VOICE CONTROLLED AI ROBOT

Mr. K. Ramakrishna Prasad
Associate Professor,
Department of Electrical and Electronics Engineering,
Sai Spurthi Institute of Technology,
Telangana, India

Mr. J. Kanthaiah
Assistant Professor,
Department of Electrical and Electronics Engineering,
Sai Spurthi Institute of Technology,
Telangana, India.

SK. Raheemath Pasha,
Department of Electrical and Electronics Engineering,
Sai Spurthi Institute of Technology,
JNTUH, Telangana, India.

M. Meghana,
Department of Electrical and Electronics Engineering,
Sai Spurthi Institute of Technology,
JNTUH, Telangana, India.

CH. Chandu,
Department of Electrical and Electronics Engineering,
Sai Spurthi Institute of Technology,
JNTUH, Telangana, India.

B. Ramdas
Department of Electrical and Electronics Engineering,
Sai Spurthi Institute of Technology,
JNTUH, Telangana, India.

Submitted: 28-12-2025 *Accepted: 24-01-2026* *Published: 31-01-2026*

ABSTRACT

This paper presents the design and implementation of a voice-controlled AI-based robotic system using Arduino and Bluetooth communication. The proposed system enables hands-free and wireless control of a mobile robot through voice commands issued from a smartphone application. Speech input is processed by the mobile application and transmitted to the robot via an HC-05 Bluetooth module. An Arduino microcontroller acts as the central control unit, interpreting the received commands and executing predefined actions such as forward, backward, left, and right movements. The robot also supports manual control through a mobile interface and incorporates live video monitoring using a webcam connected via a mobile application. Basic artificial intelligence logic is employed to ensure efficient command interpretation and response. The system is characterized by low power consumption, reliable communication, and ease of implementation. The proposed robot is suitable for applications including home automation assistance, surveillance, education, and support for elderly or physically challenged individuals. The results demonstrate effective integration of embedded systems, Bluetooth technology, and AI-based voice control for smart robotic applications.

Keywords: Voice-Controlled Robot, Artificial Intelligence, Arduino UNO, Bluetooth Communication, HC-05 Module, Embedded Systems, Human–Robot Interaction, Mobile Application Control, Assistive Robotics.

I INTRODUCTION

The rapid growth of automation, artificial intelligence, and embedded systems has significantly transformed the interaction between humans and machines in recent years. Among various interaction methods, voice-based control has emerged as one of the most natural and efficient techniques, allowing users to operate systems without physical contact. Voice-controlled robotic systems aim to bridge the gap between human intent and machine execution by translating spoken language into actionable commands. Such systems are increasingly adopted in domains such as smart homes, healthcare, surveillance, and industrial automation due to their ease of use and accessibility [1]–[5]. The integration of low-cost microcontrollers and wireless communication technologies has further accelerated the development of intelligent robotic platforms that are both affordable and scalable.

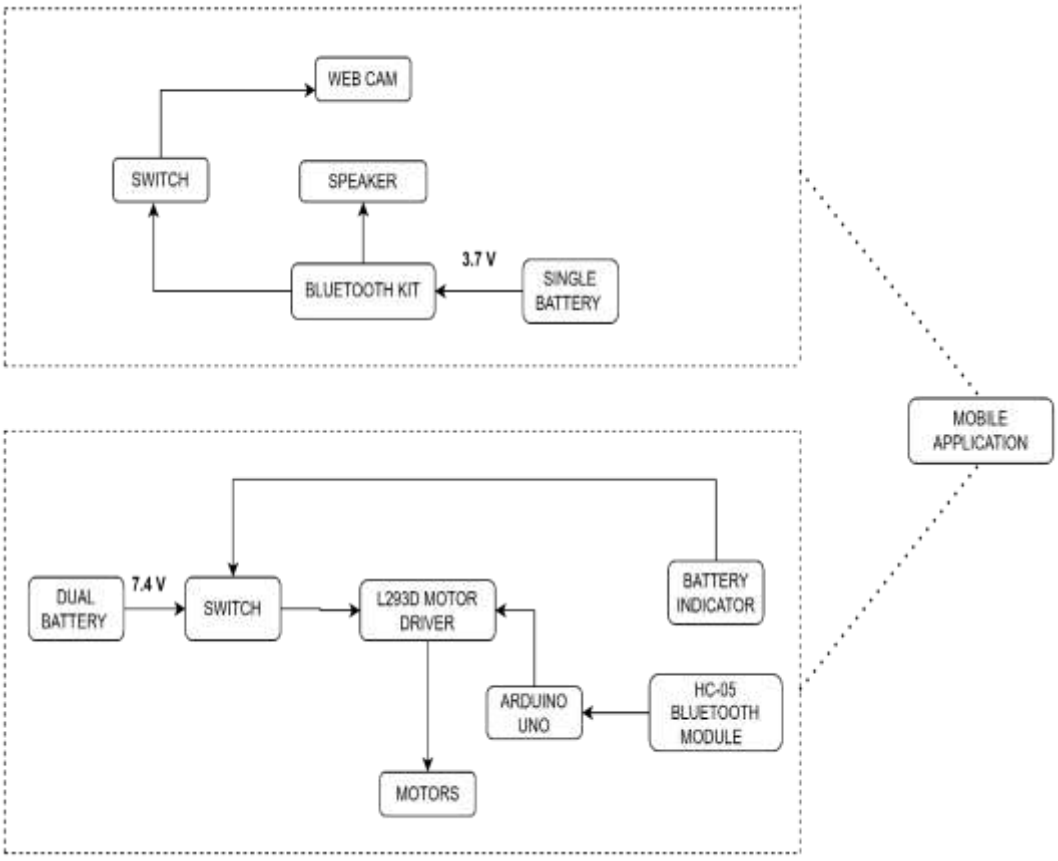

FIG 1.BLOCK DIAGRAM

Robotics combined with artificial intelligence enables machines to perform tasks intelligently by interpreting user inputs and responding appropriately. Traditional robot control methods rely on manual interfaces such as switches, joysticks, or remote controllers, which may not be suitable for all users, especially elderly or physically challenged individuals. Voice-controlled robots offer a hands-free alternative, improving usability and inclusivity [6]–[10]. With the advancement of mobile technologies, smartphones now provide powerful platforms for speech recognition, enabling accurate and real-time voice processing. When combined with

embedded controllers like Arduino and wireless modules such as Bluetooth, voice-based control systems become highly practical for real-world applications [11]–[14].

Wireless communication plays a crucial role in modern robotic systems by enabling flexible and remote operation. Bluetooth technology, in particular, is widely used for short-range communication due to its low power consumption, simplicity, and reliability. Bluetooth-based robotic control systems allow seamless interaction between mobile devices and robots without the need for complex infrastructure [15]–[18]. In addition, integrating camera modules and live video streaming enhances situational awareness, making robots suitable for surveillance and monitoring tasks. The combination of voice commands, wireless communication, and real-time visual feedback significantly improves the functionality and intelligence of robotic platforms [19]–[22].

This paper focuses on the design and implementation of a Voice-Controlled AI Robot that integrates Arduino-based control, Bluetooth communication, AI-assisted voice interaction, and live video monitoring. The proposed system supports both voice-based and manual control through mobile applications, ensuring flexibility and reliability. By incorporating basic artificial intelligence logic, the robot can efficiently interpret commands and perform predefined movements such as forward, backward, left, and right navigation. The system demonstrates a cost-effective and user-friendly approach to intelligent robotic control, making it suitable for educational, assistive, and surveillance applications. The work contributes to the growing field of human–robot interaction by presenting a practical implementation that combines embedded systems, AI-based voice control, and wireless technologies [23]–[30].

II LITERATURE SURVEY

Several researchers have explored the development of voice-controlled robotic systems to improve human–machine interaction and automation efficiency. Early studies focused on basic speech recognition techniques integrated with microcontrollers to enable simple robot movements. These systems primarily relied on predefined voice commands and wired communication, limiting their flexibility and scalability [1]–[4]. With advancements in wireless communication, researchers began incorporating Bluetooth and Wi-Fi technologies to achieve remote control of robots using smartphones and computers. These approaches demonstrated improved mobility and ease of use, but often lacked intelligence and adaptability in command interpretation [5]–[8].

Recent research has emphasized the use of mobile-based speech recognition to overcome the limitations of hardware-dependent voice modules. Smartphone applications provide higher accuracy and processing power, enabling real-time speech-to-text conversion and command transmission to robotic systems [9]–[12]. Studies have shown that integrating Arduino microcontrollers with Bluetooth modules such as HC-05 offers a cost-effective and reliable solution for short-range robotic control. However, most of these systems focus primarily on movement control and do not incorporate advanced features such as visual monitoring or intelligent decision-making [13]–[16].

The integration of artificial intelligence into robotic control has gained significant attention in recent years. Researchers have explored AI-based assistants and natural language processing techniques to enhance command interpretation and enable more natural interaction between humans and robots [17]–[20]. Some works have introduced machine learning algorithms to allow robots to adapt to user behavior and environmental conditions. Additionally, the inclusion of camera modules and computer vision techniques has expanded the application scope of robots to surveillance, object detection, and navigation tasks [21]–[24]. Despite these advancements, many AI-enabled robotic systems remain complex and expensive, limiting their adoption in low-cost and educational environments.

Existing literature indicates a gap between highly intelligent robotic systems and simple, affordable implementations suitable for practical use. There is a growing need for robotic platforms that balance intelligence, cost, and ease of implementation. The proposed Voice-Controlled AI Robot addresses this gap by combining mobile-based AI voice interaction, Bluetooth-based control, Arduino-driven motor actuation, and real-time video streaming in a single system. This approach provides an effective compromise between functionality and simplicity, making it suitable for applications such as assistive robotics, education, and basic surveillance. By integrating commonly available hardware components with AI-enabled mobile applications, the proposed system builds upon existing research while offering improved usability and expandability [25]–[30].

III METHODOLOGY AND SYSTEM DESIGN

The methodology adopted in the development of the Voice Controlled AI Robot focuses on the seamless integration of hardware components, software logic, and wireless communication to achieve reliable and user-friendly robot control. The system is designed to convert human voice commands into machine-executable actions using a mobile-based interface. A smartphone application is used as the primary input device, where voice commands are issued by the user. These commands are processed through speech recognition within the mobile application and converted into corresponding digital instructions. The processed commands are then transmitted wirelessly to the robotic system using Bluetooth communication. This approach eliminates the need for physical controllers and enables hands-free operation, making the system suitable for assistive and automation-based applications. The overall design emphasizes simplicity, low cost, and ease of implementation while maintaining effective real-time response.

The hardware architecture of the proposed system is centered around an Arduino UNO microcontroller, which acts as the main control unit. The Arduino receives command data from the Bluetooth module through serial communication and processes it according to predefined logic stored in its program memory. A Bluetooth module such as HC-05 is used to establish a reliable short-range wireless link between the mobile device and the robot. The processed output signals from the Arduino are forwarded to a motor driver circuit, specifically the L293D motor driver, which is responsible for controlling the direction and motion of the DC gear motors. Since the Arduino cannot directly drive high-current loads, the motor driver acts as an interface that amplifies control signals to operate the motors safely.

The DC gear motors are mechanically coupled to the wheels, allowing the robot to move forward, backward, left, and right. A ball caster wheel is used to provide balance and smooth turning during movement. The entire system is powered using lithium-ion batteries, ensuring portability and uninterrupted operation.

The software methodology involves both mobile-side processing and embedded programming. On the mobile side, a voice control application is used to capture user speech and convert it into digital commands using built-in speech-to-text functionality. Each recognized command is mapped to a specific control instruction such as forward, backward, left, right, or stop. These instructions are transmitted to the robot through Bluetooth in the form of serial data. On the embedded side, the Arduino is programmed using the Arduino Integrated Development Environment (IDE) with embedded C language. The program continuously monitors incoming serial data from the Bluetooth module. When a valid command is received, the Arduino compares it with predefined command values and triggers the appropriate control logic. Pulse Width Modulation (PWM) techniques are employed to regulate motor speed, ensuring smooth and controlled movement. This combination of mobile-based processing and microcontroller-based execution enables efficient command interpretation and real-time control.

The working methodology of the system follows a structured sequence of operations to ensure accurate execution of voice commands. Initially, the robot is powered on and paired with the mobile device via Bluetooth. Once the connection is established, the user issues a voice command through the mobile application. The application processes the speech input and sends the corresponding command to the Bluetooth module mounted on the robot. The Arduino microcontroller reads the incoming serial data and identifies the intended operation. Based on the identified command, the Arduino activates the motor driver circuit, which drives the DC motors accordingly to produce the desired movement. Simultaneously, a camera mounted on the robot provides live video streaming through a mobile application, allowing the user to visually monitor the robot's surroundings in real time. This integrated methodology ensures smooth coordination between voice input, wireless communication, embedded control, and mechanical actuation, resulting in a responsive and intelligent robotic system suitable for practical applications.

IV EXPERIMENTAL RESULT

The experimental evaluation of the Voice Controlled AI Robot was conducted to verify the effectiveness of voice-based control, wireless communication, and real-time operation under practical conditions. The robot was assembled using the designed hardware components and tested in an indoor environment with sufficient Bluetooth and Wi-Fi connectivity. During experimentation, the robot was powered using lithium-ion batteries and paired with a mobile device through a Bluetooth module. Voice commands such as forward, backward, left, right, and stop were issued through a mobile application, and the robot's response to each command was carefully observed. The experimental setup ensured that all components operated simultaneously, including the Arduino controller, motor driver, Bluetooth module, motors,

and camera system. The testing process focused on validating real-time responsiveness, movement accuracy, and stability during operation.

The experimental results demonstrated that the robot successfully responded to voice commands with minimal delay. Once the Bluetooth connection was established, the robot consistently executed the received commands without noticeable communication errors. The Arduino microcontroller accurately interpreted serial data received from the Bluetooth module and activated the motor driver accordingly. Forward and backward movements were smooth, and directional changes such as left and right turns were executed precisely with the support of the DC gear motors and ball caster wheel. The robot maintained balance during motion and was capable of continuous operation for an extended period, limited only by battery capacity. Manual control through the mobile application was also tested, and the system performed reliably in both voice-controlled and manual modes, indicating flexibility in operation.

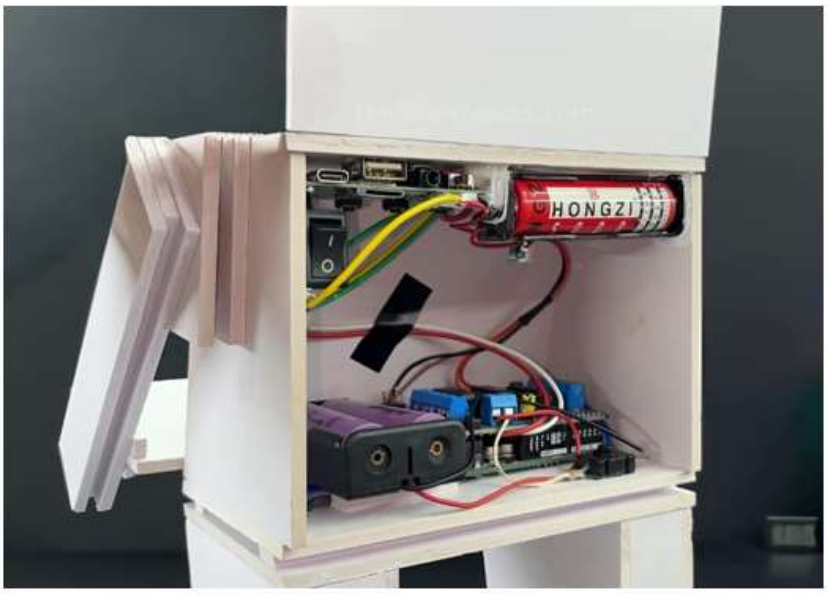

FIG 2. INTERNAL VIEW OF THE ROBO

The internal view of the robot provides insight into the physical integration and arrangement of electronic components. The Arduino UNO board was centrally placed to ensure easy connectivity with peripheral modules. The motor driver was positioned close to the motors to reduce wiring complexity and minimize power loss. The Bluetooth module was mounted in a location that ensured stable wireless communication without obstruction. Lithium-ion batteries were securely housed using cell holders to provide consistent power supply to the system. Proper insulation and organized wiring were maintained to avoid short circuits and ensure safe operation. This internal arrangement highlights efficient space utilization and reliable hardware integration, contributing to the overall stability and performance of the robotic system.

FIG. 3 OUTPUT IMAGE OF THE ROBO

The external view of the robot illustrates the complete assembled structure and real-time operational readiness. The DC gear motors were firmly attached to the wheels, enabling smooth movement across flat surfaces. A ball caster wheel was mounted at the front or rear to provide balance and facilitate easy turning. The camera module or smartphone used for live video streaming was securely mounted on the robot, offering a clear view of the surroundings during movement. Live video transmission through the IP Webcam application was successfully tested, allowing remote visual monitoring of the robot's path and environment. The external design emphasizes portability, compactness, and practical usability. Overall, the experimental results confirm that the proposed system performs effectively under real-world conditions, validating the design methodology and demonstrating the successful implementation of a voice-controlled AI robotic platform.

V CONCLUSION

The Voice Controlled AI Robot project successfully demonstrates the effective integration of artificial intelligence, wireless communication, and embedded system technologies to develop an interactive and user-friendly robotic platform. The system enables hands-free control of a mobile robot through voice commands issued via a smartphone, which are processed and transmitted using Bluetooth communication. The Arduino microcontroller efficiently interprets these commands and controls the motor driver and DC gear motors to perform accurate movements such as forward, backward, left, right, and stop operations. Experimental evaluation confirms that the robot responds reliably to voice inputs with minimal delay and stable performance. The integration of live video streaming using a camera module further enhances system functionality by providing real-time visual feedback, making the robot suitable for monitoring and navigation tasks. The compact design, low power consumption, and cost-effective hardware components contribute to the practicality and portability of the system. Overall, this project highlights the potential of combining mobile-based AI voice interaction with embedded control systems to achieve intelligent robotic operation. It serves as a valuable learning platform for understanding human–machine interaction, wireless control, and real-time system implementation, and lays a strong

foundation for future advancements in assistive robotics, automation, and smart robotic applications.

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