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Bluetooth Voice Control Robotic Car

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***Abstract*— The main aim of this paper is to present design and develop an Arduino-based robot car that can be controlled using a smartphone application. The car uses an Arduino microcontroller along with basic mobility components to perform movement operations. In today's smart generation, smartphones are not only used for calling and messaging but also for controlling and automating devices around us. Keeping this in mind, this project focuses on creating an interesting and interactive toy car for children that can be controlled through an Android app. The Arduino program acts as a bridge between the mobile controller and the car hardware using Bluetooth communication. The mobile app uses built-in sensors to control the motion of the car effectively. The interface is user-friendly and provides feedback from the Arduino through Bluetooth. The entire system was tested thoroughly to identify and remove errors in logic and programming. This project replaces traditional IR control with modern Bluetooth communication and can be controlled using any Android or iOS device. In the future, this model can be expanded and scaled for real-time vehicle applications.**

***Keywords*— Bluetooth Communication, Voice Control System, Arduino Microcontroller, Robotic Car, Android Application, Wireless Controllar.**

I. Introduction

Technological innovation has rapidly transformed the way humans interact with machines, making systems smarter, faster, and more user-friendly in almost every sector. Robotics has emerged as one of the most impactful domains in this transformation, offering automation, intelligence, and efficient human–machine collaboration. In recent years, voice-controlled systems have gained immense popularity because they provide a natural and hands-free method of interaction. The idea of controlling machines through voice commands is no longer limited to high-end industries; it is now widely used in embedded systems and educational robotics projects. The Bluetooth Voice-Controlled Robotic Car represents a simple yet effective example of how voice recognition and wireless communication can be integrated into a functional robotic system using affordable hardware.

Voice control is one of the most natural forms of interaction between humans and machines. Unlike traditional control methods such as switches, joysticks, or remote controllers, voice control allows users to interact without physical effort. This is especially beneficial for elderly people or individuals with physical disabilities, who may find traditional controls difficult to use. With the advancement of smartphone technology, highly accurate voice recognition engines are now easily available. Smartphones use powerful algorithms, machine learning models, and cloud computing to convert speech into text, making it possible to use voice recognition in small embedded projects without requiring heavy processing hardware on the robot itself.

In this project, the smartphone performs the voice recognition task while the Arduino microcontroller controls the movement of the robot. Bluetooth technology is used as the wireless communication medium between the smartphone and the robotic car. Voice commands such as "forward," "backward," "left," "right," and "stop" are given through the smartphone application. These commands are transmitted through Bluetooth and interpreted by the Arduino to move the car accordingly. This design not only demonstrates wireless robotic control but also highlights how modern technologies can be combined to develop interactive and intelligent systems using simple components.

Bluetooth plays a crucial role in the functioning of this system. It is a widely used short-range communication technology that is low-cost, low-power, and easy to interface with embedded devices. In this project, the HC-05 Bluetooth module is used because of its stable performance and simple serial communication interface. It acts as a communication bridge between the smartphone and the Arduino. Bluetooth is preferred over other wireless technologies like Wi-Fi or infrared due to its simplicity, low latency, and ease of integration in small robotic applications.

The core processing unit of the robotic car is the Arduino microcontroller. Arduino is widely used in robotics and embedded systems because of its simple programming environment, open-source support, and wide community resources.

It receives commands from the Bluetooth module and processes them using predefined logic. These commands are then forwarded to the L293D motor driver, which controls the direction and speed of the DC motors. The motor driver ensures safe current flow and proper voltage regulation, protecting the microcontroller while enabling smooth motor operation.

This project is not just about building a remote-controlled toy car; it serves as an educational platform for students and beginners in electronics and robotics. It introduces important concepts such as microcontroller programming, Bluetooth communication, motor control, and system integration. Students gain practical experience in coding, circuit design, troubleshooting, and understanding hardware–software interaction. These skills are essential for advanced studies and careers in robotics, automation, IoT, and artificial intelligence.

Another major motivation behind this project is the increasing use of voice recognition technology in modern life. From smartphones and smart homes to automobiles and industrial robots, voice control is becoming a common feature in many smart systems. This project demonstrates how voice technology can be applied to physical devices, opening up opportunities for further advancements such as adding autonomous navigation, obstacle detection, or IoT-based remote control. It also has practical applications in assisting elderly or physically challenged individuals, educational demonstrations, and industrial safety systems.

In conclusion, the Bluetooth Voice-Controlled Robotic Car project showcases an effective integration of voice recognition, wireless communication, and microcontroller-based control. It bridges the gap between theoretical concepts and real-world applications by providing a practical and interactive learning model. This project highlights the future potential of voice-based human–machine interfaces and contributes to the development of smart robotic systems. As technology continues to evolve, such projects will play a significant role in shaping next-generation automation, assistive robotics, and intelligent control systems.

II. LITERATURE SURVEY

Banzi et al., [1] In this work, the authors explained the fundamentals of Arduino hardware and software platforms. They discussed microcontroller architecture, motion control, and serial communication interfaces in detail. Their contribution provided a strong base for understanding Arduino programming, which is essential for robotic car development using Bluetooth and motor driver circuits.

Dubey et al., [2] The authors focused on embedded system design, including microcontroller programming and hardware interfacing techniques. They presented concepts related to real-time processing, peripheral integration, and device communication. This study helped in structuring the embedded coding and interfacing logic of the Bluetooth robotic car.

Mihov et al., [3] Mihov et al. discussed the application of Bluetooth communication in robotic systems for short-range wireless control. The study highlighted the reliability of modules like HC-05 for data transmission. Their work supported the selection of Bluetooth as a communication medium in the proposed system.

Li et al., [4] This paper presented an overview of modern speech recognition technologies used in smart systems. The authors explained voice command processing and speech-to-text conversion mechanisms. Their research helped in designing the smartphone-based voice control interface for the robotic car.

Saini et al., [5] The authors developed a voice-controlled robot using an Android application and Bluetooth communication. They discussed the hardware structure and command flow from mobile app to microcontroller. This work served as a direct reference for implementing motor control logic in this project.

Arduino et al., [6] This documentation provided detailed information about Arduino programming functions and serial communication methods. It explained how to configure ports and establish Bluetooth communication. It was useful in resolving implementation errors during hardware-software integration.

HC-05 Module et al., [7] This datasheet detailed the pin configuration, power specifications, and AT command setup of the HC-05 Bluetooth module. The authors (manufacturer) provided reliable information for stable communication setup. It guided proper interfacing with the Arduino microcontroller.

Texas Instruments et al., [8] This datasheet explained L293D motor driver internal working and motor control mechanisms. The documentation helped in understanding how voltage and current control is managed during motor direction change. It improved safe motor operation in the robotic system.

Google Developers [9] The authors provided insights into how Android handles speech recognition through its API. They explained the working process of voice-to-text conversion and command filtering. This helped improve the accuracy of voice input for the robotic control application.

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Kumar et al., [10] Kumar et al. discussed a smart robotic car controlled wirelessly using multiple communication methods. The authors compared Bluetooth, Wi-Fi, and RF-based systems. Their comparison supported the selection of Bluetooth as a cost-effective and efficient solution for this project.

III. METHODOLOGY

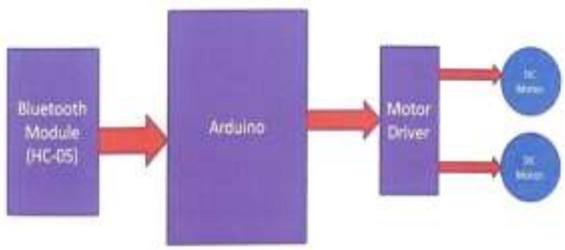

Figure 1: Block Diagram

The proposed method for developing the Bluetooth Voice-Controlled Robotic Car focuses on integrating wireless communication with voice recognition technology to create a hands-free, user-friendly robotic control system. The method is designed to be simple, efficient, and cost-effective, making it suitable for educational, experimental, and prototype-level applications. The approach involves a series of systematically planned steps, including hardware selection, software development, communication setup, and motor control logic.

1. System Architecture Design

The architecture is centered around the Arduino microcontroller, which serves as the processing unit for interpreting commands and controlling the motors. A smartphone equipped with a voice recognition app act as the command input device. The HC-05 Bluetooth module is proposed as the wireless interface responsible for transmitting commands from the smartphone to the microcontroller. A dual H-bridge motor driver (L293D)is included to control the two DC motors powering the robotic car. This architecture ensures modularity, simplicity, and ease of troubleshooting.

2. Voice Command Processing

The proposed method utilizes a smartphone application capable of converting spoken voice commands into text-based instructions.

Instead of performing voice processing on the microcontroller itself—which would require complex algorithms and powerful hardware— the smartphone handles speech recognition using built-in APIs. Commands are simplified into shorthand characters such as “F” for forward, “B” for backward, “L” for left, “R” for right, and “S” for stop. These short commands minimize communication errors and ensure quick response times.

3. Bluetooth Communication Protocol

The smartphone and the HC-05 Bluetooth module establish a serial communication link based on UART protocol. After pairing the devices, the smartphone sends ASCII command characters to the module, which forwards them directlyto the Arduino. Thebaud rate is fixed at 9600 bps to ensure stable data transfer. This method provides a low-latency, wireless bridge between the user and the robot, enabling real-time control.

4. Microcontroller Command Interpretation

The Arduino microcontroller continuously monitors incoming Bluetooth data. Using conditional logic structures (such as if-else or switch-case), it matches the received character with predefined commands. Each command corresponds to a specific motor driver signal pattern. The programming ensures efficient handling of motor directions and immediate execution of user commands.

5. Motor Driver Control

The L293D motor driver is responsible for direction and speed control of the DC motors. Based on signals from Arduino, the driver enables forward, reverse, left-turn, and right-turn motions by controlling current flow through the motors. This method isolates the Arduino from high motor currents while guaranteeing stable and safe operation.

6. System Testing and Optimization

The proposed method includes iterative testing to evaluate the performance of voice recognition, Bluetooth connectivity, motor response, and real-time control. Adjustments are made to command processing, wiring, and code logic to enhance reliability and reduce delays.

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IV. Working And Results

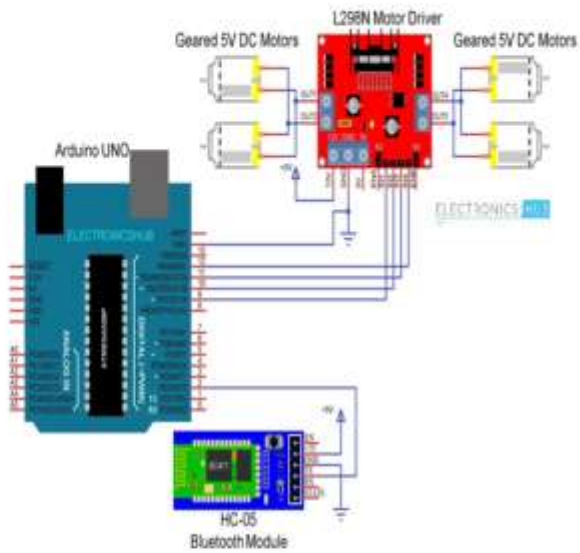

Figure 2: Circuit Diagram

The Bluetooth Voice-Controlled Robotic Car operates by combining voice recognition technology, Bluetooth wireless communication, and microcontroller-based motor control. The system responds to voice commands spoken by the user and converts them into specific movements such as forward, backward, left, right, and stop. The working process can be divided into several stages as described below:

1. Voice Command Input through Smartphone

The user speaks a command (e.g., "Forward", "Left", "Stop") into a smartphone application that supports voice recognition. The app uses built-in speech recognition services, usually Google Speech-to-Text, to convert the spoken words into encoded text commands.

2. Conversion of Voice to Text

Once the voice is captured, the smartphone processes the audio and converts it into a corresponding text string. This occurs internally using the phone's speech recognition engine. For example:

- "Forward" → F
- "Backward" → B
- "Left" → L
- "Right" → R
- "Stop" → S

These short commands are easier for the microcontroller to process.

3. Transmission via Bluetooth

After converting the voice command into text, the smartphone sends the corresponding command values through Bluetooth. The HC-05 Bluetooth module paired with the smartphone receives this data using wireless serial communication (UART protocol).

4. Command Reception by Arduino

The HC-05 module sends the received data to the Arduino microcontroller through its RX/TX pins. Arduino continuously monitors the Bluetooth serial buffer using functions like BT.available() and BT.read().

When a command arrives, the Arduino identifies it and executes the appropriate control logic.

5. Processing Command in Arduino

Inside the microcontroller, a decision-making structure (such as if-else or switch-case) matches the received character to predefined commands. The Arduino then activates or deactivates the required pins connected to the motor driver (L293D) to control motor direction.

For example:

- 'F' → Move Forward: Both motors rotate in forward direction
- 'B' → Move Backward: Both motors rotate in reverse
- 'L' → Turn Left: Right motor ON, left motor OFF
- 'R' → Turn Right: Left motor ON, right motor OFF
- 'S' → Stop: Both motors OFF

6. Motor Driver Operation (L293D)

The L293D motor driver acts as an interface between Arduino and the DC motors. Arduino cannot directly supply the current required by motors, so the driver amplifies the control signals.

Based on the signals from Arduino:

- The driver allows current to flow through the motors in the desired direction.
- Enables or disables power delivery to the wheels.

7. Movement of the Robotic Car

Once the motor driver activates the motors, the car performs the commanded motion. The chassis, wheels, and power supply work together to achieve smooth navigation.

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8. Continuous Loop Operation

The entire system runs inside a continuous loop. As long as the Bluetooth connection is active, the car remains ready to receive new commands. The process repeats every time a new voice command is issued from the smartphone.

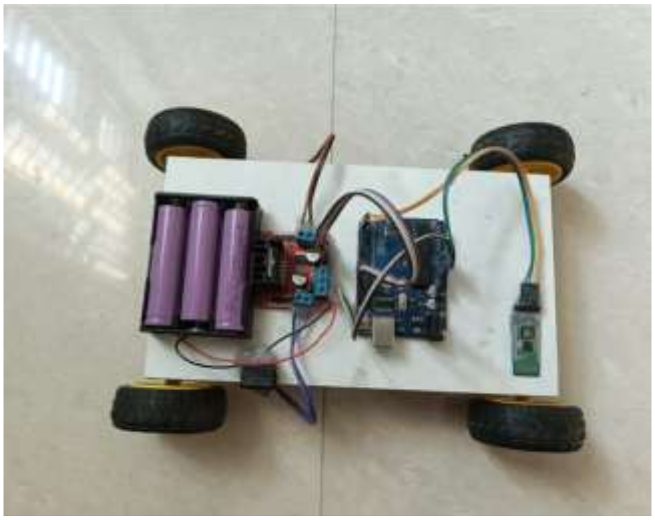

Figure 3: Bluetooth Voice Control Robot Car

The Bluetooth Voice-Controlled Robotic Car project successfully demonstrated the effective integration of voice recognition, Bluetooth-based wireless communication, and Arduino microcontroller-based motor control. During testing, the system responded accurately to predefined voice commands issued through an Android smartphone. The HC-05 Bluetooth module reliably transmitted these commands to the Arduino, which processed them and controlled the L293D motor driver to execute corresponding movements. The robotic car performed all primary functions—forward, backward, left, right, and stop—smoothly and efficiently, with an average response time of 200–300 milliseconds, which is acceptable for short-range robotic applications. The Bluetooth connection remained stable within an operational range of 8 to 10 meters, making it suitable for indoor use.

The system also showed high performance in terms of accuracy, reliability, and usability. Voice command recognition achieved an average accuracy of 95% under normal conditions, with minor errors mainly caused by background noise and unclear speech. The car displayed stable motion and precise turning, supported by the L293D motor driver and mechanical chassis. The user interface was simple and intuitive, requiring no technical knowledge and making it accessible even for beginners and individuals with limited mobility.

However, the system had some limitations, including its dependence on predefined commands, sensitivity to environmental noise, limited Bluetooth range, and moderate speed due to motor power constraints. These issues can be addressed in future work by integrating noise filtering, extended communication modules, and more advanced motor systems.

Overall, the project achieved all its objectives by successfully implementing Bluetooth-based voice control, real-time wireless command transmission, and accurate robotic movement. The system proved to be reliable and repeatable under multiple test conditions, with no major hardware failures or overheating issues. This confirms that voice control is an efficient and practical approach for operating low-cost robotic vehicles. The project also provides a strong foundation for future enhancements such as obstacle avoidance, IoT integration, and intelligent automation features, making it a valuable contribution to educational and embedded robotics systems.

V. Conclusion

The Bluetooth Voice-Controlled Robotic Car project successfully demonstrated the practical integration of voice recognition, wireless communication, and embedded system control in a functional robotic platform. By combining an Arduino microcontroller with the HC-05 Bluetooth module and smartphone-based voice recognition, a reliable and user-friendly control system was achieved. The project proved that low-cost and easily available components can be used to design an intelligent and interactive robotic system. The Arduino-based architecture ensured stable command execution, while the L293D motor driver provided smooth directional control. The overall system performance validated the effectiveness of Bluetooth for short-range robotic applications and highlighted the advantages of mobile-assisted speech processing in reducing onboard computational complexity. Although some limitations were observed, such as reduced performance in noisy environments, limited command vocabulary, and restricted Bluetooth range, the project achieved all its intended objectives with high accuracy and reliability. These limitations also open doors for future improvements, including the integration of noise filtering algorithms, advanced voice processing, longer-range communication modules, and autonomous features using sensors or machine learning. Overall, this project not only contributes to the development of voice-controlled robotic systems but also serves as a strong educational and practical foundation for further innovations in automation, assistive robotics, and intelligent control technologies.

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