Research Paper on Voice Controlled Robotic Car

Aditya Garje[*1], Ritesh Patil [*2], Komal Shitole[*3], Kiran Tamboli [*4] ,Ms. Kriti Sachdeva[*5]
[*1,2,3,4]Student, Artificial Intelligence & Machine Learning,
Progressive Education Society's, Modern College of Engineering,
Shivajinagar, Pune-05.
[*5]Assistant Professor, Department of Artificial Intelligence & Machine Learning,
Modern College of Engineering, Shivajinagar, Pune-05.

Abstract:
The development of robotic vehicles has significantly advanced in recent years, driven by technological innovations in robotics, artificial intelligence, and the Internet of Things (IoT). This paper presents a robotic voice-controlled car that utilizes a combination of voice commands and obstacle avoidance systems, along with integration of Google Maps for navigation. The system architecture, components used, and algorithms for voice recognition, obstacle detection, and Google Maps API integration are detailed. The performance evaluation demonstrates the effectiveness and reliability of the proposed robotic car in real-world environments.

Keywords:
Robotic car; Voice control; Obstacle avoidance, Human–Machine Interaction, Speech Recognition System

Introduction:

The proliferation of artificial intelligence and machine learning technologies has enabled the development of autonomous systems capable of navigating complex environments. Among these advancements, voice-controlled robotic vehicles represent a significant area of research, as they provide enhanced accessibility and interaction capabilities for users. This paper explores the design and implementation of a robotic voice-controlled car that incorporates an obstacle avoidance mechanism demonstrating its effectiveness in enhancing accessibility, navigation safety, and real-time autonomous operation.

A. Background: Voice-controlled robotic systems have gained attention due to their ability to simplify interactions and enhance usability. Recent developments in natural language processing (NLP) and speech recognition have made it feasible to employ voice commands in a wide range of applications, including robotics, enabling more intuitive and efficient human–machine interaction.

B. Objectives: The primary objectives of this research are to design and implement a robotic car that:

1. Responds to voice commands for basic control.
2. Detects and avoids obstacles autonomously.
3. Utilizes Google Maps API for navigation, providing efficient route planning and real-time updates.

System Design:

The proposed system architecture consists of several key components, including a microcontroller, motor drivers, sensors, a microphone for voice recognition, and a wireless communication module.

Hardware Components:

1. **Arduino Uno R3:**

- USB socket present in R3 version
- Has additional pins (SCL and SDA) near the AREF pin
- Introduced an IOREF pin that allows shields to adapt to the voltage level till
3.3 V and 5 V.

2. **L293D:**

- Parts Protection: components without needing additional external components.
- Size: smaller size of IC
- Power efficient: more power efficient consumes 600 mA current

3. **Ultrasonic Sensor:**

- Ultrasonic sensors are used to measure distances with good accuracy by emitting ultrasonic waves
- Since ultrasonic sensors use sound waves, they do not require physical contact with the object to measure its distance.

4. IR Sensor:

- Obstacle Detection: emit infrared light and detect the reflection from an object
- Motion Sensing: detect changes in infrared radiation, which is typically emitted by humans and animals

5. Bluetooth Module:

- For giving wireless commands using mobile phone.
- Bluetooth is a universal standard and is supported by almost every smartphone, tablet, and computer

6. Li-Ion Battery:

- Rechargeable: It can be recharged hundreds to thousands of times, making it cost effective in the long term.
- Has a high energy density
- More environmentally friendly.

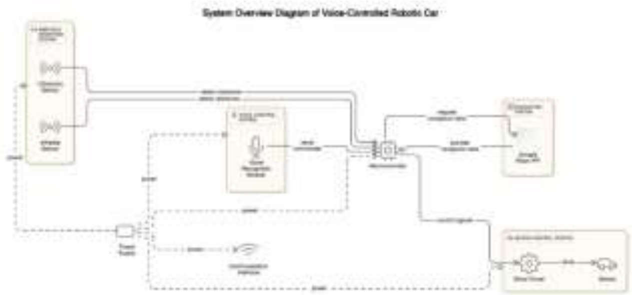
Software Components:

1. **Start**: Initialize all components (Wi-Fi module, motor controller, sensors, and voice recognition system).
2. **Connect to Wi-Fi:** Connect to the Wi-Fi network for remote command and control. If the connection is unsuccessful, retry until connected.
3. **Wait for Voice Command:** Listen for voice commands from a user interface (e.g., smartphone app). Recognize and interpret commands (e.g., forward, backward, left, right, stop).
4. **Receive Voice Command:** Translate the received voice command into movement instructions. If a command is received: continue to the next step. If no command is received: return to "Wait for Voice Command."
5. **Obstacle Detection (Sensor Check):** Continuously check for obstacles using distance sensors (e.g., ultrasonic or infrared). If an obstacle is detected within a set threshold, activate the obstacle avoidance system.
6. **Obstacle Avoidance Routine**
   - If an obstacle is detected:
     - Stop the robot.
     - Determine the direction to avoid the obstacle (left or right based on sensor input).
     - Adjust the movement direction accordingly.
   - If no obstacle is detected: proceed with the current voice command.
7. **Execute Movement Command:** Control motors to execute the movement command (e.g., forward, backward, left, right). Continuously monitor sensors for any obstacle during movement.
8. **Loop Back:** Return to "Wait for Voice Command" and repeat the process.
9. **Stop:** If a stop command is issued by the user or due to a critical error: halt all functions and disconnect from Wi-Fi.

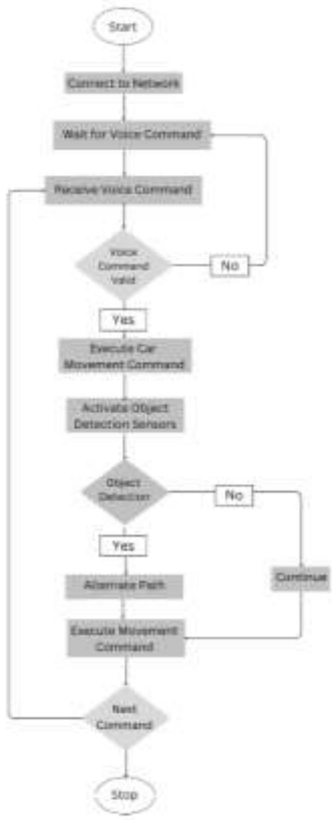
Methodology:

1. **Robotic Navigation and Obstacle Avoidance:** Robotic navigation and obstacle avoidance are critical components in robotics, enabling robots to move within their environments safely and efficiently while detecting and avoiding obstacles in real time.
2. **Ultrasonic Sensors:** Ultrasonic sensors are used to identify obstacles within the environment by emitting ultrasonic waves and measuring the reflected signals to determine the presence and distance of nearby objects.
3. **Voice Recognition Modules and Ultrasonic Sensors:** Voice recognition modules rely on Natural Language Processing (NLP) techniques and speech recognition systems to interpret user commands. These modules enable hands-free and user-directed control of the robotic system, improving accessibility, usability, and human–machine interaction.
4. **Obstacle Detection Using Ultrasonic Sensors:** Ultrasonic sensors are widely used for obstacle detection due to their simplicity, low cost, and effectiveness. The sensor transmits ultrasonic waves that reflect off obstacles, allowing the system to calculate distance and take appropriate actions to avoid collisions.

Architecture Diagram:



Flow Chart:



Flowchart Diagram for Car Activation

Applications:

1.Assistive Mobility

- **For People with Disabilities**: Voice-controlled robotic cars can provide mobility solutions for people with physical disabilities or those unable to operate traditional controls. Obstacle avoidance ensures safe navigation, especially in cluttered or challenging environments.
- **Elderly Assistance:** It can help elderly individuals by allowing them to control the car through voice commands, offering a safer way to get around without the need for complex driving operations**.**

2.Warehouse and Logistics

- **Automated Transport:** In warehouses, these robots can be used for transporting goods between different sections. Voice commands allow human workers to direct the robots efficiently, and obstacle avoidance ensures safe operation in dynamic environments with people and objects moving around.
- Inventory Management: Voice-controlled cars can assist in carrying or tracking inventory, responding to commands from warehouse personnel, and avoiding other equipment and obstacles.

3.Education and Research

- **STEM Education:** Voice-controlled and obstacle-avoiding robotic cars are useful in educational settings, teaching students about robotics, AI, automation, and programming through interactive learning.
- **Human-Robot Interaction Research:** These robots provide an excellent platform for studying and improving human-robot interaction, voice recognition, and obstacle avoidance algorithms.

4.Military and Défense

- **Reconnaissance and Surveillance:** Voice-controlled robotic vehicles can be deployed in reconnaissance missions, where remote voice commands allow soldiers to control the robot's movements while maintaining a safe distance. Obstacle avoidance minimizes the risk of damage in rugged terrains.
- **Search and Rescue Missions:** These robotic vehicles can assist in search and rescue operations in hazardous environments. Voice control allows rescuers to direct the robot remotely, while obstacle avoidance aids in navigating debris-strewn or tight spaces.

5.Healthcare

- **In-Hospital Transport:** The robotic car could be used in hospitals for tasks like transporting medical supplies or samples. Voice control simplifies interactions with medical personnel, and obstacle avoidance helps avoid collisions in busy corridors.
- **Patient Assistance:** For patients with limited mobility, the robotic car can be a helpful tool for moving objects around a room or delivering items to their bedside.

6.Agriculture

- **Automated Field Tasks:** In agricultural settings, the robot can be used for tasks like monitoring crops, collecting soil samples, or transporting equipment across the field. Voice control allows hands-free operation, and obstacle avoidance helps in navigating uneven terrains**.**

7.Home Automation

- **Household Assistance:** In a smart home setup, a voice-controlled robotic car could help with daily tasks like delivering items around the house or carrying small objects. Obstacle avoidance makes it safer to use in homes with pets, children, or varying layouts.

8.Entertainment and Leisure

- **Interactive Toy or Companion:** Voice-controlled robotic cars can be used as interactive toys or companions for children and adults alike, with obstacle avoidance enhancing the experience by making them autonomous and safe indoors.

Results:

When developing a robotic voice-controlled car with obstacle avoidance capabilities, you can expect a variety of results and functionalities**:**

1. Voice Control:

- Basic Commands: The car should respond accurately to voice commands such as "move forward," "turn left," "reverse," and "stop."
- Voice Recognition: Enhanced voice recognition to minimize misinterpretation of commands, even in noisy environments.

2. Obstacle Detection and Avoidance:

- Sensor Integration: The car should be equipped with ultrasonic sensors, LIDAR, or cameras that can detect obstacles in its path.
- Real-time Processing: The ability to process sensor data in real-time to make quick decisions when an obstacle is detected.
- Navigation Adjustments: Automatically alter its path to avoid collisions, potentially identifying the best route around obstacles**.**

3. Maneuverability:

- Smooth Navigation: The car should be able to navigate around objects smoothly and maintain control while following voice commands**.**
- Dynamic Routing**:** Capability to recalibrate its path dynamically if new obstacles are detected.

4. Performance Metrics:

- Response Time: Measure the lag between voice command issuance and the car’s response.
- Obstacle Detection Range: The effective range and accuracy of detection sensors**.**
- Success Rate: The percentage of successful obstacle avoidance maneuvers compared to total encountered obstacles.

5. User Interaction:

- Feedback Mechanism: Providing users with feedback (audio or visual) when an obstacle is detected and action is taken (e.g., "Obstacle detected, changing course").
- Learning Capability: If using machine learning, the car may improve its navigation and obstacle detection over time.

6. Power Management:

- Battery Efficiency: Monitoring the power consumption of the system, especially when running sensors and voice recognition continually.
- Charging Solutions: If applicable, include automatic return to charging stations when batteries are low.

7. Safety Features:

- Emergency Stop: A command (voice or physical) that immediately halts the car's movement in case of an emergency.
- Speed Regulation: Ability to limit speed to enhance safety, particularly in tighter environments.

8. Autonomous Operation (if applicable):

- The potential to operate independently in predefined environments or to follow designated paths while responding to voice commands and avoiding obstacles.

9. Deployment Scenarios:

- Performance in various environments (indoor vs outdoor) and surface types (smooth, rough, etc.).

Ultimately, the specific expected results will depend on the design, hardware, and software integration. Testing and iteration will play a crucial role in realizing the intended functionality and performance of the robotic car.

Conclusion:

This project successfully demonstrates the design and implementation of a voice-controlled car using Wi-Fi technology, GPS API, and NLP-based systems, highlighting the potential of IoT in enhancing user convenience and system interactivity. The system effectively integrates multiple technologies to create a seamless and intelligent vehicle control mechanism, catering to the growing demand for smarter and safer vehicular solutions.

By utilizing Wi-Fi technology, the car establishes a reliable communication network, ensuring smooth interaction between the user and the vehicle. Natural Language Processing (NLP) enables the system to understand and process voice commands, allowing the user to control the car hands-free. This feature not only improves accessibility but also contributes to safety, particularly in scenarios where manual operation is impractical. The incorporation of GPS API technology further enhances the system's functionality by enabling real-time location tracking and navigation. This allows users to receive precise information about the car's position and set navigation goals, making the system practical for real-world applications.

Throughout the development process, the project successfully addressed several technical challenges, including optimizing command recognition accuracy, maintaining a stable Bluetooth connection, and ensuring real-time data processing from the GPS module. These solutions contribute to the system's overall reliability and robustness.

The successful completion of this project underscores the transformative potential of combining IoT with artificial intelligence and advanced APIs. It sets a foundation for further advancements in voice-controlled systems, including potential integrations with 5G technology for faster communication, improved NLP algorithms for better command interpretation, and advanced AI for predictive analytics and decision-making.

In conclusion, the voice-controlled car system not only serves as a proof of concept for IoT-based automation but also demonstrates how these technologies can pave the way for future innovations in smart transportation. This project highlights the immense potential of IoT-driven solutions in creating a safer, more efficient, and more interactive mobility ecosystem.

References:

[1] M. R. Raihan, R. Hasan, F. Arifin, S. Nashif, and M. R. Haider, "Design and Implementation of a Hand Movement Controlled Robotic Vehicle with Wireless Live Streaming Feature," 2019 IEEE International Conference on System, Computation, Automation and Networking (ICSCAN), 2019.

[2] Jun Ma and Yuchun Du, "Study on the Evaluation Method of InVehicle Gesture Control," 2017 IEEE 3rd International Conference on Control Science and Systems Engineering.

[3] M. A. Masrur, A. G. Skowronska, J. Hancock, S. W. Kolhoff, D. Z. Mcgrew, J. C. Vandiver, and J. Gatherer, "Military-Based Vehicle-to- Grid and Vehicle-to-Vehicle Micro grid—System Architecture and Implementation," IEEE Transactions on Transportation Electrification, vol. 4, no. 1, pp. 157–171,2018.

[4] E. Ciapessoni, D. Cirio, G. Kjolle, S. Massucco, A. Pitto, and M. Sforna, "Probabilistic risk-based security assessment of power systems considering incumbent threats and uncertainties," 2017 IEEE Power & Energy Society General Meeting,2017

[5] Yoon Lee, Shang Tan, Yeh Goh, Chern Lim. 2019 IEEE 3rd Advanced Information Management, Communicates, Electronic and Automation Control Conference (IMCEC) – 2019.

[6] Young Eun Song, Chang Il Kim, Moon Hyung Song, Gwang Soo Lee, Jae Hwan Lim, Kichang Leeand Moon Sik

Kim, "Development of Intelligent Riding Comfort Monitoring System for Automated Vehicle,"2018.

[7] L. Jiang, M. Xia, X. Liu, and F. Bai, "Givs: Fine-Grained Gesture Control for Mobile Devices in Driving Environments," IEEE Access, vol. 8, pp. 49229–49243, 2020.

[8] Feiyu Chen, Honghao Lv, Zhibo Pang, Member, IEEE, Junhui Zhang, Yonghong Hou, Ying Gu, Huayong Yang, Member, IEEE, and Geng Yang, WristCam: A Wearable Sensor for Hand Trajectory Gesture Recognition and Intelligent Human-Robot Interaction. , 2018 IEEE.