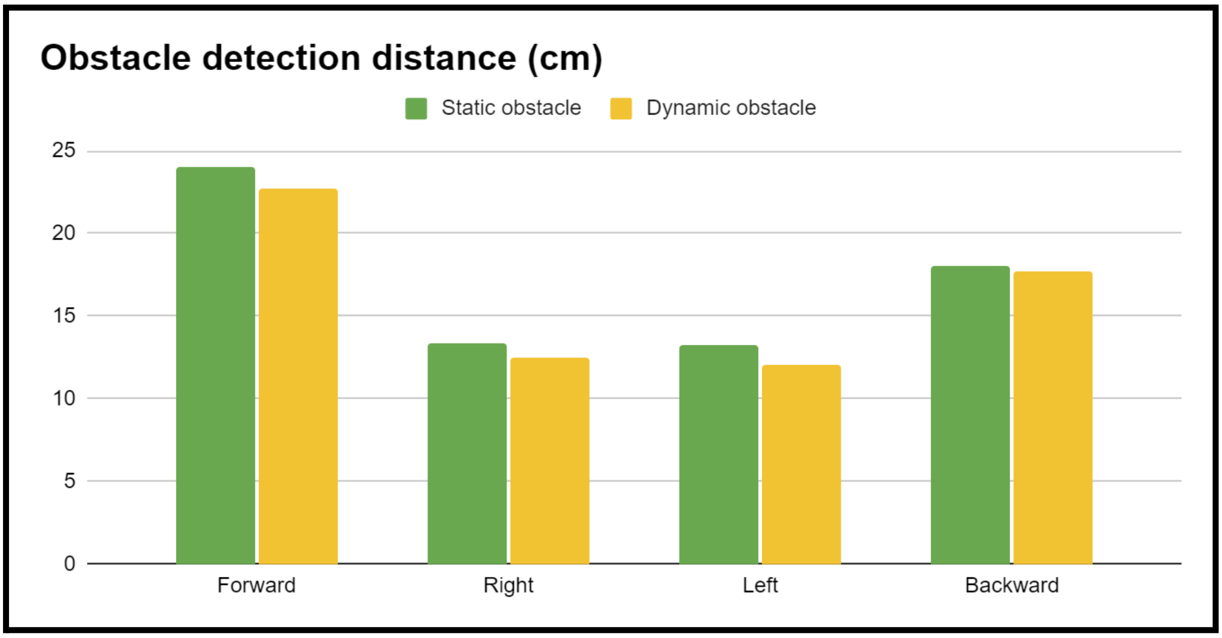

Figure 65: Obstacle detection graphical analysis according to command

From the provided graph it can be observed that the prototype's obstacle detection stopped itself after going a little further than the given threshold for detection of an obstacle in the environment. The error for the detection is tabulated and graphically represented in the following table 33 and figure 66 respectively.

Direction	Static obstacle	Dynamic obstacle
Forward	3.70%	9.20%
Right	11.00%	17.00%
Left	11.67%	19.50%
Backward	9.75%	11.38%
Average error	9.03%	14.27%

Table 33: Different obstacle error detection

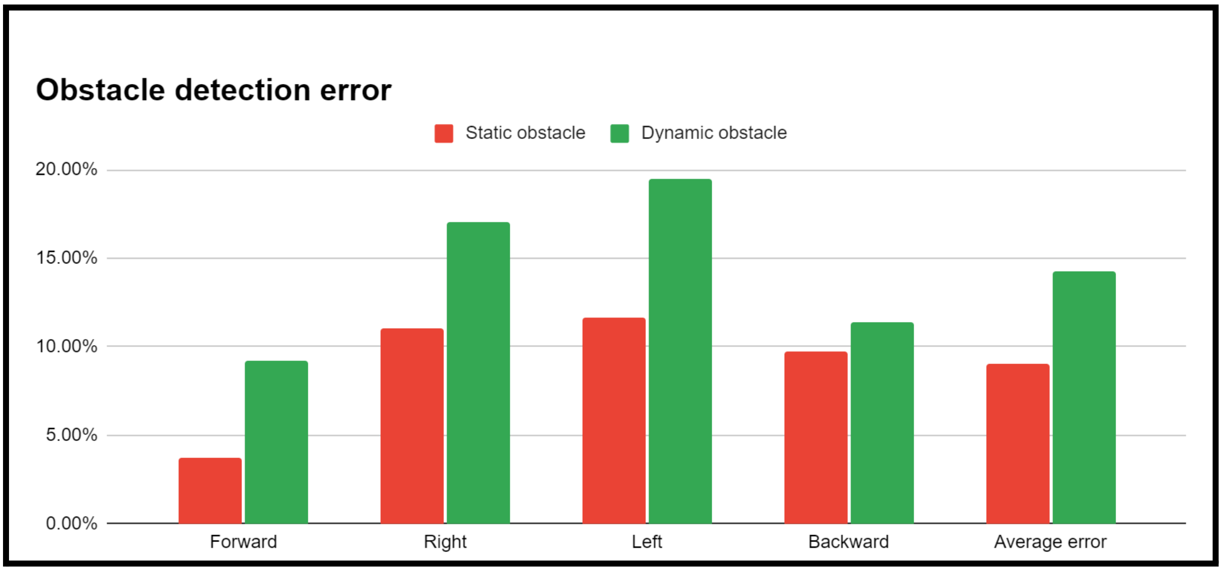

Figure 66: Obstacle detection error graphical analysis for different obstacle

From the tables and graphs we can observe that the obstacle detection system performed just as planned, there was minor error in the detection distance. The average error for the static obstacles was 9.03% and for dynamic obstacles it was 14.27%. So, from this we can infer that the system can detect static obstacles with more precision than dynamic obstacles, but for both kinds of obstacles, the obstacle detection system works within acceptable error limits.

For the safety mechanism, the system is equipped with a fall detection system which relies on the orientation of the wheelchair. If the wheelchair's direction orientation has an angle of more than a given threshold then the fall detection algorithm detects it and sends a SMS notification and turns on the buzzer until the original position is restored. The onboard collision detection algorithm works when the system is at rest and collides with something. In that case the system sends an alert SMS to the authorized person's mobile regarding this and the buzzer is also switched on for 5 seconds. The SOS button in the wheelchair, if held for more than 5 seconds, then the buzzer gets turned on for 10 seconds and a SMS notification is also sent. For all these events the SMS received is shown below.

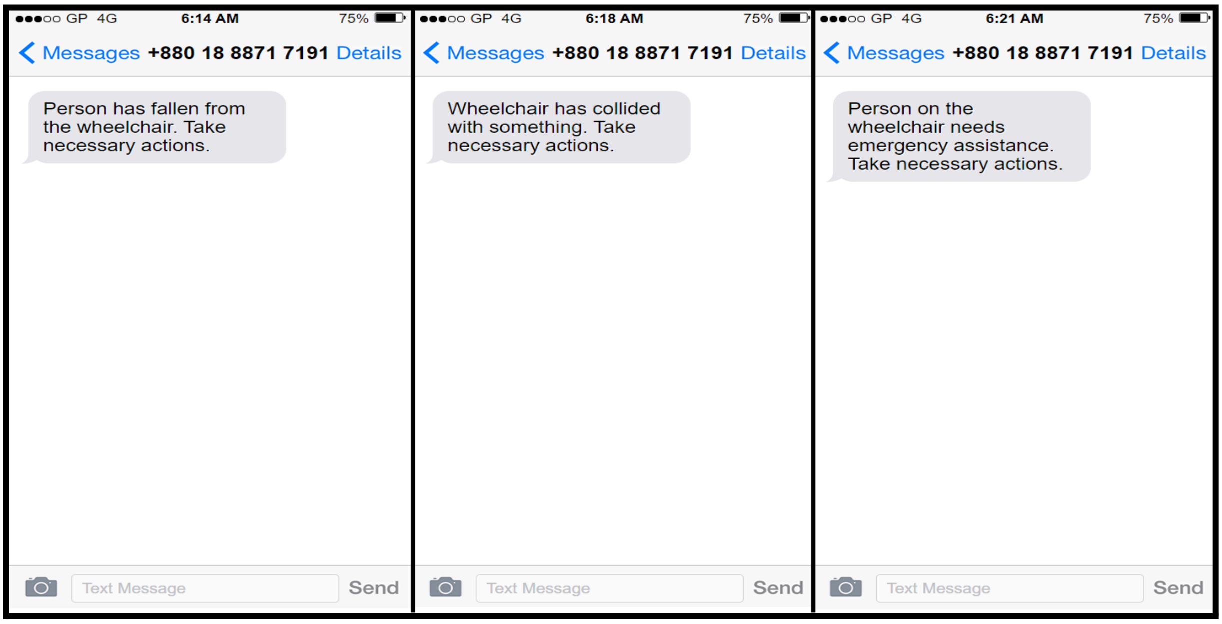

Figure 67: SMS notification of wheelchair additional security features

The time to receive the SMS was recorded to measure the latency of the alert system. The collected data is tabulated below:

	Fall		**Collision**		**SOS Button**
Direction	SMS Time (s)	Average SMS time (s)	SMS time (s)	Average SMS time (s)	Average SMS time (s)
Forward	6.74	5.915	5.92	6.065	5.7
Forward	6.19		6.71		4.48
Forward	5.78		4.73		5.16
Forward	4.95		6.9		4.89
Right	5.73	5.82	7.12	6.21	5.24
Right	6.12		5.48		5.17
Right	4.9		5.92		4.38
Right	6.53		6.32		5.12
Left	5.12	5.375	6.18	7.3125	5.46
Left	6.36		8.58		4.73
Left	4.54		9.12		5.033
Left	5.48		5.37		
Backward	4.93	5.3875	6.56	6.56	
Backward	6.52		7.93		
Backward	5.59		5.12		
Backward	4.51		6.63		

Table 34: wheelchair additional security features SMS time delay data

All the recorded latency data for the SMS alert system is graphically represented in the following graph:

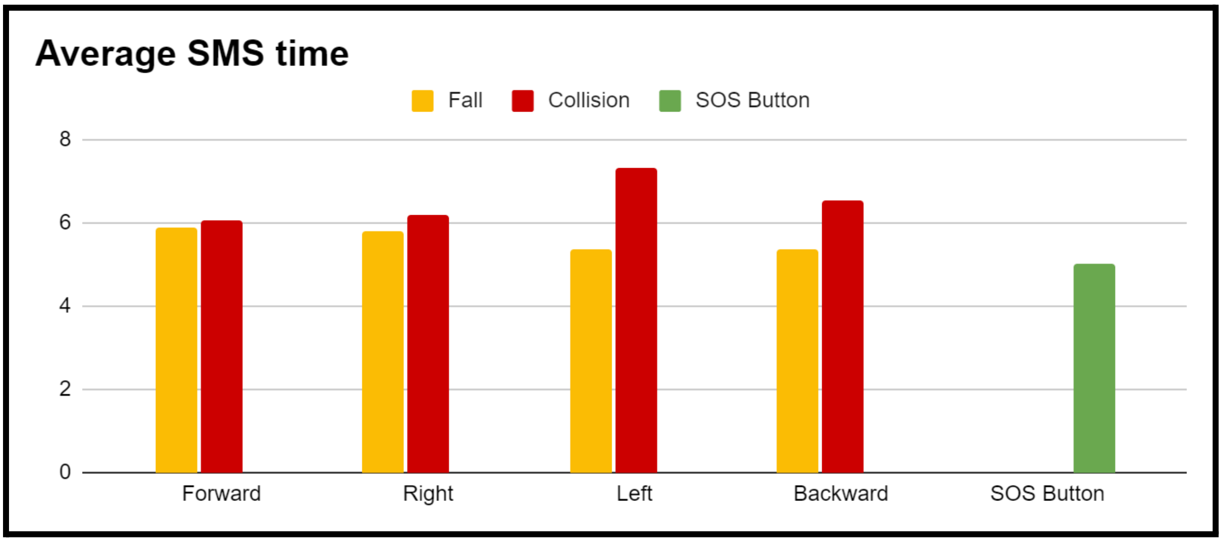

Figure 68: Graphical representation of average SMS time

We can observe that the latency of SMS alert system is around 5-6 seconds.

In order to validate the health monitoring portion of the implemented prototype we have collected data of different persons with the developed prototype and commercially available equipment. For the temperature acquisition accuracy, we have tested the implemented system on a total of 4 persons. The data were collected with an interval of 30 minutes between each measurement. The collected data is tabulated in the following table.

Volunteer	Data from the prototype	Data from thermometer	Error	Squared Error
1	98.285	98.4	0.115	0.013225
	98.28	98.2	-0.08	0.0064
	98.517	98.6	0.083	0.006889
	98.443	98.4	-0.043	0.001849
	98.562	98.5	-0.062	0.003844
2	97.65	97.6	-0.05	0.0025
	97.285	97.3	0.015	0.000225
	97.525	97.5	-0.025	0.000625
	97.462	97.5	0.038	0.001444
	97.632	97.6	-0.032	0.001024

3	99.135	99.1	-0.035	0.001225
	98.896	98.9	0.004	0.000016
	99.073	99	-0.073	0.005329
	98.675	98.7	0.025	0.000625
	98.479	98.5	0.021	0.000441
4	98.469	98.5	0.031	0.000961
	98.632	98.6	-0.032	0.001024
	98.576	98.6	0.024	0.000576
	98.432	98.5	0.068	0.004624
	98.71	98.6	-0.11	0.0121
			MSE	0.0032

Table 35: Temperature acquisition accuracy

From the provided table above the implemented system's temperature acquisition system has a mean squared error of only 0.0032. To visualize the deviation of measurement between the implemented prototype and commercially available thermometer is presented in the following graphical representation.

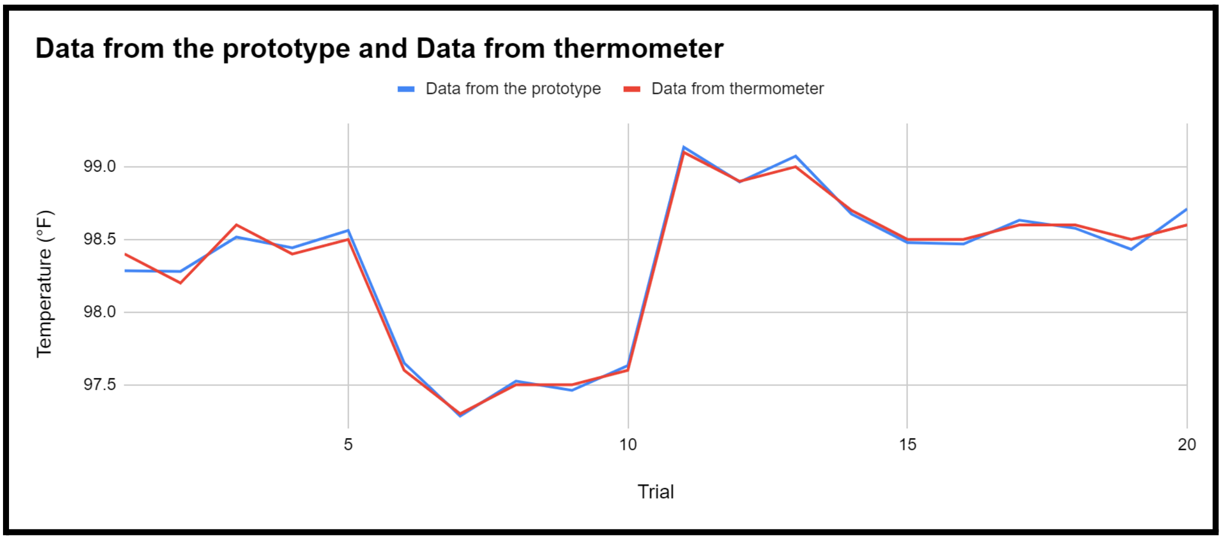

Figure 69: Graphical representation of temperature measurement accuracy

From the graph it can be seen that the implemented prototype has very less deviation from measured values from a commercially available device. However, one thing to be noted is that the implemented prototype's temperature measurement initially takes around 5 minutes to properly measure the temperature. Though there is initial latency present, for continuous monitoring it won't be a hindrance as with initial small settling time the device provides accurate values. The deviation of the thermometer's measured value and the implemented prototype's measured value can be seen from the following figure where a measured data is provided.

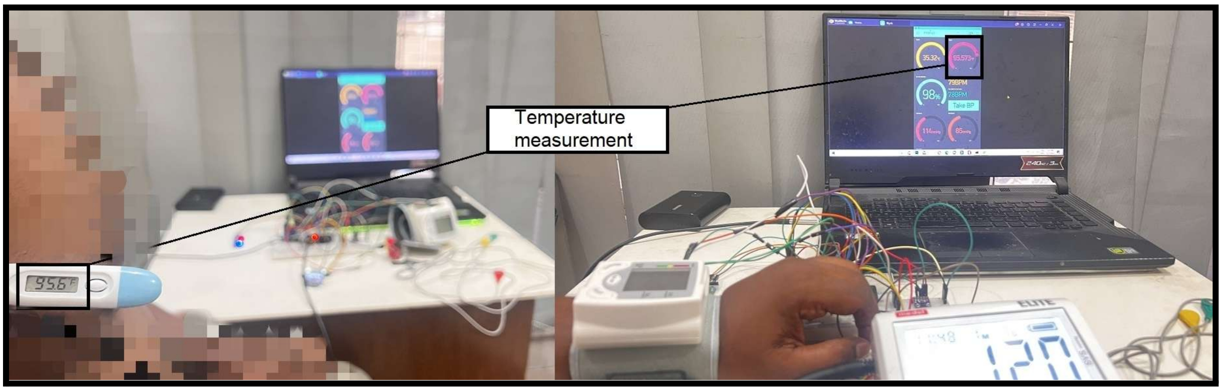

Figure 70: Digital thermometer and IoT device screen.

For the oxygen saturation and pulse rate measurement validation, we measured these parameters for a total of 4 persons with the implemented prototype and a commercially available pulse oximeter. The measurements are taken with a time interval of 15 minutes. The measured data are tabulated as follows.

Volunteer	Oxygen saturation				Heart rate			
	Data from the prototype	Data from commercial devices	Error	Squared Error	Data from the prototype	Data from commercial devices	Error	Squared Error
1	98	99	1	1	84	87	-3	9
	99	99	0	0	89	90	-1	1
	97	99	2	4	86	88	-2	4
	98	98	0	0	93	92	1	1
	99	98	-1	1	86	85	1	1
2	98	99	1	1	96	94	2	4
	96	98	2	4	94	92	2	4
	99	98	-1	1	88	88	0	0
	98	98	0	0	82	81	1	1
	99	99	0	0	98	97	1	1

3	98	97	-1	1	78	77	1	1
	99	99	0	0	85	86	-1	1
	99	99	0	0	72	73	-1	1
	98	97	-1	1	79	80	-1	1
	98	98	0	0	95	96	-1	1
4	97	99	2	4	89	91	-2	4
	98	99	1	1	97	95	2	4
	98	98	0	0	93	93	0	0
	97	98	1	1	81	79	2	4
	99	98	-1	1	86	84	2	4
			MSE	1.05			MSE	2.35

Table 36: Heart rate data acquisition accuracy

From the tabulated results we can observe an only 1.05 mean squared error for the implemented oxygen saturation measurements. The tabulated data for oxygen saturation can be further visualized from the following graph.

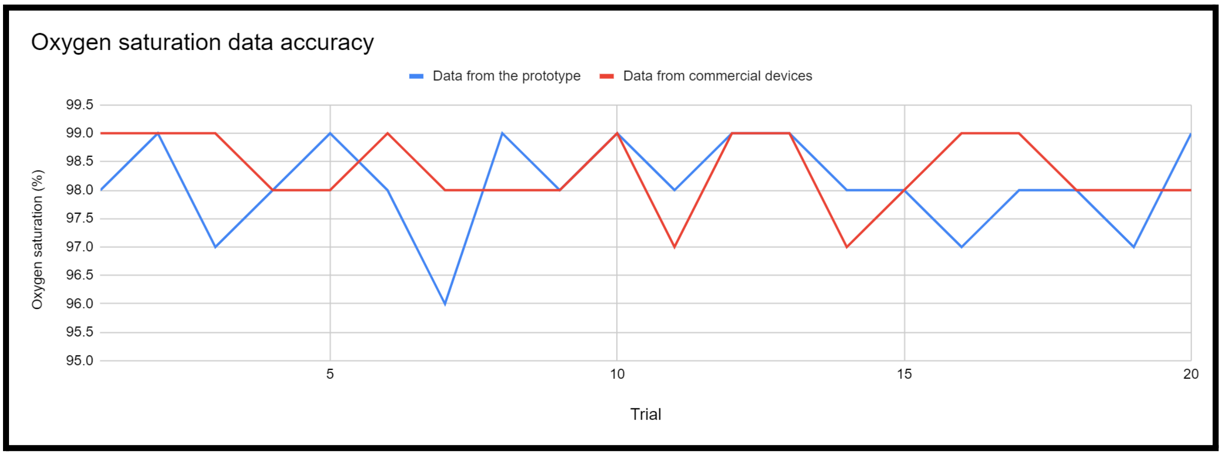

Figure 71: Graphical representation of spo2 measurement accuracy

The above attached table shows an only 2.35 mean squared error for the heart rate monitoring system. The deviation of the results can be visualized through the following graphical representation.

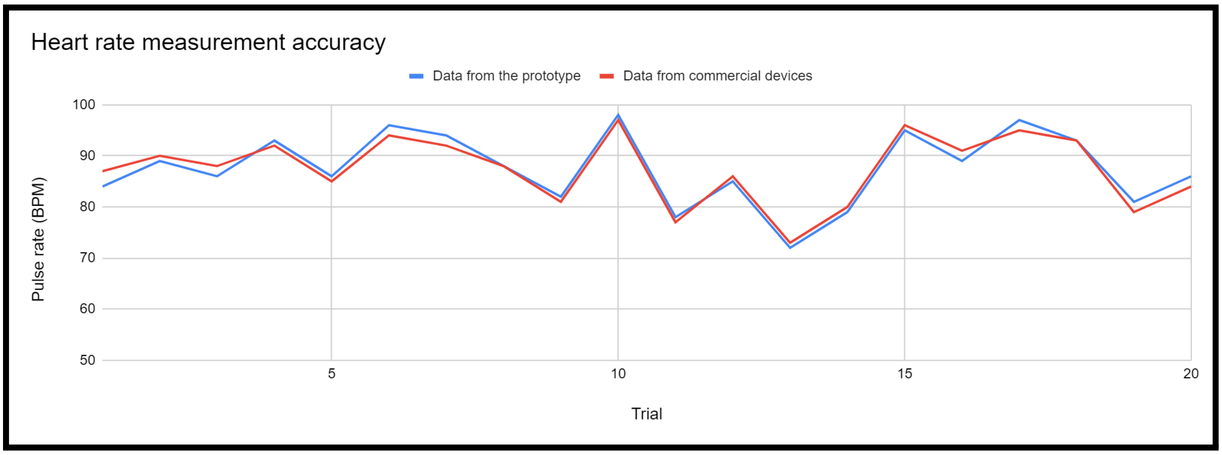

Figure 72: Graphical representation of heart rate measurement accuracy

From the above attached 2 graphical representations, it's evident that the implemented oxygen saturation and heart rate measurement system performs quite accurately. One measured value of the implemented device and the commercially available device is given as comparison in the following figure.

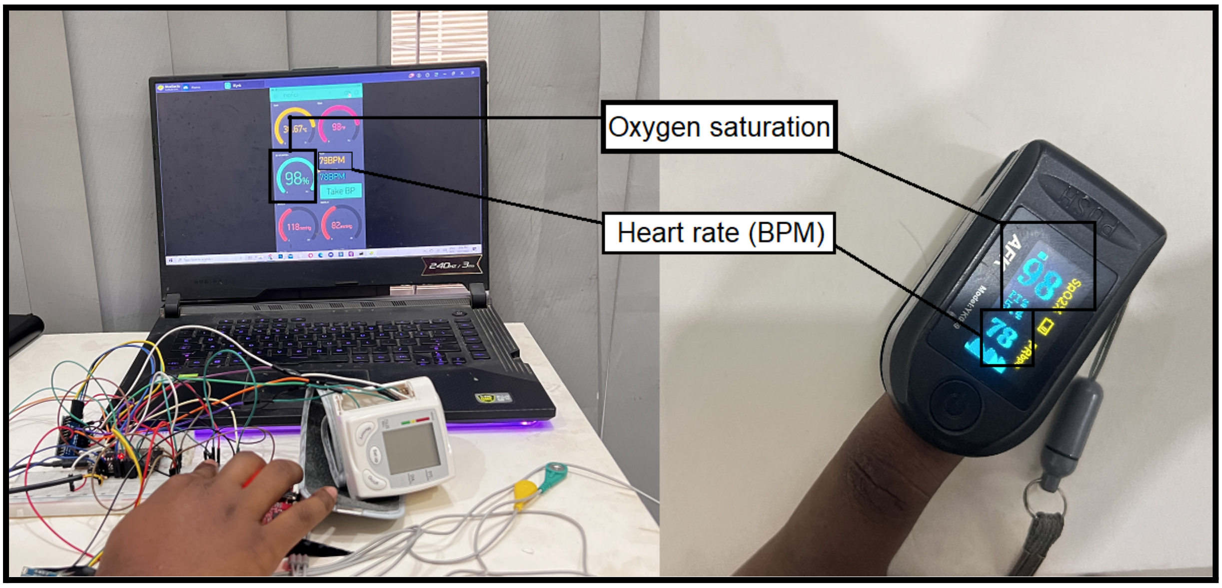

Figure 73: Pulse oximeter and prototype image.

In order to validate the blood pressure machine's accuracy we took measurements from 4 people with an interval of 30 minutes. In order to check the accuracy we used another approved machine ESH (European Society of Hypertension). The measured values are tabulated below.

Volunteer	Systolic blood pressure				Diastolic blood pressure			
	Data from the prototype	Data from commercial devices	Error	Error %	Data from the prototype	Data from commercial devices	Error	Error %
1	122	128	6	4.7	74	80	-6	7.5
	142	135	-7	5.2	83	89	-6	6.7
	129	138	9	6.5	82	78	4	5.1
	130	136	6	4.4	77	72	5	6.9
	135	142	7	4.9	68	77	-9	11.7
2	128	135	7	5.2	82	90	-8	8.9
	135	129	-6	4.7	86	78	8	10.3
	117	125	8	6.4	85	74	11	14.9
	141	133	-8	6.0	75	81	-6	7.4
	130	122	-8	6.6	91	85	6	7.1
3	112	118	6	5.1	73	79	-6	7.6
	135	129	-6	4.7	70	68	2	2.9
	109	117	8	6.8	85	78	7	9.0
	119	113	-6	5.3	71	74	-3	4.1
	106	113	7	6.2	76	80	-4	5.0
4	117	128	11	8.6	84	82	2	2.4
	125	117	-8	6.8	74	79	-5	6.3
	120	129	9	7.0	78	84	-6	7.1
	122	115	-7	6.1	81	84	-3	3.6
	115	123	8	6.5	69	73	-4	5.5
		MAPE		5.88%		MAPE		7.00%

Table 37: Blood pressure data acquisition accuracy

The deviation of the measured values can be visualized using the following 2 graphical representations.

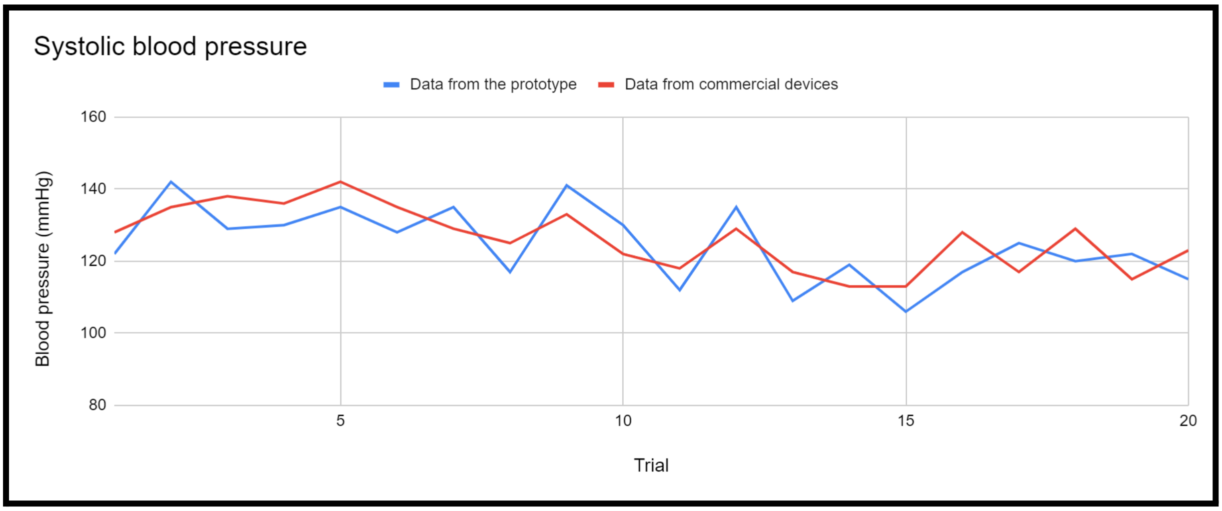

Figure 74: Graphical representation of systolic blood pressure measurement accuracy

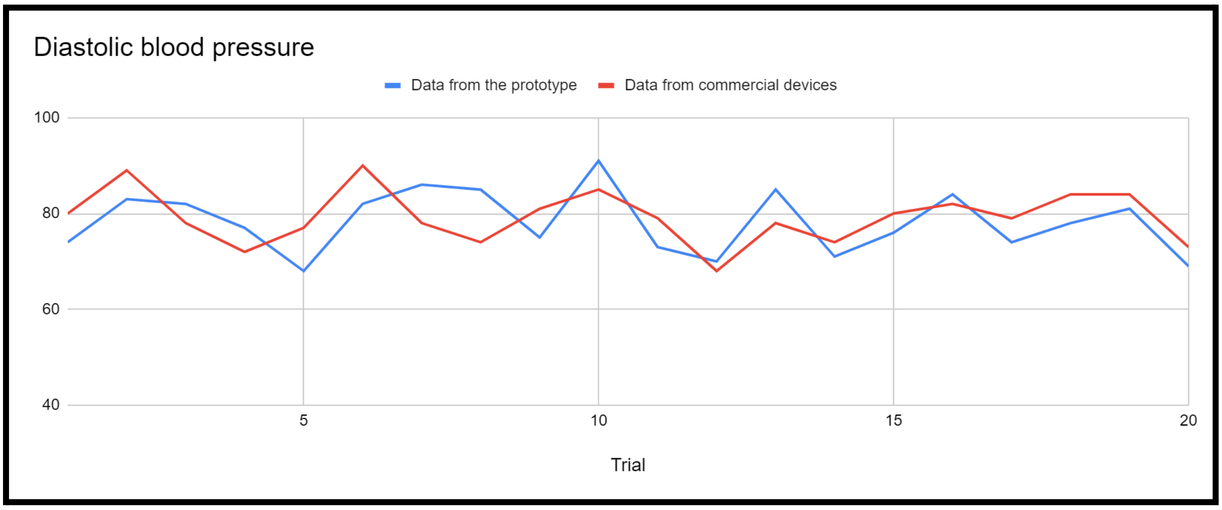

Figure 75: Graphical representation of diastolic blood pressure measurement accuracy

From the above attached table for blood pressure measurement and graphical representations, we can observe that the implemented prototype's measurement device has a quite noticeable fluctuation from the device used as baseline device. From the table we can see for systolic pressure the mean absolute percentage error is 5.88% and for diastolic pressure the mean absolute percentage error stands at around 7.00%, which is quite high. The acquired data from the implemented prototype is received from the CK101S blood pressure machine. The deviation of measurement of the implemented prototype from the baseline device may be due to the accuracy issue of the used blood pressure machine. But still with the slight accuracy issue, the implemented prototype still gives a proper trend of the blood pressure which can be used as an early indication of any abnormalities for the target demography. A side by side image of blood pressure measurement from the implemented prototype and base device is shown below.

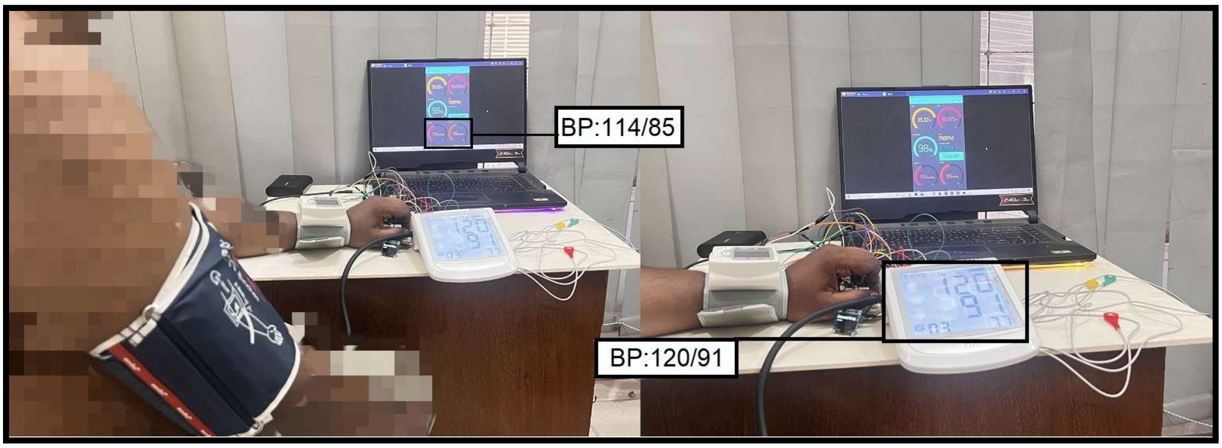

Figure 76: Blood pressure machine.

For ECG acquisition we connected the leads to two persons and acquired their ECG signal. The setup to acquire ECG signal and the acquired ECG signals are as follows.

Figure 77: Graphical representation of ECG measurement

Figure 78: Graphical representation of ECG measurement

For the implemented prototype, we have acquired ECG signal using both the placement options available. The acquired ECG signal could not be verified with medically approved ECG due to resource constraints. However the acquired ECG can be used as initial indication to any abnormality in heart condition and further necessary actions can be taken to address the abnormal health condition of the concerned person.

The implemented prototype was successful to notify incase of any abnormality noticed in the oxygen saturation, heart rate and temperature. The SMS notification system is the same as the fall, collision and SOS notification. The latency observed here is similar to that presented in table 34. The SMS notifications sent from the implemented prototype can be seen in the following figure.

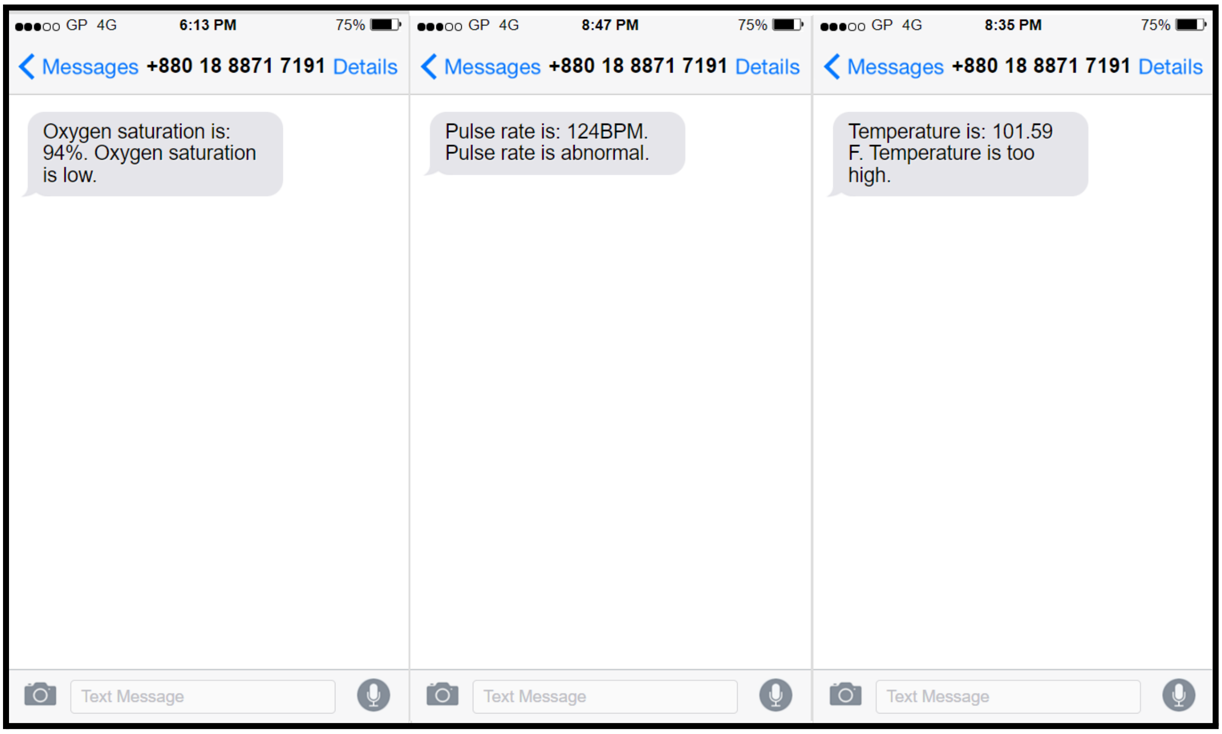

Figure 79: SMS notification feature of health monitoring

The implemented prototype's acquired execution time is tabulated in the following table:

Simulated Result		Implemented Prototype	
Command	Execution time (s)	Command	Execution time (s)
Activation	2.9875	Activation	1.931
Forward	1.026	Forward	1.402727273
Right	1.084	Right	1.393235294
Left	1.11	Left	1.421212121
Backward	0	Backward	1.345588235
Stop	1.036	Stop	0.895

Table 38: prototype's acquired execution time

The tabulated results are graphically represented in the following graph:

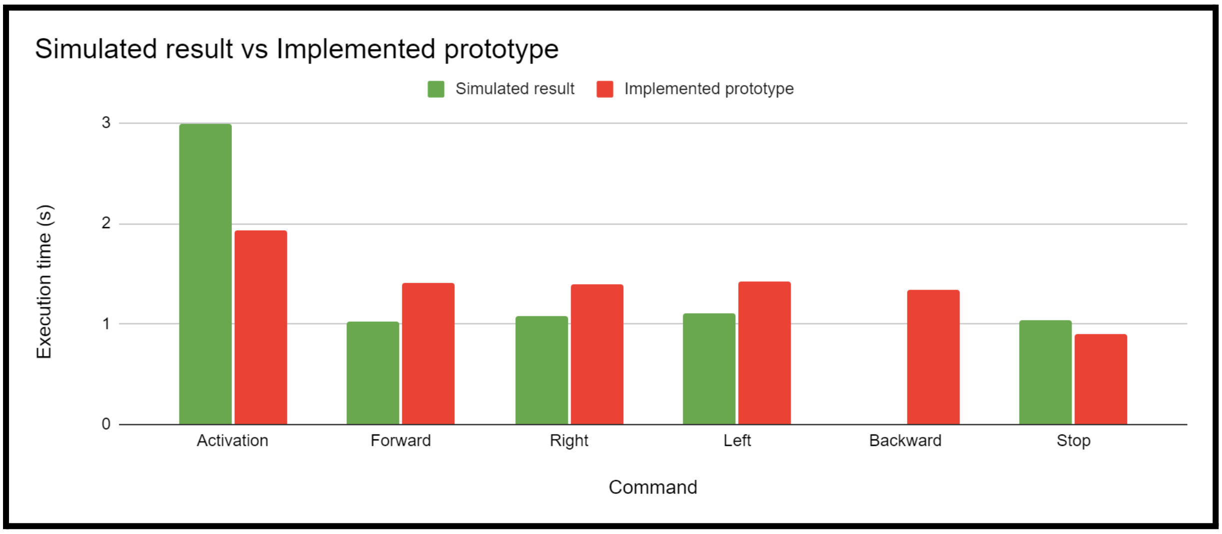

Figure 80: prototype's acquired execution time graphical analysis

During the simulation phase, the backward movement option was not present in the system. But except that the implemented prototype shows similar execution time for all the commands, specifically the trend is similar. From the graph's it's visible that the activation command took the highest time to execute in the simulation and the same has happened for the implemented prototype too. Further, the other commands like forward, right and left took a similar amount of time to execute in both the simulation and implemented prototype. Regarding the stopping command of the wheelchair, in the simulation it took the least time and the same has happened for the implemented prototype too. So, regarding the execution time, the implemented prototype and simulation gives identical results.

In terms of accuracy from simulated results shown in table 14, we achieved an accuracy of 96% and in the implemented prototype from table 26 we have found an overall accuracy of 97.22%, which is close to the simulated results. Regarding the health monitoring section, the simulated result shows only the measurement of connected devices. The implemented device is perfectly capable of taking readings via the connected sensor's and also able to determine any abnormalities in health trends perfectly as found in simulated results.

From all the analysis we can state that the implemented prototype meets the desired requirements and also provides identical results when compared with the initial simulated results.

5.4 Conclusion

To conclude, the optimal solution with necessary modifications properly fills in the criteria of all the objectives set for the project. The different subsystems, such as the health monitoring system, obstacle and fall detection system, notification mechanisms are completely functional and working. The stakeholders requirements are also given special attention to and further modifications to the prototype will be made if the requirements are updated. Through multiple trials and troubleshooting sessions, the final desired prototype has been built for demonstration.

Chapter 6

Impact Analysis and Project Sustainability [CO3, CO4]

6.1 Introduction

The dependency of sustainability and the impact of this project is the key factor that bridges the model's concept forth to stakeholders. This project was developed after careful consideration and analysis of multiple tradeoffs between the model requirements set by the stakeholders and other engineering constraints.

6.2 Assess The Impact of Solution

In the modern world, progress in societal view towards disabled people has been steered into a positive direction through the endless contribution of different government agencies, NGOs and other institutions. This proposed project aims to build further on this growth and to help establish further acceptance of all people. The impacts of this project have been illustrated below.

Rehabilitation and mental empowerment

The project is set up in such a manner that it would be most effective and safe in an indoor environment only. Evenstill it provides an excellent means of self-propelled movement for people bound by their disabilities. The added degree of freedom to mobility paves the path towards mental empowerment.

Real time remote monitoring capabilities

The single database system allows data from multiple patients to be stored securely and be viewed simultaneously. Therefore a single authorized personnel can be given the task for carrying out soft analysis of multiple patients at a time instead of multiple personnel assigned to multiple patients.

Decrease the workload of caretakers

The dedicated health monitoring system drastically decreases the workload on assigned caretakers by allowing remote soft analysis of biometric data. This gives more time for authorities to analyze data and take decisions before the circumstances turn dire.

Safety features further fortifying unassisted movement

The integrated safety features would provide substantial confidence to both the patients and the assigned caretakers, thus further promoting the idea of unassisted and unsupervised movement.

Real time emergency notification system

To mitigate unforeseen accidents, our SOS and notification system would prove to be very reliable for faster action protocols.

Scope for investment

Our initiative aims to cater to an unattended demography of people (Quadriplegia patients), thus industry stakeholders would be attracted to invest and provide resources for development.

6.3 Evaluate The Sustainability

Sustainability of a given project is determined by its merits and demerits in a wide range of fields. This project is designed to work hand in hand with the Persons with Disabilities' Rights and Protecting Acts of 2013. The government of Bangladesh is a signed party of this document that lives to establish equal rights for people of all disabilities. Thus political convenience is somewhat achievable. Fulfillment of the need for independent movement for persons without the ability to do so and empowerment of all people regardless of physical aptitude fills in the criteria for social need and of cultural acknowledgement. Finally, with a new assembled invention comes a job with a new set of expertise requirements. The brainwave controlled wheelchair requires people with expertise in maintenance of such a system. Moreover, with multiple users of the system and the in-built health monitoring system, vacancy is set for a monitor and analyser of the data. Thus with the opportunity of creating new employment opportunities, workforce capital is built. To summarize, it is assessed that this project aims to excel in political expediency, social desirability, cultural acceptability and human capital among other things.

6.4 Conclusion

A wheelchair designed and customized for quadriplegic patients would set a new milestone in the industry instigating need for further research done down the line. To summarize, we believe that this project can improve the mental health of targeted patients, promote acceptance without prejudice, grant smoother accessibility to essential rights and decrease the workload on all other parties involved.

Chapter 7

Engineering Project Management [CO11, CO14]

7.1 Introduction

A successful project requires its scopes to be defined at a very early stage while strictly maintaining a predefined timeline for the progress of the project. Project management helps us define the plan of approach towards the objectives of the project, the individual processing and the deliverables of the project. Besides project related activities, the management also involves maintaining consistent communication between both the project members and also all concerned stakeholders. Next, one must also set up contingency protocols in case of unwanted emergencies. Proficiency in project management is greatly displayed at the demonstration of the project when the predefined timeline is followed thoroughly.

7.2 Define, Plan, and Manage Engineering Project

EEE-400P

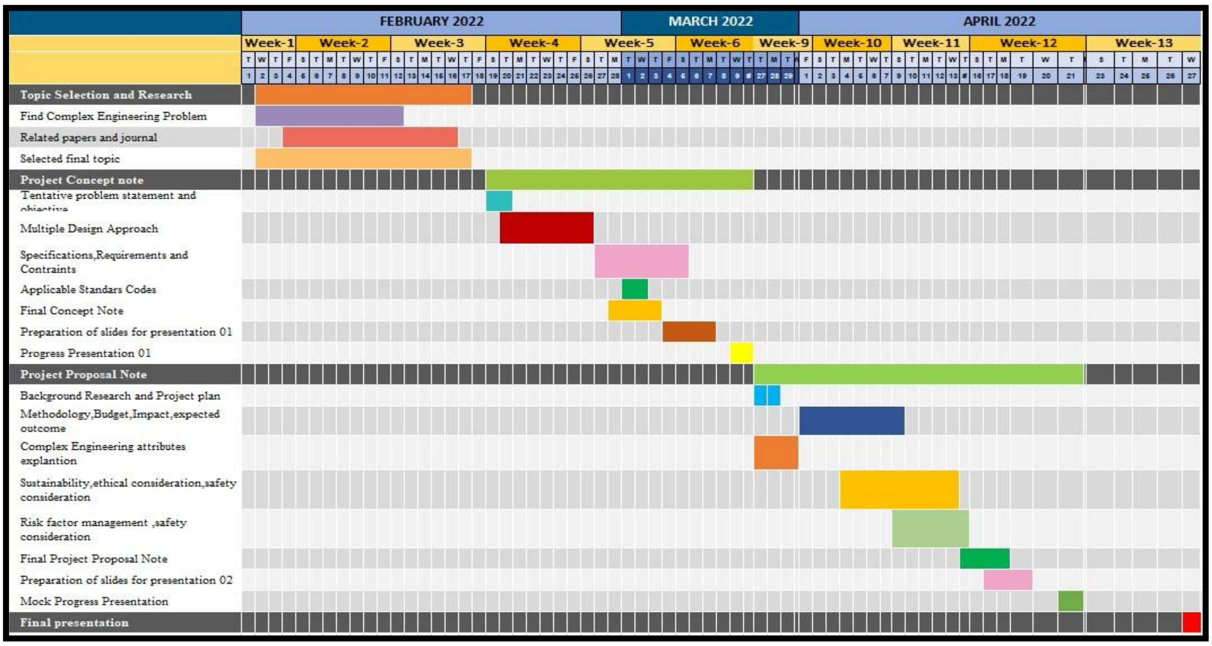

Figure 81: EEE-400P project plan gantt chart.

Task	Start date	End date	Duration
Topic Selection and Research	02/02/2022	17/02/2022	16
Find Complex Engineering Problem	02/02/2022	12/02/2022	11
Related papers and journal	04/02/2022	16/02/2022	13
Selected final topic	02/02/2022	17/02/2022	16
Project Concept note	19/02/2022	10/03/2022	20
Tentative problem statement and objective	19/02/2022	20/02/2022	2
Multiple Design Approach	20/02/2022	26/02/2022	7
Specifications,Requirements and Constraints	27/02/2022	05/03/2022	7
Applicable Standards Codes	01/03/2022	02/03/2022	2
Final Concept Note	28/02/2022	03/03/2022	4
Preparation of slides for presentation 01	04/03/2022	07/03/2022	4
Progress Presentation 01	10/03/2022	10/03/2022	1
Project Proposal Note	24/03/2022	21/04/2022	29
Background Research and Project plan	27/03/2022	28/03/2022	2
Methodology,Budget,Impact,expected outcome	01/04/2022	09/04/2022	9
Complex Engineering attributes explanation	24/03/2022	30/03/2022	7
Sustainability,ethical consideration,safety consideration	04/04/2022	13/04/2022	10
Risk factor management ,safety consideration	09/04/2022	14/04/2022	6
Final Project Proposal Note	14/04/2022	18/04/2022	5
Preparation of slides for presentation 02	17/04/2022	19/04/2022	3
Mock Progress Presentation	21/04/2022	21/04/2022	1
Final presentation	28/04/2022	28/04/2022	1

Table 39: Project planning table with duration for EEE400 P.

EEE-400D

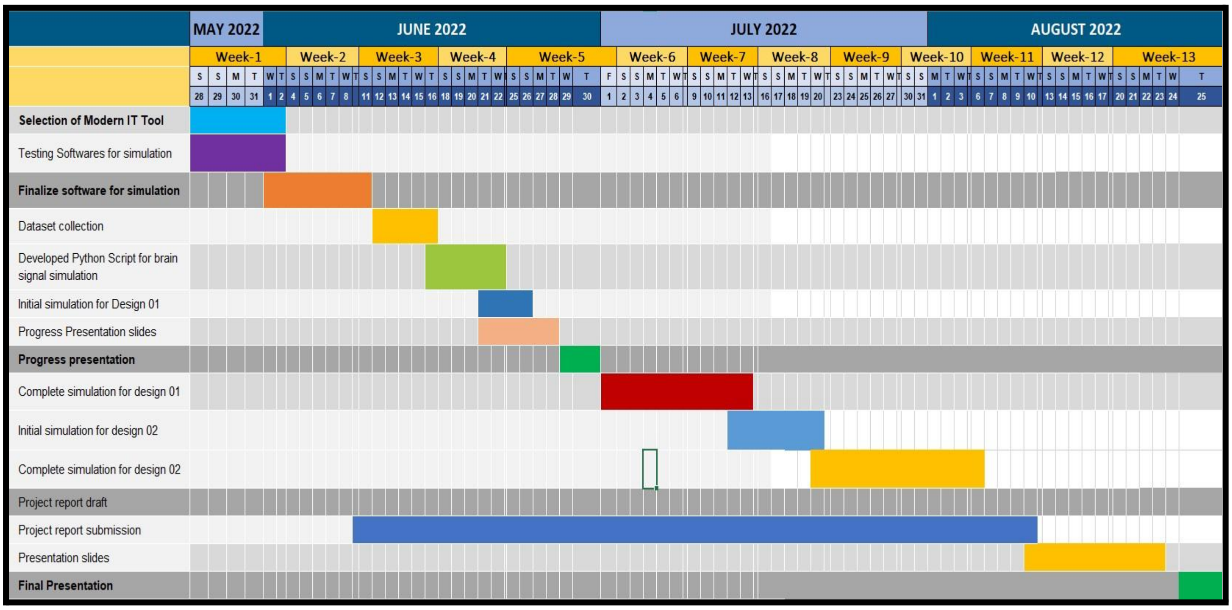

Figure 82: EEE-400D project plan gantt chart.

Task	Start Date	End Date	Duration
Selection of Modern IT Tool	28/05/2022	03/06/2022	7
Testing Softwares for simulation	28/05/2022	03/06/2022	7
Finalize software for simulation	01/06/2022	11/06/2022	11
Dataset collection	13/06/2022	16/06/2022	4
Developed Python Script for brain signal simulation	16/06/2022	22/06/2022	7
Initial simulation for Design 01	21/06/2022	26/06/2022	6
Progress Presentation slides	21/06/2022	28/06/2022	8
Progress presentation	30/06/2022	30/06/2022	1
Complete simulation for design 01	1/07/2022	13/07/2022	13
Initial simulation for design 02	12/07/2022	20/07/2022	9
Complete simulation for design 02	27/07/2022	06/08/2022	4

Project report draft	09/06/2022	10/08/2022	63
Project report submission	10/08/2022	23/08/2022	3
Presentation slides	10/08/2022	23/08/2022	7
Final Presentation	25/08/2022	25/08/2022	1

Table 40: Project planning table with duration for EEE400 D.

EEE-400C

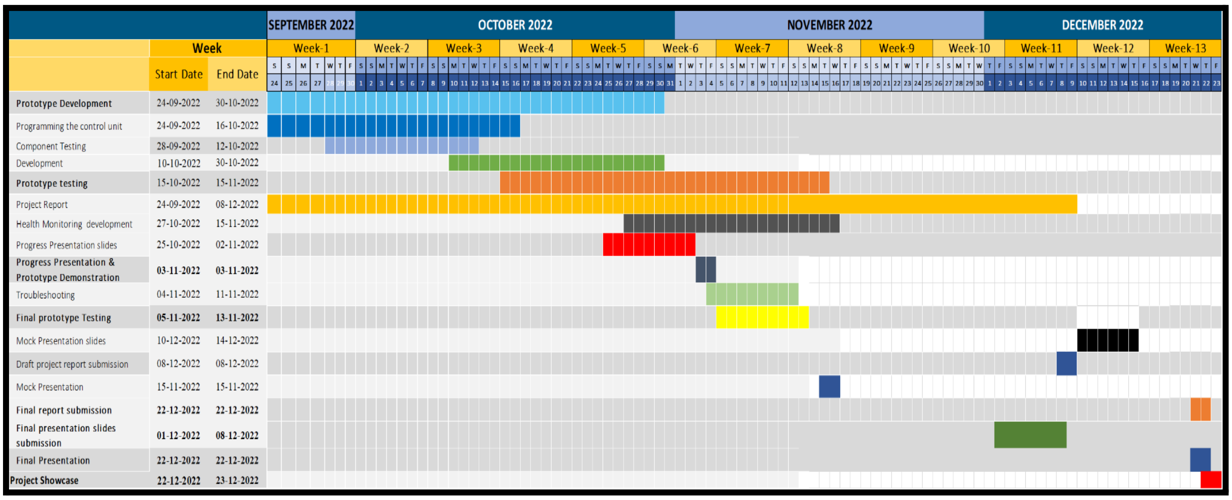

Figure 83: EEE-400C project plan gantt chart.

Task	Start Date	End Date	Duration
Prototype Development (small scale)	24/09/2022	30/10/2022	36
Programming the control unit	24/09/2022	16/10/2022	22
Component Testing	28/09/2022	12/10/2022	14
Development	10/10/2022	30/10/2022	20
Prototype testing	15/10/2022	15/11/2022	30
Project Report	24/09/2022	08/12/2022	44
Health Monitoring development	27/10/2022	15/11/2022	18
Progress Presentation slides	25/10/2022	02/11/2022	8
Progress Presentation & Prototype	03/11/2022	03/11/2022	1

Demonstration			
Troubleshooting	4/11/2022	11/11/2022	7
Final prototype Testing	5/11/2022	13/11/2022	9
Mock Presentation slides	10/12/2022	14/12/2022	4
Draft project report submission	08/12/2022	08/12/2022	1
Mock Presentation	15/11/2022	15/11/2022	1
Final report submission	22/12/2022	22/12/2022	1
Final presentation slides submission	01/12/2022	08/12/2022	7
Final Presentation	22/12/2022	22/12/2022	1
Project Showcase	22/12/2022	23/12/2022	2

Table 41: Project planning table with duration for EEE400 C.

7.3 Evaluate Project Progress

Biomedical projects with integrated electronic components are almost always prone to different dangers and hazards due to their sensitive nature. Evidently, this project is no exception. Most electricity based projects come with the possibility of electrical hazards. These may include mild shocks in sensitive regions. To avoid this, proper insulation of all exposed components should be ensured. The motor driver or the control system may also fail, thus an override switch along with a mechanical joystick can be added. Personal emergencies can be tackled with a SOS call system. And lastly, sensor accuracy issues should also be taken into consideration. Thus thorough examination of all components used should be done before assembling. The aforementioned risks along with the management procedures are given below in a tabular format.

Risk response matrix:

	Risk Event	Management Procedure	Contingency Plan
1	Electrical hazards due to faulty connections.	Ensure proper isolation and insulation of all connecting ports, wires and associated components.	If the accelerometer data gives evidence of sudden jolts of motion due to shock, immediate cautionary SMS text would be sent to authorized persons along with automatic buzzer alert.
2	Motor control failure.	Thoroughly check motor driver connections and ensure uninterrupted connection between EEG signal acquisition device and the microcontroller.	Addition of a manual override switch along with an easy to use joystick to allow manual motor control if needed.
3	Patient's personal emergencies requiring professional assistance.	Setting up a protocol for a SOS call for distress. This may be "3 continuous forced eye blinks" to notify caretakers about their needed attention	An easy to press button shall be set up along with the mini joystick. This button also provides SOS facilities.
4	Sensor acquisition errors	Replacing faulty components with thoroughly checked components bought from reliable and recognized institutions.	Additional backup sensors should be stockpiled at the institution or household that uses the product.

Table 42: Table for risk management analysis & contingency planning.

Other risks may develop during the day to day usage of the wheelchair. These are concerned with the movement operation and position of the user on the wheelchair. Some paralyzed patients may be aligned in a manner that deprives them of vision of the ground level in front of them when using the wheelchair. The possibility of obstacles or small objects in the pathway may lead to dangerous situations. Hence we have employed an obstacle detection system along with our brain controlled system to ensure further safety. There is also a risk of the user falling from the wheelchair unable to communicate. To manage this, a fall detection system has also been implemented.

7.4 Conclusion

Project management is the foundation for all successful projects. Without proper management, it would be extremely difficult to be consistent in carrying out the objectives set for the project. Even with pristine management and following set guidelines, there is always room for unwanted risks. Therefore one must also consider keeping contingency plans for different probable risks. These factors ensure proper delivery of the core objectives of the project.

Chapter 8

Economical Analysis [CO12]

8.1 Introduction

Economic analysis is an essential part of the research done for a product. It is used to evaluate the costs and benefits of the project product. It gives the pioneers an overall and general idea of how feasible and accessible the project product is to the mass. Regardless of the different objectives of such analysis, an important part of it is to evaluate and predict different responses to a product. These may include profit generation, timely allocation of research and development costs and so forth. All in all, it gives a clearer understanding of business outcomes.

8.2 Economic Analysis

The economic analysis of a product helps pave the path towards efficient and optimal resource allocation for generating revenue from a project/product. It shows the trade off between cost effectiveness and product performance. The current wheelchair industry is concentrated heavily on accommodating and catering towards patients with partially active limbs. An example may include using hand pedals to drive a torque sensor based wheelchair to increase battery longevity, as demonstrated in [25]. However, the current industry is not focused heavily on catering to patients who have next to no physical movement capabilities. With the growing demand for day to day wheelchairs that allow movement without need for external assistance, our project aims to fill this unattended category by providing means of independent mobility to all patients regardless of their physical capabilities. The stakeholders have also made remarks on the need for such a wheelchair so that they can provide better services to the large demography of fully paralyzed patients. The product would be designed to be completely modular, which essentially means that it can be configured to most already existing wheelchairs thus cutting down the costs even more. Therefore, with mass production of the modular system, the supply would meet the demand for such a product and cost effectiveness can be increased.

8.3 Cost Benefit Analysis

An examination of costs and benefits is used to determine whether a project is feasible. A cost-benefit analysis, which is a component of economic analysis, has the advantage of providing accurate, quantitative direction for decisions pertaining towards the development of the product if it is conducted correctly and with precise assumptions. The project does not have to be finished for the lowest cost possible in order to be cost-effective. The project's components and sensors' efficacy, performance, and durability are the most crucial aspects. The market offered a wide range of sensors and components for the development of the prototype design, making it challenging to choose the best option in terms of price and performance. We must choose the component that is simultaneously cost-efficient and effective if we want to get the finest results. Although each of the components chosen for the prototype model has certain pros and cons. This governance procedure is crucial if the end product is to guarantee consumer satisfaction. While only one Arduino Mega is utilized as the CPU in Design-2, Design-1 uses both an Arduino Mega and an ESP-32 microcontroller to process data from the sensors. Although employing two different MCUs in Design Approach 1 adds to the cost of the prototype, the analysis of the simulated outcomes in Chapter 4 justifies the need for using two separate MCUs in terms of computation, latency, portability, and efficiency despite the additional cost. Furthermore, in order to transmit the data to the server, we employed an ESP-32 as a Wi-Fi shield for Design 1 and a GSM module for Design

2, which is more expensive than the communication mechanism used in Design Approach 1. The methodology used to measure blood pressure in both the designs is another key differentiating factor in terms of cost between the two designs. In design approach 1, we chose a low-cost consumer-grade blood pressure cuff that costs around 1400 taka, and we utilized the I2C protocol to extract the measured data. In contrast, in design approach 2, we selected a blood pressure sensor that costs about 6000 taka. The expensive blood pressure sensor's monitoring of O2 saturation and heart rate, although, is a bonus function. But, design approach 1 uses a 380 taka sensor to achieve the same goal. Therefore, the blood pressure, oxygen saturation, and heart rate acquisition devices for design method 1 are less expensive as a whole than that for design approach 2.

For design approach 1 a table containing the core components are provided below:

Component	Price	Strength	Weakness
Arduino Mega	3300	1. More available I/O pins compared to any available MCU 2. Easily swappable	1. No on board chip for internet connectivity 2. Expensive than other Arduinos
ESP-32	740	1. On board chip for internet connectivity 2. Easily swappable	1. No parallel processing option
Blood pressure machine	1400	1. Readily available for consumer 2. Provides heart rate information too 3. Low cost device	1. No direct interface to connect to a MCU
MAX30100	380	1. Provides oxygen saturation and heart rate data too	1. Need of polling continuously making it difficult to integrate

Table 43: Core Components Analysis For Design-1

For design approach 2 a table containing the core components are provided below:

Component	Price	Strength	Weakness
Arduino Mega	3300	1. More available I/O pins compared to any available MCU 2. Easily swappable	1. No on board chip for internet connectivity 2. Expensive than other Arduinos
ESP-32	740	1. On board chip for internet connectivity 2. Easily swappable	1. No parallel processing option
Blood pressure sensor	6000	1. Readily available for consumer 2. Provides oxygen saturation and heart rate information too 3. Readily available interface to connect to MCUs	1. Too much expensive 2. Not available in local market, needs to import it

Table 44: Core Components Analysis For Design-2

We can clearly identify the differences between the core components of both Design-1 and Design-2 by comparing Tables 43 and 44. This makes it evident why design approach 1 is more economically advantageous for stakeholders than design approach 2.

8.4 Evaluate Economic and Financial Aspects

The key factor that gives this project an advantage in the market in both economic and financial aspects is the fact that the market for this product is almost essentially uninitiated or catered to. Hence, a successful project will provide an excellent opportunity for expansion. This model works closely for patients who have absolutely no control over physical attributes from below the neck (Quadriplegic) by overcoming the need for physical labor. With the additional joystick feature, the product can be usable by patients with all sorts of paralysis. The remote data viewing capabilities along with the different dedicated safety features are also an attractive option for most wheelchairs. With the core objective of the project as providing means of fully independent movement of people with disabilities, this project has a positive impact in the social and economic fields. The following budget is allocated for the implementation of a prototype:

Components	Units	Price (BDT)	Website link
Brainsense BCI Headset	1	15,000	brainsense is a low cost brain computer interface device - BCI
Arduino Mega 2560	1	1600	Arduino Mega 2560 CH340 Robotics Bangladesh
ESP-32	2	1480	ESP32 ESP-32S 30P NodeMCU Development Board Wireless WiFi Robotics Bangladesh
Arduino Pro Mini (3.3V)	1	450	https://bdspeedytech.com/index.php?route=product/product&product_id=3385
MPU 6050	1	220	6DOF MPU-6050 3 Axis Gyro With Accelerator Sensor Bangladesh
DS-18b20	1	270	Waterproof DS18B20 Digital Thermal Probe or Sensor Robotics Bangladesh
HC-SR04	4	440	https://store.roboticsbd.com/sensors/22-ultrasonic-sensor.html
Max30100	1	380	https://bdspeedytech.com/index.php?route=product/product&product_id=2594&search=max30100
ECG sensor	1	790	https://store.roboticsbd.com/sensors/391-ad8232-ecg-measurement-module-kit-robotics-bangladesh.html
Blood pressure device	1	1400	https://www.daraz.com.bd/products/sphygmomanometer-wrist-monitor-digital-lcd-heart-beat-rate-pulse-meter-measure-d4-i239589155-s1182966332.html?spm=a2a0e.searchlistcategory.list.65.107b2544DuwBHG&search=1
L298N Motor Driver	1	195	https://store.roboticsbd.com/motor-driver/376-l298n-h-bridge-dual-motor-driver-stepper-motor-driver-robotics-bangladesh.html
Buzzer	2	90	https://store.roboticsbd.com/sensors/1738-active-speaker-buzzer-module-for-arduino-5v-robotics-bangladesh.html
Bluetooth	2	730	https://store.roboticsbd.com/robotics-parts/905-arduino-bluetooth-bangladesh-hc-05.html
Display	1	380	https://store.roboticsbd.com/arduino-shield-module/1328-096-inch-i2c-oled-display-white-robotics-bangladesh.html

Geared motor	2	900	12V 50RPM Geared Motor 25mm
Hard board	1	100/ pcs	Hardboard Flywood we buy | ClickBD
Wheel	2	740	https://bdspeedytech.com/index.php?route=product/product&product_id=3457&search=wheel
Caster Wheel	2	240	https://bdspeedytech.com/index.php?route=product/product&product_id=2213&search=wheel
Wires	**	165	Jumper Wire Set
Switch	5	75	https://www.daraz.com.bd/products/mini-dc-on-off-switch-5-pieces-i141508609.html
11.1V 2200MAH 30C 3S LIPO Battery	1	2700	https://bdspeedytech.com/index.php?route=product/product&product_id=219&search=battery
LIPO battery Charger	1	400	Imax-B3 Pro (bdspeedytech.com)
Headset Battery AAA (Sunlight 1.5v) (3pcs per use)	1	45	Cycle Energy Blue Rechargeable Battery AAA size http://www.sscamerabd.com/product/battery-charger-aa-uniross/
Miscellaneous	-	200	BJT/MOSFET,RESISTORS ETC.
Joystick	1	95	https://store.roboticsbd.com/robotics-parts/393-joystick-5pin-breakout-module-for-arduino-robotics-bangladesh.html
TOTAL		29,085	

Table 45: Budget for optimal design prototype.

Components	Units	Price (BDT)	Website link
Brainsense BCI Headset	1	15,000	https://www.pantechsolutions.net/brainsense-bci
Arduino Mega 2560	1	1600	Arduino Mega 2560 CH340 Robotics Bangladesh
ESP-32	2	1480	ESP32 ESP-32S 30P NodeMCU Development Board Wireless WiFi Robotics Bangladesh
Arduino Pro Mini (3.3V)	1	450	https://bdspeedytech.com/index.php?route=product/product&product_id=3385
MPU 6050	1	220	6DOF MPU-6050 3 Axis Gyro With Accelerator Sensor Bangladesh

DS-18b20	1	270	Waterproof DS18B20 Digital Thermal Probe or Sensor Robotics Bangladesh
HC-SR04	4	440	https://store.roboticsbd.com/sensors/22-ultrasonic-sensor.html
Max30100	1	380	https://bdspeedytech.com/index.php?route=product/product&product_id=2594&search=max30100
ECG sensor	1	790	https://store.roboticsbd.com/sensors/391-ad8232-ecg-measurement-module-kit-robotics-bangladesh.html
Blood pressure device	1	1400	https://www.daraz.com.bd/products/sphygmomanometer-wrist-monitor-digital-lcd-heart-beat-rate-pulse-meter-measure-d4-i239589155-s1182966332.html?spm=a2a0e.searchlistcategory.list.65.107b2544DuwBHG&search=1
L298N Motor Driver	1	195	https://store.roboticsbd.com/motor-driver/376-l298n-h-bridge-dual-motor-driver-stepper-motor-driver-robotics-bangladesh.html
Buzzer	2	90	https://store.roboticsbd.com/sensors/1738-active-speaker-buzzer-module-for-arduino-5v-robotics-bangladesh.html
Bluetooth	2	730	https://store.roboticsbd.com/robotics-parts/905-arduino-bluetooth-bangladesh-hc-05.html
Display	1	380	https://store.roboticsbd.com/arduino-shield-module/1328-096-inch-i2c-oled-display-white-robotics-bangladesh.html
Headset Battery AAA (Sunlight 1.5v) (3pcs per use)	1	45	Cycle Energy Blue Rechargeable Battery AAA size http://www.sscamerabd.com/product/battery-charger-aa-uniross/
Joystick	1	95	JoyStick 5Pin Breakout Module For Arduino Robotics Bangladesh
Miscellaneous	-	1000	BJT/MOSFET,RESISTORS,WIRES ETC.
Wheelchair (motorized)	1	Approximately 40,000	Locally made wheelchair.
TOTAL		64,565	

Table 46: Budget for design 01.

8.5 Conclusion

It is evident that the future sustainability of a product does not only depend on the system's performance and efficiency but also greatly on the accessibility of the product as a result of the responsible economic decisions made for the product. Economic analysis helps us thoroughly analyze the different tradeoffs needed to make the project more sustainable and accessible. Therefore, it is absolutely integral that an in-depth analysis is done parallel to the project development.

Chapter 9

Ethics and Professional Responsibilities [CO2, CO13]

9.1 Introduction

Ethical considerations are an integral part of an engineering project. It ensures that the project lies within the boundaries of a good moral and societal point of view. Alongside the ethical considerations, one must also take into account the professional responsibilities towards a project. These responsibilities guide us in displaying our engineering skills through the project. Both the ethical considerations made and the professional responsibilities acknowledged help in making the project more economically, environmentally and socially acceptable.

9.2 Identify Ethical Issues and Professional Responsibility

This project envisions the concept of self-driven movement whilst ensuring safety protocols and providing means of non-verbal communication for health status. The Internet of Things (IoT) plays a crucial role in tying the system together. The amalgamation of the different subsystems is a step towards technological advancement. Parallel to technological advancements, we have also kept in mind the immense need to be responsible towards the ethical issues and professional responsibilities towards the project. Due to the sensitive nature of the intended demography, several elements have to be considered. Some of these considerations are given below.

A. Biomedical engineering projects require extensive work done for the safety of the patients using the project. This project provides various means of safety for different events.

B. Faulty equipment and mismanagement of wiring can cause a great health hazard. We have taken extra care at assembling only approved components to avoid such events.
C. The inability to verbally communicate properly is a common trait to paralyzed patients. We have provided non-verbal means of communication so that the patients are not deprived of the option of calling for help.
D. The Internet of Things (IoT) plays an integral role in putting the different subsystems together and to have them work in harmony. Moreover, sensitive health data of patients will be transmitted and visualized continuously. We have made sure to install the communication protocols in a way as to not to jeopardize the data.

9.3 Apply Ethical Issues and Professional Responsibility

The core essence of this project deals with assisting handicapped individuals towards realizing self-driven motion.

Use of consent forms before product usage

Biomedical projects require proper trials on real-life patients for feasibility. Therefore, external documents for consent of preliminary users should be formulated before trial sessions.

Seek approval from concerned professional authorities

It is essential that the project follows the protocols of and receives approval from the Ethical Review Committee of BRAC university, as well as all concerned stakeholder parties. The Center for Rehabilitation of the Paralyzed (CRP) plays an important role in the industry that caters to the paralyzed. Hence, we have been working closely with them to acquire all the different needs of the user demography.

Set up physical safety protocols

The obstacle detection system is installed in such a way taking into consideration the patients with minor cognitive disabilities so that false/misdirecting signals do not lead to harm. The fall detection system sends a notification to authorized caretakers when an unwanted fall occurs.

Usage of commercially approved components

It is crucial that only globally approved components are used for assembling, ensuring that absolutely no harm is done to the patients from the configuration. The plug and play set up of the project ensures further isolation of the different components from the users.

Integrated emergency notification system

Since the project aims for unsupervised movement, we have added an SOS system for the patients to ask for assistance remotely whenever needed. In the case of an accident and the patient not being able to use the SOS system, we have the automated SMS notification system that alerts nearby caretakers.

Ensuring proper data encryption

Stakeholders, such as CRP, were especially concerned about the security of personal data transmission over an unsecure network. To ensure a degree of assurance over data security, this project aims to follow the protocols set by IEEE 1459-99, which dictates a standard for secure networks for information sharing over wireless mediums.

Ensuring accessibility to the mass

Customized wheelchairs can cost a lot, hence we have tried to keep the costs low so that the accessibility of the wheelchair is increased to a larger demographic.

9.4 Conclusion

The brainwave controlled wheelchair primarily aims to assemble different subsystems as a token to technological advancements while, in parallel, taking great consideration of the requirements of its users, both ethically and professionally. By fulfilling these criterias, we hope that there is greater acceptance of our product and that institutions/individuals are encouraged to use such a model.

Chapter 10

Conclusion and Future Work

10.1 Project Summary/Conclusion

Quadriplegic patients are a demography of people not catered adequately when it comes to independence of self-realized movement. This was also affirmed by our stakeholder - Center for Rehabilitation of the Paralyzed (CRP). The purpose of this project is to provide necessary capability to such patients to realize the aforementioned independence. Key differences were observed in the main control mechanism, communication protocols, portability and system response time of each of the models. With that being said, we have come to the conclusion that design 1 outclasses other models when it comes to ease of control, reliable safety features, reliable responses and cost analysis.

10.2 Future work

The essence of research is that it is unending. Keeping that in mind, several modifications can be made to each of the subsystems of our project to further tune the usability and efficiency of each of them. Some of these further advancements are listed below.

Machine learning applications

Neural network architectures can greatly assist in translating and classifying different brain electrical signal activity into desired actions. A demonstration was shown in [26] where the classified imagination of each hand's movement. This can be used in the control mechanism to direct the wheelchair to go in left or right directions respectively to the imagination of left or right hand movement. A processor can be equipped with the weights of the neural architecture model thus quickly carrying out classification remotely. This in essence allows further customization to the control mechanism.

Predetermined assistive navigation

The core essence of this project is to provide comfort and ease to a person of disability by providing means of least physical labor. This could be taken a step further by providing a memory storage along with a global positioning system (GPS) to store the different routes that a user takes from different locations. Additional sensors such as LiDAR or cameras along with machine vision techniques could be used to keep track of the position and dimension of objects along the predetermined route. In [27], the writers have suggested that such a system would allow the wheelchair to automatically go from one location to another predefined one without the user needing to interact with the system.

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 47: Attributes of Complex Engineering Problems (EP).

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

P1 - Depth of knowledge required

This project necessitates prior expertise in several domains of electrical engineering. As a result, courses such as signal processing, microprocessor interfacing, digital logic design for circuit configurations, databases and computer networks for data storage and transmission, and lastly neural network or machine learning to construct a finely tuned classifier are available. To accomplish this project, expertise from various sectors is brought together, defining the level of knowledge necessary.

P4 - Familiarity of issue

According to statistics, around 10% of Bangladesh's overall population suffers from some sort of impairment. This initiative intends to try to offer access to a tiny subset of the aforementioned demographic, therefore going into an area of topic that is rarely addressed.

P5 - Extent of Applicable Codes

This endeavor necessitates that we adhere to a variety of globally established codes. To construct the system, the standard codes must be followed.

P6 - Extent of Stakeholder Involvement and Needs

To properly execute the project, we require stakeholder feedback on their varied demands. Another thing to keep in mind is that the demands of the numerous users to whom our system caters must be met.

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 48: Attributes of Complex Engineering Activities (EA).

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

A1 - Range of Resources

We rely on the right usage of EEG acquisition headsets, obstacle detection technologies, IOT-based monitoring, and other tools to execute our project. The BCI technology employed here is in its early stages.

A4 - Consequences to Society and the Environment

Many disabled persons in society regard themselves as a burden since they require assistance to move from one location to another. Our devised system will considerably improve these people's quality of life in society.

A5 - Familiarity

Working with the previously specified targeted subset of people necessitates following certain protocols from a few areas. For example, for EEG capture, there are ethical and technical (10-20 system) standards that must be followed. Individually, these ideas are brought together to form a single functional project.

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Appendix A.

Codes:

Control mechanism (Arduino Mega 2560):

```
#include <Mindwave.h>
#include <Wire.h>
#include <NewPing.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>

#define SCREEN_WIDTH 128
#define SCREEN_HEIGHT 64

int btnPin = 2;
int xValue, yValue;
int btnStatus = 0;
int btnTime = 0;
int controlStatus = 0;
int spPWM = 0;
int cal = 0;
unsigned long dispTime = 0;

Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, & Wire, -1);
Mindwave mindwave;
int blinksignal = 0;
int blinks = 0;
unsigned long time;
unsigned long time0;
unsigned long time1;
unsigned long time2;
unsigned long time3;
unsigned long timeCheck;
unsigned long ledTimer = 0;
unsigned long ledTimerSpan = 0;

int actuateStatus = 0;
int motorA1 = 12, motorA2 = 11, motorB1 = 10, motorB2 = 9;
unsigned long menuTime0 = 0;
int last = -1;
int choice = 0;
int forwardLed = 28, rightLed = 30, leftLed = 26, backLed = 34;
int isActivated = 0;
int ledChoice = 0;
int movingDir = 0;
unsigned long blinkReset = 0;

int buzzer = 32;
```

```
int sonarFecho = 52, sonarRecho = 50, sonarLecho = 48, sonarBecho = 46;
int sonarFtrig = 53, sonarRtrig = 51, sonarLtrig = 49, sonarBtrig = 47;
int maxDis = 400;
NewPing sonarF(sonarFtrig, sonarFecho, maxDis);
NewPing sonarR(sonarRtrig, sonarRecho, maxDis);
NewPing sonarL(sonarLtrig, sonarLecho, maxDis);
NewPing sonarB(sonarBtrig, sonarBecho, maxDis);

int forwardDistance = 0, rightDistance = 0, leftDistance = 0, backDistance = 0;

void setup() {
  if (!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) {
    for (;;)
    ;
  }
  delay(1000);
  display.clearDisplay();
  display.setTextSize(2);
  display.setTextColor(WHITE);
  Serial.begin(MINDWAVE_BAUDRATE);
  pinMode(buzzer, OUTPUT);
  pinMode(forwardLed, OUTPUT);
  pinMode(rightLed, OUTPUT);
  pinMode(leftLed, OUTPUT);
  pinMode(backLed, OUTPUT);
  pinMode(btnPin, INPUT_PULLUP);
}

void updateSurrounding() {
  if (movingDir == 1) {
    forwardDistance = sonarF.ping_cm();
  }
  if (movingDir == 2) {
    rightDistance = sonarR.ping_cm();
  }
  if (movingDir == 3) {
    leftDistance = sonarL.ping_cm();
  }
  if (movingDir == 4) {
    backDistance = sonarB.ping_cm();
  }
}

void moveForward() {
  digitalWrite(forwardLed, HIGH);
  digitalWrite(leftLed, HIGH);
  digitalWrite(rightLed, HIGH);
  digitalWrite(backLed, HIGH);
  int sp1 = (255 * (spPWM / 100.0)) / 1.5;
  analogWrite(motorA1, sp1);
  digitalWrite(motorA2, LOW);
```

```
  int sp2 = (255 * (spPWM / 100.0) + 255 * (spPWM / 100.0) * (cal / 100.0)) /
1.5;
  analogWrite(motorB1, sp2);
  digitalWrite(motorB2, LOW);
}

void moveBackward() {
  digitalWrite(forwardLed, HIGH);
  digitalWrite(leftLed, HIGH);
  digitalWrite(rightLed, HIGH);
  digitalWrite(backLed, HIGH);
  analogWrite(motorA1, LOW);
  int sp1 = (255 * (spPWM / 100.0)) / 1.5;
  analogWrite(motorA2, sp1);
  analogWrite(motorB1, LOW);
  int sp2 = (255 * (spPWM / 100.0) + 255 * (spPWM / 100.0) * (cal / 100.0)) /
1.5;
  analogWrite(motorB2, sp2);
}

void moveRight() {
  digitalWrite(forwardLed, HIGH);
  digitalWrite(leftLed, HIGH);
  digitalWrite(rightLed, HIGH);
  digitalWrite(backLed, HIGH);
  analogWrite(motorA1, 50);
  digitalWrite(motorA2, LOW);
  digitalWrite(motorB1, LOW);
  analogWrite(motorB2, 50);
}

void moveLeft() {
  digitalWrite(forwardLed, HIGH);
  digitalWrite(leftLed, HIGH);
  digitalWrite(rightLed, HIGH);
  digitalWrite(backLed, HIGH);
  digitalWrite(motorA1, LOW);
  analogWrite(motorA2, 50);
  analogWrite(motorB1, 50);
  digitalWrite(motorB2, LOW);
}

void stopChair() {
  digitalWrite(forwardLed, LOW);
  digitalWrite(leftLed, LOW);
  digitalWrite(rightLed, LOW);
  digitalWrite(backLed, LOW);
  digitalWrite(motorA1, LOW);
  digitalWrite(motorA2, LOW);
  digitalWrite(motorB1, LOW);
  digitalWrite(motorB2, LOW);
```

```
}

void onMindwaveData() {
  if (mindwave.quality() < 70) {
    return;
  }
  if ((mindwave.quality() < 95) && (blinksignal == 0)) {
    if (millis() - time2 < 2000) {
      return;
    }
    time = millis();
    time0 = millis();
    blinks = 1;
    blinksignal = 1;
    if (isActivated == 1) {
      blinksignal = 0;
      if (movingDir != 0) {
        stopChair();
        ledTimerSpan = millis();
        movingDir = 0;
        ledChoice = 1;
        digitalWrite(forwardLed, HIGH);
        digitalWrite(leftLed, LOW);
        digitalWrite(rightLed, LOW);
        digitalWrite(backLed, LOW);
        delay(600);
      } else {
        time2 = millis();
        if (ledChoice == 1) {
          moveForward();
          movingDir = 1;
        }
        if (ledChoice == 2) {
          moveRight();
          movingDir = 2;
        }
        if (ledChoice == 3) {
          moveLeft();
          movingDir = 3;
        }
        if (ledChoice == 4) {
          moveBackward();
          movingDir = 4;
        }
      }
      delay(600);
      return;
    }
    delay(600);
    return;
  }
```

```
  if ((blinksignal > 0) && (blinksignal < 4) && isActivated == 0) {
    time = millis();
    if (blinksignal > 0) {
      blinksignal = 1 + blinksignal;
    }
    time1 = millis() - time0;
    blinkReset = millis();
  }
  if (millis() - blinkReset > 4000) {
    blinksignal = 0;
  }
  if ((mindwave.quality() < 95) && (time1 > 1000) && isActivated == 0 &&
blinksignal != 0) {
    time = millis();
    blinks = 2;
    isActivated = 1;
    ledChoice = 1;
    ledTimer = millis();
    ledTimerSpan = millis();
    digitalWrite(forwardLed, HIGH);
    digitalWrite(leftLed, LOW);
    digitalWrite(rightLed, LOW);
    digitalWrite(backLed, LOW);
    blinksignal = 0;
  }
  delay(600);
}

void detectObstacle() {
  if (movingDir == 1 && forwardDistance < 25 && forwardDistance > 0) {
    stopChair();
    ledTimerSpan = millis();
    movingDir = 0;
    ledChoice = 1;
    digitalWrite(forwardLed, HIGH);
    digitalWrite(leftLed, LOW);
    digitalWrite(rightLed, LOW);
    digitalWrite(backLed, LOW);
  } else if (movingDir == 2 && rightDistance < 20 && rightDistance > 0) {
    stopChair();
    ledTimerSpan = millis();
    movingDir = 0;
    ledChoice = 1;
    digitalWrite(forwardLed, HIGH);
    digitalWrite(leftLed, LOW);
    digitalWrite(rightLed, LOW);
    digitalWrite(backLed, LOW);
  } else if (movingDir == 3 && leftDistance < 20 && leftDistance > 0) {
    stopChair();
    ledTimerSpan = millis();
    movingDir = 0;
```

```
    ledChoice = 1;
    digitalWrite(forwardLed, HIGH);
    digitalWrite(leftLed, LOW);
    digitalWrite(rightLed, LOW);
    digitalWrite(backLed, LOW);
  } else if (movingDir == 4 && backDistance < 20 && backDistance > 0) {
    stopChair();
    ledTimerSpan = millis();
    movingDir = 0;
    ledChoice = 1;
    digitalWrite(forwardLed, HIGH);
    digitalWrite(leftLed, LOW);
    digitalWrite(rightLed, LOW);
    digitalWrite(backLed, LOW);
  }
  if (movingDir == 0 && forwardDistance < 20 && rightDistance < 10 &&
leftDistance < 10 && forwardDistance > 0 && rightDistance > 10 && leftDistance >
10) {
    digitalWrite(buzzer, HIGH);
    delay(2000);
    digitalWrite(buzzer, LOW);
    delay(2000);
  }
}
void getKnob() {
  if (millis() - dispTime > 500) {
    spPWM = map(analogRead(A0), 0, 1023, 0, 100);
    cal = map(analogRead(A1), 0, 1023, -25, 25);
    display.clearDisplay();
    display.setCursor(0, 10);
    display.println("Speed:" + String(spPWM) + "%");
    display.println("Cal:" + String(cal) + "%");
    if (controlStatus) {
      display.println("Ctrl: J");
    } else {
      display.println("Ctrl: B");
    }
    display.display();
    dispTime = millis();
  }
}
void joystickControl() {
  if (controlStatus) {
    xValue = analogRead(A2);
    yValue = analogRead(A3);
    if (xValue > 470 && xValue < 550 && yValue > 470 && yValue < 550) {
      movingDir = 0;
      stopChair();
    } else if (xValue > 550 && yValue >= 254 && yValue <= 700) {
      movingDir = 1;
      updateSurrounding();
```

```
  if (movingDir == 1 && forwardDistance < 25 && forwardDistance > 0) {
    stopChair();
    movingDir = 0;
  } else {
    moveForward();
  }

  digitalWrite(forwardLed, LOW);
  digitalWrite(leftLed, LOW);
  digitalWrite(rightLed, LOW);
  digitalWrite(backLed, LOW);
} else if (xValue < 470 && yValue >= 254 && yValue <= 700) {
  movingDir = 4;
  updateSurrounding();
  if (movingDir == 4 && backDistance < 20 && backDistance > 0) {
    stopChair();
    movingDir = 0;
  } else {
    moveBackward();
  }
  digitalWrite(forwardLed, LOW);
  digitalWrite(leftLed, LOW);
  digitalWrite(rightLed, LOW);
  digitalWrite(backLed, LOW);
} else if (xValue >= 254 && xValue <= 700 && yValue < 470) {
  movingDir = 3;
  updateSurrounding();
  if (movingDir == 3 && leftDistance < 20 && leftDistance > 0) {
    stopChair();
    movingDir = 0;
  } else {
    moveLeft();
  }
  digitalWrite(forwardLed, LOW);
  digitalWrite(leftLed, LOW);
  digitalWrite(rightLed, LOW);
  digitalWrite(backLed, LOW);
} else if (xValue >= 254 && xValue <= 700 && yValue > 550) {
  movingDir = 2;
  updateSurrounding();
  if (movingDir == 2 && rightDistance < 20 && rightDistance > 0) {
    stopChair();
    ledTimerSpan = millis();
    movingDir = 0;
    ledChoice = 1;
    digitalWrite(forwardLed, HIGH);
    digitalWrite(leftLed, LOW);
    digitalWrite(rightLed, LOW);
    digitalWrite(backLed, LOW);
  } else {
    moveRight();
```

```
      }
      digitalWrite(forwardLed, LOW);
      digitalWrite(leftLed, LOW);
      digitalWrite(rightLed, LOW);
      digitalWrite(backLed, LOW);
    }
  }
}

void checkBtn() {
  if (digitalRead(btnPin) == LOW) {
    if (btnTime == 0) {
      btnTime = millis();
    }
    if (millis() - btnTime > 3000) {
      if (controlStatus) {
        controlStatus = 0;
        getKnob();
        while (digitalRead(btnPin) == LOW)
        ;
      } else {
        controlStatus = 1;
        getKnob();
        while (digitalRead(btnPin) == LOW)
        ;
      }
      btnTime = 0;
    }
  }
  if (digitalRead(btnPin) == HIGH) {
    btnTime = 0;
  }
}

void brainControl() {
  mindwave.update(Serial, onMindwaveData);
  if ((millis() - ledTimer) > 4000 && ledChoice != 0) {
    if (ledChoice == 1 && (millis() - ledTimer) > 4000) {
      digitalWrite(forwardLed, LOW);
      digitalWrite(leftLed, LOW);
      digitalWrite(rightLed, HIGH);
      digitalWrite(backLed, LOW);
      ledTimer = millis();
      ledChoice = 2;
    }
    if (ledChoice == 2 && (millis() - ledTimer) > 4000) {
      digitalWrite(forwardLed, LOW);
      digitalWrite(leftLed, LOW);
      digitalWrite(rightLed, LOW);
      digitalWrite(backLed, HIGH);
      ledTimer = millis();
```

```
      ledChoice = 4;
    }
    if (ledChoice == 4 && (millis() - ledTimer) > 4000) {
      digitalWrite(forwardLed, LOW);
      digitalWrite(leftLed, HIGH);
      digitalWrite(rightLed, LOW);
      digitalWrite(backLed, LOW);
      ledTimer = millis();
      ledChoice = 3;
    }
    if (ledChoice == 3 && (millis() - ledTimer) > 4000) {
      digitalWrite(forwardLed, HIGH);
      digitalWrite(leftLed, LOW);
      digitalWrite(rightLed, LOW);
      digitalWrite(backLed, LOW);
      ledTimer = millis();
      ledChoice = 1;
    }
    if (movingDir != 0) {
      digitalWrite(forwardLed, HIGH);
      digitalWrite(leftLed, HIGH);
      digitalWrite(rightLed, HIGH);
      digitalWrite(backLed, HIGH);
    }
  }
  if (millis() - ledTimerSpan >= 20000 && isActivated == 1 && movingDir == 0) {
    movingDir = 0;
    ledChoice = 0;
    isActivated = 0;
    digitalWrite(forwardLed, LOW);
    digitalWrite(leftLed, LOW);
    digitalWrite(rightLed, LOW);
    digitalWrite(backLed, LOW);
  }
  if (millis() - time3 > 1000 && movingDir != 0) {
    updateSurrounding();
    detectObstacle();
    time3 = millis();
  }
}

void loop() {
  if (controlStatus) {
    joystickControl();
  } else {
    brainControl();
  }
  checkBtn();
  getKnob();
}
```

Control mechanism (ESP-32):

```
#include "WiFi.h"
#include <Wire.h>
#include <HTTPClient.h>

const char * ssid = "Wheelchair";
const char * password = "12345678";
unsigned long fall_time = 0;
unsigned long crash_time = 0;
const int MPU_addr = 0x68;
int16_t AcX, AcY, AcZ, Tmp, GyX, GyY, GyZ;
int minVal = 265;
int maxVal = 402;
double xAngle;
double yAngle;
double zAngle;
int buzzer = 23;
int Sensor = 26;
int logic = 25;
int val2;
int val;
String serverName = "http://api.greenweb.com.bd/api.php?token=API_TOKEN&to=";
String smsNumber = "01315352025,01682993031";
void setup() {
  pinMode(buzzer, OUTPUT);
  Wire.begin();
  Wire.beginTransmission(MPU_addr);
  Wire.write(0x6B);
  Wire.write(0);
  Wire.endTransmission(true);
  pinMode(logic, INPUT);
  pinMode(Sensor, INPUT);
  WiFi.begin(ssid, password);

  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
  }
}
void updateFall() {
  Wire.beginTransmission(MPU_addr);
  Wire.write(0x3B);
  Wire.endTransmission(false);
  Wire.requestFrom(MPU_addr, 14, true);
  AcX = Wire.read() << 8 | Wire.read();
  AcY = Wire.read() << 8 | Wire.read();
  AcZ = Wire.read() << 8 | Wire.read();
  int xAng = map(AcX, minVal, maxVal, -90, 90);
  int yAng = map(AcY, minVal, maxVal, -90, 90);
  int zAng = map(AcZ, minVal, maxVal, -90, 90);
```

```
  xAngle = RAD_TO_DEG * (atan2(-yAng, -zAng) + PI);
  yAngle = RAD_TO_DEG * (atan2(-xAng, -zAng) + PI);
  zAngle = RAD_TO_DEG * (atan2(-yAng, -xAng) + PI);
  delay(100);
}
void sendClashSMS() {
  String msg = "Wheelchair has collided with something. Take necessary
actions.";
  HTTPClient http;
  msg.replace(" ", "+");
  String serverPath = serverName + smsNumber + "&message=" + msg;
  http.begin(serverPath.c_str());
  int httpResponseCode = http.GET();
  if (httpResponseCode > 0) {
    String payload = http.getString();
  } else {
    http.end();
    delay(100);
    sendClashSMS();
  }
  http.end();
}
void sendFallSMS() {
  String msg = "Person has fallen from the wheelchair. Take necessary actions.";
  HTTPClient http;
  msg.replace(" ", "+");
  String serverPath = serverName + smsNumber + "&message=" + msg;
  http.begin(serverPath.c_str());
  int httpResponseCode = http.GET();
  if (httpResponseCode > 0) {
    String payload = http.getString();
  } else {
    http.end();
    delay(100);
    sendFallSMS();
  }
  http.end();
}
void fallStatus() {
  updateFall();
  while ((xAngle > 30 && xAngle < 100) || (xAngle < 330 && xAngle > 250)) {
    digitalWrite(buzzer, HIGH);
    if (millis() - fall_time > 60000 || fall_time == 0) {
      sendFallSMS();
      fall_time = millis();
    }
    updateFall();
  }
  while ((yAngle > 30 && yAngle < 100) || (yAngle < 330 && yAngle > 250)) {
    digitalWrite(buzzer, HIGH);
    if (millis() - fall_time > 60000 || fall_time == 0) {
```

```
      sendFallSMS();
      fall_time = millis();
    }
    updateFall();
  }
  digitalWrite(buzzer, LOW);
}

void loop() {
  fallStatus();
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    WiFi.disconnect();
    WiFi.reconnect();
  }
  val = digitalRead(Sensor);
  val2 = digitalRead(logic);
  if (val == HIGH && val2 == HIGH && millis() - crash_time > 60000)
    crash_time = millis();
  digitalWrite(buzzer, HIGH);
  sendClashSMS();
  delay(1000);
  digitalWrite(buzzer, LOW);
}
}
```

Health monitoring (Arduino Pro Mini):

```
#include <Wire.h>
#define BP_START_PIN(2)
#define VALVE_PIN(3)

volatile byte i2c_data_rx;
volatile uint16_t count;
volatile uint8_t sys, dia, hr;

void setup() {
  Serial.begin(9600);
  pinMode(BP_START_PIN, OUTPUT);
  digitalWrite(BP_START_PIN, HIGH);
  pinMode(VALVE_PIN, INPUT);
  pinMode(4, INPUT);
  pinMode(5, INPUT);
  pinMode(6, INPUT);
  pinMode(7, INPUT);
  Wire.begin(0x50);
  Wire.onReceive(receiveEvent);
}
```

```
void takeECG() {
  unsigned long ecgTime = millis();
  while (millis() - ecgTime < 60000) {
    if ((digitalRead(6) == 1) || (digitalRead(7) == 1)) {
      Serial.println('!');
    } else {
      Serial.print('E');
      Serial.println(analogRead(A0));
    }
  }
}
void loop() {
  if (digitalRead(5) == HIGH) {
    takeECG();}
  if (digitalRead(4) == HIGH) {
    digitalWrite(BP_START_PIN, LOW);
    delay(100);
    digitalWrite(BP_START_PIN, HIGH);
    delay(5000);
    while (digitalRead(VALVE_PIN) == 0) {
      delay(1000);
    }
    delay(2000);
    if (count == 0) {
      Serial.println("nd");
    } else if (count == 35) {
      Serial.println("B:" + String(sys) + "/" + String(dia) + "_" + String(hr));
    } else {
      Serial.println("error");
    }
    count = 0;
    delay(3000);
  }
}
void receiveEvent(int iData) {
  if (iData > 0) {
    while (iData--) {
      i2c_data_rx = Wire.read();
      count++;
      if (count == 28) {
        sys = i2c_data_rx;
      }
      if (count == 29) {
        dia = i2c_data_rx;
      }
      if (count == 30) {
        hr = i2c_data_rx;
      }
    }
  }
}
```

Health monitoring (ESP-32):

```
#include <Wire.h>
#include <WiFi.h>
#include <BlynkSimpleEsp32.h>
#include "MAX30100_PulseOximeter.h"
#include <SimpleTimer.h>
#include <OneWire.h>
#include <DallasTemperature.h>
#include <HTTPClient.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>

int bpVal;
#define SCREEN_WIDTH 128
#define SCREEN_HEIGHT 64
Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, & Wire, -1);

#define RXp2 16
#define TXp2 17
String rcv = "";

const int oneWireBus = 15;
int tempO2 = 0;
OneWire oneWire(oneWireBus);
DallasTemperature sensors( & oneWire);
char auth[] = "UQqVzVMN6IEpcGo6ZTGYAW6VLDAtpFnQ";
char ssid[] = "Wheelchair";
char pass[] = "12345678";
float temperatureC;
float temperatureF;
#define REPORTING_PERIOD_MS 3000
SimpleTimer timer;
SimpleTimer timer2;
int BP_START_PIN = 5;
int VALVE_PIN = 18;
int ecgPin = 19;
float notTemp = 0;
int notO2 = 0, notPulse = 0, notSys = 0, notDia = 0, tempLastPulse = 0;
String bpData = "";
PulseOximeter pox;
uint32_t tempLastReport = 0;
uint32_t pulseLastReport = 0;
uint32_t o2LastReport = 0;
uint32_t tsLastReport = 0;
uint32_t nottempLastReport = 0;
uint32_t bpLastReport = 0;
uint32_t bpReportTime = 60000;
void onBeatDetected() {
  ;
}
```

```
void decideNoti() {
  if (notTemp != 0 && millis() > 300000) {
    if (notTemp > 100) {
      if (millis() - nottempLastReport > 300000) {
        sendSMS("Temperature is: " + (String) notTemp + "°F. Temperature is too
high.");
        nottempLastReport = millis();
      }
    }
  }
  if (notPulse != 0) {
    if (notPulse > 110 && notPulse != tempLastPulse) {
      if (millis() - pulseLastReport > 60000) {
        sendSMS("Pulse rate is: " + (String) notPulse + "BPM. Pulse rate is
abnormal.");
        pulseLastReport = millis();
        tempLastPulse = notPulse;
      }
    }
  }
  if (notO2 != 0) {
    if (notO2 < 95) {
      if (millis() - o2LastReport > 60000) {
        String message = "Oxygen saturation is: " + (String) notO2 + "%. Oxygen
satuation is low.";
        sendSMS(message);
        o2LastReport = millis();
      }
    }
  }
}

void updateDisplay() {
  Blynk.syncVirtual(V1, V9, V3, V4, V5);
  display.clearDisplay();
  display.setTextSize(2);
  display.setTextColor(WHITE);
  display.setCursor(0, 0);
  display.println("T: " + (String) notTemp + char(247) + "F");
  display.println("O2: " + (String) notO2 + "%");
  display.println("BPM: " + (String) notPulse);
  display.println("BP:" + (String) notSys + "/" + (String) notDia);
  display.display();
}

BLYNK_WRITE(V1) {
  notTemp = param.asFloat();
}
BLYNK_WRITE(V9) {
  notPulse = param.asInt();
}
```

```
BLYNK_WRITE(V3) {
  notO2 = param.asInt();
}
BLYNK_WRITE(V4) {
  notSys = param.asInt();
}
BLYNK_WRITE(V5) {
  notDia = param.asInt();
}
void setup() {
  Serial.begin(115200);
  Serial2.begin(9600, SERIAL_8N1, RXp2, TXp2);
  Serial2.setTimeout(9);
  pinMode(BP_START_PIN, OUTPUT);
  pinMode(VALVE_PIN, INPUT);
  pinMode(ecgPin, OUTPUT);
  digitalWrite(ecgPin, LOW);
  digitalWrite(BP_START_PIN, LOW);
  if (!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) {
    for (;;)
    ;
  }
  delay(1000);
  display.clearDisplay();
  display.setTextSize(2);
  display.setTextColor(WHITE);
  display.setCursor(0, 10);
  display.println("Connecting...");
  display.display();
  Blynk.begin(auth, ssid, pass, "103.198.136.121", 8080);
  display.clearDisplay();
  display.setTextSize(2);
  display.setTextColor(WHITE);
  display.setCursor(0, 10);
  display.println("Connected!");
  display.display();
  Blynk.syncVirtual(V7, V1, V9, V3, V4, V5);
  sensors.begin();
  if (!pox.begin()) {
    for (;;)
    ;
  } else {
    digitalWrite(1, HIGH);
  }
  pox.setIRLedCurrent(MAX30100_LED_CURR_24MA);
  pox.setOnBeatDetectedCallback(onBeatDetected);
  timer.setInterval(1000 L, getSendData);
  timer2.setInterval(25 L, updateMAX);
}
```

```
void measureBP() {
  pox.shutdown();
  digitalWrite(BP_START_PIN, HIGH);
  delay(1000);
  digitalWrite(BP_START_PIN, LOW);
  delay(5000);
  while (digitalRead(VALVE_PIN) == LOW) {
    delay(500);
    Blynk.run();
  }
  delay(500);
  rcv = Serial2.readString();
  if (rcv.startsWith("B") > 0) {
    if (!Blynk.connected()) {
      while (!Blynk.connected()) {
        Blynk.connect(10000);
      }
      Blynk.run();
    }
  } else if (rcv.startsWith("error") > 0) {} else {
    digitalWrite(BP_START_PIN, HIGH);
    delay(1000);
    digitalWrite(BP_START_PIN, LOW);
    delay(10000);
    measureBP();
  }
  pox.begin();
}
BLYNK_WRITE(V8) {
  int value = param.asInt();
  if (value == 1) {
    measureBP();
  }
}
BLYNK_WRITE(V7) {
  int value = param.asInt();
  bpReportTime = value * 60000;
}
BLYNK_WRITE(V6) {
  int value = param.asInt();
  if (value == 1) {
    digitalWrite(ecgPin, HIGH);
    delay(1000);
    digitalWrite(ecgPin, LOW);
  }
  Blynk.virtualWrite(V6, 0);
}
void sendSMS(String msg) {
  pox.shutdown();
  HTTPClient http;
  msg.replace(" ", "+");
```

```
  String serverPath =
"https://api.greenweb.com.bd/api.php?token=API_TOKEN&to=01315352025,01682993031&
message=" + msg;
  http.begin(serverPath.c_str());
  int httpResponseCode = http.GET();
  if (httpResponseCode > 0) {
    String payload = http.getString();
  } else {
    delay(1000);
  }
  http.end();
  pox.begin();
}
void loop() {
  decideNoti();
  timer.run();
  timer2.run();
  Blynk.run();
  if (Blynk.connected() && rcv.length() > 0) {
    pox.shutdown();
    bpData = rcv;
    Blynk.virtualWrite(V4, rcv.substring(rcv.indexOf(":") + 1,
rcv.indexOf("/")));
    Blynk.virtualWrite(V5, rcv.substring(rcv.indexOf("/") + 1,
rcv.indexOf("_")));
    Blynk.virtualWrite(V9, rcv.substring(rcv.indexOf("_") + 1, rcv.length()));
    rcv = "";
    Blynk.virtualWrite(V8, 0);
    bpLastReport = millis();
    pox.begin();
  }
  if (millis() - bpLastReport > bpReportTime) {
    Blynk.virtualWrite(V8, 1);
    measureBP();
  }
  pox.update();
  if (millis() - tsLastReport > REPORTING_PERIOD_MS) {
    tempO2 = pox.getSpO2();
    if (pox.getHeartRate() > 0 && pox.getSpO2() > 0) {
      tempO2 = pox.getSpO2();
      if (tempO2 < 97) {
        tempO2 += 3;
      }
      if (tempO2 > 100) {
        tempO2 = 99;
      }
      bpVal = (int) pox.getHeartRate();
      Blynk.virtualWrite(V2, bpVal);
      Blynk.virtualWrite(V3, tempO2);
    }
    tsLastReport = millis();
```

```
  }

  if (millis() - tempLastReport > 10000) {
    pox.shutdown();
    sensors.requestTemperatures();
    temperatureC = sensors.getTempCByIndex(0);
    temperatureF = sensors.getTempFByIndex(0);
    Blynk.virtualWrite(V0, temperatureC);
    Blynk.virtualWrite(V1, temperatureF);
    tempLastReport = millis();
    pox.begin();
  }
}

void getSendData() {
  updateDisplay();
}
void updateMAX() {
  pox.update();
}
```

FYDP (P) SPRING 2022 Summary of Team 03 Log Book/ Journal

GROUP 03

Development of a Brain Computer Interface (BCI) for Disabled Patients to Control Their Wheelchair using Brain Waves with Health Monitoring System

	Final Year Design Project (P) Summer 2021		
Student Details	**NAME & ID**	**EMAIL ADDRESS**	**PHONE**
Member 1	Sk Tahmed Salim Rafid	sk.tahmed.salim.rafid@g.bracu.ac.bd	01315352025
Member 2	Redwan Ahmed Miazee	redwan.ahmed.miazee@g.bracu.ac.bd	01682993031
Member 3	Md. Kutubuddin Byzid	md.kutubuddin.byzid@g.bracu.ac.bd	01533154707
Member 4	Afsana Anjum Anika	afsana.anjum.anika@g.bracu.ac.bd	01315352024
ATC Details:			
ATC 3			
Chair	Prof.Dr. AKM Abdul Malek Azad	a.azad@bracu.ac.bd	01556528695
Member 1	Md. Nahid Haque Shazon	nahid.haque@bracu.ac.bd	
Member 2	Afrida Malik	afrida.malik@bracu.ac.bd	

General Notes:

1. In addition to detail journal/logbook fill out the summary/key steps and progress of your work
2. Reflect planning assignments, who has what responsibilities.
3. The logbook should contain all activities performed by the team members (Individual and team activities).

FYDP (P) SPRING 2022 Summary of Team 03 Log Book/ Journal

Date/Time /Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
02.02.2022 (FYDP committee class)	1. Rafid 2. Redwan 3. Byzid 4 .Anika	Introductory session of **EEE400 (P)**		**N/A it was an introductory meeting**.
03.02.2022 Meeting 1(Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. We discussed about our interested areas and searched for relevent documents . 2.We finalized some sector to work with such as iot based project , solar monitoring , biomedical engineering projects and also AI related projects .	1. Rafid 2. Redwan 3. Byzid 4. Anika **Task 1: Completed** **Task 2: Completed**	
07.02.2022 Meeting 2 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Finalized 4 ideas to present in front of ATC panel members . 2.Evaluated whether the selected topic ideas are complex engineering problems or not.	Task 1. Rafid,Redwan, Byzid and Anika. Task 2: Rafid, Redwan, Byzid and Anika . **Task 1: Completed** **Task 2: Completed**	
10.02.2022 (FYDP committee class))	1. Rafid 2. Redwan 3. Byzid 4. Anika	Lecture 2 Introduction to Engineering Design Process taken by Md. Mosaddequr Rahman (MDR) Professor and Chairperson , Department of EEE, Brac University .		
12.02.2022 (Meeting 1 with ATC	1.Prof. Dr. AKM Abdul Malek Azad	1. ATC introduction ,	Task 2: Rafid, Redwan, Byzid and Anika .	1.Prepare logbook

panel members)	2. Md. Nahid Haque Shazon 3. Afrida Malik . 4. Rafid 5. Redwan 6. Byzid 7. Anika	2. Presented our 4 ideas in front of ATC panel and got approval of brain controlled wheel chair project with iot based health monitoring .	 **Task 2: Completed**	2. Start writing concept note . 3. Mail us the progressive concept note and logbook . 4. Accepted yout idea .you can go with it .
15.02.2022 Meeting 3 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Read multiple papers about EEG signal acquisition and and methods of controlling the wheel chair. 2. Read multiple papers on fall detection ,obstacle avoidance and health monitoring . 3. Researched about available EEG headsets in current market place .	Task 1: Rafid & byzid Task 2: Redwan & Anika Task 3: Rafid, Redwan, Byzid and Anika . **Task 1: Completed** **Task 2: Completed** **Task 3: Completed**	
17.02.2022 Lecture 3 (FYDP committee class)	1. Rafid 2. Redwan 3. Byzid 4. Anika	How to Identify a Complex Engineering Design Project taken by Dr. Abu S. M. Mohsin (MOH) , Assistant Professor, Department of EEE, Brac University .		

FYDP (P) SPRING 2022 Summary of Team 03 Log Book/ Journal

17.02.2022 Meeting 4 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Preparing log book . 2. Finalizing document for reference in our project . 3. Starting of concept note. 4. Equipment list .	Task1:Redwan & Rafid . Task 2: Byzid and Anika. Task 3 : Rafid, Redwan, Byzid and Anika . Task 4: Rafid, Redwan, Byzid and Anika . **Task 1: Completed** **Task 2: Completed** **Task 3: partially completed** **Task 4: Completed**	
19.02.2022 (Meeting 2 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad 2. Md. Nahid Haque Shazon 3. Afrida Malik . 4. Rafid 5. Redwan 6. Byzid 7. Anika	1. Disscussion about our project methodology, algorithms . 2. Mail the concept note draft by 26th february to ATC members. 3. System level requirements (need to do a meeting with CRP to understand partical requirements by such patients) 4. Project required compenents list. 5. We need to update our project title to make it more comprehensible .	Task1:Redwan,Rafid,Byzid and Anika. Task 2: Redwan Task 3 : Rafid, Redwan, Byzid and Anika . Task 4: Rafid,Byzid,Anika and Redwan. . Task 5: Rafid,Byzid,Anika and Redwan. .	1. Make block diagram of your algorithm . 2. Correct your Logbook 3. Submit all documents in pdf format and sent mail in the same thread. 4.Need to discuss system level requirement

			Task 1: Completed **Task 2: Completed** **Task 3: Partially Completed** **Task 4: Completed** **Task 5: Completed**	criterion with CRP . 5. Update of our project title .
20.02.2022 Meeting 5 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Concept note draft . 2. Update the logbook	Task 1: Rafid,Byzid,Redwan and Anika Task 2 : Redwan	
			Task 1: Partially completed . **Task 2: Completed**	
23.02.2022 Meeting 6 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Concept note drafted final version .	Task 1: Rafid,Byzid,Redwan and Anika	
			Task 1: Completed	
24.02.2022 Lecture 4 (FYDP committee class)	1. Rafid 2. Redwan 3. Byzid 4. Anika	Lecture 04 Complex Engineering Problem Identification taken by Dr. Abu S. M. Mohsin, Assistant Professor, Department of EEE, Brac University.		

25.02.2022 Meeting 7 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Evaluate whether the multiple design approaches are matching with the attributes. 2. Update and mail the logbook and draft of concept note .	Task 1: Rafid,Byzid,Anika and Redwan. Task 2: Redwan **Task 1: Completed** **Task 2: Completed**	
01.03.2022 Meeting 8 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Update problem statement according to the review . 2. Update the Logbook .	Task 1: Rafid,Byzid, Redwan and Anika. Task 2: Redwan **Task 1: Completed** **Task 2: Completed**	
02.03.2022 Lecture 5 (FYDP committee class)	1. Rafid 2. Redwan 3. Byzid 4. Anika	Lecture 5 Review of Project Proposal Preparation taken by Mohaimenul Islam Lecturer, Department of EEE, Brac University.		
03.03.2022 Meeting 9 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Update multiple approach block diagram . 2. Give proper references . 3. Mail the revised version of concept note and logbook till 03-03-2022.	Task 1: Rafid,Byzid, Redwan and Anika. Task 2: Rafid,Byzid, Redwan and Anika. Task 3: Redwan **Task 1:**	

			Completed **Task 2: Completed** **Task 3: Completed**	
06.03.2022 Meeting 10 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Presentation Slide preparation for Concept note draft . 2. Update logbook.	Task 1: Rafid,Byzid, Redwan and Anika. Task 2: Redwan **Task 1: Completed** **Task 2: Completed**	
10-03-2022 (FYDP progress presentation with ATC panel and FYDP committee members)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Functional requirements should be more specific and precise. 2. Component level requirements have to included . 3.Clarify how EEG signal will be aquired . 4.Update the title of project and remove IOT from title. 5. From design methodology remove arduino and other sensors name. Use simple box . Dont write any component name in design approach directly(Arduino) .		
16-03-2022 Meeting 11 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Update the title of our project and also remove the IOT word from the title. 2. Update functional requirements. 3. Update design approach block diagrams .	Task1:Redwan, Rafid,Byzid and Anika. Task 2: Redwan Task 3 : Rafid, Redwan, Byzid and Anika .	

		4. Add Component level requirement . 5. logbook update.	Task 4: Rafid,Byzid,Anika and Redwan. Task 5: Redwan **Task 1: Completed** **Task 2: Completed** **Task 3: Completed** **Task 4: Completed** **Task 5: Completed**	
24-03-2022 Lecture 6 (FYDP committee class)	1. Rafid 2. Redwan 3. Byzid 4. Anika	Lecture 6 Report Writing and Presentation Techniques taken by Md. Rakibul Hasan Lecturer, Department of EEE, Brac University.		
27-03-2022 Meeting 12 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Project proposal note planning . 2. Budget planning (Tentative) 3. Update logbook.	Task 1: Rafid,Byzid, Redwan and Anika. Task 2: Rafid,Byzid, Redwan and Anika. Task 3: Redwan **Task 1: Completed** **Task 2: Completed**	

FYDP (P) SPRING 2022 Summary of Team 03 Log Book/ Journal

			Task 3: Completed	
01-04-2022 Meeting 13 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Started writting project proposal note . 2.Updated logbook.	Task 1: Rafid,Byzid, Redwan and Anika. Task 2: Redwan **Task 1: Partially Completed** **Task 2: Completed**	
02.04.2022 (Meeting 4 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad 2. Md. Nahid Haque Shazon 3. Afrida Malik . 4. Rafid 5. Redwan 6. Byzid 7. Anika	1. Prepare "Budget" for the prototype and for both the designs, as well as the "Project Plan" by next submission on 7th April,2022. 2. Write the "Background" part on existing research done on this project from the collected 17 papers as mentioned. 3. Fix the formatting and follow the given template. 4. Prepare the Gantt chart for EEE400 P , EEE400 D and EEE400 C along with tabular format respectively. 5. Provide explanation/justification for choosing the criteria of "Complex	Task1:Redwan, Rafid,Byzid and Anika. Task 2: Byzid, Anika Task 3 : Rafid, Redwan . Task 4: Rafid, and Redwan. Task 5: Byzid,Anika. Task 06: Rafid, Redwan. Task 07: Redwan.	1. Take either design approach 2 or approach 3. 2. Fix the alignment for the entire project proposal and specially "Expected Outcome". 3. Make sure the writing style is professional. (Follow research papers). 4. Add proper references of the project

		Engineering Problems (EP)" and "Complex Engineering Activities (EA)". 6. Write "Methodology" section with detailed flowchart and also provide adequate explanation. 7. Update the entries regarding suggestions from FYDP progress presentation into the logbook .	**Task 1: Completed** **Task 2: Completed** **Task 3: Completed** **Task 4: Completed** **Task 5: Completed** **Task 6: Completed** **Task 7: Completed**	(Follow IEEE format of referencing). 5. Remove "note" - word from cover page. 6. Add an entry of progress presentation held on 10 March,2022 in the logbook .
04-04-2022 Meeting 14 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Worked on Budget and Project planning and updated to proposal note . 2. Started writing Problem statement and background. 3. Started preparing gantt chart and tabulation . 4. Logbook update.	Task1:Redwan, Rafid,Byzid and Anika. Task 2: Byzid, Anika Task 3 : Rafid, Redwan . Task 4: Rafid, and Redwan **Task 1: Completed** **Task 2: Partially Completed**	

			Task 3: Partially Completed **Task 4: Completed**	
06-04-2022 Meeting 15 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Complete background and problem statement . 2. Complete gantt chart and project planning tabulation. 3. Provide explanation/justification for choosing the criteria of "Complex Engineering Problems (EP)" and "Complex Engineering Activities (EA)". 4. Write "Methodology" section with detailed flowchart and also provide adequate explanation. 5. Logbook update.	Task1:Redwan ,Rafid,Byzid and Anika. Task 2: Rafid,Redwan, Byzid and Anika Task 3 : Byzid, Anika Task 4: Rafid, and Redwan. Task 5: Redwan **Task 1: Completed** **Task 2: Completed** **Task 3: Completed** **Task 4: Completed** **Task 5: Completed**	

07-04-2022 Lecture 7 (FYDP committee class)	1. Rafid 2. Redwan 3. Byzid 4. Anika	Lecture 7 Project Safety, Sustainability and Environmental Impact taken by Mohaimenul Islam Lecturer, Department of EEE, Brac University.		
07-04-2022 Meeting 16 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Fix the formatting and follow the given template. 2. Give Proper references . 3. Review of project Proposal note . 4. Logbook update.	Task1:Redwan, Rafid and Byzid. Task 2: Byzid, Anika. Task 3 : Rafid, Redwan, Byzid and Anika. Task 4: Redwan **Task 1: Completed** **Task 2: Completed** **Task 3: Completed** **Task 4: Completed**	

09.04.2022 (Meeting 5 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad 2. Md. Nahid Haque Shazon 3. Afrida Malik . 4. Rafid 5. Redwan 6. Byzid 7. Anika	1. Submit draft proposal note by 21st April , final presentation slide by 17th April and Final mock presentation on 23rd April. 2. Maintain proper capitalization in "Scopes and Objective" section. 3. Mention "Figure-01 / Figure-02" in the description part of "Multiple Design Approaches" section. 4. Mention "Figure-03" in the description part of "Methodology" section. 5. Provide the sum for each approach and prototype in "Budget" section. 6. P1 and P3 of the attributes section must be revised. 7. Logbook Update.	Task1:Redwan, Rafid,Byzid and Anika. Task 2: Byzid, Anika Task 3 : Rafid, Redwan . Task 4: Rafid, and Redwan. Task 5: Byzid,Anika. Task 06: Rafid, Redwan. Task 07: Redwan. **Task 1: Partially Completed** **Task 2: Completed** **Task 3: Incomplete.** **Task 4: Incomplete.** **Task 5: Incomplete.** **Task 6: Partially Completed** **Task 7: Completed**	1. Decrease the font-size of each of the sub-topic names according to given format. 2. Remove unwanted content from the "Problem statement and Background" section. 3. Align and position the gantt charts in "Project Plan" section to make them more comprehensible 4. Follow proper uniform referencing. 5. Fix the referencing in "Problem statement and Background" by including proper spacing.

12-04-2022 Meeting 17 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1.Update Sustainabolity and Risk Management . 2.Update Safety considerations. 3. Correct references in backgrounf part. 4. Add budget "total" required amount for each model. 5. Logbook Update.	Task 1: Rafid and Byzid. Task 2: Redwan and Anika. Task 3: Byzid Task 4: Anika Task 5: Redwan **Task 1: Completed** **Task 2: Completed** **Task 3: Completed** **Task 4: Completed** **Task 5: Completed**	
14-04-2022 Meeting 18 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Mentioned "Figure-01 / Figure-02" in the description part of "Multiple Design Approaches" section.	Task1: Redwan. Task 2: Rafid. Task 3 : Rafid,	

		2. Mentioned "Figure-03" in the description part of "Methodology" section. 3. Updated ethical consideration and risk management and analysis. 4. Decrease the font-size of each of the sub-topic names according to given format. 5. Omit irrelevant paragraph from Problem Statement section. 6. Started preparing slide for presentation. 7. Logbook Update.	Redwan, Byzid and Anika . Task 4: Anika. Task 5: Byzid. Task 06: Rafid, Redwan,Byzid and Anika . Task 07: Redwan.	
			Task 1: Completed **Task 2: Completed** **Task 3: Completed** **Task 4: Completed** **Task 5: Completed** **Task 6: Partially Completed** **Task 7: Completed**	
17-04-2022 Meeting 19 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Complete the slide . 2. Logbook updated .	Task 1: Rafid, Redwan, Byzid and Anika . Task 2: Redwan.	

			Task 1: Completed **Task 2: Completed**	
21-04-2022 Meeting 20 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Complete the Proposal note final draft . 2. Logbook updated .	Task 1: Rafid, Redwan, Byzid and Anika . Task 2: Redwan.	
			Task 1: Completed **Task 2: Completed**	
23-04-2022 (Meeting 6 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad 2. Md. Nahid Haque Shazon 3. Afrida Malik . 4. Rafid 5. Redwan 6. Byzid 7. Anika	1. Mock Presentation of Final Proposal . 2. Logbook Update.	Task 1: Rafid, Redwan, Byzid and Anika . Task 2: Redwan.	1. Delete Reference slide. 2. project plan after budget in slide sequence 3.Add conclusion and future work slide 4. Title case format check in
			Task 1: Completed **Task 2: Completed**	

				slides. 5.Use pointers during presentation . 6.Add slide number and update specifications part .
26-04-2022 Meeting 20 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Delete Reference slide. 2. project plan after budget in slide sequence 3.Add conclusion and future work slide 4. Title case format check in slides. 5. Add slide number and update specifications part . 6. Logbook Update	Task1: Redwan. Task 2: Rafid. Task 3 : Byzid and Anika . Task 4: Anika. Task 5: Byzid. Task 06: Redwan. **Task 1: Completed** **Task 2: Completed** **Task 3: Completed** **Task 4: Completed** **Task 5: Completed** **Task 6: Completed**	

27-04-2022 Final Presentation (FYDP committee class)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Final Proposal Presentation to all ATC panel members and FYDP Committe.		

FYDP (D) Summer 2022 Summary of Team 03 Log Book/ Journal

GROUP 03

Development of a Brain Computer Interface (BCI) for Person with Disabilities to Control Their Wheelchair using Brain Waves along with Health Monitoring System.

	Final Year Design Project (P) Summer 2021		
Student Details	**NAME & ID**	**EMAIL ADDRESS**	**PHONE**
Member 1	Sk Tahmed Salim Rafid	sk.tahmed.salim.rafid@g.bracu.ac.bd	01315352025
Member 2	Redwan Ahmed Miazee	redwan.ahmed.miazee@g.bracu.ac.bd	01682993031
Member 3	Md. Kutubuddin Byzid	md.kutubuddin.byzid@g.bracu.ac.bd	01533154707
Member 4	Afsana Anjum Anika	afsana.anjum.anika@g.bracu.ac.bd	01315352024
ATC Details:			
ATC 3			
Chair	Prof.Dr. AKM Abdul Malek Azad	a.azad@bracu.ac.bd	01556528695
Member 1	Afrida Malik	afrida.malik@bracu.ac.bd	
Member 2	Mohammad Tushar Imran	thushar.imran@bracu.ac.bd	

General Notes:

1. In addition to detail journal/logbook fill out the summary/key steps and progress of your work
2. Reflect planning assignments, who has what responsibilities.
3. The logbook should contain all activities performed by the team members (Individual and team activities).

FYDP (D) Summer 2022 Summary of Team 03 Log Book/ Journal

Date/Time /Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
02.06.2022 (FYDP committee class)	1. Rafid 2. Redwan 3.Anika	Introductory session of **EEE400 (D)**		Byzid was absent due to emergency. Informed FYDP committee and approved by FYDP committee. (accident of his friend)
05.06.2022 Meeting 1(Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Preliminary meeting on approaches for simulation. 2. Investigating the process to connect EEG Headset to arduino. 3. logbook update.	Task 1: Rafid, Redwan, Byzid, Anika. Task 2: Rafid, Redwan, Byzid, Anika. Task 3: Redwan. **Task 1: Partially Completed** **Task 2: Completed** **Task 3: Completed.**	
07.06.2022 Meeting 2 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Develop initial model and perform simple tests. 2. Discussion on effective validation method for both designs. 3. Logbook update.	Task 1: Rafid, Redwan, Byzid, Anika. Task 2: Rafid, Redwan, Byzid, Anika.	

			Task 3: Redwan.	
			Task 1: Partially Completed **Task 2: Completed** **Task 3: Completed.**	
11.06.2022 (Meeting 1 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad 2. Rafid 3. Redwan 4. Byzid 5. Anika	1. Read journals for EEG data collection and collect EEG datasets. 2. Finalize software which will be used for simulation for FYDP 400D. 3. Go through Literature review for simulation process. 4. Start writting final design report for FYDP 400D. 5. Find approaches for software based simulation. 6. Update logbook and make necessary changes.	Task 1: Rafid, Anika, Byzid, Redwan. Task 2: Redwan, Rafid, Anika , Byzid. Task 3: Redwan, Anika. Task 4: Byzid. Task 5: Rafid. Task 6: Redwan.	1. No Hardware can be used in FYDP 400D for simulation . 2. Define the requirements of Pc to overcome simulation problem and get back to ATC Panel with specifications and proper explanation. 3. Avoid grammatical errors in logbook.

			Task 1: Completed **Task 2: Partially Completed** **Task 3: Completed.** **Task 4: Partially Completed** **Task 5: Completed** **Task 6: Completed.**	4. Make changes in investigate communication method. 5. Collect data sets of EEG Signals. 6. Correct logbook on FYDP introductory session attendee list.
13.06.2022 Meeting 3 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Go through some relevent papers for simulation process. 2. Short list the simulation software. 3. Discuss on approaches for simulation. 4. Start writing Background research and Survey for Final Year Design report. 5. Start working on collecting EEG datasets from various sources. 6. Correct logbook and update it .	Task 1: Rafid, Anika, Byzid, Redwan. Task 2: Redwan, Rafid, Anika , Byzid. Task 3: Rafid, Redwan, Anika, Byzid. Task 4: Byzid, Anika. Task 5: Rafid, Redwan. Task 6: Redwan.	

			Task 1: Completed **Task 2: Partially Completed** **Task 3: Completed.** **Task 4: Partially Completed** **Task 5: Partially Completed** **Task 6: Completed.**	
16.06.2022 Meeting 4 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Complete draft of background research and survey for Final year Design Report. 2. Finalize software for simulation and review requirements for computer . 3. Collect EEG datasets. 4. Logbook update.	Task 1: Rafid, Anika, Byzid, Redwan. Task 2: Redwan, Rafid, Anika, Byzid. Task 3: Rafid, Redwan, Anika, Byzid. Task 4: Redwan.	
			Task 1: Completed **Task 2: Completed** **Task 3: Completed.**	

			Task 4: Completed	
18.06.2022 (Meeting 2 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad . 2. Mohammad Tushar Imran. 3. Rafid 4. Redwan 5. Byzid 6. Anika	1.Add system levels specifications and component levels specification separately. 2. Acquire system level requirements from CRP. 3. Update logbook and make necessary changes . 4. Validation of choosing proteus over matlab software.	Task 1: Rafid, Anika, Byzid, Redwan. Task 2: Redwan, Rafid & Byzid. Task 3: Rafid, Redwan, Anika, Byzid. Task 4: Rafid & Byzid.	1. Correct logbook month entry . 2.Follow Reference format IEEE style.
			Task 1: Completed **Task 2: Partially Completed** **Task 3: Completed.** **Task 4: Completed**	

20.06.2022 Meeting 5 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Prepared questions for system level requirements regarding stakeholder requisitions. 2. Fixed schedule and planning to visit stakeholder firm (CRP). 3. Rephrase the component level specifications, objectives, requirements, constraints and update system level specification from existing works. 4. Initial Simulation on process (data feeding to proteus by python script). 5. Logbook Update.	Task 1: Rafid, Anika, Byzid, Redwan. Task 2: Redwan, Rafid, Anika, Byzid. Task 3: Redwan, Byzid. Task 4: Rafid, Anika. Task 5: Redwan **Task 1: Completed** **Task 2: Completed** **Task 3: Completed.** **Task 4: Partially Completed** **Task 5: Completed.**	

23.06.2022 Meeting 6 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Update Selection of Modern Engineering/IT Tools in final year design report . 2. Rephrase Multiple Design Approaches, Attributes, update references and revised budget in final year design report. 3. Complete initial simulation on process (data feeding to proteus by python script). 4. Logbook Update.	Task 1: Rafid, Byzid. Task 2: Redwan, Byzid, Anika. Task 3: Rafid, Redwan. Task 4: Redwan **Task 1: Partially Completed.** **Task 2: Partially Completed** **Task 3: Completed.** **Task 4: Completed.**	
25.06.2022 (Meeting 3 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad . 2. Afrida Malik. 3. Mohammad Tushar Imran. 4. Rafid 5. Redwan 6. Byzid 7. Anika	1. Project plan (provide ghantt chart with task duration table). 2. Add another coloumns in budget for units . 3. Include risk management matrix. 4. Add one column in component level specification as component description.	Task 1: Rafid, Redwan, Anika, Byzid. Task 2: Redwan, Rafid. Task 3: Byzid, Anika. Task 4: Byzid, Anika.	1. Add “comparison” in table of content’s as 4.3 sub-section. 2.Add two sub-section in functional verification section in table of contents. 3. Try to present system level

		5. Include engineering tools in section 5. 6. Update simulation progress. 7. Logbook update.	Task 5: Rafid, Anika, Byzid, Redwan. Task 6: Rafid, Redwan. Task 7: Redwan. **Task 1: Completed** **Task 2: Completed** **Task 3: Completed.** **Task 4: Completed** **Task 5: Partially Completed** **Task 6: Partially Completed.** **Task 7: Completed.**	requirement also in tabular format . 4. In multiple design approach first give description then diagram. 5. Rephrase point 2 of non-functional requirements and contraints. 6. Write prototype budget for optimal design in heading instead of writing prototype budget . 7. Remove indentation of reference section from table of content and also allign properly with context. 8. Keep all documentation of products. 9. Look for ways to work with attention level parameters.
26.06.2022 Meeting 7 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Revise our FYDP 400D project plan . 2. Visited stakeholder firm (CRP) and had a discussion about our project and system level requirements. 3. Update system level specification in tabular format .	Task 1: Rafid, Redwan, Anika, Byzid. Task 2: Rafid, Redwan, Byzid. Task 3: Byzid, Anika.	

		4. Logbook update.	Task 4: Redwan.	
			Task 1: Partially Completed. **Task 2: Completed.** **Task 3: Partially Completed.** **Task 4: Completed.**	
28.06.2022 Meeting 8 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Update table of contents(add sub sections as suggested by ATC panel and also make necessary changes). 2. Add risk management matrix in risk management analysis. 3. Simulation Update of design 01. 4. Preparation of progress presentation slides. 5. Logbook update.	Task 1: Rafid, Redwan. Task 2: Byzid, Anika. Task 3: Rafid, Redwan, Anika, Byzid. Task 4: Rafid, Redwan, Anika, Byzid. Task 5: Redwan.	
			Task 1: Completed. **Task 2: Completed.** **Task 3: Partially Completed.**	

			Task 4: Partially Completed. **Task 5: Completed.**	
29.06.2022 Meeting 9 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Update impact analysis and ethical consideration of final year design report . 2. Prepare and submit draft progress presentation slide . 3. Logbook update.	Task 1: Rafid, Redwan, Anika, Byzid. Task 2: Rafid, Redwan, Anika, Byzid. Task 3: Redwan. **Task 1: Completed.** **Task 2: Completed.** **Task 3: Completed.**	
30.06.2022 (FYDP committee class)	1. Abu Hamed M. Abdur Rahim 2. Md. Rakibul Hasan 3. Afrida Malik 4. Rafid 5. Redwan 6. Anika 7. Byzid	Progress Presentation of FYDP 400D to ATC panel members and FYDP committee.		1. Rahim sir asked us how our system is different from others and is it available in market or not? 2. Rakibul sir said it was a nice presentation.

04.07.2022 Meeting 10 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Updated unit section in all design budget. 2. Added component description in component level specifications . 3. Simulation update . 4. Logbook update.	Task 1: Rafid, Redwan. Task 2: Byzid, Anika. Task 3: Rafid, Redwan, Anika, Byzid. Task 4: Redwan. **Task 1: Completed.** **Task 2: Completed.** **Task 3: Partially Completed.** **Task 4: Completed.**	
16.07.2022 Meeting 11 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Update design approach component visual diagram . 2. Update system level specifications in tabular format . 3. Update simulation process of design 01 and 02. 4. Logbook update.	Task 1: Rafid, Anika. Task 2: Byzid, Redwan. Task 3: Rafid, Redwan, Anika, Byzid. Task 4: Redwan. **Task 1: Partially Completed.** **Task 2: Completed.**	

			Task 3: Partially Completed. **Task 4: Completed.**	
19.07.2022 Meeting 12 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Write prototype budget for optimal design in heading instead of writing prototype budget. 2. Remove indentation of reference section from table of content and also allign properly with context. 3. Simulation update. 4. Logbook Update.	Task 1: Rafid, Anika. Task 2: Byzid, Redwan. Task 3: Rafid, Redwan, Anika, Byzid. Task 4: Redwan.	
			Task 1: Completed. **Task 2: Completed.** **Task 3: Partially Completed.** **Task 4: Completed.**	

21.07.2022 (Meeting 4 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad . 2. Afrida Malik. 3. Mohammad Tushar Imran. 4. Rafid 5. Redwan 6. Byzid	1. Add page numbers to table of contents. 2. Mention Table no. for each table along with its names. 3. Change font size for Gantt chart. 4. Shorten first segment of expected outcome and elongate 2nd part about actual impact. 5. Elaborate on "ethical consideration" section. 6. Update "system level requirements" with numerical data. 7. Simulation Update . 8. Logbook Update.	Task 1: Anika, Byzid. Task 2: Redwan, Byzid. Task 3: Rafid, Anika. Task 4: Byzid, Anika. Task 5: Rafid, Byzid, Redwan, Anika. Task 6: Rafid, Redwan. Task 7: Rafid, Byzid, Redwan, Anika. Task 8: Redwan. **Task 1: Completed.** **Task 2: Completed.** **Task 3: Partially Completed.** **Task 4: Completed.** **Task 5: Completed.** **Task 6: Completed.**	1. Logbook update: Write progress status for ATC meetings as well in the logbook. 2. Use uniform color for font. 3. Write "first" instead of "initial" in first line of multiple design 1. 4. Use larger diagram for Multiple Design Approach 1. 5. Check grammatical errors in risk management section. 6. **Anika was absent due to medical emergency of her sister.** 7. Start working on report section 6 & 7 .

			Task 7: Partially Completed. **Task 8: Completed.**	
27.07.2022 Meeting 13 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Add page numbers to table of contents and use uniform color for font. 2. Mention Table no. for each table along with its names. 3. Logbook update: Write progress status for ATC meetings as well in the logbook. 4. Shorten first segment of expected outcome and elongate 2nd part about actual impact. 5. Simulation Update .	Task 1: Anika, Byzid. Task 2: Redwan, Byzid. Task 03: Redwan. Task 4: Byzid, Anika. Task 5: Rafid, Byzid, Redwan, Anika. **Task 1: Completed.** **Task 2: Completed.** **Task 3: Completed.** **Task 4: Completed.** **Task 5: Partially Completed.**	

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29.07.2022 Meeting 14 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Elaborate on "ethical consideration" section. 2. Update "system level requirements" with numerical data. 3. Change font size for Gantt chart. 4. Simulation Update. 5.Logbook Update.	Task 1: Rafid, Byzid, Redwan, Anika. Task 2: Rafid, Redwan. Task 3: Rafid, Anika. Task 4: Rafid, Byzid, Redwan, Anika. Task 5: Redwan. **Task 1: Completed.** **Task 2: Completed.** **Task 3: Partially Completed.** **Task 4: Partially Completed.** **Task 5: Completed.**	
30.07.2022 (Meeting 5 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad . 2. Afrida Malik. 3. Mohammad Tushar Imran. 4. Rafid 5. Redwan	1. Change red colour from design 02 block diagram. 2. Write section 6, 7 and 13 of final year design report and submit draft by 10th august, 2022. 3. Final design report submission on August 20. 4. Final presentation slide submission on 23rd August.	Task 1: Redwan, Anika. Task 2: Rafid, Redwan, Byzid, Anika. Task 3: Rafid, Anika, Redwan, Byzid.	1. Improve Gnatt chart picture quality. 2. August 13th discussion on draft report . 3. August 20th Mock Presentation. 4. Use footer in video presentation.

	6. Byzid 7. Anika	5. Simulation update of design 01 & 02. 6. Battery monitoring segment mention SOC instead of current and voltage measurement. 7. Add pressure sensor and ECG sensor in health monitoring part. 8. Logbook update.	Task 4: Rafid, Byzid, Redwan, Anika. Task 5: Rafid, Byzid, Redwan, Anika. Task 6: Rafid, Redwan. Task 7: Rafid, Byzid. Task 8: Redwan.	5. Add red light in buzzer. 6. Mention design 01 and design 02 comparison both performance wise and cost analysis of optimal solution.
			Task 1: Completed. **Task 2: Partially Completed.** **Task 3: Partially Completed.** **Task 4: Partially Completed.** **Task 5: Completed.** **Task 6: Completed.** **Task 7: Completed.** **Task 8: Completed.**	

02.08.2022 Meeting 15 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Update red colour from design 02 block diagram . 2. Add pressure sensor and ECG sensor in health monitoring part. 3. Update section 6, 7 and 13 of final year design report. 4. Simulation update of design 01 & 02. 5. Update budget for design 01 & 02. 6. Logbook update.	Task 1: Redwan, Anika. Task 2: Rafid, Byzid. Task 3: Rafid, Anika, Byzid, Redwan. Task 4: Rafid, Byzid, Redwan, Anika. Task 5: Redwan, Rafid. Task 6: Redwan.	
			Task 1: Completed. **Task 2: Completed.** **Task 3: Partially Completed.** **Task 4: Partially Completed.** **Task 5: Completed.** **Task 6: Completed.**	

05.08.2022 Meeting 16 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Gantt chart update. 2. Update block diagram of design 01 & 02. 3. Simulation update of design 01 & 02. 4. Battery monitoring segment mention SOC instead of current and voltage measurement. 5. Update section 6, 7 and 13 of final year design report. 6. Update design approach 01 & 02. 7. Logbook update.	Task 1: Redwan, Anika. Task 2: Rafid, Redwan. Task 3: Rafid, Anika, Byzid, Redwan. Task 4: Rafid, Redwan. Task 5: Rafid, Anika, Byzid, Redwan. Task 6: Rafid, Anika, Byzid, Redwan. Task 7: Redwan.	
			Task 1: Completed. **Task 2: Completed.** **Task 3: Completed.** **Task 4: Completed.** **Task 5: Partially Completed.** **Task 6: Completed.** **Task 7: Completed.**	

06.08.2022 (Meeting 6 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad . 2. Afrida Malik. 3. Mohammad Tushar Imran. 4. Rafid 5. Redwan 6. Byzid 7. Anika	1. Update section 7 and 13 of final year design report. 2. Remove design 02 block diagram red line . 3. Add segment wise picture in section 6 and provide descriptions on the final year design report. 4. Make simulation video of both designs and send it to ATC panel members by 12th August. 5. Add 13.1 missing attributes P7 of complex engineering problems. 6. Logbook update.	Task 1: Rafid, Anika, Byzid, Redwan. Task 2: Rafid, Redwan. Task 3: Anika, Byzid, Rafid and Redwan. Task 4: Rafid, Redwan, Byzid and Anika. Task 5: Byzid, Anika. Task 6: Redwan.	1. Gantt chart formating . 2. Correct reference no 21 as IEEE thesis style format. 3. Add figure title and number in design 2 block diagram in section 6.
			Task 1: Completed. **Task 2: Completed.** **Task 3: Completed.** **Task 4: Partially Completed.** **Task 5: Completed.** **Task 6: Completed.**	

08.08.2022 Meeting 17 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Update section 7 and 13 of final year design report. 2. Correct reference no 21 as IEEE thesis style format. 3. Add figure title and number in design 2 block diagram in section 6 & Remove design 02 block diagram red line . 4. Add segment wise picture in section 6 descriptions on the final year design report. 5. Logbook update.	Task 1: Rafid, Anika, Byzid, Redwan. Task 2: Rafid, Redwan. Task 3: Rafid, Redwan. Task 4: Anika, Byzid, Rafid and Redwan. Task 5: Redwan. **Task 1: Completed.** **Task 2: Completed.** **Task 3: Completed.** **Task 4: Completed.** **Task 5: Completed.**	
10.08.2022 Meeting 18 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Add 13.1 missing attributes P7 of complex engineering problems. 2. Complete draft of final year design report FYDP and send it to ATC panel members. 3. Simulation video of design 01 & design 02. 4. Logbook update.	Task 1: Byzid, Anika. Task 2: Rafid, Anika, Byzid, Redwan. Task 3: Rafid, Redwan, Byzid and Anika. Task 4: Redwan.	

			Task 1: Completed. **Task 2: Completed.** **Task 3: Partially Completed.** **Task 4: Completed.**	
13.08.2022 (Meeting 7 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad . 2. Afrida Malik. 3. Mohammad Tushar Imran. 4. Rafid 5. Redwan 6. Byzid 7. Anika	1. Update page 5 reference 19 Authors name. 2. Add Swot analysis in section 7. 3. Prepare presentation slide for FYDP final presentation. 4. Drop P7 attribute from 13.1 of complex engineering problems. 5. Logbook update.	Task 1: Anika, Byzid. Task 2: Byzid, Redwan. Task 3: Rafid, Redwan, Byzid and Anika. Task 4: Rafid and Redwan. Task 5: Redwan. **Task 1: Completed.** **Task 2: Completed.** **Task 3: Completed.** **Task 4: Completed.** **Task 5: Completed.**	1. Check fomatting of final report and remove unnecessary space. 2. Mock presentation on 20th August. 3. Final project report submission on 20th August. 4. Submit final video of simulation by 16th August. 5. Write “approximately cheaper” instead of writing specific numbers in summary table. 6. Show only main part in simulation video and length should not exceed 2 min for both designs.

15.08.2022 Meeting 19 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Start preparing presentation slide for final presentation of FYDP D. 2. Add swot analysis in section 7 of final year design report. 3. Update page 5 reference 19 Authors name. 4. Drop P7 attribute from 13.1 of complex engineering problems. 5. Logbook update.	Task 1: Rafid, Redwan, Byzid and Anika. Task 2: Byzid, Redwan. Task 3: Anika, Byzid. Task 4: Rafid and Redwan. Task 5: Redwan. **Task 1: Partially Completed.** **Task 2: Completed.** **Task 3: Completed.** **Task 4: Completed.** **Task 5: Completed.**	
17.08.2022 Meeting 20 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Update presentation slide for final presentation of FYDP D. 2. Check fomatting of final report and remove unnecessary space. 3. Logbook update.	Task 1: Rafid, Redwan, Byzid and Anika. Task 2: Byzid, Redwan, Rafid and Anika. Task 3: Redwan.	

			Task 1: Partially Completed. **Task 2: Completed.** **Task 3: Completed.**	
19.08.2022 Meeting 21 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Finalize the presentation slide for FYDP D final presentation. 2. Finalize the FYDP D final design report. 3. Logbook update.	Task 1: Rafid, Redwan, Byzid and Anika. Task 2: Byzid, Redwan, Rafid and Anika. Task 3: Redwan.	
			Task 1: Completed. **Task 2: Completed.** **Task 3: Completed.**	

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20.08.2022 (Meeting 8 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad . 2. Afrida Malik. 3. Mohammad Tushar Imran. 4. Rafid 5. Redwan 6. Byzid 7. Anika	1. Mock Presentation for FYDP 400D. 2. Add pictures in slides to make it look more standard and attractive. 3. Make necessary corrections as ATC panel members suggested. 4. Logbook update.	Task 1: Rafid, Redwan, Byzid and Anika. Task 2: Byzid, Redwan, Rafid and Anika. Task 3: Rafid, Redwan, Byzid and Anika. Task 4: Redwan. **Task 1: Completed.** **Task 2: Completed.** **Task 3: Completed.** **Task 4: Completed.**	1. Provide caption in all pictures shown. 2. Update component level schematic diagram with necessary changes. 3. Divide presentation slides equally no second turn in presentation. 4. Remove full stops from left column of risk management. 5. Correct Mobile application as ATC panel suggested. 6. Put comma in final budget numerical value.

FYDP (D) Summer 2022 Summary of Team 03 Log Book/ Journal

21.08.2022 Meeting 22 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Add pictures in slides to make it look more standard and attractive. 2. Update the component level block diagrams. 3. Mark the necessary values in the pictures of the slide. 4. Update the slide's punctuations as instructed by the ATC panel members. 5. Update logbook.	Task 1: Byzid and Anika. Task 2: Redwan and Rafid. Task 3: Rafid, Redwan, Byzid and Anika. Task 4: Rafid, Redwan, Byzid and Anika. Task 5: Redwan.	
			Task 1: Completed. **Task 2: Completed.** **Task 3: Completed.** **Task 4: Completed.** **Task 5: Completed.**	

FYDP (D) Summer 2022 Summary of Team 03 Log Book/ Journal

<table>
<tr>
<td rowspan="2">27.08.2022 (Meeting 9 with ATC panel members)</td>
<td rowspan="2">1.Prof. Dr. AKM Abdul Malek Azad .

2. Afrida Malik.

3. Mohammad Tushar Imran.

4. Rafid
5. Redwan
6. Byzid</td>
<td rowspan="2">1. Review given by ATC Panel members on Final Year Design Report, Logbook and Final Presentation Slides.

2. Correct table of contents spacing, punctuation marks.

3. Remove analysis conclusion slide’s picture.

4. Logbook update.</td>
<td>Task 1: Rafid, Redwan, Byzid and Anika.

Task 2: Byzid and Anika.

Task 3: Rafid, Redwan,

Task 4: Redwan.</td>
<td rowspan="2">1. Add today’s meeting in final logbook and mention Anika’s reason of absence (Anika was absent due to high fever).

2. Remove page no from table of contents page.

3. Correct punctuation marks (comma) in budget segment.

4. Print one hardcopy of FYDP 400D Report and submit it to ATC panel members.

5. Submit Updated FYDP 400 D Report, Logbook and Slides by 27th August.</td>
</tr>
<tr>
<td>Task 1: Completed.

Task 2: Completed.

Task 3: Completed.

Task 4: Completed.</td>
</tr>
</table>

27.08.2022 Meeting 23 (Group members discussion)	1. Rafid 2. Redwan 3. Byzid 4. Anika	1. Update table of content's spacing, punctuation marks. 2. Remove analysis conclusion slide's picture. 3. Review Final Year Design Report, Logbook and Final Presentation Slides. 4. Logbook update.	Task 1: Byzid and Anika. Task 2 Rafid, Redwan, Task 3: Rafid, Redwan, Byzid and Anika. Task 4: Redwan.	
			Task 1: Completed. **Task 2: Completed.** **Task 3: Completed.** **Task 4: Completed.**	

GROUP 03

Development of a Brain Computer Interface (BCI) for Person with Disabilities to Control Their Wheelchair using Brain Waves along with Health Monitoring System.

	Final Year Design Project (P) Summer 2021		
Student Details	**NAME & ID**	**EMAIL ADDRESS**	**PHONE**
Member 1	Sk Tahmed Salim Rafid	sk.tahmed.salim.rafid@g.bracu.ac.bd	01315352025
Member 2	Redwan Ahmed Miazee	redwan.ahmed.miazee@g.bracu.ac.bd	01682993031
Member 3	Md. Kutubuddin Byzid	md.kutubuddin.byzid@g.bracu.ac.bd	01533154707
Member 4	Afsana Anjum Anika	afsana.anjum.anika@g.bracu.ac.bd	01315352024
ATC Details:			
ATC 3			
Chair	Prof.Dr. AKM Abdul Malek Azad	a.azad@bracu.ac.bd	01556528695
Member 1	Afrida Malik	afrida.malik@bracu.ac.bd	
Member 2	Mohammad Tushar Imran	thushar.imran@bracu.ac.bd	

General Notes:

1. In addition to detail journal/logbook fill out the summary/key steps and progress of your work
2. Reflect planning assignments, who has what responsibilities.
3. The logbook should contain all activities performed by the team members (Individual and team activities).

FYDP (C) FALL 2022 Summary of Team 03 Log Book/ Journal

Date/Time/ Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
30.09.2022 (FYDP committee class)	1. Abu S.M. Mohsin, PhD. 2. Rafid 3. Redwan 4. Anika 5. Byzid	Introductory session of **EEE400 (C).**		
06.10.2022 (Meeting 1 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad . 2. Afrida Malik. 3. Mohammad Tushar Imran. 4. Rafid 5. Redwan 6. Byzid 7. Anika	1. Start writing FYDP 400 C final report and submit the update to ATC panel members before every meeting. 2. Modify the Prototype video according to given instructions and send it to ATC panel members before next meeting. 3. Logbook Update.	Task 01: Rafid, Redwan, Anika, Byzid. Task 02: Rafid, Redwan, Anika, Byzid. Task 03: Redwan. **Task 01: Partially Completed.** **Task 02: Completed.** **Task 03: Completed.**	1. Maintain CRP system level requirements carefully. 2. Consult with CRP officials regarding variable speed functionality. 3. Demonstrate the Prototype video at the very beginning of the meeting. 4. We should think about how we are planning to train the patients. 5. If the patients suggest a new pattern according to his or her convenience there should be a way to make the change. 6. We have to make 3 copies of the final report, one for the library, one for the ATC and another one for the FYDP.

				7. Explain the speed control issues and modified(motor) new prototype model to ATC Panel memebrs in the next meeting.
08.10.2022 Meeting 01 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Start writing FYDP 400 C final report. 2. Optimize the Prototype as per ATC comments. 3. Logbook Update.	Task 01: Rafid, Redwan, Anika, Byzid. Task 02: Rafid, Redwan, Anika, Byzid. Task 03: Redwan. **Task 01: Partially Completed.** **Task 02: Completed.** **Task 03: Completed.**	
10.10.2022 Meeting 02 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Update FYDP 400 C final report. 2. Logbook Update.	Task 01: Rafid, Redwan, Anika, Byzid. Task 02: Redwan. **Task 01: Partially Completed.** **Task 02: Completed.**	
11.10.2022 Meeting 03 (Group	1. Rafid 2. Redwan 3. Anika	1. Update the Prototype demonstration video according to ATC panel members comments.	Task 01: Rafid, Redwan, Anika, Byzid.	

Members Discussion)	4. Byzid	2. Logbook Update.	Task 02: Redwan. **Task 01: Completed.** **Task 02: Completed.**	
16-10-2022 (Meeting 2 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad . 2. Afrida Malik. 3. Mohammad Tushar Imran. 4. Rafid 5. Redwan 6. Byzid 7. Anika	1. Update New Segments in the final year design report. 2. Make necessary changes in final year design report as ATC panel members suggested. 3. Discussion about CRP meeting and Project demonstration. 4. Update logbook as ATC panel member suggested.	Task 01: Rafid, Redwan, Anika, Byzid. Task 02: Byzid, Rafid. Task 03: Rafid, Redwan, Anika, Byzid. Task 04: Redwan. **Task 01: Partially Completed.** **Task 02: Completed.** **Task 03: Completed.** **Task 04: Completed.**	1. Try to complete all old point those are related to 400 P&D report and start writing new chapters as well. 2. Add a emergency control option in prototype. 3. Video explanation in CRP meeting must be clear and understable. 4.CRP meeting will be taken place on 22nd october or 24th october, 2022. Final date and time will be informed later.
17.10.2022 Meeting 04 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Update final year design report as ATC panel members suggested. 2. Logbook Update.	Task 01: Rafid, Redwan, Anika, Byzid. Task 02: Redwan	

			Task 01: Partially Completed. **Task 02: Completed.**	
18.10.2022 Meeting 05 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Update final year design report as ATC panel members suggested. 2. Logbook Update.	Task 01: Rafid, Redwan, Anika, Byzid. Task 02: Redwan **Task 01: Partially Completed.** **Task 02: Completed.**	
20-10-2022 (Meeting 3 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad . 2. Afrida Malik. 3. Mohammad Tushar Imran. 4. Rafid 5. Redwan 6. Byzid 7. Anika	1. Modify formatting of Table of Contents in final year design report. 2. Start writing Chapter 5 & 8 in final year design report. 3. Modify Project Plan in Final year design report. 4. Take preparation regarding CRP project demonstration which will be held on 22nd october, Saturday 10:30 am at their premises located in savar. 5. Logbook update and make necessary changes.	Task 01:, Redwan, Anika. Task 02: Rafid, Redwan, Anika, Byzid. Task 03: Redwan, Rafid. Task 04: Rafid, Redwan, Anika, Byzid. Task 05: Redwan.	1. Add a table in 3.2 section on the final year design report. 2. Try to add graphical analysis in chapter 4, 4.4 section if possible. 3. Think about project future work all together with group members and include it in final year design report. 4. Ask CRP regarding speed control

			Task 01: Completed. **Task 02: Partially Completed.** **Task 03: Completed.** **Task 04: Completed.** **Task 05: Completed.**	mechanism requirements.
21.10.2022 Meeting 06 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Discussion held on how we are going to present our prototype in CRP. Divided our work and rehearsed according to it. 2. Finalize the demonstration video and also the Prototype Wheelchair. 3. Logbook update.	Task 01: Rafid, Redwan, Anika, Byzid. Task 02: Rafid, Redwan, Anika, Byzid. Task 05: Redwan. **Task 01: Completed.** **Task 02: Completed.** **Task 03: Completed.**	

22-10-2022 CRP project demonstration at Savar, CRP premises.	1. Rafid 2. Redwan 3. Anika 4. Byzid 5. Afrida Malik	1. Demonstrate our Prototype Wheelchair in front of CRP official delegates and also tested it with their physician. 2. Visit their Wheelchair maitenance factory and talked with their technician regarding their techinical requirements. 3. We received valuable feedback and system level requirements from CRP doctors and physicians after they have tested our Prototype. They want some additional features to incorporate in our prototype. 4. We took some photos and videos with CRP delegates after our meeting and they were very much happy and satisfied with our presentation.		1.To attach a mirror on the wheelchair hand-rest to allow vision from the back side to ensure safer back movement. 2. Variable speed control can be integrated. 2.They want a joystick with a large knob for manual movement if needed. 3. Safety belt must be there in wheelchair. 4. Product need to be cost effective as per CRP delegates so that it can be accessible to all tiers of people.
23.10.2022 Meeting 07 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Modify formatting of Table of Contents in final year design report. 2. Modify Project Plan in Final year design report. 3. Update Future work in chapter 10 of final year design report. 4. Logbook update and make necessary changes.	Task 01: Redwan, Anika. Task 02: Redwan, Rafid. Task 03: Rafid, Redwan, Anika, Byzid. Task 04: Redwan. **Task 01: Completed.** **Task 02: Completed.** **Task 03: Completed.**	

			Task 04: Completed.	
25.10.2022 Meeting 08 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Start writing Chapter 5 & 8 in final year design report. 2. Add a table in 3.2 section on the final year design report. 3. Update graphical analysis in chapter 4, section 4.4. 4. Add speed control mechanism, joystick control,back movement in Wheelchair Prototype. 5. Update stakeholder system level specification and requirements. 6. Logbook update.	Task 01: Rafid, Redwan, Anika, Byzid. Task 02: Redwan, Rafid. Task 03: Rafid, Byzid. Task 04: Rafid, Redwan, Anika, Byzid. Task 05: Redwan, Byzid. Task 06: Redwan.	
			Task 01: Partially Completed. **Task 02: Partially Completed.** **Task 03: Completed.** **Task 04: Partially Completed.** **Task 05: Completed.** **Task 06: Completed.**	

FYDP (C) FALL 2022 Summary of Team 03 Log Book/ Journal

27-10-2022 (Meeting 4 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad . 2. Afrida Malik. 3. Mohammad Tushar Imran. 4. Rafid 5. Byzid 6. Anika 7. **Redwan (Leave of absence provided to ATC panel members for Father's operation)**	1. Complete chapter 5 & 8 of final year design report for EEE400-C. 2. Start preparing presentation slide and send to the ATC panel members within 31th October. 3. Logbook Update.	Task 01: Rafid, Redwan, Anika, Byzid. Task 02: Rafid, Redwan, Anika, Byzid. Task 03: Redwan. **Task 01: Partially Completed.** **Task 02: Completed.** **Task 03: Completed.**	1. Complete chap 3, section 3.2 table. 2. Work on additonal features provided by CRP.
30.10.2022 Meeting 09 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Update progress presentation slides and Demonstration Video. 2. Started working on Health Monitoring(Temparature, O2 saturation and Heart rate.) 3. Logbook Update.	Task 01: Redwan, Rafid, Byzid, Anika. Task 02: Rafid, Byzid. Task 03: Redwan. **Task 01: Partially Completed.** **Task 02: Partially Completed.** **Task 03: Completed.**	

31.10.2022 Meeting 10 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Update progress presentation slides and submit it to ATC panel members. 2. Logbook Update.	Task 01: Redwan, Rafid, Byzid, Anika. Task 02: Redwan. **Task 01: Completed.** **Task 02: Completed.**	
03.11.2022 (FYDP committee class)	1. Abu S.M. Mohsin, PhD. 2.Afrida Malik. 3. Rafid 4. Redwan 5. Anika 6. Byzid	Progress Presentation of FYDP 400C to ATC panel members and FYDP committee.	Task 01: introduction was done by Byzid. Task 02: CRP stakeholder representation done by Redwan. Task 03: Prototype video demonstration done by Rafid. Task 04: Conclusion and other CO sections done by Anika.	1.Overall we finished our presentation on time accordingly. 2. Mohsin sir said A3(Innovation) of Complex Engineering Activities (EA) & P5 (Extent of applicable codes) Complex Engineering Problem (EP) doesn't fit with your project. 3. Mohsin sir also asked us from where did we get the ethical permission and from whom. 4. Mohsin sir asked whether the brain data from headset was sent to the server or not and whether the data is publicly accesible. 5. What sort of server are we using and why we are using blynk server why not others?

				6. Mohsin sir wanted to see full Developed Real Wheelchair prototype in final Demonstration.
10.11.2022 Meeting 11 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Started working on Health Monitoring (ECG and blood pressure). 2. Updated final year design report for EEE400-C.	Task 01: Rafid, Byzid, Redwan, Anika. Task 02: Rafid, Byzid, Redwan, Anika **Task 03: Partially Completed.** **Task 04: Partially Completed.**	
12.11.2022 Meeting 12 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Started working on Additional features suggested by CRP delegates and health Monitoring features. 2. Updated our server Blynk 1.0 3. Logbook Update.	Task 01: Redwan, Rafid, Byzid, Anika. Task 02: Rafid, Byzid. Task 03: Redwan. **Task 01: Partially Completed.** **Task 02: Completed.** **Task 03: Completed.**	

13.11.2022 (Meeting 5 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad . 2. Afrida Malik. 3. Mohammad Tushar Imran. 4. Rafid 5. Redwan 6. Byzid 7. Anika	1. Implement speed control mechanism in prototype and show to ATC panel members in next meeting. 2. ECG data acquisition and health monitoring features needs to updated. 3. Complete section 5.3 and 8.3 in the final year design report of EEE400 C. 4. Make necessary changes in Logbook as suggested.	Task 01:Rafid, Redwan, Byzid, Anika. Task 02: Rafid, Byzid, Redwan, Anika. Task 03: Rafid, Byzid, Anika. Task 04: Redwan. **Task 01: Completed.** **Task 02: Partially Completed.** **Task 03: Partially Completed.** **Task 04: Completed**	1. Add page numbers to final year design report and mention it in table of contents. 2. Remove figure number "49, 54, and 55" from section 5.2. 3. Remove task 1 and task 2 from group meeting 11 in the logbook. 4.Try to finish health monitoring features as per gantt chart schedule. 5. Check formatting in Logbook.
14.11.2022 Meeting 13 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Update Health Monitoring features and acquired ECG data from sensor. 2. Update page number in final year design report. 3. Update speed control features in prototype. 4.Logbook Update.	Task 01:Rafid, Redwan, Byzid, Anika. Task 02: Redwan. Task 03: Rafid, Redwan, Byzid, Anika. Task 04: Redwan.	

			Task 01: Partially Completed. **Task 02: Completed.** **Task 03: Completed.** **Task 04: Completed**	
16.11.2022 Meeting 14 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Update 5.3 and 8.3 in the final year design report of EEE400 C. 2. Update Health Monitoring features. 3. Logbook Update.	Task 01: Rafid, Redwan, Byzid, Anika. Task 02: Rafid, Redwan, Byzid, Anika. Task 03: Redwan. **Task 01: Partially Completed.** **Task 02: Partially Completed.** **Task 03: Completed.**	
17.11.2022 (Meeting 6 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad . 2. Afrida Malik. 3. Mohammad Tushar Imran.	1. Update health monitoring pictures and description in the final year design report. 2. Incorporate section 5.3 in the final year design report and submit it by next meeting. 3. Joystick features should be added by next week in the Prototype.	Task 01: Rafid, Redwan. Task 02: Rafid, Byzid, Anika. Task 03: Rafid, Redwan. Task 04: Redwan, Rafid.	1. Validate blood pressure with manual machine also. 2. Try to complete 5.2 health monitoring part and add pictures associated with it.

	4. Rafid 5. Redwan 6. Byzid 7. Anika	4. Finalize your additional features suggested by CRP and incorporate in your Prototype.	**Task 01: Partially Completed.** **Task 02: Partially Completed.** **Task 03: Completed.** **Task 04: Completed.**	
19.11.2022 Meeting 15 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Start working on blood pressure accuracy and ECG data aquisition. 2. Update joystick features in Final prototype. 3. Logbook Update.	Task 01: Rafid, Byzid, Anika, Redwan. Task 02: Redwan, Rafid. Task 03: Redwan. **Task 01: Partially Completed.** **Task 02: Partially Completed.** **Task 03: Completed.**	
22.11.2022 Meeting 16 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Update Joystick feature and finalize all CRP suggested features in Final Prototype. 2. Update Final year design report section 5.3. 3. Logbook Update.	Task 01: Redwan, Rafid. Task 02: Byzid, Rafid, Anika, Redwan. Task 03: Redwan.	

			Task 01: Completed. **Task 02: Partially Completed.** **Task 03: Completed.**	
26.11.2022 Meeting 17 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Take real time data for Control Mechanism Error and time delay analysis. 2. Logbook update.	Task 01: Rafid, Redwan, Byzid, Anika. Task 02: Redwan **Task 01: Partially Completed.** **Task 02: Completed.**	
27.11.2022 Meeting 18 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Take real time data for Control Mechanism Error and time delay analysis. 2. Update Final year design report section 5.3. 3. Logbook update.	Task 01: Rafid, Redwan, Byzid, Anika. Task 02: Rafid, Redwan, Byzid, Anika. Task 03: Redwan **Task 01: Partially Completed.** **Task 02: Partially Completed.** **Task 03: Completed.**	

28.11.2022 Meeting 19 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Working on blood pressure and ECG section in health monitoring. 2. Update final prototype picture in section 5.2. 3.Logbook update.	Task 01: Rafid, Byzid, Anika, Redwan. Task 02: Byzid, Anika. Task 03: Redwan. **Task 01: Partially Completed.** **Task 02: Completed.** **Task 03: Completed.**	
30.11.2022 Meeting 20 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Take real time data Control Mechanism for Error and time delay analysis. 2. Working on blood pressure and ECG section in health monitoring. 3. Update Final year design report section 5.3. 4. Logbook update	Task 01: Rafid, Redwan. Task 02: Rafid, Byzid, Anika, Redwan. Task 03: Rafid, Byzid, Anika, Redwan Task 04: Redwan **Task 01: Completed.** **Task 02: Partially Completed.** **Task 03: Partially Completed.** **Task 04: Completed.**	

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01.12.2022 (Meeting 7 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad . 2. Afrida Malik. 3. Mohammad Tushar Imran. 4. Rafid 5. Redwan 6. Byzid 7. Anika	1. Mock Presentation on 08-12-2022. Prepare slide and final prototype video by next meeting. 2. Complete Health Monitoring part in final year design report. 3. Logbook Update.	Task 01: Redwan, Rafid, Byzid, Anika. Task 02: Rafid, Byzid, Redwan, Anika. Task 03: Redwan. **Task 01: Completed.** **Task 02: Completed.** **Task 03: Completed.**	1. Change heading name (person 1/ person 2) in analysis table and align centrally. 2. Complete Health Monitoring part and update pictures in report. 3. In logbook specify what kind of error analysis data you have taken.
03.12.2022 Meeting 21 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Started working with new blood pressure device and acquired data from the machine. 2. Working on final prototype video. 3. Update health monitoring part in final year design report. 4. Collected data for implemented health monotoring. 5. Logbook Update.	Task 01: Redwan, Rafid, kutub, Anika. Task 02: Rafid, Byzid, Redwan, Anika. Task 03: Byzid, Rafid, Redwan. Task 04: Rafid, Byzid, Redwan, Anika. Task 05: Redwan. **Task 01: Completed.**	

			Task 02: Partially Completed. **Task 03: Partially Completed.** **Task 04: Partially Completed.** **Task 05: Completed.**	
05.12.2022 Meeting 22 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1.Worked on ECG data acquisition. 2. Started preparing final presentation slide of EEE400-C. 3. Collected data for implemented health monotoring. 4. Logbook Update.	Task 01: Rafid, Byzid, Anika, Redwan. Task 02: Rafid, Byzid, Redwan, Anika. Task 03: Rafid, Byzid, Anika, Redwan. Task 04: Redwan.	
			Task 01: Completed. **Task 02: Partially Completed.** **Task 03: Partially Completed.** **Task 04: Completed.**	

07.12.2022 Meeting 23 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Update final presentation slide of EEE400-C. 2. Update final presentation video of EEE400-C. 3. Update health monitoring part in final year design report. 4. Collected data for implemented health monotoring. 5. Logbook Update.	Task 01: Redwan, Rafid, Byzid, Anika. Task 02: Rafid, Byzid, Redwan, Anika. Task 03: Byzid, Rafid, Redwan. Task 04: Rafid, Byzid, Redwan, Anika. Task 05: Redwan.	
			Task 01: Completed. **Task 02: Completed.** **Task 03: Completed.** **Task 04: Completed.** **Task 05: Completed.**	

01.12.2022 (Meeting 8 with ATC panel members)	1.Prof. Dr. AKM Abdul Malek Azad . 2. Soptorshi Paul (RA) 3. Saurov Podder (RA) 4. Rafid 5. Redwan 6. Byzid 7. Anika	1. Mock Presentation for FYDP 400 C final presentation. 2. Review and Feedbacks given for final presentation slide for EEE400C. 3. Finalize report along with logbook submission with in 22nd december.	Task 01: Redwan, Rafid, Byzid, Anika. Task 02: Rafid, Byzid, Redwan, Anika. Task 03: Byzid, Rafid, Redwan, Anika. **Task 01: Completed.** **Task 02: Completed.** **Task 03: Completed.**	1. Try to reduce some slides and mention all slides in the introduction part of your presentation, don't skip slides. 2. Mention the SOS button is capasitive touch button clearly in presentation. 3. Remove supplementary slides and make it separate.
11.12.2022 Meeting 24 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Review final year design report with latest pictures and graphs. 2. Update table of contents, list of figures, list of tables, list of acronyms and appendix in final year design report. 3. Logbook Update.	Task 01: Redwan, Rafid, Byzid, Anika. Task 02: Rafid, Byzid, Redwan, Anika. Task 03: Byzid, Rafid, Redwan, Anika. **Task 01: Partially Completed.** **Task 02: Completed.** **Task 03: Completed.**	

14.12.2022 Meeting 25 (Group Members Discussion)	1. Rafid 2. Redwan 3. Anika 4. Byzid	1. Review final year design report and prepare for final presentation with slides and prototype video. 2. Logbook update.	Task 01: Redwan, Rafid, Byzid, Anika. Task 02: Rafid, Byzid, Redwan, Anika..	
			Task 01: Completed. **Task 02: Completed.**	
15.12.2022 (FYDP committee class)	1. Abu S.M. Mohsin, PhD. 2. Rafid 3. Redwan 4. Anika 5. Byzid	Final Presentation of FYDP 400C to ATC panel members and FYDP committee.		