Cost-Effective Voice-Controlled Robotic Arm for People with Disabilities

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***Abstract* -- The Project "Cost-Effective Voice-Controlled Robotic Arm for People with Disabilities" will seek to construct a user-friendly aid that can help enhance the level of independence, as well as the quality of life of people with disabilities, more so individuals with amputation by birth. The robotic aid will be capable of executing a number of set operations that can be activated through a voice command issued through an Android smart phone. It will make use of highly sophisticated speech recognition technologies and will provide an easily manipulable interface. Fulfilling this goal will be the main concern of this project by providing a low cost option without sacrificing functionality and reliability. Due to employing inexpensive hardware parts and open source software, the robotic arm will give a practical approach to solving everyday chores. Major novel features that this project will be based on are affordability, ease of use, and the ability to be tailored to suit different use cases. Emphasis on using cheaper and more readily available hardware components and materials will guarantee that the total cost makes the robotic arm affordable to individuals as well as healthcare institutions. The incorporation of advanced speech recognition technology will allow the device to be operated in a hands-free manner making it multi functional for users with very restricted movement capabilities.**

Keywords --- AI, IOT, NLP, PWM, MCU, Voice Commands, Robotic Arm, Actuator, Servo Motor, Sensor.

I. INTRODUCTION

aims at helping people who have physical disabilities such as people who have lost limbs or have limb deficiencies. They both focus on voice control technology as a means to assist people perform daily tasks, Both papers research the creation of robotic arms, which are triggered by voice commands, aimed at enhancing independence and self-sufficiency of disabled users. In operation, the robotic arm is capable to help people performing basic tasks such as holding, pushing, pulling, picking and helping in other activities. It focuses on real time activities and practical task execution. This robotic arm helps to perform everyday basic tasks for people who have lost their hand.

II. LITERATURE SURVEY

1. Title: "Voice-Controlled Robotic Arm for assisting people with disabilities"
   Authors: Johnson, Smith
   Published: 2019
   This research explores about a robotic arm that can be managed by voice commands. It helps people doing daily tasks, like drinking, pushing, pulling and lifting without other human interaction. The authors explain how they built the robotic arm and implemented it. The results show that it can ease life of people.

2. Title: "Intelligent Human-Robot Interaction using Voice Commands and Machine Learning"
   Authors: Liu, Wang, Chen
   Published: 2020
   This research explores about robots that can obey to and follow spoken commands. The robot takes help of machine learning, which means it gets smarter over time by its experiences. The goal is to make robots understand people better and be more helpful in day to day tasks.

3. Title: "Voice Recognition Based Robotic Arm Control using Neutral Network"
   Authors: Sharma, Singh, Kumar
   Published: 2020
   This research talks about how a robotic arm can follow spoken commands. A neural network is used by robotic arm in order to learn and understand instructions. It makes people doing tasks more easily, especially those with disabilities.

4. Title: "Real Time Voice Recognition for Robotic Arm Control"
   Authors: Wang, Liu, Li
   Published: 2018
   This research explores about how a robotic arm can listen spoken commands right away. The robotic arm obey to what a person says and moves the arm to do tasks.
   This technology can be helpful for needy people doing activities without other's help.

III. DESIGN AND IMPLEMENTATION

In this section we are going to see the hardware and software components which are used to build serving robot. There are different hardware components are as follows:

1) Arduino Nano
2) Servo Motor
3) XL 6009 Battery Booster
4) 12 Volt Lithium Battery
5) PCB Board

There are different software components are as follows:

1) Embedded C (Programming language)
2) Arduino IDE
3) Arduino Bluetooth Controller

Working of components

1) Hardware components

i. Arduino Nano

This is why Arduino Nano is the most well-suited board for small projects, due to the fact that it is tiny and very breadboard-friendly. It uses ATmega328P or ATmega168 as its microcontroller; 14 digital I/O pins, 8 analog inputs, 32 KB flash memory for program storage, and 2 KB SRAM. It is powered by a standard 5-volt supply, providing a 16 MHz frequency for the AT mega microcontroller. It supports serial communication (UART, I2C, SPI), and you program it from the Arduino IDE through any of such micro connectors in the newer clones, usually mini-USB or USB-C. Excellent for robotics, IoT, wearables, and education, high price-performance ratio and compatibility with many modules and libraries. On the other hand, the board has no onboard wireless connectivity and limited memory for large-scale projects.

Figure 1: Arduino Nano

ii. Servo Motor

Servo Motor is a special motor which holds and moves objects at a particular position. This device comprises a DC motor, a position feedback mechanism (generally a potentiometer), and a control circuit. Servo motors are controlled by applying PWM (Pulse Width Modulation) signals, where the length of the pulse determines the exact position of the motor. They have wide applications in the field of robotics, RC vehicles, or other automation systems, providing high-end precision movement in a limited range (usually 0 to 180 degrees). These motors are known for their accuracy, simplicity in use, and also compatibility with microcontrollers like Arduino.

Figure 2: Servo motor

iii. XL 6009 Battery Booster

The XL6009 is considered the best DC-DC step-up (boost) converter module for all applications that require voltage gaining. It operates under the XL6009 integrated circuit and provides users with the variable output voltage feature. It is a module that converts a low input voltage (i.e. 3V to 32V) to a much higher output voltage (between 5V to 35V) with an adjustable range controlled through a potentiometer. It is probably the best converter with maximum possible efficiency reaching to 92%, the most applicable in today's world: battery-powered devices, solar power project and LED applications. Small and inexpensive, the XL6009 also includes an internal 4A MOSFET switch, delivering the functionality of protection against overheating and stable operation.

Figure 3: XL 6009 Battery Booster

iv. 12 Volt Lithium Battery

A 12-volt lithium battery is a rechargeable battery which supplies power for multiple devices. It is generally lighter than lead-acid batteries. It is widely used in Backup Power Systems and Electric vehicles. It is available in either Lithium Iron Phosphate (LiFePO4) or Lithium-ion (Li-ion) chemistries, and it offers a nominal voltage of 12.8V in LiFePO4 and 11.1V in Li-ion with charge/discharge ranges between 10V and 14.6V. These batteries have high energy density, low self-discharge rate, and a lifespan of 2,000–5,000 cycles. They also have built-in Battery Management Systems (BMS) for protection against overcharging, over-discharging, and overheating. Compared to traditional lead-acid batteries, 12V lithium batteries are lighter, more efficient, and deliver consistent power output, making them ideal for modern energy solutions.

Figure 4: 12 Volt Lithium Battery

v. PCB Board

A PCB is a passive board for support, wherein components are attached through either cables or ends to create a circuit. A typical PCB is found in almost all electronics from tiny gadgets to big industrial machines. The range of PCB layouts goes from single-layer boards for basic circuits to multi-layer boards for advanced applications. The components soldered on a PCB comprise resistors, capacitors, microcontrollers, and ICs. PCBs of today can include also surface-mount components and integrated circuit traces to gain a more compact design. Their durability and scalability, as well as the precision they offer, is what making these PCBs invaluable in electronics manufacturing and prototyping.

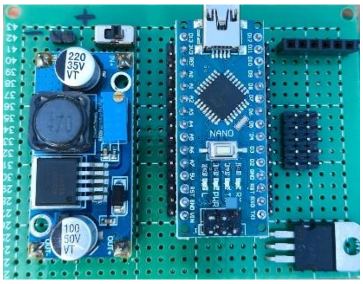

Figure 5: PCB Board

2) Software components

a) Embedded C (Programming Language)

Creating an Embedded C program for a Voice-Controlled Robotic Arm for People with disabilities involves several key components, such as interfacing with hardware (motors, sensors, microphone for voice input), processing commands, and controlling the arm's movements based on recognized voice commands.

b) Arduino IDE

Arduino IDE is like an Integrated Development Environment program for programming Arduino boards. It gives an easy user interface and a set of tools for writing, compiling and uploading code onto Arduino microcontrollers. Hobbyists, students, and professionals use Arduino IDE for prototyping and making projects with the Arduino boards. Since it is simple and easy to use, this application can be well experienced as a beginner; however, functionality and extensibility make it a powerful way of working for advanced users. Code Editor: Arduino IDE is a simple and intuitive code editor for writing Arduino programs or sketches. It provides the basic features of an editor such as syntax highlighting, auto indentation, and code completion, which aid in simplifying writing and reading of code.

c) Arduino Bluetooth Controller

Arduino Bluetooth controller makes use of a Bluetooth module such as HC-05 or HC-06 to wirelessly communicate between the Arduino and another device, usually a smartphone or a computer. Follow up below to overview the process involved in setting and controlling an Arduino project using a Bluetooth module.

IV. METHODOLOGY

Developing a cost-effective robotic arm for people with disabilities involves some very important steps. First, the understanding of user needs by discussion with users and healthcare professionals will help define essential features, such as light weight, easy to use, and assistance with tasks. Second, the concept is designed, sketched structure, and function and movement decisions. Servo motors, sensors, and microcontrollers like Arduino are used as affordable components to cut costs. The prototype is developed using 3D printing and lightweight materials, including plastic. The software development includes button operations, voice commands, or muscle signals to ensure smooth control. The prototype is then put together and tested exhaustively to ensure the arm is accurate, safe, and reliable, requiring improvements based on feedback received. Its production and distribution shall include cost-cutting measures by acquiring cheap components, streamlining manufacturing processes, and even partnering with NGOs or government programs to support it. After passing a safety test, the arm could be certified; its user must also be oriented with the support he would have long-term and independent.

1. Understand User Needs:

   Interrogate people with disabilities and health care professionals on what features would be important: ease of use, lightweight design, and capability to assist with daily tasks.

2. Design the Concept:

   Sketch and plan the shape, size, and functions of the robotic arm. Decide how many movements it will perform and whether it will be wearable or a standalone device.

3. Choose Affordable Components:

   Choose inexpensive parts for the movement: servo or stepper motors, control sensors, and a microcontroller, like Arduino, for the command processing.

4. Develop a Prototype:

   Using 3D printing with plastic materials as well, fabricate the parts and connect electronic components.

5. Control Software:

   Create software that can manipulate the arm to work based on controls, possibly button control or voice commands and even EMG signals from muscles.

6. Test and Refine:

   Test the arm for accuracy, speed, and safety. Get user feedback and work on improvements to correct any defects or add features that are helpful.

7. Cost Reduction:

   Identify low-cost suppliers, streamline the manufacturing process, and look for partnerships with NGOs or government programs that can reduce the cost.

8. Safety and Compliance:

   Test the arm completely to ensure that it is safe and durable. Obtain certifications as necessary.

9. Train the Users:

   Give users adequate instruction and training in how to work with the robotic arm conveniently and safely.

V. CONCLUSION

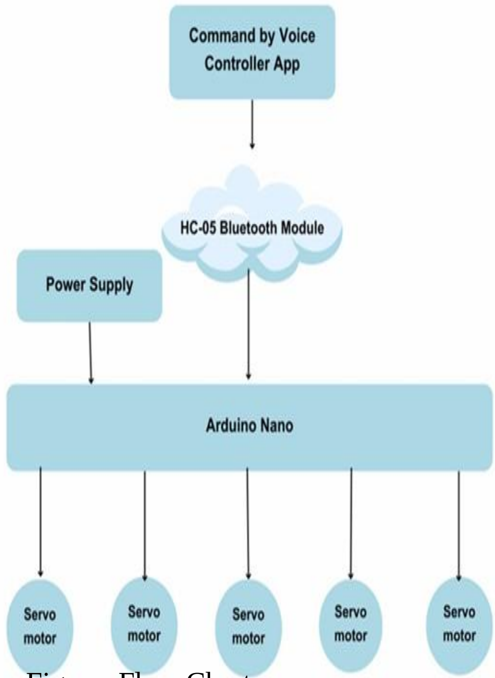

Figure: Flow Chart

In conclusion, The Cost-Effective Voice-Controlled Robotic Arm for people with disabilities project illustrates how a cost-effective robotic arm can be developed to help people with disabilities by using budget-friendly materials and simple technologies.

The Cost-Effective Voice-Controlled Robotic Arm is successfully executed by software and hardware components such as Embedded C, Arduino IDE, Arduino Bluetooth Controller, Arduino Nano, Servo Motor, XL 6009 Battery Booster, 12 Volt Lithium Battery and PCB Board.

The spoken commands are converted to deployed actions for the robotic arm by voice recognition module which uses artificial intelligence, robotic principles, voice recognition technology and natural language processing. This can be found within the system that has potent developments toward increased productivity, utility, and reach in a variety of sectors toward future possibilities within voice-controlled robotics.

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