# Smart Rocker-Bogie Wheelchair with Voice Control and IoT-Based Health Monitoring

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***Abstract:*** *The proposed Smart Rocker-Bogie Wheelchair with Voice Control and IoT-Based Health Monitoring is designed to enhance mobility, safety, and healthcare for physically disabled individuals. Unlike conventional wheelchairs, this system incorporates a Rocker-Bogie Mechanism, allowing smooth and stable navigation over uneven terrains, ramps, and obstacles, ensuring greater adaptability in various environments. Powered by an ESP32 microcontroller, the wheelchair features Bluetooth-based voice control, enabling users to operate it effortlessly through voice commands, reducing the need for manual handling and enhancing accessibility for individuals with severe disabilities. To ensure user safety and well-being, the system integrates a pulse oximeter and a temperature sensor for real-time health monitoring, tracking vital parameters such as oxygen saturation ($SpO_2$) and body temperature continuously. Additionally, a vibration sensor detects falls and automatically triggers emergency alerts to caregivers, enhancing safety in case of accidents. The system is equipped with cloud connectivity via the Ubidots IoT platform, enabling remote health monitoring, data logging, and real-time alerts, allowing caregivers and healthcare professionals to monitor patient conditions and respond promptly to any emergencies.*

***Keywords:*** *Rocker-Bogie Mechanism; ESP32 Microcontroller; Ubidots; Arduino IDE*

## I. INTRODUCTION

The Smart Rocker-Bogie Wheelchair with Voice Control and IoT-Based Health Monitoring is designed to enhance both mobility and healthcare. The system incorporates a Rocker-Bogie Mechanism, a technology inspired by planetary rovers, allowing the wheelchair to traverse uneven surfaces, stairs, and inclines with greater stability and adaptability. Unlike standard mobility aids, this smart wheelchair is powered by an ESP32 microcontroller and features Bluetooth-based voice control, enabling users to navigate effortlessly through hands-free voice commands. This feature significantly benefits individuals with limited upper body strength or motor impairments, providing them with greater autonomy in movement. Beyond mobility, the system integrates real-time health monitoring, equipped with a pulse oximeter and temperature sensor to continuously track oxygen saturation ($SpO_2$), heart rate, and body temperature. A vibration sensor detects falls and automatically sends alerts to caregivers, ensuring immediate response in case of an emergency. The integration of cloud connectivity via the Ubidots IoT platform allows for remote health monitoring, enabling caregivers and healthcare professionals to track user conditions in real time. The collected data can be used to analyze health trends, detect anomalies, and provide early warnings for potential medical conditions.

The wheelchair is also designed with a rechargeable battery system, ensuring long-lasting operation and energy efficiency. Its ergonomic design focuses on comfort and ease of use, making it a practical solution for individuals who rely on mobility assistance in their daily lives. The project aims to enhance independence, safety, and healthcare accessibility, making mobility assistance more intelligent, user-friendly, and adaptable to various environments.

## II. FUNCTIONAL OVERVIEW

The "Smart Rocker-Bogie Wheelchair with Voice Control and IoT-Based Health Monitoring" is an innovative and advanced solution designed to improve the mobility and health management of users with physical disabilities or limited mobility. It integrates a rocker-bogie suspension system that ensures enhanced stability and comfort, particularly over rough or uneven terrain. The system keeps the wheelchair level, even when navigating obstacles such as curbs or gravel, thus reducing the risk of tipping over and providing a smoother ride outdoors.

The wheelchair also comes equipped with a voice control system, allowing users to operate it hands-free. This feature is particularly useful for those with limited or no hand mobility, enabling them to control the wheelchair through simple voice commands like "move forward," "turn left," or "stop." This enhances the user's independence and convenience, as they no longer have to rely on traditional manual controls. Furthermore, the wheelchair incorporates IoT-based health monitoring, continuously tracking key health parameters such as heart rate, blood pressure, and oxygen levels. This data is sent in real-time to healthcare professionals or stored for future analysis. Through this technology, caregivers and medical providers can monitor the user's health remotely, offering timely intervention if needed. The system also provides automatic alerts if any health metrics deviate from normal ranges, ensuring quick response in case of emergencies.

In addition to these features, the wheelchair is powered by a long-lasting rechargeable battery, optimized for extended usage without frequent recharging. It may also include smart charging features, notifying users when the battery is low and ensuring it is charged in an efficient manner. Safety features, such as obstacle detection sensors and an emergency stop function, help prevent accidents and ensure that the user can safely navigate their environment. The design of the wheelchair is user-friendly and comfortable, with ergonomic seating and adjustable footrests and armrests for long-term use. It is also lightweight and compact, making it easy to maneuver both indoors and outdoors. The integration of a mobile app provides further customization and tracking options, allowing users or caregivers to adjust settings and monitor health metrics remotely.

Overall, the Smart Rocker-Bogie Wheelchair with Voice Control and IoT-Based Health Monitoring offers a comprehensive solution that combines advanced mobility, convenience, and real-time health tracking to enhance the quality of life for its users.

## III.METHODOLOGY

The existing system is a GPS and GSM-enabled smart wheelchair designed to assist physically disabled individuals by providing enhanced mobility, safety, and communication features. This system primarily focuses on real-time location tracking and emergency alert mechanisms to ensure user security and allow caregivers to monitor the wheelchair's position whenever necessary. The system is managed using an Arduino Uno microcontroller, which controls various essential modules, including GPS, GSM, and motor functions. The GPS module continuously tracks the wheelchair's position, transmitting the data via the GSM module to caregivers or emergency contacts in case of distress. Additionally, the system includes a panic button that, when activated, sends an SOS message with the real-time location to predefined contacts, ensuring quick assistance during emergencies.

Key Features of the Existing System: -

1. Microcontroller-Based Control (Arduino Uno)

2. GPS-Based Location Tracking

3. GSM-Based Emergency Alert System

4. Basic Motorized Mobility

Disadvantages of the Existing System: -

While the existing system offers basic mobility and safety features, it has several limitations that hinder its effectiveness, accessibility, and adaptability in real-world applications.

1. Limited Terrain Adaptability

2. Lack of Advanced Control Mechanisms

3. No Automated Obstacle Detection and Avoidance

4. No Fall Detection Mechanism

5. Lack of IoT-Based Remote Monitoring

**PROPOSED SYSTEM**

The proposed system introduces a Smart Rocker-Bogie Mechanism-based Wheelchair, specifically designed to improve mobility, safety, and health monitoring for physically disabled individuals. This innovative system is built around modern microcontroller technology and IoT-enabled monitoring, ensuring both ease of navigation and real-time health assessment. Below is a detailed breakdown of its features and functionality:

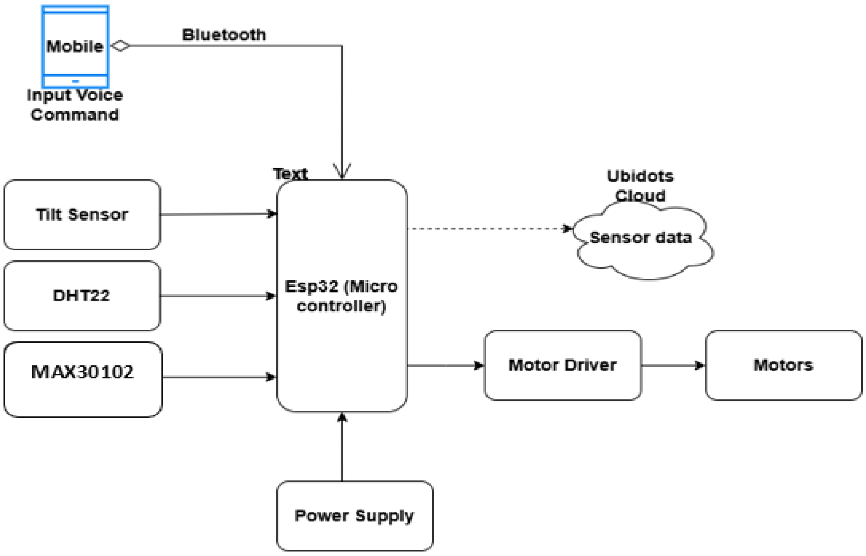


Fig.1: Block Diagram of Proposed System

Features: -

1.Advanced Mobility with Rocker-Bogie Mechanism

2.ESP32-Based Microcontroller System

3.Voice-Controlled Navigation via Bluetooth

4.IoT-Based Health Monitoring System

5.Cloud Connectivity via Ubidots

## IV.COMPONENTS

The components in Smart Rocker-Bogie Wheelchair with Voice Control and IoT-Based Health Monitoring is explained in this section. This contain both hardware and software components.

Let’s talk about them one by one:

**HARDWARE COMPONENTS**

(1) ESP WROOM 32 Microcontroller: -

The ESP-WROOM-32 is a highly integrated microcontroller module designed by Express if Systems,

widely known for its application in Internet of Things (IoT) and embedded systems. One of the standout features of the ESP-WROOM-32 is its integrated connectivity options. The module supports 2.4 GHz IEEE

802.11 b/g/n Wi-Fi, enabling robust wireless communication over local and internet networks. Additionally, it incorporates Bluetooth dual-mode functionality, allowing for both Classic and Low Energy (BLE) connections.

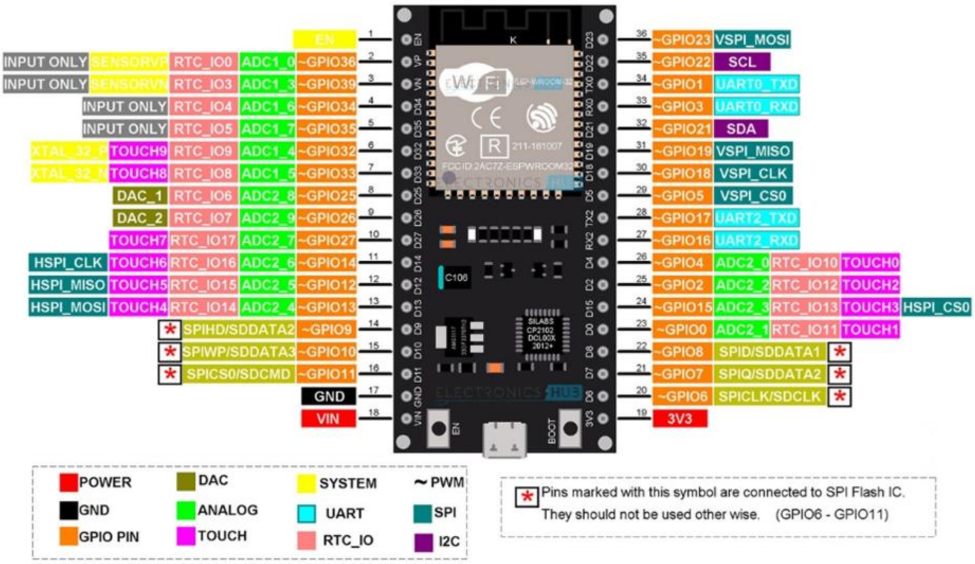


Fig.2: Pin Description of ESP WROOM 32 Microcontroller

The ESP-WROOM-32 is equipped with a rich set of peripherals, including 34 programmable GPIO pins, multiple SPI, I2C, UART interfaces, and ADC (12-bit) and DAC (8-bit) capabilities. These features allow the module to interface with a variety of sensors, actuators, and other devices, offering significant flexibility in hardware design. Its built-in temperature sensor, Hall effect sensor, and capacitive touch pins expand its utility for specialized applications.

Power efficiency is another critical aspect of the ESP-WROOM-32. It supports multiple low-power modes, making it suitable for battery-operated devices. Features like the ultra-low-power (ULP) co-processor allow the module to perform tasks like sensor data monitoring or GPIO control while consuming minimal power. This energy efficiency makes it ideal for projects such as remote environmental monitoring, asset tracking, and smart agriculture.

(2) Lithium-ion Batteries: -

Lithium-ion (Li-ion) batteries are rechargeable energy storage devices that have become ubiquitous in modern electronics, portable devices, and electric vehicles due to their high energy density, lightweight design, and long cycle life. Li-ion batteries are a type of rechargeable battery that utilizes lithium ions as the primary charge carriers. It typically consists of one or more electrochemical cells, each containing a positive electrode (cathode), a negative electrode (anode), and an electrolyte solution. During charging, lithium ions move from the positive electrode to the negative electrode, where these are stored in the anode material.


Fig.3: Li-ion Batteries

(3) Motor: -

The motor serves as the system's actuator, converting electrical energy into mechanical energy. It performs tasks such as driving mechanical systems, rotating components, or moving loads based on commands from the ESP32. The motor's operation is closely monitored and controlled to ensure efficiency, safety, and reliability. Its performance is influenced by inputs from the potentiometer and speed sensor.

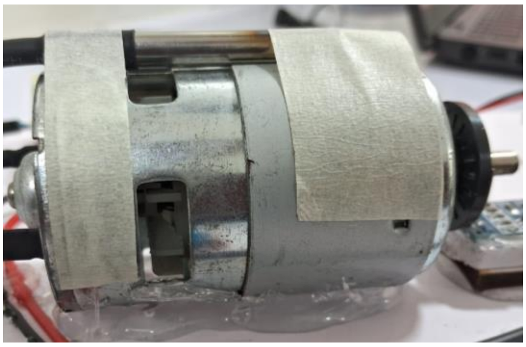

Fig.4: Motor

(4) Tilt Sensor: -

A tilt sensor is a device that detects the inclination or angular movement of an object with respect to gravity. It is widely used in various applications, including safety systems, robotics, and assistive devices like wheelchairs. In this system, the tilt sensor plays a critical role in detecting abnormal movements, falls, or inclinations of the wheelchair**,** ensuring user safety**.**

Fig.5: Tilt Sensor

(5) DHT22 Sensor: -

The DHT22 is a widely used temperature and humidity sensor that provides precise environmental measurements. It is commonly used in weather monitoring systems, smart home applications, and healthcare devices. In this rocker-bogie mechanism-based wheelchair, the DHT22 sensor is used to monitor the patient's body temperature and surrounding humidity to ensure comfort and safety.

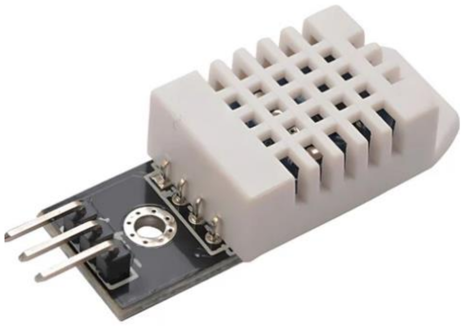

Fig.6: DHT22 Sensor

(6) L298N Motor Driver: -

The L298N motor driver module is a popular dual H-Bridge motor driver that allows to control two DC motors or one stepper motor simultaneously. It is widely used in robotics, motorized wheelchairs, and automation projects due to its ability to drive high-power motors with simple control signals from microcontrollers like ESP32**,** Arduino.

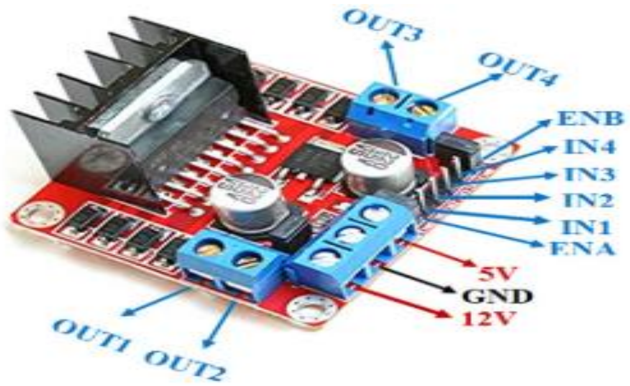


Fig.7: L298N Motor Driver

(7) MAX30102 Heart rate and Pulse Oximeter Sensor: -

The MAX30102 is an advanced optical biosensor module designed for heart rate (HR) and blood oxygen saturation (SpO2) monitoring. It is widely used in wearable health devices, fitness trackers, and medical applications to measure pulse rate and oxygen levels using photoplethysmography (PPG). The MAX30102 sensor works using Photoplethysmography (PPG), which measures changes in blood volume using light absorption.

Fig.8: MAX30102 Heart Rate and Pulse Oximeter Sensor Module

**SOFTWARE COMPONENTS**

(1) Arduino IDE: -

The Arduino IDE provides a user-friendly interface for programming Arduino boards, making it accessible to beginners and experienced developers alike. It supports a wide range of Arduino-compatible boards, including the popular Arduino Uno, Nano, Mega, and others, as well as third-party boards based on the Arduino platform. The IDE is available for Windows, macOS, and Linux operating systems, allowing users to develop Arduino projects on their preferred platform.

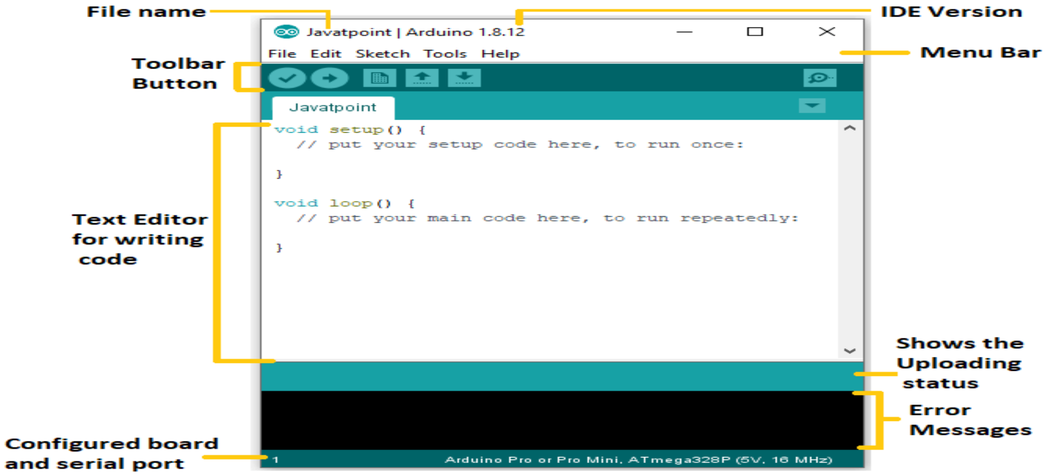


Fig.9**:** Arduino IDE

(2) UBIDOTS: -

Ubidots is an Internet of Things Development Platform helping thousands of IoT Entrepreneurs, System Integrators, and Businesses launch and scale their IoT projects without having to hire a software team.

Ubidots provides 3 tiers to power your IoT Development cycle:

- Ubidots STEM: A free tier for makers, students, researchers, and hobbyists learning about the possibilities of IoT.
- Ubidots Cloud: Our main deployment, offered under the traditional SaaS model (Software as a Service).
- Ubidots Enterprise: For customers requiring dedicated support, service levels, and/or support for large volumes of devices or data.

  Optional: Ubidots Private Cloud deployment.

The main entities in Ubidots are:

- Devices
- Variables
- Dots

## V. WORKFLOW OF PROPOSED SYSTEM

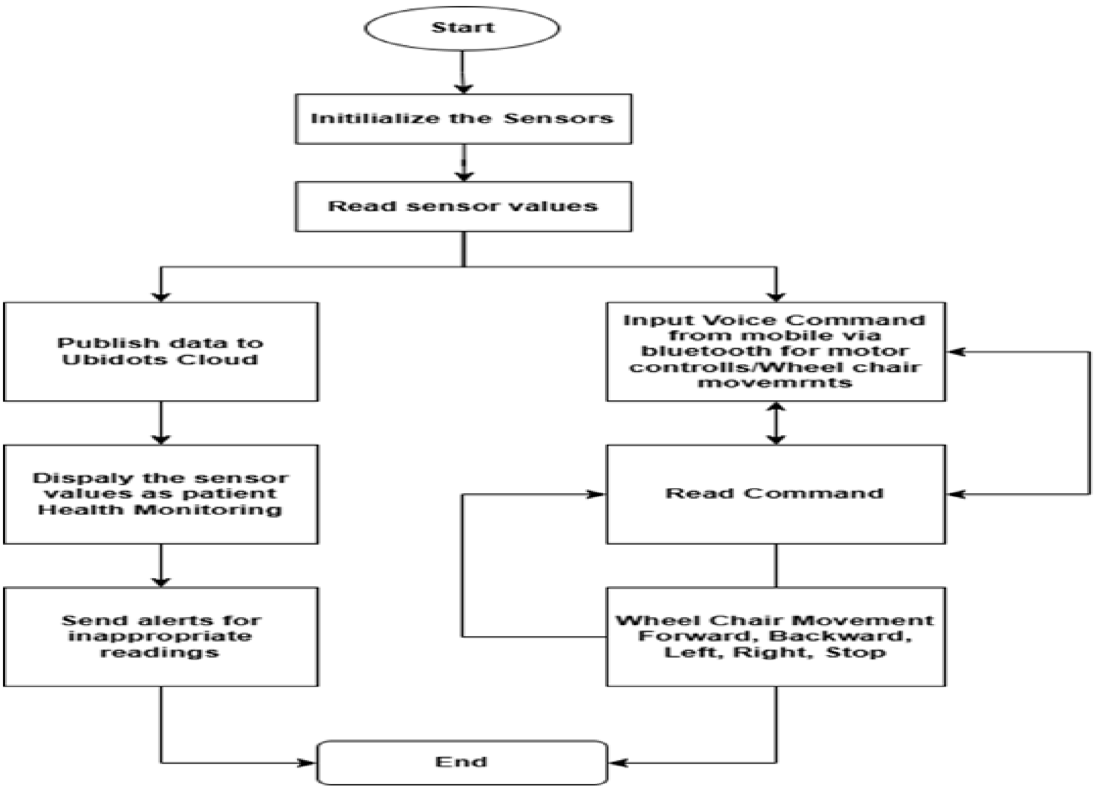


Fig.10: Workflow of Proposed System

1. Start

- The system is powered on and initialized for operation.
- It checks for the availability of essential components like the ESP32 microcontroller, sensors, Bluetooth module, and motor drivers.

2. Initialize the Sensors

- The system initializes all sensors, including:
    - Pulse Oximeter (SpO2 Sensor): Measures the user's oxygen saturation and heart rate.
    - Temperature Sensor: Monitors the body temperature to detect fever or abnormal conditions.
    - Vibration Sensor**:** Detects sudden impacts or falls for user safety.
- The sensors perform a self-test to ensure proper functioning before collecting data.

3. Read Sensor Values

- Once initialized, the sensors begin collecting real-time data.
- The system continuously monitors values such as heart rate, oxygen level, and body temperature.
- The vibration sensor detects any abnormal movement or falls.

4. Two Parallel Processes

- ✓ Health Monitoring
- ✓ Wheelchair Control

IoT-Based Health Monitoring

5. Publish Data to Ubidots Cloud

- The collected sensor data is sent to Ubidots, an IoT cloud platform, via Wi-Fi using the ESP32 microcontroller.
- This allows remote monitoring by caregivers and healthcare providers.
- Data logs are maintained for future reference and analysis.

6. Display the Sensor Values for Patient Health Monitoring

- The real-time sensor readings are displayed on the user's mobile app or a web dashboard.
- The interface provides visual representation in the form of graphs and alerts.
- Caregivers can track health metrics and respond proactively.

7. Send Alerts for Inappropriate Readings

- If the system detects abnormal readings, it triggers an alert.
- Examples of alerts:
  - High Temperature: Signals possible fever.
  - Low Oxygen Level: Indicates respiratory issues.
  - Fall Detection**:** Sends emergency alerts to caregivers.
- Alerts can be sent via SMS, email, or mobile notifications.

Voice-Controlled Wheelchair Navigation

5. Input Voice Command from Mobile via Bluetooth for Motor Controls/Wheelchair Movements

- The user provides voice commands through a mobile application or a Bluetooth-enabled device.
- Possible commands:
  - "Move Forward"
  - "Move Backward"
  - "Turn Left"
  - "Turn Right"
  - "Stop"

6. Read Command

- The ESP32 microcontroller processes the voice command and determines the required motor action.
- The system filters out background noise to avoid unintended movements.

7. Wheelchair Movement (Forward, Backward, Left, Right, Stop)

- The microcontroller sends signals to the motor driver, which controls the wheelchair's movement accordingly.
- The Rocker-Bogie Mechanism enables smooth traversal over uneven surfaces, stairs, and obstacles.
- Safety features prevent sudden acceleration or unintended movements.

8. End

- The system continues to function until powered off or reset.
- Data is stored for analysis and review in future sessions.

## VI. CONCLUSION

The Smart Rocker-Bogie Mechanism-based Wheelchair presents an innovative and intelligent mobility solution for physically disabled individuals, integrating advanced mobility, IoT-based health monitoring, and voice-controlled navigation. By leveraging the Rocker-Bogie Mechanism, the wheelchair ensures seamless movement over uneven terrains, significantly enhancing user independence and accessibility.

The ESP32 microcontroller serves as the central processing unit, efficiently managing sensor data, voice commands, and real-time communication with the Ubidots IoT cloud platform. The inclusion of health monitoring sensors such as a pulse oximeter, temperature sensor, and fall detection system ensures that users' vital signs are continuously tracked. Additionally, the Bluetooth-based voice control system provides a hands-free navigation experience, making it easier for users with limited hand mobility to operate the wheelchair with simple voice commands.

By combining mobility, real-time health tracking, and smart automation, this wheelchair represents a technologically advanced, safe, and user-friendly solution for enhancing the quality of life of disabled individuals.

The advanced wheelchair features cutting-edge technologies for enhanced user experience and independence. It boasts solar and energy efficiency features, including solar charging, regenerative braking, and improved battery management. Additionally, it incorporates innovative control systems, such as Brain-Computer Interface (BCI) for thought-controlled operation, Gesture & Eye-Tracking Control for hands-free use, and Multi-Mode Communication for seamless connectivity via Wi-Fi, GSM, LoRaWAN, and Bluetooth 5.0. Furthermore, it offers Smart Home Integration, enabling users to control home appliances, doors, and lights via IoT and voice assistants. The wheelchair's design is also Modular & Customizable, featuring a foldable, lightweight, and ergonomic build for optimal user comfort.

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