<u>An-Najah National University</u>

Faculty of Engineering & Information Technology

Presented in partial fulfillment of the requirements for Bachelor degree in Computer Engineering

Graduation Project 2

Smart WheelChair

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We cannot fail to extend our sincere thanks to everyone who contributed to completing the Graduate Project, whether by refining it or revising it. We also extend our sincere thanks to all of our friends and colleagues who provided assistance and assistance during the preparation of this Graduate project.

Disclaimer:

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Abstract:

As the global population ages, the demand for innovative mobility solutions for individuals with disabilities and limited mobility continues to grow. And as the genocide in Gaza extends so it leaves huge casualties, especially among children.

Smart wheelchair is a mobility aid aim to enhance the independence and comfort of disables, the children and elderly and others with physical disabilities who are too weak to move around independently. The aim of this project is to create and apply a smart wheelchair with health monitoring and alerts for children whose with physical disabilities.

This project is important because it provides the safety and mobility needs of children with disabilities or health conditions that limit their independent safety movement, improve user safety by integrating sensors that detect obstacles, and potential overturning. It also helps in monitoring the health by providing continuous real-time monitoring of the user's heart rate and oxygen percent to alert caregivers of any irregularities. In addition, it enables caregivers to receive real-time updates on the user's health and safety status on web page via Wi-Fi, improving response times during emergencies. It also promotes user comfort by allowing the users to control the wheelchair comfortably through a joystick while automating hazard detection.

The purpose of this project is to develop a smart wheelchair system that combines integrated sensors for enhanced safety and monitoring with contemporary control capabilities. a joystick to operate and facilitate wheelchair mobility. The automated moving and avoiding the obstacles depend on take the continuous reading from all ultrasonic sensors around the wheelchair and then apply the algorithms on this data to decided which is the next destination moving forward or changing direction. Additionally, the system's sensors which monitor the user's vital signs and include an oxygen percent and heart rate sensor provide real-time health data. A weight sensor is incorporated into the system to track whether the user is seated. Due to this, the user's seating status can be accurately detected based on the pressure that is applied. A gyroscope is positioned to detect any tilt or possible overturning of the wheelchair in order to prevent accidents. All of the sensor data is sent over Wi-Fi to a web page on mobile phone or PCs so that caretakers or medical experts can remotely check on the user's condition. Through enhanced user safety and health monitoring, this smart wheelchair offers a comprehensive solution for individuals with mobility issues.

Although smart wheelchairs have been attempted before, this idea offers a more complete integration of health monitoring and safety functions. Most comparable apps concentrate on either mobility or health monitoring on their own. For instance, although some smart wheelchairs on the market today may include obstacle detection or joystick control, our concept adds real-time health monitoring to provide consumers with a complete solution.

Chapter 1:

Introduction:

1. General Background

It's still difficult to find a good mobility choice for children with disabilities. Finding devices that are suited to their child's specific requirements is a problem that caregivers frequently face. Caretakers are forced to manually sort through a variety of alternatives that might not be feasible because many of the possibilities are either too complicated or not customized for the physical needs of children. Furthermore, certain potentially helpful devices are not always obvious in searches, which results in lost possibilities for improved care, Smart technology is being used in mobility solutions, such a smart wheelchair made especially for infants with disabilities, to address these problems, by providing a modern wheelchair solution, this project aims to reduce the difficulties faced by parents of children with disabilities. Four movement modes: manual, manual with recommendation, semi-automatic and automatic, will be available in the proposed wheelchair, providing users with flexibility according to their requirements and preferences, Essential features include as Obstacle Avoidance via sensors that immediately detect and avoid obstacles guaranteeing mobility safety, State Monitoring Sensors to evaluate the wheelchair's condition and guarantee optimal efficiency, Health Monitoring keeping an eye on the child's health thanks to integrated sensors that provide real-time readings of vital indications including blood oxygen percent and heart rate.

2. Objectives

- Increase Self-Sufficiency via Provide easy-to-use controls and assistance technologies to enable children to experience mobility that promotes independence and helps the development of their cognitive and motor skills.
- Provide a user-friendly interface that will be easy for caretakers to use and keep an eye on the wheelchair while giving medical professionals and family quick access to Controller.

- Four movement modes: manual, manual with recommendation, semi-automatic and automatic will be available in the proposed wheelchair.
- Include an Obstacle Avoidance ability via sensors that detect and then make a response to avoid obstacles.
- State Monitoring Sensors to detect the wheelchair's condition and guarantee optimal efficiency.
- Health Monitoring that provide real-time readings of vital indications including blood oxygen percent and heart rate.
- Simple Web Page Monitoring and Controlling the Chair.

3. Organization of the Report

The report's organization aims to give readers a thorough grasp of the Smart Wheel Chair. Chapter 2 explores the theoretical Background and previous studies after this introduction, laying the foundation for this project.

The platform's development process is described in Chapter 3. In Chapter 4, discussion and results are presented, providing an understanding of the project's results.

In Chapter 5, recommendations and conclusions are combined to give a comprehensive summary of the project's journey.

Chapter 2

Theoretical Background and Previous Work:

2.1 Previous Work and Literature Review:

Out of 70 million disabled persons, barely 5 to 15% have access to wheelchairs, according to the World Health Organization (WHO). As a result, we must give a cost-effective smart that uses the newest parts and technology to minimize costs while offering a wide range of functions [1]. Patients with limited mobility still encounter major obstacles while using wheelchairs in public and other settings, and many still rely on others to help them maneuver their wheelchairs [2]. Instead of requiring frequent human interaction, it would be considerably simpler if the wheelchair design required for their task was automated and controlled by the individual.[3] The smart wheelchair is an electric wheelchair that has sensors and a computer built in to make patient mobility easier and more effective. [4]. It gives people who are disabled the chance to travel Additionally, this reduces the human effort required of the wheelchair user to move the wheels. [5]. Smart wheelchairs can be equipped with different sensors, including camera, infrared, and ultrasonic. These wheelchairs use computers that interpret sensor input data and generate a command that is output to the chair's motor to move wheels [6]. The development of joystick control uses an intelligent control device to operate the wheelchair system and this is the most significant development in this control. [7]. When circumstances call for quick decisions, this results in deadly collisions, because patients with upper extremity disabilities are unable to use the joystick smoothly and flexibly. for that cutting-edge technology must take the place of the traditional joystick method [8]. Hardware components and advanced sensor technologies and control algorithms were added to control the wheelchair, detect impediments, and do away with the need for outside help. An ultrasonic sensor monitors the distance between it and obstacles, and if an obstacle is found, both motors stop. The technology guarantees safety by identifying and avoiding impediments and increases user autonomy by making control simple [9]. The integration of Internet of Things (IoT) technology into assistive technology has attracted a lot of attention lately, especially about improving mobility options for older people and people with disabilities. With their intuitive, real-time control and data exchange capabilities, Internet of Things (IoT)-based systems have shown an original approach to human-machine interaction [10].

Chapter 3

Methodology

In this chapter, we dive into more details about the implementation of the solution for the previously described problem, discussing the work we've done to deliver the final value to various stakeholders that will benefit from this prototype in addition, a comprehensive overview of different technologies and tools utilized throughout the development process, and the obstacles we faced in it, and the user interface for both mobile and web platforms will be provided.

3.1 Standards and Specifications

In the development of Smart Wheelchair, a selection of powerful tools to ensure robustness, efficiency, and scalability, aligning with established standards and specifications. Here is a highlight of the key tools and their roles in adhering to industry standards:

1**. Programming Languages**: Arduino IDE the most popular method for programming the ESP32 is using the Arduino IDE with C++. Arduino provides a simplified environment and a large community of resources, making it accessible to beginners.

2. **Web Page**: HTML and CSS to make a simple web page to show the reading of sensors and have control.

3. **Communication:**

1) **ESP-NOW** (Modified **IEEE 802.11**): peer-to-peer protocol to make a connection between 2 ESPs.
2) **Wi-Fi (IEEE 802.11 Standard)**: to communicate to the server and exchange data.
3) Serial communication:
    a) **I²C (Inter-Integrated Circuit)**: A protocol used to interface with Max30102 and MPU6050
    b) **UART (Universal Asynchronous Receiver-Transmitter)**: A simple, asynchronous serial communication protocol used to interface with Dfplayer.

3.2 Constraints

3.2.1 Cost of original and efficient sensors:

The cost of the original and effective sensors is high so because of that we forced to get copy and cheaper ones like we do with Max30102 sensor that has problems in software and readings and instability in it.

3.2.2 Complexity of local network:

The complexity of the university network that we couldn't use to set the server up and use it to work in all the areas of it so we forced to make a new local network as a hotspot to deploy and communicate with it in short range.

3.2.3 Memory size:

The size of Esp EPROM hindered to include more alerting methods like email notifications because of the huge size of its library.

3.2.4 Children lack in controlling motors:

Because of their immature motor abilities and lack of coordination, children and young children require a simple and user-friendly control interface. This requires the development of new input devices like as joystick-based and limits the application of some advanced control systems.

3.2.2 Considering advanced technologies

Complex hardware and software integration is needed for advanced technologies like obstacle detection, communication and real-time monitoring, which can make development and production more difficult.

3.2.3 Very heavy body weight:

The heavy weight of the wheelchair that was manufactured using plywood that required high-torque motors to move it, as the mass of the cart reached 8 kilograms. With the addition of each motor, each of which weighs 1 kilogram, the mass became 10 kilograms, or a little more, in addition to the weight of the battery that operates the motors.

3.2.4 Battery life and power management:

The battery life of the smart wheelchair needs to be long enough to allow for daylong use without the need for regular recharging. Designing with the latest technologies while maintaining energy economy is difficult.

3.3 Components And Sensors

3.3.1 Ultrasonic Sensors (HC-SR04)

A device that measures distance using sound waves is called an ultrasonic sensor. High-frequency sound pulses, usually 40 kHz, are emitted, and the time it takes for the echo to return after rebounding off an object is measured. The distance to the object is then calculated by the sensor using this time and the sound speed. Ultrasonic sensors, which are frequently employed in robotics, automotive, and industrial applications, are perfect for identifying obstructions, determining liquid levels, and simplifying navigation in settings where conventional optical sensors might not work well.

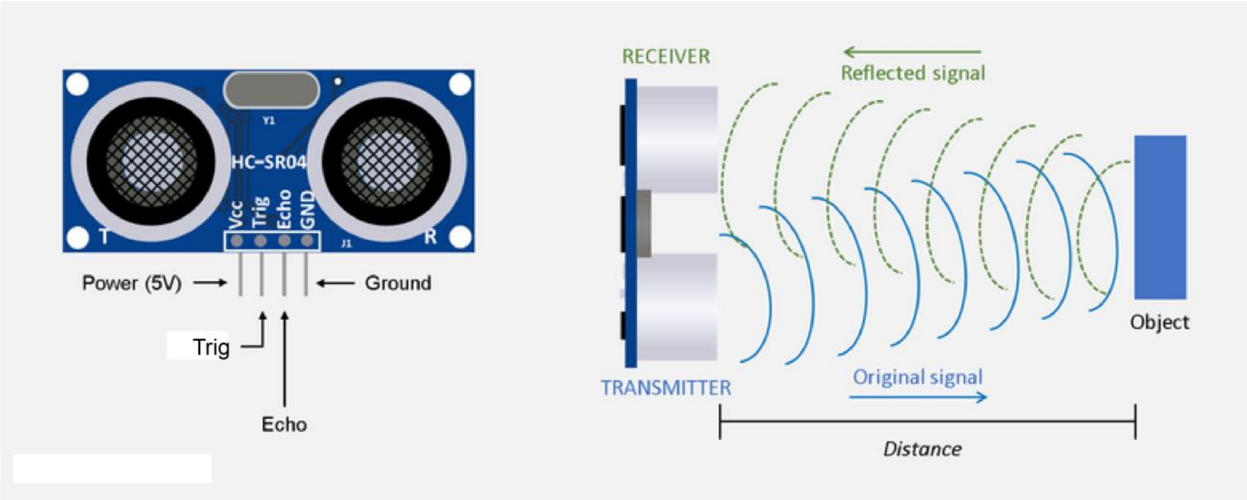

Figure 1: HC-SR04

3.3.2 Max30102 (Oximeter and Heart-rate Sensor):

The MAX30102 is a wearable and medical device that combines a heart-rate sensor and pulse oximeter. It measures oxygen saturation (SpO2) and pulse rate by sensing changes in blood volume through a fingertip or earlobe using two LEDs (red and infrared) and a photodetector. Because of its small size and low power consumption, it is often used in fitness trackers and health monitoring devices.

Issues with Accuracy: The MAX30102 may have issues with accuracy, especially when used by people with darker skin tones or in low-perfusion environments. Because of its sensitivity to background noise, readings may be off.

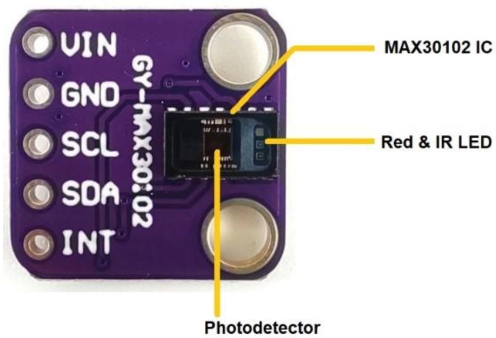

Figure 2: Max30102

3.3.3 Load sensor 50 kg with hx711:

Weighing and other weight-sensitive projects frequently use a 50 kg load sensor together with a HX711 load cell amplifier. A 24-bit precision analog-to-digital converter (ADC) made especially for load cells, the HX711 enables accurate measurement of small signals from the load cell even when noise is present. Here is a simple setup guide and overview.

Required Components:

A strain gauge sensor that transforms a force into an electrical signal is the 50 kg load cell. The HX711 Module is an ADC module that transforms the load cell's signal into a digital signal that microcontrollers can understand.

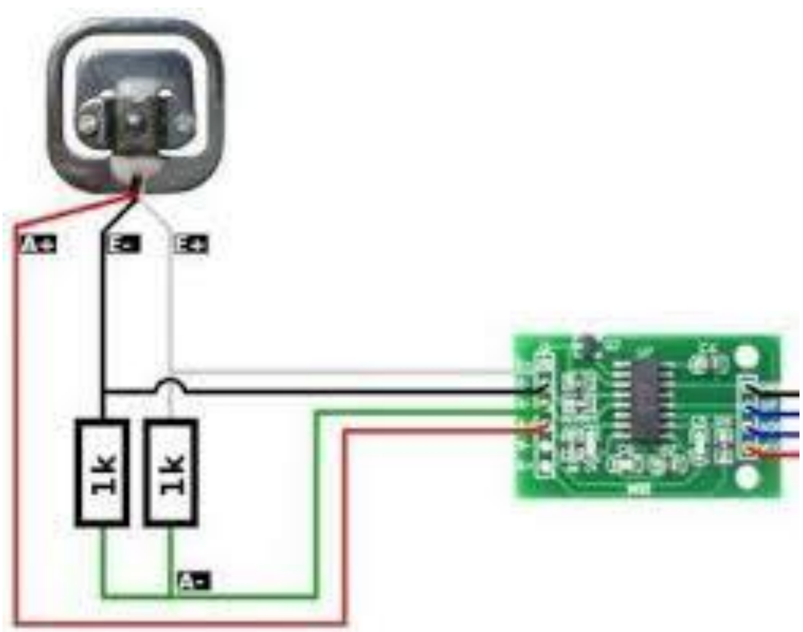

Figure 3: Load sensor 50 kg with hx711

3.3.4 MPU-6050:

MPU-6050 is motion-tracking device that have 3-axis accelerometer and a 3-axis gyroscope. It uses I^2C interface to communicate with a microcontroller like an Arduino or Raspberry Pi. Applications whose including motion sensors, controlling device, robotics, and drones all make extensive use of it.

The MPU6050 is popular because it merging gyroscope and accelerometer sensors into a one chip, and offering a collection of motion data at a low cost.

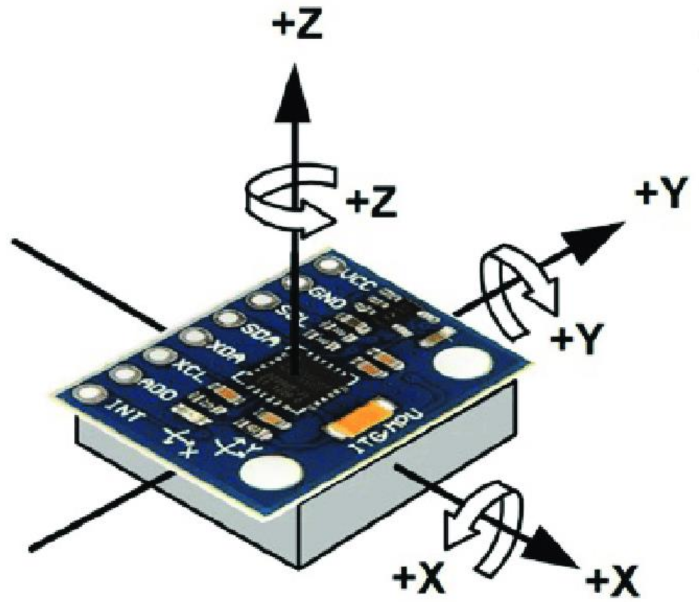

Figure 4: MPU-6050

3.3.5 Esp32:

Espressif Systems created the low-cost, low-power ESP32 system-on-chip (SoC). It is used for Internet of Things (IoT) applications, because it combines Wi-Fi and Bluetooth capabilities with wide range of input, output pins, that makes it useful for a difference projects, like wearable technology, sensor, and home automation.

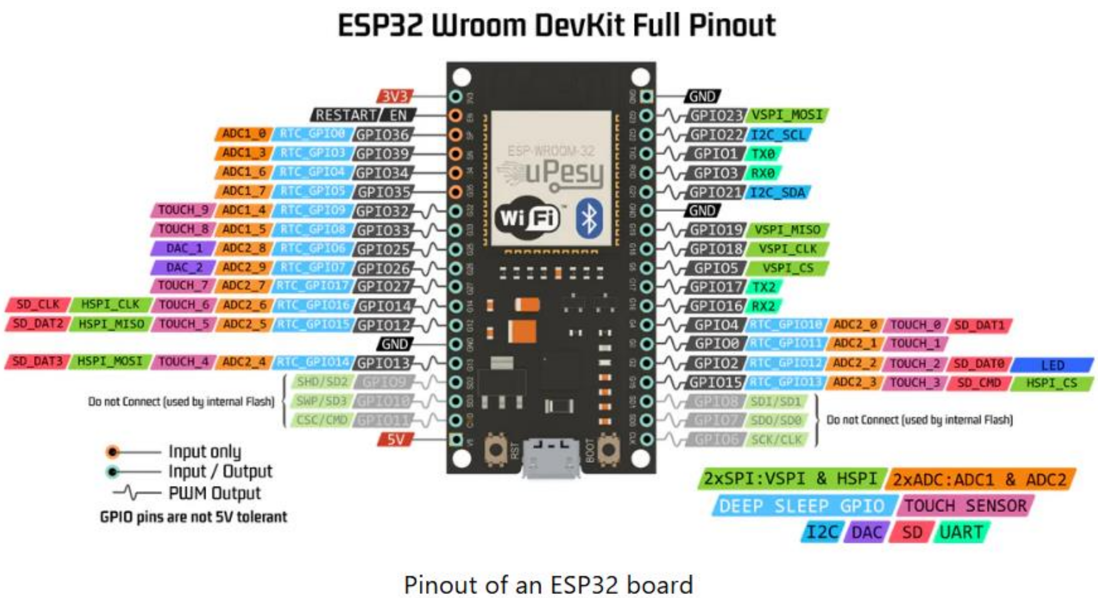

Figure 5: Esp32

3.3.6 NEMA stepper motor 23HS7628:

NEMA 23 stepper motors have high-torque like 23HS7628 are usually used in robots, CNC machines, and 3D printers, and applications that need precision. It gives significant power for moving heavy weights with accurate control, with holding torque about 1.26 Nm (126 N.cm). With 200 steps per revolution and average step angle of 1.8°, this motor offers Good positional precision. Because of its dependability and compatibility with different drivers, 23HS7628 is well-liked by professionals and enthusiasts, which makes it adaptable to a wide range of mechanical and automated systems.

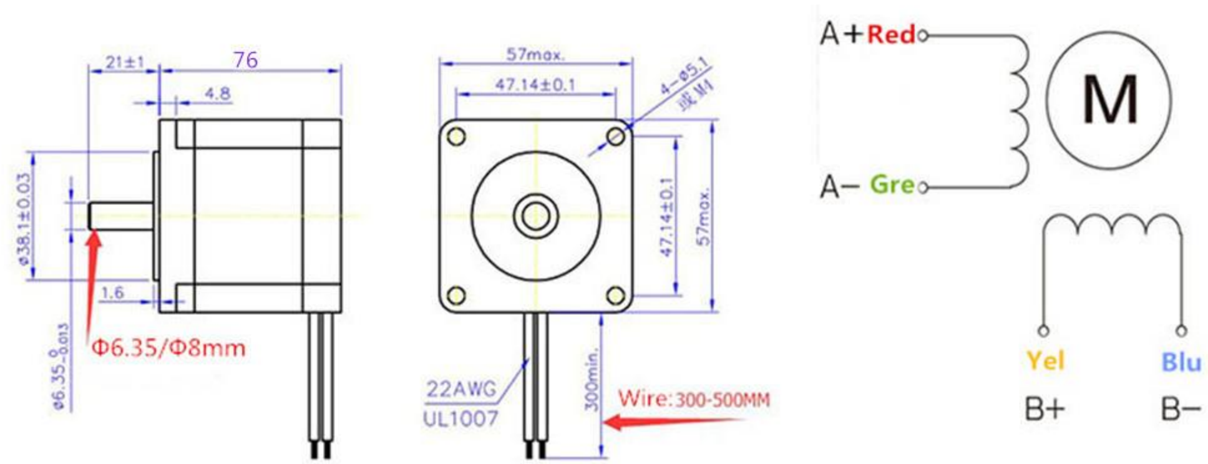

Figure 6: NEMA 23 stepper motor 23HS7628

3.3.7 Stepper Motor Driver (ysdiv268n 5A):

YSDIV268N is a powerful driver for stepper motor, made to precisely and effectively drive stepper motors. It can handle currents up to 5A. For smooth motion control in applications such as robotics, 3D printing, and CNC machines, this driver works well with high-torque motors such as NEMA 23. YSDIV268N micro stepping capabilities improve the motor's movement precision by enabling finer step resolution and smooth operation. It offers flexible range of configurations by supporting several input voltage ranges. It has protection against each of current, voltage and heating.

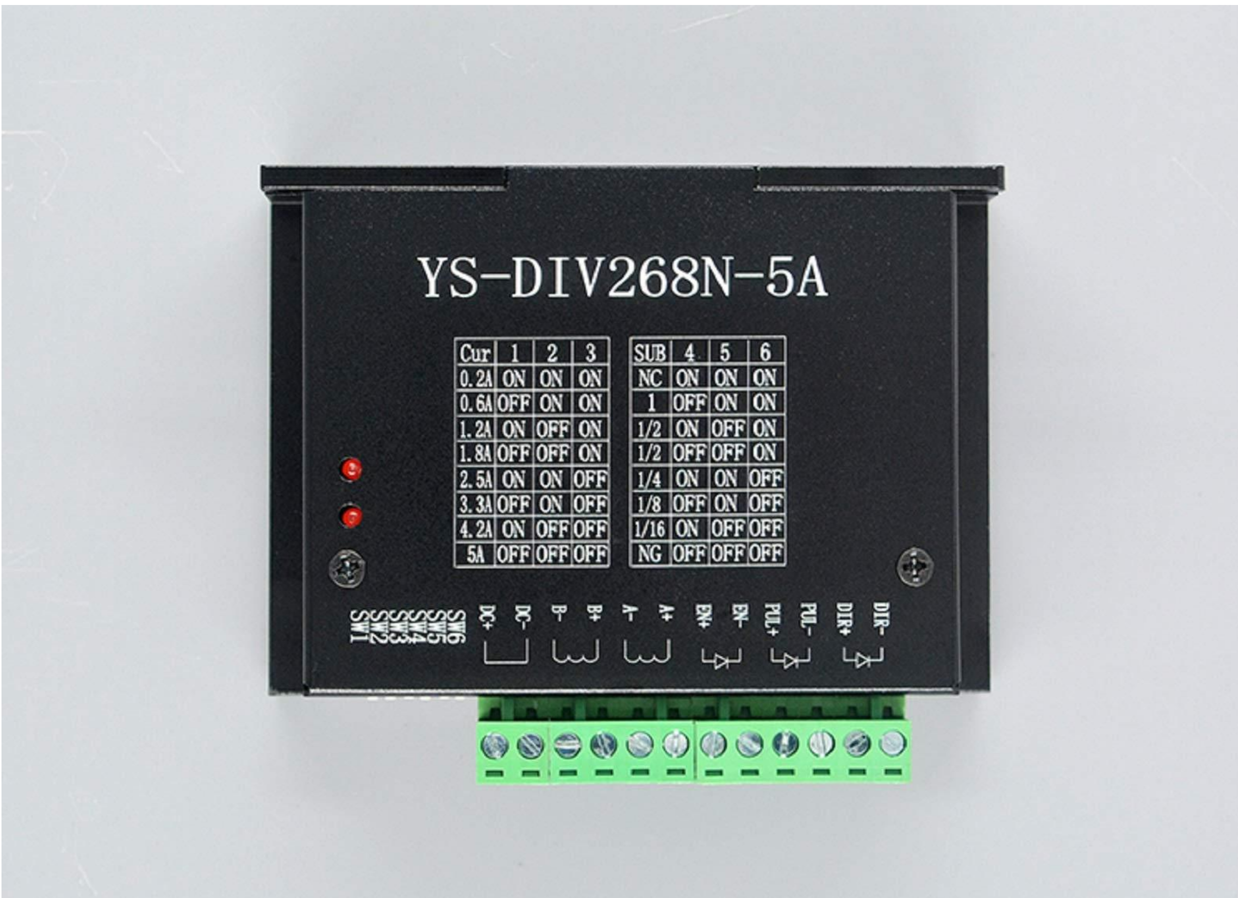

Figure 6: Stepper Motor Driver (ysdiv268n 5A)

3.3.8 Df Player:

DFPlayer Mini is a small and reasonably priced MP3 module, made for microcontroller projects. It put at the end to the need for an additional MP3 decoder to enable to play MP3 files straight from a microSD card. that makes it good for applications that need audio, like music players and voice announcements.

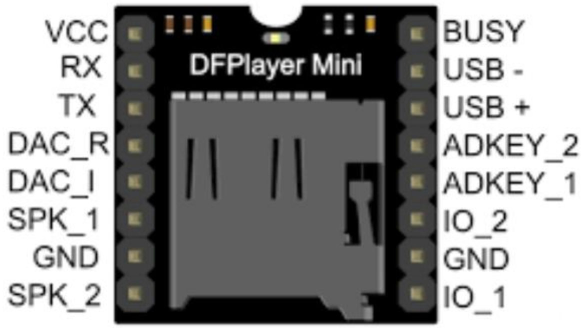

Figure 7: Df Player

3.3.9 IR sensor:

An IR (infrared) sensor is a tool for pattern recognition, proximity measurement, and object detection. It measures the reflection or disruption caused by an item by releasing infrared light. VCC, GND and OUT pins are commonly seen on infrared sensors; the detection signal is supplied by the OUT pin. Line-following robots, obstacle detection, and motion-tracking applications are just a few of the robotics, automation, and object detection systems that make extensive use of these sensors. And we use it to detect if there is a stair.

Figure 8: IR Sensor

Design:

3.4 Web Page:

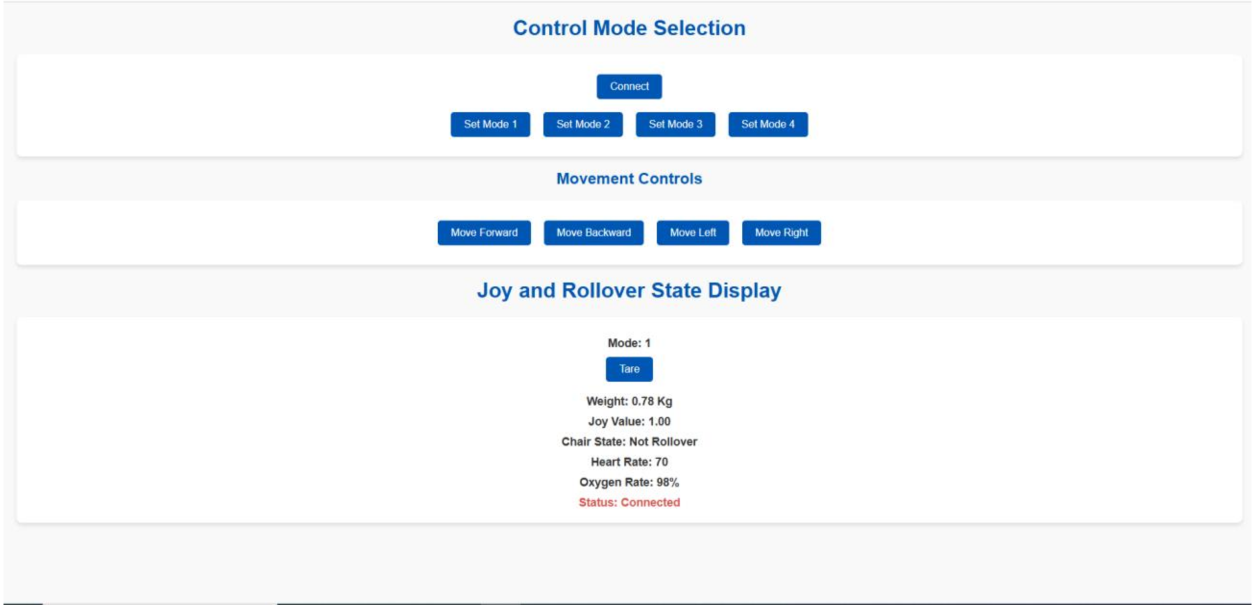

Figure 9: Web Page Control

This page is used for a wheelchair control user interface. And this is an explanation of how it works:

1. Control Mode Selection:

- **Buttons:**
    - **Connect:** Likely used to establish a connection with the server.
    - **Set Mode 1, Set Mode 2, Set Mode 3, Mode 4:** Used to switch between different operating modes of the device.
- **Four movement modes:**
    - **Mode 1 (Manual):** The user has the full control and all sensors will be off.
    - **Mode 2 (Manual with recommendation):** The user has the control, but if an obstacle is detected then the chair will **give** him **recommendations** to avoid the obstacles.
    - **Mode 3 (Semi-Automatic):** The user has the control, but if an obstacle is detected then the sensor will **take** an **action** to avoid the obstacle.

- **Mode 4 (Play-around):** The chair has full control so it does automatic movement depending on sensor making behavior like playing or moving around.

2. Movement Controls:

- **Directional Buttons:**
  - **Move Forward, Move Backward, Move Left, Move Right:** These buttons are used for controlling the smart wheelchair movement in particular directions.

3. Joy and Rollover State Display:

This section displays operational data of the smart wheelchair and the current status:

- **Mode:** shows the operating mode that is currently in use (e.g., "Mode: 1").
- **Tare Button:** Used to calibrate sensors or reset weight.
- **Weight:** Shows the current measured weight (e.g., "0.78kg").
- **Joy Value:** Shows the encoding value of the joystick (e.g., "1.00").
- **Chair State:** Shows whether the chair is in a "rollover" state or not.
- **Heart Rate:** Shows the current heart rate reading (e.g., "70").
- **Oxygen Percent:** Shows the oxygen saturation level (e.g., "99%").
- **Status:** Shows the status of the connection, such as "Connected, Not Connected".

3.5 Chair Design:

The design of the chair has 4 ultrasonic sensors around the chair 2 of them in the front one on each side left and right and have another 2 sensors one on the left and the other on the right side of the chair, and IR sensor at the bottom of the front of the chair to detect stairs and stop the moving, have gyroscope inside the chair to detect if there are rollover happened to the chair or no and dfplayer to give recommendations to the user, the joystick has designed to be wireless to control the chair and has with it heartrate and oxygen level sensor.

Front Side:

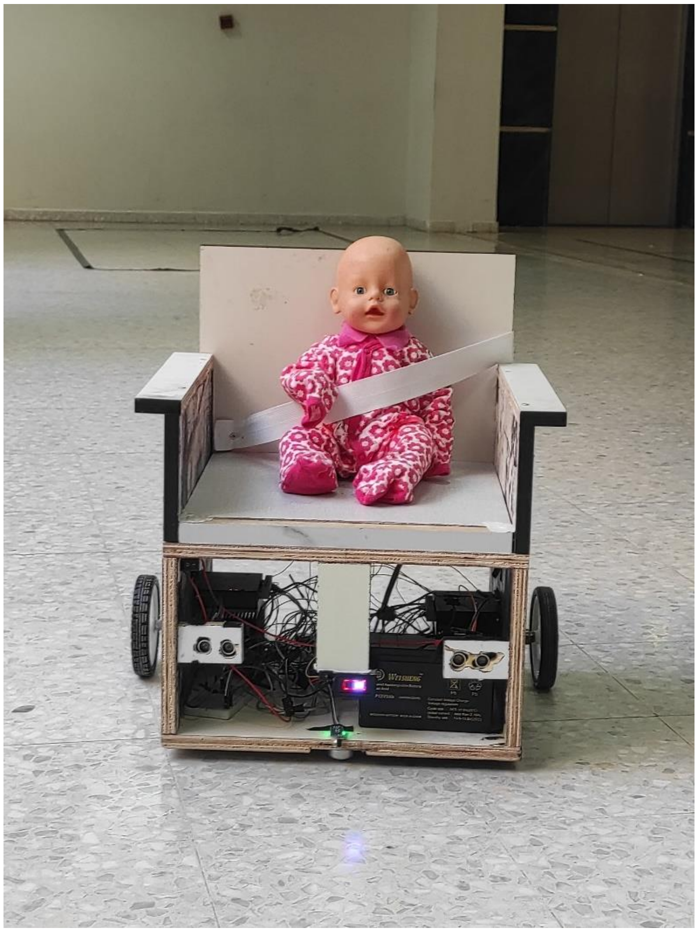

Figure 10: Front Side

Back Side:

Figure 11: Back Side

Right Side:

Figure 12: Right Side

Left Side:

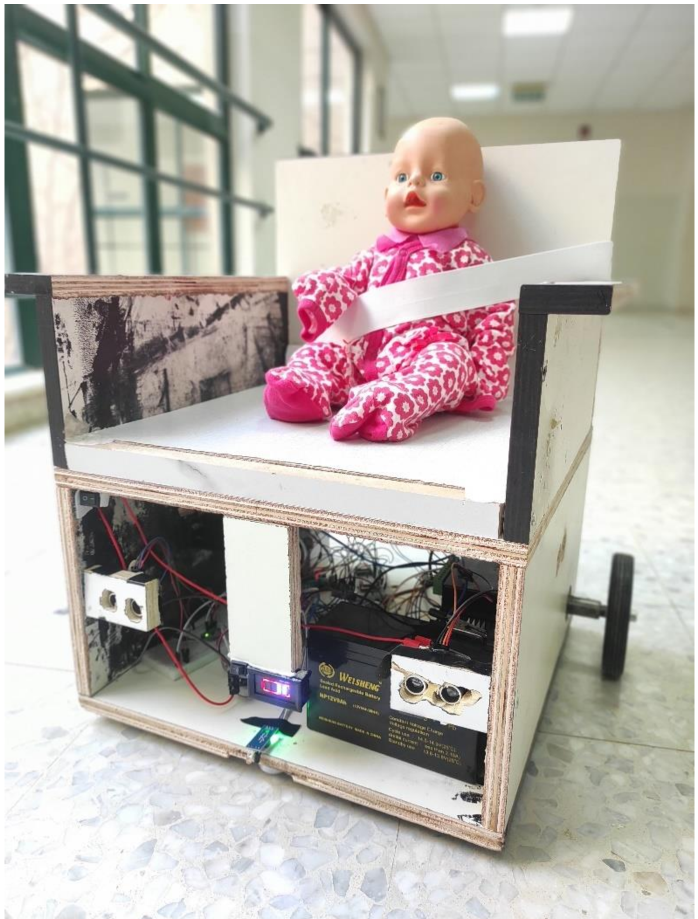

Figure 13: Left Side

Chapter 4

Results and Discussion

The smart wheelchair system's development and deployment produced positive results in terms of usability, functionality, and user satisfaction. The wheelchair's several modes of operation, safety precautions, health monitoring features, and the incorporation of IoT for real-time control and data exchange were the main areas of focus.

4.1 Operational Modes:

The smart wheelchair was successfully tested in Four modes of operation:

Manual Mode: A joystick or other similar manual controls could be used by users to control the wheelchair. For users who like direct control, this mode's excellent accuracy and responsiveness make it ideal.

Semi-Automatic Mode: The wheelchair is used for obstacle detection to help in movement while receiving user inputs. This mode was especially successful in lessening the user's mental and physical strain.

Manual with recommendation: The user has the control, but if obstacle is detected then the chair will give him recommendations to avoid the obstacles.

Play-around Mode: The wheelchair uses the sensors to avoid obstacles and navigate on its own. this mode is perfect for individuals with restricted physical capabilities or to make the child busy and engaged.

4.2 Safety and Obstacle Avoidance:

Improved Safety by adding sensors for obstacle avoidance and detection. The wheelchair has a good accuracy rate of over 80% in avoiding obstacles during the testing.

4.3 Health Monitoring:

One of the smart wheelchair's greatest features is that can monitor the health in real-time. that have a sensor for measuring oxygen levels and heart rate, and send the information to his parent through the Internet Web Page. Allowing to acquire medical attention.

4.4 Discussion:

The results show that smart wheelchairs which are internet-enabled have the potential to transform senior citizen and disabled to have mobility solutions. A complete solution that takes into both mobility and health issues is offered by the integration of multi modal control, obstacle avoidance, health monitoring, and internet connectivity.

However, challenges like the need for strong connectivity in remote areas and optimizing the system for prolonged battery life and enhance the movement remain areas for improvement. Future work could also explore the integration of advanced machine learning algorithms for navigation and predictive health monitoring.

4.5 Result Image:

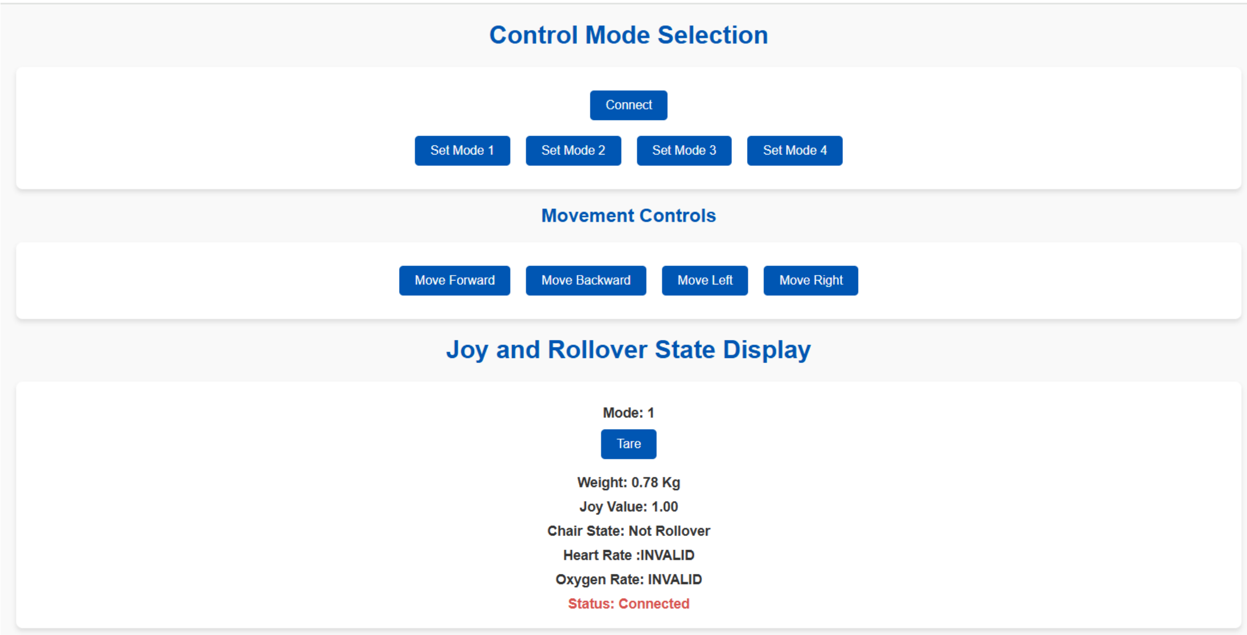

Figure 14: Heart Rate and oxygen without value

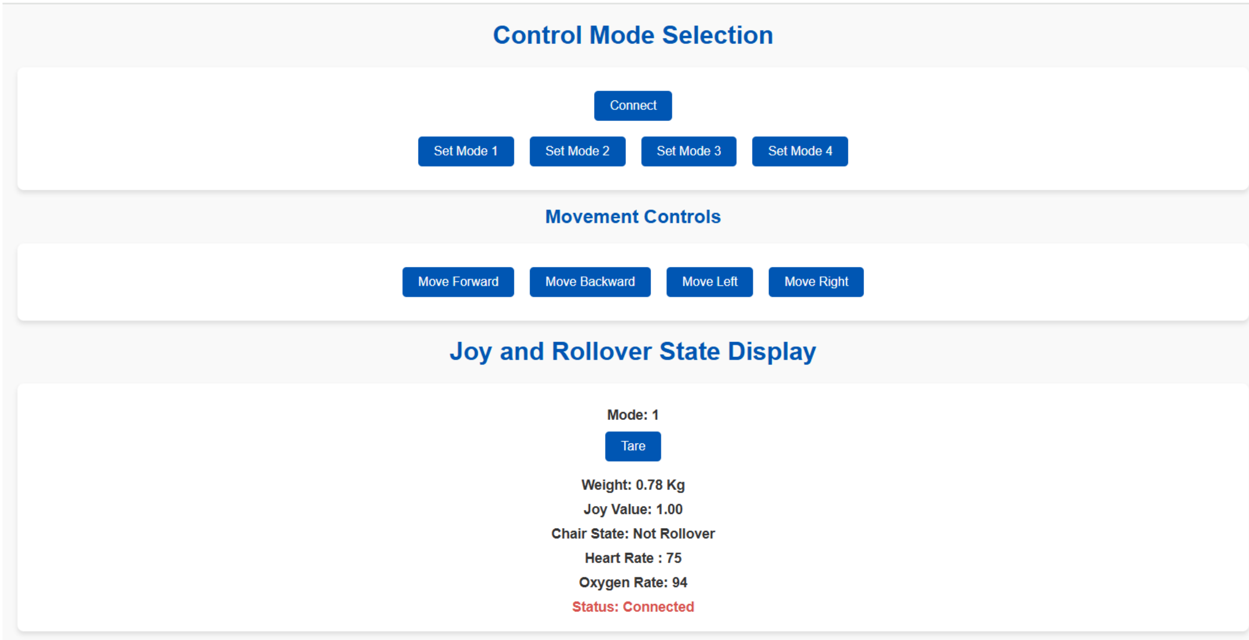

Figure 15: Heart Rate and oxygen with value

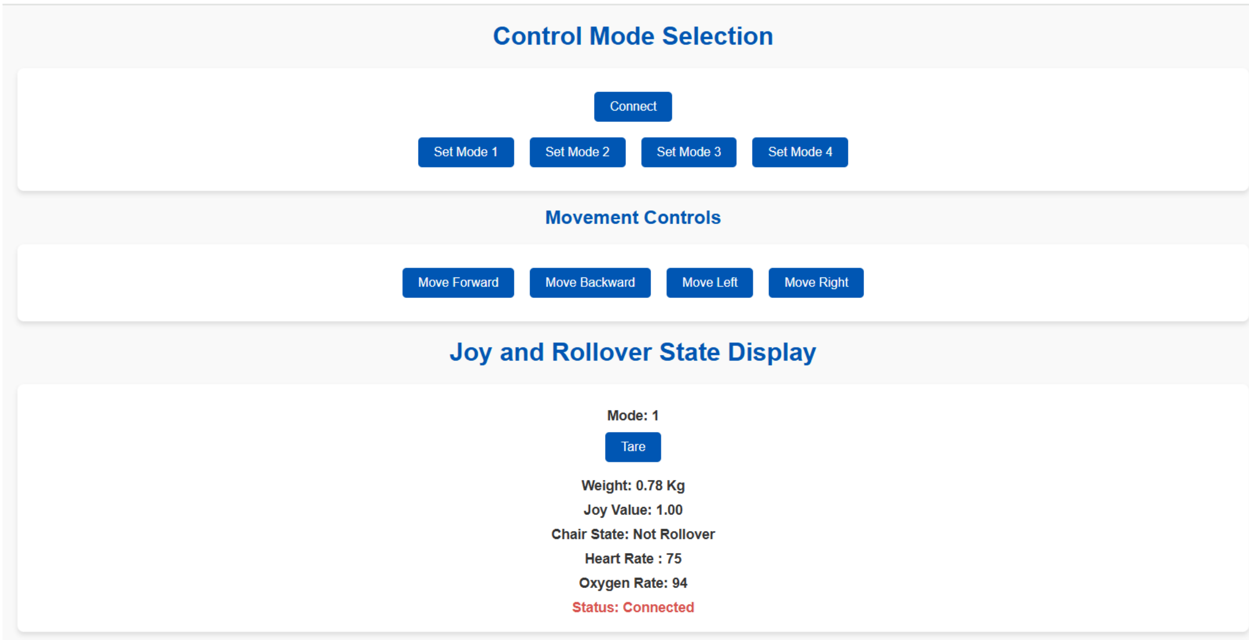

Figure 16: Not rollover reading

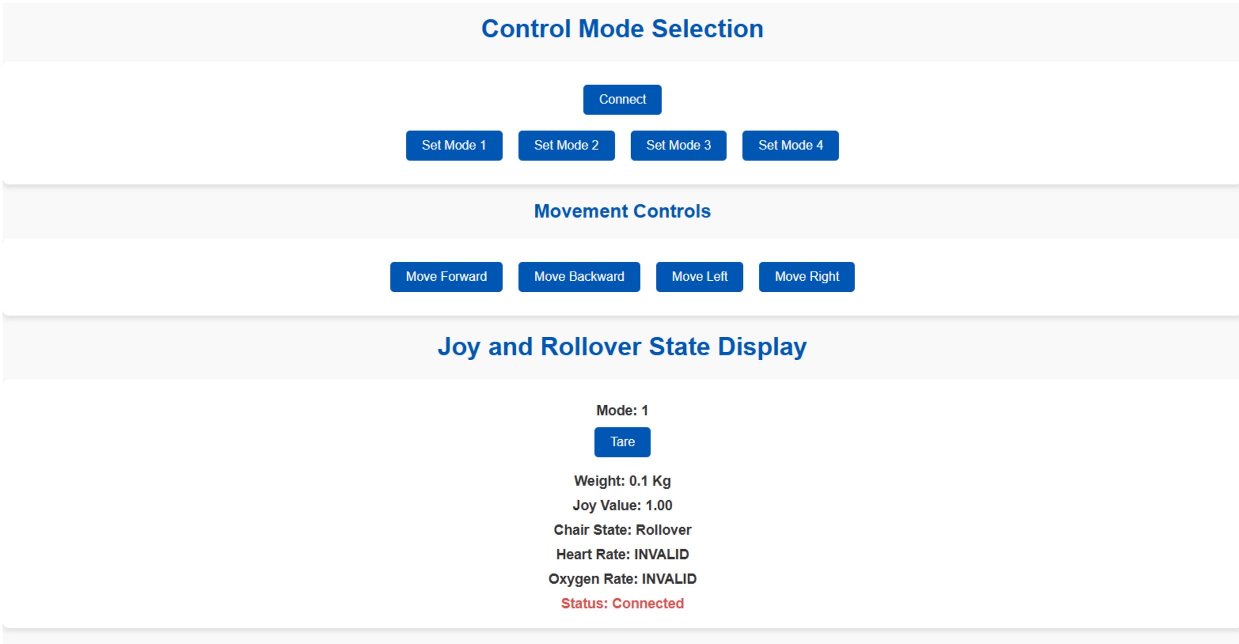

Figure 17: Rollover reading

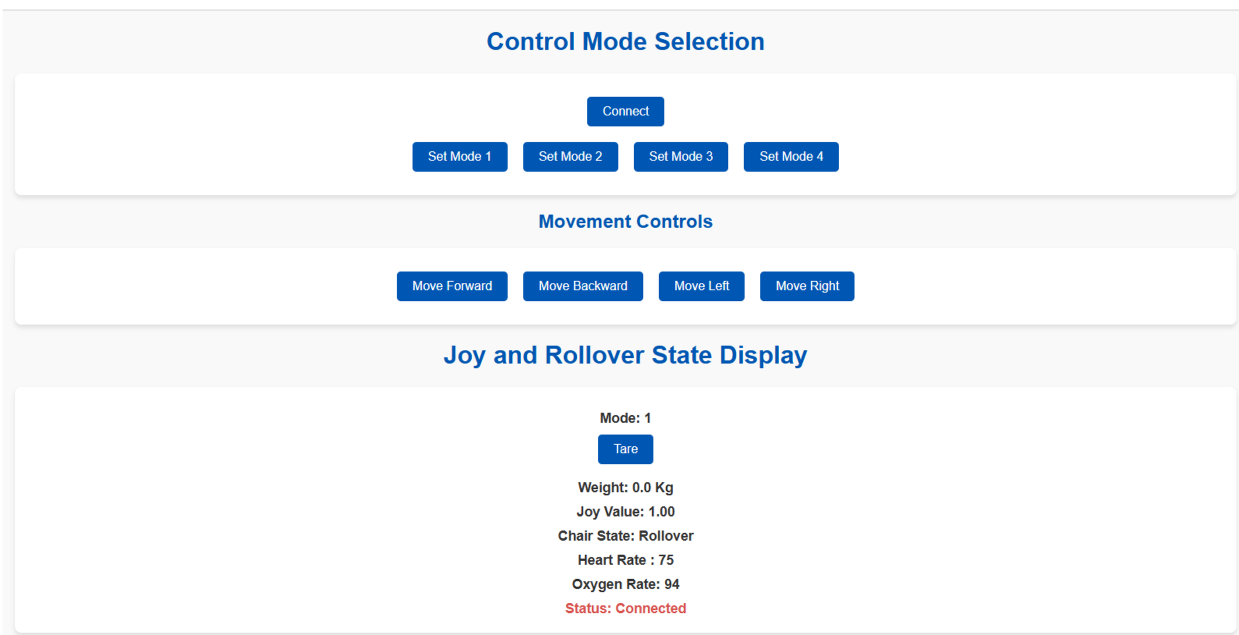

Figure 18: Without Weight

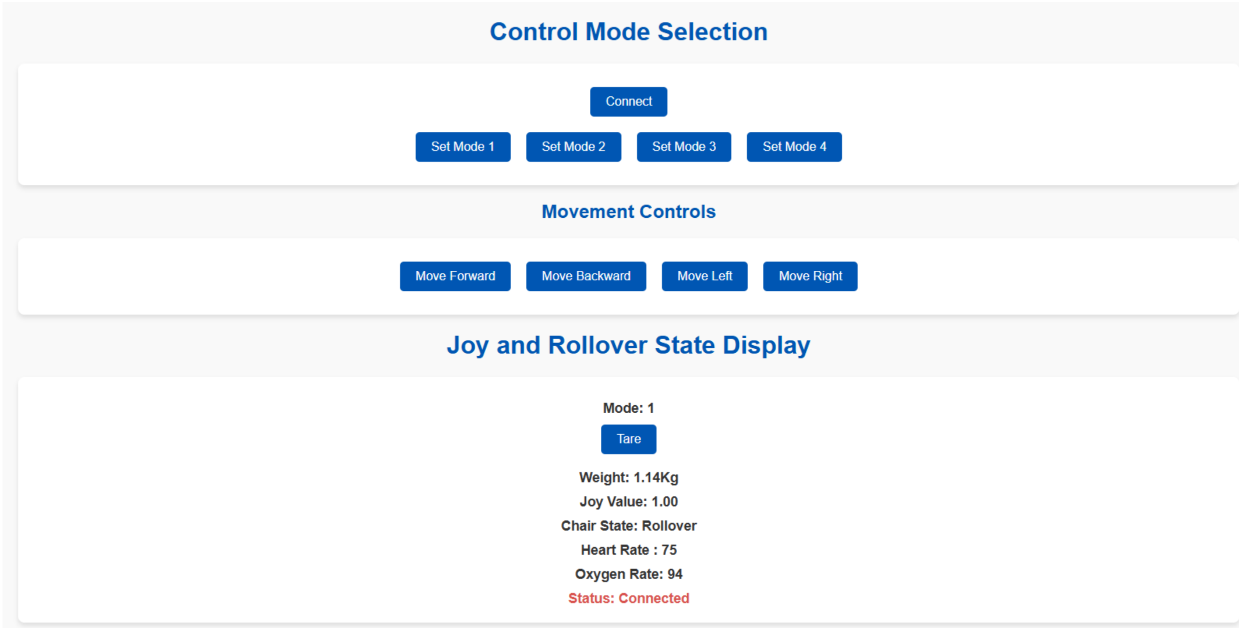

Figure 19: With Weight

*For More Videos and Demo use this Link.

Chapter 5

Conclusion:

5.1 Summary

The project aimed to close the gap between people with mobility issues and accessible technology by creating a simple efficient smart wheelchair system. The cutting-edge features of the wheelchair, like its friendly controls and obstacle detection, show the success of this project. Users' quality of life is greatly enhanced by the smart features, which make it simpler to move around safely and effectively.

5.2 Recommendations for Improvement

There are several chances to improve the smart wheelchair system’s overall efficacy. First, need to study user behavior and offering support like route recommendations or control adjustments depending on preferences merging machine learning algorithms with cutting-edge artificial intelligence will improve navigation, by adding voice recognition for multiple languages, and Accessibility would also be expanded. including a feedback system will help to continuous improvement and user satisfaction would be ensured, where carers and users can offer recommendations. Last but not least, regular feedback gathering is a top priority and is crucial to resolving usability issues and making sure the system changes to meet user needs and technology improvements.

5.3 Lessons Learned

Some of the crucial lessons and abilities acquired during the creation of the smart wheelchair system. We Learned about sensors and how to use them and how to program them using esp32 and know about different motors and how to connect and use them and how to use Wi-Fi features and implement simple web pages using esp32 and deploy it on it, and how to test user and get feedback to detecting possible problems early is one of important lesson. And how to Interact with users throughout the testing stages revealed possibilities for development and offered helpful details about the system's practical operation. And the need to include dependable hardware components and guarantee compatibility between the wheelchair's mechanical systems and software was another important lesson that learned. The project also showed the necessity of upgrades and maintenance in order to handle new problems and adjust to technology developments.

5.4 Future Work and Directions

- Real-time location tracking.
- voice-command functionality.
- People tracking system.
- Add Solar cells to charge the battery.

5.5 References:

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Appendix:

First code:

https://drive.google.com/file/d/16DCW7h1zutZ4KyKUG9fjPLr4mKhH-vgh/view?usp=sharing

Second code:

https://drive.google.com/file/d/16NDPj8hPCU89B8Zydflrot6UaLCCning/view?usp=sharing