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Interactive Control of a Robotic Arm using Voice Recognition

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Abstract

This research focuses on interactive control of a robotic arm using voice recognition, providing a user-friendly approach to controlling robotic systems through voice commands. The system is built on Arduino, integrating key components such as servo motors for precise movements, Bluetooth for wireless communication and motor drivers for higher torque applications. The HC-05 Bluetooth module supports voice recognition, enabling external devices to control the robotic arm through voice commands. This setup allows for quick responses and minimal human intervention. The proposed robotic arm supports actions such as pick and place, moving forward, backward, right, and left.

Keywords: Voice Recognition, HC-05 Bluetooth Module, Servo Motor, Robotic Arm, Arduino.

1. Introduction

The incorporation of voice recognition technology with robotic systems signifies a notable progression in the realm of human-robot interaction. This proposed method aims to develop an interactive management system for a robotic arm using voice recognition, with the objective of establishing a platform for seamless interaction and task execution. Recently, there has been a rising interest in developing robotic systems capable of comprehending and responding to commands, providing users with a more seamless and efficient method of communication. By integrating a robotic arm into the framework, the research scopes to

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enhance its capacity to carry out physical tasks such as object handling and assembly, thereby enhancing its usefulness across various applications, ranging from manufacturing to assistive robotics. This research investigates the hardware and software components necessary for building such a system, including the selection of sensors, actuators, and speech recognition algorithms. These components and software's are integrated to develop robust control algorithms to ensure accurate and reliable operation. The experiments carried out on the proposed robotic arm proved its capability to respond according to the commands given.

1.1 Objectives

To construct a robot that can be operated using voice commands by integrating the speech recognition component with the hardware to execute instructions.

2. Literature Review

The robotic arm for picking and placing items is a crucial technology in manufacturing industries, specifically designed to execute these operations efficiently. This study emphasizes the importance of adhering to safety protocols, when performing tasks such as sending robotic vehicles into hazardous areas to collect samples for chemical analysis [14], Wireless cameras accessible through the application facilitate remote monitoring and control of camera movements [1]. This research utilizes a vehicle that is fitted with a Bluetooth module, microphone, and speaker for receiving voice commands and delivering responses. It employs the Easy VR voice recognition module for interpreting and understanding voice instructions. The Arduino interacts with the motor controller to regulate the vehicle's motion. The system's efficiency is validated through multiple trials and evaluations [2]. This study investigates the voice command analysis for a collaborative robot, emphasizing the examination of different voice directives, their consistency, and dependability in human-robot collaboration [3]. This study developed and constructed a voice-operated pick-and-place robot using Raspberry Pi. Python, an open-source programming language known for its simplified syntax, utilized to program the Raspberry Pi-based robot [4]. This study focuses on creating a voice command system using the ROS middleware framework. The voice control system was tailored for the JACO 2, a 6-degree-of-freedom assistive robotic arm. Two individuals affected by neurodegenerative conditions tested the usability of the robot, controlling it through the JACO 2 joystick and the newly developed voice command system [5]. The setup enables an Android device to command a robotic arm. The Android device transmits Bluetooth instructions, which

are received by the Bluetooth receiver integrated into the receiver circuit. The Bluetooth receiver is connected to the 8051 microcontroller, which processes incoming signals. It then directs the motor to move the robotic arm in accordance with the received commands [6]. This system is designed for controlling a robot using speech commands. The speech is captured by a microphone and processed on a computer using Mel Frequency Spectral Coefficients algorithms. Subsequently, the commands are converted into a format that the robot can understand and execute movements accordingly. It operates through an Android device that sends voice commands to a Raspberry Pi to enable this functionality [7]. This study designed and constructed a pick-and-place robotic arm vehicle that can be controlled through an Android application using voice commands. The controller (ATMEGA328P) was programmed using the Arduino programming language, a simplified and open-source variant of C++ known for its user-friendly architecture. Integration of the control unit with a Bluetooth device enabled the capture and interpretation of voice commands [8]. This research discusses the transmission of commands to control the movement of the robot through an Android application. Four motors are connected to the microcontroller: two for controlling the arm and gripper movements, and two for controlling the body movement of the robot [9]. The project aims to develop a pick-and-place robotic arm vehicle equipped with a soft-catching gripper designed to minimize pressure on sensitive objects (such as bombs) for safety purposes. The robotic vehicle is controlled remotely through an Android application. A key feature of this robot is its soft robotic gripper, which prevents exerting excessive pressure on delicate objects, ensuring safety during operations [10].

This study focuses on enabling the Easy VR module to convert voice commands received from the transmitter into digital signals. These signals are then transmitted to the robot through a ZIGBEE module. On the receiver side, another ZIGBEE module receives these commands and executes the corresponding operations [11]. This study aims to utilize a Bluetooth module, interface controller, and Android integration. The controller interfaces with the Bluetooth module through UART protocol. Based on commands received from Android, the motion of the robot can be controlled [12]. The research aims to create a pick-and-place robotic vehicle equipped with a soft robotic gripper, designed to safely handle delicate objects such as bombs to prevent accidental detonation. Commands from the Android application is transmitted to the receiver to govern the vehicle's movements [13]. This research details the

development of a robotic arm controlled wirelessly through hand gestures. The robotic system consists of two main assemblies: a transmitter assembly mounted on gloves, which includes an APC-220 module, Arduino board, gyroscope, and accelerometer; and a receiver assembly (the robotic arm) featuring an APC-220 module, Arduino board, servo motors, and arms mounted on a circular revolving base constructed from acrylic sheets [15]. The proposed work aims to design a budget-friendly pick-and-place robotic arm that responds to voice commands, addressing the expense typically associated with existing models.

3. Proposed Work

The aim of this research is to develop a budget-friendly robotic arm that responds to voice commands. The system integrates various components, including servo motors for precise movements, a servo motor driver for controlling multiple servos, a Bluetooth module for wireless communication, and a DC gear motor for high torque operations. A DC converter and motor driver manage power effectively, supported by a 12V battery as the primary energy source. An LCD display system provides feedback and status information. Designed for simple household tasks, this proposed design aims to innovate robotics by merging voice control with robotic manipulation, opening new applications for more natural and efficient human-robot interactions. Commands are given as input through a voice-controlled app, transmitted to an Arduino UNO through a Bluetooth module, and displayed on the LCD. Figure 1 illustrates the block diagram and the Table 1 shows the details of the components used.

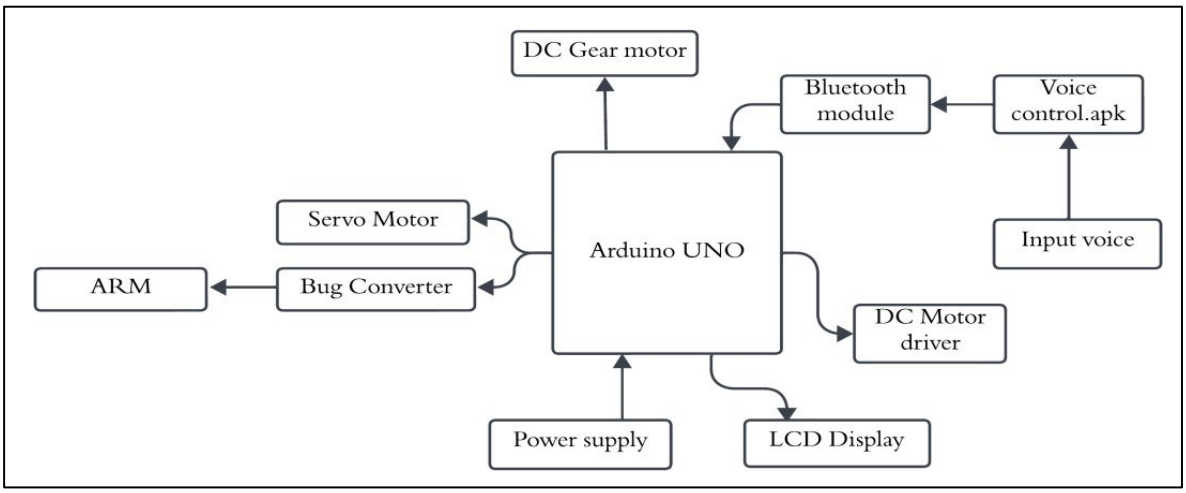


Figure 1. Block Diagram

Table 1. Components and Uses

Name of the Components	Uses	Model
Arduino Uno	Data from several drivers and motors can be processed by Arduino UNO	UNO R3
Servo Motors	Ensures accurate positioning and precise angular control	SG 90
Servo Motor Driver	Controls the servo motor based on the commands received from the Arduino	16C X 12
Bluetooth Module	Enables wireless communication	HC 05 Bluetooth 3.0, Serial Port Profile (SPP)
Dc Convertor	Converts DC Voltage (e.g., 12V to 5V)	LM 2596 Converts DC Voltage (e.g., 12V to 5V)
Motor Driver	Provides the necessary power and signals to drive the motors. ensures smooth and controlled movement of the robotic arm's actuators, such as grippers or other end-effectors.	L298N
DC Gear Motor	used in joints or for lifting operations in robotic arms by providing various torque ratings and speed capabilities suitable for moving heavier parts of the robotic arm	775 (12V)
Battery	Serves as the primary power source for the robotic arm system. Powers all components, including the Arduino, motors, and peripherals.	12 V
LCD Display	Provides visual feedback and status information	16 X 2 or 20 X 4 LCD

- **Arduino UNO R3**

A brain of the robotic arm is known as Arduino. It is responsible for any movements happening while executing the command. Arduino's flexibility allows customization and integration of additional features which are needed. This mapping is very essential for quick

and accurate execution of robotic arm movements. It involves associating each command with the appropriate servo or motion action. Figure 2. shows the Arduino UNO R3.

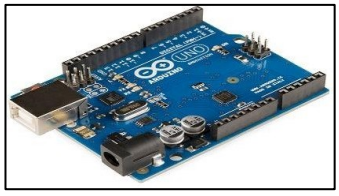


Figure 2. Arduino UNO R3

- **LCD Display**

An LCD screen can display useful information to the user such as the current command, system status or error messages. This feedback helps users understand the system's operation and troubleshoot any issues. Figure 3. shows the LCD Display 2 x 16.

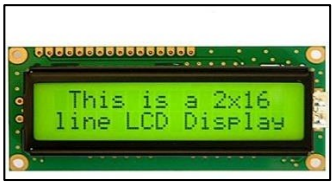


Figure 3. LCD Display 2 x 16

- **Servo Motors**

The Servo Motors is mainly used for the robotic arm's precise angular movements. The servo motor driver allows for a multi axis control and complex movements. The Arduino send a signal to control the angle and speed of the servos, enabling precise control over the arm's movements. Figure 4. shows the Servo Motor SG90.

Figure 4. Servo Motor SG90

- **DC Gear Motor**

To manage heavier movements such as lifting or rotating larger sections of the arm, DC motors are utilized. These motors offer increased torque, crucial for handling heavier loads.

Motor drivers regulate the speed and direction of the DC motors, following commands from the Arduino to ensure smooth and controlled operation. Figure 5. shows the DC Gear Motor 775 (12V).

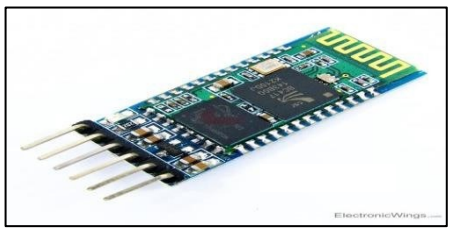
Figure 5. DC Gear Motor 775 (12V)

- **Battery**

The DC convertor manages the system power needs, converting the energy from a 12V battery to a suitable level for the robotic arm's components. This stable power source ensures consistent performances and reduces the risk of power related malfunctions

- **Microphone and Bluetooth Module**

The initial point of interaction is the microphone through which it captures a voice commands. The microphone should be in a good condition. It should capture a command properly so that a voice-controlled robot can move correctly according to it. The Bluetooth module has connected the robotic arm with the external device, providing a wireless communication. It operates in a range of 10-15 meters.



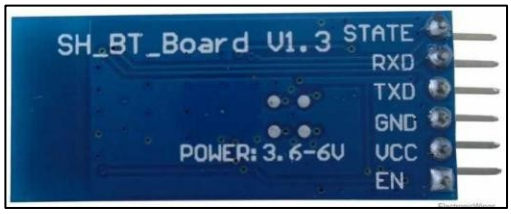


Figure 6. Bluetooth module HC-05 **Figure 7.** Bluetooth Module HC-05 Pin Diagram

Figure 6. shows Bluetooth Module HC-05 and Figure 7. shows Bluetooth Module HC-05 Pin Diagram. The Bluetooth serial module HC-05 facilitates communication between serial-enabled devices through Bluetooth.

4. Working Principle

The exploration of interactive robotic arm control begins with a detailed breakdown of its operational process, components, and safety features, offering a comprehensive understanding of its functionality. Initially, the user communicates commands through voice inflections into a microphone. These commands are then transmitted wirelessly to the robotic arm through a Bluetooth module like the HC-05, enabling seamless connectivity with external devices such as smartphones or tablets. The Bluetooth module plays a critical role in the system by facilitating remote control without the limitations of wired connections, thereby enhancing flexibility and user convenience. Figure 8. shows the flowchart of Voice Recognition

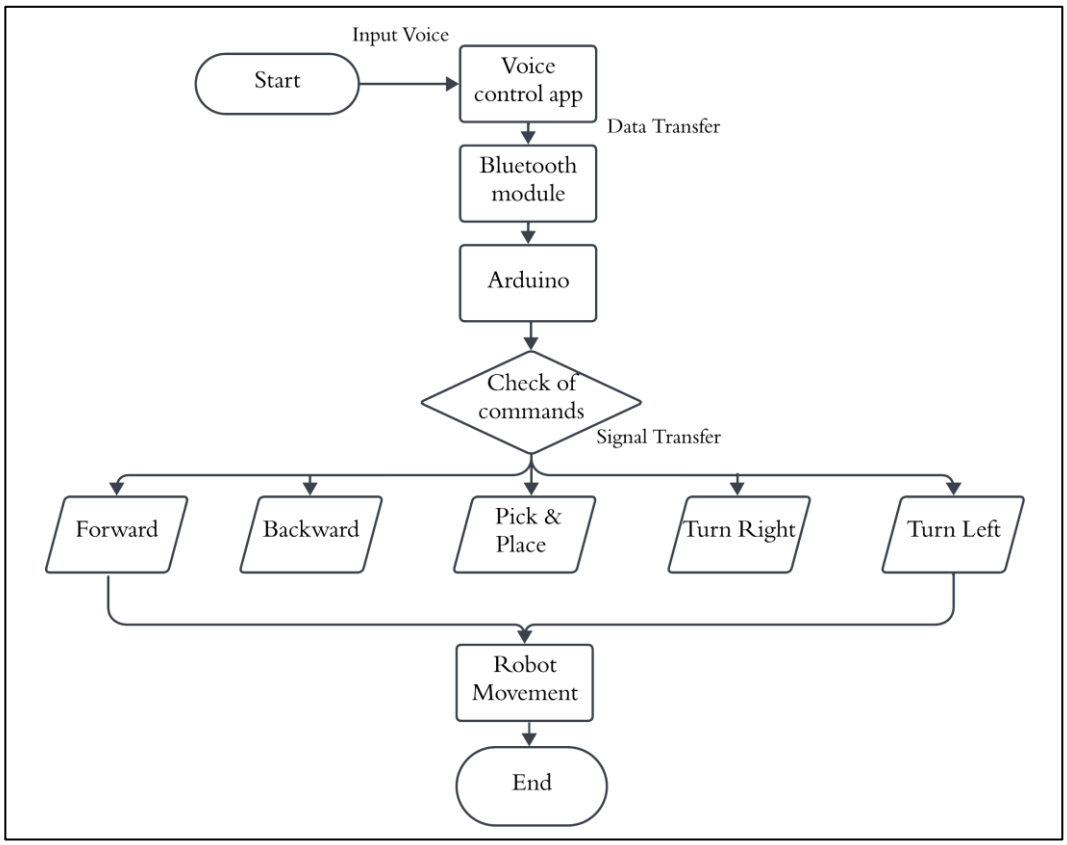


Figure 8. Flowchart of Voice Recognition

4.1 Software Used

The Android application for our voice-controlled robot can be created using the MIT App Inventor. Figure 9 shows the interface of MIT App Inventor, displaying the block design developed for the application. The Arduino is programmed using a variant of C++ to handle commands and regulate connected components, with necessary libraries added to ensure smooth functionality. The code is developed and uploaded using the Arduino IDE.

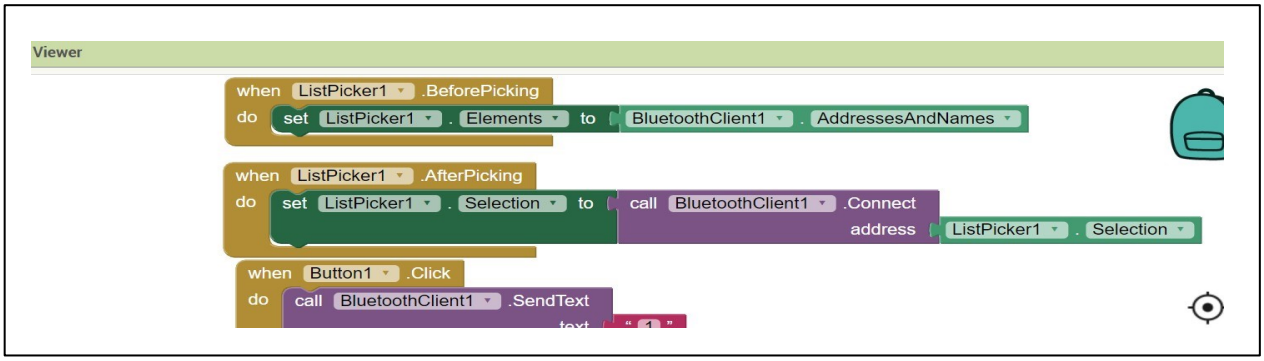


Figure 9. Block Design of App

4.2 Voice Recognition Application

The proposed design utilizes a voice recognition application to process input commands accurately and efficiently. This software is crucial for recognizing and executing correct commands, often incorporating preprocessing features to enhance speech-to-text accuracy. A software used in this project is 'VoicrControlled,' available for download as a mobile application. Figures 10 and 11 display the interface of the app and logo.

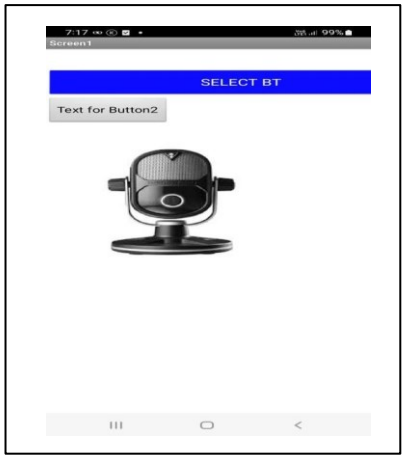


Figure 10. Interface of the App

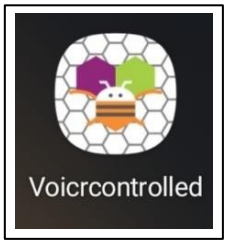


Figure 11. Logo of the App

5. Results and Discussion

The hardware prototype of the proposed work is displayed below. Figure 12.

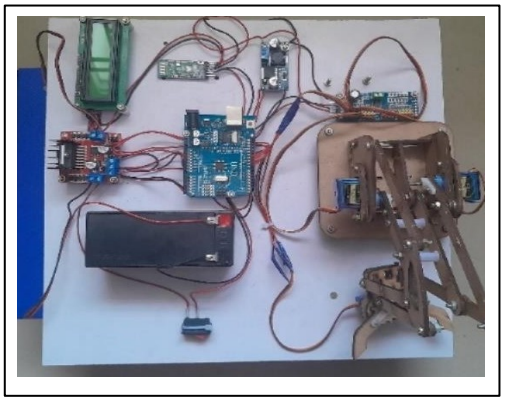


Figure 12. Proposed Model

Open the VoicrControlled App and give the command of the pick and place. The command will be displayed in the LCD. Figure 13. shows command displaying in LCD Display.

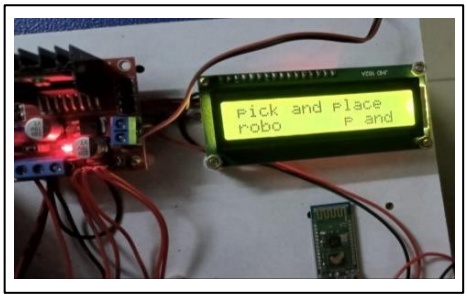


Figure 13. Command Displaying in LCD

After that the Robotic arm responds to the command by picking up the object and placing it. Figure 14. shows an object is picked.

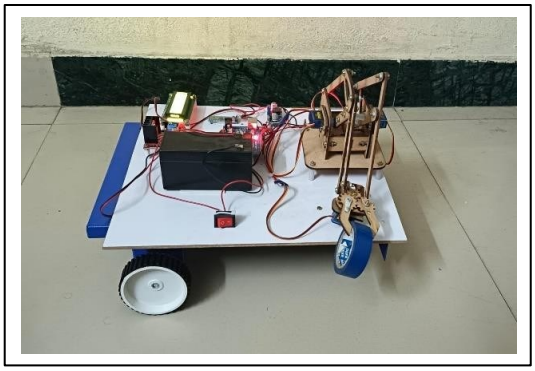


Figure 14. An Object is Picked

Figure 15 depicts the object placed using the robotic arm.

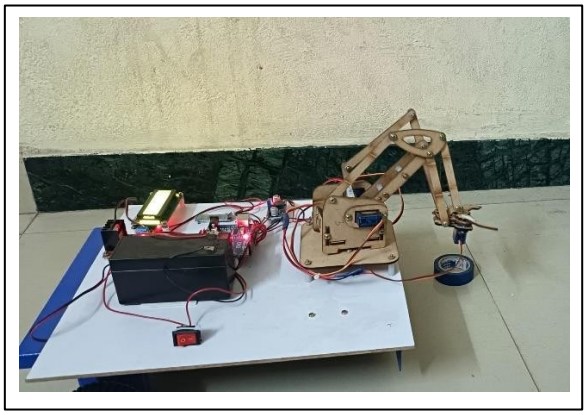


Figure 15. An Object is Placed

The research combines voice control technology with a robotic arm for user interaction and control. It includes servo motors for reliable movement, a Bluetooth module for wireless communication, and an Arduino-based control system. The robotic arm demonstrates automation and assistive technology applications. Voice commands are the primary interface, aimed at reducing human involvement. Improving voice recognition accuracy and robustness remains a challenge. The research aims to enhance voice recognition capabilities in the future through advancements in machine learning and data processing. Integration with technologies like computer vision could further enhance the robotic arm's autonomy, situational awareness, and capability for complex interactions and tasks.

6. Conclusion

The research develops a robotic arm that can be controlled interactively using voice commands, using advanced technologies like servo motors for precise movement and Bluetooth for wireless communication. It focuses on making robot control more intuitive and accessible, moving away from manual controls to voice commands. This shift aims to improve efficiency and create new possibilities, especially for helping people with disabilities. By combining different technologies, the research aims to make robots more responsive and useful in everyday tasks, marking a step forward in how humans and robots can work together effectively.

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