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# VOICE-ACTIVATED ROBOTIC ARM USING RASPBERRY PI PICO

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## ABSTRACT
This paper creates a voice-controlled robotic arm that can perform tasks based on spoken commands sent through a mobile app. It uses Bluetooth to connect the app to a Raspberry Pi Pico microcontroller, making the control process smooth and wireless. The robotic arm is made up of carefully chosen hardware, like DC motors for basic movements and servo motors for precise actions. By combining these elements, the arm can handle various tasks effectively. Using the Raspberry Pi Pico adds flexibility and affordability to the system, allowing for future improvements and expansions. Overall, this paper simplifies human-robot interaction by introducing voice commands, making it easier for users to control the robotic arm from their mobile devices.

## 1 INTRODUCTION
This paper introduces a user-friendly interface for controlling robotic arms, addressing the complexity often associated with traditional methods. By integrating voice commands and a mobile app, it aims to make robotic arm manipulation more intuitive and accessible.
Utilizing Bluetooth and a Raspberry Pi Pico microcontroller, the system enables seamless communication between user commands and robotic actions. This approach overcomes challenges inherent in traditional control mechanisms. The report details the system's development, functionality, and potential applications across educational, assistive, and industrial sectors. By bridging the gap between human and machine interaction, the paper demonstrates the feasibility of integrating voice control into robotics, laying the groundwork for future advancements.

### Background and Motivation
This paper aims to democratize access to robotics by developing a voice-controlled robotic arm using Raspberry Pi Pico. By leveraging Raspberry Pi's versatility and the RP2040 chip, it simplifies interaction with robotic systems, making them accessible to hobbyists, students, and enthusiasts.
Integrating voice control enhances convenience and versatility, allowing hands-free operation and intuitive commands. This innovation has broad applications, including home automation, assistive technology, educational papers, and industrial automation prototyping.
By showcasing the potential of Raspberry Pi Pico and voice recognition technology, the paper inspires creativity and innovation in robotics and embedded systems, fostering learning and accessibility in the field.

**Objectives of the paper**

1. Robotic Arm Construction: Utilize Raspberry Pi Pico to build a robotic arm.
2. Voice Control Integration: Integrate voice recognition for verbal control of the robotic arm.
3. Precision Movement: Ensure accurate arm movements for tasks like object manipulation.
4. User-Friendly Interface: Develop an intuitive interface with feedback for easy arm control.
5. Scalability: Design for future upgrades, integrating more sensors or actuators.
6. Documentation and Guides: Provide thorough instructions for assembly, setup, and operation for easy replication.

**Scope**

1. Mechanical Design: Create a three-degree-of-freedom robotic arm for basic tasks like grabbing objects.
2. Electronics Integration: Integrate Raspberry Pi Pico with motors, servos, and sensors.
3. Voice Recognition System: Implement a voice recognition system compatible with Raspberry Pi Pico for user commands.
4. Movement Control: Develop precise algorithms for accurate arm movement based on voice commands.
5. User Interface: Design a display and buttons for feedback and manual control of the arm.
6. Testing and Optimization: Conduct extensive testing to ensure reliability in various scenarios.
7. Documentation and Guides: Produce detailed instructions and manuals for assembly and usage.
8. Future Enhancements: Consider upgrades like additional sensors or IoT integration for future iterations.

**Previous Works**

Robotic arm control mechanisms are pivotal in numerous applications, spanning industrial automation to assistive technologies. A. Coelho et al.(2018), S. Saxena et al. (2019), D. Rajput et al., (2017). This review scrutinizes existing systems, with a focus on manual control panels, joysticks, and computer-based interfaces. Additionally, alternative methods such as voice activation and mobile application-driven interfaces are explored. S. Singh and S. Sharma (2018). Manual Control Panels and Joysticks: Manual control panels and joysticks have historically served as the cornerstone of robotic arm control systems, prized for their direct manipulation and tactile feedback. Users can finely regulate the arm's movements through physical interaction with these interfaces. M. A. Hossain(2020). However, inherent limitations exist; N. Ghosh et al.(2019) notably, users must be physically present at the control panel, constraining remote operation. Moreover, these systems pose challenges for individuals with limited mobility and necessitate substantial learning curves for proficient operation.

Computer-Based Interfaces:

Computer-based interfaces offer advanced control capabilities, including precision and programmability. These interfaces leverage software applications running on computers to orchestrate intricate movements and sequences. T. Ojha and S. K. Mahapatra (2016). Despite their considerable advantages, such as executing complex tasks, they also present drawbacks. Users often require programming expertise or familiarity with specific software, acting as barriers for novices. Furthermore, their dependency on computing resources may impede accessibility in environments lacking robust computer infrastructure.

Alternative Control Methods:

Researchers have explored alternative control methods to surmount the limitations of traditional interfaces. Voice activation and mobile application-driven interfaces have emerged as promising alternatives. Voice activation empowers users to command the robotic arm through verbal directives, facilitating remote operation and intuitive interaction. Mobile application-driven interfaces provide flexibility and convenience, allowing control from handheld devices like smartphones or tablets.

While manual control panels, joysticks, and computer-based interfaces continue to dominate robotic arm control, alternative methods offer avenues for enhancement. Voice activation and mobile application-driven interfaces present innovative solutions to bolster accessibility and user experience. Future endeavors should concentrate on refining these alternative methodologies and seamlessly integrating them into robotic arm control systems to augment usability and efficacy.

**Proposed System**

The proposed system revolutionizes robotic arm control by blending voice activation, mobile app interface, and alternative input methods. It aims to make controlling robotic arms easier and more flexible than traditional methods.

Users can manipulate the arm effortlessly through a mobile app using voice commands, eliminating the need for physical controls. This offers greater convenience and freedom, especially for those unfamiliar with technical interfaces.

Additionally, the system offers diverse control options, such as flex sensors, which detect hand gestures for controlling the arm. This enhances versatility, catering to users' preferences and abilities.

Using a Raspberry Pi Pico microcontroller ensures efficient communication and control. Its small size, affordability, and versatility make it perfect for embedded systems. Bluetooth connectivity enables wireless communication, boosting flexibility and mobility.

In essence, this system represents a significant leap in robotic arm control technology, providing a user-friendly, intuitive, and adaptable solution that surpasses traditional methods.

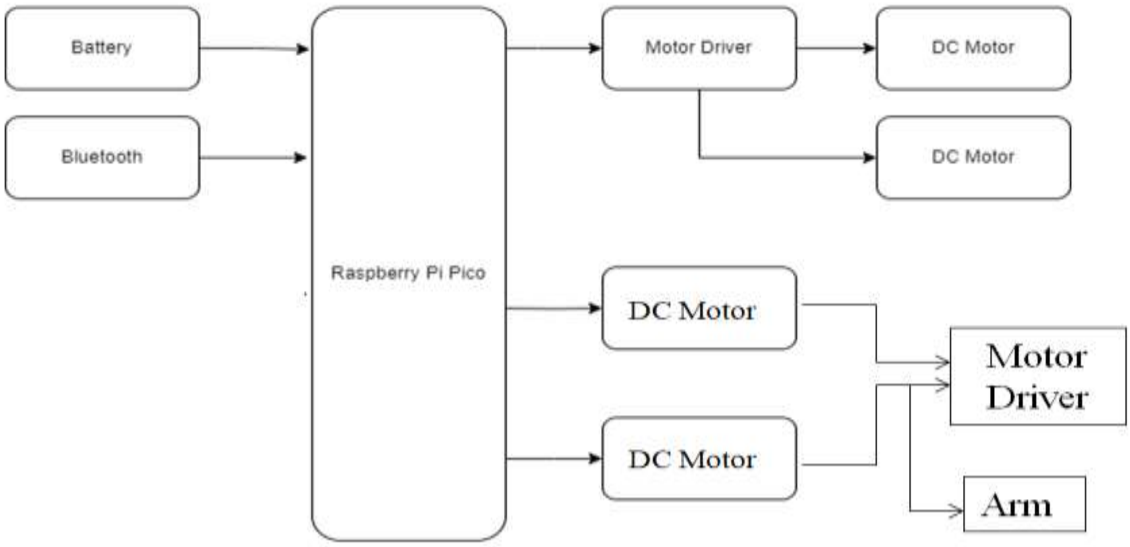



Fig 4.1 Block Diagram

**Working**

The paper "Voice-Activated Robotic Arm Using Raspberry Pi Pico" outlines a low-cost microcontroller-based arm designed to aid individuals with disabilities. These arms, typically guided remotely, are intelligent agents driven by computer programming. Embedded systems, crucial to these arms, combine software and hardware to perform specific tasks. They control, monitor, or assist equipment operation, often subtly integrated into the system. From simple functions to complex operations, embedded systems vary widely. Designing the voice-controlled arm with Raspberry Pi Pico involves selecting suitable hardware like Bluetooth modules and defining specific tasks tailored to the needs of disabled individuals. Input from potential users ensures the design meets their requirements.

**Hardware Requirements**

Pi Pico is the first microcontroller from the manufacturers of Raspberry Pi, based on the Raspberry Pi's RP2040 microcontroller chip and working on ARM's Dual-core cortex M0+ architecture. It works at frequencies up to 133MHz and albeit looking powerless when compared to the other members of the Pi family it has a lot to offer. Unlike the other Pi boards which are basically a Linux based single board computer, Pico is a budget friendly microcontroller with 264kB multi-bank high-performance SRAM, 16 kb of on-chip cache, and 2MB of flash storage.

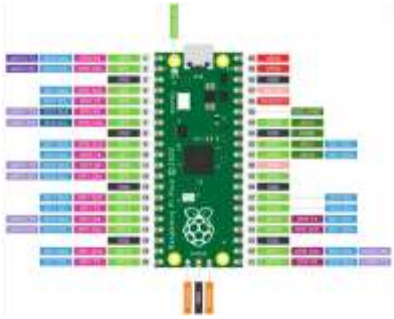


Fig 4.1 Raspberry Pi Pico

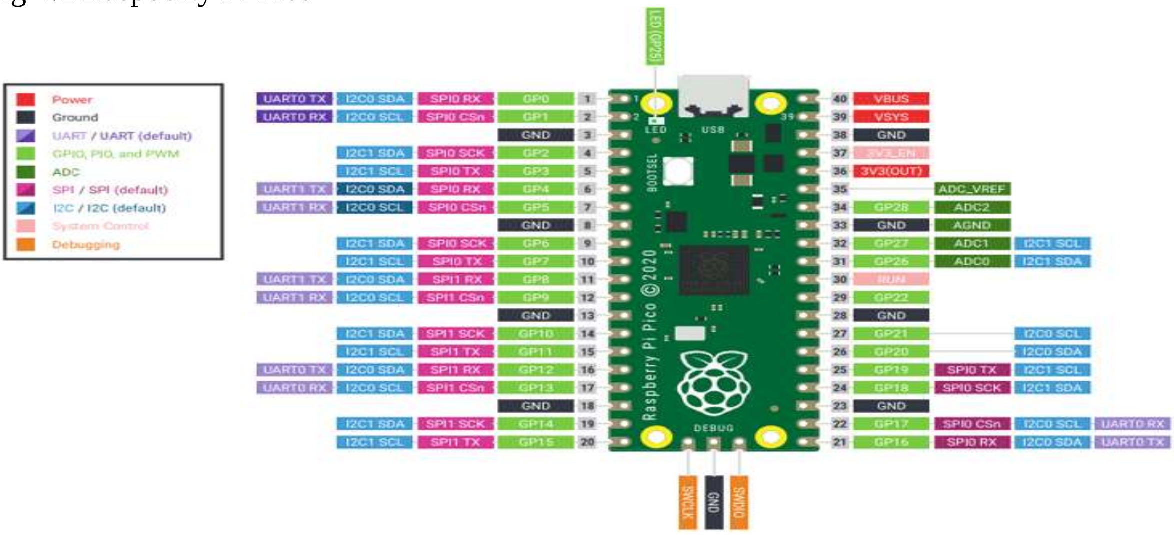
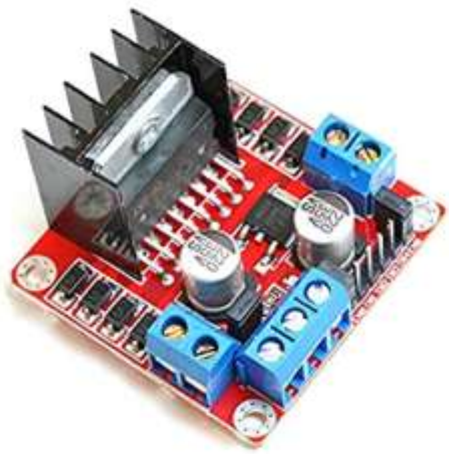



Fig 4.2Raspberry Pi Pico Pinout Diagram

Fig 4.3 L298 Motor



Driver

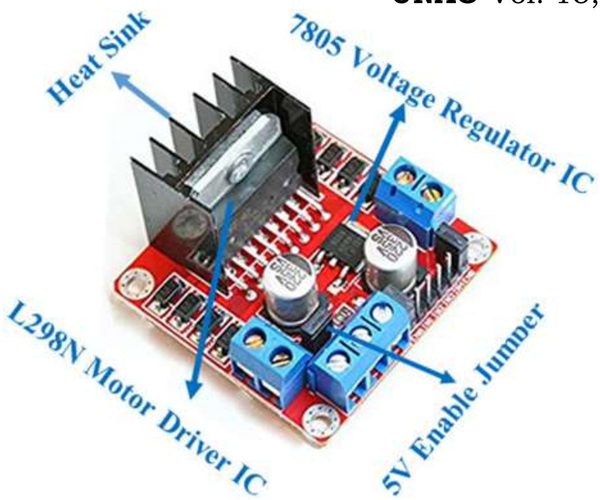



Fig 4.4 L298N Module

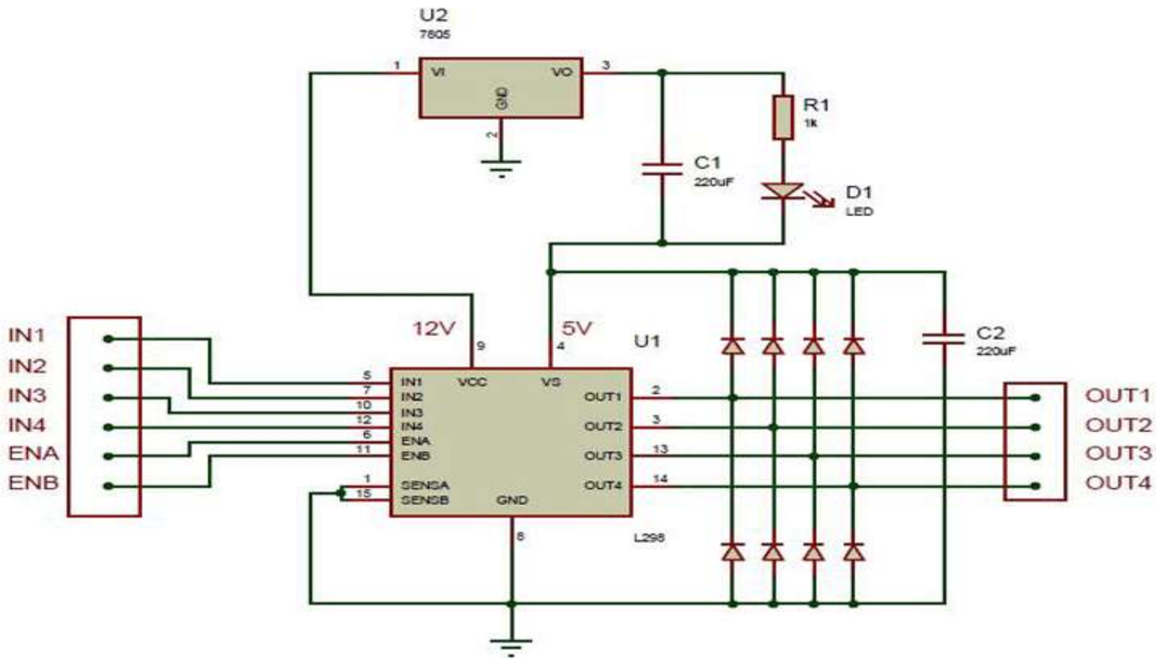



Fig 4.5 Internal Circuit diagram

Fig. 4.6 HC05Bluetooth


Fig. 4.7 Pin-out Configuration of HC-05

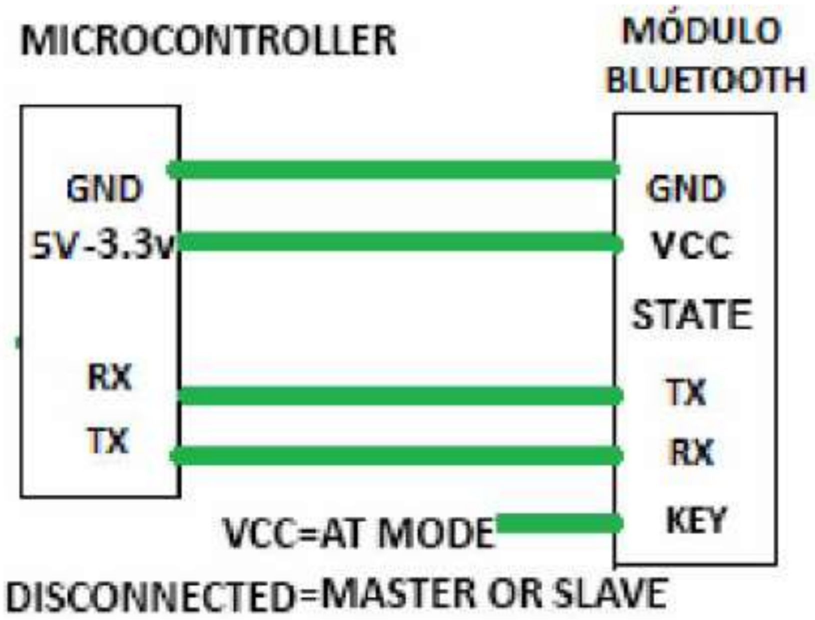


Fig. 4.8 Application Circuit

**5. OUTPUT**

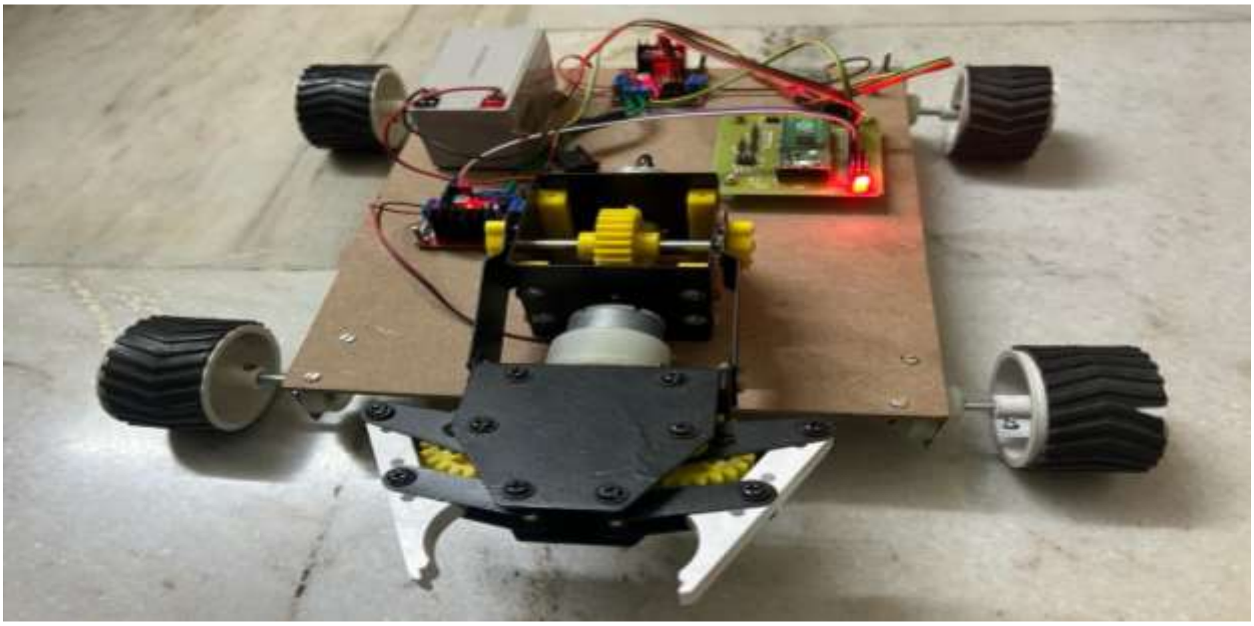


Fig. 5.1 Output

The paper involves creating a versatile robotic arm system controllable via voice commands and a Bluetooth application. The arm includes a base with omnidirectional movement and capabilities for pick and release operations.

Robotic arms are widely used across industries for precise object manipulation. This paper aims to develop a system suitable for diverse applications, integrating both voice and Bluetooth control functionalities.

The Raspberry Pi Pico, powered by the RP2040 chip, serves as the microcontroller board. It facilitates interaction with various components like motor drivers and sensors, running the control algorithm and coordinating arm movements based on user commands received via voice or Bluetooth.


Fig. 5.2 Mobile Application

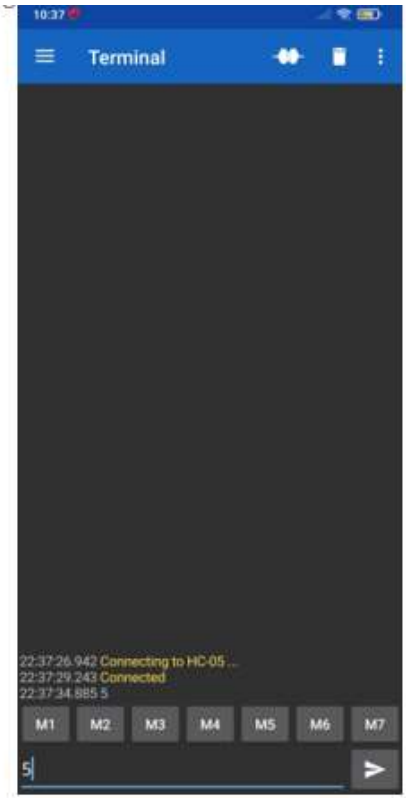



Fig. 5.3 Bluetooth Application

In our paper, we've developed a mobile application using MIT App Inventor to streamline control over the robotic arm system. This app offers users a straightforward and convenient interface for operating the arm in various directions and executing pick-and-place operations.

The mobile app boasts a user-friendly interface designed to be intuitive and easy to navigate. It incorporates directional buttons or sliders for controlling the arm's movement in different directions, including forward, backward, left, right, and diagonal movements. Additionally, buttons or toggles are available for initiating pick-and-place operations, allowing users to command the arm to grasp and release objects effortlessly.

**Commands for Serial Bluetooth Application**

**Voice Commands**

1-Front
2-Back
3-Left
4-Right
5- Stop
6-Up
7-Down

- Front
- Back
- Left
- Right
- Stop

8-Pick
9-Place

- Down
- Catch
- Release

## 6.CONCLUSION

Our paper, "Voice-Activated Robotic Arm Using Raspberry Pi Pico," successfully demonstrates the integration of flex sensors and voice control to manipulate a robotic arm. Throughout this journey, we've explored hardware components and programming techniques, showcasing how they harmonize to create an interactive and intuitive robotic system.
The addition of voice control enhances the user experience by enabling hands-free operation of the robotic arm. Users can effortlessly issue commands through voice prompts, fostering a seamless and natural interaction with the system.
Our paper exemplifies the potential of merging cutting-edge technologies to craft interactive and intelligent robotic systems. By harnessing components like flex sensors, Raspberry Pi Pico microcontroller, and voice recognition modules, we've showcased the fusion of hardware and software advancements driving innovation in robotics.
This exploration underscores the importance of staying updated on emerging technologies and their applications, laying the groundwork for the development of more sophisticated and adaptable robotic solutions.

### 6.1 Future Scope

Future iterations of the paper could involve enhancing the robotic arm's autonomy through machine learning algorithms for gesture recognition or object detection. Additionally, integration with Internet-of-Things platforms could enable remote monitoring and control of the robotic arm, opening up new possibilities for remote operation and collaboration.
In conclusion, our paper has demonstrated the potential of integrating flex sensors and voice control to create a versatile and interactive robotic arm system. By harnessing the synergy between hardware components and programming techniques, we have showcased the capabilities of modern robotics technology. As we look to the future, we are excited about the possibilities for further refinement and expansion, driving innovation and pushing the boundaries of what is possible in robotics.

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