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Bionic Arm Using Muscle Sensor V3

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Abstract*: Current motorized limb prostheses provide rudimentary functionality for the application in everyday life. Together with a poor cosmetic appearance, this is the reason why a large percentage of amputees do not use their prosthetic device regularly. This paper seeks to present an overview of current state of the art research on neural interfaces. The focus lies on non-invasive recording with EMG and especially High-Density EMG sensors. Additionally, direct machine learning and pattern recognition algorithms for the decoding of the recorded signals are discussed. Finally, promising research directions for advanced prosthesis control will be discussed. The bionic arm uses EMG signals to control each action of the hand. In order to control them, we need to record the EMG signal for different actions. And compare it with real-time values to move the hand in a different manner. There are separate servo motors to control the actions of each finger separately. So these are programmed by using microcontrollers.

***Keywords:* EMG, EEG, Invasive, Non-invasive, Intra-muscular, Prosthetic, Muscle Potential, Muscle Firing Rate.**

1. INTRODUCTION

The human arm is kinematically redundant with respect to reaching and grasping tasks in a 3-D dimensional (3D) workspace. As a result, an upper limb exoskeleton designed for stroke rehabilitation requires a motion control strategy that can render natural arm postures. Conventionally, motion control has been viewed as a matter of the structure and function of the central nervous system. Studies from the perspective of neuroanatomy have focused on relating motor functions to different cortical, sub-cortical, and spinal subsystems [2]. From the perspective of neurophysiology, Donders law has been applied to arm postures in reaching movements, yet it is violated when pointing at a target with the elbow flexed [3]. On the other hand, the equilibrium point (EP) hypothesis specifies physiological variables used by the central nervous system (CNS) as control variables, to address the redundancy problem (i.e., the behavior of the uncontrolled manifold) in the human motor system at the muscle level [4]. Unlike the neurophysiological perspective, a robotic viewpoint considers the human body, particularly the musculoskeletal system, as a mechanical system with kinematic and kinetic properties. The behaviors of this mechanical system are constrained by its physical structures and the laws of physics. The neural system does not so much to dictate the movement of this mechanical system as to enhance the compatibility of the system with the environment so that the task can be completed according to the requirements and with satisfactory performance [5]. According to Clement, Bugler and Oliver, 2011, loss of a hand can be devastating. The primary causes of hand loss include; trauma, dysvascularity, and neoplasia. 67% of males have upper limb amputees. Upper limb amputations most commonly occur during the productive working years with sixty percent between the ages of 16 and 54. [1]

2. BASIC CONCEPTS

2.1 BIONICS

An electro-mechanical device that replaces parts of the body and possesses natural human capabilities (WORLDINFO, 2014). According to NATURE, 2014, Bionics also refers to prostheses interconnected with the nervous system and operated by myoelectric control. [2]

2.2 Prothesis

This refers to an artificial device used to replace a missing body part (”Nature,” 2014). Its functions to restore an amount of normal functioning to the amputee (”Made How,” 2014). The five generic types of prostheses include • Postoperative, • Initial, preparatory, • Definitive and • Special-purpose (Michael J. Quigley, 1988). [2, 3]

2.3 Myoelectric Control

This refers to the process of surgically grating an artificial limb onto living bone. The process enables efficient energy transfer and fits between body and prosthesis (Communication, 2014). [2]

3. METHODS

Here are the methods which are used in controlling Bionic Arm.

3.1 Electroencephalography (EEG) Recording

The following are the fundamental blocks of building an Electroencephalographic capturing system [2, 4]

- Conducting electrodes
- Signal Conditioners with Gain
- Analog to Digital Converters
- Capturing Device

Fig 3.1 Brain Signal Recording

The signals are taken from the scalp by using suitable electrodes. The signals coming from the electrodes are very weak with low amplitude and high noise content. In order to manipulate or process this signals, we need to condition these signals by using various digital or analog signal conditioners. Initially, the low amplitude signals are first amplified to a proper readable gain by using amplifiers then these are converted into a digital signal so that we can easily read and understand them. [14]

3.2 EMG

EMG or Electromyography is one of the common methods of recording signals used to control bionic devices. It is a non-invasive method of recording. It does not measure the activity of brain directly instead it measures the electric potential which is generated from a muscle cell. In this section, we will describe the methods of recording EMG signals and also recent advancement in the research of EMG recording. There are different methods exist to control prosthetic devices using EMG. The most common commercial application of Bionics use dual-site approach and single site approach the former uses signals of direct muscles for Exon, Pronation (Extension) and supination and the latter one use only one source of the signal to control both directions by giving different levels of contraction of muscles in a single site. Signal recording the common signal recording is mainly achieved using monopolar and mono-deferential setups. In monopolar recording system, the Electrodes senses the muscle signals and referencing electrodes will be kept away from source whereas mono dierential concept is mainly based on two electrodes one places on muscle ber at an XED interelectrode distance to record the local dierents. [12, 13]

There are two types of recording:

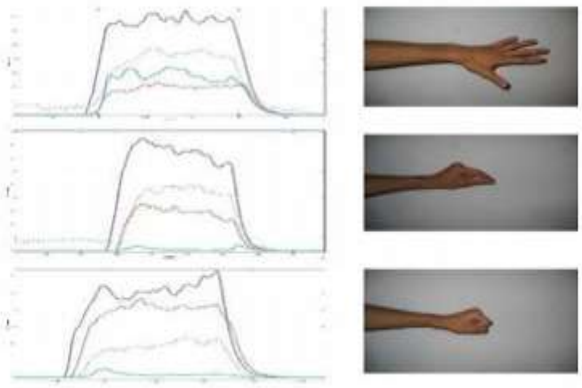

Fig 3.2 Variation of EMG Signals Based on Finger Movements

3.2.1 Invasive Recording

The most efficient and high-quality methodology for acquiring neural signal activities is by placing electrodes below the skull surgically but these are very dangerous for the patients because in this method the skull is break and electrodes are immersed into it so there are chances that the patient can be get infected due to the presence of a foreign object so the body may reject it. [7, 9, 15]

In the invasive method of signal acquisition, the electrodes are directly placed on the surface of the brain to record the activities of the cerebral cortex. This method was discovered at Montreal Neurological Institute in the year 1950.This method was used to treat the patients with epilepsy to find out the area of cortex which generated an epileptic seizure. The signals are taken by microelectrodes from local eld potentials. This leads to a resolution (spatial) of one cm and resolution (temporal) five mille seconds. The action potential of individual neurons can be measured if the electrodes are used with high sampling rate greater than ten kilohertz. The reason for this massive increase in resolution is, that the potentials are primarily produced by cortical pyramidal cells which lie several layers below the surface of the cortex.

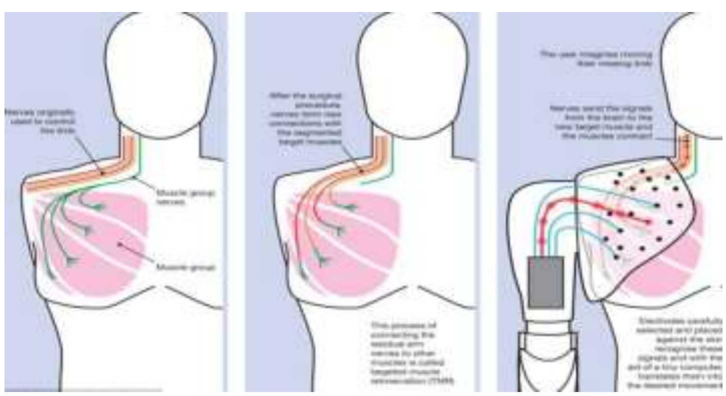

Fig: Method of Invasive Emg Recording

3.2.2 Non-Invasive Type

In the non-invasive method of EMG recording, the electrodes are placed on the surface of the skin. Usually, we use three electrodes an active reference and ground electrode to measure the electrical activity in a muscle cell. The electric potential in the electrode is caused due to the changes in the expansion and contraction of the muscle. When the muscle expands there will be a high potential compared with muscle contraction. In these methods, the firing angle, the time required for the brain signals to reach muscle is measured. [6, 8, 17, 18]

4. DISCUSSION

The bionic arm uses EMG signals to control each action of the hand. In order to control them, we need to record the EMG signal for different actions. The EMG signal of every action or movement of the arm is stored. Whenever the arm is to be moved we get a unique signal. In the real time application, we compare the signals we receive with stored values and identify the motion of the arm. There are separate servo motors to control the actions of each finger separately. According to the motion, we give signals to each servo motors and control the rotation and direction of the servo motors. These achieved by using microcontrollers, here Atmega 328 P-PU

Fig 4.1 Structure of Bionic Arm, Muscle Sensor v3 used to take EMG Signals to Control Arm

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