

Voice + Manual Controlled IoT Robotic Vehicle

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Abstract: *Robotic vehicles are increasingly used in industries, security systems, and hazardous environments where human presence can be risky. Traditional robotic systems often operate either manually or automatically, which limits their flexibility and efficiency. This project presents a Voice + Manual Controlled IoT Robotic Vehicle that uses the ESP32 microcontroller as the main controller and the L298N Motor Driver Module to control DC motors. The system allows the robotic vehicle to be controlled through a mobile application using voice commands and manual buttons via Bluetooth or Wi-Fi communication. Additionally, an ultrasonic sensor is used to detect obstacles in real time and automatically change the direction of the robot to avoid collisions. The ESP32 processes sensor data and user commands and controls the movement of the vehicle accordingly. This system improves flexibility, reduces human effort, enhances safety in dangerous environments, and demonstrates an efficient and cost-effective IoT-based robotic control solution suitable for automation, surveillance, and educational applications.*

Keywords: *Robotic*

I. INTRODUCTION

Robotics technology has rapidly developed in recent years and is widely used in industries, security systems, military operations, and research applications. Robotic vehicles are especially useful in environments where human presence can be dangerous or difficult. These robots help perform tasks such as surveillance, exploration, and transportation while reducing human effort and risk. However, many traditional robotic vehicles operate either fully manually or fully automatically, which limits their flexibility and efficiency in different situations.

The Internet of Things (IoT) provides a smart solution by enabling wireless communication, remote control, and real-time data exchange between devices. In a Voice + Manual Controlled IoT Robotic Vehicle system, a microcontroller such as the ESP32 is used to control the robot and manage communication with a mobile application through Bluetooth or Wi-Fi. The system also uses an ultrasonic sensor to detect obstacles and prevent collisions, while the L298N Motor Driver Module controls the speed and direction of the DC motors. This integration allows the robot to operate in multiple modes such as manual control, voice command control, and automatic obstacle avoidance. As a result, the system provides flexible operation, improved safety, and efficient robotic control for applications in automation, surveillance, and educational projects.

II. METHODOLOGY

The system architecture is built around the ESP32 microcontroller, which acts as the central processing unit of the robotic vehicle. It receives commands from the mobile application, processes sensor data, and controls the movement of the robot through the motor driver. The main components of the system include:

Components:

- Ultrasonic Sensor:

Detects obstacles in front of the robot by measuring the distance between the robot and nearby objects. If an obstacle is detected within a specific range, the system automatically stops or changes the direction of the robot to avoid collision.



- Servo Motor:

The servo motor is used to rotate the ultrasonic sensor left and right. This helps the robot scan the surrounding area and detect obstacles from multiple directions.

- ESP32 Microcontroller:

The ESP32 acts as the brain of the system. It receives commands from the mobile application through Bluetooth or Wi-Fi and processes the data from the ultrasonic sensor. Based on the received commands or sensor readings, it sends signals to the motor driver to control the movement of the robot.

- L298N Motor Driver Module:

The motor driver controls the speed and direction of the DC motors. Since the ESP32 cannot directly supply enough current to run motors, the L298N module acts as an interface between the controller and the motors.

- DC Motors:

DC motors are responsible for moving the robotic vehicle. They allow the robot to move forward, backward, left, and right depending on the commands received from the ESP32.

- Mobile Application:

A mobile application is used to control the robot through voice commands or manual buttons. The application connects wirelessly to the ESP32 and sends movement commands such as forward, backward, left, right, and stop.

- Wireless Communication:

The system uses Bluetooth or Wi-Fi communication to transmit commands from the mobile application to the ESP32, enabling real-time control of the robotic vehicle.

- Control System:

The ESP32 processes both user commands and sensor data to decide the movement of the robot. The system supports multiple modes including manual control, voice command control, and obstacle avoidance for safe and flexible operation.

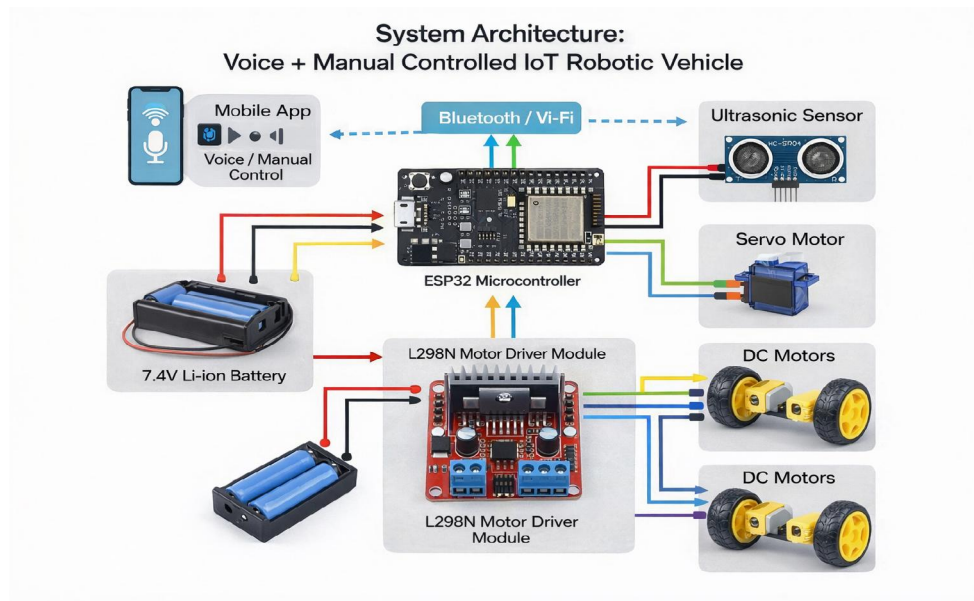


Fig.1 IOT based industrial waste water management system Architecture.

III. SYSTEM OVERVIEW

The Voice + Manual Controlled IoT Robotic Vehicle is designed to provide flexible and intelligent control of a robotic car using wireless communication and sensor-based automation. The system uses the ESP32 microcontroller as the



central controller to process commands from a mobile application and control the movement of the robot. The robotic vehicle can operate in different modes such as manual control, voice command control, and obstacle avoidance mode. An ultrasonic sensor is used to detect obstacles in front of the robot, while the L298N Motor Driver Module controls the speed and direction of the DC motors. This system enables real-time control, improves operational safety, and allows users to control the robot easily using a smartphone application.

1. Objective Definition

- To design a robotic vehicle that can be controlled through voice commands and manual inputs using a mobile application.
- To integrate wireless communication technology for real-time robot control.
- To implement obstacle detection and avoidance using sensors.
- To develop an IoT-based robotic system that is flexible, efficient, and easy to operate.

2. System Architecture

- Controller: The ESP32 microcontroller processes commands from the mobile application and controls the robot's movement.
- Sensors: Ultrasonic sensor detects obstacles in front of the robot.
- Motor Control: The L298N Motor Driver Module controls the speed and direction of the DC motors.
- Connectivity: Bluetooth or Wi-Fi communication connects the robot with the mobile application.
- Actuators: DC motors drive the movement of the robotic vehicle.

3. Data Acquisition and Analysis

- Real-Time Monitoring: The ultrasonic sensor continuously measures the distance between the robot and nearby objects.
- Command Processing: The ESP32 receives commands from the mobile application and processes them instantly.
- Decision Making: Based on sensor readings or user commands, the robot decides its movement direction.

4. Automated Control Systems

- In obstacle avoidance mode, the robot automatically stops or changes direction when an obstacle is detected.
- In voice control mode, the robot responds to voice commands sent from the mobile application.
- In manual control mode, the robot moves based on button inputs from the mobile application.

5. User Interface and Dashboards

- A mobile application is used as the user interface for controlling the robot.
- The application provides buttons for manual control and voice command features.
- The interface is designed to be simple and user-friendly so that the robot can be easily controlled from a smartphone.

6. Functionality

- Obstacle Detection: Detects objects using the ultrasonic sensor and avoids collisions.
- Voice Command Control: Allows the user to control the robot using voice commands.
- Manual Wireless Control: Enables the user to control the robot using buttons in the mobile application.
- Wireless Communication: Uses Bluetooth or Wi-Fi for communication between the mobile phone and the robot.

7. System Components

- ESP32 Microcontroller
- Ultrasonic Sensor
- L298N Motor Driver Module



- DC Motors
- Servo Motor
- Battery Power Supply
- Mobile Application

8. Challenges

- Maintaining stable Bluetooth or Wi-Fi communication.
- Ensuring accurate obstacle detection using the ultrasonic sensor.
- Managing power consumption for longer battery life.
- Ensuring smooth switching between different control modes.

System Features

- Real-Time Control: Immediate response to user commands from the mobile application.
- Obstacle Avoidance: Automatic detection and avoidance of obstacles.
- Voice and Manual Control: Dual control system using voice commands and manual buttons.
- Wireless Communication: Uses Bluetooth or Wi-Fi for remote control.
- Multi-Mode Operation: Supports automatic and manual control modes.

Implementation

1. Overview

The Voice + Manual Controlled IoT Robotic Vehicle is developed to demonstrate the integration of robotics, wireless communication, and sensor-based automation. The system allows users to control the robotic vehicle using voice commands and manual controls from a mobile application.

Installation and Preparation

1. Project Planning and Requirement Analysis

1.1 Define Objectives and Scope

- Understand the requirements for building the robotic vehicle.
- Define the working modes such as manual control, voice control, and obstacle avoidance.
- Plan the system design and hardware components.

1.2 Identify Key Performance Indicators (KPIs)

- Response time of the robot to user commands.
- Accuracy of obstacle detection.
- Stability of wireless communication.

1.3 Budget and Resource Planning

- Allocate budget for electronic components such as sensors, motors, controllers, and communication modules.
- Organize tools and equipment required for building the robotic vehicle.

2. System Design and Component Selection

2.1 Selection of Hardware Components

- Microcontroller: ESP32 for system control and communication.
- Motor Driver: L298N Motor Driver Module for controlling DC motors.
- Ultrasonic Sensor: For obstacle detection.
- DC Motors: For movement of the robotic vehicle.
- Servo Motor: For rotating the ultrasonic sensor.
- Battery: To supply power to the entire system.



3. Installation of Hardware Components

3.1 Install Sensors

- Mount the ultrasonic sensor at the front of the robot.
- Connect the sensor to the ESP32 pins.
- Ensure proper wiring and stable placement.

3.2 Install Motor Driver and Motors

- Connect the DC motors to the motor driver module.
- Connect the motor driver to the ESP32.
- Verify motor rotation direction and speed control.

3.3 Power Supply Setup

- Connect the battery to power the ESP32 and motor driver.
- Ensure proper voltage regulation and stable connections.

4. System Integration and Configuration

4.1 Programming the Controller

- Upload the control program to the ESP32 using Arduino IDE.
- Configure Bluetooth or Wi-Fi communication with the mobile application.

4.2 Mobile Application Setup

- Install a robot control mobile application.
- Connect the application with the ESP32 using Bluetooth or Wi-Fi.

5. Testing and Validation

5.1 Functional Testing

- Test movement commands such as forward, backward, left, and right.
- Verify obstacle detection functionality.

5.2 Debugging

- Identify issues related to motor control or communication.
- Correct errors in code or hardware connections.

6. Training and Documentation

- Prepare documentation for system operation and troubleshooting.
- Provide instructions for using the mobile application to control the robot.

7. Maintenance and Support

7.1 Regular Monitoring

- Check sensor alignment and motor connections.
- Ensure stable wireless communication.

7.2 System Improvement

- Update software to improve performance.
- Add additional sensors or IoT features for advanced functionality.

IV. RESULT

Mobile Application:

A dedicated mobile application was developed to control and monitor the robotic vehicle. The application allows users to send commands such as forward, backward, left, right, and stop using buttons or voice commands. The robot



successfully receives these commands through wireless communication and responds in real time, making the control system simple and user-friendly.

Obstacle Detection and Avoidance:

The robotic vehicle was able to detect obstacles using the ultrasonic sensor. When an object is detected within a certain distance, the system automatically stops or changes direction to avoid collision. This improves the safety and reliability of the robot during movement.

Motor Control System:

The ESP32 microcontroller effectively controls the movement of the robot by sending signals to the L298N Motor Driver Module. The motor driver successfully manages the speed and direction of the DC motors, allowing smooth movement of the robot in different directions.

Wireless Communication:

The system successfully establishes a wireless connection between the mobile application and the ESP32. Commands are transmitted quickly, enabling real-time control of the robotic vehicle without noticeable delay.

Improved Functionality:

The integration of sensors, microcontroller, and motor driver resulted in an efficient robotic system capable of manual control, voice control, and obstacle detection. This combination makes the robot suitable for applications such as surveillance, remote vehicle control, and educational robotics projects.

Future Improvements:

Additional sensors such as GPS modules, cameras, or advanced obstacle detection sensors can be integrated to enhance the functionality of the robotic vehicle. The system can also be improved by adding autonomous navigation features and improving the mobile application interface for better user experience.

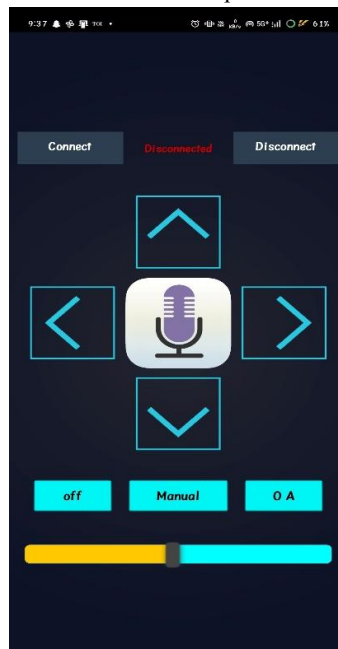


Fig. 1 Car Controlling App



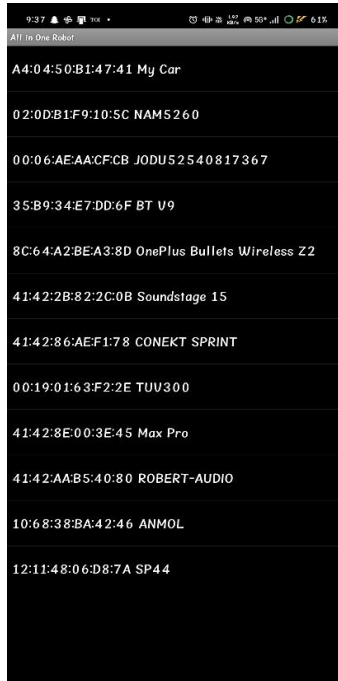


Fig. 2 Bluetooth Connectivity with Bluetooth Module Name

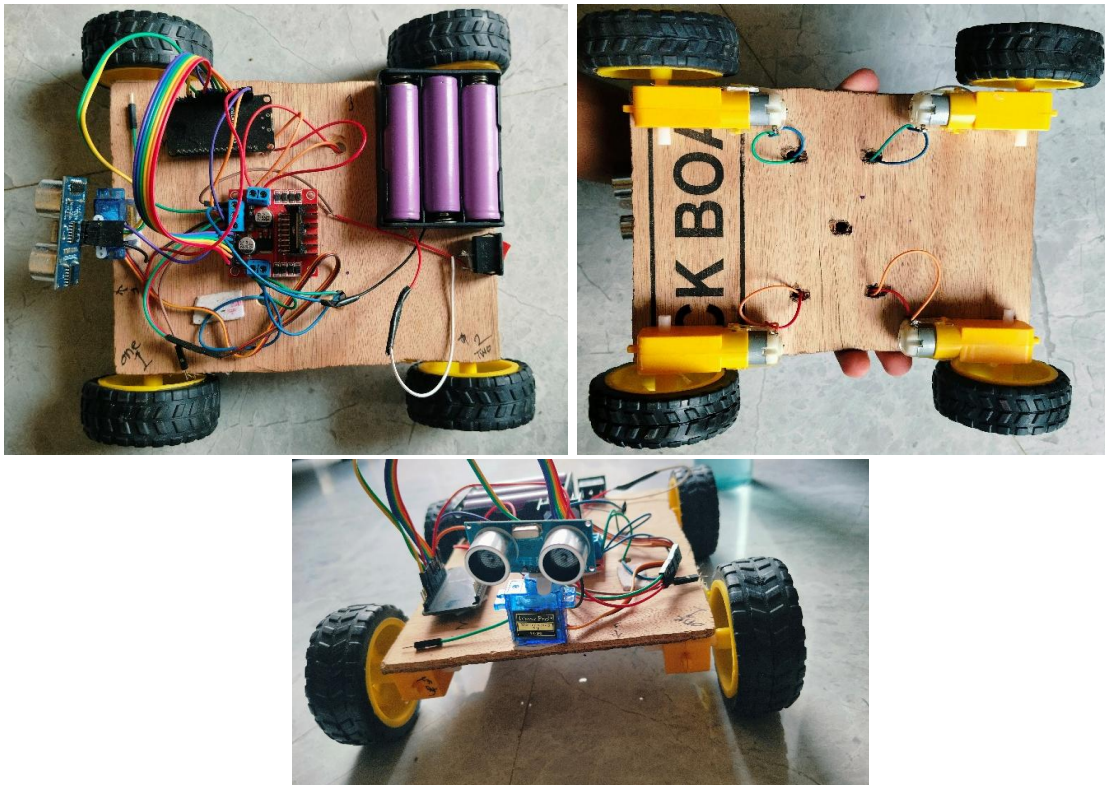


Fig. 3 Main Hardware system



Dataflow:

• Data Collection:

Sensors such as the ultrasonic sensor continuously detect obstacles and measure the distance from objects. This data is sent to the ESP32 microcontroller for processing.

• Data Transmission:

Commands from the mobile application (voice or manual buttons) are transmitted to the ESP32 through a Bluetooth module such as HC 05 Bluetooth Module.

• Data Processing:

The ESP32 processes the received commands and sensor data. Based on the command or obstacle detection, it decides the movement direction of the robot.

• Motor Control:

The ESP32 sends control signals to the L298N Motor Driver Module, which controls the speed and direction of the DC motors.

• Action:

The DC motors move the robotic vehicle forward, backward, left, or right. If the ultrasonic sensor detects an obstacle, the system can stop or change direction automatically to avoid collision.

V. APPLICATIONS

1. Surveillance and Security

The robotic vehicle can be used for monitoring and security purposes in restricted or dangerous areas. It can move around and inspect locations without risking human safety.

2. Industrial Monitoring

The robot can be used inside factories or warehouses to monitor equipment, check pathways, and inspect areas that may be difficult or unsafe for workers to access.

3. Military and Defense Applications

Robotic vehicles can assist in surveillance, bomb detection, and monitoring border areas. They help reduce risks for soldiers by performing dangerous tasks remotely.

4. Rescue and Disaster Management

The robot can be used in disaster situations such as earthquakes, fires, or collapsed buildings to explore areas where humans cannot easily enter. It helps rescue teams locate victims and assess the situation.

5. Educational and Research Purposes

This project is very useful for students and researchers to learn about robotics, embedded systems, and IoT technologies using controllers like the ESP32 and motor control modules like the L298N Motor Driver Module.

6. Smart Home and Automation

The robotic vehicle can be integrated with smart home systems to perform simple tasks such as remote monitoring or moving objects within a controlled environment.

VI. FUTURE ENHANCEMENT

In the future, the robotic vehicle can be improved by adding more advanced technologies. Artificial Intelligence (AI) can be used to make the robot move automatically and avoid obstacles more efficiently. A camera can be added with the ESP32 to provide live video monitoring through the mobile application.

The mobile app can also be improved with better voice control and internet connectivity for remote access. Additional sensors can be added to increase the robot's capabilities. A better power system and improved motor control using the L298N Motor Driver Module can make the robot more efficient and reliable.



VII. CONCLUSION

The Voice and Manual Controlled IoT Robotic Vehicle provides a simple and effective way to control a robot using a mobile application. The ESP32 microcontroller processes commands and controls the movement of the robot through the L298N Motor Driver Module.

The ultrasonic sensor helps the robot detect obstacles and avoid collisions, improving safety. Overall, the system demonstrates how wireless communication and sensors can be used to create a smart and efficient robotic vehicle for applications like surveillance, monitoring, and educational robotics.

VIII. DISCUSSION

The voice and manual controlled robotic vehicle is designed to provide an efficient and flexible way to control a robot using a mobile application. Traditional robotic vehicles usually require direct manual control or wired connections, which limits mobility and convenience. By using wireless communication and sensors, this system allows the robot to be controlled remotely and operate more efficiently.

The system uses the ESP32 microcontroller to process commands from the mobile application and control the robot's movement through the L298N Motor Driver Module. The ultrasonic sensor helps the robot detect obstacles and avoid collisions, improving safety and performance.

The integration of voice control, manual control, and obstacle detection makes the robotic vehicle more intelligent and user-friendly. This system can be useful for applications such as surveillance, industrial monitoring, and educational robotics while reducing human effort and improving operational efficiency.

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