Realization of Real Time Robotic Arm Control System Based on EEG Signal

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ABSTRACT

The paper has the idea of manipulating a prosthetic hand by the virtual simulation environment using a neural interface based on a Brain Computer Interface (BCI), which will introduce a new pattern for the manipulation of a prosthetic hand. Prosthesis is defined as an artificial approach, which is used to replace a disabled body part for a normal function. The hand is activated by a motor which is driven by micro- switches, DC motors and relays. This brainwave based cerebrum controlled prosthetic hand has been introduced for utilization by totally incapacitated patients.

Keywords- **Brain Computer Interface, Brain Sensor, Electroencephalographic Signals,Hand Prosthesis, TGAM**

I. INTRODUCTION

The loss of all or part of the arm is a catastrophic event for a patient and a significant challenge to rehabilitation professionals and prostheticengineers. The large, upper extremity amputee population in India has, historically, been poorly served, with most having no access to support or being provided with ineffective prostheses. With the increasing number of people experiencing amputation, there is considerable motivation to advance the technology capabilities of the lower and upper limb prosthesis. India, constituting 17.6% of the world's population, has around 5, 28,000 arm amputees. According to the Association of Physical Medicine, surgical amputations are performed with two objectives: first, to eliminate or counteract the cause, to reduce risk and preserve life and second, to allow adequate subsequent rehabilitation to achieve the best fit of prosthesis and restore motor functions associated with the hand as well as possible.

Early prosthetics were simple. They were frequently only small digits that were immovable, or more famously, pegs and hooks. Later advances enabled the movement of the prosthesis, but they looked very different from a human hand. They were claws that would not have looked out of place on industrial robots. As technology advanced, the hands became more natural. However, they still required cables and harnesses to be attached to the working arm to pull them. Myoelectric prostheses were developed, providing more freedom of movement and more movement in general. However, myoelectric prostheses are very expensive. In addition, they rely upon the nerves of the arm to be undamaged. Should the nerves be damaged, the myoelectric is useless.

The Neural Cognitive approach to hand Prosthesis is a low cost Prosthetic, a Brain Control Interface (BCI) device that can be fitted onto amputees' limbs. Mind Waves– or more precisely the ability of the mind to focus and to concentrate– controls the Prosthetic.

II. HAND PROSTHESIS

Currently there are various types of upper limb prostheses and these vary within the limits of the basic needs of patients who use them. Some prostheses seem very real; others have such an advanced technology that can be considered as robots. Some prostheses do not move at all (aesthetic prosthesis), others can be set only in specific positions and others are mechanical and are controlled by muscles, wires and steel cables [9]. However in all the above types of prosthesis, the control mechanism has been a limiting factor in their functionality.

A prosthetic limb is an artificial device or a replacement of missing body part. A prosthetic arm is a fake arm for those who amputated their arm. Earlier armories used prostheses mainly in battle to hold sword and shield. Modern prosthetic principles evolved after II world war. In 1949 first myoelectric switch was developed. Earlier body powered prosthesis components have not much changed because most of the research has

III. BRAIN COMPUTER INTERFACE

A brain computer interface, or BCI belongs to the group of natural interfaces, these are used as a means of interaction (HMI), because they allow the manipulation of applications or devices by
focused on externally powered prosthesis and high cost of manufacturing also a prime issue.

The first micro-controlled prosthetic knees became available in the early 1990s. The Intelligent Prosthesis was first commercially available microprocessor controlled prosthetic knee. Blatchford & Sons, Ltd., of Great Britain, in 1993 made walking with the prosthesis feel and looks more natural. An improved version was released in 1995 by the name Intelligent Prosthesis Plus. Blatchford released prosthesis, the Adaptive Prosthesis, in 1998 [1]. The Adaptive Prosthesis utilized hydraulic controls, pneumatic controls and a microprocessor to provide control action.

The first experiment with a healthy individual was done by the British scientist Kevin Warwick in 2002. In this case an implant was interfaced directly into nervous system. The electrode array, containing hundred electrodes, was placed in the median nerve. The signals produced were detailed enough that a robot arm was able to mimic the actions of prosthetic arm.

IV. ENCEPHALOGRAPHIC SIGNALS (EEG)

The electrical signals produced by the brain are generated by the potential difference across the cell membrane of neurons and this process is the basis for the functioning of our nervous system. Registration of these bio signals is what is known as electroencephalogram (EEG) and the rhythms of neuronal activity are communication language typical of neurons. As we have advanced signal processing algorithms that help to understand the meaning of the EEG signals were generated clinical and technologic al applications that until recently belonged to the area of science fiction [17].The Fig.2.shows certain physical or mental conditions that may occur in patients who are diagnosed and is due to the interpretation of EEG.

Recording and interpretation of the electro-encephalographic (EEG) signals without dependence mechanical devices. The use of natural interfaces for people with disabilities is a novel application, because with these and with the use of robotic prostheses, the user can perform natural movements executed before losing his limb.

V. MICROCONTROLLER

The Arduino Mega 2560 is the high-end model of the Arduino Group's line of products. Boasting 54 I/0 ports, 18 analog ports, 4 serial ports, and several shield connectors; the Arduino Mega is the perfect microcontroller to manipulate a prosthetic arm. The Arduino Mega uses two serial ports to communicate with the Mind Wave and the Dynamixel MXD64 servomotor. At the same time, it is able to send PWM output to servomotor. By reading the incoming brainwaves from the Mind Wave Mobile, the Arduino Mega's software decides the values of focus and relaxation to move the servomotors. The Arduino Mega 2560 is inexpensive and is a completely open-source device from both hardware and software point of view.

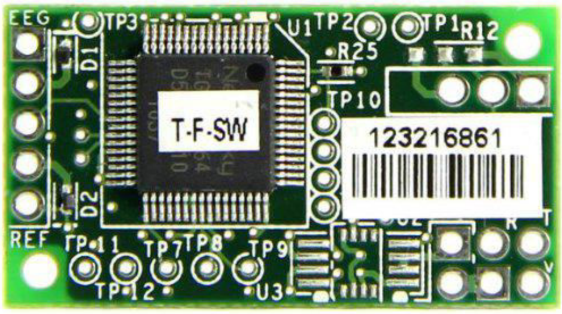

Fig1. TGAM sensor chip

A. PROGRAMMING INTERFACE APPLICATION (API)

Neurosky offers a set of suites that allow the interpretation of the EEG signals and operate through a PC BCI application that serves as APIeasily programmed with a variety of sources,from Processing to C/++ to
Touch OSC.It also enables the construction of any kind of software library for any kind of device.

VI. BRAIN SENSOR AND HEADSET

The brain sensor used is Think Gear ASIC Module (TGAM) sensor. The TGAM is NeuroSky's primary brainwave sensor ASIC module designed for processing and outputting EEG frequency spectrums, EEG signal quality, raw EEG, and three NeuroSky eSense meters - attention; meditation; and eye blinks.

Headband is a device for monitoring electrical signals generated by neural activity in the brain.

It consists of a sensor chip, pre-auricular electrode clip, single EEG electrode placed on FPz, battery, Bluetooth transmitter between the sensor Bluetooth and the PC Bluetooth.

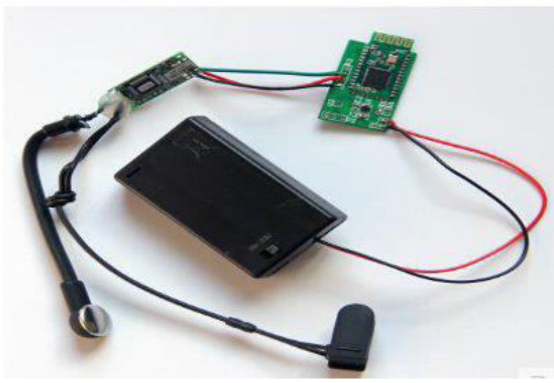

Figure 2: Brain sensor headset components

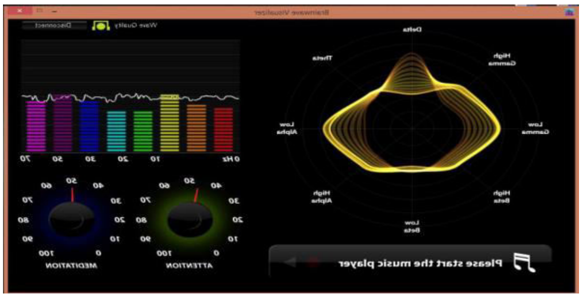

Figure 3: Mind wave Mobile Core output on PC screen

The software application is called Mind Wave Mobile Core. The output on the screen shows e-sense meters and the raw EEG signals along with frequency variations.

VII. SYSTEM DESIGN

This system can be broadly dived into four stages. Figure shows the schematic outline of these four Stages. These four stages are EEG signal detection, EEG signal acquisition, Signal transmission and mapping into appropriate robotic arm actions

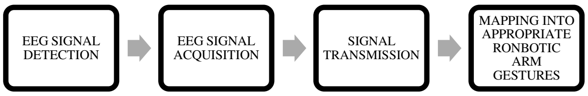

Figure 4: Schematic outline of various stages involved.

The signals obtained by the electrodes and further processed by TGAM chip will be transferred by battery of normally 9V. The headset comes with Power switch, a sensor tip; flexible ear arm and using Bluetooth transmitter which is there in the headset, for this headset need to give power using an AAA ground connection Ear clip. In this Headset we use non-invasive sensor that won't cause any painto the user who wears the headset. After inserting a battery switch on the headset using the power switch the LED indicator will blink and if the Red color light not blinking the headset is powered on but not connected to the computer's Bluetooth. If the Blue color not blinking that means the headset is powered on and connected. If the red or blue color blinks it shows that the Battery getting low. The Data transmitted by the headset will be received by the Computer's Bluetooth receiver. And then all these data will be analyzed by the Matlab. The Matlab will help in extracting the raw data. In the Matlab the data will be received from the port pin which they are giving the same port number for the Bluetooth receiver and Matlab in the back panel.
Two types of data can be measured by the brain sensor headset i.e. Attention level and Meditation level. These levels will be received by microcontroller which will help in controlling the robotic arm actions. The microcontroller should continuously analyze the incoming brainwavesand map them into the appropriate actions.
The attention and meditation level are the twoparameters to control different actions of therobotic arm. These values can be classified intodifferent levels. For each level a specific actionwill be set. According to raw brainwaves sent tothe microcontroller, which it will check against
The classified levels and perform the predefinedaction.

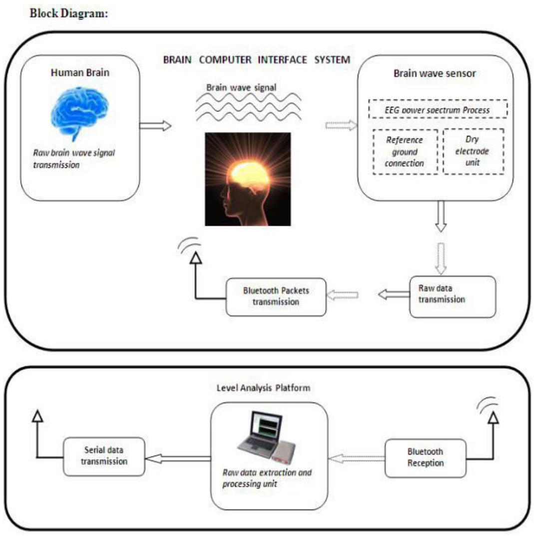

Figure 5: Block diagram for headband and BCI application

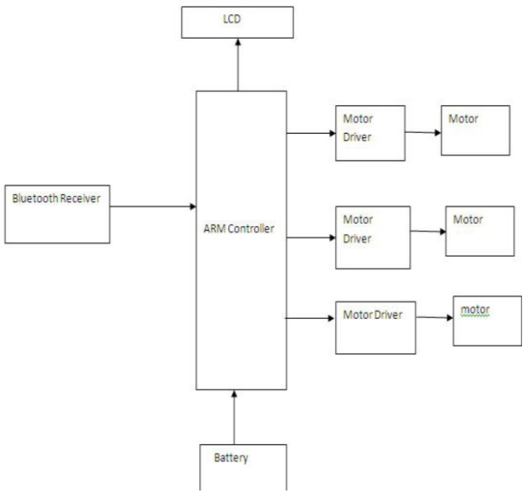

Figure 6: Block Diagram for prosthetic arm

VIII. RESULT AND DISCUSIONS

The research and development of brain-controlled robotic arm has received a great deal of attention because they can help physical handicapped people improve their quality of life. In this paper, we presented a comprehensive up-to-date review of the complete systems, design of this system, and evaluation issues of brain-controlled mobile robots. The headset doesn't give the 100%accuracy of brainwaves but it is too good for its price and it can give up to 85% accuracy of brain waves. This is due to single EEG sensors. Greater accuracy can be achieved by using more number of sensors. After connecting the Headset with PC using Bluetooth, we need to wear the headset on the head and then we need to run the code for acquiring raw brainwaves using Matlab.

The command window in Matlab shows the attention values detected by the headset. After getting these attention values a graph will be generated. From here these signals will be transferred to the prosthetic arm through RF wireless transmission, the signals will be collected by RF receiver and sends to the microcontroller.

The microcontroller reads the brainwaves sent and maps it to the predefined actions. Then accordingly gives commands to the servo motor of prosthetic arm. Thus the prosthetic arm can be controlled using brainwaves voluntarily.

IX. CONCLUSIONS

The system that we are developing for controlling the prosthetic arm through electroencephalographic data, we were able to classify user data to outputs given by the brain sensor headset system. Unfortunately, we were unable to control the arm with the accuracy necessary to complete our movement task. In order to complete the given task, we will need to either reduce the complexity of the task or improve the effectiveness of our classification system. Our system could be further improved through gathering more data and using different optimization techniques to increase the classification of ranges. A longer training time for the user would allow the user to easily control the arm more accurately. Also more number of EEG sensors would improve the accuracy and would help in classifying it into more ranges.

X. ACKNOWLEDGEMENTS

The authors thank the Management and Principal of ACS College of Engineering, Mysore road, Bangalore for permitting and supporting to carry out the research work.

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