Voice-Controlled Obstacle-Avoiding UGV Using ESP32

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***Abstract*—This paper presents a voice-controlled unmanned ground vehicle (UGV) built using an ESP32 microcontroller and an L298N motor driver. The UGV is controlled via voice commands using a Bluetooth-connected Android application. An ultrasonic sensor is integrated to detect and avoid obstacles in the path; a buzzer provides alerts when an obstacle is detected. This low-cost and scalable platform serves as a prototype for intelligent robotics systems with human–robot voice interaction and autonomous navigation.**

I. Introduction

Voice-based human-robot interaction offers an intuitive control method for robotic platforms. In recent years, voice recognition integrated with embedded systems has enabled robots to respond to spoken commands and perform autonomous tasks. In this project, we demonstrate a voice-controlled UGV prototype using the ESP32 microcontroller and the L298N motor driver. The system is enhanced with an ultrasonic sensor for obstacle detection and a buzzer for user alerting when obstacles are detected.

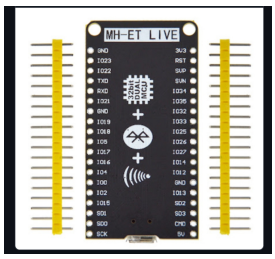
II. Hardware Setup

The components used in this project are listed in Table I.

TABLE I
List of Components

S.No	Component
1	ESP32 Development Board
2	L298N Motor Driver Module
3	DC Motors (2×)
4	Toy Car Chassis with Wheels
5	Breadboard
6	Connecting Wires
7	Ultrasonic Sensor (HC-SR04)
8	Buzzer Module
9	Power Bank with USB Cable

A. Motor Connections (ESP32 to L298N)



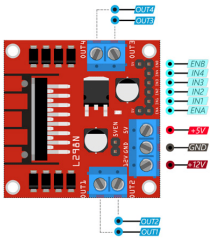


TABLE II
ESP32 to L298N Motor Driver Connections

ESP32 Pin	L298N Pin	Description
GPIO 23	IN1	Motor A direction control
GPIO 22	IN2	Motor A direction control
GPIO 21	IN3	Motor B direction control
GPIO 19	IN4	Motor B direction control
5V	VCC	Power supply to driver
GND	GND	Common ground

B. Ultrasonic Sensor Connections (HC-SR04)

TABLE III
Ultrasonic Sensor to ESP32 Connections

HC-SR04 Pin	ESP32 Pin
VCC	5V
GND	GND
Trig	GPIO 2
Echo	GPIO 4

Fig. 1. Ultrasonic Sensor (HC-SR04) Module

C. Buzzer Connection

TABLE IV
Buzzer to ESP32 Connection

Buzzer Pin	ESP32 Pin
VCC	3.3V
GND	GND
Signal	GPIO 13

III. Software Setup

A. Voice Control via Android App

1) Install the **Arduino Bluetooth Controller** app from the Google Play Store.
2) Upload the voice-control code tothe ESP32 using PlatformIO.
3) Create a new PlatformIO project, select the board and framework, and replace the contents in `src/main.cpp` with the downloaded code.
4) Power the ESP32 via a power bank and establish a Bluetooth connection from the mobile app.
5) Use the voice control section to issue commands: `Forward`, `Back`, `Left`, `Right`, `Stop`.
6) The UGV moves accordingly. If the ultrasonic sensor detects an obstacle within a threshold distance, the buzzer will alert and the vehicle can pause or change direction.

IV. Conclusion and Future Work

We have implemented a voice-controlled UGV using the ESP32 microcontroller and L298N motor driver, enhanced with an ultrasonic sensor for obstacle detection and a buzzer for user alerting. This low-cost prototype is ideal for academic demonstrations and rapid AI prototyping in robotics.

Future work may include:

- On-board offline speech recognition (e.g., using TensorFlow Lite) to remove dependency on cloud services.
- Advanced obstacle-avoidance algorithms (e.g., using multiple sensors or vision modules).
- Integration of a camera or GPS module for smart navigation and environment mapping.

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