IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

Volume 15, Issue 6, June 2026

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 9.867

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 9.867 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 15, Issue 6, June 2026 ||

| DOI:10.15662/IJAREEIE.2026.1506006 |

Smart Wheelchair Operated by Head Motion for Disabled Individuals

Dr. Saurabh V. Lawate[1], Dr Kiran Kimmatkar[2], Suraj M. Bhoyar[3], Namit M. Shende[4], Aniket S. Tumdam[5], Sahil S. Bhoyar[6], Sneha P. Dayare[7], Prajwal A. Apturkar[8]

Professor, Department of Electrical Engineering, Vidarbha Institute of Technology, Nagpur, Maharashtra, India[1]

HOD, Department of Electrical Engineering, Vidarbha Institute of Technology, Nagpur, Maharashtra, India[2]

U.G. Student, Department of Electrical Engineering, Vidarbha Institute of Technology, Nagpur, Maharashtra, India[3,4, 5,6,7,8]

ABSTRACT: A cognitive radio(CR) is a transceiver which automatically detects available channels in wireless spectrum and accordingly changes its transmission or reception parameters. In this paper, it proposes an algorithm for the energy-efficient and spectrum- aware communications requirements in CR network. It enables each node to determine and regulate its transmission strategy to provide minimum energy consumption without sacrificing end-to-end delay performance and also maximizes overall spectrum utilization. Spectrum sensing is one of the essential parameter to be considered in CR networks. Therefore, the security aspect of spectrum sensing should be addressed well. Using a Trust-Worthy algorithm, it improves the trustworthiness of the Spectrum sensing in CR-Networks. It implemented using Network Simulator-2.

KEYWORDS: Smart Wheelchair, ESP32, MPU6050, Head Motion Control, IoT, Obstacle Detection, GPS Tracking, Embedded Systems, Assistive Healthcare, Intelligent Mobility System.

I. INTRODUCTION

The rapid advancement of embedded systems, IoT technology, and intelligent healthcare devices has created new opportunities for improving mobility and independence for physically disabled individuals. Conventional wheelchairs generally require manual operation or joystick-based control, which creates difficulties for users suffering from paralysis, spinal cord injuries, neuromuscular disorders, or severe upper-limb disabilities. To overcome these limitations, this project presents a Smart Wheelchair Operated by Head Motion, an intelligent hands-free mobility assistance system designed for differently-abled individuals [1,2].

The proposed system uses an ESP32 microcontroller integrated with an MPU6050 gyroscope and accelerometer sensor mounted on a wearable helmet or head cap to detect real-time head movements. Based on the detected head orientation, the wheelchair movement is controlled automatically. Backward head movement moves the wheelchair forward, while left and right head tilts control directional turning. Ultrasonic sensors are integrated for obstacle detection and collision avoidance to improve user safety during movement [3].

In this paper, it proposes the proposed wheelchair includes an emergency alert and monitoring mechanism using GPS and IoT communication technologies. In abnormal conditions such as wheelchair tipping or sudden impact detection, the system activates buzzer alerts and transmits emergency notifications along with live GPS location to caregivers or family members. The wheelchair uses dual high-torque DC geared motors controlled through BTS7960 motor driver modules for stable movement operation. The developed prototype provides a low-cost, reliable, user-friendly, and intelligent mobility solution suitable for hospitals, rehabilitation centers, elderly care systems, and smart healthcare applications & Networks.

Mobility assistance systems and intelligent healthcare technologies have become increasingly important for improving the quality of life of physically disabled individuals. Conventional wheelchairs generally require manual operation or joystick-based control, which creates difficulties for users suffering from paralysis, spinal cord injuries, neuromuscular disorders, or severe upper-limb disabilities. Many users are unable to operate traditional wheelchairs independently due to limited hand movement and reduced motor control, increasing dependency on caregivers for daily mobility.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 9.867 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 15, Issue 6, June 2026 ||

| DOI:10.15662/IJAREEIE.2026.1506006 |

To overcome these limitations, modern smart wheelchair systems are being developed using embedded systems, IoT communication, motion sensing, and intelligent automation technologies. Head movement-based wheelchair control systems provide a natural and hands-free method of operation, improving accessibility and user independence. By using gyroscope and accelerometer sensors, wheelchair movement can be controlled through simple head gestures without requiring physical effort or joystick interaction. [1]

This presents a Smart Wheelchair Operated by Head Motion using an ESP32 microcontroller, MPU6050 gyroscope and accelerometer sensor, ultrasonic obstacle detection sensors, GPS monitoring, and IoT communication technologies. The system continuously detects head movement and automatically controls wheelchair direction. Backward head movement moves the wheelchair forward, while left and right head tilts control directional turning. Ultrasonic sensors improve safety through obstacle detection and collision avoidance mechanisms. radius.

II. LITERATURE REVIEW

The development of smart wheelchair systems has progressed significantly in recent years due to advancements in embedded systems, IoT technology, motion sensing, and intelligent healthcare devices. Researchers have focused on developing wheelchair systems that improve mobility independence, user safety, and accessibility for physically disabled individuals suffering from paralysis, spinal cord injuries, neuromuscular disorders, and severe upper-limb disabilities [1].

Early wheelchair systems mainly depended on manual operation or joystick-based control mechanisms. Although these systems improved mobility support, they were difficult to operate for users with limited hand movement or weak muscle control. These limitations motivated researchers to develop gesture-based and hands-free wheelchair control systems using embedded sensors and intelligent controllers [2].

Later, researchers introduced motion-controlled wheelchair systems using accelerometers, gyroscopes, Arduino, ESP32, and ARM-based microcontrollers. These systems demonstrated that head movement and gesture recognition could be used for wheelchair navigation and direction control at low cost. However, many early systems suffered from inaccurate gesture detection, delayed response, false triggering, and poor movement stability under continuous operation [3].

III. RESEARCH METHODOLOGY

The methodology of the proposed Smart Wheelchair Operated by Head Motion is developed based on embedded motion sensing, intelligent wheelchair control, obstacle detection, emergency monitoring, and IoT communication technologies. The complete system is implemented as a real-time prototype using an ESP32 controller, MPU6050 gyroscope and accelerometer sensor, ultrasonic obstacle detection sensors, GPS module, BTS7960 motor driver modules, and dual DC geared motors.

The proposed system continuously detects the user’s head movement using an MPU6050 sensor mounted on a wearable helmet or head cap. The sensor measures head orientation, tilt angle, acceleration, and gyroscope motion data in real time and transmits the data to the ESP32 microcontroller for processing. The developed methodology combines motion sensing, embedded processing, intelligent motor control, wireless communication, and safety monitoring into a single integrated healthcare mobility platform.

The prototype demonstrates improved wheelchair accessibility, reduced caregiver dependency, enhanced user safety, and reliable hands-free operation suitable for hospitals, rehabilitation centers, elderly care systems, and smart healthcare applications

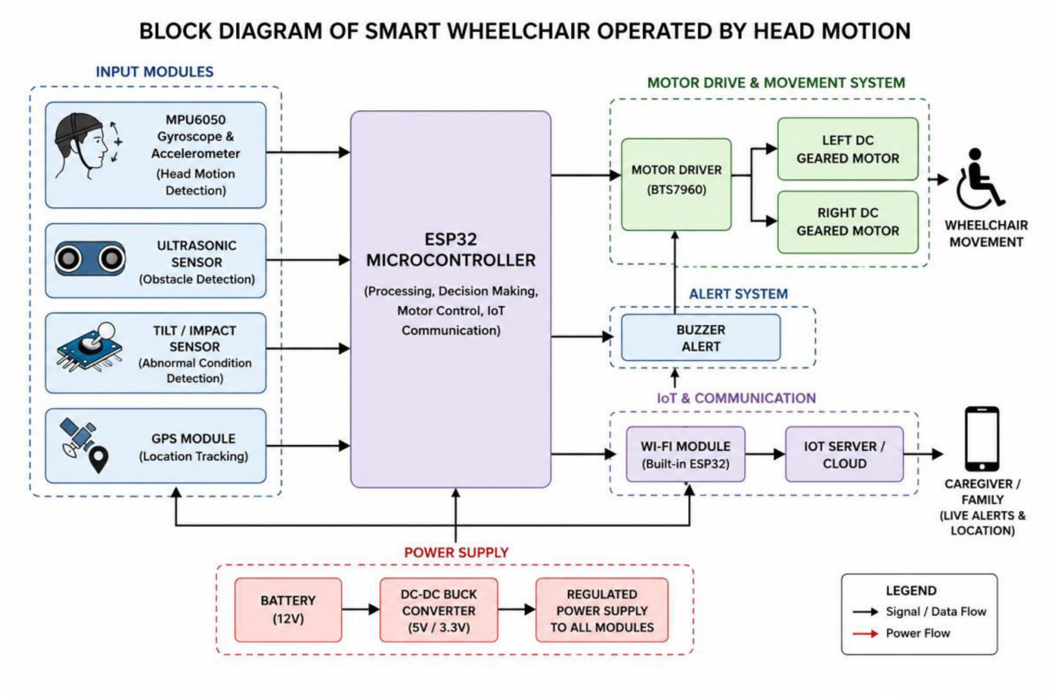
.

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 9.867 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 15, Issue 6, June 2026 ||

| DOI:10.15662/IJAREEIE.2026.1506006 |



(Figure 1. Block Block Diagram of Proposed Smart Wheelchair)

3.1. HARDWARE IMPLEMENTATION

3.1.1. ESP32-Based Sensing and Control Unit

- ESP32 serves as the main controller of the smart wheelchair system.
- Provides dual-core processing, Wi-Fi, Bluetooth, and low power consumption.
- Receives motion data from the MPU6050 sensor.
- Processes head movements and controls wheelchair navigation in real time.

3.1.2. Sensor Network and Communication

- MPU6050 sensor detects head tilt, acceleration, and orientation.
- Sensor data are transferred to ESP32 via I2C communication.
- Ultrasonic sensors provide obstacle detection and collision avoidance.
- GPS module enables real-time location tracking and emergency monitoring.
- Wi-Fi and Bluetooth support wireless communication with dashboard and mobile devices.

3.1.3. Processing and Motor Control Unit

- ESP32 performs motion processing, decision-making, and safety monitoring.
- Executes movement commands: Forward, Left, Right, and Stop.
- Controls BTS7960 motor drivers connected to DC geared motors.
- Ensures smooth and stable wheelchair movement.
- Continuously monitors sensor data for safe operation.

3.1.4. Safety and Emergency Monitoring

- Detects obstacles within predefined safety limits.
- Activates buzzer alerts during unsafe conditions.
- Restricts wheelchair movement to prevent collisions.
- Sends emergency alerts and GPS coordinates to caregivers.
- Enhances user safety through continuous monitoring.

3.1.5. IoT Communication and Monitoring

- ESP32 transmits system data to the IoT platform.
- Supports remote monitoring and tracking.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 9.867 | A Monthly Peer Reviewed & Refereed Journal |
|| Volume 15, Issue 6, June 2026 ||
| DOI:10.15662/IJAREEIE.2026.1506006 |

- Provides real-time updates to caregivers and healthcare personnel.
- Enables integration with mobile and web-based monitoring systems.

3.2. SOFTWARE IMPLEMENTATION
3.2.1. Sensor Data Acquisition and Firmware Processing
- ESP32 acquires real-time data from MPU6050, ultrasonic sensors, and GPS module.
- Head tilt, acceleration, orientation, obstacle distance, and location data are continuously monitored.
- Supports stable multi-sensor operation without data loss.

3.2.1. Intelligent Motion Control and Safety Monitoring
- ESP32 processes head movements to control wheelchair motion.
- Recognizes Forward, Left, Right, and Stop commands.
- Detects obstacles and unsafe conditions.
- Activates safety mechanisms to prevent accidents.

3.2.2. IoT Backend and Database Communication
- Wheelchair data are transmitted to a remote server.
- Stores movement status, GPS coordinates, alerts, and logs.
- Uses PHP APIs and MySQL database for monitoring.

3.2.3. LCD Display and Alert Interface
- LCD displays system status and warning messages.
- Buzzer provides audible alerts during unsafe conditions.
- Enhances user awareness and safety.

3.2.4 Real-Time Monitoring Dashboard
- Displays live wheelchair status and GPS tracking.
- Shows obstacle alerts and emergency notifications.
- Enables remote monitoring by caregivers and healthcare staff.

failures in the sensing of primary users are assumed to cause the collisions among the transmissions of primary users and CR-Networks nodes.

IV. EXPERIMENTAL SETUP

The experimental evaluation of the proposed Smart Wheelchair Operated by Head Motion system was carried out using a real-time prototype setup to study its performance under practical operating conditions. The proposed system was implemented and experimentally validated using a prototype smart wheelchair platform designed for practical indoor mobility operation. The setup consisted of an ESP32 microcontroller, MPU6050 gyroscope and accelerometer sensor, ultrasonic obstacle detection sensors, GPS tracking module, BTS7960 motor driver modules, dual DC geared motors, LCD display, buzzer alert system, rechargeable battery supply, and IoT monitoring dashboard. The MPU6050 sensor was mounted on a wearable helmet or head cap to continuously detect head movement and orientation during wheelchair operation.

The wheelchair prototype was tested under multiple real-time movement conditions including forward movement, left turning, right turning, obstacle avoidance, emergency alert activation, and continuous movement monitoring. Obstacle conditions were intentionally created using nearby objects and barriers to evaluate the collision avoidance capability of the system. Additionally, wheelchair tipping and abnormal movement conditions were simulated to test emergency alert generation and GPS tracking functionality.

All experiments were performed using physical hardware components instead of software-only simulations, ensuring realistic sensor behavior, motor response, and embedded processing performance. This hardware-based validation improves the practical reliability and real-world applicability of the proposed system for hospitals, rehabilitation centers, elderly care systems, and smart healthcare environments.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 9.867 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 15, Issue 6, June 2026 ||

| DOI:10.15662/IJAREEIE.2026.1506006 |

Figure 4 Back View & Side View Smart Wheelchair Prototype

V. RESULT

The experimental evaluation of the Smart Wheelchair Operated by Head Motion system shows that it performs reliably in real-time conditions, with stable motion control, effective obstacle detection, and consistent emergency monitoring. The system achieved an average response time of about 0.43 seconds and maintained high detection accuracy above 95% for head movement, obstacle detection, and GPS tracking. The IoT dashboard provided near real-time updates with low latency and stable performance during continuous operation. Although minor limitations were observed due to sensor calibration, sudden head movements, environmental noise, and network dependency, the overall results confirm that the system is efficient, responsive, and suitable for assistive mobility applications.

Fig. 5 Simulation time SMART WHEELCHAIR OPERATED BY HEAD MOTION FOR DISABLED INDIVIDUALS

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 9.867 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 15, Issue 6, June 2026 ||

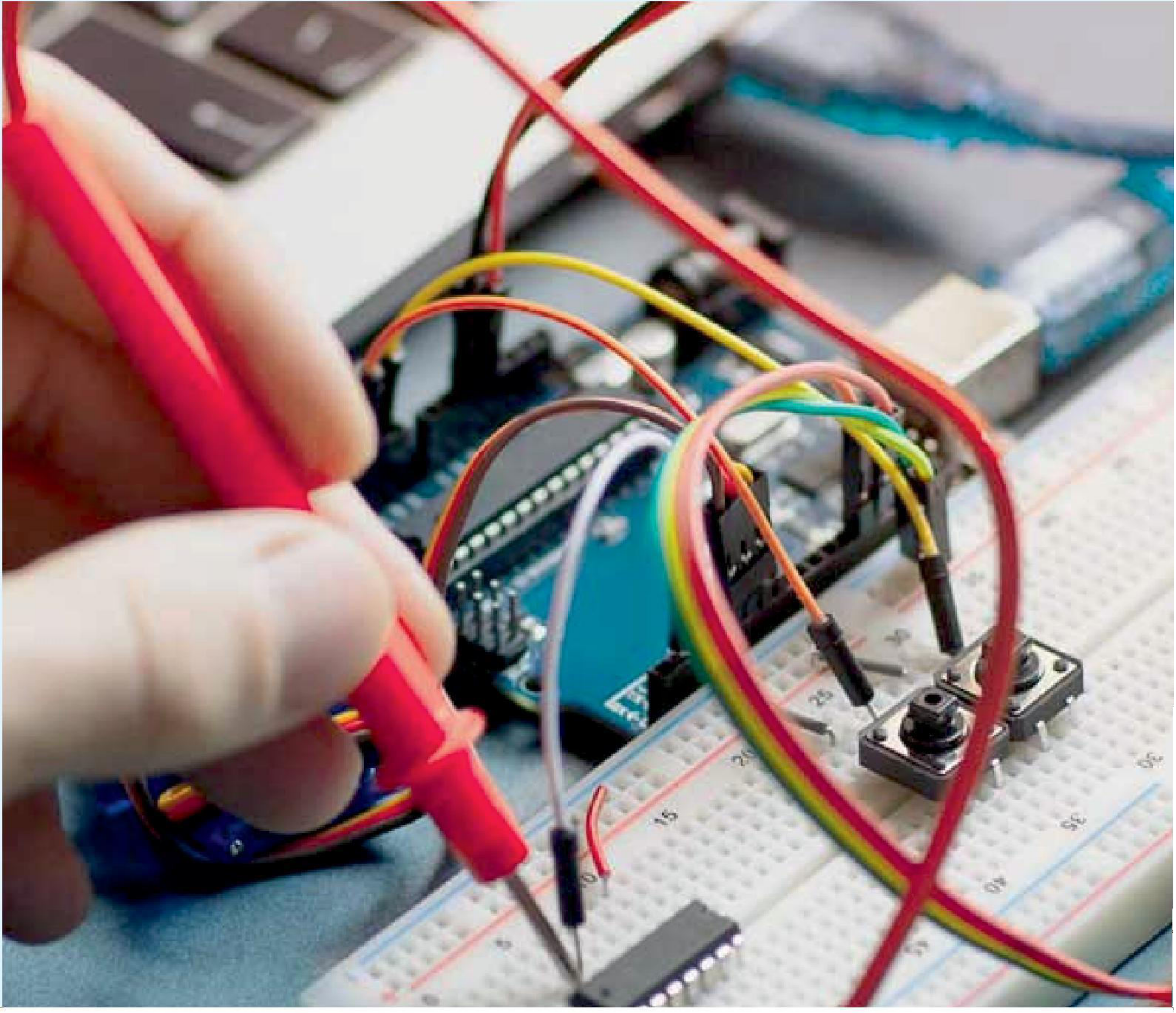
| DOI:10.15662/IJAREEIE.2026.1506006 |

VI. CONCLUSION

In this paper, a Smart Wheelchair Operated by Head Motion using ESP32, MPU6050, ultrasonic sensors, GPS tracking, and IoT-based monitoring has been presented. The system integrates hardware components, embedded firmware, motion-processing algorithms, motor control, emergency alert mechanisms, and a real-time dashboard to enable hands-free wheelchair operation, obstacle avoidance, and continuous safety monitoring for physically disabled users. Experimental results show effective real-time performance with reliable system integration, achieving 95–97% head movement detection accuracy, ~96% obstacle detection accuracy, and an average response time of approximately 0.43 seconds. Although minor variations may occur due to sudden head movements or network instability, the results confirm the system’s practical reliability. Overall, the proposed solution demonstrates a low-cost and scalable approach for intelligent assistive mobility, suitable for healthcare environments, rehabilitation centers, and smart healthcare applications..

REFERENCES

[1] M. Haque, S. Rahman, and M. Hossain, “Head Movement Controlled Smart Wheelchair for Disabled People,” International Journal of Advanced Embedded Systems, vol. 12, no. 3, pp. 45–52, 2021.
[2] A. González-Cely, J. Camacho, and L. Vargas, “IMU-Based Intelligent Wheelchair Navigation Using Head Gesture Recognition,” IEEE Access, vol. 10, pp. 78541–78553, 2022.
[3] P. Sharma and R. Verma, “ESP32-Based Smart Wheelchair with Gesture Control and Obstacle Detection,” International Journal of Engineering Research and Technology (IJERT), vol. 13, no. 5, pp. 210–218, 2024.
[4] A. Haddad, Y. Lahrech, and N. Ait Oufroukh, “Ultrasonic Sensor-Based Collision Avoidance System for Smart Wheelchairs,” International Journal of Smart Healthcare Systems, vol. 9, no. 2, pp. 95–104, 2023.
[5] R. Patel, S. Rao, and P. Deshmukh, “IoT-Based Emergency Monitoring and GPS Tracking System for Smart Wheelchairs,” Journal of Embedded Healthcare Technologies, vol. 7, no. 1, pp. 33–41, 2022.
[6] D. Syahputra, M. Lubis, and A. Prasetyo, “Integrated IoT Smart Wheelchair with Bluetooth Communication and Fall Detection,” International Journal of Intelligent Assistive Systems, vol. 11, no. 4, pp. 121–130, 2024.
[7] A. Joshi and V. Mishra, “Real-Time Wheelchair Motion Control Using MPU6050 and Embedded Processing,” International Journal of Electronics and Communication Engineering, vol. 15, no. 6, pp. 56–64, 2023.
[8] H. Zhang, Y. Xu, and T. Zhao, “Modular Head Posture-Controlled Wheelchair System for Assistive Healthcare Applications,” IEEE Sensors Journal, vol. 24, no. 2, pp. 1440–1450, 2024.
[9] Espressif Systems, “ESP32 Series Datasheet,” 2024.
[10] InvenSense, “MPU6050 Gyroscope and Accelerometer Sensor Datasheet,” 2023.
[11] HC-SR04 Ultrasonic Sensor Technical Documentation, 2023.
[12] BTS7960 High Current Motor Driver Module Datasheet, 2023.
[13] NEO-6M GPS Module Technical Manual, 2024.
[14] Arduino Documentation, “ESP32 Programming and Embedded System Development,” 2024.
[15] S. Kumar and R. Singh, “Assistive Mobility Technologies for Differently-Abled Individuals,” Journal of Smart Healthcare Engineering, vol. 8, no. 3, pp. 88–97, 2023.



International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering