International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 03 | Mar -2017 www.irjet.net p-ISSN: 2395-0072

Brainwave Controlled Robotic Arm

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Abstract - *There are about 5 million disabled people. These disable people are affected with various neuromuscular disorders. In order to express themselves, one must provide them with augmentative and alternative communication. For this, Brain-computer interface system (BCI) has been developed to address this need. The basic assumption of project reports the design, construction and a testing replica of the human arm which aims to be dynamically as well as kinematically accurate. The delivered device tries to resemble the movement of biological human hand by reading the signals generated by brain waves. The brain waves are sensed by sensors in the neurosky headset and generate alpha, beta and gamma signal. Then this signal is processed by the microcontroller and the movement is then generated to the artificial hand via servo motors. Patient that suffer from amputee below the elbow can benefit from this bio-robotic arm.*

Key Words: **Neurosky headset, Bluetooth module HC-05, Arduino, servo motors**

1. INTRODUCTION

In India, there are five million disabled folks (in movement/motor function). The disable folks affected with varied incapacitated disorders like induration disorder or amyotrophic lateral sclerosis (ALS), brain or medulla spinal is injury, myasthenia, brain-stem stroke, encephalopathy etc. that we tend to should offer a basic communication so as to offer them a chance to specific themselves.

Today with growing, new technology improvement in gadgets is reaching the nice height. Every technology is seeking for fewer human interference, additional automation. What concerning everything happen together with your thoughts? 2 main technologies were developed over time: Brain-computer interface (BCI) and Electrooculography (EOG) primarily based system. The EOG primarily based system could be a technique for mensuration the potential of the membrane by analyzing the encompassing muscles, whereas BCI could be a non-muscular line that permits someone to send commands or messages to an automatic system like robots or prosthetic device, by means that of his brain activity to specific themselves.

With the introduction for interfacing of a brain in 1970, brain-computer interface (BCI) has currently knowledgeable lots of development and is gaining a large scope everywhere the planet. The brain-computer interface interacts with the external parameters and thus the thorough method is in real time. Brain-computer interface was developed to endorse disable folks that found it troublesome to convey things to others. If they supplied with communication methodologies that don't involve any reasonably muscular motion they'll be able to work by their bio-mechanical artificial arm and BCI have a significant half during this. This has been boon to all or any disabled folks. Also, it's increased technologies and natural philosophy to the next level. By the assistance of the encephalogram signals, the disabled person gets the management of external parameters. The essential building blocks for this interfacing are: signal extraction, signal acquisition, and signal distribution. There are a varied brain options which might be wont to enhance communication and event connected bodily function rhythm. Once the disabled person is unable to use giant motion then these options can prove helpful to them.

There are varied classes into that the brain signal is classed. This classification is finished supported the frequencies they possess. These signals are alpha, beta, and gamma, theta rays. Supported these frequencies the signals may be distinct to completely different classes. The neurons area unit in constant motion inside the body and there's a tiny low quantity of ionic current that flows through them. The characteristics that play a significant role in process a BCI system area unit the brain signals, options extracted through it, commands allotted to associate output device, and also the realization of style.

Within the following chapter, we tend planning to study brain-computer interface and changing brain signal into the movement of the arm.

2. METHODOLOGY

1.1 System Design

EEG-based brainwave management arm could be a brain management interface system that controls the action of the robotic arm using brainwaves for the part of commanding signal. Whereas, these area unit useful as same because the regular human hand. Figure one shows the fundamental diagram of the brainwave controlled a robotic arm. This may offer the informing of all elements that may be employed in interfacing a robotic arm.

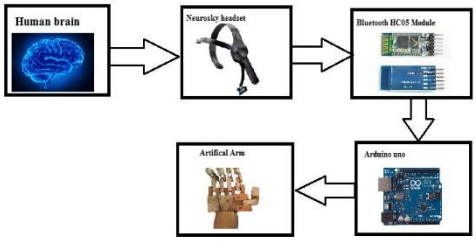

Fig -1: Basic block diagram of Brainwave Controlled Robotic Arm.

This system as briefly classified into following four stages. Figure 2 shows the classification of the following four stages. These are Signal detection, Signal acquisition, Signal transmission, and Mapping signal to the arm.

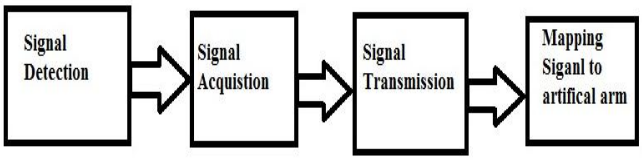

Fig -2: Four stages of Robotic Arm

1.1.1 Signal Detection

This stage firstly targets at the careful detection of the EEG signal from the human brain. The human brain consists of million number of neurons. Each nerve cells are connected to one another by dendrites and axon. Each and every time we think, move, and feel, sense our neurons are at work. These signals are generated by an electric potential, these are carried out by ions on a membrane of individual neurons. To detect various signals, these can help for interpreting what they mean and use them to control a device of some kind. EEG measures voltage fluctuations emerging from ionic current within the neurons of the brain. In the brain, there are millions of neurons, each of which creates small electric voltage fields. EEG is a superposition of many elementary signals. The basic of an EEG signal in normal adult basically ranges from about 1 μV to 100 μV. These signals are generally described in frequency ranges.

Table -1: Brain activities generated in frequency

Brainwave type -Frequency Range			
Delta	1-3Hz	L-Beta	13-17Hz
Theta	4-7Hz	H-Beta	18-30Hz
L-Alpha	8-9Hz	L-Gamma	31-40Hz
H-Alpha	10-12Hz	H-Gamma	41-50Hz

Brainwave speed is measured in Hertz (cycles per second) and they are divided into bands delineating slow, moderate, and fast waves.

a. Delta Waves

Delta brainwaves are slow, loud brainwaves (low frequency and deeply penetrating, sort of a drum beat). They're generated in deepest meditation moreover as untroubled sleep. Delta waves suspend external awareness. Also, they're the supply of sympathy. Healing and regeneration are excited during this state. That's why deep restorative sleep is thus essential to the healing method.

b. Theta Waves

Theta brainwaves occur most frequently in sleep however also are dominant in deep meditation. It acts as our entrance to learning. In theta, our senses are withdrawn from the external world additionally as targeted on signals originating from at intervals. It's that twilight state that we tend to unremarkably only expertise the amount as we tend to wake or doze off to sleep. In theta, we tend to are in a dream; vivid representational process, intuition and knowledge on the far side our traditional aware awareness. It's wherever we tend to hold our 'stuff', our fears, troubled history, and nightmares.

c. Alpha Waves

Alpha brainwaves are dominant throughout quietly flowing thoughts and in some thoughtful states. Alpha is that the power of being here, within the present. It's the resting state for the brain. Alpha waves aid overall mental coordination, calmness, alertness, mind/body integration and learning.

d. Beta Waves

Beta brainwaves dominate our normal waking state of consciousness. It's a 'fast' activity. It present once we are alert, attentive, engaged in problem-solving, judgment, decision making, and engaged within the focused mental activity.

Beta brainwaves are any divided into 3 bands; Lo-Beta may be thought of as a 'fast idle, or musing. Beta is that the high engagement or actively computation one thing out. Hi-Beta is highly advanced thought, group action new experiences, high anxiety, or excitement. Continual high-frequency process isn't associate economical way to run the brain, because it takes an amazing quantity of energy.

e. Gamma Waves

Gamma brain waves are the fastest of brain waves. This is relate to simultaneous processing of information from different brain areas. It passes information rapidly. In gamma waves the most subtle of the brainwave frequencies is the mind has to be quiet to access it. Gamma is also above the frequency of neuronal firing, so how it is generated remains a mystery. Gamma rhythms modulate perception and consciousness. The greater presence of Gamma relates to expanded consciousness and spiritual emergence.

1) Neurosky Mind wave Headset

The human brain is formed up of billions of interconnected neurons; the patterns of interaction between the neurons are portrayed as thoughts and emotional states. Each interaction between neurons creates associate discharge. On these charges are not possible to live from outside the skull. The activity created by many thousands of synchronic discharges aggregates into waves which may be measured. Totally different {completely different} brain waves square measure the results of different patterns of the neural interaction. These patterns cause waves characterized by completely different amplitudes and frequencies. The contraction of muscles is additionally related to distinctive wave patterns. Of these patterns is however some Neurosky devices observe blinks.

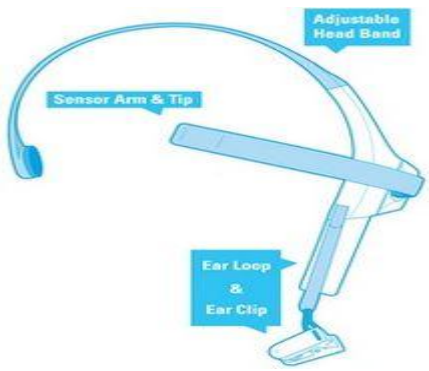

Fig -3: Neurosky Mind Wave Headset

2) Think Gear

The think Gear connector runs as a background method on your laptop. This is often accountable for directional telephone receiver information from the serial port to an open network socket. It's available on each Windows and OS X. Any language contains a socket library ought to be ready to communicate with it.

1.1.2 Signal Acquisition

Signal acquisition is the method of sampling signals that measure universe conditions. This converts the resulting samples into digital numeric values which might be manipulated by a computer.

The signals scan by Neurosky Mind wave headset is distributed to Bluetooth module. The headset only detects, processes, and converts the signals into digital type.

1.1.3 Signal Transmission

Bluetooth HC 05 Module

Signal transmission is completed between the Bluetooth HC-05 and microcontroller. Bluetooth HC-05 could be a wireless communication protocol. It's utilized in 2 devices for sending as well as receiving the data. It's free to use within the wireless communication protocol whereas the range of the Bluetooth is a smaller amount than different wireless communication protocols like Wi-Fi and Zigbee. It operates at the frequency of the 2.41 GHz.

The HC 05 Bluetooth module is that the most popular module within the Indian market. It's largely utilized in the embedded projects. It's simple to use and straightforward, its worth is low. These modules are designed for the clear wireless association setup. It is extremely simple to use within the Bluetooth interface protocol.

1.1.4 Mapping signal to Robotic/Prosthetic Arm

The signal received from Bluetooth HC-05 module transceiver has to be mapped to the Robotic/Prosthetic arm in the microcontroller (i.e. Arduino Uno). The received signal will act as a command signal to control the arm.

a) Arduino Uno

Arduino board design use a variety of microprocessors & microcontrollers. The boards are equipped with sets of digital and analog input and output pins that may be interfaced to various expansion boards and other circuits. The microcontrollers are typically programmed using features from the programming languages C and C++.

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input and output pins, 6 as analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or battery. This microcontroller based Arduino is easy to use for beginners and can run on Mac, Windows, and Linux. This also

supports cross-platform and easy programming environment.

b) Robotic/Prosthetic Arm

An artificial arm is a man-made device that is integrated into a human to replace a natural organ, for the purpose of duplicating a specific function so that the patient may return to normal life as soon as possible. New plastics and other materials, such as carbon fiber have allowed artificial arm to become stronger and lighter, limiting the amount of extra energy necessary to operate the arm. This technology has been used in both animals and humans. This artificial arm having servo motors each individually connected to the five finger. These servo motors will help in controlling function such as extension and flexion. These movements will be controlled by the command signal generated from Arduino Uno according to the brainwaves value received. Hence, the arm is controlled by using the command signal on a real time basis.

3. EXPERIMENTAL STUDY

This artificial arm uses Arduino Uno platform continuously for analyzing the incoming EEG signals and map them to appropriate actions. This system consists of two important sections. The first one is brainwave headset provided by Neurosky Mind wave and the other one is Bluetooth module which is used for reception of the signal. Signal acquisition is done by Bluetooth module HC-05. The other section is Arduino which process incoming data and map into the robotic arm. Neurosky mind wave headset and Arduino will be interlinked with the help of Bluetooth wireless communication and on the other hand, the robotic arm or artificial arm is connected to the Arduino.

The attention and meditation level is the parameter to control the three action of the artificial arm. These values can be classified into two different ranges. For this two ranges, a specific action is set. These actions will be performed by the Arduino according to the incoming raw EEG signals. The table below will help to understand the classified ranges.

Table -2: Commands for the control of the Artificial Arm

Actions	Range Assigned
Flexion (Closing Fingers)	69 above
Extension(Opening Fingers)	70 below
Elbow Movement	50 above

4. RESULT

The research and development of this robotic arm have achieved great attention because they enhanced disable people for their quality of life.

Fig -4: Design of Robotic Arm

In this paper, we had discussed complete review and design of the system and evaluate complication of brainwave artificial hand. For this research, the attention value has been classified in two sets, of which these movements control the main action of hands. While the first movement gives flexion i.e. closing all fingers then the attention range is 69 above whereas, when the second movement gives extension i.e. opening of all fingers, then the attention range is 70 below. At meditation level, the attention range will be at 50 above and elbow will start to move.

As per the above ranges, the result have been taken from 10 different persons and then acquired to a better solution.

5. CONCLUSIONS

The above-developed system for controlling the prosthetic arm through electroencephalographic data shows promise. We were able to classify user data to 3 outputs given by the Neurosky Mind wave headset system. Unfortunately, we were unable to control the arm with the veracity necessary to complete all the movement task. In order to complete the given task, we will need to either curtail the complexity of the task or revamp the potency of our classified system. Our system could be further revised and improved through collecting more data and using different optimization techniques to upsurge the classification of ranges. An extensive training time would allow the user to readily control the arm more accurately. Also, a number of EEG sensors would boost the accuracy and would help in exploring it into more ranges. If the accuracy could be increased, then we suppose the prosthetic arm could be successfully implemented in real world situation. For future work, we would like to delve into these techniques to increase the accuracy so that we could start running trials on the efficiency of this control

system. We could also then check out the use of the system on different people and in diverse experimental environments.

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