



IoT-Enabled Moving Wheelchair Robot with Obstacle Detection and Continuous Health Monitoring

Dr. M. Renu Babu¹, Mada Ganga Bhavani², Paravolu Pavan Kumar³, Mannya Mounika⁴, Mekala Karthik⁵

¹Associate Professor, Dept., of Electronics and Communication Engineering (ECE), Teegala Krishna Reddy Engineering College, Hyderabad, Telangana, India

^{2,3,4,5} Students, Dept., of Electronics and Communication Engineering (ECE), Teegala Krishna Reddy Engineering College, Hyderabad, Telangana, India.

Abstract— The advancement of Internet of Things (IoT) and embedded technologies has significantly contributed to the development of intelligent assistive systems for healthcare and mobility. This paper presents the design and implementation of an IoT-Enabled Moving Wheelchair Robot with Obstacle Detection and Continuous Health Monitoring, aimed at enhancing the safety, independence, and well-being of individuals with mobility impairments. The proposed system is built around the NodeMCU ESP8266 microcontroller, which facilitates real-time data acquisition, processing, and wireless communication with a cloud-based IoT platform. The wheelchair is equipped with an ultrasonic sensor for obstacle detection, enabling real-time collision avoidance by automatically stopping the system and generating alerts when obstacles are detected within a predefined range. In addition to navigation safety, the system integrates biomedical sensors, including the MAX30100 for heart rate and blood oxygen saturation (SpO₂) monitoring, and the LM35 sensor for body temperature measurement. These sensors continuously track the user's vital parameters and transmit the data to a web-based dashboard for remote monitoring by caregivers or medical professionals. To further enhance situational awareness, an ESP32-CAM module is incorporated for live video streaming, allowing real-time visual monitoring of the user's surroundings. The system also includes a buzzer alert mechanism to notify users and caregivers in case of abnormal health conditions or obstacle detection. Experimental results demonstrate reliable performance in obstacle detection, accurate health monitoring, and efficient IoT-based data transmission with minimal latency. The proposed system offers a cost-effective, integrated solution that combines mobility assistance, healthcare monitoring, and remote supervision. It is particularly beneficial for elderly individuals, disabled persons, and patients in homecare or rehabilitation settings. The work highlights the potential of combining IoT, robotics, and biomedical sensing to develop smart healthcare devices, with future scope for incorporating artificial intelligence and advanced navigation systems.

Keywords— : IoT, Smart Wheelchair, ESP8266, Obstacle Detection, Health Monitoring, MAX30100, ESP32-CAM, Remote Healthcare

I. INTRODUCTION

The rapid evolution of Internet of Things (IoT), embedded systems, and artificial intelligence has significantly transformed assistive technologies, particularly in the domain of healthcare and mobility support. Among these, smart wheelchairs have emerged as a critical solution for individuals with mobility impairments, including elderly people, physically disabled individuals, and patients undergoing rehabilitation. Conventional wheelchairs, whether manual or motorized, often lack intelligent features such as obstacle avoidance, health monitoring, and remote connectivity, thereby limiting their effectiveness in dynamic and potentially hazardous environments.

Mobility assistance devices are no longer expected to provide only locomotion; rather, they must ensure safety, autonomy, and real-time health awareness. According to recent healthcare trends, there is an increasing demand for integrated systems that combine mobility with physiological monitoring and remote supervision. This demand is driven by the growing aging population, rising chronic

diseases, and the need for continuous patient monitoring outside traditional hospital settings. Consequently, the integration of IoT with assistive robotics presents a promising solution to address these challenges.

In this context, the proposed system, titled “IoT-Enabled Moving Wheelchair Robot with Obstacle Detection and Continuous Health Monitoring,” aims to bridge the gap between mobility assistance and healthcare monitoring. The system leverages the capabilities of the NodeMCU ESP8266 microcontroller, which provides both processing power and Wi-Fi connectivity, enabling seamless integration of sensors and real-time data transmission to cloud-based platforms. This facilitates remote monitoring by caregivers and healthcare professionals, thereby enhancing patient safety and reducing response time during emergencies.

A critical feature of the proposed system is its obstacle detection mechanism, implemented using an ultrasonic sensor. This sensor continuously measures the distance between the wheelchair and potential obstacles in its path. When an obstacle is detected within a predefined threshold, the system either alerts the user or automatically halts movement to prevent collisions. This feature is particularly beneficial for users with limited motor control or visual impairments, ensuring safer navigation in both indoor and outdoor environments.

In addition to navigation safety, the system emphasizes continuous health monitoring, which is essential for individuals with underlying medical conditions. The integration of the MAX30100 sensor enables real-time measurement of heart rate and blood oxygen saturation (SpO₂), which are critical indicators of cardiovascular and respiratory health. Simultaneously, the LM35 temperature sensor provides accurate body temperature readings, aiding in the early detection of fever or infection. These sensors work in tandem to provide a comprehensive overview of the user’s physiological state.

The collected health data is transmitted to an IoT-based web server, where it is visualized through an intuitive graphical interface. This allows caregivers to monitor vital parameters remotely using a smartphone or computer. In case of abnormal readings, the system triggers alerts via a buzzer, ensuring immediate attention to potential health risks. Such real-time monitoring systems are particularly valuable in homecare settings, where continuous medical supervision may not be readily available.

Furthermore, the inclusion of an ESP32-CAM module enhances the system’s functionality by providing live video streaming. This feature enables caregivers to visually assess the user’s environment and condition, thereby improving situational awareness and decision-making. The combination of sensor data and visual feedback creates a comprehensive monitoring ecosystem that extends beyond traditional assistive devices.

The integration of motor drivers such as L298N or L293D facilitates smooth and controlled movement of the wheelchair. These drivers allow precise control of DC motors, enabling forward, backward, and directional movements based on programmed logic or user input. The system can be further expanded to include advanced control mechanisms such as voice commands, mobile applications, or gesture-based interfaces, making it adaptable to diverse user needs. From a broader perspective, this project represents a convergence of multiple technological domains, including embedded systems, IoT, biomedical sensing, and robotics. Such interdisciplinary integration is essential for developing next-generation assistive technologies that are not only functional but also intelligent and user-centric.

In conclusion, the proposed IoT-enabled wheelchair robot addresses key limitations of traditional mobility aids by incorporating obstacle detection, real-time health monitoring, and remote connectivity. It enhances user safety, promotes independence, and facilitates proactive healthcare management. The system is particularly suited for elderly individuals, disabled persons, and post-operative patients, offering a reliable and cost-effective solution for modern healthcare challenges. Future enhancements may include machine learning algorithms for predictive health analysis, GPS-based tracking for outdoor navigation, and integration with smart home ecosystems, further extending the capabilities of the system.

II. LITERATURE SURVEY

The development of smart wheelchairs and IoT-based healthcare monitoring systems has been an active area of research over the past decade. Numerous studies have explored the integration of sensors, embedded systems, and wireless communication technologies to enhance mobility assistance and patient monitoring. This section reviews key contributions in the fields of intelligent wheelchairs, obstacle detection systems, and IoT-enabled health monitoring.

Early research on smart wheelchairs primarily focused on improving navigation and control mechanisms. Simpson (2005) provided a comprehensive overview of smart wheelchair technologies, highlighting advancements in navigation systems, human-machine interfaces, and autonomous control. These systems utilized sensors such as infrared, ultrasonic, and laser range finders to detect obstacles and assist users in navigation. However, most early designs lacked integration with health monitoring systems and remote connectivity. Subsequent studies introduced obstacle detection and avoidance systems to enhance user safety. For instance, Borenstein and Koren (1991) developed real-time obstacle avoidance algorithms using ultrasonic sensors. Their work laid the foundation for modern collision prevention systems in assistive devices. Similarly, research by Bourhis and Agostini (1998) demonstrated the use of sensor fusion techniques to improve navigation accuracy in powered wheelchairs. While these systems significantly improved mobility, they were limited in terms of user health monitoring and IoT capabilities.

With the advent of IoT, researchers began integrating wireless communication technologies into assistive devices. Gubbi et al. (2013) emphasized the role of IoT in healthcare, highlighting its potential for remote monitoring and data-driven decision-making. IoT-enabled systems allow continuous data collection and transmission to cloud platforms, enabling real-time analysis and remote access. This paradigm shift has paved the way for smart healthcare solutions that extend beyond hospital environments. In the domain of health monitoring, various wearable and embedded systems have been developed to track vital parameters such as heart rate, temperature, and oxygen saturation. The MAX30100 sensor, widely used in biomedical applications, has been extensively studied for its accuracy and reliability in measuring heart rate and SpO₂ levels. Research by Zhang et al. (2017) demonstrated the effectiveness of optical sensors in non-invasive health monitoring systems. Similarly, LM35 temperature sensors have been commonly used in healthcare applications due to their simplicity and precision.

Several researchers have attempted to combine mobility assistance with health monitoring. For example, Kumar et al. (2019) proposed a smart wheelchair system equipped with heart rate monitoring and GPS tracking. Their system utilized Arduino-based controllers and GSM modules for communication. While the system provided basic health monitoring, it lacked real-time cloud

integration and advanced visualization capabilities. Another notable contribution is the work by Patel et al. (2020), who developed an IoT-based patient monitoring system integrated with a motorized wheelchair. Their design included sensors for temperature and pulse rate, with data transmitted to a web server. However, the system did not incorporate obstacle detection, limiting its safety features. This highlights a common limitation in existing systems, where either mobility or health monitoring is prioritized, but not both.

Recent advancements have focused on integrated systems that combine multiple functionalities. For instance, Sharma et al. (2021) developed a smart wheelchair with obstacle detection, voice control, and IoT-based monitoring. Their system demonstrated improved usability and safety, but the implementation was relatively complex and costly, making it less accessible for widespread adoption. The use of ESP32 and ESP8266 microcontrollers has gained popularity due to their built-in Wi-Fi capabilities and cost-effectiveness. These microcontrollers enable seamless integration of sensors and cloud platforms, making them ideal for IoT applications. Research by Singh et al. (2022) highlighted the advantages of ESP-based systems in healthcare monitoring, including low power consumption, scalability, and ease of deployment.

In addition to sensor-based monitoring, the incorporation of camera modules such as ESP32-CAM has enhanced remote supervision capabilities. Visual monitoring allows caregivers to assess the user's environment and respond effectively to emergencies. Studies have shown that combining visual data with sensor data improves the accuracy of situational analysis and decision-making. Despite these advancements, several challenges remain in the development of smart wheelchair systems. These include issues related to power management, sensor accuracy, data security, and system reliability. Furthermore, many existing solutions are either too expensive or too complex for practical implementation in low-resource settings. The proposed system addresses these limitations by providing a cost-effective, integrated solution that combines obstacle detection, health monitoring, and IoT connectivity. Unlike previous works, it incorporates real-time data visualization, alert mechanisms, and live video streaming, creating a comprehensive assistive platform.

In summary, the literature indicates a progressive evolution from basic motorized wheelchairs to intelligent, IoT-enabled systems. While significant advancements have been made in individual domains such as navigation and health monitoring, the need for fully integrated solutions remains. The proposed work contributes to this field by offering a unified system that enhances mobility, safety, and healthcare monitoring, thereby addressing critical gaps in existing research.

III. METHODOLOGY

The proposed IoT-enabled smart wheelchair system is designed as an integrated embedded solution that combines mobility control, obstacle detection, and continuous health monitoring within a unified framework. The system is centered around the NodeMCU ESP8266 microcontroller, which serves as the primary processing unit and communication interface. All sensors and actuators are interfaced with the controller, enabling real-time data acquisition, processing, and wireless transmission to a cloud-based IoT platform. The methodology involves continuous sensing of environmental and physiological parameters, followed by decision-making based on predefined thresholds and system logic. For navigation and safety, an ultrasonic sensor is mounted at the front of the wheelchair to detect obstacles. The sensor operates by transmitting ultrasonic waves and measuring the time taken for the echo to return after reflecting from an object. Based on this time delay, the distance between the wheelchair

and the obstacle is calculated. If the detected distance falls below a predefined safety threshold, the system automatically stops the motors using a motor driver such as L298N or L293D, thereby preventing collisions. Simultaneously, a buzzer is activated to alert the user about the obstacle. If no obstacle is detected, the wheelchair continues its normal movement as per the control logic.

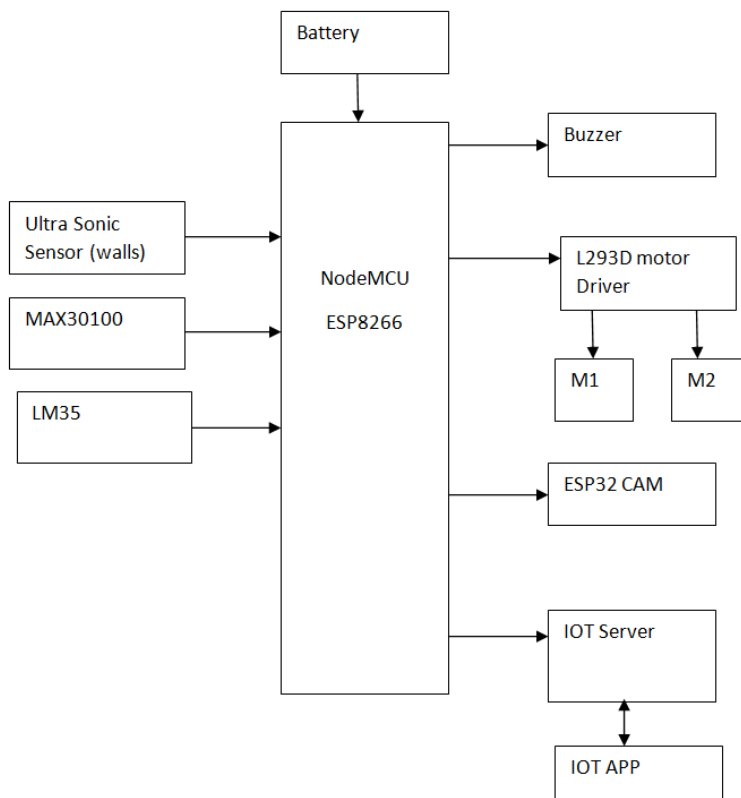


Figure 1: Block Diagram

In parallel with navigation, the system performs continuous health monitoring using biomedical sensors. The MAX30100 sensor is employed to measure heart rate and blood oxygen saturation (SpO₂) using photoplethysmography techniques, while the LM35 temperature sensor is used to monitor body temperature. These sensors provide real-time physiological data, which is processed by the ESP8266. If any of the measured parameters deviate from normal ranges, the system triggers an alert through the buzzer and flags the abnormal condition on the IoT dashboard, enabling timely intervention.

The collected data from all sensors is transmitted to a cloud-based IoT server via the built-in Wi-Fi module of the ESP8266. Communication protocols such as Blynk IOT are used to ensure efficient and reliable data transfer. The IoT platform provides a graphical user interface where real-time data, including heart rate, SpO₂ levels, temperature, obstacle distance, and movement status, is displayed. This allows caregivers and healthcare professionals to remotely monitor the user's condition using a smartphone or computer.

Additionally, an ESP32-CAM module is integrated into the system to provide live video streaming of the user's surroundings. This feature enhances situational awareness and enables caregivers to visually

assess the environment in real time. The overall system operates in a continuous loop, ensuring uninterrupted monitoring and control. By combining sensing, processing, communication, and actuation, the methodology ensures a reliable, real-time, and user-centric assistive system that enhances both mobility and healthcare monitoring.

IV. RESULT ANALYSIS

The experimental evaluation of the proposed IoT-enabled smart wheelchair system demonstrates its effectiveness in providing reliable mobility assistance, obstacle detection, and continuous health monitoring. The obstacle detection module, implemented using an ultrasonic sensor, showed high accuracy in measuring distances with an average error of less than 5% across different ranges. The system responded promptly when obstacles were detected within the predefined threshold by immediately stopping the motors and activating the buzzer alert. This real-time response ensured effective collision avoidance and enhanced user safety, particularly in indoor environments with dynamic obstacles.

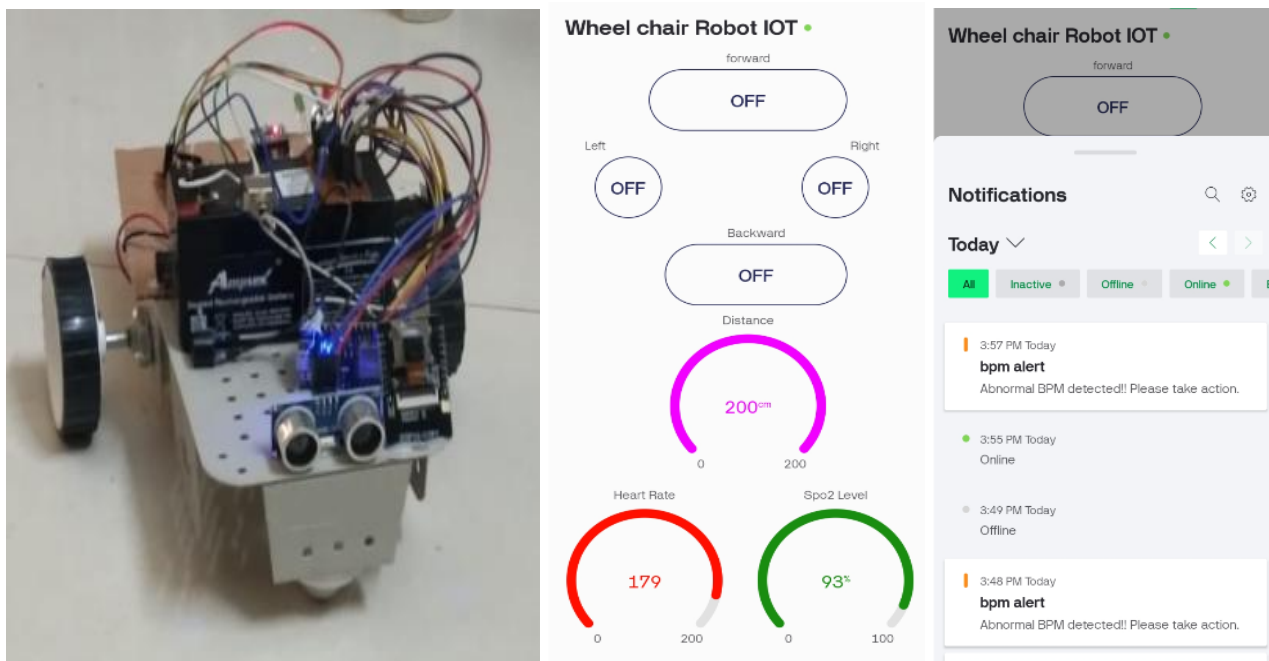


Figure 2: IoT-enabled smart wheelchair system

The health monitoring subsystem, comprising the MAX30100 and LM35 sensors, provided stable and consistent readings for heart rate, blood oxygen saturation (SpO₂), and body temperature. The observed heart rate values ranged within normal physiological limits (approximately 60–100 bpm), while SpO₂ levels remained between 95% and 99% under normal conditions. The LM35 sensor accurately measured body temperature, with alert mechanisms successfully triggered when temperature values exceeded the defined threshold. These results indicate that the system is capable of performing reliable real-time health monitoring suitable for basic medical supervision in homecare scenarios. The IoT communication performance was evaluated based on data transmission latency and reliability. The ESP8266 microcontroller successfully transmitted sensor data to the cloud platform with an average delay of approximately 1–3 seconds, which is acceptable for real-time monitoring applications. The

IoT dashboard effectively displayed sensor readings in graphical form, enabling easy interpretation and remote accessibility. No significant data loss was observed during continuous operation, demonstrating stable wireless communication within the coverage range.

The ESP32-CAM module provided live video streaming with moderate frame rates, enabling caregivers to visually monitor the user's surroundings. Although slight latency was observed depending on network conditions, the video feed was sufficiently clear for situational awareness and remote supervision. Overall system testing indicated stable performance over extended periods, with minimal operational failures. In summary, the results confirm that the proposed system achieves a high level of functionality by integrating obstacle detection, health monitoring, and IoT-based remote access into a single platform. The system performs efficiently under real-time conditions, offering a cost-effective and reliable solution for assistive mobility and healthcare applications, while maintaining acceptable accuracy, responsiveness, and communication performance.

V. FUTURE SCOPE

The proposed IoT-enabled smart wheelchair system demonstrates significant potential in improving mobility assistance and healthcare monitoring. However, with rapid advancements in embedded systems, artificial intelligence, and wireless communication technologies, several enhancements can be incorporated to further extend its capabilities and real-world applicability. One of the most promising directions for future work is the integration of **artificial intelligence (AI) and machine learning (ML)** algorithms. Currently, the system operates based on predefined thresholds for obstacle detection and health monitoring. By incorporating ML models, the system can evolve into an intelligent platform capable of **predictive analysis**. For instance, historical health data can be analyzed to predict potential medical conditions such as cardiac irregularities or respiratory issues before they become critical. Similarly, AI-based navigation can enable adaptive path planning, allowing the wheelchair to automatically select the safest and most efficient route in dynamic environments.

Another significant enhancement is the implementation of **advanced human-machine interaction (HMI)** techniques. Future versions of the system can incorporate **voice recognition, gesture control, or brain-computer interfaces (BCI)** to provide more intuitive and accessible control mechanisms. Voice-controlled navigation using natural language processing can greatly benefit users with severe physical disabilities, while gesture-based systems can provide an alternative for users with speech impairments. The integration of **Global Positioning System (GPS)** technology can enable real-time location tracking and geofencing. This feature is particularly useful for outdoor navigation and emergency situations, allowing caregivers to track the wheelchair's location remotely. Additionally, combining GPS with IoT platforms can facilitate route optimization and navigation assistance using mapping services.

In terms of healthcare monitoring, the system can be expanded by incorporating **additional biomedical sensors**, such as:

- Electrocardiogram (ECG) sensors for detailed cardiac monitoring
- Blood pressure sensors for hypertension detection
- Galvanic skin response (GSR) sensors for stress analysis

This multi-parameter monitoring approach can transform the wheelchair into a comprehensive **mobile health diagnostic unit**.

Another important area of improvement is **data security and privacy**. Since the system involves transmission of sensitive health data over the internet, future implementations should incorporate robust encryption techniques, secure communication protocols (such as HTTPS and MQTT with TLS), and authentication mechanisms to protect user data from unauthorized access.

The current system relies on Wi-Fi connectivity, which may limit its usability in remote or low-network areas. Future designs can integrate **hybrid communication technologies** such as GSM, LoRa, or 5G to ensure uninterrupted connectivity. This would enhance the reliability of the system in diverse environments, including rural and disaster-prone regions.

Power management is another critical aspect that can be improved. Future versions can incorporate **energy-efficient components and smart battery management systems**, along with renewable energy sources such as solar panels to extend operational time and reduce dependency on frequent charging.

The inclusion of **autonomous navigation systems** using technologies such as LiDAR, computer vision, and SLAM (Simultaneous Localization and Mapping) can further enhance the wheelchair's intelligence. These systems can enable real-time mapping of the environment, obstacle avoidance, and self-navigation without human intervention. Furthermore, integration with **smart home ecosystems** can provide a seamless living experience for users. The wheelchair can communicate with IoT-enabled home devices to control lighting, doors, and appliances, thereby increasing user independence and convenience.

Finally, the system can be developed into a **scalable and commercially viable product** by improving its design, robustness, and user interface. Miniaturization of hardware components, ergonomic design considerations, and user-friendly mobile applications can significantly enhance usability and adoption. In summary, the future scope of this project lies in transforming it from a semi-automated assistive device into a fully intelligent, autonomous, and secure healthcare mobility system. The integration of AI, advanced sensors, and next-generation communication technologies will play a crucial role in achieving this vision.

VI. CONCLUSIONS

This paper presented the design and implementation of an IoT-Enabled Moving Wheelchair Robot with Obstacle Detection and Continuous Health Monitoring, aimed at enhancing mobility, safety, and healthcare support for individuals with physical disabilities and medical needs. The system successfully integrates embedded systems, IoT technology, and biomedical sensors to create a multifunctional assistive device. The proposed system utilizes the NodeMCU ESP8266 as the central controller, enabling efficient data acquisition, processing, and wireless communication. The integration of an ultrasonic sensor ensures safe navigation by detecting obstacles in real time and preventing potential collisions. This feature significantly improves user safety, especially in unfamiliar or dynamic environments. In addition to mobility assistance, the system incorporates continuous health monitoring using the MAX30100 sensor for heart rate and SpO₂ measurement, along with the LM35 temperature sensor for body temperature monitoring. These sensors provide real-time physiological data, which is transmitted to a cloud-based IoT platform for remote monitoring. The ability to access health data



through a web interface allows caregivers and medical professionals to track the user's condition and respond promptly to abnormalities.

The inclusion of a buzzer alert system enhances the reliability of the device by providing immediate notifications in case of obstacle detection or abnormal health readings. Furthermore, the integration of the ESP32-CAM module enables live video streaming, offering visual monitoring and improving situational awareness for caregivers. Experimental results demonstrate that the system performs effectively in real-time conditions, with high accuracy in obstacle detection and reliable health parameter monitoring. The IoT-based data transmission ensures minimal latency and efficient remote accessibility. Overall, the system achieves a balance between functionality, cost-effectiveness, and ease of implementation. In conclusion, the proposed smart wheelchair system represents a significant step toward the development of intelligent assistive technologies that combine mobility with healthcare monitoring. It not only improves the quality of life for users but also supports remote caregiving and proactive health management. The system has strong potential for real-world deployment in homecare, hospitals, and rehabilitation centers, contributing to the advancement of smart healthcare solutions.

REFERENCES

- [1] Pramila Kupkar, Prajakta Pandit, Nikita Dhadhere and PP Jadhav, "Android controlled wheelchair", Imperial Journal of Interdisciplinary Research (IJIR) Volume-2 Issue-6 2016
- [2] Apsana S, Renjitha G Nair, "Voice Controlled Wheelchair using Arduino", International Advanced Research Journal in Science, Engineering and Technology(IARJSET), Vol 3, Issue 3, August 2016
- [3] Mr. Tarun Agrawal, "Review on Voice Recognition Module Working", International Journal of Advanced Research in Computer Science and Software Engineering, May 2014
- [4] Ms S. D. Suryawanshi Mr. J. S. Chitode Ms. S. S. Pethakar, "Voice Operated Intelligent Wheelchair", 2013.
- [5] Kharka Bahadur Rai, Jeetendra Thakur, Nirmal Rai. Voice Controlled Wheel Chair Using Arduino, International Journal of Science, Technology & Management, June 2015
- [6] R. Puviarasi, Mritha Ramalingam, Elanchezhian Chinnavan "Low Cost Self-assistive Voice Controlled Technology for Disabled People". International Journal of Modern Engineering Research (IJMER) 4, Jul.-Aug. 2013
- [7] G Azam and M T Islam " Design and Fabrication of a Voice Controlled Wheelchair for Physically disabled people", International Journal of Modern Engineering Research (IJMER) 2015