E-Wheel Connect: IOT-Integrated Wheelchair

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Many people suffer from temporary or permanent physical disabilities due to illness or accidents. For those daily activities are difficult and require a wheelchair for locomotion and is very essential. Manual or electrical wheelchair are satisfying most of the low and middle level disability person where they can use the wheelchair independently. However, in severe cases, it is difficult or impossible to use wheelchair independently. IoT-based smart wheelchair enhances mobility and independence for individuals with mobility impairments. The project integrates sensors, actuators, and communication modules with mobile app integration to enable obstacle detection and avoidance. Extensive testing validates the system's effectiveness in navigating complex environments. The project showcases the potential of IoT technology in creating intelligent wheelchair systems, empowering users with increased mobility, safety, and independence. It also provides an opportunity for visually or physically impaired persons with obstacle detection system, which minimize the chance of collision which using it. We tried to provide all the features required in a smart wheelchair at lowest price for the people to afford it without any difficulty and to use utmost independent on others.

Keywords —Smart Wheelchair, IoT-Technology, Automatic Lighting, Obstacle detection, Ultrasonic Sensor, Blynk, Rain shade Activation, Remote operation

I. INTRODUCTION

The global rise in the ageing population and the increasing number of individuals with disabilities—approximately 15% of the world's population, including 285 million who are visually impaired or blind—has intensified the demand for assistive mobility solutions. With annual wheelchair demand exceeding 30 million units, user concerns regarding comfort, safety, and independence are driving advancements in smart wheelchair technologies.

Traditional manual and electric wheelchairs often require physical effort or external assistance, limiting user autonomy. In contrast, smart wheelchairs integrate sensors, cameras, and communication technologies to offer enhanced human-machine interaction, mobility control, and remote monitoring. Despite their potential, widespread adoption remains limited due to cost concerns.

This research focuses on the design and development of an IoT-based smart wheelchair aimed at enhancing mobility, safety, and independence for users with physical impairments caused by age, accidents, or medical conditions. The proposed system incorporates real-time obstacle detection using ultrasonic, infrared, or laser sensors to ensure safe navigation and reduce the risk of collisions. By leveraging IoT technologies, this project seeks to create an affordable, intelligent wheelchair system that improves the overall quality of life for individuals with mobility challenges.

II. LITERATURE REVIEW

Maryam Amur and Suresh Manic [1] presented an IoT-based smart wheelchair aimed at improving the mobility and independence of disabled users. Their research focused on integrating IoT technology with sensors and communication modules to ensure efficient obstacle detection and seamless navigation. A user-friendly interface was also emphasized to enhance the overall user experience and promote accessibility.

Sasikala P. [2] proposed a Wi-Fi-enabled Human-Machine Interface (HMI) wheelchair system for people with disabilities. The system included a sensor-equipped wheelchair, a microcontroller, and a Wi-Fi communication module. User commands such as directional inputs were detected by sensors and transmitted to the microcontroller, which in turn controlled the wheelchair's movement. This design facilitated real-time wireless communication, ensuring smooth and intuitive control.

Mundane et al. [3] developed an automated electric wheelchair system designed to increase independence and maneuverability. The authors utilized sensors like ultrasonic and accelerometers to detect obstacles and interpret user commands. A microcontroller processed these inputs and controlled the motors accordingly, enabling the wheelchair to move safely and efficiently in real-world environments.

A smart wheelchair system leveraging IoT was explored by Panchamia et al. [4]. Their design incorporated sensors, actuators, microcontrollers, and a wireless communication module to collect and process data from the environment and user. This system allowed for connectivity with smartphones and tablets, enabling remote control, real-time health monitoring, obstacle avoidance, and location tracking—enhancing the overall usability and functionality.

Richard et al. [5] examined the use of Human-Machine Interface (HMI) for smart wheelchair navigation. The proposed solution featured a GUI-based control system that allowed users to interact with the wheelchair via touch input, selecting direction and speed effortlessly. The system included sensors for environmental awareness, microcontrollers for signal processing, and actuators to execute movement commands, resulting in a highly intuitive and responsive control mechanism.

While primarily designed for autonomous vehicles, recent studies have highlighted the potential of advanced sensory technologies in assistive mobility. Zhan et al. [6] introduced an object recognition method using fused LiDAR and infrared imaging, which could potentially be adapted for wheelchair navigation in complex environments. Similarly, Liu et al. [7] developed a real-time object recognition system using 3D LiDAR, and Zhao et al. [8] demonstrated the effectiveness of fusing 3D LiDAR and camera data for robust obstacle detection, both of which offer promising applications in the context of assistive devices. Lastly, Ravi et al. [9] applied LiDAR-based mobile mapping for precise lane width estimation, showcasing the high-resolution environmental perception capabilities that could be repurposed for wheelchair systems operating in outdoor settings.

III. PROPOSED WORK

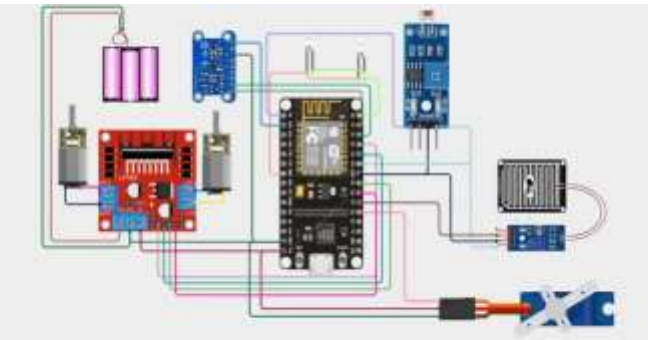
The E-Wheel Connect is a smart, IoT-integrated wheelchair designed to improve mobility, safety, and independence for users with physical disabilities. The system operates by gathering real-time data from multiple sensors to intelligently assist users in their daily activities.

An ultrasonic sensor is mounted on the wheelchair to detect obstacles in the path, ensuring safe navigation and preventing collisions. A gyroscope is used to detect motion orientation and maintain stability, especially on uneven surfaces. The LDR (Light Dependent Resistor) sensor monitors ambient light levels, allowing the system to adjust lighting for user comfort to keep track of weather conditions, a DHT sensor measures temperature and humidity, and a rain sensor detects rainfall, enabling the system to notify the user or take precautionary measures.

At the core of the system lies a microcontroller, which processes input from all sensors and sends appropriate control signals. These signals operate servo motors responsible for moving the wheelchair in the desired direction.

The integration of IoT connectivity allows caregivers or family members to remotely monitor the wheelchair's status and location in real-time. This not only enhances safety but also allows timely assistance during emergencies.

Overall, the wheelchair functions as an intelligent assistant, capable of adapting to the user's environment while ensuring comfort, autonomy, and enhanced mobility.



System Design Overview

Microcontroller (ESP8266):

The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability developed by Espressif Systems. It operates at 3.3V logic level, contains a 32-bit Tensilica L106 microprocessor, and supports a clock frequency of up to 160 MHz. It features multiple GPIO pins, PWM outputs, ADC, SPI, I2C, and UART communication protocols, allowing it to interface directly with sensors, actuators, and communication modules.

Power Supply:

The power system includes a regulated power source capable of delivering steady voltage (usually 5V for peripherals and 3.3V for ESP8266). Power may come from rechargeable Li-ion batteries, combined with DC-DC buck converters or linear regulators (e.g., AMS1117) to maintain safe voltage levels. The current rating must be sufficient to drive motors, sensors, and communication modules simultaneously.

Rain Sensor:
Typically consists of a rain-detecting plate with exposed copper traces. When water bridges the traces, resistance decreases, causing a change in voltage across the analog output pin. The module usually includes a comparator circuit and potentiometer to set sensitivity, with digital and analog outputs compatible with microcontroller inputs.

DHT Sensor (DHT11 / DHT22):
These sensors integrate a thermistor and a capacitive humidity sensor, controlled via a proprietary single-wire protocol. They communicate digital signals (not analog voltages) through timed high/low pulses that represent temperature and humidity data. DHT22 offers better accuracy and range compared to DHT11.

LDR Sensor (Light Dependent Resistor):
An LDR is a photoresistor made from a cadmium sulfide (CdS) material whose resistance decreases with increasing light intensity. It is used in a voltage divider circuit to produce an analog voltage that can be read by the ADC pin of a microcontroller. It has a slow response time and is often affected by ambient temperature.

Gyroscope Sensor:
Usually an MPU6050 or similar module that combines a 3-axis gyroscope and 3-axis accelerometer using MEMS (Micro-Electro-Mechanical Systems) technology. It communicates via I2C protocol, transmitting orientation and acceleration data in real-time. The sensor includes onboard digital motion processing (DMP) to offload computation from the microcontroller.

Servo Motor:
A servo motor consists of a DC motor, gearbox, position sensor (usually a potentiometer), and control circuitry. It receives PWM signals, where the pulse width (typically between 1 ms and 2 ms) determines the angular position. The internal circuit compares the feedback from the position sensor with the command and adjusts the motor's rotation accordingly.

DC Motors (Motor 1 and Motor 2):
Brushed DC motors convert electrical energy into mechanical motion through commutators and brushes. They are simple, robust, and provide high torque. Voltage controls their speed, and reversing polarity changes direction. They require external power beyond microcontroller capacity and must be interfaced using drivers.

Motor Driver:
A motor driver like L298N or L293D is an H-Bridge circuit that allows control over the direction and speed of DC motors. It takes low-power control signals from the microcontroller and uses transistors (usually MOSFETs or BJTs) to switch a higher current to the motors. It includes enable pins, direction control pins, and sometimes internal diodes to handle back EMF from motors.

LEDs:
Light Emitting Diodes are semiconductor devices that emit light when forward biased. They require a current-limiting resistor to prevent damage due to overcurrent. The microcontroller can switch them on or off via GPIO pins, or vary brightness using PWM signals.

IoT Server / Cloud:
Cloud platforms (e.g., Firebase, Thingspeak, Adafruit IO, or AWS IoT Core) receive data via REST APIs, MQTT, or WebSocket. The microcontroller sends data in structured formats (JSON, XML) via HTTP POST requests or MQTT publish messages. These platforms allow real-time dashboards, remote device control, alert generation, and integration with other systems like Google Sheets or IFTTT.

IV. IMPLEMENTATION RESULT

The implementation of the *E-Wheel Connect* smart wheelchair system involves the seamless integration of hardware components, sensors, and IoT technology to enhance user mobility, safety, and autonomy. At the heart of the system lies the **ESP8266 microcontroller**, which serves as the brain of the wheelchair. This Wi-Fi-enabled controller gathers input from various sensors, processes data, and facilitates communication with cloud platforms for real-time monitoring.

To detect obstacles and assist in safe navigation, **ultrasonic sensors** are mounted on the wheelchair, providing continuous feedback about the environment. The system's balance and orientation are monitored using a **gyroscope sensor**, which helps prevent tipping or instability, especially when navigating uneven terrain.

The **servo motor** plays a critical role in translating control commands into mechanical movement, offering precision steering and direction changes. For propulsion, **DC motors** are used to drive the wheelchair's wheels, providing adequate torque for forward and backward movement. These motors are managed through a **motor driver module** (such as L298N), which acts as a bridge between the low-power microcontroller and high-power motors, ensuring reliable and responsive control.

A **regulated power supply**—typically from rechargeable Li-ion batteries—ensures stable operation across all components. Voltage regulation circuits ensure the ESP8266 and other sensors operate within safe power limits.

All sensor data and control events are processed locally by the microcontroller and periodically transmitted to an **IoT cloud platform** such as Firebase or ThingSpeak. This connection allows caregivers and family members to monitor the wheelchair's location, status, and environment in real-time. Alerts can be generated automatically in case of abnormal readings or emergency conditions.

LED indicators on the system provide visual cues for system status, warnings, or successful commands. The entire setup works cohesively to deliver a smart, responsive, and connected mobility solution for users who need assistance due to physical disabilities.

This implementation demonstrates how readily available electronics and IoT tools can be combined to create an affordable and scalable assistive device, improving the quality of life for millions of individuals with mobility challenges.

V. CONCLUSION

The In conclusion, the IoT-based smart wheelchair project with mobile app navigation and obstacle detection has demonstrated promising results in enhancing mobility and improving the user experience for wheelchair users. The integration of IoT technology, sensors, and mobile app control has provided accurate obstacle detection, efficient navigation, and real-time alerts, ensuring user safety and convenience. The project has highlighted the potential of IoT-based solutions in addressing the challenges faced by individuals with mobility impairments. The IoT-based smart wheelchair project can continue to evolve, offering even more advanced and user-centric features to enhance the mobility, independence, and overall quality of life for individuals with mobility impairments.

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