DEVELOPMENT OF ARTIFICIAL ROBOTIC ARM BASED ON NEURAL CONTROL INTERFACE

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ABSTRACT

The goal of our project is to design and develop the Artificial Robotic Arm Based on Neural Control Interface. The neural control interface (NCI) is also refers as Brain Computer Interface (BCI) or Brain-Machine Interface or Mind-Machine Interface. Basically, we are developing a robotic arm that can control by the brain signals of user. Brain Computer Interface (BCI), is a direct link to communication between brain and an external device. BCI acquires electronic signal from the brain and decode them to facilitate individuals communicating with the external world. As our project we are developing 2 degree of freedom upper limb prosthesis. For that we are using Electroencephalography (EEG) method to record, analyze and signal processing for getting an output that moves the upper limb prosthetic. In this report we are presenting the basic idea and search to get brain-waves from the brain and decode them from micro-volt signal into require form to proceed them further for implementing our ultimate goal of movement of artificial robotic arm. The system is capable of acquiring signals from brain and differentiating between two different movements of brain signals. The developed prosthesis will be capable of providing adaptive gripping on individual fingers.

Keywords: Electroencephalography, EEG, Arduino, Wave parsing, DC motors, Micro-controllers.

1 .INTRODUCTION

There are billions of neurons interlinked in human brain. Human thoughts and their emotional states influence the interactions across these neurons. Every interaction across these neurons generates an electric discharge, which can't be recorded using today's technology. Although, the activity generated by millions of concurrent electric discharges collected into waves which can recorded. The sequence of interactions between these neurons is a result of different brain states. These patterns of inter-action create wave of non-identical amplitudes and frequencies. These wave patterns can be used to form emotional state of the brain. The goal of this project is to record electric influences in the brain due to firing of these neurons, parse wave to get attention and meditation level of brain and use it to move a robot. There are various techniques available to detect electric activity in brain. One technique is named as Electroencephalography (EEG). EEG records the voltage fluctuation across the scalp that results from the inter-action across the neurons in the human mind. These voltage fluctuations are processed and output to a micro-controller by EEG sensor. The data achieved from EEG sensor are saved in micro-controller. The micro-controller uses different methods to process and parse the data. The attention and meditation levels are obtained from processed data. These levels are used to control the direction and motion of the arm. [1]

2. WORKING MECHANISM

2.1 Signal Acquisition

First of all, Signal acquisition is the process of capturing brain signals that measures physical conditions. The brain signals could be recorded from the neural activity, surface of the brain, or from the scalp. These signals are stored in EEG sensor and then transfer those signals to filter device by using blue-tooth. The strength of this captured signals are usually low, that is why they need to be amplified. So, to be used by computer applications, they need to be digitized. EEG sensor has numbers of channels like: 8, 12, 16, 20, and 36 channels. [2]

2.2 A/d Conversation

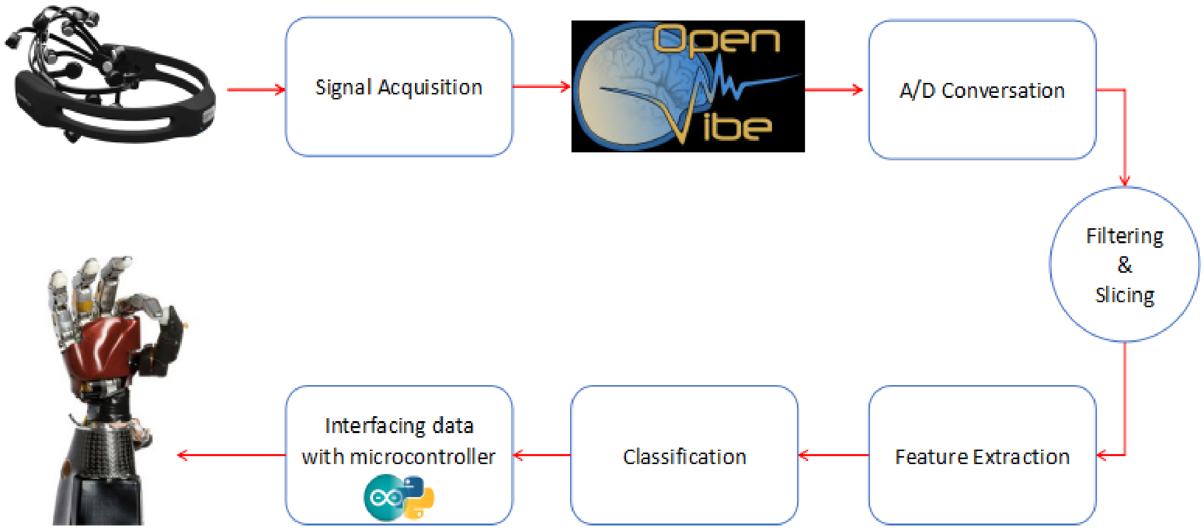
Next step is A/d conversation by which Analog signals are converted into digital signals. These Analog signals has been passed through monitoring, acquiring, analysing and processing data from sensors, which aren’t be done with digital computers and processors. Therefore, this system needs an intermediate device to convert the Analog signal data into digital signal data in order to communicate with the digital processors like micro-controllers and microprocessors. These signals are in micro-volts and frequency ranges is between 0.3Hz to 43Hz. [3]

2.3 Filtering & Slicing of signal

After signal acquisition, the process of filtering and slicing is carried out to remove unwanted features, noise and components from the signal. [4]

2.4 Feature Extraction

Data analysis software provides the important packages like feature extraction. However, MATLAB and other software are also support feature extraction. Feature extraction means extracting specific signal features.Moreover, EEG recordings not only contain electrical signals from the brain, but also have several unwanted signals. Those unwanted brain signals might make the wrong analysis of the EEG data and may lead to error in conclusions. Therefore, the digitized signals must be subjected to feature extraction procedures. [5]



(Fig.1)

2.5 Classification of signal

There are mainly five types of brain signals like DELTA, THETA, ALPHA, BETA, and GAMMA. For which real time data is very complex and varies with lots of factors responsible for classification. Brainwaves classification has able to give good results for some kinds of data signal. [6]

2.6 Interfacing Data with Micro-controller

At the end, perfectly extracted data is transferred to micro-control by the mean of external parallel device. [7]

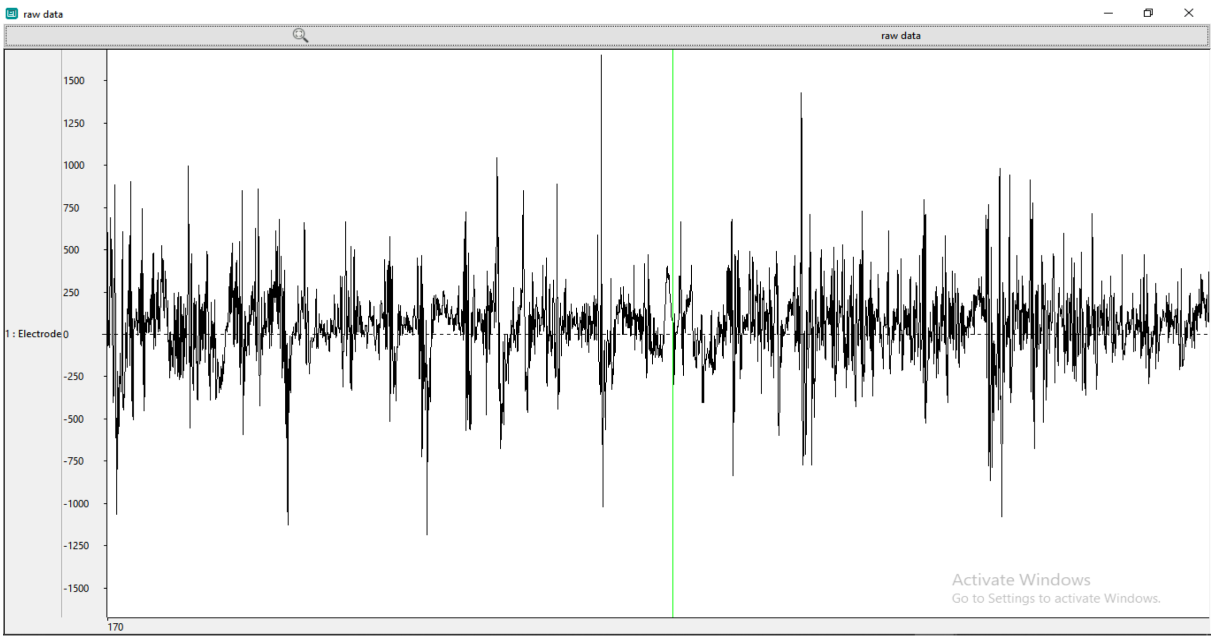
3. PROCEDURE

First of all, user wears the sensor, on pre-position location over the head and tries to touch all the electrodes to scalp. Then EEG sensor records the data and transmits it to software for signal processing in real time. After that programmed sequence executed and generates required form of filtered signal, by the software. For that we are using Open-vibe open source software. [8] Which is linked with Python script and further with Arduino IDE. Then it is transferred to the IDE and program of Arduino differ the values of signals according to the intense thinking of user. And also generate command from that to actuate motor to perform willing motion of arm. (Fig.1)

4. RESULT

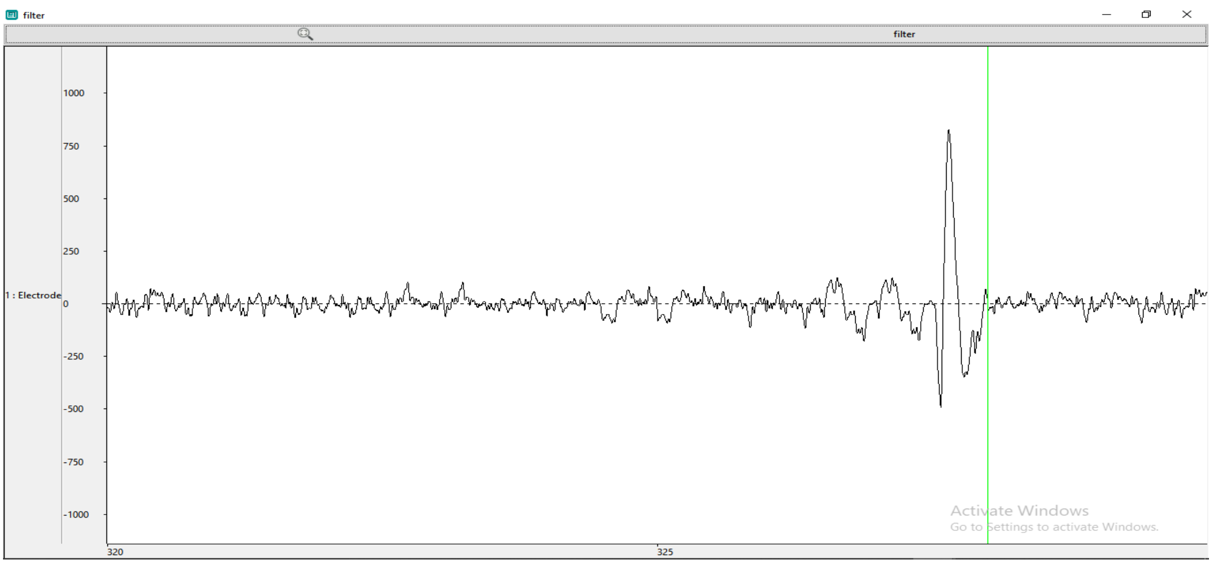
In this phase, first we generate the open-vibe program, which is able to do signal processing by using its various functions for getting required form of brain signals that can eventually able to determine the state of brain either it is Alpha wave (8-13Hz) or Beta wave (14-40Hz). For that the NeuroSky mind wave mobile sensor is used, which is based on EEG (electroencephalogram) technology. [9]

By connecting this sensor to the open-vibe software through its signal acquisition client by blue-tooth configuration, the raw data that comes from brain before signal processing is shown in fig.2.



(Fig.2)

The raw data received from brain by this method is from 0.3Hz to 100Hz. So, for getting only alpha and beta waves for BCI purpose, the signal processing (filtering) is required. Which can be implemented using open-vibe's various box tools. (Fig.3)



(Fig.3)

4.1 PYTHON DATA

After getting required frequency range of brain-waves, the data needs to be transferred to the micro-controller for further classification of signals to operate the arm in 2 degree of freedom. The processed data can be transferred by various tools provided by open-vibe such as VRPN, TCP and LSL EXPORT (Gipsa). [10]

Here, we use the LSL EXPORT box feature of this software that sends the data on stream through the serial port of computer and it can be catch by the serial communication on the micro-controller.

For that purpose the python scripting is used, which is able to direct the data from open-vibe to Arduino (micro-controller) .So, it is used as a mediator. (Fig.4)

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Connected to outlet OpenViBE Stream@DESKTOP-9SJ4M6N
([-1.542832851409912, 0.0], 657179.386283785)
([5.641021728515625, 0.0], 657179.943389799)
([-0.5643870234489441, 0.0], 657180.382429685)
([-5.341785907745361, 0.0], 657180.880454007)
([3.293853521347046, 0.0], 657181.380708878)
([-9.559350967407227, 0.0], 657181.882584856)
([-17.460247039794922, 0.0], 657182.381653587)
([9.773477554321289, 0.0], 657182.880489195)
([0.4714730083942413, 0.0], 657183.379728492)
([7.485873222351074, 0.0], 657183.880273667)
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([-10.420040130615234, 0.0], 657186.882061918)
([4.647010326385498, 0.0], 657187.3968222)
([8.220911026000977, 0.0], 657187.879458471)
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([-19.11962890625, 0.0], 657188.879882686)
([-5.8095316886901855, 0.0], 657189.381294373)
```

(Fig.4)

4.2 ARDUINO

The serial port of computer is directly connected to the Arduino hardware, which enables the serial communication between both and with the help of python, the data of filtered brain-signals, can be read on the serial monitor. [11]

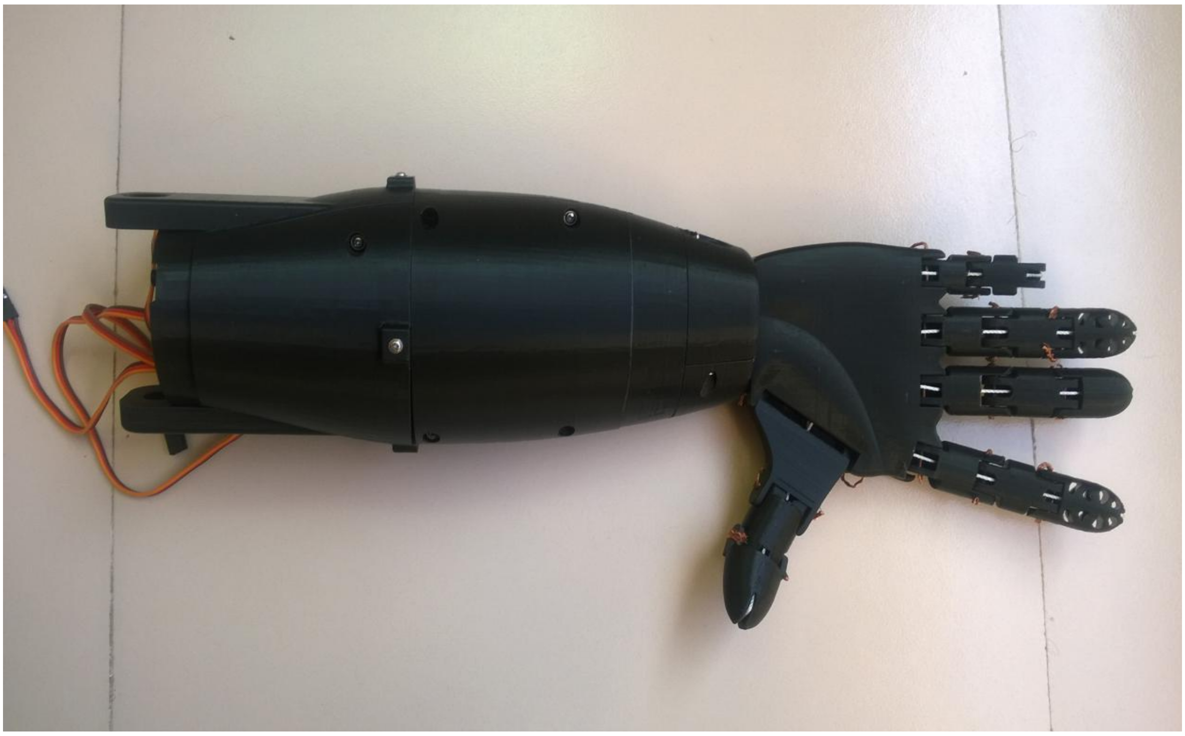
The Arduino program further classifies the different frequency range of signals and gives the command as per it programmed task to the servo motors of the prosthetic arm.

4.3 3D PRINTED ARM

The prosthetic arm is 3d printed arm, made of PLA material with the layer thickness of 0.02mm.And overall weight is about 300gm (without motors fitted in it).It basically upper-arm consists forearm, wrist, palm, fingers.

The design of this arm is adopted from existing design on internet. [16]

The complete printed and motor fitted arm is as shown in Fig.5.



(Fig.5)

5. CONCLUSION

Neural Computer Interface has become a great help to such physically disabled persons to communicate and control their environment using their thoughts. The present work has proved that without any movement of actual hand, changes in brain activity in the sensory motor area can be made by humans just by the thinking of such movements. The mental practice is needed to get control on sensory motor rhythms. As the BCI allows people to communicate and control appliances with just the use of brain signals it opens many gates for disabled people. There are various possible future applications. Even though this field of science has growing vastly in last few years, yet we are away from the scene where people drive brain-operated wheelchairs on the roads. New technologies need to be developed and other brain imaging techniques, such as MEG and MRI [12], need to be exploring to develop the future BCI. As time passes BCI might be a part of our everyday lives.

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