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Robotic Arm Using Brain Computer Interface

Alin Mathew[1], Della Paul[1], Dona Maria George[1], Vinija Kurian[2]
[1]UG Student, [2]Assistant Professor, Department of Electronics and Communication, Viswajyothi College of Engineering and Technology, Vazhakulam, Kerala, India
Email: *alinmathew0127@gmail.com*
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Abstract

We live at that time in the history where the technology is advancing in a speed faster than ever. With the advent of powerful computers and increased knowledge about human brain, the scope of connecting our brains to machines have rapidly risen. Brain Computer Interface, commonly referred to as BCI is a direct communication pathway between an enhanced or wired brain and an external device. BCIs are often directed at researching, mapping, assisting, augmenting or repairing human cognitive or sensory motor functions. BCIs connect the brain to a computer system. It can be used to achieve aims like restoring sight, hearing, movement, ability to communicate etc. The project we are planning to do is to make a robotic arm which is controlled entirely by brain signals. The main functions we aim to incorporate in this project is the opening and closing of the arm. This is a basic point and it can be built upon. Something as basic as this will be a huge step in the lives of a disabled or paralyzed person. The conventional BCI systems are usually expensive, complex and lack portability. We plan to make an affordable, comparatively low cost, portable and at the same time, an efficient system. By making the system portable it makes a more preferable solution for handicapped persons. We mainly focus on building a prosthetic arm (robotic arm) that can be controlled using then brain signal. To achieve that we use the brains EEG signals. Also the computer is replaced with an embedded system that supports its portability. The required signals are obtained from an EEG headset; it is then processed and converted into respective commands for the movement of a robotic palm. As future advancements we will be trying to make the arm more movable and the same can be used for home automation.

Keywords: *Brain Computer Interface, Electroencephalography, Headband, Prosthetic, Portability*

INTRODUCTION

As the powers of modern computers grow, the chance of making old science fictions into reality is more increased than ever. Imagine using someone's brain to hear, see or feel specific sensory inputs. Consider the potential to manipulate machinery merely with thoughts. More than a factor of convenience it can be a life altering thing for severely disabled people. In this project we are intending to control a robotic arm just using brain signals [1]. This may seem to be a simple project, but for a disabled person, it can be very revolutionary. Brain Computer Interface is a direct communication pathway between a brain and an external device. Unlike neuro-modulation BCI allows information to be transmitted from and to the brain [2]. The BCI system reads signals from an array of neurons and it uses computer chips and programs to translate the signals into action. BCIs focusing on motor neuroprosthesis aim to either restore movement in individuals with paralysis or provide devices to assist them, such as interfaces with computers or robotic arms. It can enable a person suffering from paralysis to write a book or control a motorized wheelchair or prosthetic limb through thought alone, and in its advanced levels, it can be used in dream reading;

man-to-man nonverbal communication (communication only by thoughts). Researches on BCIs began in the 1970s. The field of BCI research and development has since focused primarily on neuroprosthetics applications that aim at restoring damaged hearing, sight and movement [3]. Due to the cortical plasticity of the brain signals from implanted prosthesis can be handled by brain like natural sensor or effector channels after adaptation. The first neuroprosthetic devices implanted in devices implanted in humans appeared in the mid-1990s. We can basically divide BCI into two types: conventional BCI and custom BCI. With our project, we are using an EEG headset to control the robotic arm [4]. It is portable, low cost and comparatively less complex. Conventional BCI lacks portability that confines its use to laboratories, while a custom BCI can be used by a person anywhere. Custom BCIs are used for outside laboratory purpose.

LITERATURE REVIEW

Objective of the Project

Some of the major application of electronics is in the healthcare industry. With the advancements in technology, the scope of electronics is also advancing. By using the latest and modern technologies, we can improve the living standards of many people [5]. One of the main applications is in neuroprosthetic. By this project, we aim to use EEG signaling to control a robotic arm. EEG signals are obtained from brain waves and these signals will then be processed to control and command the arm. This technology can be used for retaining the use of destroyed or damaged neurons and thus provide a prosthetic arm for a person.

History of BCI

Electroencephalography (EEG) is the most studied non- invasive interface mainly due to its fine temporal resolution, ease of use, portability and low setup cost. But the technology is somewhat susceptible to noise. Niels Birbaumer trained severely paralyzed people to self-regulate the slow cortical potentials in their EEG to such an extent that these signals could be used as a binary signal to control a computer cursor.

His later research has focused on developing technology that would allow users to choose the brain signals. They found easiest to operate a BCI including Mu and beta rhythms. A further parameter is the method of feedback used and this is shown in studies of P300 signals .Patterns of P300 waves are generated involuntarily [6]. When people see something they recognize and they allow BCIs to decode categories of thoughts without training patients first. By contrast, the bio feedback methods described above require learning to control brainwaves so the resulting brain activity can be detected. In 2009, the NC-TU Brain-Computer-Interface-headband was reported. The signal processing module measured alpha activity and the blue tooth enabled phone assessed the patient's alertness and capacity for cognitive performance.

Custom and Conventional BCI

In this project, we used EEG based BCI which is non- invasive type. The EEG we are familiar with is a 32 channel complex setup connected to a computer and is usually used in medical applications and laboratory purposes. This is called conventional BCI. They are complex, expensive and is non- portable. They support very less practical. While custom BCI is comparatively portable and of low cost. Reduction in number of channels helps in reducing the setup time.

Components

EEG Headset: We are using Neurosky's EEG headset to obtain the necessary control signals. Neurosky, Inc. manufactures BCI technologies. It allows low cost EEG research and products and

uses inexpensive dry electrode. It mainly records the attention level, meditation level and eye blinking of person. It does so with the help of Neurosky EEG chip, called TGAM module (ThinkGear ASIC Module). It consists of a dry electrode as sensor. It touches the forehead, the contact and reference points located on the ear pad, and the on-board chip.

Figure 1: *Headset.*

Figure 2: *Brain wave.*

Figure 3: *EEG chip.*

Microcontroller: Arduino Nano is the microcontroller used for this project. It is ATmega328P based small, bread- board friendly board. It has similar functionality as that of Arduino Duemilanove, but in a different package. It has a total of 14 digital Pins and 8 Analog pins. Among these pins 3, 5, 6, 9, 10, and 11 gives the necessary PWM control signal. The digital pins can be used to interface sensors. 0V and 5V is the operating voltage for digital pins. The analog pins can measure analog voltage from 0V to 5V using any of the 8 Analog pins.

Figure 4: *Arduino Nano.*

Servo Motor: Five servo motors are used for the movement of robotic arm. A servo motor is a linear or rotary actuator, which finds its major applications in robotics, CNC machinery etc. The servo motor is made up of DC motor and is controlled by a variable resistor. The control signal is a PWM signal obtained from the Arduino board.

Figure 5: *Servo motor.*

Bluetooth Module HC-05: The Bluetooth module HC- 05 is a master/slave module. By default the factory setting is slave. The slave modules cannot initiate a connection to another Bluetooth device, but can accept connections. Master module can initiate a connection to other devices. The user can use it simply for a serial port replacement to establish connection between MCU and GPS, PC to your embedded project etc.

Figure 6: *Bluetooth module.*

METHODOLOGY

A low cost embedded BCI consists of a mind wave headset to acquire the EEG signals, a microcontroller, Bluetooth module and 3D printed robotic arm. The main aim of our project is to design and implement a prosthetic arm for the disabled. The currently available technology in the area of neuro-prosthetic is brain controlled electronic system that is used with the conventional BCI, which is costly as well as lacks portability. The custom BCI basically supports portability and is comparatively low cost. The necessary brain waves are obtained using the Neurosky Mind wave Headset. This acts as the control signal for the arm. The processed brain signals are send via Bluetooth to the Arduino board and are given as command to the respective servo motors. The rotation of the motors enables the movement of the arm.

Block Diagram

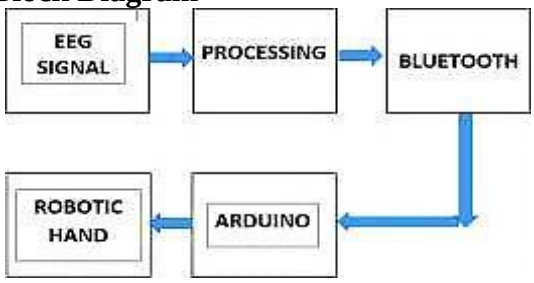

Figure 7: *Block diagram.*

The block diagram consists of brain wave sensing EEG electrodes, signal amplifier, a microcontroller system and a robotic arm. The minute electrical signals of the brain are sensed using EEG signal. These electrodes are able to sense these weak signals. This signal is then given to a microcontroller. The controlling signals from the microcontroller are used to drive the motor. The motor enables the movement of arm. The entire system is expected to consume 1W of power and can be powered by a rechargeable 5V battery. The brain waves for each action are studied and the device is trained accordingly. The signals are first obtained and then processed for feature extraction, filtered and the signals are then amplified. These signals are obtained from EEG based on brain wave pattern.

CONCLUSION

New developments in technology have helped to make the lives of people better and better. One of the main areas of improvement achieved by advancing technologies is in the field of healthcare and rehabilitation. Something as basic as moving a finger for a paralyzed, disabled or handicapped person is in fact a huge step in bettering their living standards. By our project, we aim to answer this issue. A small prototype is prepared with a 3D printed arm controlled by motors. The controlling signals are obtained from Neurosky Headband, which collects the brains EEG signals.

FUTURE SCOPE

As the humanity is more advancing and the efficiency of technology is also increasing, many innovative technologies like artificial intelligence have been trending for a long time now. Making a device work just with our thoughts was considered to be a great scope for science fiction, but now it has been an area of scientific research. With our project, we would like to incorporate more movements for the arm.

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