TEKNOFEST

AEROSPACE AND TECHNOLOGY FESTIVAL

TECHNOLOGY FOR HUMANİTY COMPETITION

PROJECT DETAIL REPORT

PROJECT CATEGORY: Benefit of Humanity, DISABLED FRIENDLY

PROJECT NAME: Voice-EMG Controlled Limb for Quadroplegics.

TEAM NAME: KHYAMMERS

TEAM ID: 67119

TEAM LEVEL: Primary School-Secondary School

TEAM MEMBERS: AMEER HAMZA, MUHAMMAD HASHIR NAJEEB

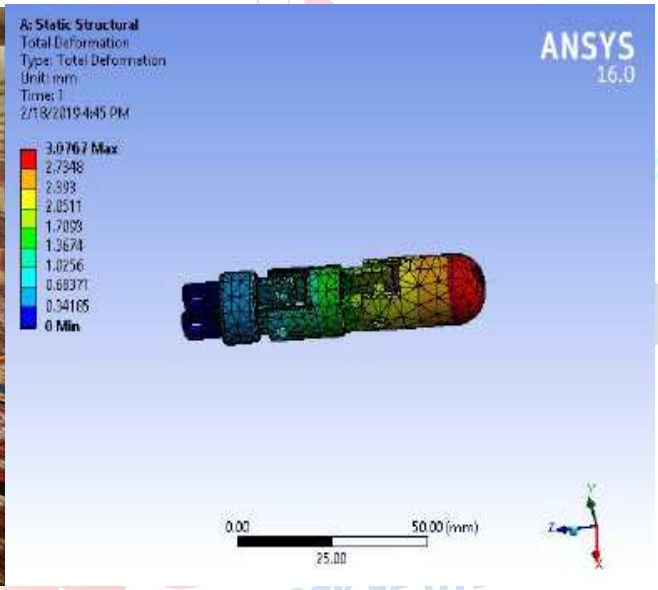
ADVISOR NAME:GOHAR KHURSHID

Project Detail Report

1. Project Summary:

Many people are suffering disabilities in upper body parts. The brain computer interfaces (BCI), myoelectric techniques and voice-controlled methods allow direct communication between the user and machine. Disable person may use this technology to improve their independence and maximize their capabilities.

The study aims to design a hybrid prototype of prosthetic hand that works on Electroencephalographic (EEG), Electromyographic (EMG) and voice-controlled techniques. The prosthetic hand is designed on a 3D modeling software SOLIDWORKS and analysis is done using ANSYS. The design will be fabricated using suitable materials and a modern manufacturing tool known as additive manufacturing, which will then be actuated by servo motors that are controlled by a microcontroller.



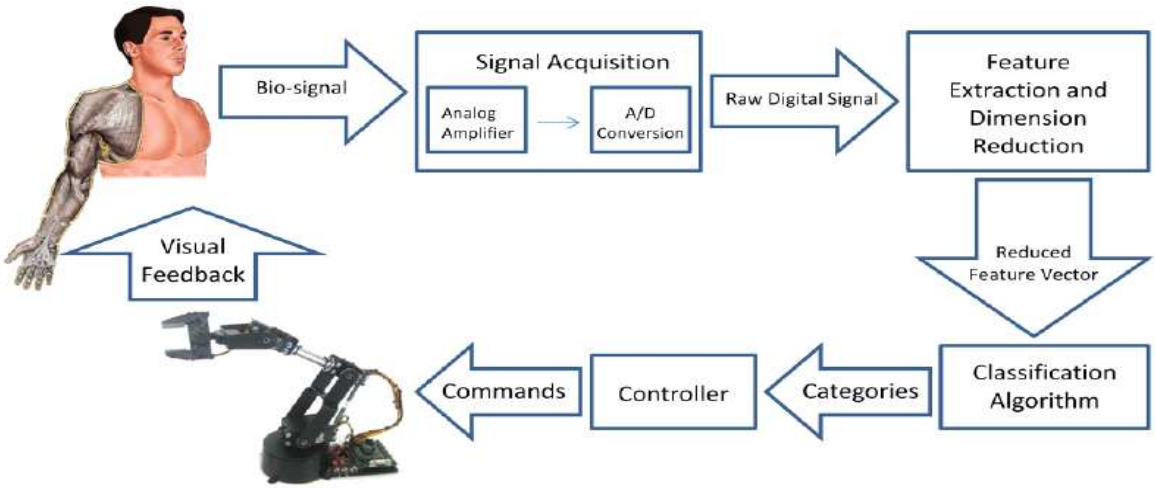
2. Problem/ Issue:

Many people are suffering from amputations and natural disabilities in upper body parts. For such people, they loses their mobility and the ability to manage daily activities as, disable persons surely need some assistance for doing their daily tasks and to perform their daily routine chores.

When an arm is amputated or lost, a prosthetic device can play an important role in rehabilitation. An artificial limb can improve mobility and the ability to manage daily activities, as well as provide the means to stay independent. When we look at the early prosthetics, they are very simple and immovable like metal hook, wooden shaft and pegs but their appearances are very different from the human hand. Later on, there is some advancement on both function and appearance. As technology improved the hand is powered through electrical and pneumatic means.

By the development of EMG (electromyography) it provides some conventional movement and larger degree of freedom. But the major disadvantage of EMG is high cost and it depends on the nerve. As the nerve is injured the EMG is useless. Similarly, there are some deficiencies in EEG based control system. A combination of both EEG and EMG can be a promising solution to minimize the defects.

3. **Solution**

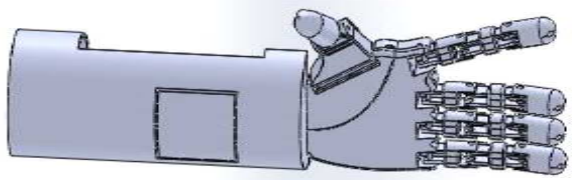


- **Electroencephalogram (EEG) Sensor:**
  EEG (electroencephalogram) is a non-invasive technique through which the electrical activity of human brain can monitored. It is done by placing an electrodes array on the scalp. When the brain act or about to act, the neurons are at work.. EEG measures these voltage fluctuations and from the aggregate of potential difference of thousands of neurons electrodes placed on the scalp are able to detect and record the activity [1]
- **Electromyogram (EMG) Sensor:**
  Electromyogram (EMG) is a kind of HMI system in which muscles electrical activity acquired by bi-potential amplifier to generate simple commands after being processed and classified, to control the prosthetic device. [17]
- **Brain Computer Interfaces (BCIs):**
  The record activity can be translated by using Brain Computer Interfaces (BCIs) which can produce the activity of brain in control output and without any invasive communication and user can communicate [2]. The advantage of interfacing BCIs system with EEG is that, EEG-BCI system with the help of human activities they can explore the features of neuro-electrical signals.
- **Human Machine Interface (HMI):**
  HMI system composed of four main stages which are data acquisition, feature extraction, classification and controller stages.[13]
  In signal acquisition stage, EMG signal is acquired by body and in order to overcome the artifacts and limit the signal band they are filtered. A/D converter is used to digitized the signal and then send to Feature extraction block. Outcome of this block is feature vector and sensed muscle contraction state information is stored in it.

For electroencephalography EEG the record activity can be translated by using Brain Computer Interfaces (BCIs) which can produce the activity of brain in control output and without any invasive communication and user can communicate [2].
From the normal activity of brain waveform is recorded and different frequency bands are used to classify them. When there is any disorder in the brain then high frequency waves are observed and, in this case, user is suffering with brain disease. Brain wave classification is listed below:
Table 1.2: Brain Waves Classification

Type	**Frequency Range (Hz)**	**Origin**
Delta	0-4	Cortex
Theta	4-8	Parietal and Temporal
Alpha	8-13	Occipital
Beta	13-20	Parietal and Frontal
Gamma	20-40	Parietal and Frontal

4. **Method**



The 3d prosthetic hand remains low in cost than the prosthetic hands available[4].The development of myoelectric prostheses has resulted in more liberty of motion. The myoelectric is ineffective when the nerves are harmed. With the advancements in technology noninvasive sensors had been developed which are placed over skin surface and the signals are captured. The Neural Cognitive Prosthesis method is a low cost prothetic tool, a brain control interface (BCI) that can be fitted on the limbs of amputees [24]. Mind waves — or more accurately the mind's capacity to focus and meditate — controls the Prosthetics.. The voice control is also used in which prosthetics are interfaced with computer and operated using voice commands. In this project Electroencephalography (EEG), Electromyography (EMG) and voice control is used to control the movements of prosthetic hand.

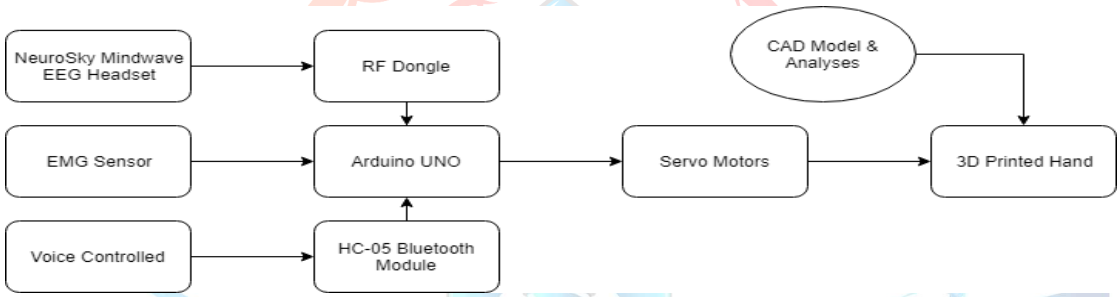
Electroencephalography (EEG): Mindwave is a device used to monitor the electrical activity of brain it is a wearable band equipped with single channel electroencephalogram sensor which captures the waves of different frequencies producing from brain against different emotions then these waves are converted to values of attention and meditation which are used to control the servo motors.

Electromyography (EMG): Myoware is equipped with differential amplifier which measures the action potential generated due to contraction and relaxation of muscles. The

potential measured are analog values which are then converted to digital values having threshold 0-1023 which are then used to control hand movements.

Voice control: Google assistant feature of transcription is used. When the user speaks the word, it is transcribed then this transcription is used to control servo motors according to the program stored in Arduino.

Three control systems are used in this robotic hand with their different methodology. EEG control method receive the signal from brain and Arduino execute with the required program stored in it. EMG system works with the activity of muscles and the threshold value are sent to Arduino. Voice control method works with the google assistant feature and signal are sent to Arduino through HC-05 Bluetooth module. Arduino contains the program for the signal processing and according to this program the servo motors rotates. The rotation of these servo motors causes the movement of hand (grasp or release). Following is a complete block diagram shows how the system works:



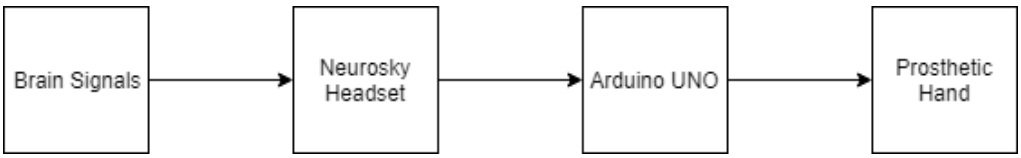
- **Results Comparison and Conclusion:**

The following table shows the comparisons of different control methods:

Method	**Training Required**	**Interfacing with Arduino**	**Noise Effect**	**Cost**
EEG	High	Bit difficult but then perfectly work	No	Between EMG and Voice controlled
EMG	Medium	Simple, but major problems with signal filtration and smoothing	No	Higher than EEG
Voice Controlled	Low but difficult to use	Simple	Very High	Less than EEG

5. **Innovative Aspect**

EEG based brain controlled robotic prosthetic hand is a BCI system uses brainwaves as command signal for controlling the action of prosthetic hand. We try to implement a BCI system through which movement of hand is achieved as normal human movement. The following figure shows the block diagram of EEG based robotic hand. All the components needed are shown in this block diagram.



In this control method, careful detection of EEG signal from the user headset is primarily target.We can control a device by detecting these signals as they can interpret their meanings. By placing electrodes (headset) on the scalp we can monitor the total electrical activity and this methodology is called electroencephalography (EEG).

Neurosky Mindwave Headset

This headset uses a dry electrode system. AAA battery is used to power the system. By using Bluetooth this headset wirelessly transmits the detected signals.

Thinkgear

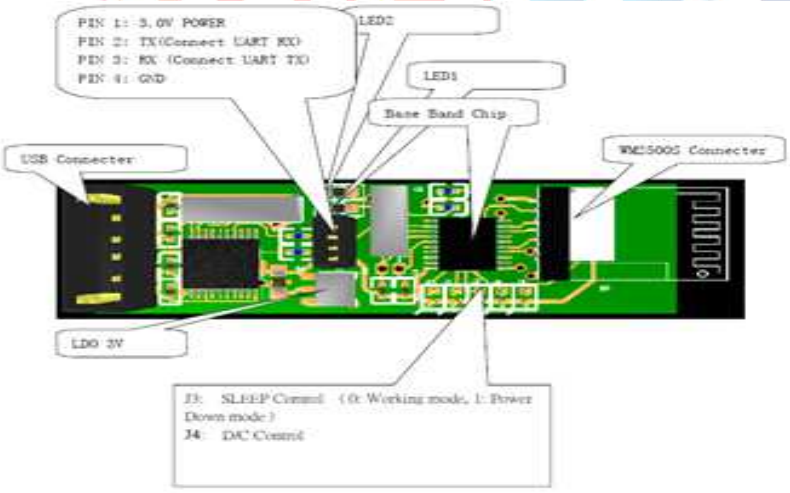
This technology enables a device to interact with the user. It includes sensor touched with forehead, contact and reference points in the ear clip and on-board chip for data processing. It also converts the raw brainwave data to digital electrical signals.

eSense

This technology is used for characterizing mental states. eSense algorithm is applied to interpret eSense metering value in the form of activity range. For example, it generates a value of 0-100 in case of user attention and meditation.

RF dongle

It is used to interface the neurosky mindwave headset to the microcontroller Arduino UNO. In this way Attention and meditation eSense values from the data stream are acquired. For interfacing it is necessary to hack the USB dongle. Dongle and LED array are connected to the Arduino board. Then code is downloaded to the Arduino board and attention eSense values can be obtained on LED array.



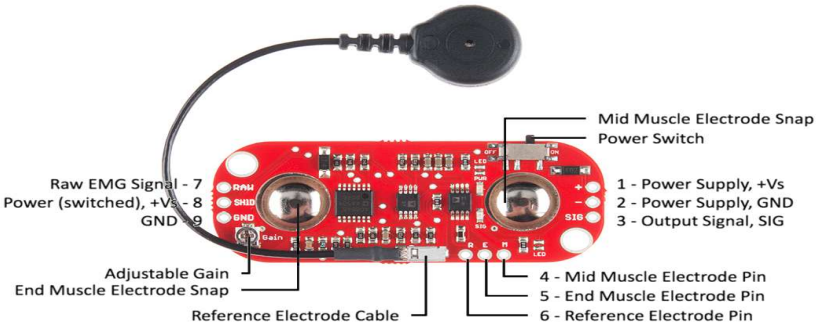
Working of EEG headset Module

As attention and meditation eSense values are generated from user mind ranges from 0-100. When a user performs a task of focusing, the attention values are generated and these values are adjusted to curl the fingers. Similarly, meditation values are generated while relaxation and they are used to open the fingers. Here we assign the value 60. When attention value goes

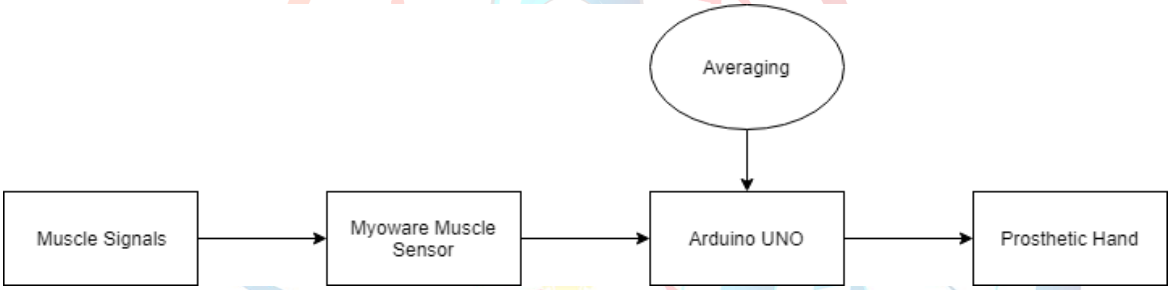
above from 60 the grasping is done and when the meditation value goes above 60 the fingers are open.

Myoware Muscle (EMG) sensor:

Myoware muscle sensor gives the analog values upon flexion and extension of muscles. Sensor is placed on the skin with the help of three electrodes. Then the analog values from sensor are converted to digital values using Arduino where threshold values are 0-1023.



Myoware Muscle Sensor



EMG control methodology

Averaging

To make the values smooth and to avoid digital signal processing techniques concept of averaging is used where we take 10-15 readings and then take the average of these readings this gave very smooth values. These values are then trained on a disabled person and used to control servomotors for the opening and closing of hand.

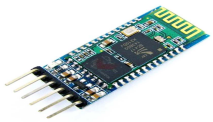
Voice Control Method

Google assistant is used for voice control. Google assistant transcribes the word which someone speaks. This transcription is used to control the prosthetic hand.

When a person speaks “Squeeze” the transcription of word is fed into Arduino through HC-05 Bluetooth module which is further used for the closing of hand. Similarly, when a person speaks “Release” the hand opens.

HC-05 Bluetooth Module

HC-05 Bluetooth module is used by android app to transmit transcribed word to Arduino.



HC-05 Bluetooth Module

6. **Applicability**

The initial goal of this project is to make a cost effective and domestically applicable prosthetic hand. The working on 3D printed prosthesis is done very rapidly in the world and many advancements have been made in this field. Now a day's different type of prosthetics is being made with the integration of different control techniques. The project is developed to reduce the cost and to find out the best control technique to use by a disable person. Additive manufacturing is used for the manufacturing of prosthetic hand and is integrated with three different control systems and successfully implement it on a disable person. Anthropomorphic motion of this prototype using electromyography, electroencephalography and voice-controlled techniques have been successfully achieved.

7. **Estimated Cost and Project Scheduling**

EEG is a relatively low-cost solution then other process. Comparisons shows that if we use EEG sensor then its cost is approximately 100-400$ US. Other surgical solutions are ranges from 10,000-120,000$ [3].

Sr.no	Material used	Cost
1	Myoware Muscle Sensor	10$
2	HC-05 Bluetooth Module	10$
3	EEG Neurosky Headset	50$
4	Arduino UNO	10$
5	Servo motor mg-995 & sg-90	5-10$
6	3D printed model of Robotic Hand	15$
7	Jumper wires	5$
8	Resistors	3$

Project Calendar

Method	**Interfacing with Arduino**	**Time(1 month)**
EEG	Bit difficult but then perfectly work.	One week
EMG	Simple, but need time with signal filtration and smoothing.	One week
Voice Controlled	Simple.	One week
3D printing	(Designing and wiring of system in 3D print)	One week

8. **Target Group of the Project Idea (Users):**

This concept has great potential for improving the function of people with upper limb amputations, especially for high-level amputations, in which the disability is greatest. It hoped that future research will develop the technique further and build synergistically with other exciting research areas.

9. **Risks**

EMG refers to a user muscle activity and they are used in different encouraging control applications. However, there are some disadvantages associated with EMG as they are dependent on user and application. This method is not useful when the user cannot produce muscle signal sufficiently. For example, if the user has totally paralyzed upper limb then device is not useful as the deficiency of signal acquisition.[15]

Similarly, EEG is also a convenient method and EEG based interfaces are widely used in prosthetics. However, EEG signals alone are not fully acceptable due to low reliability, low user adaptability, low accuracy and low data transfer rates.
By making a combination of both systems of these control methods can be a promising solution i.e take the advantage of each signal and minimize the limitation of each.
Voice Sensor Prosthesis Control: Prosthetic arm/hand can be controlled by user in the form of voice commands. Microphone is used to record the voice commands. The embedded system (Raspberry Pi) is connected to microphone. Voice commands are converted into text using Google's API with the help of Raspberry Pi(controller) and with the pre-recorded commands this text is compare. There is a continue feedback goes to the embedded system regarding the current position of servo motors.[21]The complete block diagram of such a systems is given :

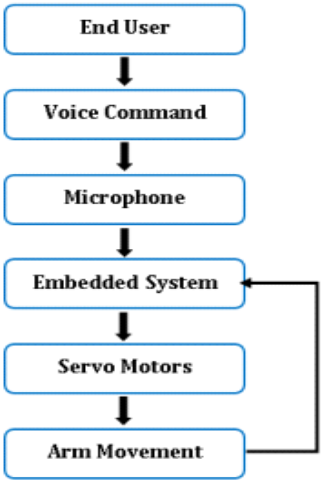


Figure 1.5: A voice command prosthesis control [21]

Purpose is to send the voice signals to servo motors. This obtained by using a Bluetooth module.

10. **Resources**

[1] "EEG-Based Brain Controlled Prosthetic Arm" 2016 Conference on Advances in Signal Processing (CASP) Cummins College of Engineering for Women, Pune. Jun 9-11, 2016
[2]Advances in Science, Technology and Engineering Systems Journal Vol. 2, No. 3, 891-899 (2017) EEG Mind Controlled Smart Prosthetic Arm – A Comprehensive Study Taha Beyrouthy* , Samer Al Kork, Joe Akl Korbane, Mohamed Abouelela
[3] R. Dilmaghani et al., "Design and Implementation of a Wireless Multi-Channel EEG Recording," in IEEE, IET International Symposium on Communication Systems, Networks and Digital Signal Processing, Newcastle, UK, 2010, pp. 741-746

[4] lnglis, Timothy. (2013, April 10). 3D Printed Prosthetic Hand with Intelligent EMG Control. Retrieved October 27, 201S, from http://www.doe.carleton.calcourses/4th_yearprojects/Am4_Ingl is Timothy 2013.pdf-.pdf
[5] D.-G. Kim, K.-S. Hong, and K.-W. Chung, "Implementation of Portable Multi- Channel EEG and Head Motion Signal Acquisition System," in 8th International Conference on Computing and Network Technology, Gueongju, KR, 2012, pp. 370-375.
[6] J.-S. Lin and S.-M. Huang, "An FPGA-Based Brain-Computer Interface for Wireless Electric Wheelchairs," Applied Mechanics and Materials, vol. 284-287, pp.1616-1621, 2013
[7] Y.T. Wang et al., "Cell-phone Based Drowsiness Monitoring and Management System," in IEEE Biomedical Circuits and Systems Conference, Hsinchu, TW, 2012, pp. 200-203
[8] D. Maus, C.M. Epstein, and S.T. Herman, "Digital EEG," in Niedermeyer's Electroencephalography: Basic Principles, Clinical Applications, and Related Fields, 6th ed., D.L. Schomer and F.H.L. da Silva, Eds.: Lippincott Williams & Wilkins, 2011, ch.7, Eds.: Lippincott Williams & Wilkins, 2011, ch. 7, pp. 119-141.
[9] Drakulic, B.S.; Berry, S.J.; Sterman, M.B., "A portable EEG recording system, "Engineering in Medicine and Biology Society, 1989. Images of the Twenty-First Century., Proceedings of the Annual International Conference of the IEEE Engineering in , vol., no., pp.1395,1396 vol.5, 9-12 Nov 1989.
[10] John G Webster, Medical Instrumentation: Application and Design, 3rd ed., New York: John Wiley & Sons Inc., 1998.
[11] Richard Aston, Principles of Biomedical Instrumentation and Measurement, New York: Macmillan Publishing Company, 1990.
[12]. Rechy-Ramirez, Ericka Janet and Hu, Huosheng.Stages of Developing Control Systems using EMG and EEG Signals: A Survey. United Kingdom : School of Computer Science and Electronic Engineering, University of Essex, 2011.
[13]. EMG Signal Decomposition: How can it be accomplished and used? Stashuk, Dan. 2001, Journal of Electromyography and Kinesiology, Vol. 11, pp. 151-173.
[14]. Ovid: Clinically Oriented Anatomy. [Online] dermatologic.com.ar/6.htm.
[15] Jonathan R. Wolpaw, Niels Birbaumer, Dennis J. McFarlanda, Gert Pfurtschellere,Theresa M. Vaughan , Brain-computer interfaces for communication and control, Clinical Neurophysiology, 113(2002), 767-791
[16]. EMG-Based Human Machine Interface System. Alsayegh, Osamah. 2000. IEEE International Conference on Multimedia and Expo, ICME. Vol. 2.
[17] Smith, M. J., & Kirk, S., & Tate, J., & Cox, D., (2014). Material characterization and preservation guidance for a collection of prosthetic limbs developed since 1960. Studies in Conservation, 59(4)
[18] “3D printing for soft robotics – a review” Science and Technology of Advanced Materials, 2018 VOL. 19, NO. 1, 243–262
[19] “Development of Cost Effective EMG Controlled Three Fingered Robotic Hand” 2012 Third International Conference on Computer and Communication Technology
[20] “VOICE CONTROL BASED PROSTHETIC HUMAN ARM” International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 07 | July 2018 www.irjet.net p-ISSN: 2395-0072 © 2018, IRJET | Impact Factor value: 7.211 | ISO 9001:2008 Certified Journal | Page 473
[21]Design and implementation of a voice-controlled prosthetic handJanuary 2011 Turkish Journal of Electrical Engineering and Computer Sciences 19(1) DOI: 10.3906/elk-0912-315
[22] Mota, A. (2017). Materials of Prosthetic Limbs.
[23] Singh, H. L. Realization of Real Time Robotic Arm Control System Based on EEG Signal.