REAL TIME BRAIN COMPUTER INTERFACE SYSTEM for CONTROL APPLICATION

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***Abstract*— the progress of the technology may be a saviour for the people in the daily lives. In several human life stages, genetic or accidental disorders can take place where brain functions normally, but the motor nerves aren't working. We are trying to Develop a technology which may be a savior for the people in the daily lives.**

This project includes a description of a brain-controlled robot, on the basis of the Brain–computer interfaces (BCI), which can be defined as systems which are capable of by-passing the traditional communication channels (in other words, thoughts and muscles) for providing direct control and communication between the brain and the physical devices through the translation of a variety of brain activity patterns to commands in the real time, with those commands, the mobile robot may be controlled.

In this project, the wave signals of the brain are analysed and based on an eye Blink. Different properties of the eye blink may be utilized for a variety of the commands, like frequency, time duration, and strength. Through it, the robot's direction is regulated.

First, we acquires the signals from the brain by used the NeuroSky mind wave sensor to obtain the eye blinks information by recording the EEG signal . EEG signals from Mind wave Mobile are transferred to a laptop via Bluetooth and stored there . We performed pre-processing of the EEG signals recorded. Then we extract the features from the EEG signals. In the next step, we performed classification of the signals recorded using the extracted features. And then the classified features are translated into commands by the Arduino microcontroller, through which the robot will be controlled.

***Keywords*— Brain-Computer-Interface(BCI), Electroencephalography (EEG), Eye blink, Signal Acquisition , Arduino.**

I. INTRODUCTION

Recently, research on BCI is leading to new directions to have anm interactive intelligent system that transform human brainwave to control signals of a computer application oriented devices [1].

The studies about the BCI have begun in the 1970"s. This technology provides the ability of ensuring communications of the brain with the external devices. The fundamental idea behind the BCI is measuring the signals of the brain which are provided to the computer systems to be processed and translated afterwards into control commands for the patient who has health issue (for example poor mobility) for manipulating their environment [2], as can be seen in Fig.1 .

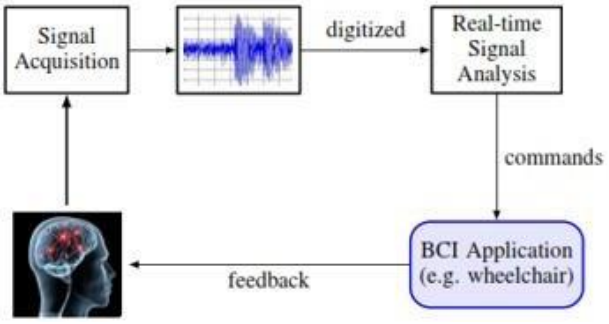

Fig. 1 Brain Computer Interface

BCI transforms electro-physiological signals from merely reflections of activity (CNS) to the target products of the activity: messages and orders that operate in the environment. It shifts a signal such as an EEG rhythm or a neuronal rate of firing from a brain function reflection to that function's end product: an output that, such as output in traditional neuro-muscular channels, that fulfills a person's intention [3].

Perfect BCI framework depends on preparing of EEG signal. It provides an elective channel to communicate with any outside framework like a PC or a wheelchair. An approach where we use eye advancement area from EEG signs to control robot has been viewed the improvement of an eye blink which offers climb to trademark signals, these exercises can be used to control an external structure. Our advantage lies in identifying and using the impact of eye related developments from the cerebrum wave sensor. The data of cerebrum movement is required for executing robot controlling technique. Electroencephalography (EEG) is the most reasonable strategy for controlling robot with cerebrum wave flags, this is an approach which records electrical waveform from the mind by utilizing terminals properly set on the head. The gadget utilized for this technique is convenient and non-invasive. It quantifies the variances of the voltage which comes about due to the ionic current within the mind"s neurons, it can record the unconstrained electrical actions of the cerebrum over some of the undefined time frames. Keeping in mind the end goal to actualize the controlling strategy, it is required to acquire the psychological order from the cerebrum and EEG signal must be pre-handled. Along these lines, it can translate the psychological charges that are detected by the mind, for instance forward, in reverse, left or right.

Mainly, there are 2 BCI technique types, which are, the invasive and the non-invasive techniques. In the invasive techniques, the signals of the brain are recorded through an implanting electrode in a direct way to the brain cortex. Whereas in the non-invasive techniques, the electrode is placed on the brain scalp. Electro-encephalography (EEG) can be considered as one of the examples of the non-invasive techniques of the detection of the activities of the brain. Electro-encephalography can be defined as the technique that is used to record the electrical activity along the scalp, which is produced through neurons firing in the brain [1].

A. Electroencephalography (EEG)

Electroencephalography It can be defined as the neuro-physiologic measure of the brain"s electrical activity through the recording of the signals from the electrodes which have been placed on scalp or, in some particular cases, in subdurally or cerebral cortex, the resultant excitement is indicated by the EEG and an electrical signal (i.e. postsynaptic potentials) from numerous neurons. Which are in some of the cases referred to as the brain-waves [4].

With regard to healthy adults, frequencies and amplitudes regarding these signals are changing from certain human state to another, like sleep as well as weakness. The features related to waves have been changing with the age. There have been 5 main waves of brain differentiated via their frequency range. Such frequency bands have been low to high frequencies referred to as alpha (α), theta (θ), beta (β), delta (δ), and gamma (γ)[5].

Delta waves, they have been in range of (0.5-3.5)Hz, have been lowest waves and occurring in the case when sleeping. In the case when waves occurring in awake state, it might be indicating brain"s physical defects. Movement might be making artificial delta waves, yet with instant analysis (only checking the raw EEG records), which might be unconfirmed or verified,as showed in Fig. 2.

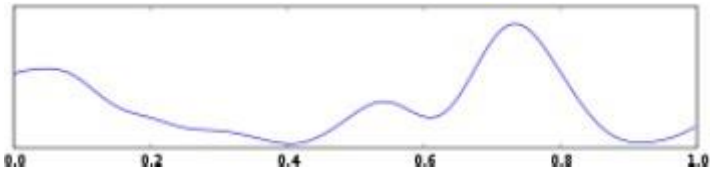

Fig. 2 Delta waves

Theta waves, they have been in range of (3.5-7.5) Hz, have been related to day-dreaming, and inefficiency, also the extremely low theta waves representing fine line between the states of being sleep and being awake. Also, the theta arising from emotional stress, particularly disappointment or frustration,as showed in Fig.

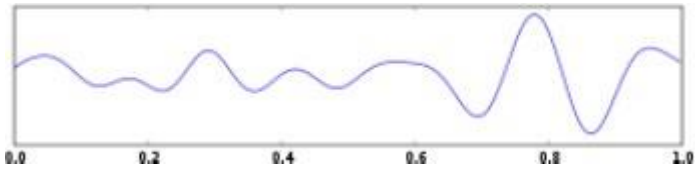

Fig. 3 Theta waves

Alpha waves, they have been in range of (7.5-12) Hz, have been slow and related to disengagement and relaxation. To think of something peaceable with closed eyes will increasing the alpha activity,as showed in Fig. 3.

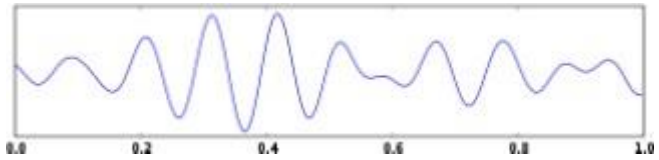

Fig. 3 Alpha waves

Beta waves, the have been in frequency range (12-30)Hz, yet they have been divided in to one and two for getting more specific range. Furthermore, the waves have been fast and small, related to the focused concentrations. also effectively specified in frontal and central areas. In the case when suppressing or resisting the movements, or to solve math tasks, there has been an increase in beta‟s activity, as showed in Fig. 4.

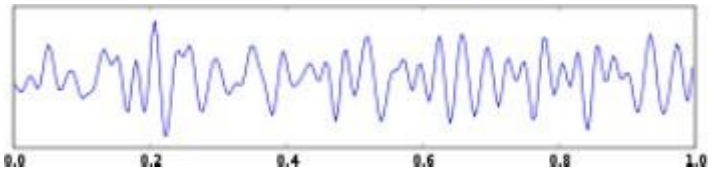

Fig. 4 Beta waves

Gamma waves, they have been in frequency range 31 Hz and more. Gamma waves are important to determine how the external world has an effect on the neural structure [6], as showed in Fig. 5.

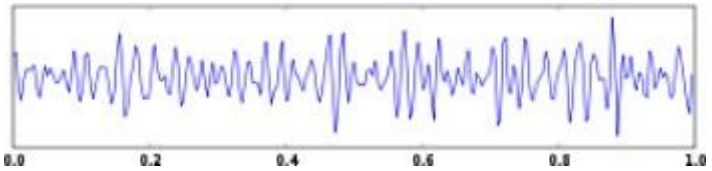

Fig. 5 Gamma waves

B. NeuroSky Mindwave headset

NeuroSky Mindwave can be defined as a sensor headset that is capable of sensing brain waves, capturing brain patterns and translating these patterns into things that can be done using a computer.[7] The mind-wave device adequately gauging and outputting EEG power spectrums as beta, alpha waves, and so on. It was embedded with attention as well as the meditation meters, also the eye blink detection. Furthermore, the NeuroSky mind wave headset , has been inexpensive module to read the human mental activities utilizing single

lead electrode. On the basis of BCI hardware study, neurosky mind wave headset has been most inexpensive modular EEG device with maximum usability score.

The Mindset contains NeuroSky think Gear™ innovation, which measures the simple electrical signs

The Think-Gear has been considered as technique in each one of the Neuro-Sky products or partner products empowering devices for interfacing with the brainwaves of wearers. It is including the sensor which touch the forehead, reference and contract points which are located in ear clip, as well as on-board chip which process all data. The eSense meters and brainwaves have been calculated on Think-Gear chip.

Stainless alloy dry sensors are collecting the neural signals, input them in to the ThinkGear chip, that is processing the signal in to usable data stream [8].

C.Eye Blinking

There is an increasing interest of the researches, which are carried out in the biological signals on the detection of the eye blink for physically assisting the impaired individuals for the verbal communication and controlling the devices.

The biological signals can be defined as the electrical signal which responds to any biological activity in the human organism. Biological signals which may be utilized for measuring the eye blinks are EEG and electro-oculogram (EOG) signals.

For recording the signal of the EOG, several electrode sensors have been placed surrounding the eyes whereas, for recording the Electro-encephalography signal, several electrode sensors are put on the brain surface. The sensors of the electrode which have been put on the brain surface have a higher relevance compared to electrode sensors which are put around eyes. Based on earlier researches, the blink of the eye which is generated by the Electro-encephalography are viewed as ocular artifacts, which possesses higher amplitude than the brain rhythms. None-the-less, those artifacts have been discovered to be usable signals [9] [10].

II. METHODOLOGY

The PIC micro-controller is not capable of working with no software. A controlling program is needed for reading the signals of the EEG from the subject, detecting two time blinks of the eye and activate the robot. A program which has been written in python, utilized for performing the operation of detection and control. The procedure of the detection of two time blinks of the eyes and activating the robot.

In this system, we used the NeuroSky headset was used for capturing EEG and eye blinking signals. The dry electrode on the headset is used to read the brainwaves, the brain waves are transmitted by the Bluetooth wireless module. At first, the program observes whether or not the amplitude of the EEG signal has exceeded the maximal threshold of the voltage, is less than the minimal threshold of the voltage or lies between the voltage thresholds. In the case of the detection of double eye blinks in 4 sec., the program will send logic 1 to the micro-controller‟s output for the purpose of driving and activating the robot‟s motors.

A. Electronics Setup

The core hardware used in this projrct are: Neurosky sensor, leds, an EPS32 development board, and my computer, the wave signals of the brain go from the head to the computer, which will process the data of the EEG searching for visually-entrained waves. In the case of detecting any, it will decide the commands that need to be given to the robot. Those commands are taken back to the board , and the leds are then guided.

B. EEG Setup

The PC works as a center of signal processing with the use of the computing environment of Python. The technology of Neurosky has been utilized for capturing the patterns of the neuro signals from the user, where single channel, dry, and bio-sensor which is located at the frontal lobe FP-1 area with minimum amount of the hair. It will deliver raw signals of the EEG with a degree of the noise and values of the artifacts. For the purpose of communicating with the computer, the Neurosky software first requires the installation on the computer. Post the completion of installation, they will establish and check the connection and start communicating with the computer through the Bluetooth. The Thinkgear technology function permits the headset to evaluate the signals of the EEG and pre-process them. It will remove the undesired artefacts and noise from data packets, which have been obtained from sensor.

C.Signal Acquisition

In order to enhance the accuracy and reduce all the other sources of noise to its minimum values, the blinking patterns of user had been recorded ten trails and the data were captured and save as a data set. The signals of the real-time EEG are taken from the human subjects with the use of a portable, simple, easy to use, and inexpensive system of the Electro-encephalography acquisition, which is the Nuerosky head-set mind wave.

D. EEG Processing

1) Feature Selection

Feature selection in the data of the EEG is a significant 1st step towards the analysis of signals. The features are chosen from a mixture of all of the attributes. In the present research, conventional statistical methods have been utilized to calculate maximum value and mean value. As soon as the computer acquires the Electro-encephalography data from Open BCI board, the initial process is to calculate maximum amplitude value and mean value of EEG. These values are base-line to decide if the peak is strong or otherwise.

2) Threshold value

In order to keep the robot moving, the eye blink signal strength has to be higher than a specific threshold as much as possible. The strength of the signal of the eye blink could differ from one user to another and does not have a certain value which is affiliated with it. For the purpose of additionally improving the sensitivity of the system, the aim is to lower the threshold of the detection in order to get more of the points in the region of the "eyes closed". None-the-less, doing so, will as well result in more points outside the area of the "eyes closed" to be detected falsely.

The selection of a sufficient threshold of detection needs balancing need for the low false alarm rate with the need for the high sensitivity. After testing a number of various values for the threshold (as can be seen in the following Table I), 150 µV appears to be providing an adequate balance for such Electro-encephalography recording. Other types of the recording could be requiring another value for the threshold. The values of the threshold empirically found it.

TABLE I

THRESHOLD VALUES

Threshold	N_TRUE	N_FALSE
50 uVrms	5	15 (42%)
100 uVrms	14	6 (73%)
125 uVrms	12	9 (66%)
150 uVrms	18	3 (94%)
200 uVrms	8	12 (39%)

3) Time of eye blinking

Following the detection of the eye blinks, the robot follows the command of the eye blink of moving in various directions, the eye blink is one of the natural human activities. For the sake of identifying whether or not the blinks of the eyes are controlling commands or the natural human actions, the strategy of the identification of the eye blinking requires being utilized in prototype. At this stage, the blinks of the eyes will be viewed as controlling commands only in the case where those two blinks have happened in a short period of time between (0.01 to 0.07 sec) and those two blinks‟ strengths are greater than natural blinks according to the threshold.

E. Software and Data processing subsystem

In this study, the graphical user interface used for controlling movement forward, right, left, stop respectively. Note that the interface used for presenting the stimuli was implemented by python language as illustrated in Fig. 6. Buttons were flashed one by one individually in a random order. Stimulation duration was 100ms with an interstimulus interval of 10ms. To select one item (the target), the user is capable of blinking two times in a short duration so as to activate the robot, and its movement depends on the LED that has been flashed at the moment. At any second, the user is able to blink two times in a short time span for changing the robot‟s direction. As soon as the user has blinked two times, its movement will change right away according to the LED which has been flashed then.

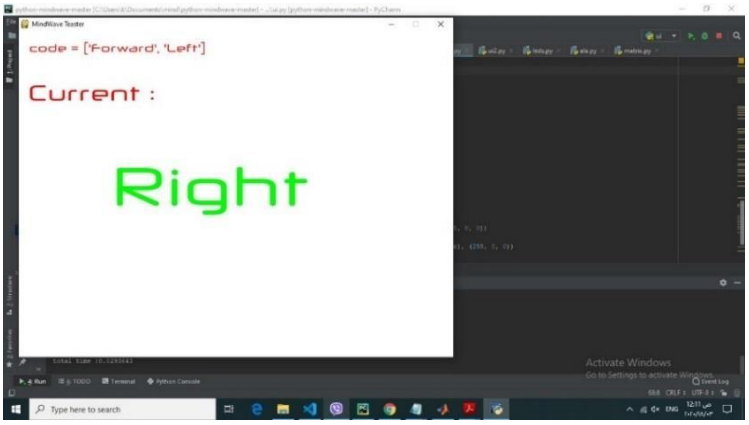

Fig. 6 Items are flashed one by one in a random order.

Therefore, a generation of the control signal is carried out. A „high‟ output has been obtained by the pin 11 of the interfaced board of arduino via port „com6‟. The LED of the transmit /receive on the board of arduino glows right after receiving a „high‟ output through the program. It indicates the transmission and receiving process. Right after receiving such „high‟ output at the circuit of the LED on the bread board, it starts glowing as can be seen in Fig. 7.

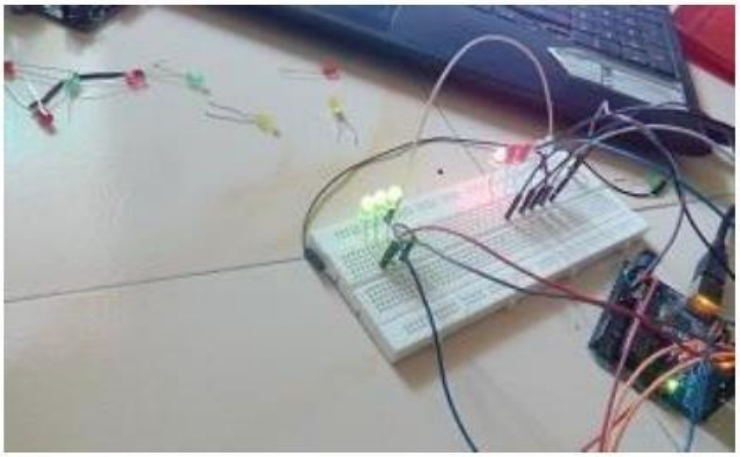

Fig. 7 leds are controlled by mind wave headset.

F. the performance of the system

System performance is evaluated through the analysis of system accuracy, as accuracy is the most important part of this project. For accessing the blink detection accuracy, the number of the false positive, false negative, true negative and true positive cases is manually calculated for each subject, as shown in Table II and Fig. 8.

TABLE II

ACCURACY OF SYSTEM

Subjects	The number of command	TP	TN	FP	FN	Accuracy
1	24	21	1	1	1	91%
2	22	19	2	0	1	95%
3	21	19	0	1	1	90%
4	21	18	1	0	2	90%
5	22	18	2	2	0	90%

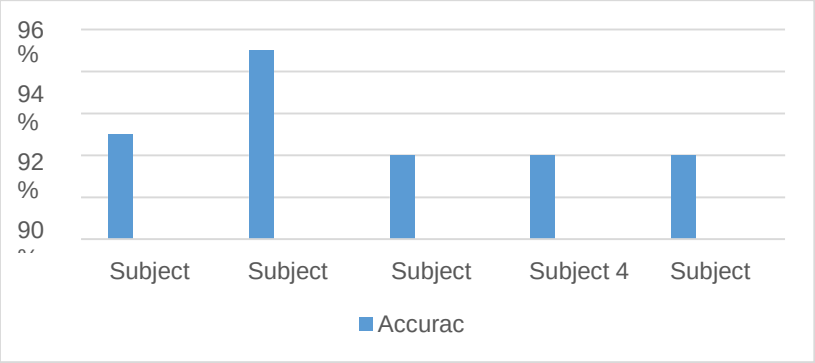

Fig. 8 Accuracy of system

III. CONCLUSIONS

In our project we have tried to achieve Brain computer interface combining the different sophisticated sensors, modules and Python programming to build the "Brain Control System" The signals obtained from the frontal part of the brain which defines the concentration and meditation level of the user is classified, analyzed and features is extracted using different algorithm so as to control of the robot

The project has been divided into several tasks for reaching the ultimate prototype:

- The first task is to deal with the signals of the brain with the use of think-gear packet and produces the brain signal interfaces (Alpha- beta- gamma- theta-ratio of mediation and attention).
- The second task Using the threshold value and the time of blinking to classify the blinking signal, where eye blinking is a control command if maximal amplitude of the peak is higher than the threshold and blinking during a short period.
- The third task has been to use the arduino for controlling the LED light rate due to the fact that it is similar to controlling the dc motor and the attention ration has been utilized as the light rate.

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