Design and Fabrication of 3D Printed Bionic Arm

DHINESH S K, PRASAD K S,

Bannari Amman Institute of Technology,
Department of Mechatronics Engineering, Erode,
Tamilnadu, India

***Abstract*—The bionic arm is an electro-mechanical device that can be primarily used and applied in the field of disability. The whole device is a combination of electrodes governed by the EMG muscle sensor that is merged in a 3D-printed mechanical design along with other smaller units. The device detects the type of muscular movement based on the voltage level provided by the EMG sensor and according to motion is performed, with the help of servomotors.The voltage level of the muscles varies depending on their movement. This phenomenon is caused by the tension that the muscles generate during their contraction. The readings collected by the sensors allow the robotic arm to interpret the movement of the muscles.**

***Keywords*—Bionic hand, Amputee,Electromyography, EMG, Control system**

I. INTRODUCTION

Any person's most valued possession is their body. The absence of a human hand is a difficult scenario that makes one appreciate the complexity of the human body. The project is driven by the goal of utilizing knowledge in the electronics area, which would primarily play a role in improving the lives of this particular impaired group of individuals. Until recently, the design of such limbs had evolved at a glacial pace. Traditional versions of such weaponry include early developments such as wooden arms. Bionic arms have a long history of being passive devices that give nothing in the way of control and mobility. However, recent breakthroughs in such devices have been made. Slowly, but steadily, we are approachingadvanced transhumanintegration.

II. OBJECTIVE

Design and build a microcontroller-based bionic arm that uses electromyography signals produced from muscle contraction to generate a variety of useful motions

III. DESIGN OF ARM

A. *Materials*

- Arduino Uno
- Servo Motors
- Electrodes
- EMG muscle sensors
- The Bionic arm

B. *Methodology*

The primary idea is to control a robotic arm with input generated from electromyography data. The input data from the muscle sensor are extracted based on the amount of muscle contraction as well as the number of contracted muscles; in other words, the higher the level of activated muscles, the greater the recorded voltage amplitude.[1] When the potentials in motor neurons are generated, this results in muscle fiber contraction. It becomes a muscle action potential when the neuron and axon cross the threshold in the Postsynaptic Membrane of the Neuromuscular Junction.

Because of the difference in potentials, the muscle potential is propagated in both directions of the muscle fiber, prompting the sliding of actin filaments on myosin. On Muscle Unit (MU) contractions, a variety of fibers are stimulated by a mixture of activations and synchronizations.[2] The frequency of MU relates to contractions that relax after each activation, resulting in temporal pules of two or more MU firing together. Muscle contractions are controlled by activations and synchronizations (MU).[3] In the suggested arm, the wrist has six degrees of freedom, the thumb has five degrees of freedom, and the remaining four fingers

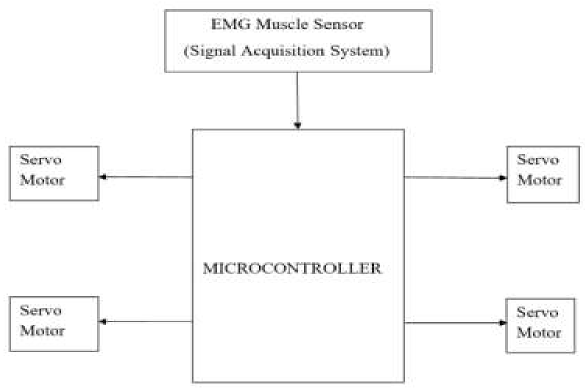

Fig 1: Block diagram of the proposed system

When connecting the EMG sensor to the microcontroller, the sensor requires 6V and a ground supply, according to the protocols and guidelines.[4] If the supply is insufficient, exceeds the EMG sensor is vulnerable to failure. Likewise, the operation must be based in a low-electricity area. Due to electrical interference, the field is disrupted.

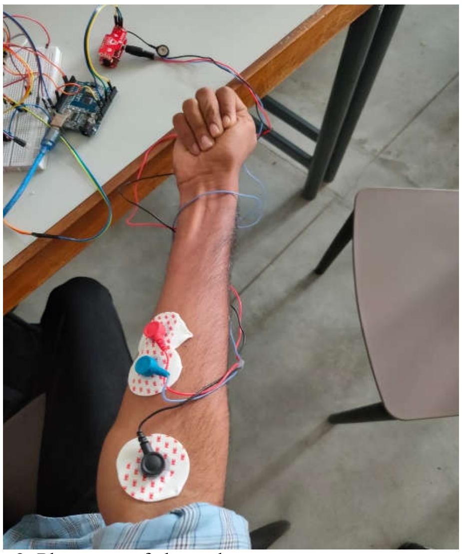

Fig 2: Placement of electrodes

The information supplied by the psychological condition of the person is also a factor in the EMG sensor. the host of the event Similarly, a common ground supply must be established. structured to reduce unwelcome vibrations.

IV Flowchart Of The System

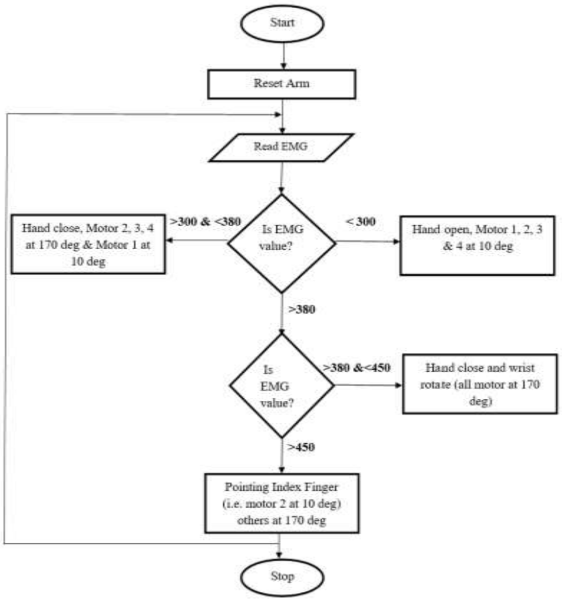

Fig 3: Flowchart of the system

If different values correspond to different types of motions, the values read by the EMG sensor constitute the basic working basis for the motion of the bionic arm. Initially, the arm is in the reset position, which denotes the open hand condition, which is used as the reference position. [5] The readings differ on an individual basis, and the arm must be calibrated accordingly. The readings in the flowchart are based on the muscular movements of one of our research participants. Wrist motion is controlled by motor one; index finger motion is controlled by motor two; thumb motion is controlled by motor three, and remaining finger motion is controlled by motor four.

Fig 4: 3D Design of Bionic Arm

When the EMG value exceeds 300 microvolts, all of the motors rotate by 10 degrees, causing the hand to open and the fishing lines to form an interface between the motors and the fingers. Similarly, if the value is between 300 and 380 micro volts, the hand closes due to the rotation of motor 1,[6] which controls the wrist by 10 degrees, and other motors, which control the fingers by 170 degrees, resulting in the complete closure of the palm. Similarly, [7]if the value is between 380 and 450 microvolts, all motors rotate 170 degrees, causing the hand to close and the wrist to rotate in a fist-like motion.[8]If the value exceeds 450 micro volts, motor 2 rotates by 10 degrees, while the other motors rotate by 170 degrees, resulting in a fist with a pointing finger. The value is continuously read, and matching motions are done based on the nature of EMG data, as previously described.[9] The time it takes for the EMG signal to arrive and the arm to move is generally determined by the delay parameter in the code and the sensor's processing capacity.[10] When a microsecond timer is used to test the planned bionic arm, it is discovered to have a delay of 500ms.

V. Result And Discussion

The graphical representation is attached, as well as the value of readings in tabular form for the various types of motion indicated by the arm. The nature of the EMG sensor signals for various postures is graphically compared. The reading obtained while the hand is in the open position is used as the reference point for comparing different hand motions. The first graph compares the nature of readings between the open and closed positions of the hand, while the second graph compares the nature of values between the reference position and the closed and rotated positions of the hand. Similarly, the contrast between the reference location and the pointing index finger.

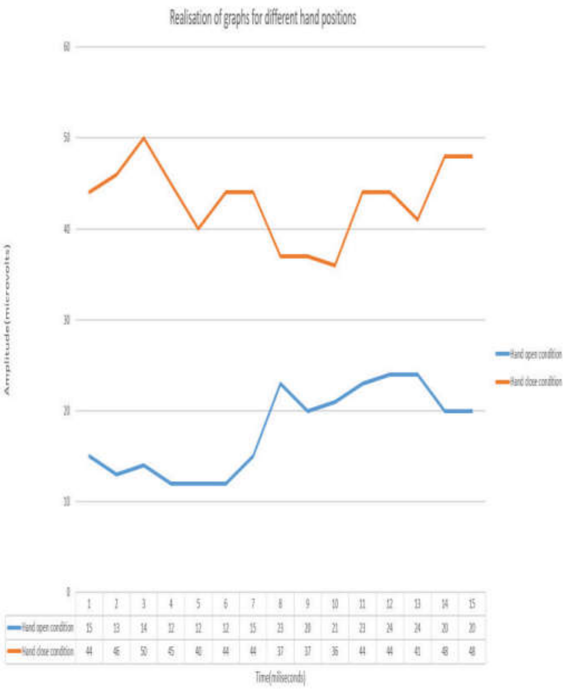

Fig 5: Graph for hand open and hand closed position

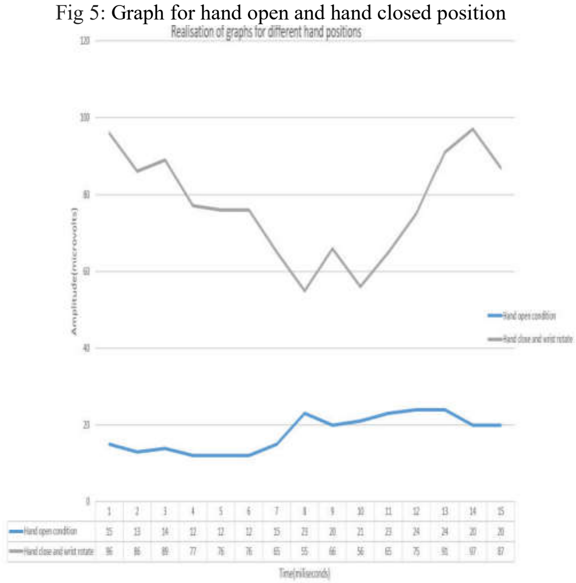

Fig 6: Graph for hand open and hand close and wrist rotate position

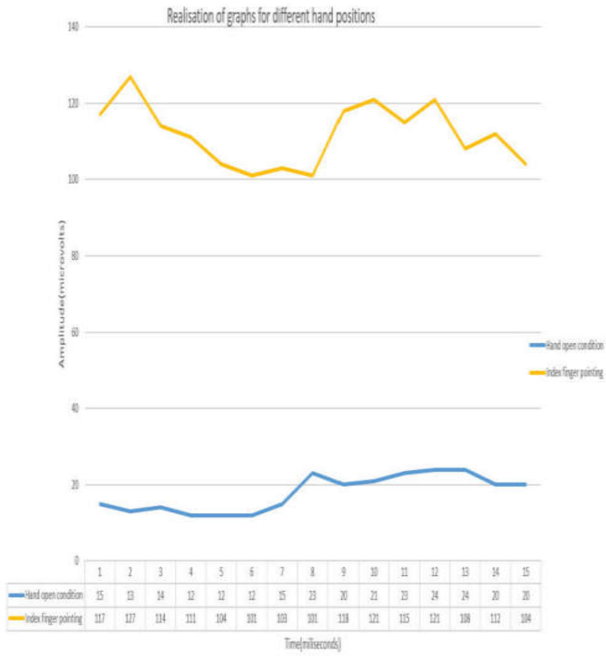

Fig 7: Graph for hand open and index finger pointing position

Due to the general benefits of a lightweight system over a large one, the arm is 3D printed, putting it ahead of traditional arms, which have a significant range of motion delay. motions as a result of their weight. The EMG sensor is the most important component. servo motors' rotational motion as a working tool. The mobility is controlled by a microprocessor that is housed inside the bionic arm. The sport of fishing the motors and the fingers is connected by a line. The result is that the Different EMG values influence different motions. Servomotors are used to create motions where the fishing is done. The line acts as a connector.

Control is based on EMG - electrical activity of muscles. EMG signal is obtained by three uECG devices (I know, it is supposed to be an ECG monitor, but since it is based on a generic ADC, it can measure any bio signals - including EMG). For EMG processing, uECG has a special mode in which it sends out 32-bin spectrum data, and "muscle window" average (average spectral intensity between 75 and 440 Hz). frequency is on a vertical axis (on each of 3 plots, low frequency at the bottom, high at the top - from 0 to 488 Hz with ~15 Hz steps), time is horizontal (old data on the left overall here is about 10 seconds on the screen)[7].

Intensity is encoded with color: blue - low, green - medium, yellow - high, red - even higher. For reliable gesture recognition, a proper PC processing of these images is required. But for simple activation of robotic hand fingers, it's enough to just use averaged value on 3 channels - sEMG conveniently provides it at certain packet bytes so Arduino sketch can parse it. These values look

much simpler.

Red, green, blue charts are raw values from sEMG devices on different muscle groups when I'm squeezing my thumb, ring and middle fingers correspondingly. For our eyes these cases clearly are different, but we need to turn those values into "finger score" somehow so a program can output values to hand servos. The problem is, signals from muscle groups are "mixed": in the 1st and 3rd case blue signal intensity is about the same - but red and green are different. In 2nd and 3rd cases green signals are the same - but blue and red are different [8]. In order to "unmix" them, I've used a relatively simple formula:

S0=V0^2 / ((V1 *a0 +b0) (V2 * c0+d0))

where S0 - score for channel 0, V0, V1, V2 - raw values for channels 0, 1, 2, and a, b, c, d - coefficients which I adjusted manually (a and c were from 0.3 to 2.0, b and d were 15 and 20, you would need to change them to adjust for your particular sensor placement anyway). The same score was calculated for channels 1 and 2.

EMG sensors placement:

In order to get reasonable readings, it's important to place sEMG devices, which are recording muscle activity, in the right places. While many different options are possible here, each requires a different signal processing approach. It may be counter-intuitive, but thumb muscle signal is better visible on the opposite side of the arm, so one of sensors is placed there, and all of them are placed close to the elbow (muscles have most of their body in that area, but you want to check where exactly yours are located [9].

The data acquisition of EMG signals is fetched from the non-invasive method using surface electrodes. And further thesignal conditioning is done for noise rejection or filtering and the signal is amplified.The next workflow is segmentation of data by disjoint and overlapping segmentation.

Then Feature extraction is the process of transforming raw data into numerical features that can be processed while preserving the information in the original data set are done based on time domain, Frequency domain, or Time-Frequency domain such as Mean absolute value (MAV) , Root mean square (RMS), Waveform length (WL), Zero crossing (ZC), Slope sign changes (SSC), Auto regressive coefficients(ARC), Frequency median (FMD), Frequency mean (FMN), Modified frequency median (MFMD), Frequency ratio (FR), Wavelet transform (WT), Short time Fourier transform (STFT), Wavelet packet transform (WPT). Then a to a predictive modelling problem where a class label is predicted for a given example of input data [10].

Control methods of prosthetic arm based on EMG can be categorized mainly according to the input information to the controller, architecture of the control algorithm, output of the controller.

VI CONCLUSION

Due to the general benefits of a lightweight system over a large one, the arm is 3D printed, putting it ahead of traditional arms, which have a significant range of motion delay. motions as a result of their weight. The EMG sensor is the most important component. servo motors' rotational motion as a working tool. The mobility is controlled by a microprocessor that is housed inside the bionic arm. The sport of fishing the motors and the fingers is connected by a line. The result is that the Different EMG values influence different motions. Servomotors are used to create motions where the fishing is done. The line acts as a connector.

Fig 8: Prototype of Bionic Arm

VII. REFERENCE

[1] Roberto Merletti and P Di Torino. Standards for reporting emg data. J Electromyogr Kinesiol, 9(1):3–4, 1999.

[2] Mamun Bin Ibne Reaz, MS Hussain, and Faisal Mohd-Yasin. Techniques of emg signal analysis: detection, processing, classification and applications. Biological procedures online, 8(1):11, 2006

[3] Ismail Ben Abdallah, Yassine Bouteraa, and Chokri Rekik. Design and development of 3d printed myoelectric robotic exoskeleton for hand rehabilitation. International Journal on Smart Sensing & Intelligent Systems, 10(2), 2017

[4] Mohammad Yahya Almuhanna. Cost-effective prosthetic hand controlled by emg. 2016.

[5] S. Hasan, K. Al-Kandari, E. Al-Awadhi, A. Jaafar, B. Al-Farhan, M. Hassan, S. Said and S. AlKork, “Wearable Mind Thoughts Controlled Open-Source 3D Printed Arm with Embedded Sensor Feedback System,”in CHIRA, Seville, Spain (2018)

[6] Farina, D., Jiang, N., Rehbaum, H., Holobar, A., Graimann, B., Dietl, H.,“The extraction of neural information from the surface EMG for the control of upper-limb prostheses: emerging avenues and challenges.,” in IEEE Trans. Neural Syst. Rehabil., (2014)

[7] S. Said1,2, M. Sheikh1, F. Al-Rashidi1, Y. Lakys1, T. Beyrouthy1, and S. alkork1, “A Customizable Wearable Robust 3D Printed Bionic Arm: Muscle Controlled” Paris (2018)

[8] Robert Leeb, Hesam Sagha, Ricardo Chavarriaga, et al. Multimodal fusion of muscle and brain signals for a hybrid-bci. In Engineering in Medicine and Biology Society (EMBC), 2010 Annual International Conference of the IEEE, pages 4343–4346. IEEE, 2010

[9] Jacek Ruminski, Adam Bujnowski, Tomasz Kocejko, Aliaksei Andrushevich, Martin Biallas, and Rolf Kistler. The data exchange between smart glasses and healthcare information systems using the hl7 fhir standard. In Human System Interactions (HSI), 2016 9th International Conference on, pages 525–531. IEEE, 2016.

[10] Peter Claudio Castellini, Angelo Emanuele Fiorilla, and Giulio Sandini. Multisubject/daily-life activity emg-based control of mechanical hands. Journal of neuroengineering and rehabilitation, 6(1):41, 2009.