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Design and Development of Robotic Arm Control by Human Hand

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A B S T R A C T

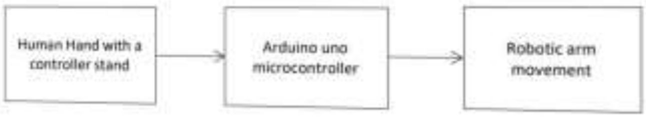
This research paper presents a novel approach to human-robot interaction through the Development of a robotic arm controlled by hand gestures and fabricated using 3D printing technology. The system integrates potentiometers in a human handstand, connected to an Arduino microcontroller, To capture hand movements and translate them into commands for servo motors in the robotic arm. This intuitive control interface allows users to manipulate the robotic arm's movements based on hand Gestures, showcasing a seamless collaboration between humans and robots. The paper discusses the Design, implementation, experimental results, and potential applications of this innovative control System.

Keywords: *Robotic arm, Hand gestures, 3D printing, Potentiometers, Arduino microcontroller, servo Motor*

1. Introduction

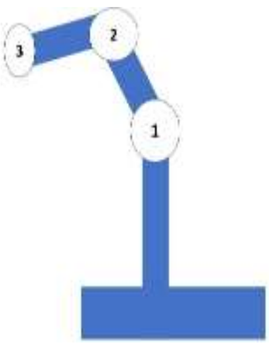
As the demand for seamless collaboration between humans and robots continues to increase, there is An urgent requirement for control interfaces that are user-friendly and efficient. The integration of Robots into various industries has revolutionized both automation and the way humans interact with These machines. A crucial aspect of robot systems is their control interface, which determines how users Can give commands and interact with them. However, traditional control methods often involve Complex interfaces or manual programming, making them less accessible and user-friendly. This Research aims to address this issue by introducing a new control mechanism that allows users to Manipulate a robotic arm through hand gestures facilitated by potentiometers. The entire system is Manufactured using 3D printing technology. The goal of this research is to develop a control system that Combines hand gestures and 3D printing technology to provide an intuitive and precise way of Controlling robotic arms, overcoming the challenges posed by traditional control methods.

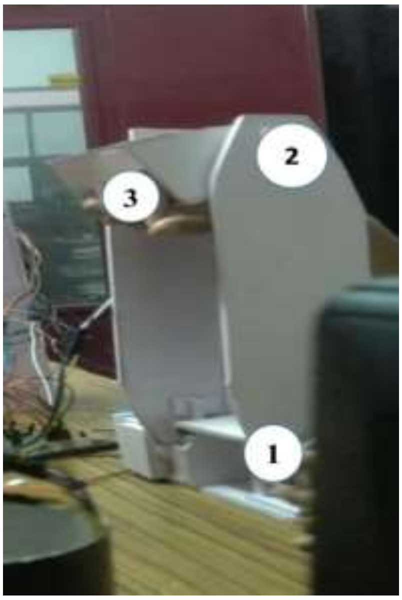
2. DESIGN AND DEVELOPMENT



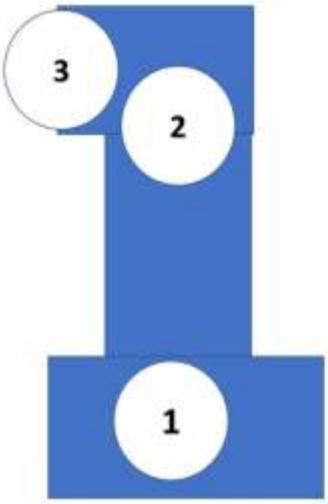
Block Diagram of working

Robotic arm

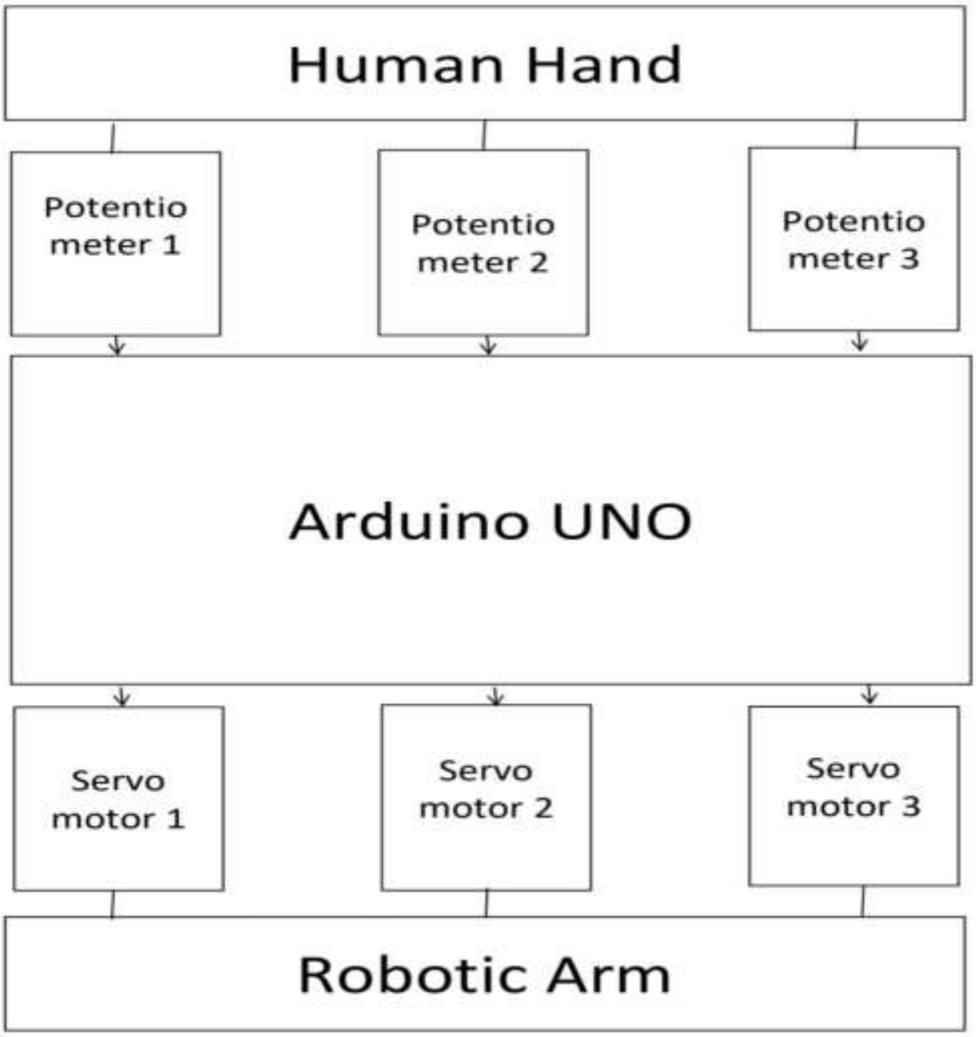




Human Hand Movement encoder Frame



Robotic Arm working Block Diagram



Actual working model

3. Proposed Methodology

The goal of this methodology is to create a robotic arm that can mimic the movement of a human hand. The 3D-printed robotic arm is controlled with the help of the SG90 servo motor, which has a torque of 1.8 kg/cm. The servo motor operates at a voltage of 4.8 to 6 volts. 3D printer technology has enabled significant advancements in various industries through the design and manufacturing of custom objects or devices. To track the human hand angle, a potentiometer is used. The potentiometer has a decent amount of resolution to work as a rotaotry encoder. The hand is composed of an Arduino Uno, which works as the brain of the system, and a Sg90 servo motor, which gives movement to the arm. The servo motor works on the PWM signal.

To achieve the goal of mimicking human hand movement, the following methodology is proposed: The potentiometer will measure the angle of the human hand movement. Firstly, the potentiometer will be calibrated to accurately measure the angle of the human hand movement. The calibration process involves mapping the range of motion of the human hand to the corresponding values on the potentiometer. Next, the Arduino Uno will be programmed to read the values from the potentiometer and convert them into servo motor positions. The servo motor positions will correspond to the different joints of the robotic arm, allowing it to mimic the movement of the human hand. To control the servo motor, the Arduino 'Servo' library will be used. Furthermore, the code will incorporate a sweeping effect by gradually increasing the duty cycle of the PWM signal from 5% to 10%, with an increment of 0.5% in each step, to achieve a smooth and realistic movement of the robotic arm.

WORKING

The potentiometers that are placed on the joints of the hand frame will help measure the angle of arm and wrist movement. The potentiometer generates the analog value. The potentiometers are connected to the analog pins of the arduino. Arduino Uno has a 10-bit ADC converter, which means that it is able to detect 1024 (2^10) analog discrete levels.

Using the map() in arduino IDE, we will be able to convert the analog values to the PWM signal. The map function is a built-in function in Arduino that performs linear remapping of a value from one range to another. The map function will be able to create the 180 pwm steps, which will then be sent to the servo motor. The arm will move with the desired movement.

Previous studies have explored different methods of controlling robotic arms,from electromyography (EMG) sensors to computer vision-based techniques. However, these methods often face challenges related to complexity, limited accuracy, or lack of user-friendliness. In contrast, our system leverages the precision of potentiometers embedded in a human handstand, offering a highly intuitive and responsive control interface. In contrast, our system utilizes potentiometers embedded in a human handstand, offering a more intuitive and responsive control interface. The mapping of hand movements to robotic arm motions at different angles is illustrated below:

Hand Movement	Robotic Arm Movement
Carper Up/Down	Joint 1
Up/Down hand from elbow	Joint 2
Finger up/Down	Joint 3

4.Hardware Used

1.MATERIAL

The frame on which the hand will move is made up of PLA 3D printer filament, which is strong and cheaper in price. PLA stands for Polylactic Acid; it is a recyclable thermoplastic polyester. The PLA does not require high-temperature printing, which makes it well-suited for 3D-printed structures.

2.SERVO

A servo motor is a special type of electric motor that combines a regular DC motor with a control circuit and feedback mechanism. This enables it to rotate to a specific position (angle) and hold it there with precision. Here's a breakdown of its working principle. Pulse Width Modulation (PWM) Generator generates a series of electrical pulses with varying widths (duty cycle). The wider the pulse, the longer the motor runs in a particular direction (clockwise or counterclockwise).

The servo motor's ability to hold a specific position is due to the closed-loop feedback system, where the potentiometer continuously provides position information that the control circuit uses for precise regulation. Servo motors typically have a limited range of motion, often 180 degrees but sometimes less.

3.POTENTIOMETER

A potentiometer, also known as a variable resistor, is a three-terminal electrical component that acts like a volume knob. Basic principle: A potentiometer consists of a resistive element, usually a long strip of carbon or metal film, with a sliding or rotating contact (wiper) that can be moved along its length. When the wiper is moved, it varies the resistance between the wiper and each end of the element. This allows you to control the amount of current flowing through a circuit.

4. ARDUINO UNO

The Arduino UNO was also the first USB-enabled board, paving the way for easier project development. Developed by Arduino.cc, the UNO remains a popular choice due to its user-friendliness compared to more complex boards like the Arduino Mega. The UNO's core lies in the ATmega328P microcontroller. Packed with 14 digital I/O pins (including 6 PWM-capable) and 6 analog inputs, it provides ample resources for various projects. It boasts a USB connector for programming, a power jack for versatility, and an ICSP header for advanced tinkering. Programming the UNO is facilitated by the Arduino IDE (Integrated Development Environment), available both online and offline for your convenience.

Software Used

Arduino IDE

Integrated Development Environment (IDE): It's a software application that combines everything you need to write, compile, and upload code to your Arduino board in one place. Java-based and Cross-platform: The software is built using Java and can run on Windows, Mac OS X, and Linux operating systems. The primary purpose of the Arduino IDE is to write code (called sketches) for Arduino boards. Once you write the code, the IDE allows you to upload it to the Arduino board, bringing your project to life. The code behind the Arduino IDE is freely available, allowing anyone to contribute and improve it. The IDE is designed to work with code written in the C and C++ programming languages, with specific guidelines for structuring that code for

The Arduino IDE comes with a built-in library called Wiring, which provides common functions for interacting with sensors, actuators, and other components. You only need to define two main functions in your code: setup() and loop(). setup() runs once when you upload the code, and loop() runs repeatedly as long as the Arduino board is powered on. The IDE uses the GNU toolchain (also included) to compile your code with the Wiring library and a pre-written main() function. This combined code is then uploaded to the Arduino board as an executable program.

5. RESULT

Experimental results demonstrate the system's capability to accurately translate hand gestures into corresponding robotic arm movements. Different hand angles lead to distinct arm motions, showcasing the system's versatility and adaptability. The system's efficiency and user-friendly interface make it suitable for a wide range of industrial applications, including assembly, pick-and-place operations, and quality control.

6. DISCUSIION

The use of 3D technology for creating artificial robotic hands is a great development in the field of robotics. This technology has allowed for the creation of customized and functional robotic arm that can closely resemble the shape and size of a natural hand, which can greatly improve the user's ability to perform daily activities.

One of the benefits of using 3D technology is that it can produce lightweight and durable prosthetics that are easy to wear and use. However, there are also challenges associated with using 3D technology, such as the availability of suitable materials for printing and the need for specialized software and expertise to design and print robotic arm.

5. CONCLUSION

In conclusion, this research paper presents a comprehensive study on a robotic arm controlled by hand gestures and developed using 3D printing technology. The system's intuitive nature, coupled with its accuracy, versatility, and importance in industry, positions it as a transformative solution for optimizing human-robot collaboration and driving innovation in industrial automation with an intuitive and user-friendly control interface, enhancing human-robot interaction in various applications such as manufacturing, healthcare, and education. Future work may focus on optimizing gesture recognition algorithms, expanding the range of supported gestures, and exploring advanced control strategies for more complex tasks.

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