GESTURE CONTROLLED PROSTHETIC HAND USING ARDUINO

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Abstract-- The intention of This undertaking is to employ Arduino technology to design and build a gesture-controlled prosthetic hand. The primary goal is to produce a responsive and user-friendly system that lets people manipulate a prosthetic hand's movements with hand gestures. The prosthetic hand's actions are translated into equivalent hand movements by utilization of an Arduino microcontroller that is interfaced with sensors and actuators.

The suggested design makes utilization of a variety of sensors—such as accelerometers or flex sensors—that are fastened to the user's hand In order to recognize various motions and gestures. The Arduino receives these sensor readings, processes them, and then uses the data analysis to initiate particular motor motions in the hand prosthesis. Furthermore, Bluetooth or wireless communication protocols can be included to make room for the hand prosthesis to be configured and controlled remotely.

Keyword—Prosthetic hand, Arduino, Gesture, Controlled

1.INTRODUCTION

The realm of prosthetics has seen remarkable advancements in recent years, with technological innovations continuously enhancing the functionality and accessibility of artificial limb solutions. Among these innovations, gesture-controlled prosthetic hands have emerged as a promising frontier, offering amputees and individuals with limb impairments greater autonomy and natural movement. This project focuses on the development of a gesture-controlled prosthetic hand using Arduino technology, aiming to create a more intuitive and responsive interface between users and their prosthetic devices.

The conventional control mechanisms for prosthetic limbs often involve limited options, such as myoelectric sensors or switches, which may not fully replicate the intricate movements of a natural hand. However, by integrating gesture recognition technology and Arduino-based microcontrollers, this project seeks help close this gap and enable consumers to control their prosthetic hands through natural hand gestures, thereby enhancing dexterity and usability.

The utilization of Arduino microcontrollers presents a cost-effective and versatile platform for this endeavor. By interfacing sensors, such as flex sensors, accelerometers, or gyroscopes, with an Arduino board, real-time hand movements and gestures can be accurately detected and translated into corresponding actions for the prosthetic hand. This approach holds the promise of creating a more intuitive and responsive control system, facilitating a more seamless interaction in between the user and the prosthetic device.

The significance of this project lies in its potential to revolutionize the field of prosthetics by providing a user-friendly, adaptable, and affordable solution for individuals with limb differences. Enabling users to control their prosthetic hands through familiar gestures can significantly improve their quality of life, independence, and overall functionality in performing everyday tasks.

and intuitive control over their prosthetic devices. This introduction sets the stage for exploring the design, development, and implementation of a gesture-controlled prosthetic hand using Arduino,highlighting its potential impact on enhancing the existence of users within the domain of assistive technology and rehabilitation engineering.

2. LITERATURE SURVEY

(i) “Modern Robotic Hand Using Robust Technology.” Volume 2, Issue 1 - 2020,Peer Reviewed Journal

Authors: Bhuvnesh Rathor , Monika Singh , Sanket Goyal, Sandeep Kumar , Rohan Giri , Rajkumar Meena , Saransh Goswami , Sanjay Kumar Yadav , Sanjay Gadwal

Methods: A condensed form within the C programming language, along with a few additions for hardware access, powers the Arduino. Approximately 300,000 lines of source code are executed through Arduino per second.

The analog inputs of the Arduino Nano, which is fixed on the glove, are affixed to the analog angle values that are acquired from the flexible sensor. The electrical hand and control glove are connected to the power source. Three servos are employed in this project: one for controlling the thumb, one for controlling the pinky and ring fingers jointly, and one for controlling the middle and index fingers jointly with an Arduino.

Advantages: Suitable for use in Industries. Utilizable in dangerous humanitarian works.

Drawbacks: Increased cost to prepare gloves and to connect it with Prosthetic Hand. If any one concerning the servo motor fails it can affect 2 fingers.

(ii) "Hand Gesture to control a low cost 3D printed Arm using Android Application."

Authors: Nurul Muthmainnah , binti Mohd Noor, Mohd Muzammel bin Musrijan

Methods: Three main parts make up the experimental setup: an Arduino Uno board, a Bluetooth gadget, and a servo motor.Five fingers will move in accordance with The motion of the servo motor, which will function as the output. To manage the hand gesture of the 3-D printed arm, the Bluetooth will receive and transfer data from the Android application the microcontroller. Concerning the servo motor and input (accelerometer sensor) are interfaced using the Arduino Uno. The smartphone is already attached in the upper arm to give the instruction to the phone.

Advantages: It can be used to assists disabled people. Wireless Connection additionally, it is cost efficient.

Drawbacks: It needs to improve the execution of 3-D printed hand gestures. major limitation can be seen on the fingers of the 3-D printed arm which is the object that easily falls when gripping and holding the material. Because of the slick surface on the fingers of the 3-D printed arm.

(iii) "Robotic Arm Controlled By Hand Gesture Using Leap Motion." University of Sindh Journal of Information and Communication Technology (USJICT) Volume 3, Issue 3, July 2019.

Authors: Rahat Ali Khan , Rozina Imtiaz, Alina Arain , Abdul Samad , Dilbar Khan.

Methods: The leap motion is the project's primary highlight. It functions as our project's brain. It is the sole element that can comprehend how the human hand moves. The foundation of it is Python programming. The programming is configured to function. When a potentially disabled person swings their hand and displays leap motion, leap motion initially recognizes the hand's motion and attempts to visualize. It notifies Arduino of the movements after observing them. The Arduino connects with the motors to carry out the necessary action after it receives this signal.

Advantages: Our project involves the creation and design of a robotic arm intended to aid individuals with disabilities. It's an low cost project which majorly helps people in the sense that it only needs The motion of the hand.

3.PROPOSED SYSTEM

3.1 Materials Used:

i .ARDUINO-UNO

The Arduino microcontroller is a powerful yet user-friendly single-board computer that features an onboard ATmega-328 microprocessor that runs at 5 V and has 2 Kb of RAM and 32 Kb of storage. At 16 MHz, the clock speed corresponds to around 300,000 lines of C source code executed every second. Together with digital and analog pins, there are a total of 28 pins. This board has three PWM (Pulse Width Modulation) output pins. It also features an ICSP header, a reset button, a USB port, a power jack, a ceramic capacitor operating at 16 MHz, and six analog inputs. Simplified C/C++ is the programming language used by Arduino.

The Arduino's input-output (I/O) pins allow it to communicate with the external world. The 14 digital I/O pins of the Arduino, numbered 0 through 13, able to be applied to read switch states and turn on and off lights and motors.

A straightforward LED flashing code and serial communication code are burned to test the board's functionality and serial port with a PC. The outcomes are as follows: How it works: When in "on" condition, the LED blinks. 2) In the "off" state, the LED does not blink.

Figure: Arduino uno

ii. PROSTHETIC HAND

A prosthetic hand is a manufactured device designed to replace a missing or non-functional hand. Its primary function is to restore a degree of functionality, mobility, and dexterity to individuals who have experienced limb loss due to injury, congenital conditions, or medical procedures.

Figure: Prosthetic hand

Components of a Prosthetic Hand:

1.**Socket:** The socket is custom-made to fit the residual limb securely. It's crucial for comfort and stability, ensuring that the prosthetic hand attaches firmly to the user.

2.**Wrist Unit:** This part connects the socket to the hand and allows for rotation, flexion, and extension movements, providing some degree of natural wrist motion.

3.**Hand Mechanism:** The hand mechanism replicates the functionality of an individual's hand to the best extent possible. Modern prosthetic hands are engineered with materials like plastics, metals, and composites to simulate the natural look and function of a hand. They can be classified into two main types:

a. **Body-Powered Prosthetic Hands:** These hands are controlled through cables and harnesses attached to the user's body movements (such as shoulder or arm motions). When the user moves a specific part of their body, tension in the cables triggers the opening and closing of the prosthetic hand.

b. **Myoelectric Prosthetic Hands:** These hands use sensors placed on the user's skin that detect muscle movements (electromyographic signals) from the remaining muscles in the residual limb. Afterwards, These indications are converted into specific hand movements, allowing for more natural and intuitive control of the prosthetic hand.

4.**Grip Patterns:** Prosthetic hands often have different grip patterns and functions (e.g., pinch grip, power grip, fine motor control) to accommodate various activities and tasks in daily life.

5.**Sensors and Control Systems:** Advanced prosthetic hands may incorporate sensors and control systems (such as microcontrollers like Arduino) to enable gesture control, touch sensitivity, or feedback mechanisms, enhancing their functionality and usability.

iii. ARDUINO IDE

The open-source electronics platform Arduino is constructed upon user-friendly hardware and software. Arduino boards have the ability to read inputs, such as a light from a sensor, a finger pressing a button, or a message from Twitter, and convert them into outputs, such as starting a motor, turning on an LED, or posting content to the internet. By sending a set of instructions to the microcontroller on the board, you can instruct your board on what to do. You use the Arduino Software (IDE), which is based on processing, and the Arduino programming language, which is based on wiring, to accomplish this. The IDE is user-friendly for novices and has sufficient flexibility for more experienced users. It functions on Linux, Windows, and Mac. It's applied by educators and students to construct inexpensive scientific apparatuses, demonstrate chemistry and physics concepts, and begin learning robotics and programming. Interactive prototypes are created by architects and designers, and artists and musicians use them for installations and to test out new musical instruments. Naturally, makers use it to construct a large number of the projects on display at events like the Maker Faire. An essential tool for learning is Arduino.

iv. PYCHARM

An easy-to-use environment for productive Python, web, and data science development is created by PyCharm, an IDE specifically designed for Python developers. It offers a wide variety of necessary tools for Python developers.

3.2 Methodology:

WEB CAM takes in live video Input.- PYCHARM(OPENCV).

Code to configure the servo motors is written on the Arduino IDE.

Port number for interfacing of Hand Gesture recognition through Python and Arduino is given.

Send the Python information to the board and reciprocate the same, through servo motors.

We have used these operations to process the input file which are controlled in the parameter block. The operations are: Capturing Gesture Movements: The control station's webcam provides an image frame for input, and each input frame undergoes additional processing to identify the palm of the hand. In order to appropriately identify the hand palm the quietest possible within the image, there are various backdrop limitations. The robot can be instructed to move in one of two major directions: forward or backward.

Thresholding of an Image Frame: Using the webcam, an image frame is captured for input. Next, this picture frame is subjected to binary thresholding in order to identify the hand palm. The minimum threshold value is first set to a particular constant. This number can be used to threshold an image, increasing the value until the algorithm recognizes a single, noise-free white blob.

Drawing Contour and Convex Hull: A threshold white blob is accustomed to determine and sketch the contour of an image frame. Because of noise, a large number of contours will be formed. Thus, the threshold value is increased, and the same process is used until a single contour is produced.

Convex Hulla: Convex hulls are created around the contour points that are formed. The list of faults in the convex hull is generated by the convexity defect. All the defect characteristics are provided within the format of vectors, and they include the defect point in the contour, the depth of the defect, and the beginning and ending points of the line in the convex hull where the defect has occurred.

Direction of Hand Palm Gesture Control: The depth, start, and end points of the convex hull line where the defect has occurred are specified by the convexity defect. The line's beginning and ending points indicate the fingertip. The point in the palm where the fingers meet is called a depth point in the defect. Command is expected by comparing the coordinate values of this spot. The midpoint of the defect line is considered in the calculations for this comparison. The depth point and this midway are then contrasted. Gesture instruction is projected to be forward for small differences in x coordinates and backward for significant differences in y coordinates. The depth, start, and end points of the convex hull line where the defect has occurred are specified by the convexity defect. The line's beginning and ending points indicate the fingertip. The point in the palm where the fingers meet is called a depth point in the defect. Command is expected by comparing the coordinate values of this spot. The midpoint of the defect line is considered in the calculations for this comparison. The depth point and this midway are then contrasted. Gesture instruction is projected to be forward for small differences in x coordinates and backward for significant differences in y coordinates.

Servo motors: The robotic arm is powered by three main servo motors: two on the side of the base plate to precisely transmit movement through the various links to the arm, and one for the base movements. In order to stabilize the base plate and prevent vibrations when the arm is in use, the servo motors will also be fixed to it.

Wherever data entry is done, it is manually recorded and categorized. It catches the essential elements of the gesture. The input gesture is fitted into the gesture recognition model. Image tracking comes after gesture image pre-processing, in which the sensors record the orientation and position of the moving object. The classifier is able to associate each input of a test movement with its corresponding gesture class, and the gesture is officially recognized.

The output window displays the hand gesture that OpenCV recognized in terms of 1s and 0s, which the Arduino IDE's serial monitor further interprets as i/p.

The OpenCV library's Hand Tracking Module handles the image processing. Attributes are imported from the library, which compacts the necessary code for extracting the binary data. It is also feasible to write the bit in a single Python file so that it only requires one program and no libraries, but it is more efficient to write the code quickly and concisely. Using the Serial Module attributes, we can send the processed image data to the serial monitor identical to COM port that the Arduino Uno is connected to. We have specified the baud rate and COM port number of our board when we declared the variable.

The hand's five servo motors enable the fingers to function. The Arduino UNO board's pulse width modulation (PWM) pins are Associated with the motors. The motors are powered by external 9V batteries in addition to the board's 5V and 3.3V sources. We have only utilized the bread board's power rails, which are where the positive and ground/negative connections are made, in order to keep the circuit looking small and neat.

Application

It can be an extremely practical tool for people who are physically challenged. Can be used for bomb dispersal in areas where There's a significant risk to human life. can become accustomed to fix space stations in orbit. It's a humanoid robotic research project. Suitable for domestic usage as well. Applicable to Chemical, Medical, and Defence Domains.

4.OUTCOMES

A lightweight and reasonably priced prosthetic hand is the outcome of the "Guesture Controlled Prosthetic Hand using Arduino" project. Because its size and weight are similar to those of a human hand, it can serve as a transracial prosthesis thanks to the use of servo motors as actuators in its lightweight construction. It makes a variety of daily tasks easier with its seven grip types. Although it mimics human hand movements, its precision might be reduced. Its uses go beyond helping people with physical disabilities; it is also applicable to the manufacturing, aerospace, mining, and other industries.

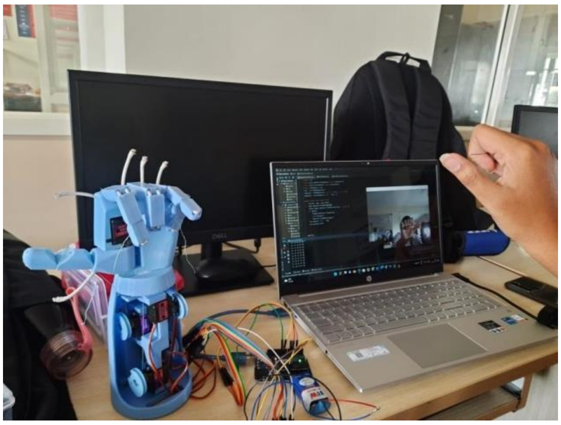

Fig. Output with thumb movement

Fig.Output Image of hand gesture recognition and formation of convex hull

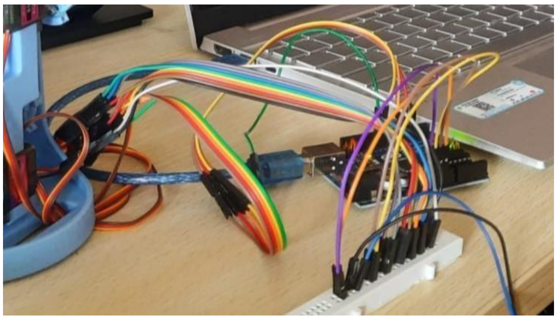

Fig.Connection of Arduino

4.CONCLUSION

The artificial hand that is being proposed is lightweight. A low-cost prosthetic hand with a lightweight structure is provided by the servo motors acting as actuators. This hand's size and weight are similar to those of a human hand, making it appropriate for usage as a prosthetic hand in transracial prosthetics. Additionally, the prosthetic hand features seven grip patterns that allow it to perform daily tasks. It functions exactly like a simulation of a human hand, albeit naturally with less accuracy. Prosthetic hands are beneficial for more than just helping individuals with physical disabilities; They are also frequently utilized. in the manufacturing, aerospace, mining, and other industries.

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