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Design and Construction of a Voice-Controlled Robotic Vehicle Using Arduino

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Abstract: This paper presents the design and construction of a voice-controlled robotic vehicle built around an Arduino Uno microcontroller, enabling a user to direct vehicle movement through spoken commands rather than manual or radio-frequency controllers. The system integrates an Arduino Uno, an L298N motor driver, an HC-05 Bluetooth module, an ultrasonic sensor, servo motors, and a regulated power supply. Voice input is captured through a smartphone application, converted to text, and transmitted over Bluetooth for execution. On reception, the Arduino interprets the command and drives a four-wheel-drive gear-motor chassis through the L298N driver, producing forward, backward, left, and right movement in response to verbal instruction. The study reviews existing approaches to robot control—including Bluetooth, Wi-Fi, radio-frequency, and gesture-based systems—and situates voice control as a simpler, more user-friendly alternative that reduces reliance on physical interfaces. Testing confirmed that the assembled prototype responded reliably to the programmed voice commands after routine troubleshooting, demonstrating the feasibility of low-cost, microcontroller-based voice control for mobile robotics. The work is positioned as a foundation for assistive and automation technologies, with anticipated applications in mobility aids for persons with disabilities, surveillance, and hazardous-environment operations, and it concludes with recommendations for extending the platform with obstacle avoidance, thermal sensing, and additional payload modules.

Keywords: *Voice Recognition; Arduino Microcontroller; Bluetooth Communication; Robotic Vehicle; Embedded Systems; Human–Machine Interaction; Assistive Technology.*

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I. INTRODUCTION

The term "robot" derives from the Czech word "robota," meaning forced labour, and today refers broadly to programmable machines capable of carrying out complex sequences of actions with limited or no human intervention (Corke, 2011). Robotic vehicles, a widely studied subclass of mobile robots, extend this idea to locomotion, and the manner in which such vehicles are commanded has itself become an active area of research. Conventional wired controllers restrict a vehicle to the length of its tether, while radio-frequency systems demand dedicated transmitter and receiver hardware, adding cost and complexity. Voice control offers a more natural alternative: a user issues a spoken instruction, which is converted to a digital command and relayed wirelessly to the vehicle, removing the need for buttons, joysticks, or line-of-sight signalling.

This project explores the design and implementation of a voice-controlled robotic vehicle built around an Arduino Uno microcontroller. Voice commands are captured through a smartphone running a speech-recognition application and transmitted to the vehicle over a Bluetooth link established with an HC-05 module. The received text command is interpreted by the Arduino, which in turn drives the L298N motor driver to execute the corresponding movement. The control methodology was designed to be simple and accessible: no specialised training or hardware is required of the user beyond a smartphone with the companion application, and the resulting system responds to a small set of core commands governing forward, reverse, and turning motion. Beyond demonstrating the underlying engineering, the work is intended as a stepping stone toward assistive technologies, since voice-based control lends itself naturally to applications where manual operation of a vehicle or device is impractical or impossible.

➢ *Significance of the Study*

Voice-controlled automation sits within the broader field of artificial intelligence, where machines are given the ability to perform tasks conventionally carried out by humans, reducing both the scope for human error and the cost of manual operation. A vehicle that can be directed by spoken command removes the need for physical controllers and the

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wiring or radio hardware they require, making the underlying control scheme cheaper, more portable, and easier to operate. Such systems are of particular value to users with limited mobility or dexterity, for whom conventional joystick- or button-based interfaces present a barrier, and they offer a foundation for further work in mobility aids, remote monitoring, and hazardous-environment robotics where direct human presence is undesirable or unsafe.

II. LITERATURE REVIEW

Robotics is generally defined as the branch of technology concerned with the design, construction, and operation of robots within automated systems (Merriam-Webster, 2016), and more formally as a field that synthesises aspects of human function through mechanisms, sensors, actuators, and computation (Craig, 2005). The discipline draws on artificial intelligence, computer vision, locomotion, and mechanical manipulation, and the specific problem of remotely directing a mobile robot has been approached through several competing communication schemes. Radio-frequency control was among the earliest methods but requires dedicated transmitter and receiver hardware and offers limited flexibility once deployed. Wi-Fi-based control, explored by Mehta (2016) and Sharma et al. (2014), extends the operating range and allows command via smartphone applications or SMS, but introduces greater power and infrastructure demands than short-range alternatives.

Bluetooth has emerged as the dominant short-range solution for hobbyist and academic robotic vehicles because of its low cost, low power consumption, and straightforward integration with microcontrollers such as the Arduino. Chaudhry (2019) and Saravanan et al. (2020) each implemented Arduino-based voice-controlled robots in which a smartphone application converts spoken input to text using built-in speech-recognition services before relaying the resulting command to the vehicle's Bluetooth module; both reported reliable directional control using only a handful of standard commands. Shafiq et al. (2019) took a more embedded approach, applying Mel-Frequency Cepstral Coefficients for feature extraction and a Hidden Markov Model for command recognition directly within the robotic system rather than delegating recognition to a phone application. Other researchers have paired Bluetooth control with additional sensing: Risanen et al. (2009) added a mechanical knock sensor to register collisions, while Mandal et al. (2016) combined Bluetooth and Wi-Fi modules with infrared sensors to support path-following and obstacle avoidance.

A further body of work has examined how robotic vehicles can be extended for surveillance, defence, and safety applications once a reliable control channel is established. Veeramani et al. (2019) and He et al. (2013) both proposed pairing voice- or Bluetooth-controlled chassis with cameras and gas or temperature sensors for military and mine-detection use, while Ansari and Kadam (2021) applied a similar Arduino-based platform to automated solar-panel cleaning. Collectively, this literature indicates that Bluetooth-mediated, smartphone-assisted voice control offers a practical balance of cost, simplicity, and responsiveness for small robotic vehicles, and that once a dependable command channel is in place, the same architecture can be adapted to a wide range of application-specific sensing and payload modules. This informed the choice of an Arduino Uno with an HC-05 Bluetooth module as the core control architecture for the present study.

III. METHODOLOGY

➢ *System Overview*

The voice-controlled robotic vehicle was designed around an Arduino Uno microcontroller acting as the central processing unit, interfaced with an L298N motor driver, an HC-05 Bluetooth module, an ultrasonic sensor, servo motors, and a regulated power supply. A smartphone application converts the user's spoken command into text using a built-in speech-recognition engine and transmits the resulting instruction to the vehicle over Bluetooth. The Arduino receives and interprets the command, then signals the L298N driver to execute the corresponding movement through the gear motors. This architecture keeps the on-board processing simple while placing the more computationally demanding task of speech recognition on the smartphone, allowing the vehicle itself to remain lightweight and low-power.

➢ *System Components*

The system integrates the components listed in Table 1, each contributing a distinct function to the overall design. The Arduino Uno board is built on the ATmega328P microcontroller, which provides the processing core, digital and analogue input/output, and the UART serial port used to communicate with the Bluetooth module and the motor driver.

Table 1 System Components and their Functions

Component	Specification / model	Function in the system
Controller board	Arduino Uno (ATmega328P, 16 MHz, 14 digital I/O, 6 analogue inputs)	Central controller; receives text commands over UART and drives the motor driver accordingly.
Motor driver	L298N dual H-bridge module	Converts the controller's logic signals into the current required to run the gear motors, giving independent bidirectional control.
Wireless link	HC-05 Bluetooth module (2.4 GHz ISM, UART)	Receives commands from the paired smartphone application and forwards them to the Arduino.
Distance sensor	HC-SR04 ultrasonic sensor	Measures distance to nearby objects; provides the basis for future obstacle-avoidance behaviour.
Actuator	Servo motor	Precise angular positioning for auxiliary steering and sensor orientation.

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Drive train	4WD chassis with DC gear motors	Provides traction, torque, and directional movement in all four basic directions.
Power supply	12 V DC battery pack with DC-DC buck converters and 5 V regulation	Supplies regulated voltage to the controller, logic, and motors from a self-contained pack; stepped down to 5 V for the microcontroller and peripherals.
Chassis	Lightweight structural frame	Houses and secures all electronic components while keeping overall weight low.

➤ *System Block Diagram*

The block diagram in Figure 1 traces the flow of a command from the user's voice, through the smartphone's speech-to-text conversion, across the Bluetooth link, into the Arduino for interpretation, and finally to the motor driver and gear motors that produce the physical movement.

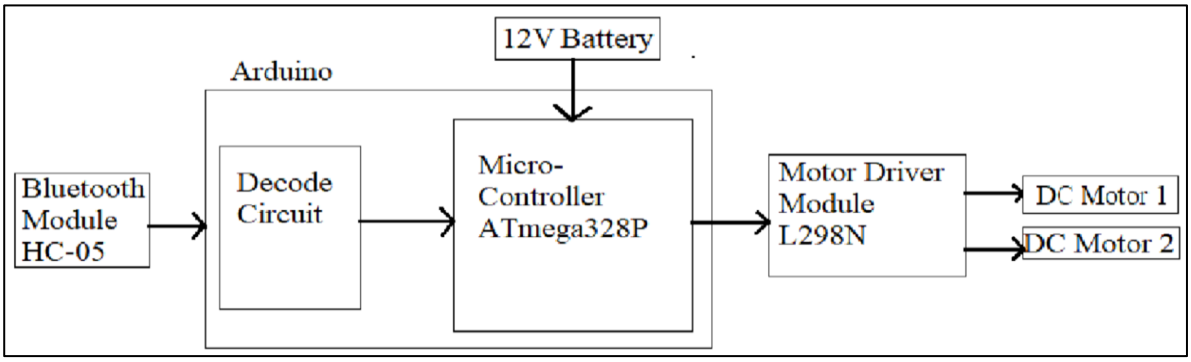

Fig 1 Block Diagram of the Voice-Controlled Robotic Vehicle

➤ *System Flowchart*

The operating logic of the vehicle is summarized in Figure 2. On power-up, the system initializes and waits for a Bluetooth connection; once paired, it listens continuously for an incoming command, matches it against the set of recognized instructions, and executes the corresponding motor action before returning to a listening state.

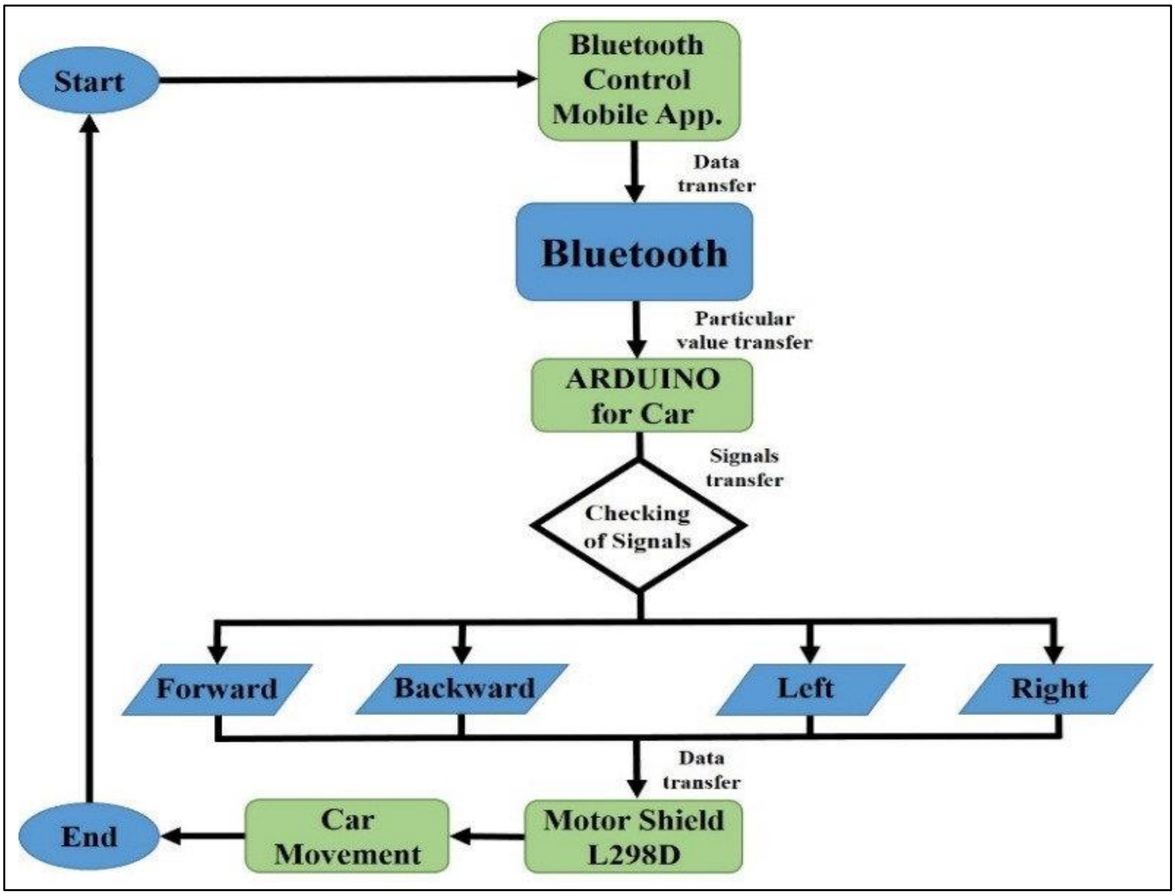

Fig 2 Flowchart of the Voice-Controlled Robotic Vehicle

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IV. RESULTS

➢ *Prototype Implementation*

The completed vehicle requires a 12 V DC power source; a voltage regulator steps this down to the 5 V needed by the microcontroller and its peripherals. On power-up, the HC-05 module is paired with the companion smartphone application, after which the system is ready to accept voice commands. Four core commands, corresponding to forward, reverse, left, and right movement, are recognised by the application, converted to a command signal, and transmitted to the Arduino, which signals the L298N driver to rotate the gear motors accordingly. Figures 3 to 5 show the wiring of the Arduino and its peripherals and the assembled chassis during construction.

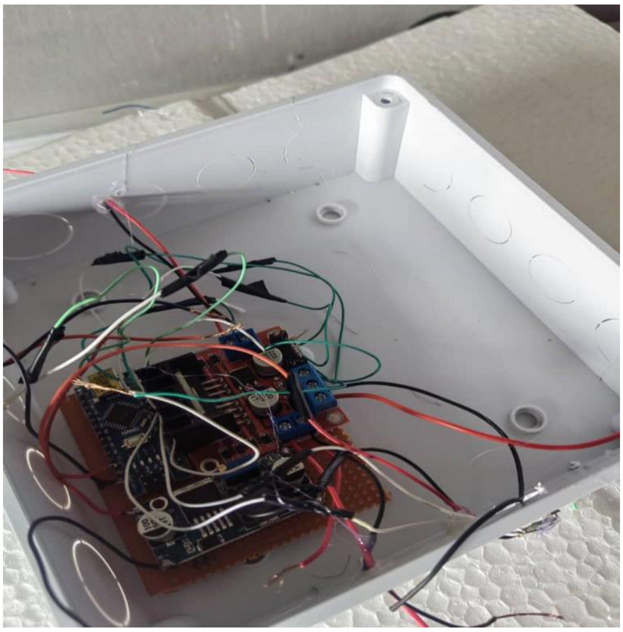

Fig 3 Connection of the Arduino and Other Components

Fig 4 Connection of the Ultrasonic Sensor

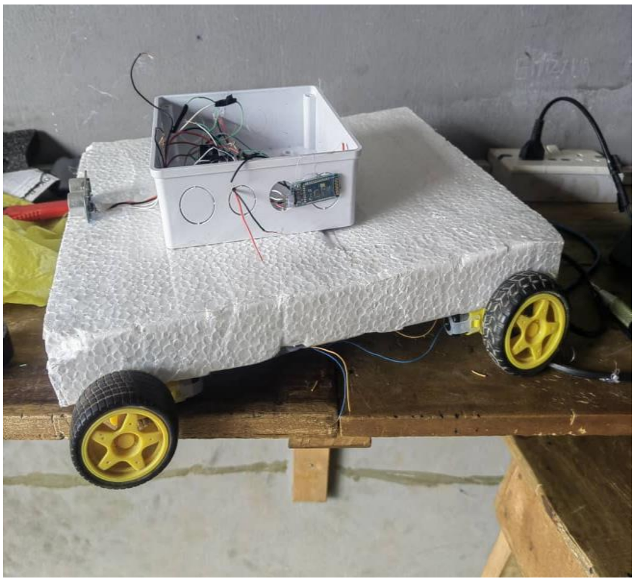

Fig 5 Side View of the Vehicle Under Construction

➢ *Testing and Results*

The assembled hardware was programmed in embedded C/C++ using the Arduino IDE and tested to verify that the microcontroller correctly recognized each programmed voice command and rejected unrecognized input. Following routine troubleshooting during construction, the system responded reliably to the intended commands, confirming that the integration of the Bluetooth module, microcontroller, and motor driver met the project's operating requirements. Figures 6 and 7 show the vehicle during testing and in its completed working form.

Fig 6 Testing the Robotic Vehicle

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Fig 7 Completed Working Robotic Vehicle

V. DISCUSSION

The central design goal was a robotic vehicle that responds reliably to spoken commands without requiring specialized operator training. This was achieved by delegating the computationally intensive task of speech-to-text conversion to a smartphone application, while keeping the on-board Arduino responsible only for interpreting the resulting short text commands and driving the motor controller. The HC-05 Bluetooth module proved an effective and low-cost channel for this communication, offering sufficient range and reliability for indoor and short-range outdoor use. The L298N driver and 4WD gear-motor arrangement gave the vehicle stable, controllable movement in all four basic directions, while the ultrasonic sensor and servo motors provide a foundation for adding obstacle detection and sensor-orientation capabilities in future iterations. Overall, the combination of Arduino-based control, Bluetooth communication, and smartphone-hosted speech recognition offers a practical and extensible architecture for voice-driven mobile robotics.

VI. CONCLUSION AND FUTURE WORK

This project successfully designed and constructed a voice-controlled robotic vehicle using an Arduino Uno, demonstrating that spoken commands relayed through a smartphone application and Bluetooth link can reliably direct a small robotic chassis. The resulting prototype is simple to operate, requiring only a paired smartphone and a small set of recognized voice commands, and is well suited to applications such as mobility assistance for persons with disabilities, monitoring in areas difficult for humans to access, and general automation tasks where manual control is impractical. The voice commands were transmitted and executed successfully across testing, confirming the feasibility of the chosen architecture and its potential to reduce human effort in settings such as industry, defense, and research.

As a prototype, the system also points toward a number of extensions. The platform could be adapted into a voice-controlled wheelchair to directly support users with mobility impairments, or fitted with a thermal camera to distinguish warm bodies for military or search-and-rescue use. A web or surveillance camera could be added for remote monitoring, while a proximity sensor would extend the design toward landmine-detection applications. Interfacing an infrared sensor would enable obstacle-avoidance and line-tracking behaviour, and the same voice-command framework could be extended to control a pick-and-place robotic arm. Finally, incorporating gas, fire, and temperature sensors would allow the vehicle to function as a voice-controlled hazard-sensing platform for explosive or fire-risk environments.

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