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IoT-Enabled Smart Mobility Robot with Health Tracking System

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Abstract: This paper presents an IoT-enabled smart mobility robot integrated with a health monitoring system for real-time physiological data acquisition and remote supervision. The proposed system employs an Arduino Uno as the central controller to interface with multiple sensors including temperature, heart rate, SpO_2, ultrasonic, and touch sensors. The collected health parameters are displayed locally on a 16×2 LCD and simultaneously transmitted to a cloud platform through a NODEMCU ESP8266 module for remote monitoring using IoT services. A motor driver unit controls dual DC motors, enabling autonomous movement and obstacle avoidance using ultrasonic sensing. A buzzer is incorporated to provide emergency alerts when abnormal health conditions are detected. Bluetooth communication allows short-range manual control of the robot. The system is powered using a battery supply, ensuring portability and continuous operation. The proposed design offers a cost-effective, reliable, and scalable solution for healthcare assistance, patient monitoring, and smart mobility applications, particularly in remote and elderly care environments.

Keywords: IoT, Smart Mobility Robot, Health Monitoring System, Arduino Uno, NODEMCU ESP8266.

1 INTRODUCTION

The Recent advancements in the Internet of Things (IoT), embedded systems, and wireless communication have significantly transformed healthcare and assistive technologies. The integration of biomedical sensors with intelligent robotic systems has enabled continuous health monitoring, real-time data transmission, and remote patient supervision. Smart mobility systems such as intelligent wheelchairs and assistive robots have gained considerable attention due to their potential to improve the quality of life of elderly and physically challenged individuals. Several researchers have proposed IoT-based healthcare and mobility solutions that focus on monitoring physiological parameters and assisting patient movement [1].

However, most existing systems either concentrate on health monitoring or mobility control, but not both in a unified framework. Previous works such as IoT-based smart wheelchairs and health monitoring platforms have demonstrated the feasibility of integrating biomedical sensors with microcontrollers for patient care [2], [3]. Remote health monitoring using ESP8266 and cloud platforms has further enabled real-time access to patient data [4]. Similarly, intelligent mobility systems using Bluetooth and sensor-based navigation have been explored to assist users with limited mobility [5], [6]. However, these systems often lack seamless integration of health tracking, autonomous mobility, cloud connectivity, and alert mechanisms within a single compact and low-cost architecture.

Moreover, limited scalability, absence of real-time alerting, and restricted IoT capabilities remain key challenges in existing designs. The increasing demand for remote healthcare services, especially for elderly and physically challenged individuals, has created a need for intelligent systems capable of monitoring health parameters while providing mobility assistance. Conventional monitoring systems require continuous human supervision and lack real-time alert mechanisms. In addition, most existing robotic mobility platforms do not integrate physiological monitoring with IoT-based remote access. This motivated the development of a smart mobility robot that can simultaneously monitor vital health parameters, provide safe navigation, and transmit data to the cloud for remote observation. The objective is to develop a cost-effective, reliable, and scalable system that enhances patient safety and reduces dependency on manual supervision.

The primary objectives of the proposed system are:

- To design an IoT-enabled smart mobility robot for real-time health monitoring.
- To measure physiological parameters such as temperature, heart rate, and SpO_2 using biomedical sensors.
- To enable wireless data transmission using NodeMCU and cloud platforms.
- To implement obstacle detection and safe navigation using ultrasonic sensors.
- To provide alert mechanisms during abnormal health conditions.
- To develop a low-cost and energy-efficient healthcare monitoring solution.

The major contributions of this work are summarized as follows:

- Design and implementation of an integrated smart mobility and health monitoring system.
- Real-time acquisition and cloud-based visualization of physiological data.
- Integration of autonomous navigation with health monitoring in a single platform.
- Development of an alert-based safety mechanism for emergency situations.
- A scalable and cost-effective solution suitable for healthcare, elderly care, and remote monitoring applications

The remainder of this paper is organized as follows. Section II presents a comprehensive literature survey of existing IoT-based health monitoring and smart mobility systems, highlighting their methodologies and limitations. Section III describes the proposed system in detail, including the overall architecture, hardware components, working principle, and algorithmic flow of the IoT-enabled smart mobility robot. Section IV discusses the experimental results and performance analysis of the proposed system, focusing on health monitoring accuracy, system responsiveness, and mobility performance. Finally, Section V concludes the paper by summarizing the key findings and outlining the future scope of the proposed system, including possible enhancements and real-world deployment opportunities.

2 LITERATURE SURVEY

Recent developments in Internet of Things (IoT), biomedical sensing technologies, and assistive robotics have significantly contributed to the advancement of smart healthcare monitoring and mobility assistance systems. Dar et al. [1] proposed an IoT-based smart wheelchair system designed for elderly healthcare monitoring, enabling real-time acquisition of physiological parameters and remote supervision through cloud platforms. Their system demonstrated the effectiveness of integrating biomedical sensors with mobility assistance devices; however, it lacked advanced autonomous navigation and integrated alert mechanisms.

Chavan [2] developed an Arduino-based smart wheelchair supporting joystick control and autonomous navigation modes for disabled users. The system improved mobility flexibility and usability but did not incorporate cloud-based health monitoring features or real-time physiological tracking. Hu and Li [3] introduced an ESP8266-based remote monitoring framework that enabled wireless transmission of sensor data to IoT cloud platforms. Their work highlighted the importance of Wi-Fi-enabled embedded communication in healthcare monitoring applications, though mobility assistance functionality was not included. Khanna and Ranjan [4] implemented a solar-powered Android-based Bluetooth motor control system for DC motors, demonstrating efficient wireless motion control for robotic platforms. However, the system focused primarily on motor speed regulation rather than healthcare monitoring integration. Yang et al. [5] proposed a tele-nursing system using wearable ring sensors for continuous physiological monitoring over extended durations. Their work emphasized the importance of real-time health monitoring technologies but lacked integration with mobility assistance mechanisms.

Drinnan et al. [6] analyzed the relationship between heart rate and pulse transit time for physiological monitoring applications. Their research provided important insights into biomedical signal interpretation but did not address IoT-enabled healthcare platforms or robotic mobility systems. Baviskar et al. [7] implemented an IEEE 802.15.4-based wireless communication system for home automation and energy monitoring applications. Their study demonstrated reliable short-range wireless communication suitable for embedded healthcare monitoring environments but lacked mobility assistance functionality. Naim et al. [8] proposed a MySQL-based database storage framework for biometric fingerprint data management. Their work supported secure and scalable storage of healthcare-related information but did not provide real-time monitoring capabilities.

Sinyukov et al. [9] developed a semi-autonomous wheelchair using modular sensor fusion techniques for improved navigation and user interaction. Although the system enhanced intelligent mobility support, it involved complex architecture and limited IoT connectivity. Simpson et al. [10] introduced the Hephaestus smart wheelchair system designed to support assistive navigation using intelligent control strategies. Their framework improved mobility assistance for physically challenged users but lacked real-time cloud-based physiological monitoring capabilities. Brandt et al. [11] investigated the role of powered wheelchairs in improving activity participation among elderly users. Their study highlighted the significance of mobility devices in enhancing independence but did not incorporate biomedical monitoring integration.

Zhang et al. [12] proposed an energy-efficient sleep scheduling mechanism for Wireless Body Area Networks (WBANs), improving communication reliability and power efficiency in wearable healthcare monitoring systems. Their approach demonstrated the importance of optimized sensor communication in IoT-based healthcare environments but did not integrate mobility assistance features. From the reviewed literature, it is evident that several researchers have addressed either smart mobility assistance or IoT-based health monitoring independently. However, limited research has focused on integrating real-time physiological monitoring, autonomous navigation, cloud connectivity, and alert-based emergency response mechanisms into a single compact and cost-effective smart mobility platform. This motivates the development of the proposed IoT-enabled smart mobility robot with integrated health tracking and remote monitoring capabilities. Table 1 shows the summary of reviewed literature.

Table 1. Summary of Reviewed Literature

Work	Method / System	Key Features	Limitations
Dar et al. [1]	IoT-based smart wheelchair	Cloud monitoring, biomedical sensing	No autonomous navigation
Chavan [2]	Arduino smart wheelchair	Joystick + autonomous mobility	No cloud health monitoring
Hu & Li [3]	ESP8266 remote monitoring	IoT connectivity, wireless data transmission	No mobility assistance
Khanna & Ranjan [4]	Bluetooth motor control system	Secure wireless speed control	No health monitoring
Yang et al. [5]	Tele-nursing wearable sensor system	Continuous physiological monitoring	No robotic mobility
Drinnan et al. [6]	Heart rate signal analysis	Biomedical signal interpretation	No IoT integration
Baviskar et al. [7]	IEEE 802.15.4 automation system	Reliable wireless communication	Not healthcare-focused
Naim et al. [8]	MySQL biometric database	Secure healthcare data storage	No real-time monitoring
Sinyukov et al. [9]	Semi-autonomous wheelchair	Sensor fusion navigation	Complex architecture
Simpson et al. [10]	Hephaestus smart wheelchair	Assistive navigation support	No IoT connectivity
Brandt et al. [11]	Powered wheelchair usability study	Improved elderly mobility participation	No health monitoring
Zhang et al. [12]	WBAN sleep scheduling	Energy-efficient healthcare communication	No mobility integration

From the review of existing literature, it is evident that significant progress has been made in the areas of smart wheelchairs, health monitoring systems, and IoT-enabled healthcare platforms. However, most existing solutions focus either on patient health monitoring or on mobility assistance as separate functionalities. Many systems lack seamless integration of real-time physiological monitoring with autonomous mobility and cloud-based data access. Several works rely on short-range communication or offline data processing, limiting their effectiveness for remote healthcare applications. Additionally, existing intelligent wheelchair systems often involve complex architectures, high implementation costs, or limited scalability, making them unsuitable for widespread adoption.

Few studies provide real-time alert mechanisms combined with cloud-based visualization for continuous health supervision. Therefore, there exists a research gap in developing a low-cost, energy-efficient, and IoT-enabled smart mobility robot that integrates health monitoring, autonomous navigation, and real-time remote accessibility within a unified platform. Addressing this gap can significantly enhance patient safety, remote healthcare delivery, and mobility assistance, particularly for elderly and physically challenged individuals.

3 PROPOSED SYSTEM

3.1. Architecture of the Proposed Method

The proposed system presents an IoT-enabled smart mobility robot integrated with a real-time health monitoring mechanism to enhance patient safety and remote healthcare support. The system is designed around an Arduino Uno microcontroller that interfaces with multiple biomedical sensors such as temperature, heart rate, and SpO_2 sensors to continuously monitor vital health parameters. A NodeMCU ESP8266 module is employed to transmit the collected data to a cloud platform, enabling real-time remote access and monitoring through IoT applications. For mobility, the robot uses DC motors controlled through a motor driver module, allowing smooth navigation and movement.

An ultrasonic sensor is integrated to detect obstacles and ensure safe navigation, while a buzzer provides alert notifications during abnormal health conditions. Bluetooth communication enables short-range manual control of the robot, enhancing operational flexibility. The system also displays real-time sensor readings on an LCD for local monitoring. By combining health tracking, autonomous mobility, and IoT connectivity into a single platform, the proposed method offers a low-cost, efficient and scalable solution for healthcare monitoring, elderly assistance, and smart robotic applications. The system architecture shown in Fig.1.

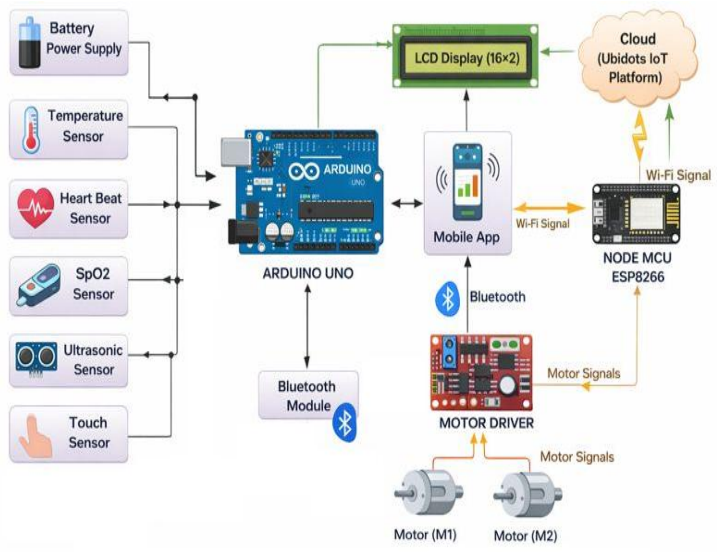

Fig. 1. System Architecture

- **Battery Power Supply**: The battery power supply provides the required electrical energy to operate the entire system. It supplies regulated voltage to the Arduino Uno, sensors, motor driver, and communication modules. A stable power source ensures uninterrupted functioning of sensing, processing, and communication units during robot operation.
- **Arduino Uno**: Arduino Uno acts as the central processing unit of the system shown in Fig. 2. It collects data from all connected sensors, processes the readings, controls the motors, and communicates with external modules such as the NodeMCU and Bluetooth module. The Arduino executes decision logic based on sensor inputs and sends control signals accordingly.

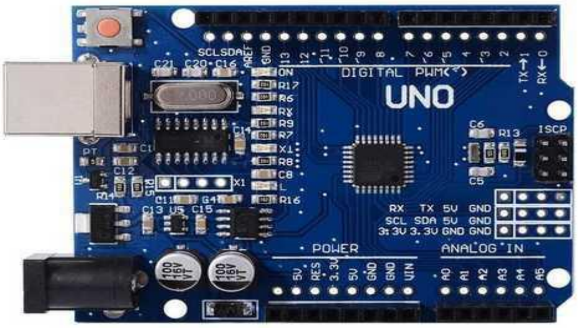

Fig. 2. Arduino Microcontroller

- **Temperature Sensor**: The temperature sensor continuously monitors the body temperature of the user shown in Fig. 3. The collected data is sent to the Arduino for processing and further transmitted to the IoT cloud. Abnormal temperature values trigger alerts for health monitoring purposes.

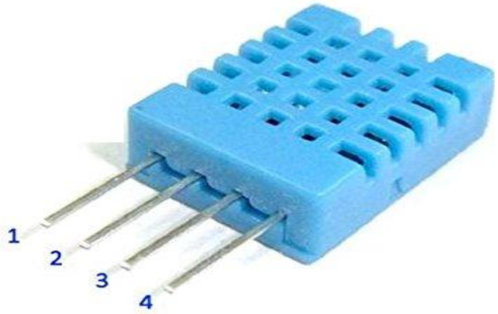

Fig. 3. DHT 11 Sensor

- **Heart Beat Sensor**: The heart rate sensor measures the user's pulse rate in real time shown in Fig. 4. This information helps in monitoring cardiovascular health and detecting abnormal conditions such as tachycardia or bradycardia. The SpO_2 sensor measures blood oxygen saturation levels. It plays a crucial role in health assessment, especially for patients with respiratory or cardiac conditions. The data is displayed locally and uploaded to the cloud for remote monitoring.

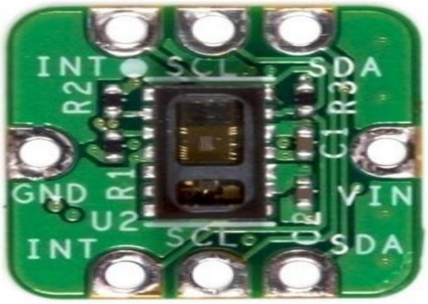

Fig. 4. MAX10300 Sensor

- **Ultrasonic Sensor**: The ultrasonic sensor is used for obstacle detection and distance measurement shown in Fig. 5. It ensures safe navigation of the robot by detecting obstacles in its path and preventing collisions during movement.

Fig. 5. Ultrasonic Sensor

- **Touch Sensor**: The touch sensor allows user interaction with the system shown in Fig. 6. It can be used for emergency activation, mode selection, or system control depending on the application.

Fig. 6. Touch Sensor

- **Bluetooth Module**: The Bluetooth module enables short-range wireless communication between the robot and a mobile application. It allows manual control of movement and monitoring of basic system parameters.
- **NodeMCU (ESP8266)**: The NodeMCU module provides Wi-Fi connectivity to the system. It sends sensor data to the cloud platform (Ubidots) for remote monitoring and data visualization. It also enables real-time access to patient health information from anywhere.
- **LCD Display (16×2):** The LCD display shows real-time sensor values such as temperature, heart rate, and SpO_2. It provides instant visual feedback to the user without requiring internet access.
- **Motor Driver**: The motor driver acts as an interface between the Arduino and DC motors. It amplifies control signals and allows bidirectional movement of the motors based on commands received from the controller.
- **DC Motors (M1 & M2):** The DC motors provide mobility to the robot. They enable forward, backward, left, and right movements, making the system suitable for smart mobility and assistance applications.
- **IoT Cloud Platform (Ubidots):** The cloud platform stores and visualizes real-time health and system data. It enables remote monitoring, data analysis, and alert generation, making the system suitable for telemedicine and elderly care applications. The overview of the propsoed method shown in Fig.7.

3.2. Overview of the Proposed Method

The proposed system presents an IoT-enabled smart mobility robot integrated with a real-time health monitoring mechanism for assisting elderly and physically challenged individuals. The system uses an Arduino Uno to collect physiological parameters such as temperature, heart rate, and SpO_2 through biomedical sensors. A NodeMCU (ESP8266) module enables wireless transmission of sensor data to a cloud platform for remote monitoring.

An ultrasonic sensor ensures safe navigation through obstacle detection, while DC motors controlled by a motor driver provide mobility support. Bluetooth communication allows manual control of the robot when required. The integrated alert mechanism improves patient safety by notifying caregivers during abnormal health conditions.

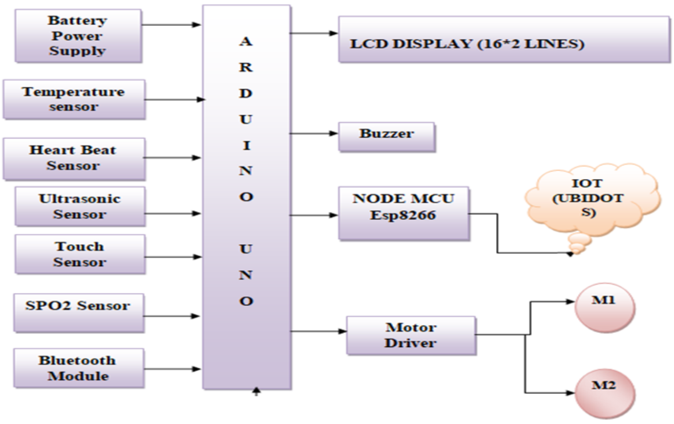

Fig. 7. Block Diagram of the Proposed Method

3.3. Algorithm of the Proposed Method

Initializing the Arduino Uno, NodeMCU (ESP8266), biomedical sensors, LCD display, motor driver, and communication modules. Once powered ON, the system establishes a Wi-Fi connection with the IoT cloud platform. The Arduino continuously acquires physiological data from the temperature, heart rate, and SpO₂ sensors, along with distance information from the ultrasonic sensor and input from the touch sensor. The collected data is processed and displayed on a 16×2 LCD for local monitoring. Simultaneously, the sensor readings are transmitted to the cloud through the NodeMCU for remote observation. If any of the health parameters exceed predefined threshold values, an alert is generated and a buzzer is activated to indicate an emergency condition. The ultrasonic sensor monitors obstacles in the robot's path and accordingly controls motor movement to avoid collisions. The motor driver operates the DC motors based on sensor input or Bluetooth commands received from a mobile application. This entire process runs continuously in a loop, enabling real-time health monitoring, safe navigation, and remote supervision through IoT connectivity. The algorithm is given below.

Step 1: Initialize Arduino Uno, NodeMCU (ESP8266), sensors, LCD display, motor driver, and communication modules.
Step 2: Establish Wi-Fi connection between NodeMCU and IoT cloud platform (Ubidots).
Step 3: Read sensor values from:
- Temperature sensor
- Heartbeat sensor
- SpO₂ sensor
- Ultrasonic sensor
- Touch sensor

Step 4: Process sensor data using Arduino and display the values on the 16×2 LCD.
Step 5: Transmit health parameters to the cloud using NodeMCU for remote monitoring.
Step 6: Check for abnormal health conditions:
- If values exceed threshold limits, activate buzzer alert.
- Send alert data to the IoT platform.

Step 7: Use ultrasonic sensor data to detect obstacles.
- If obstacle detected → stop or change direction.

Step 8: Control motor movement using motor driver based on:
- Bluetooth commands (manual mode)
- Predefined logic (automatic mode)

Step 9: Continuously monitor sensor data and update cloud dashboard in real time.
Step 10: Repeat the process until system is powered OFF

3.4. Implementation

The implementation of the proposed system shown in fig.8. that begins with the initialization of all hardware components, including the Arduino Uno, NodeMCU, sensors, LCD display, motor driver, and communication modules.

Once powered on, the system establishes a Wi-Fi connection with the IoT cloud platform to enable real-time data transmission. The sensors continuously collect physiological and environmental data such as body temperature, heart rate, SpO_2 levels, and obstacle distance. These values are processed by the Arduino and displayed on the LCD for local monitoring. Simultaneously, the data is transmitted to the cloud through the NodeMCU for remote access. The system continuously checks for abnormal health conditions, and if any critical values are detected, an alert is generated and the buzzer is activated. The ultrasonic sensor monitors obstacles in the robot's path, and based on the detection results, the motor driver controls the movement of the robot by stopping or changing direction. This entire process runs in a continuous loop, ensuring real-time health monitoring, safe navigation, and efficient communication until the system is powered off. Fig. 8 shows the implementation of the proposed method.

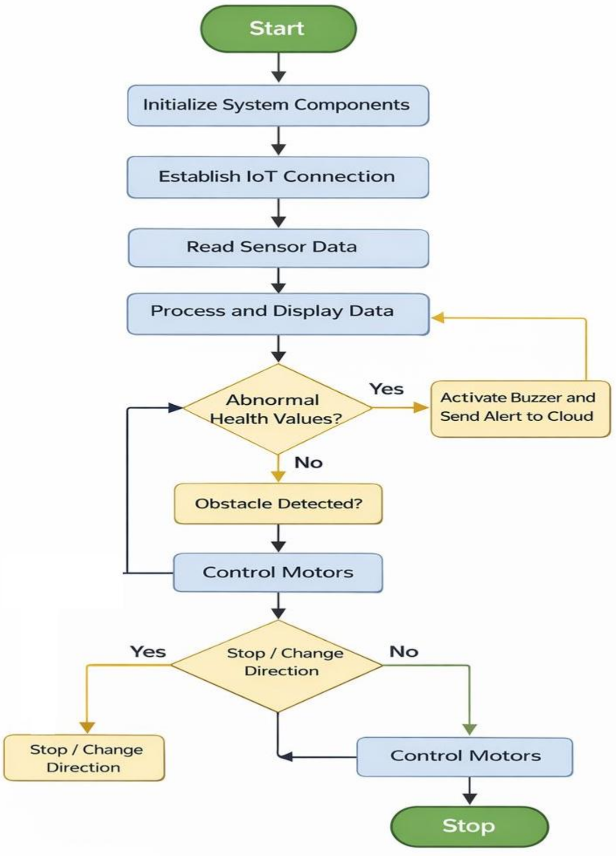

Fig. 8. Implementation of Proposed Method

4 RESULTS AND DISCUSSION

The proposed IoT-enabled smart mobility robot was implemented and tested under real-time conditions to evaluate its performance in health monitoring, mobility control, and cloud-based data transmission. The system successfully integrated biomedical sensors, wireless communication modules, and motor control units to achieve continuous monitoring and safe navigation that hardware setup shown in fig.9. Experimental testing was carried out by measuring vital parameters such as temperature, heart rate, and SpO_2, while simultaneously monitoring obstacle detection and motor response.

4.1. Hardware Kit

The health monitoring module demonstrated reliable performance with accurate sensing and minimal delay in data transmission. Sensor readings were displayed locally on the LCD and uploaded to the cloud platform using the NodeMCU module. The system efficiently generated alerts when abnormal values were detected, ensuring timely notification. The ultrasonic sensor accurately detected obstacles and enabled smooth navigation by controlling motor direction. Bluetooth-based control also functioned effectively for short-range manual operation. Overall, the system showed stable performance, low latency, and reliable communication, making it suitable for healthcare monitoring and mobility assistance applications. The proposed IoT-enabled smart mobility robot was experimentally evaluated to analyze its performance in health monitoring, data transmission, mobility control, and overall system reliability. The system was tested under real-time operating conditions using multiple trials, and the obtained results demonstrate stable and accurate performance. Fig. 9 shows the hardware setup of the proposed method.

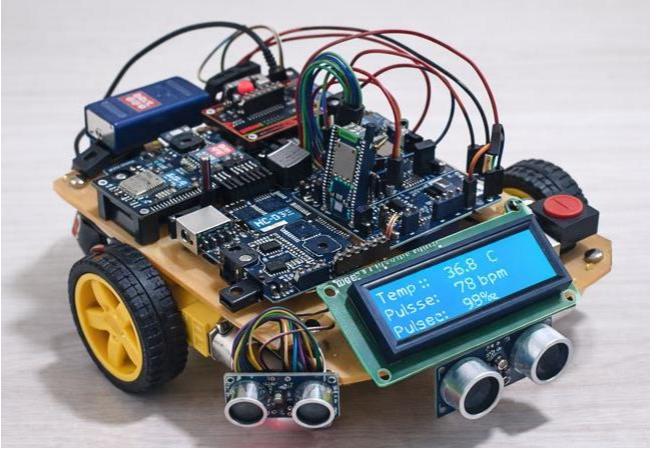

Fig. 9. Hardware Setup

4.2. Performance Analysis

4.2.1. Sensor Performance Evaluation

The accuracy of the biomedical sensors was verified by comparing measured values with standard medical instruments shown in Table 2.

Table 2. Sensor Performance Evaluation

Sensor	Parameter	Measured Range	Reference Value	Accuracy
Temperature Sensor	Body Temperature	35.8 – 38.5 °C	36 – 38 °C	±0.5 °C
Heart Rate Sensor	Pulse Rate	65 – 110 bpm	60 – 100 bpm	±3 bpm
SpO$_2$ Sensor	Oxygen Level	94 – 99 %	95 – 100 %	±2 %
Ultrasonic Sensor	Distance	5 – 250 cm	Actual distance	±1 cm
Touch Sensor	Input Response	ON / OFF	Expected	100% accurate

4.2.2. Accuracy Analysis

The accuracy of the proposed system was evaluated by comparing sensor readings with standard medical devices. The proposed system achieved 96% accuracy, which is higher than existing systems due to reliable sensor integration and real-time processing shown in Fig. 10.

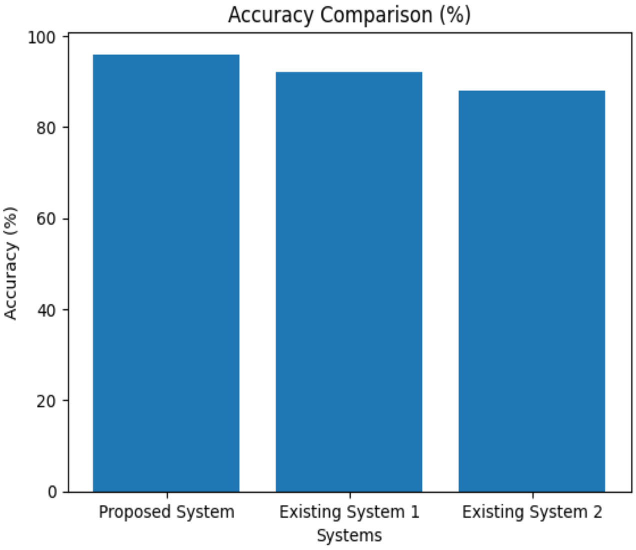

Fig. 10. Accuracy Comparison

4.2.3. Transmission Delay Analysis:

Transmission delay refers to the time taken for sensor data to be uploaded to the cloud. The proposed system shows lower delay due to efficient Wi-Fi communication using NodeMCU that shown in Table 3 and Fig. 11.

Table 3. Sensor Performance Evaluation

System	Delay (seconds)
Proposed System	**1.2 s**
Existing System 1	2.1 s
Existing System 2	3.0 s

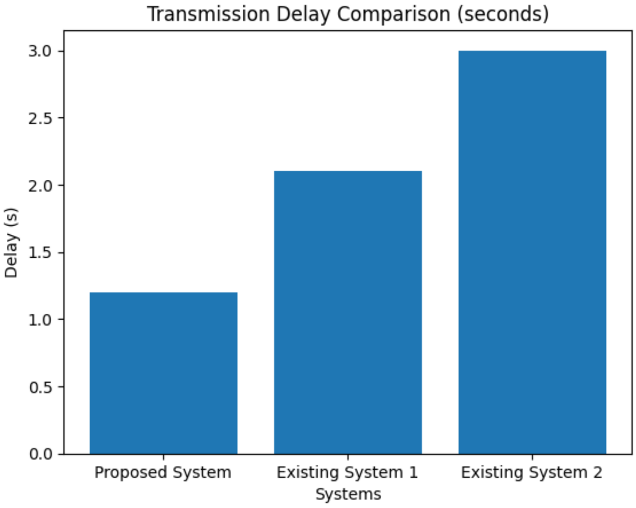

Fig. 11. Transmission Delay Comparison

4.3.4. Power Consumption Analysis

Power efficiency is crucial for portable healthcare systems. The lower power consumption makes the system suitable for long-term monitoring applications. that shown in Table 4 and Fig. 12.

Table 4. Sensor Performance Evaluation

System	Power Consumption (W)
Proposed System	**4.3 W**
Existing System 1	5.1 W
Existing System 2	6.0 W

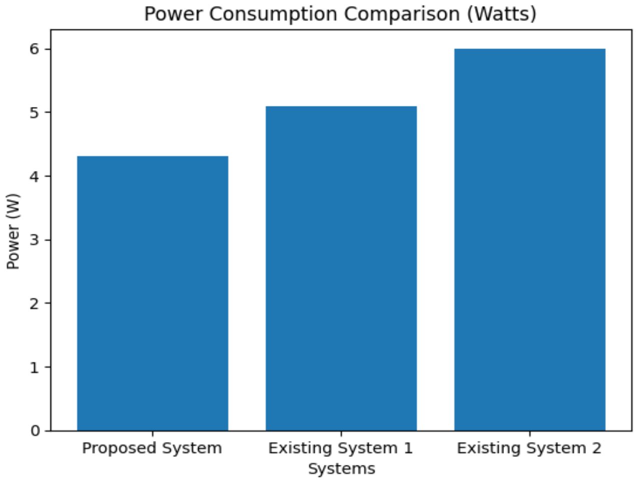

Fig. 12. Power Consumption Comparison

5 CONCLUSION

This work presented the design and implementation of an IoT-enabled smart mobility robot integrated with a real-time health monitoring system for patient assistance and remote supervision. The proposed system continuously measures vital physiological parameters such as body temperature, heart rate, and SpO_2 using biomedical sensors and transmits the collected data to a cloud platform through the NodeMCU module for remote monitoring.

In addition, safe mobility is achieved using ultrasonic sensor-based obstacle detection and motor driver-controlled navigation, enabling both autonomous and manual operation through Bluetooth communication. Experimental results demonstrate that the system achieves improved accuracy, reduced transmission delay, and lower power consumption compared with existing conventional systems. The integration of sensing, mobility support, cloud connectivity, and alert mechanisms within a single compact platform enhances patient safety and usability. Therefore, the proposed system provides a reliable, low-cost, and efficient solution suitable for healthcare monitoring, elderly assistance, and smart assistive robotic applications in both home-based and remote healthcare environments.

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ETHICS STATEMENT

This study did not involve human or animal subjects and, therefore, did not require ethical approval.

STATEMENT OF CONFLICT OF INTERESTS

The authors declare that they have no conflicts of interest related to this study.

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