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Electromyography Sensor Controlled Bionic Hand for Disabled Persons

Journal of Electrical Systems

Abstract: - The word "Bionic" is amalgam of domain Biology as well as Electronics. In today's era, we come across new emerging technology which is rapidly evolving. Bionic hand is one of its kinds. However, with upgrade technology the demand for bionic hand will continue to increase day by day in upcoming years with wider awareness. The major purpose behind the project is to help an individual to improve the sensation, integration with the body and the control. The development and operation of bionic hand has been explained and controlled by Electromyography Muscle Sensor. Signals from an amputee muscle are gathered by bionic arms to function. The muscle sensor is the main component which senses electrical activity of our muscles and translate those activity which results in flexing of finger with the help of servo motors. 3-D printing is used in the design and construction of the bionic arm. The result we obtain here after demonstration is 80% movement of little finger, ring finger, middle finger and fore finger as well as 30% movement of Thumb finger. Along with this when pressure is strongly applied, the signals from the muscle goes to the sensor and hence result in approximate 75% movement of all five fingers together.

Keywords: Electromyography Muscle Sensor, Bionic Hand, Servo Motor, Arduino

I. INTRODUCTION

The World Health Organization (WHO) estimates that there are currently more than 1 billion persons with disabilities worldwide. 80 percent of them reside in low-income nations where only 1-2 percent of the disabled population gets access to therapy. Many individuals in impoverished nations are born without hands or digits as a result of various conflicts, diseases, etc. An individual's control, integration with the body, and feeling can all be improved with the use of bionic hands. Electromyography (EMG) signals from a group of body muscles can be used to control the suggested system. The main objective is to design a Bionic hand, designed on a 3D printer by using EMG control platform. Bionic hand is the electromechanical device that has been made in the form so that it attaches to the human body and duplicate the functionality of our natural arm/hand. Bionic hand attaches to the body with sensors that contact the skin. Bionic hand requires users to retain their muscles to perform actions. Bionic hand uses the sensor which is connected to the electrodes that touches to the skin and record the activity of the muscle through a process called electromyography. One can easily remove and reattach the bionic hand device without affecting its usage. Bionic prosthetics technology is becoming an intuitive day by day because it takes up the specific electrical impulses generated from our muscles and then translates those impulses into the actions such as grasping motions. Are artificial limbs that work by the signals that are provided by the individual's muscles through the muscle sensor. Some bionic limbs also depend upon the electrical signals that are coming from the brain and nerves so as to get the proper movements limb suggests. Both mechanical and electrical power can be used in bionic hands, as well as a combination of the two. For example when a person puts on the bionic limb and flexes the muscle above it or below the limb sensor will react because it is getting the signal out of the muscles of an individual and it will elicit an appropriate movement that user wishes to have, suppose the person has put the bionic arm and normally want to open the hand. This sends the signal to the myoware muscle sensor attached to their skin and further goes in the bionic arm to flex the hand and have the movement.

II. RELATED WORK

Neural controlled prosthesis hand [1] gives two solutions over the available prosthesis hand. First one is to develop mechanical system which gives more degree of freedom and second is controlling the additional skill to move hand. B. Hudgins, P. Parker presents [2] a new method for controlling a multifunction prosthesis by categorising myoelectric signals. The article "EMG Controlled Bionic Arm" by M. Gauthaam and S. Satish Kumar [3], which was published in the 2011 Proceedings of the National Conference on Innovations in Emerging

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Technology, explains that the human hand is a complicated system with many degrees of freedom. In both clinical and scientific settings, energy signals are employed to operate artificial hands presents in this paper's review of conventional techniques. Features are extracted from several times agreements of myo electric signal to an artificial Network and two control signals are derived from natural contraction patterns that come through the sensor. According to the electric signal generation models, the electric signal measured using the surface of the electrode is stochastic. These common assumptions are the foundation of the myo electric control system. And this explains why the combined motor unit activity in the pickup zone of the electrons is random. It is feasible to anticipate a modest variation in the value of a certain feature between individuals due to the nature of the electric signal, and this is particularly true in cases where the muscle structure has been altered as a result of an amputation or congenital abnormality. The information in this section suggests that the myoelectric signal has a significant structure at its commencement of contraction and relaxation, and that this structure is distinct from contractions that yield various link functions. In addition to reviewing the conventional approaches for using an EMG signal to control artificial hands in clinical and research settings, this article also discusses potential future advancements for these devices' control schemes. M. Decca [4] [5], reviews the conventional approaches to controlling artificial hands using an EMG signal and discussed potential future advancements in the management of these devices.

The author of "Bionic Hand" in IJERT- International Journal of Engineering Research & Technology [6], Sahla Yoosuf Husain Ahmed, discussed how bionic prosthetic hands are fast developing. The need for a broader understanding will grow along with technology advancements in both the demand for and use of bionic hands. The literature summarizes the significant developments in computing engineering and medicine that contributed to the creation of the bionic hand prosthesis that is currently on the market. The human hand is by nature complicated, making it difficult to replace its functions with a binary device. For this reason, these simple controllable prosthetic limbs that rely on the system of cables tied to the muscles have been developed. When the user contracts or relaxes particular muscles, electrodes in the socket detect the muscle signals and send them to the sensor, which converts them to the battery-powered motors to move the fingers and hand. Electric upper limb technologies use these electrical signals to control the movements of prosthetics. The only functions that the hand prosthetics that are now available can perform are opening and shutting the hand. This severely restricts the prosthesis' utility in comparison to the several degrees of mobility in a fully functional hand. S.Sudarshan presented in [7] Since the muscles in the remaining arm continue to function normally, limb replacement procedures can use the electromyogram (EMG) signals from these muscles. A Myoelectric Prosthetic Arm is one such option; it regulates the prosthetic arm's movement by using the patient's EMG impulses. Bionic hand presented in [8] uses a myo sensor, which is found in the forearm. Muscle signals have been recorded using it. Root mean square (rms) was used to construct the muscle signal feature extraction process. By utilising back propagation through an artificial neural network to recognise the movement signal pattern, a sort of bionic hand movement was discovered. In order to move the bionic hand, the microprocessor processed the output data from back propagation and sent it to the servo motors. Michaela Snajdarova, Jan Barabas, Roman Radil [9] creates a system that can classify signals in real-time and control a prosthetic hand when worn by a human, more development will be done in the areas of prerecorded EMG signal processing and neural network categorization of different hand movements. This suggested work [10] shows how to build and operate an affordable, reliable, and flexible bionic arm that is managed by an Arduino microcontroller. 3-D printing was used in the design and construction of the bionic arm, and silicone was used for casting. Tests conducted on amputees in real time have demonstrated the low-cost bionic arm's ability to grasp a variety of objects with effectiveness.

Author [11] examined the literature and provided an overview of the significant developments in engineering, computing, and medicine that have resulted in the creation of the bionic hand prostheses that are on the market today. As this field of medicine develops, it will be critical for the medical community to comprehend the evolution of bionic hands and the technology that powers them. The work presented in [12], discussed two stages in the context of an amputation below the elbow that involves two actions: opening and closing the hand. First, the body-powered prosthetic hand is developed and controlled using the surface electromyography signal (sEMG) through a servo motor and the dsPIC30f4013 processor. Next, software based on fuzzy logic concept is used to detect and process the patient's EMG signal, and it is used to teach the patient how to control the movements without the need to have the prosthetic arm fitted. Author Praveen designed and developed real time bionic hand using EMG sensor is presented in this paper [13]. In this work [14], we examine how ten healthy participants responded to support from an elbow-powered exoskeleton that applied a proportionate EMG control. This system does not require any particular calibration; it only provides an approximate estimate of the user's muscular torque. Development of few more prosthesis hands is shown in [15],[16] and [17]. Low cost wearable EMG based prosthesis hand is presented in [16] and robotic hand for interactive humanoids is explained in [17].

III. PORPOSED MODELLING

The Bionic hand in our case is 3D printed hand designed cautiously which appears more like a human hand. Bionic hand in our case can be controlled by EMG sensor connected to the muscles which are detected by body part. To control the bionic arm Muscles are tensed firmly in the certain way so to get an desired output that is flexing of fingers. EMG Muscle Sensor detects the electrical signal when electrodes are placed on the skin's surface and contacted. It then feeds the signal to Arduino UNO's input analogue pins to control system. The code for these signals was written in the IDE Arduino programme. The code includes a few grip patterns that show how the little, ring, middle, fore, and thumb fingers should be held in both closed and open positions. Analogue to digital converter (ADC) built into Arduino transforms analogue signals into digital signals. The Servo motors receive these digital signals from an Arduino's digital output pin. The movement of the servo motors is dependent on the output voltage generated by an Arduino. The five fingers are attached to servo motors that are linked together with nylon wire and thread. The servo motors' output tends to move the fingers in predictable patterns, such as open and shut grips. In this way, Bionic hand works with the help of Myoware Muscle Sensor, Servo motors and Arduino UNO. Figure 1 and 2 gives the work flow of a system and hardware components used to build a hand.

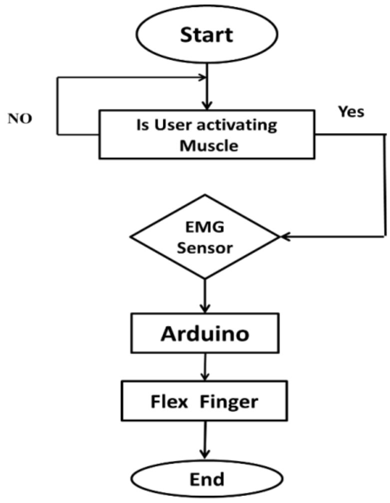


Figure. 1 Work flow of a system

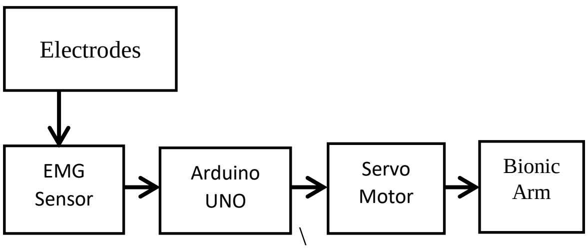
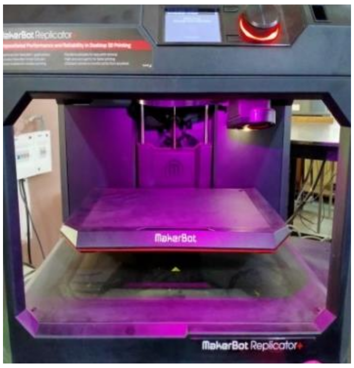


Figure. 2 Block diagram of a Bionic Hand

1.1. Bionic Arm

In this case, the bionic arm is a carefully constructed and 3D printed arm that matches a human hand more. Using a layering technique, 3D printing uses computer-aided design (CAD) to produce three-dimensional things. We use CAD (computer-aided design) software to create our model. CAD is a design and technical documentation tool that automates the process of manual drafting. Over the past ten years, advances in 3D printing have made 3D printed prosthetics a viable choice. We used a 3D printing equipment and precise dimensions to produce a model that resembles a human hand almost exactly. The Maker boat Replicator+ 3D printer was used to make a bionic hand. We can create intricate shapes using 3D printing while utilising less material than we would with conventional manufacturing techniques. Figure 3 displays different modules of 3D printer.



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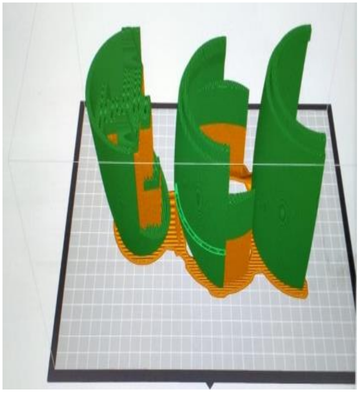

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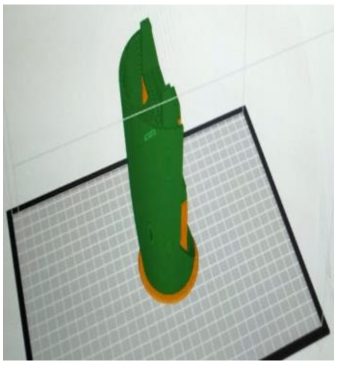


(c)

(d)

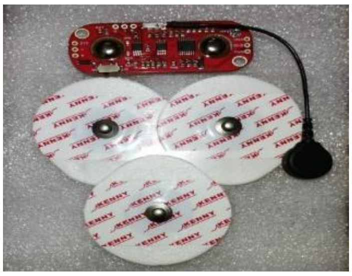
(e)

Figure. 3 Modules of 3D printing: (a) Internal structure of 3D printer (b) 3D view of fingers (c) 3D view of little finger (d) 3D printed palm and (e) 3D printed separate finger parts

1.2. Electromyography Sensor

When you perform a specific movement, your muscles produce tiny electrical impulses that the EMG sensor, also known as an electromyography sensor, detects. When muscles contract, an electrode placed on the skin's surface creates an electrical signal that is sensed by an EMG muscle sensor, which records the motions of the muscles. The signal's amplitude, which can range from 0 to 10 millivolts (peak to peak) or 0 to 1.5 millivolts (rms). The EMG signal's frequency ranges from 0 to 500 Hz. However, the EMG signal's useful energy is predominately between 50 and 150 Hz. Assembly of EMG sensor is shown in figure 4.

(a)



(b)

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Figure. 4 Muscle sensor: (a) Electrodes mounted on hand (b) Electrodes (c) EMG sensor

1.3. Servo Motor

A servo motor, which is a rotary actuator or linear actuator, can be used to precisely control the angular or linear position, velocity, and acceleration. Standard servo with high speed and torque is the MG995.The MG995 High-Speed Digital Servo Motor rotates 180 degrees, or 90 degrees in each direction. It is a digital servo motor that interprets PWM signals more quickly and effectively. The fingers typically move in response to the servo motors' output. Figure 5 shows servo motor used in the system

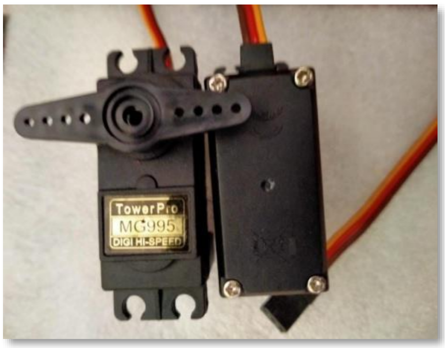


Figure. 5 MG995 Servo motor

1.4. Arduino UNO

Analogue to digital converter (ADC) built into Arduino transforms analogue signals into digital. The actuators receive these digital signals from an Arduino's digital output pin. The servo motors are these actuators. The movement of the servo motors is dependent on the output voltage generated by an Arduino. Five servo motors that are threaded together are attached to the five fingers. Figure 6 displays an Arduino UNO.

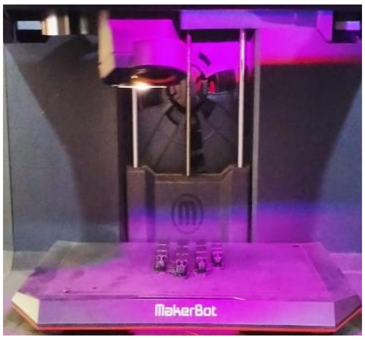
Figure. 6 Arduino UNO

1.5. 3D Printing

Some fundamental ideas and platforms were needed for additive manufacturing in order to produce the product. The creation of a digital model of the product using software is a fundamental requirement of 3D manufacturing. We may use Solid Works Computer Aided Design (CAD) software to create a digital model of. Because it is so simple to use and run, Solid Works is widely used. The proposed prosthetic hand's 3D CAD model is made to be the same size and weight as a normal human hand, and all of the mechatronic parts are made to fit inside the hand. Apply input the software-generated file to a 3D printer after configuring all the software's parameters. The 3D printer will read the file and create the item using the specified parameters and dimensions. 3D printing is not possible with any material. Polylactic Acid (PLA) is the material used in the 3D printing technique to create 3D models. Figure 7 shows 3D printer parts and Polylactic Acid material(PLA) used for 3D printing.

(a)

(b)



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(d)

Figure. 7 3D printer and Polylactic Acid material: (a) View of 3D printer (b) Polylactic Acid material assembly (c) Maker Bot (d) Mould of fingers

You can write Arduino programmes with any programming language that has a compiler that can produce binary machine code. The Arduino project offers the cross-platform Java application known as the Arduino integrated development environment (IDE). It came from the Wiring project's IDE and the Processing programming language project. It provides an easy-to-use one-click method for assembling and uploading programmes to an

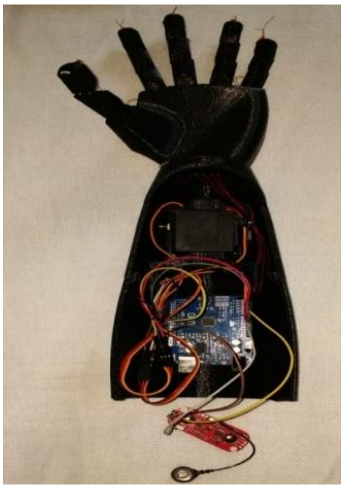
Arduino board and includes a code editor with automatic indentation, syntax highlighting, and brace matching. A "sketch" is an Arduino IDE-created programme.

The programming languages C and C++ are supported by the Arduino IDE. The "Wiring" software library from the Wiring project is made available by the Arduino IDE and offers a variety of standard input and output operations. The Arduino IDE uses the programme to transform the executable code into a text file in hexadecimal coding after compilation and linking using the GNU tool chain. A loader programme in the board's firmware then loads this text file into the Arduino board.

IV. RESULTS AND DISCUSSIONS

The result of Bionic hand is obtained as shown in Figure 8. Figure 8 (a) shows polylactic acid (PLA) material printed complete 3D printed hand. Figure 8 (b) expresses hardware assembly on 3D printed hand. Figure 8 (c) states closing movement of fingers and Figure (d) shows opening movement of fingers. Here when an EMG sensor is placed on the surface of the skin with the help of electrodes and contracted, electrical signal is generated and further feed to Arduino UNO to its input analog pins. This analogue signal is converted by the Arduino UNO, which then outputs a digital signal. The servo motors receive these digital signals from the Arduino's digital output pin. The servo motors that move the finger open and close are driven by the output voltage that an Arduino generates.

The result we obtain here after demonstration is 80% movement of little finger, ring finger, middle finger and fore finger as well as 30% movement of Thumb finger. Along with this when pressure is strongly applied, the signals from the muscle goes to the sensor and hence result in approximate 75% movement of all five fingers together. Table 1 gives comparative analysis of the system with other systems on the basis of parameters like processor, sensor, motors, finger movement and 3D printed material.



(a)

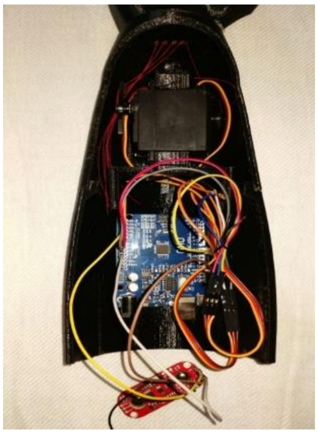


Figure. 8 Results of finger movement: (a) 3D printed hand (b) Hardware assembly on 3D printed hand (c) Closing of fingers (d) opening of fingers

Parameters	Paper[10]	Paper [12]	Proposed system
Processor & Sensor	Arduino UNO & Myoware sensor	DSP Processor & Myoware sensor	Arduino IoT MKR 1000 & Myoware sensor
Finger movement	Finger movement	Opening and closing hand	Five finger movement, Opening and closing hand
Servo motor	Six servo motor	-	Two Servo motor
3 D printing material	3 D printed hand	Silicon material coating hand used	Polylactic acid (PLA)material is used

Table 1 Comparison with other system

V. CONCLUSION

The aim of our proposed system is to construct a sensor based Bionic hand. Gradually, this becomes an example of companionship between man and machine further enhancing the technology to next level. The results we obtain here is the movement of the finger open and close. To look more appealing we hide visible mechanics and strings. However, these bionic prostheses hand still have to overcome considerable hurdles and many further modifications are required for performing smooth daily activities. Hence, we conclude that our system will be very cheap with wide application and advanced technology. For this project our team was successfully able to improve and design a unique bionic arm. As the technology progresses, we are likely to progress with it and many changes to be occurred which is not a bad thing.

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