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Mind Controlled Robotic Arm using EEG Classification of Neurons as per Expressive and Cognitive Suite

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ABSTRACT*:* The field of Robotics is growing fast in order to make the people's life efficient and easy. There are various machines or robots designed and manufactured in this particular field to help the handicapped people facing the problems like blindness, broken legs or arms, body part dislocation etc. As, there are limitations in the robotic works, the people are focusing on more accuracy provided by robots. The mind controlled robotic arm (OUM v0.1) is the next step in order to achieve more accuracy. Thus, to overcome the mentioned problem, we are designing and manufacturing a robotic arm in order to make it more useful by the people residing in the mentioned category. OUM (One Universal Mind) is a field created by us and thus we are developing various projects in it. The project OUM v0.1 aims to develop and engineer a Robotic Arm which will be controlled directly by human being's brainwaves. These brainwaves will be sensed by using EEG (Electroencephalogram) technology. The intelligence in this technology is to build an algorithm which will grasp the current activity of human brain i.e. collecting the information generated by Neurons which are activated by human brain and convert them into plan of actions which will be processed by robot using Digital Signal Processing (DSP) technique. OUM v0.1 robot will then receive the human brainwaves as digital input and will work accordingly. The robot motions and movements of robotic arm will be completely depend on the brainwaves which human beings will produce.The methodology of this project is based on the fields of **Robotics**, **Artificial Intelligence (AI)**, **Intenet of Things(IoT)** and **Artificial Neural Networks (ANN)**.

The project cost will be increased according to the sensors used in this project. OUM v0.1 will be the advanced robot of the generation and it will not be developed on the basis of any particular domain as we are trying to merge the different domains in this single project. Hence, this will be an innovation in the field of above mentioned domains.

KEYWORDS*:*Artifical Intelligence(AI); Internet of Things(IoT); Robotics; Arduino; Emotiv; Electroencephalogram(EEG); Digital Signal Processing(DSP).

I. INTRODUCTION

The project is to analyze the human brain system and to use extensively by performing some real time activities implementing on the robotic arm in order to address the common social issues such as physically challenged, military applications, medical and healthcare applications etc.

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People who are physically challenged having various physical illness are the main focus behind developing the project. They can make use of the robot arm in order to take control over various actions which are impossible for handicapped people.A considerable amount of research effort has been channelled towards the identification and utilization of information of human emotions. Various ways of human-computer and human-machine interaction have been studied in the effort of enabling computers and machines to be more alert to the emotions and affective needs of human beings. The BCI (Brain Computer Interface) is the latest innovation in the field of Artificial Neural Network and channelize human emotions or using them efficiently for some activities or actions.

OUM (One Universal Mind) is a field created by us and thus we are developing various projects in it. The project OUM v0.1 aims to develop and engineer a Robotic Arm which will be controlled directly by human being's brainwaves. These brainwaves will be sensed by using EEG (Electroencephalogram) technology. The intelligence in this technology is to build an algorithm which will grasp the current activity of human brain i.e. collecting the information generated by Neurons which are activated by human brain and convert them into plan of actions which will be processed by robot using Digital Signal Processing (DSP) technique. OUM v0.1 robot will then receive the human brainwaves as digital input and will work accordingly. The robot motions and movements of robotic arm will be completely depends on the brainwaves which human beings will produce.

This project also aims to provide a helping hand for handling various hazardous chemicals in medical industry or to provide more accuracy for performing any healthcare based actions.

The robot arms are very useful in military bases in order to handle heavy loads and to handle dangerous weapons and to perform transportation from one place to another. Also, this project includes the industrial use in order to perform accurate tasks which human beings lacks in some tasks but by using their brains as the brain activities have the accuracy which will provided to robots.

II. RELATED WORK

Sr. No	Paper/ Journal Title	Publication	Abstract
1.	Classifications of Human emotions from EEG signal using Statistical feature of Neural Networks.	IJIE (International Journal of Integrated Engineering).	A statistical based system for human emotions classification by using electroencephalogram (EEG) is proposed in this paper. The data used in this study is acquired using EEG and the emotions are elicited from six human subjects under the effect of emotion stimuli. This paper also proposed an emotion stimulation experiment using visual stimuli. From the EEG data, a total of six statistical features are computed and back-propagation neural network is applied for the classification of human emotions. In the experiment of classifying five types of emotions: Anger, Sad, Surprise, Happy, and Neutral. As result the overall classification rate as high as 95% is achieved.
2.	Brain–Controlled Wheelchairs: A Robotic Architecture.	IEEE Robotics and Automation Magazine.	Independent mobility is core to being able to perform activities of daily living by

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			oneself. However, powered wheelchairs are not an option for a large number of people who are unable to use conventional interfaces, due to severe motor–disabilities. For some of these people, non–invasive brain–computer Interfaces (BCIs) offer a promising solution to this interaction problem and in this article we present a shared control architecture that couples the intelligence and desires of the user with the precision of a powered wheelchair .We show how four healthy subjects are able to master control of the wheelchair using an asynchronous motor–imagery based BCI protocol and how this results in a higher overall task performance, compared with alternative synchronous P300 – based approaches.
3.	Brain Computer Interface System for Mind Controlled Robot using Bluetooth.	IJCA (International Journal of Computer Applications).	This paper describes the Mind Controlled Robot based on Brain Computer Interface (BCI) using Lab VIEW to analysis the brain waves. BCIs are systems that may bypass typical channels of communication (i.e., muscles and thoughts) to supply direct communication and management between the human brain and physical devices by translating different patterns of brain activity into commands in real time. With these commands a mobile robot can be controlled. The intention of the project work is to develop a mechanism that may assist the disabled folks in their everyday life to do some work freelance on others. Here, they tend to are analyzing the brain wave signals. Human brain consists of innumerable interconnected neurons. The patterns of interaction between these neurons are delineating as thoughts and emotional states. In step with the

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			human thoughts, this pattern are going to be dynamical that successively manufacture totally different electrical waves.

III. PROPOSED ALGORITHM

A. *Design Considerations:*

- AnEmotiv EPOC EEG Headset.
- USB Dongle.
- Arduino Microcontroller.
- Java Front-End Application
- Control signals are generated for arm actuators for performing sensible movements of robotic arm
- Sensors are deployed on the robotic arm to detect any obstacle i.e obstacle sensor or various temperature conditions i.e temperature sensor.

B. *Description of the Proposed Algorithm:*

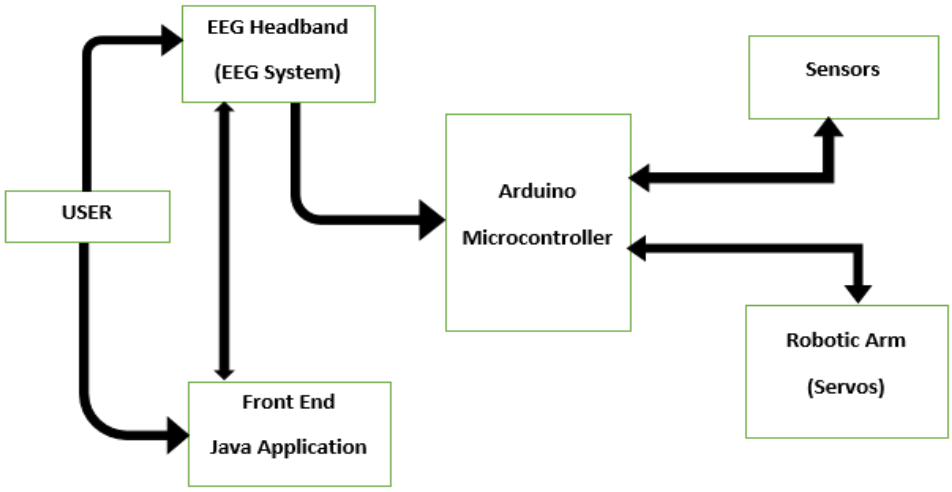

Fig. 1 System Architecture/Design

The system architecture or design of system describes how the system will interact with the user and also several components with having their own work/role as a system component. The components are,

1) **Java Front-End Application:** The java application describes the interaction of an application with the user. This application indicates two main suites, Expressive and Cognitive Suite. In Expressive suite, we have used the several human expressive functionalities such as blinking, eye brow raising, smiling and clenching. The status of this is shown in the form of zero(0) and one(1). On the other hand, Cognitive suite is the actual neural suite which captures the real time EEG data about thinking any particular activity such as Push, Pull, etc. The real time EEG status of data captured by EPOC headset is displayed in the form of percentage.
2) **EEG Headset:** In this project, we are using Emotiv EPOC EEG headset which is mainly used to capture the EEG data and transmit to the computer using their own USB dongle. The maker had also provided their own

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application to check the status of all the electrodes whether they are connected to the scalp or not. By using the application, we can train the user profile by thinking out some activites which we need to send it on our robot arm.

3) **Arduino Microcontroller:**ArduinoAtMega 2560K is used to capture the EEG packets sent out by the USB dongle on serial monitor and by using Arduino's own IDE, we can measure and capture the packets on its own serial monitor.
4) **Robot Arm and Sensors:** The robotic arm consist of several servos to perform the movements using 5 DOF (Degrees of Freedom) and sensors are attached to the arm just to make ensure the arm is not having any difficulties performing its movements.

Functions of EEG Headband

- Enable the user to interact with the EEG hardware.
- Enable the user to deploy the headband easily on the scalp.
- Making less use of Electrode gel that leads towards tedious deployment of headband.
- Headband must have emergencyon/off switch.

Functions of USB Dongle

- Make successful communication with the EEG headband.
- Perform data transfer between Arduino and headband.
- Organizing the analog signals generated from brainwaves into group of data packets.

Functions of Arduino microcontroller

- Accept the input in the form of data packets.
- Perform desired algorithm to convert thepacket into frames containing digital signals in the form of bits.
- Send control signal over servos according to accepted input.

Functions of Java Application

- Enable the user to perform checking of each electrode on the scalp of its brain.
- Enable the user to interact with the desired user interface for performing sending data operations and to display the graph activity of electrodes.

- **Software interface:**
- **Front End:**

The front end will have the JAVA stand-alone Application which will provide the desired user interface in order to make connection of brain with EEG system. Also, it will provide various graphical and signalling interface in order to show the connection status and the data transfer between human brainwaves and microcontroller to achieve customer satisfaction.

- **Back End:**

The back end will consist of an algorithm which is developed in Arduino IDE which will take cover on the every activity of robot arm and it is also responsible to make connection with the EEG headband. It also takes care of data transfer & the additional works depending upon use of various sensors being used. It gives output as control signals to servos used in robot arm as per the defined commands in Embedded C language.

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- **Hardware Interface:**

  - **USB dongle to Arduino:** The Arduino microcontroller consist of receiver and transmitter pins which are used for communications with external modules or devices. The USB dongle associated with the EEG headband is interfaced with ArduinoRx,Tx pins in order to obtain the data transfer.
  - **Servo motors:** The servos or servo motors associated with robotic arm structure are connected to Arduino. These will perform or actuate in angles which take input form EEG system.
  - **Pulleys/Gear Mechanism:** Small pulleys will be used to control the movement of fingers or gear mechanism will be used.
  - **EEG Headband:** The main product is the EEG headband which performs main operation of taking input as brainwaves and send the data on the USB dongle which communicates with it.

IV. PSEUDO CODE

Blink Function:

Following is the pseudo code to show how to perform the blink operation carrying out on a particular servo which sends out a keyword A on Arduino IDE's serial monitor.

```
if (EmoState.INSTANCE.ES_ExpressivIsBlink(eState) == 1)
{
        if(flag1==0)
        {
                System.out.println("Blink");
                robot.keyPress(KeyEvent.VK_A);
                robot.keyRelease(KeyEvent.VK_A);
                flag1=1;
                starttimer();
        }
        else
        {
                if(time>=2)
                {
                        stopWorker2=true;
                        time=0;
                        flag1=0;
                }
        }
        l2.setText("1");
}
elseif (EmoState.INSTANCE.ES_ExpressivIsBlink(eState) == 0)
{
        l2.setText("0");
}
```

V. SIMULATION RESULTS

The simulation study involves the java Front-End application which is connected after the EPOC headset is placed and connected to the scalp. As the EPOC gets started, it communicates with the application showing the real time status on application. The application shows the status about Expressive suite commands and Cognitive suite commands carried out at real time by human brain. Then, these real time data is compared with the user's Emotiv profile which was trained as per specific commands selected by user. If it matches with the trained profile, then the application specific code generated a particular keyword to be sent on the serial monitor of Arduino's IDE. Then, the Arduino program only checks which keyword it gets and perform the servo movements as per the keyword.

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The Fig. 2 shows the UI of the application that interacts with Arduino and Emotiv EPOC. It is an interface which actually acts as an interface between them. It also displays all the Expressive and Cognitive Suite status through which user gets to know whether the arm is working accordingly or not. The Fig.3 shows the comparison between the EOG and EEG technology, carrying out the various expressions on both technologies resulting that EEG is the better phalography technique to capture the neurons rather than using EOG (Electrooculograph).

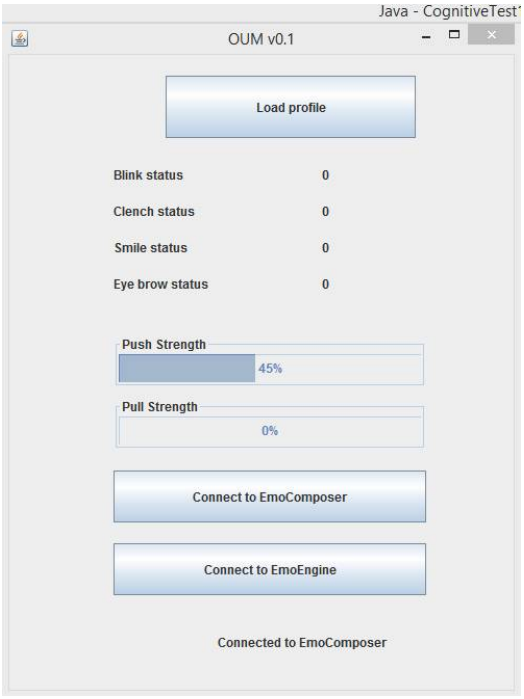

Fig. 2 GUI of the System

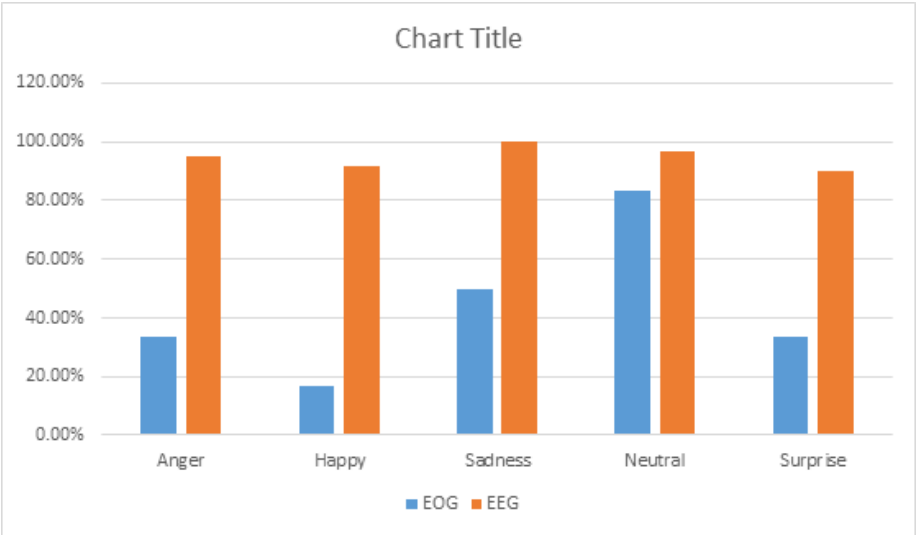

Fig. 3 Emotions captured by EOG vs EOG

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VI. CONCLUSION AND SCOPE

The project OUM aims to develop and engineer a Robotic Arm which will be controlled directly by human being's brainwaves. These brainwaves will be sensed by using EEG (Electroencephalogram) technology. The intelligence in this technology is to build an algorithm which will grasp the current activity of human brain i.e. collecting the information generated by Neurons which are activated by human brain and plan of actionswhich will beprocessed by robot using Digital Signal Processing (DSP) technique. A robot will then receive the human brainwaves as digital input and will work accordingly. The robot motions and movements of robotic arm will be completely depends on the brainwaves which human beings will produce.

The robot arm has various DOF (Degree of Freedoms) which decide the arm movements and motions which has the defined angles for it. The servos which are used in robot arm will decide DOF as per the sent brainwaves which are digitally processed and which has some finite value provided by EEG.

The product is supposed to be for the physically challenged people and to perform the tasks which are not performed by human being but having the same accuracy as the human brain has. The following are the perspectives of the project:

- **Cross-platform support**: Offers operating support for the most known and commercial operating systems.
- **User Privacy:** The users are allowed to create their own account at front end in order to access the system by themselves only.
- **Help Section:** The help section provides user in order to make proper decisions about making the right connections, proper utilization of system, etc.
- **Efficiency:** The basic need about this project that it should work efficiently and the product release will be having several versions in orderto provide maximum efficiency.
- **Dependencies:** The product is highly depend upon the human brain activities which are considered as neurons. The product is also depend on the interface between the hardware which is to be used and the USB dongle used by the EEG headband.

Scope:

- **Use in Day to Day life:**

People who are physically challenged having various physical illness are the main focus behind developing the project. They can make use of the robot arm in order to take control over various actions which are impossible for handicapped people.

- **Medical & Healthcare:**

This project also aims to provide a helping hand for handling various hazardous chemicals in medical industry or to provide more accuracy for performing any healthcare based actions.

- **Military& Industrial Use:**

The robot arms are very useful in military bases in order to handle heavy loads and to handle dangerousweapons and to perform transportation from one place to another. Also, this project includes the industrial use in order to perform accurate tasks which human beings lacks in some tasks but by using their brains as the brain activities have the accuracy which will provided to robots.

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BIOGRAPHY

Sharang Deo is a final year student in the Computer Engineering Department, Sinhgad Institute of Technology & Science, narhe, Pune University. His idea OUM was shortlisted as one of the top 100 idea as per ink Ink Talks 2013 panel. Currently, he is doing his BE project on "Mind controlled Robotic Arm". His area of interests are Robotics, Databases, Image processing, Networking and Information Security.

Raju Sharma is a final year student in the Computer Engineering Department, Sinhgad Institute of Technology & Science, narhe, Pune University. Currently, he is doing his BE project on "Mind controlled Robotic Arm". He has done many projects based on android. His area of interests are Robotics, Databases, Image Processing, Networking and Android.

KajalKumari is a final year student in the Computer Engineering Department, Sinhgad Institute of Technology & Science, narhe, Pune University. Currently, she is doing her BE project on "Mind controlled Robotic Arm". Her area of interests are Robotics, Databases, Data Mining, Networking and Mathematics. She has won gold medal in National MathsOlympiad .

S.G Pawar is an assistant professor in the Computer Engineering Department, Sinhgad Institute of Technology & Science, narhe, Pune University. He is an expert in Image Processing and Embedded System. He has more than 5 years of experience in these fields.