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Mind Controlled Prosthetic Limb

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ABSTRACT: Every year, there are millions of people undergo limb amputations, and almost one in six of the world's entire inhabitant suffers from neurological disorders. Most of the beset are unable to perform their basic errands in their day-to-day life. Until a few years ago prosthetic arms succor no definite efficacy to the one wearing them apart from donating an illusion of the limb, but now with the progress in technology, prosthetic arms can set the utility to imitate the actual purpose of limbs. While using brain implants to peruse the brain signals, one can reign prosthetic arms which are contoured in place of the limbs. Howbeit, this technique is invasive, perilous, and very exorbitant. Hence, this technology cannot be affordable to many people. Our paper strives to shed light on a nonevasive inexpensive approach to mind wave-controlled prosthetics without the use of brain implants. We have used an EEG headset to read the brainwaves allowing the user to move the robotic arm without having any implants. EEG headset is also an economical alternative to extravagant brain implants and it can be easily worn on the head and removed whenever required. This allows us to succor a wider demographic by proposing a reasonable mind-controlled prosthetic arm. Electro Encephalo Gram-based Brain-Computer Interface robotic arm can help as a substantial aid for seriously disabled people in their systematic activities, substantially to aid them to move their arm voluntarily. This paper put forward and implements a brain signal (mind) controlled robotic arm to yield contradictory movements in the prosthetic arm. The scheme uses a unique electrode pair acquisition strategy, microcontroller-based robotic arm module. The key lies in the mapping of the EEG signal to the robotic arm to accomplish the objective. In this project, we are developing a frugal, BCI robotic arm that will help the physically confronted to lead an independent life with the help of their brain signals using non-invasive techniques.

KEYWORDS: Brain Computer Interface (BCI), Brainwaves, EEG sensor, NeuroskyMindwave Headset, Robotic arm.

I. INTRODUCTION

In India, there are about 5 million crippled people. For disabled people with critical neuromuscular disarray such as brainstem stroke,multiple sclerosis, or amyotrophic lateral sclerosis (ALS),brain or spinal cord injury,cerebral palsy. We must provide fundamental communication proficiency to give them the possibility to demonstrate themselves. One solution that has been evolved, Brain-Computer Interface (BCI) systems. A BCI is a non-muscular communication channel that validates a person to dispatch commands and messages to an automated system such as a prosthesisorrobotic arm, utilizing his/her brain activity.

Early prosthetics were simple. They w 1e routinely only small digits that were unbudgeable or more magnificently, pegs and hooks. Later advances enabled the motionof the prosthesis, but they resembled very different from a human hand. They were claws that would not examine out of place on industrial robots. Myoelectric prostheses were advance providing more freedom of movement and more movement in general. However, myoelectric prostheses are very expensive. In addition, they anticipate upon the nerves of the arm to be unimpaired. Should the nerves be vandalizing, the myoelectric is useless. This is being decoded by modern BCI's. The electrical waves will be recognized by the brain wave sensor (EEG headset) and it will transfigure the data into packets and transfer through a Bluetooth medium. PC/Laptop will receive the brain wave raw data and it will extract and process the signal using the Mat lab platform. Then the control instruct will be circulated to the robotic arm to activity and perform the actions.

Accordingly, the mind-controlled robotic arm is a low-cost Prosthetic, a Brain authority Interface (BCI) device that can be fitted onto amputees' limbs. Mind Wavesor more accurately the potentiality of the mind to focus and to concentrate controls the Prosthetic. It is an upper extremity prosthetic arm that uses a microcontroller

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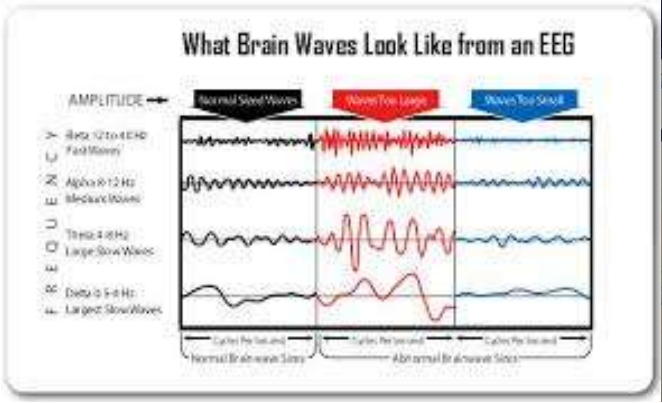
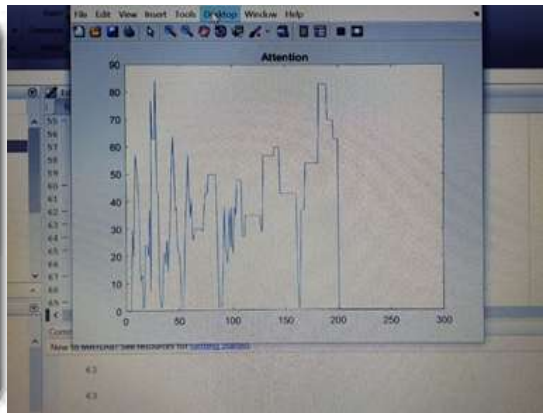
to estimate the brainwaves inscribe by an EEG headset and has servos in the arm and the fingers of the prosthetic hand based on those measurements. It uses indicators from the brain to change the purpose of the arm.

II. LITERATURE REVIEW





2.1 Nature of EEG Signals

The EEG extracted from the brain scalp through a single electrode is the local field potentials (LFP) integrated over an area $10cm^2$ or more. These LFP's are spatially and temporally evened as well. The LFP's are initiated as a result of the synaptic pursuit of hundreds of neurons over the integrated area in a contemporized manner and it ranges substantially following the brain activity. The intensity, orientation, and congenital regularity of interconnections in the cortex are crucial in it. Modern EEG acquisition procedures had even advanced to digitize these signals and make them accessible for digital signal processing. This is done after providing enough amplification to the acquired signals and bringing them up to the milli-volt level. The electrode placement plays a key role in this system arrangement.

2.2 EEG Wave Groups

Every electrode in an EEG signal acquisition setup consign a large mass of data and it makes the entire process of signal acquisition complicated. The data thus procured carries a range of constituents that can be moreover categorized based on several parameters such as frequency and even shape of the waveform. These components don't have an independent existence and the emanation of a single component can be even dominant to others depending upon the mental state of the subject.

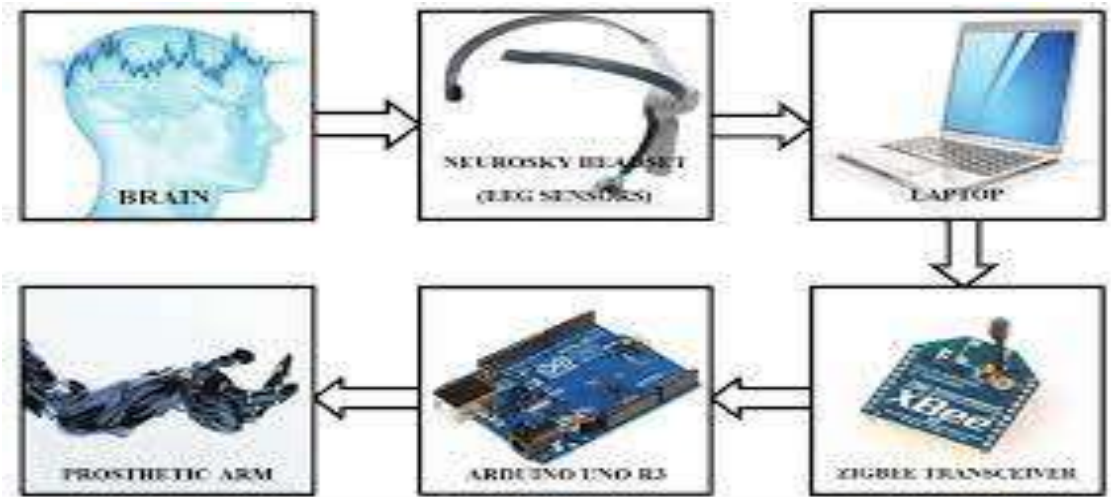


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fig 2.1:basic block diagram of brainwave

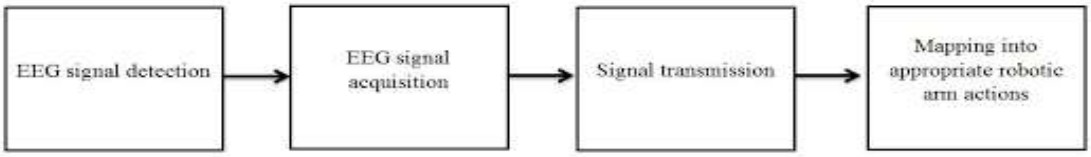

Fig.2.2 : stages of robotic arm

III. PROBLEM IDENTIFICATION

a. Every day we kept seeing people with disabilities and we could not stand it. So, when we gotta do a project or an idea, it's often something about a prosthetic limb that helps humanity or people with disabilities.

b. So, we kept thinking about how to solve this in a modern way. Until one day we realized Prosthetics is the solution, they can give disabled people more power.

c. That's why we started to care and started inventing, atfirst, we failed a lot but we keep on moving from designing the building blocks of the Prosthetic Limb and connecting things.

d. Finally, we fabricated the prosthetic limb to help people with special needs, instead of not having an available hand, to have an artificial hand with our prosthetic limb and do their basic errands, people who have difficulty in moving can get to objects that are out of their reach.

e. Our hand mimics real hand movements and to have an artificial prosthetic limb they do not have to save huge money.

3

IV. SYSTEM DESIGN

EEG-based brainwave Prosthetic arm could be a brain managed interface system that commands the operation of the robotic arm using brainwaves for the part of commanding signal. Whereas, these areas are as useful as the regular human hand. Above figure shows the basic diagram of the brainwave controlled by arobotic arm. This may offer the information of all elements that may be employed in interfacing a robotic arm.

This system is briefly categorized into the following four stages. The below Figure proclaims the categorization of the following four stages. These are Signal detection, Signal transmission,Signal acquisition, and Mapping signal to the arm.

V. SIGNAL DETENTION

This stage firstly targets the careful detection of the EEG signal from the human brain. The human brain comprise of millions of neurons. Each nerve cell is connected by dendrites and axons. Each time we think, move, and feel, sense our neurons are at work.

These signals are originated by an electric potential, these are accomplished by ions on a membrane of independent neurons. To detect several signals, these can help for interpreting what they mean and use them to regulate a tool of some kind. EEG measures voltage variations from ionic current within the neurons of the brain. In the brain, there are numerous neurons, each of which generates small electric voltage fields. EEG is a superposition of many elementary signals. The base of an EEG signal in normal adult's ranges from around 1 μV to 100 μV. These signals are normally described in frequency ranges.

- The model consists of 3 modules out of which one is a software module, one is a mechanical module and one is an electric module. This is a generalized architecture that can be modified according to the required use case.
- Brainwave speed is calculated in Hertz (cycles per second) and that they are classified into bands

This signal extraction can be made possible by using two devices. i.e., Either by NEUROSKY MINDWAVE or by using NEXTMIND, NEXTMIND is more complex but we can derive various kinds of parameters while using the device. NEXTMIND provides more accurate data on a particular focusing point by determining the position of our eyeball and mental focus

4.1. Neurosky Mind wave Headset

The human brain is made from billions of interconnected neurons; the patterns of interlinkage between the neurons are portrayed as thoughts and emotional states. Each association between neurons creates associate discharge. These charges aren't possible to measure from outside the skull. The activity produced by many thousands of synchronic discharges aggregates into waves which can be measured. Different brain waves square evaluates the results of different patterns of neural interaction. These patterns cause waves characterized by various amplitudes and frequencies. The contraction of muscles is additionally associated with distinctive wave patterns. Of these patterns however some Neurosky devices observe blinks.

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4.2.NEXTMIND

It is one of the breakthrough neurotechnologies, with an easy set-up and several demo apps that allow you to feel your new sense of control. This is a product that came into existence during these days. Direct Brain instructions are the act of controlling digital technology utilizing your mental focus. Next Mind technology recognizes the act of focusing attention and employs it to instruct digital entities in real-time, giving you a greater sense of freedom and control. It takes lower than a minute to calibrate the device. Once the interface is set up you can start directing digital entities with your mind. From the instant you start focusing, you can see your brain controlling the object. As you focus more, the neural feedback on the digital object increases until it obeys your command The speed of interaction varies from person to person. But altogether, the more familiar you become with the technology the quicker and facile it is to use.

NextMind determines neural action in the visual cortex — the place where vision takes place. Whereas eye-tracking determines the position of the eyeball. ... By evaluating neural signals, realizing visual cues, and decoding the active focus of attention, NextMind technology transfigures intentions into actions. It does this using a regular signal that it overlays on controllable constituents of a software's graphical user interface. That way, when you focus on a peculiar item, it can interpret that into a "press" action, or a "hold and move," or any further number of potential output results. Any object you perceive persuades a distinct response in your visual cortex. This neural response is reflected as an exclusive fluctuation in the EEG. Your visual cortex does not just acquire input from your eyes — it also amplifies the firing of neurons for the characteristics you are intentionally taking part in.

- Discreet hints show you the mind-enabled objects you can focus on.
- Your neural signals are rendered into digital instructions in real-time.
- Your active focus on entities allows you to sway them.

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4.3. Think Gear

The Think Gear connector runs in the background method on the laptop. This is often in charge of directional telephone receiver information from the serial port to an open network socket. It's available on Windows and OS X. Any language that contains a socket library needs to be able to communicate with it

4.3. Control Module

The software-based processingunit translates the raw EEG serial data pertaining to a particular thought to the physical activity like the lifting of an arm, gripping an object, etc. This is done using a Long Short-Term Memory Neural Network which, in our implementation, we have trained using a custom prepared dataset.

4.4. MatLab

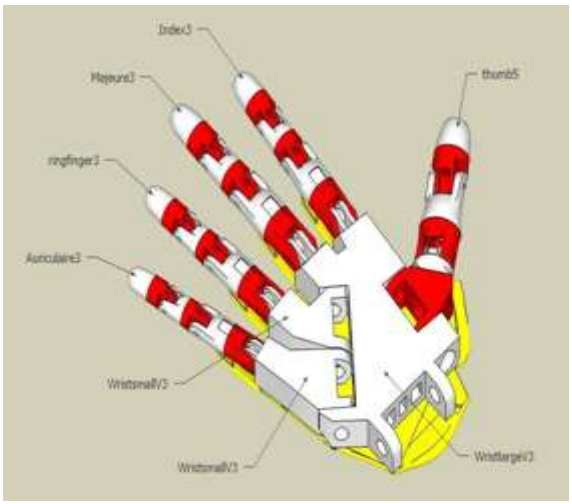
Program is written in MatLab in order to suck the attention signals from the mindwave headset After running the program with the brainwave headset connected the MatLab will show a graph as an output showing the attention level of our brain.

4.5. ARDUINO IDE

This software is used to activate the servo motors according to the attention signal obtained from the headset in MatLab. A corresponding program is written in this software to activate individual servomotors corresponding to the attention value attained.

4.6. Robotic Arm

This is the physical motorized robotic arm which will contain the exoskeleton and the actuators required to move the various parts of the arm to emulate real arm movements. Actuators may include various servomotors for precise movement. A microcontroller is used to control all the motors in the arm.



VI. METHODOLOGY

6.1.Signal Acquisition

Signal acquisition is the process of sampling signals that calculate universe conditions. This transforms the resulting samples into digital numeric values which will be manipulated by a computer. The signals granted by the Neurosky Mind wave headset are distributed to the laptop. The headset only detects, processes, and transforms the analog signals into several digital signals.

6.2. Mapping signal to Prosthetic Arm

The signal received from the Bluetooth HC-05 module transceiver has to be portrayed to the Robotic/Prosthetic arm in the microcontroller (i.e., Arduino Uno). The acquired signal will act as a command signal to manage the arm. a) Arduino Uno Arduino board design uses a range of microprocessors & microcontrollers. The boards are provided with sets of digital and analog input and output pins that will be interfaced to numerous expansion boards and other circuits. The microcontrollers are generally programmed using the programming languages like C and C++. It has 6 analog inputs,14 digital input and output pins, an ICSP header, a power jack,a USB connection, and a reset button. We just needed to simply connect it to a computer with a USB cable or battery. This microcontroller-based Arduino is easy to use for beginners and also supports a cross-platform and easy programming environment.

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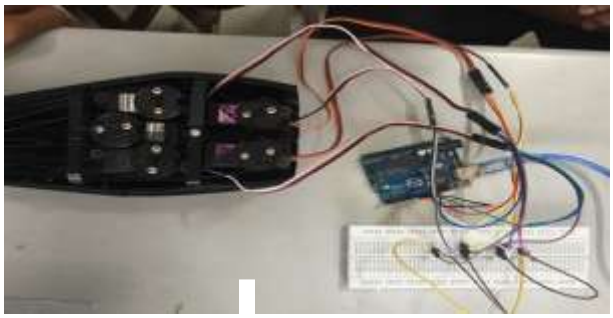
6.3.Prosthetic Arm

An artificial arm is a man-made device that is integrated into a human to restore a natural organ, to duplicate a specific function so that the patient may return to normal life as soon as possible. This artificial arm has servo motors each individually connected to the five fingers. These servo motors will help in controlling functions such as extension and flexion. These movements are controlled by the command signal generated from Arduino Uno in line with the brainwaves value obtained. Hence, the arm is managed by using the signal on a real-time basis.



VII. FABRICATED PROTOTYPE

- ✓ The designed robotic hand model is printed successfully using 3D print technology.
- ✓ All five servo motors are fixed to the arm and each servo motor is connected to each finger by means of strings.

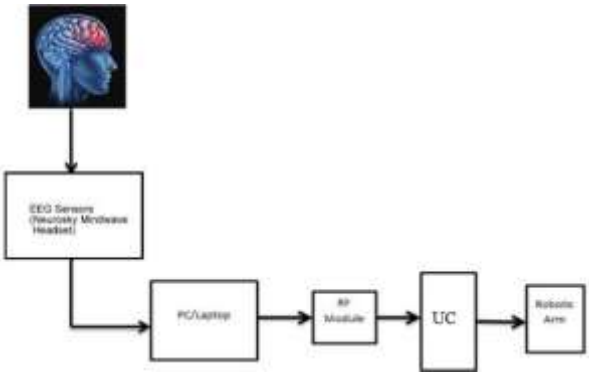
VIII. APPLICATIONS

1.The project was designed to help the paralyzed person to regain their controls and motion by transmitting the brain signals to a modern prosthetic arm and do their basic errands

1. Developing external controlling devices where paralysis (paraplegia)caused due to trauma, or conditions such as Monoplegia, Hemiplegia, Paraplegia, and Quadriplegia, when any part of the relay system on our body gets damaged

2. Set up robotic devices that can be controlled by our mind.

3. Exoskeleton devices which are currently in research and upcoming in the future especially for military applications can be made under this principle



IX. CONCLUSION

To turn down the complexity of the task or improve the effectiveness of our classification system.This system can be further improved by gathering more data and using different optimization techniques to increase the classification of ranges. By training the user will be able to easily control the arm more accurately. Also, more EEG sensors would improve the accuracy and would help in classifying it into more ranges. If the accuracy could be improved, then we believe the robot arm could be successfully controlled in a real-world situation.In the future, we like to explore these techniques to increase the accuracy of this system so that we could go ahead running trials on the effectiveness of this control system. We can use this system on different people, and in different experimental environments.

Through the help of the EEG headset (NeuroskyMindwave), we would be able to read the brain waves of the test patient and classify them using the LSTM neural network. If this approach is to be used in real life, the accuracy of the model needs to be increased and the time required to classify the brainwaves needs to be reduced. For increasing the accuracy, more sensitive equipment must be used to reduce the noise in recording the brainwaves. A larger dataset will help train a more accurate model. The arm in our POC model currently consists of a single gripper which provides limited functionality. For more realistic, real-world functionality, a few more classes must be added to the model to assign various physical actions

SOME OF THE ADVANTAGES FROM THE ABOVE RESULTS

1.This device can restore the lost abilities of humans and controls
2. We can neglect the use of complex wired prosthetic systems which are currently in use
3. We can also derive several bionic systems using this principle
4. Cost efficient since 3D printing is used.
5. User friendly
6. It works irrespective of the user and it is easy to set up and remove

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