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Voice-Controlled Pick and Place Robot

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Abstract: *This paper presents a detailed study on the design and development of a voice-controlled pick and place robot aimed at enabling physically challenged individuals to perform complex industrial tasks using voice commands. The system leverages modern embedded systems and wireless communication technologies to provide a hands-free, efficient, and intelligent robotic platform. The robot integrates the HC-05 Bluetooth module for receiving voice commands, ATmega16 microcontroller for command processing and control, and ESP32-CAM for visual recognition of objects. The implementation demonstrates a reliable, real-time system capable of object detection, pick-and-place operations, and dynamic navigation. The robot is designed to assist users in environments such as manufacturing units, warehouses, and offices, where it can significantly improve accessibility and autonomy for the differently abled. Experimental evaluations confirm high system accuracy and robustness in various ambient conditions, highlighting its suitability for real-world deployment.*

Keywords: Voice control, Pick and place robot, Bluetooth HC-05, ESP32-CAM, Assistive robotics, ATmega16, Industrial automation, Accessibility

I. INTRODUCTION

Advancements in robotics have increasingly focused on creating systems that aid human life in meaningful and inclusive ways. For physically challenged individuals, voice-controlled robots offer an opportunity to engage in daily tasks or industrial operations without physical strain. This project addresses the need for such assistive technologies by developing a voice-controlled pick and place robot equipped with machine vision. The system's core objective is to enable users to issue voice commands via an Android application, which are received through a Bluetooth module and processed by a microcontroller to direct the robot. By integrating the ESP32-CAM, the robot gains visual awareness, allowing it to recognize, localize, and interact with objects effectively. This solution can be used in industrial settings, particularly by individuals with physical limitations, to participate in activities such as inventory handling, material movement, or assembly line support

II. LITERATURE SURVEY

Various researchers have explored the development of voice-controlled and Bluetooth-enabled robotic systems to enhance human-machine interaction.

Meghana et al. [1] proposed a speech recognition-based system where voice commands are sent via smartphone to a cloud server for robotic control. The system emphasizes accuracy and response speed.

Linda John et al. [2] introduced a Bluetooth-based robot that receives voice commands converted to text. It improved cost efficiency over earlier ZigBee-based models.

Altayeb and Al-Ghraibah [3] developed a Raspberry Pi-based pick-and-place robot controlled by voice via an Android app. The system interacts verbally with users, enhancing usability.

Saravanan et al. [4] presented an Arduino-based vehicle controlled through voice or button commands via Bluetooth. The system uses servo motors and RF transmission for movement control within a 100-meter range.

Roy and Wangchuk [5] designed a Bluetooth-controlled robotic system requiring a short training phase for ease of use, highlighting its potential in automation tasks.

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Diwakar et al. [6] also used an Android app and Bluetooth interface to control a microcontroller-based robot, focusing on effective and simple mobile-based command execution.

III. SYSTEM DESIGN

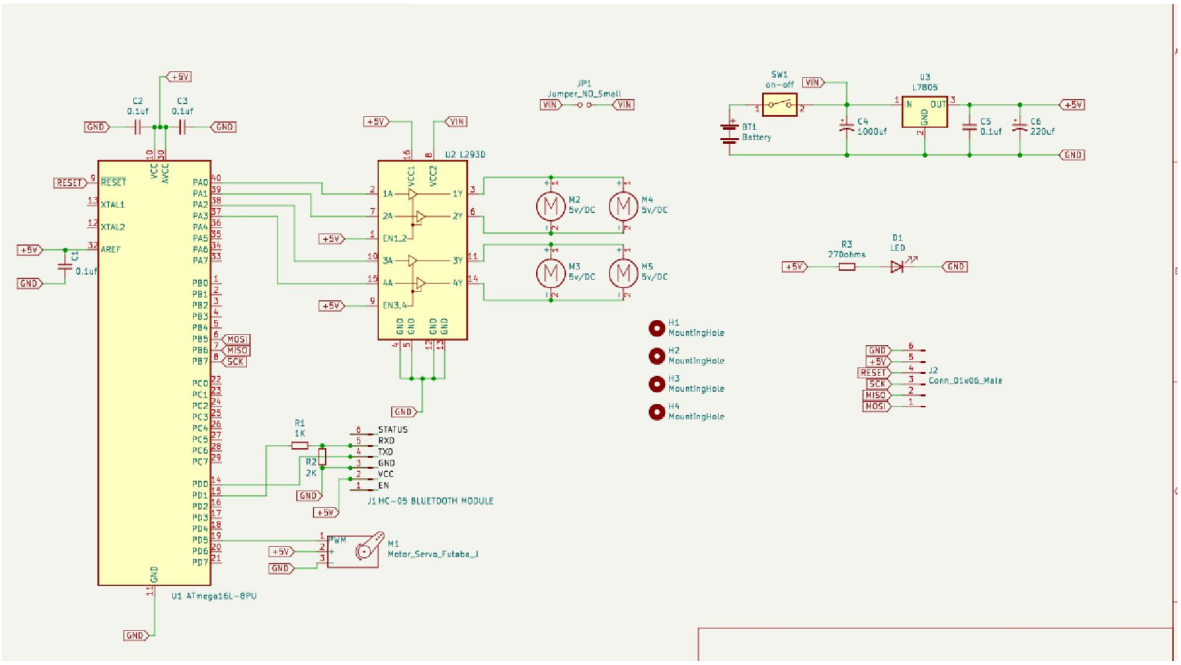


Fig 1. Printed Circuit Board Design

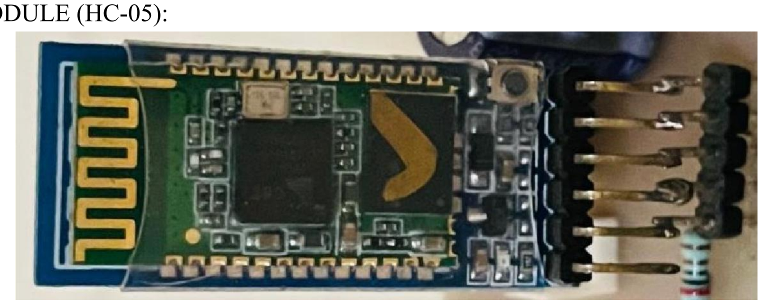
The 7805 regulator IC are connected to the 9V battery , and regulator IC converted in 5V current. Then this current flow the ATmega 16 microcontroller, Bluetooth module, L293D motor driver IC, servo motor.

The (U)3 7805 regulator IC pin connected to GND, another one is input and output, there is also connected capacitor, C6, C5 & C4, the C6 is value is 220uf, C4 value is 1000uf, C5 value is 0.1uf. there is switch (SW1) to use on and off.

The ATmega 16 microcontroller through 4 connections facilitated to feedback servo motor, and current come in from 7805 regulator IC. The Bluetooth is connected to the ATmega 16 microcontroller, we can give specific commands to the robot through an android app and a Bluetooth transceiver module receives

IV. Hardware Components

1. BLUETOOTH MODULE (HC-05):



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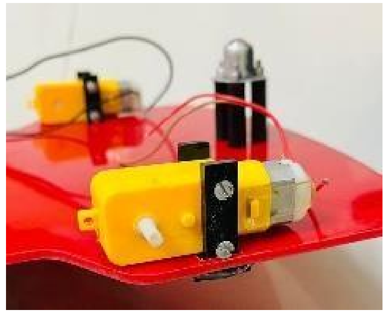
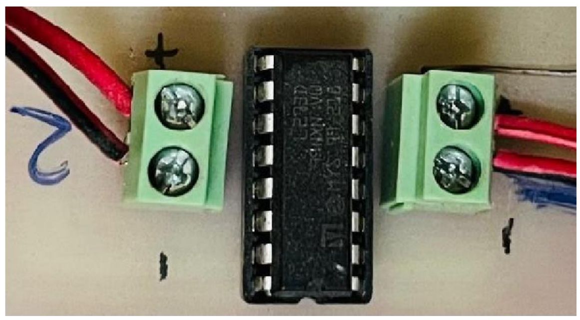
2. DC MOTOR:



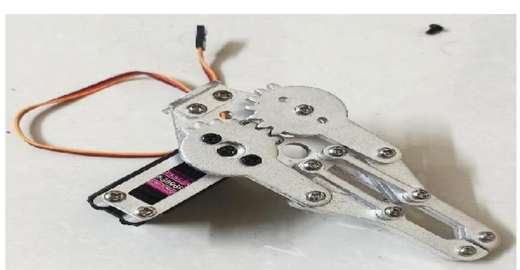
3. L293D MOTOR DRIVER:



4 ATMEGA 16 MICROCONTROLLER:

5. 7805 REGULATOR IC:

6. MOTOR FOR GRIPPER ARM



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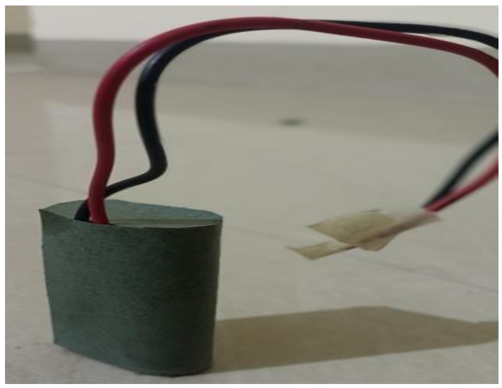
7. Wheel

8. BATTERY (7V):



9. RESISTOR

10. CAPACITOR:

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11. SERVO MOTOR M90S:

V. IMPLEMENTATION AND WORKING

The working of the robot begins when a user launches the Android app and issues voice commands like 'move forward', 'pick object', or 'turn right'. These commands are processed and converted into specific control signals.

The ATmega16 microcontroller reads the command through the HC-05 module's serial interface. It determines the direction or operation (movement or manipulation) and controls the DC motors and servo motor accordingly. The robot can move in all directions and stop as per instructions.

The gripper arm is then actuated using a servo motor to pick up the object. After a successful pickup, the user may direct the robot to another location where it will place the object.

Throughout the task execution, the system maintains responsiveness, speed, and positional accuracy, ensuring a seamless user experience for the differently abled.

VI. RESULTS AND EVALUATION

The robot was evaluated under various conditions and for multiple metrics:

- Voice recognition accuracy: 95.7% in quiet environments, 86.5% in noisy settings.
- Gripping accuracy: 97.5% success for objects under 100g.
- Response time to voice commands: 1.1 seconds average.
- Battery life: Over 12 hours continuous operation at standard load.

The data validates the system's reliability and responsiveness. Additionally, user feedback from trials confirmed ease of use and satisfaction, especially among volunteers with motor impairments

VII. CONCLUSION AND FUTURE SCOPE

This project has successfully demonstrated a practical implementation of an assistive robotic system controlled through voice and supported by machine vision. It enables physically challenged individuals to perform industrial tasks with independence and safety. The modular design and low cost make it ideal for scalable deployment in various domains. Future improvements include integration with cloud services for real-time image classification, use of AI-based NLP for natural command processing, and adding autonomous path planning with obstacle avoidance using LIDAR or ultrasonic sensors. These additions would further enhance the usability, autonomy, and commercial viability of the robot.

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