

VOICE CONTROL BASED PROSTHETIC HUMAN ARM

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Abstract – In the present world, the number of amputee cases is rising every year, which needs to be resolved. Currently many different types of prosthetic arm, which are medically certified, are around the market. These are either too expensive or don't satisfy the needs of the patients to the fullest. In this paper, we provide a technological advancement for the arm by enabling voice control and even manage to cut down the cost of the electronic and mechanical equipment required in building a working prototype of the prosthetic arm. Our prototype resembles the functional structure of the biological human arm. Most of the complex movements of the arm and hand is made possible by achieving near perfect replication of the movements of the biological human arm. The joints of the fingers on the prosthetic arm have been modelled based on the biological human fingers to replicate all the actions typically obtainable by any human finger. The prototype of the prosthetic arm presented here doesn't rely on the biological signals from the nerve endings of the residual arm in the human body, hence it can easily replace the prosthetic arm which rely on phantom limb, as the human brain loses the phantom limb sensation after a period of about six to eight months. In this paper, we have specifically tackled this above problem and even provided an advancement in the form of voice control commands to the robotic prosthetic arm which we modelled using economical devices and equipment to cut down the heavy cost of affording a prosthetic arm.

Key Words: Prosthetic arm, Voice control, Phantom limb, Nerve endings, Residual arm.

1. INTRODUCTION

The prototype that is designed consists of 6 degrees of freedom from shoulder to wrist and 6 degrees of freedom on the palm along with the fingers. 2 degrees of freedom on the shoulder joint, 2 on the elbow and 2 on the wrist which gives the overall movement of the prosthetic arm similar to a human arm. Moving on to the fingers, thumb has 2 degrees of freedom and other fingers have 1 degree of freedom each. The fingers are made of 3 joints, the mechanism is further explained later.

Brandi House et al. [3] presented in their work, the first working model of making a robotic arm do simple task such as moving a candy from initial position to the destination using voice commands. Modelling neural networks and developing algorithms to recognize human speech and using them for controlling robots

was first shown here. S. Mohamed Sulaiman et al. in their paper [1] have described the design of a three fingered robotic upper limb that can take human voice commands as inputs. They configured the elbow joint. R. Aswin Balaji et al. [2] ventured a method to simplify robot programming. Their goal was to make the complex technical languages used for robot programming more intuitive, easier, and faster to grasp. Abhinav Salim et al. [4] presented a design of a working robotic arm which takes in voice/speech signals using a speech processing unit and microcontroller. They pre-coded the necessary movements of the motors to perform different tasks. A speech recognition module was trained for recognizing the inputs like 'move forward' etc. and executed in real-time. Young June Shin et al. [5] demonstrated high performance in power and precision of a humanoid arm/hand by using three actuation principles - Electromagnetic joint lock mechanism, twisting actuation and distributed actuation.

We have taken inspiration from the aforementioned works and designed a prosthetic arm that can do most of the typical tasks required by an amputee. It can further even be programmed to do things that a human arm cannot do.

2. TECHNICAL WORKING

2.1 Block Diagram

The user can control the prosthetic arm in the form of human voice commands. The voice commands are recorded using a microphone. The microphone is connected to the embedded system (Raspberry Pi). The Raspberry Pi (controller) converts the voice commands into text using Google's API and compares the text with the pre-coded commands, for example 'pick up' or 'wave'. The Raspberry Pi sends the position data to servo motors based on the voice command it received. If the voice is not audible or unclear there is another option, i.e., remote control. The servo motors give their current position as feedback to the embedded system and a distance sensor is used to detect the nearby objects to pick or drop them. This is put in the form of block diagram below in Fig -1.

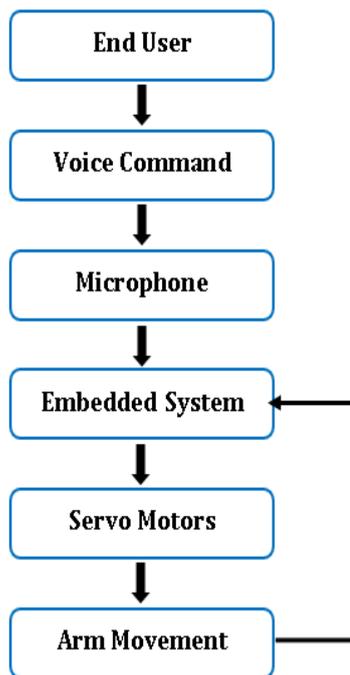


Fig -1: Flow Diagram

2.2 Structure and Working

The prosthetic arm prototype modelled using 6 heavy and 6 mini servo motors is displayed in Fig -2. It has two servo motors to control the two degrees of the shoulder, one degree of freedom pitch - the up/down movement and the other degree of freedom roll - the forward/backward movement. There are two servo motors to control the motion of the elbow joint and two servo motors to control the wrist movement. The shoulder joint experiences the most torque among the six servos as it has the longest support to connect the motors increasing the torque experienced by the shoulder joints. This model uses 35 Kg torque servo motor at the shoulder. The elbow joints experience lesser torque compared to the shoulder. Hence the model uses 20Kg servo motors at the elbow joint. A small amount of torque is experienced at the wrist joint which only needs a 10Kg servo motors to provide a stable movement. All the six servo motors are controlled individually to complete the motion of the arm. At the palm of the arm, there is an ultrasonic sensor to detect the presence of an object to further consolidate the movement of the arm in a smooth and uninterrupted way. The working model of the finger joint movement and the embedded system of the prosthetic arm is discussed further.



Fig -2: Prosthetic Arm Mechanical Structure

A set of predefined motions are available on the arm linked to the voice commands. New commands and motions can be defined for an array of use cases based on the user needs. A distance sensor is placed on the palm of the arm to detect nearby objects and help the arm to pick the object easily if necessary.

2.3 Embedded System

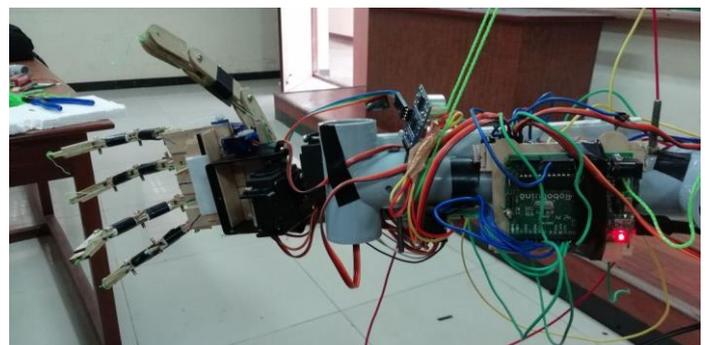


Fig -3: Embedded System Connections

The voice input is taken into the Prosthetic arm i.e. the commands are picked up by the microphone connected to the embedded system. The embedded system consists of a Raspberry Pi for data processing and control of the arm and SIM 1200 model for providing the Raspberry Pi with constant network access. The data processing is done at this block with the data acquired from the microphone and the feedback data obtained from the Servo motors. The raspberry pi (Fig-4) computes this data and passes on new set of data points for the movement of the servo motors to the desired location.



Fig -4: Raspberry Pi

2.4 Control Logic

The Raspberry pi waits for the signal from the user to record the voice commands. Raspberry pi starts recording the audio when the signal is given. Google API is used to convert the speech to text and the text is compared with the pre-saved commands. The position data is sent to the servo based on the command given by the user. The distance sensor is used to give feedback to the entire arm and is used to adjust the motion of the arm based on the surroundings. A detailed Control Flow block diagram is shown in Fig-5.

Test case: If a “Wave” command is given to the system; the arm moves in a way which depicts a Wave motion. This is achieved by moving the arm to upper position by controlling the shoulder and elbow joints and moving the elbow roll axis in clockwise-direction up to 30 degree and in anti-clockwise direction up to 30 degrees.

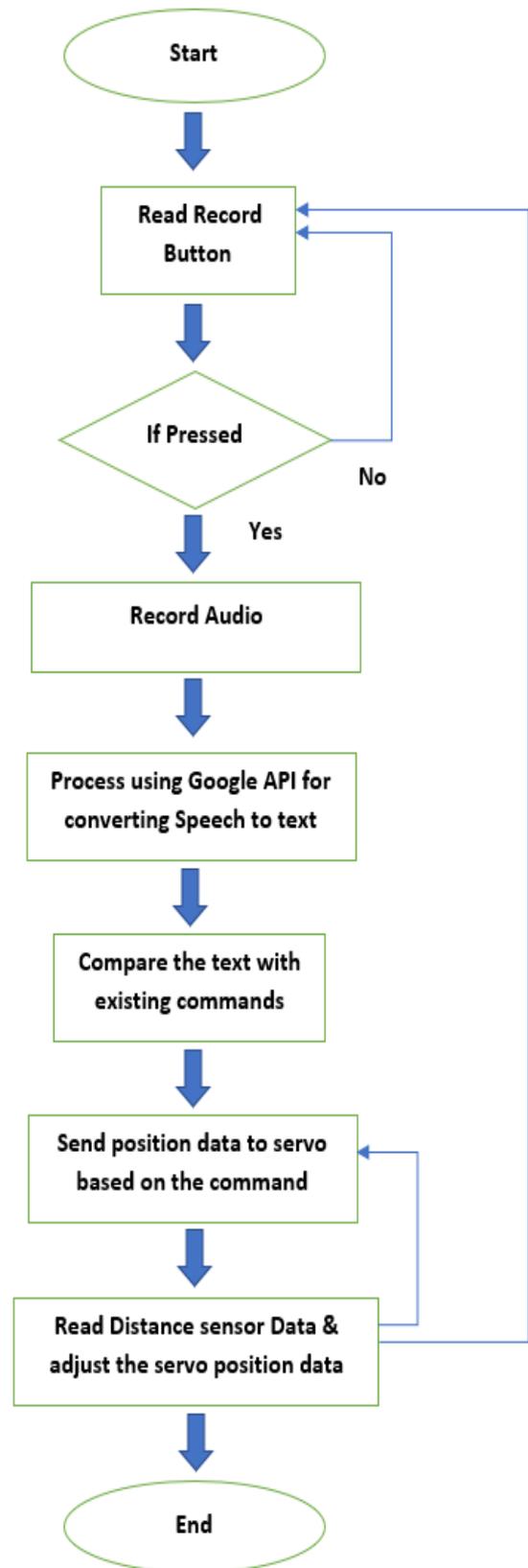


Fig -5: Control Flow

2.5 Finger Joint Mechanism

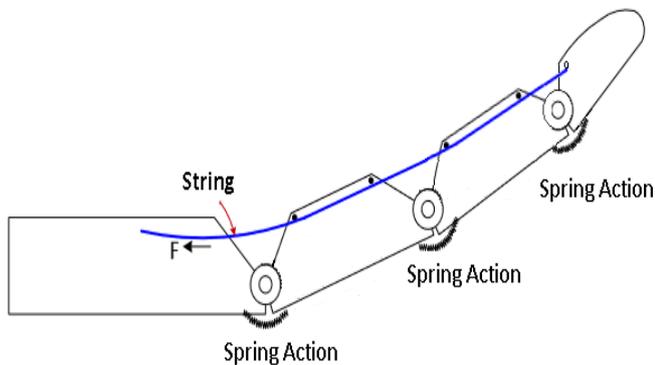


Fig -6: Finger Joint Mechanism

In our prototype of the prosthetic arm, we were able to depict the near perfect movement of the human fingers by a unique mechanism. **Fig -6** shows the overview of the mechanism used to achieve the finger movements. There are five fingers on the model. Each finger has a different servo controlling the finger movement. The thumb has 2 servos controlling the motion as there are 2 degrees of freedom for the thumb. The servo in the fingers turns clockwise to control the inward motion of the finger i.e. towards the palm of the arm. A retraction mechanism is used to retract the finger back to its original position i.e. away from palm after the servo turns anticlockwise. The second servo on the thumb is used to control the position of the thumb to change the angle at which the thumb interacts with the object.

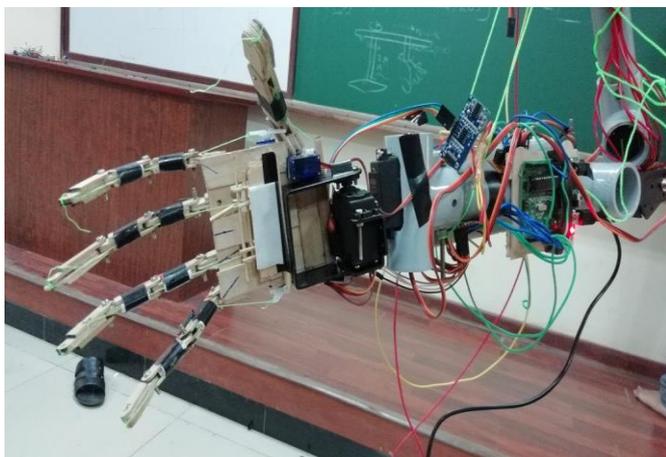


Fig -7: Prosthetic Arm fingers movement inwards

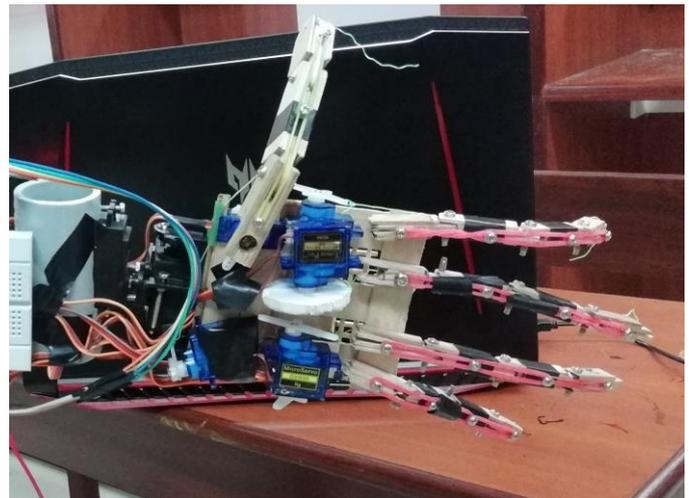


Fig -8: Prosthetic Arm fingers movement outwards

3. CONCLUSIONS

Human robot interaction (HRI) has a wide range of applications; prosthetics is one of them. In this paper, we have taken up a medically inclined issue and solved it. This study involves intricate mechanical design of the arm as well as electronic control. A low-cost, yet functional prosthetic arm was designed and tested to take human vocal commands as inputs. Alternatively, when voice isn't audible, it can take remote control inputs as well. The arm can potentially do all quintessential tasks done by a human arm on daily-basis.

4.FUTURE SCOPE

As for enhancement of our design, we can use our own neural network model for recognizing human voice commands instead of Google speech-to-text API which requires internet connection. Currently we coded a few basic commands like 'Grab', 'Release', 'Wave', 'move forward', 'move backward'. The number of commands can be increased based on the requirement and the memory of the embedded system, for instance "tying shoe laces" can eventually be coded. This technique can also be implemented on various other wearable aids (like leg or walking aids) or different fields as well.

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