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Low-Cost Robotic Arm for Differently Abled Using Voice Recognition

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Abstract
In recent years, there has been a significant increase in research and applications focused on controlling robotic arms, which are programmable mechanical arms with capabilities similar to human arms. While the concept of building mechanical arms is not new, the design and specifications can vary widely across different projects. Our team successfully developed a functional prototype of a voice-controlled robotic arm specifically designed for individuals with physical disabilities. The primary goal of our project was to create an affordable robotic hand that is both lightweight and durable. Robotics remains an intriguing and active area of research within the field of Engineering. Our voice-controlled robot executes predefined actions based on user commands, which are inputted through an Android phone. Leveraging the widespread use and user-friendly interface of the Android operating system, we established a Bluetooth connection between the phone and the robotic arm. The hand's movements are orchestrated using servo motors arranged at specific angles and positions, controlled by a microcontroller. This setup enables the microcontroller to interpret voice commands from the smartphone and adjust the grip of the robotic hand accordingly. .

INTRODUCTION

Traumatic injuries, congenital defects, and illnesses can lead to limb loss, often resulting from military combat, accidents involving vehicles or motorcycles, and various medical conditions. These experiences can deeply impact a person's self-esteem, mental well-being, lifestyle, career, and recreational activities. Our objective is to create a functional prototype of a voice-controlled robotic arm tailored for individuals with physical disabilities. This robotic arm is designed to handle tasks like reaching for and grasping objects, whether hazardous or non-hazardous, that are out of reach for the user. Our primary aim is to develop a lightweight and durable voice-controlled robotic arm that promotes inclusion in society and enhances the quality of life for people with disabilities. This project's focus is on assisting individuals with disabilities in their daily lives, offering them effortless control over the robotic arm. The arm's articulated fingers can flex at the joints, adapting to the shape of objects as instructed by the user for grasping. Ultimately, this project seeks to advance the field with a cost-effective voice-controlled robotic arm for the benefit of physically disabled individuals, enabling them to regain a full range of movement despite amputations, injuries, or congenital limb absence

RELATED WORKS

The goal of [1] was to establish a human-machine communication interface integrating the 6-DOF Jaco mechanical arm with a Leap Motion controller. An algorithm was devised to ensure an optimal mapping of user hand movements tracked by the Leap Motion controller, aiming for a more natural human-computer interaction and seamless control of the robotic arm. The application of this human-robot interface was explored within the context of Ambient Assisted Living, introducing several use case scenarios.

A proposal [2] has been made to create a mechanical arm controlled by natural human arm movements, with input data captured through accelerometers. This arm's development utilized the ATmega32 and ATmega640 platforms in conjunction with a computer for signal processing. Ultimately, this arm model aims to address challenges such as reaching for and grasping objects, whether hazardous or non-hazardous, that were previously out of reach for the user.

[3] illustrates the design and development of an ATmega-based robotic arm that responds to signals and can be programmed to follow a specific path and task. The system detects the user's arm movements, and the robotic arm replicates these motions accordingly. Potentiometers embedded in a glove capture the signals, which then control the positioning of servo motors responsible for moving the arm's components

A novel interface for remotely controlling a robotic arm was presented in [4], utilizing inertial motion trackers. This interface incorporates two types of motion trackers: the Xsens Xbus Kit trackers and the Razer Hydra Controller, where the former determines the robotic arm's positioning within a 3D space.

A recent proposal [5] introduced a cutting-edge robot controlled through an accelerometer-based system, where the accelerometers are affixed to human arms to capture signals and positions. Utilizing an Artificial Neural Network with backpropagation, this system effectively interprets arm signals and positions, achieving an impressive recognition rate of 92% and enabling intuitive control of the robotic device

In [6], a design was proposed for controlling a robotic arm remotely either via a LAN connection or over the Internet, allowing users to remotely control the arm and receive sensory feedback signals. The robotic arm operates using a master-slave control procedure, and it includes a camera that captures images and transmits them to the control station.

In [7], the development and enhancement of an affordable and user-friendly interface for controlling a 6-DOF robotic arm are detailed. This robotic arm features six single-axis revolute joints. The teleoperator, acting as the master, utilizes the Man Machine Interface (MMI) to operate the arm in real-time. The MMI incorporates simple motion capture devices that translate movements into analog voltages, which in turn generate corresponding activation signals in the robotic arm

In [8], a controlled robotic arm design incorporating myoelectric and body activity signals is presented. This implementation utilizes signals detected through Arduino Uno R3 and ARM processor boards to enable remote control of the arm, suitable for hazardous operational environments where users can safely operate the arm. The rotational axis of the robotic arm, controlled by Servomotor, is determined by pulse width modulation signals received from the microcontroller via Bluetooth 4.0 wireless technology.

In [9], a voice-activated robot arm with artificial intelligence capabilities is introduced, allowing control through associated input. This system enables users to interact with the robot using natural language, offering advantages such as rapid data input operations and hands-free functionality. The robot can comprehend the meaning of natural language commands, translating them into control data to execute tasks. Artificial intelligence techniques are employed to enhance the robot's ability to understand voice commands and act accordingly.

In [10], a voice-controlled personal assistant robot was developed, capable of receiving human voice commands through its built-in microphone and executing various tasks such as movements, rotations, wake-up/shutdown actions, and object relocation. Real-time processing of voice commands is facilitated through an offline server, with speech signals directly transmitted to the server via a USB connection. Potential improvements and applications in home settings, hospitals, vehicle systems, and industries are also discussed

In [11], a remote control system for a robot arm, designed for picking and placing objects, is structured using an Android application. The Android app acts as a remote transmitter with a considerable range advantage, while the Bluetooth receiver is connected to a microcontroller for driving DC motors via a motor driver for basic movement functionalities. The microcontroller utilized is the Atmega328 programmed with Arduino software. Additionally, the arm's vertical movement is constrained by a mechanical push-button switch. The robot is capable of traversing various surfaces smoothly or ruggedly, moving forward, backward, left, and right, with a carrying capacity of up to 2kg.

The project described in [12] delves into the creation and execution of a "Voice Controlled Robotic Arm," which includes three key components: the Voice Recognition module, the Robotic Arm, and the Platform. Its objective is to establish a wireless voice-controlled arm with a ZIGBEE transmitter and receiver setup, enabling operation within a 10 to 50-meter range. This robotic arm performs a range of movements, from lifting and lowering objects to picking and placing them, while the platform navigates in directions such as right, left, forward, and backward.

PROPOSED SYSTEM

This project demonstrates the functionality of a voice-controlled mechanical arm, with a primary focus on its potential benefits for paralyzed individuals and those with motor impairments. The arm is connected to an Arduino via a Bluetooth module, requiring authentication through a username and password upon application login. Subsequently, users input voice commands that are recognized by the system, which then verifies if the command matches predefined actions. If so, the arm executes the corresponding actions; otherwise, the application awaits the next predefined input command

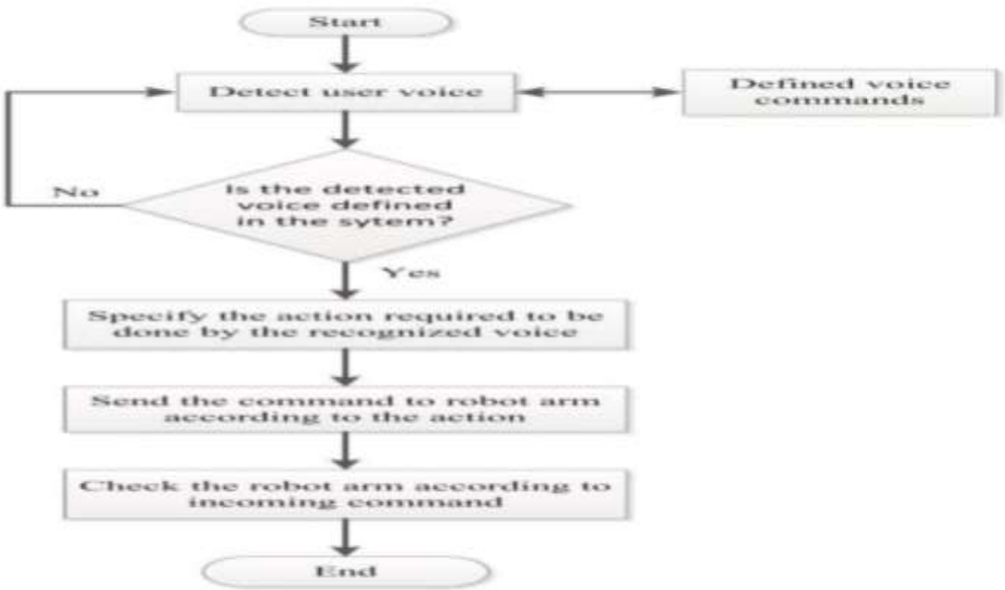

Fig 1. Flow chart diagram of the system.

HARDWARE DESCRIPTION

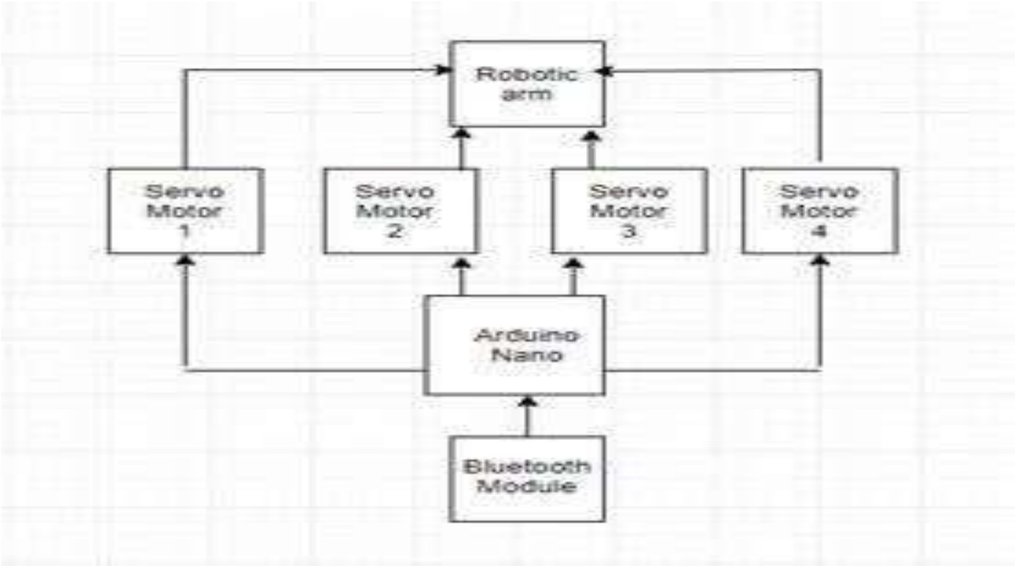

Fig 2. Block Diagram of the system.

The hardware component includes a custom-designed plastic robotic hand with individually controllable fingers. Four servo motors are utilized to control the finger movements, with each servo linked to a finger and initially set at 0 degrees alignment. The Arduino Nano serves as the central controller for managing both finger movement and communication between the hardware and the application. A Bluetooth module is integrated with the Arduino for serial communication, allowing the Arduino to receive commands from a paired Bluetooth device. Upon receiving a command, the servo circuitry adjusts the finger positions accordingly

The major hardware requirements of the system are:

Arduino UNO

UNO R3 SMD is the open source Embedded Development board based on Atmega328 SMD Package Microcontroller. Because Atmel is moving more and more of their production capacity to surface mount

ICs, the DIP packaged ATmega is becoming more and more difficult to get. To keep up with demand, we now offer the Uno R3 with an SMD ATmega. The board is identical to the PTH version of the Uno, but you won't be able to remove the Atmega without some hot-air.

Voice Module

Voice recognition is a technique that facilitates a natural, convenient human-machine interface using the voice recognition module. It extracts and analyses voice features of humans delivered to a machine or computer through the mic. The Voice recognition technique is classified into many types based on different criteria such as the scope of the users, the number of words used for recognition, and the naturalness of speaking. If the voice recognition level is more than 95%, then only voice recognition is practically used

Servo Motor Driver

It controls 16 free-running PWM outputs with 16-Channel 12-Bit PWM/Servo Driver using only 2 pins. You can even chain up 62 breakouts to control up to 992 PWM outputs. It's an I2C-controlled PWM driver with a built-in clock. That means you do not need to continuously send it to signal to tie up your microcontroller, it is completely free running. It is 5V compliant, which means you can control it from a 3.3V microcontroller and still safely drive up to 6V outputs. This is good when you want to control white or blue LEDs with 3.4+ forward voltages. 6 address select pins so you can wire up to 62 of these on a single I2C bus, a total of 992 outputs

SOFTWARE DESCRIPTION

Before accessing the application, Bluetooth pairing is required, and the login page verifies credentials through username and password authentication. If Bluetooth connection fails or the phone is in airplane mode, an "Login Failed" message is displayed; otherwise, it shows "Connection established." Upon login, a new page incorporates a voice recorder feature that sends recorded voice to Google API for processing, converting speech to text, and matching it with predefined commands to control the hardware accordingly.

Android App.

RESULT AND ANALYSIS

This project operates based on two predefined commands, "open" and "close," to control its functionality, adjusting the robotic arm's position based on the input received. The accuracy of the system is influenced by environmental conditions, with a higher success rate observed in quiet environments compared to noisy ones. Optimal Speech Recognition performance is achieved when the receiver is near the user, as distant microphones can lead to increased errors. Additionally, the system is password protected prevent unauthorized usage, as it is not user-dependent.

Fig 7. Hardware Implementation.

FUTURE SCOPE

Future work will involve introducing more complex tasks and sentences to the system, with the potential to utilize this robotic arm as a third arm. While our current focus is on restoring motion functions for individuals with arm loss, ongoing research suggests that similar technology can enhance human capabilities. Robotic arms offer versatility in hazardous environments such as industrial welding and disaster response, highlighting their broad applicability beyond rehabilitation contexts

CONCLUSION

Today, innovation is creating a similar way in accordance with quickly expanding human needs. The work done to address these issues makes life less demanding each day, and these studies are concentrated in robotics. These days, the most created field of robot arms is in the industry and medical field. Discourse acknowledgment innovation offers the chance to include characteristic dialects correspondence with the robot in a common and simple way. The discourse acknowledgment module was interfaced to the automated arm with the assistance of the Arduino board. The information and yield ports were chosen advantageously and the Arduino board was modified likewise.

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