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Electroencephalography Signals Based Face Interaction for Directional Control System

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Abstract: Recently, the Electroencephalography (EEG) signals of human brain are considered by researchers for performing different applications that can solve numerous problems. These research works tackle the problems of movements for sever disabled people. In this paper, a directional control system based on EEG signals of human brain is proposed. The EEG signals are read using a Five Channels Emotiv headset that includes seven nodes. The read EEG signals are sent using WiFi technique to the Raspberry Pi III for processing and producing directional control signals. The four movement directions are represented by indicators as a prototype to simulate the direction control, as well as the ON/OFF signal as a master key. Different case studies are considered to test the proposed system over the expected circumstances.

Keywords: EEG signals, embedded systems, control system, Emotiv headset.

1. INTRODUCTION

A disabled person is a person who doesn't able to move some or all of his limbs (both arms and legs). Those persons are literally "locked-in" their bodies, have no control over their surroundings. Such cases occur for many reasons, for example, a spinal cord injury or brain stroke [1]. Researches showed that electroencephalography (EEG) signals recorded from the scalp can be used in many non-muscular control and communication systems. These systems are usually called Brain Computer Interface (BCI) [2] and [3].

Amongst the human bio-signals, EEG signal is considered as one of the weakest signals and it is likely to interfere with other signals that are on the same range of frequencies. The amplitude of such signal is very low (0.5-100 µV), which makes it very difficult to record [4] and [5].

In this paper, a directional control system is presented based on EEG signals taken from human brain with Emotiv headset. The EEG signals control the on/off of five LEDs attached to a whiteboard and connected to a Raspberry Pi III. Figure (1) shows the proposed system block diagram.

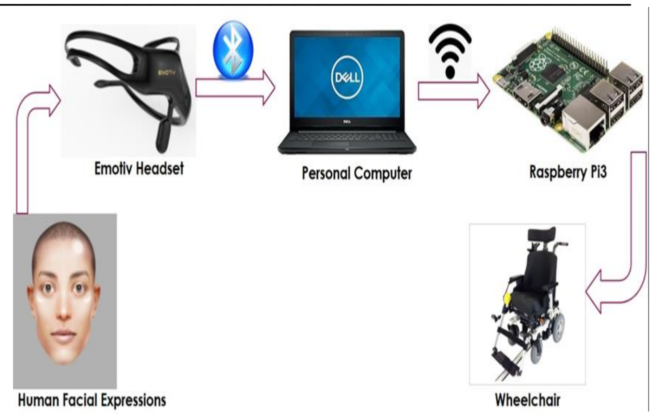

Figure 1. System block diagram.

2. RELATED WORKS

The system in [4], was proposed to evaluate the driving of a participant in different mental situations. The participant was experimented with a few questions regarding his/her stress level. Meanwhile, EEG signals were acquired by Emotiv headset, visualized and recorded by Emotiv control panel. If the driver has been found mentally unstable, an alarm is would ring indicating that the driver is not ready to drive.

In [5], a system was developed to control a servo motor. The movement of the servo motor was controlled by an Arduino micro-controller. When the servo motor received a pulse from the PC, it rotated at 90^{o} movement,

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and rotated 90° backward to its original position when it received the second pulse. The main purpose of this research was to help people who lost their limbs due to an accident. A BCI system was developed in [6] to control the movement of a quadcopter by identified brain concentration and eye blink. EEG data was captured by Emotiv Epoc headset and sent to data processing computer to analyze it in real time. They found that the developed system used less data and computational source as compared to the traditional BCI-controlled quadcopter systems. In [7], a wearable system was introduced that detected user's emotions from facial expressions while the user wears glasses with built-in camera. They used USB serial communication to transfer the acquired images. They used intensities in each pixel of images as features. As a consequence, they required a dimension reduction method, because the number of dimensions were too large to use for classification. As compared to the wearable device used in this research, it extracted facial expressions from EEG signals. It didn't need a USB cable, it transferred the data wirelessly

The system in [8] showed how a Brain Computer Musical Interface (BCMI) can be implemented with Emotiv Insight headset as an input and signal processing device. Data collected via Bluetooth is then routed over the network formatted for OSC protocol. It was concluded that the Emotiv Insight headset is a fascinating choice for a BCIM because of its low price and ease.

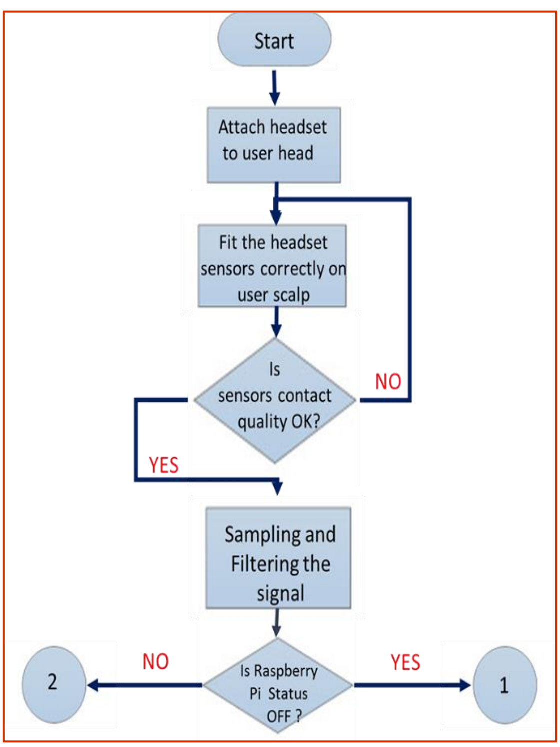

Figure 2a. Headset connection flowchart.

3. The Proposed System Description

The proposed system is designed based on the two main parts: Emotiv headset and Raspberry Pi with related LEDS. For easing the reading fluency, this section can be divided into three subsections as follows.

3.1 The Proposed Algorithm

The proposed algorithm can be summarized as a flowchart, shown in Fig. 2. As mentioned above, EEG data is collected with Emotiv headset. The user should check first that the sensors touches his/her skin to ensure good signal reception. The signal is then sampled at rate 128 Hz, and bandpass filtered between 0.2 Hz and 43 Hz. Power-line noise at 50 Hz and 60 Hz are also attenuated before the data are sent to the wireless transmitter [6]. Fig. 2a shows the headset connection flowchart.

A Bluetooth dongle is attached to the PC to receive the signal from the headset. After the signals reception, the headset checks weather the Raspberry Pi is On or Off. If it was Off, the headset detects only blinking signals and discard signals that come from other facial expressions. In order to turn Raspberry Pi ON, the number of blinks should be more or equal to five blinks within six seconds. Once the number of blinks satisfies the condition, the headset can detect other facial expressions signal. The surprise and frown signals have other condition to fulfil. The power of these signals has to be above the threshold. Otherwise, the signal is ignored. This process is depicted in Fig. 2b.

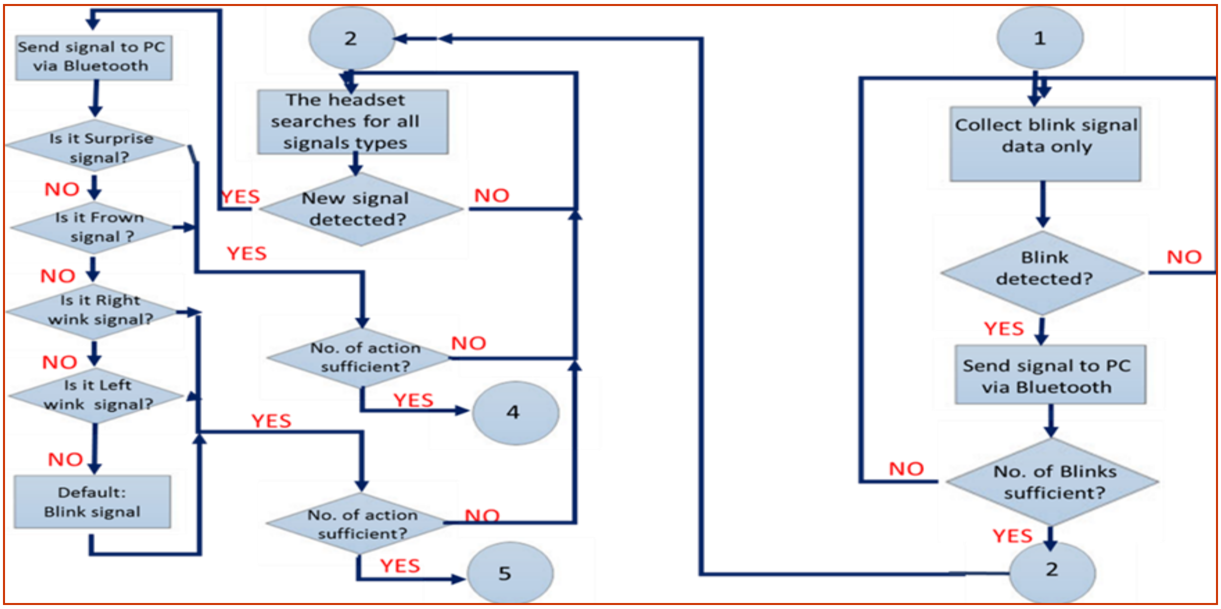

Figure. 2b. Signal processing in PC.

The signal is sent in a form of a message to the Raspberry Pi. Once the message is received, it is checked to verify its content. Each message satisfies different condition as shown in Fig. 2c, and each condition that is executed, sends HIGH signal to different GPIO pin to turn an LED ON/OFF.

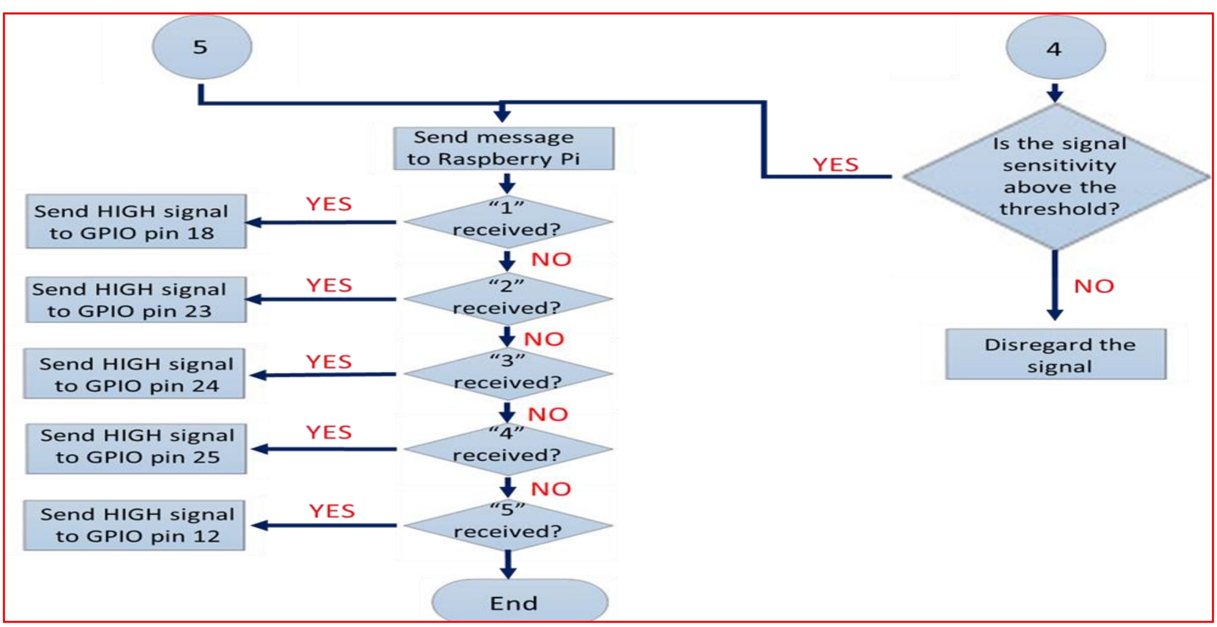

Figure. 2c. Signal processing in Raspberry Pi

3.2 Emotiv Insight Headset

In this research, the main unit is the Insight headset, which is manufactured by Emotiv Company and shown in Fig. (3). It is an easy to use BCI system with reasonable accuracy that detects EEG signals and maps them to a computer device for further processing. The headset technical specifications are listed in Table (1).

Figure 3. Emotiv insight headset.

Table I. Insight Technical Specification.

Number of Channels	5
Reference electrodes	2
Connectivity	Bluetooth 4.0 LE
Conductive Gel	Not required
Battery	Internal Lithium Polymer
Battery life	4 hours minimum

In order to measure the right brain activities, it is important to detect the signal from different cortical structures that are distributed all around the brain [8]. The electrode locations for such headset are shown in Fig. 6.

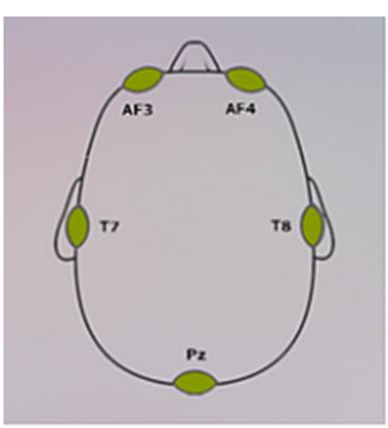

Figure 4. Electrode locations in Emotiv insight headset

Emotiv headset comes with many fascinating features, one of these is the facial expression detection suit. This feature simulates the face of the person wearing the headset and displays the expressions in real time on an avatar that represents the human face. Fig. 5 shows the facial expressions adopted in this work

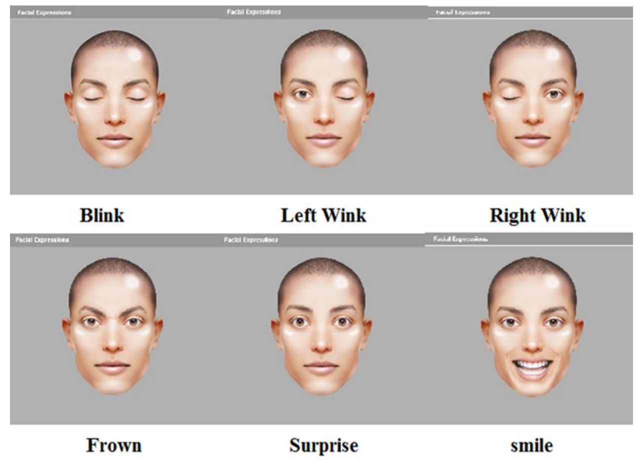

Figure 5. Facial Expressions.

Most EEG devices ignore the signals that are picked up from facial muscles and the eyes and consider them as noise. The Emotiv headset does not only filter these signals before inferring the brain signals, but it also classifies them to identify which muscle group are causing them [10].

3.3 Raspberry Pi Minicomputer

The Raspberry Pi is a low price, small size computer that is equipped with keyboard and mouse developed by the Raspberry Pi foundation in UK. Python language was used to program it because it is simple and easier to understand [11]. Fig. 6 shows the Raspberry Pi III, used in this work.

Figure 6. Raspberry Pi III.

In this project the Raspberry Pi receives the signal from the PC and uses that signal to control the LEDs ON/OFF states as indicates through its GPIO pins.

4. Experimental Results

In order to test the designed system, different experiments are performed related to the considered four directional actions as well as the on/off set. It is well known that the directional actions are forward, backward, right turn and left turn, represented in raising brows, furrow brows, right wink and left wink, respectively. The blink face action is used for activate/deactivate (ON/OFF) the whole system as master ON/OFF switch.

When the user raises his/her brows, a signal is generated from the face muscles, detected by the electrodes and moved to PC for the next processing steps. In order to ensure that unintentional face movement are not considered and ignored, the user has to raise his/her brows five times within five seconds interval. Fig. 7 shows how the green LED (forward action) is turned ON as a consequence of raising brows.

Fig. 8 shows that the yellow LED (backward action) is turned ON when the user furrows his/her brows. The same technique, used above, was applied to avoid unintentional furrowing.

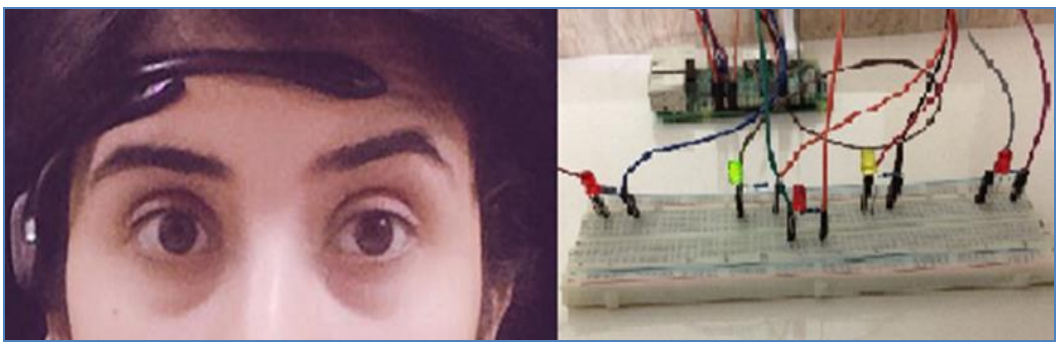

Figure 7. The effect of raising brows.

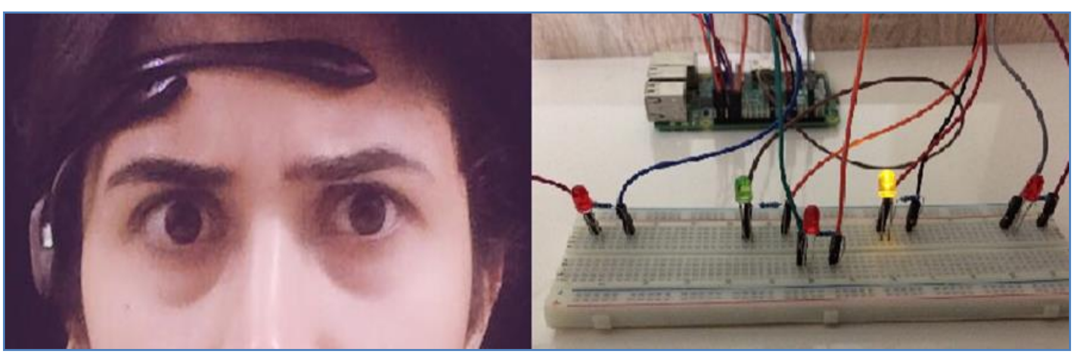

Figure 8. The effect of furrow brows.

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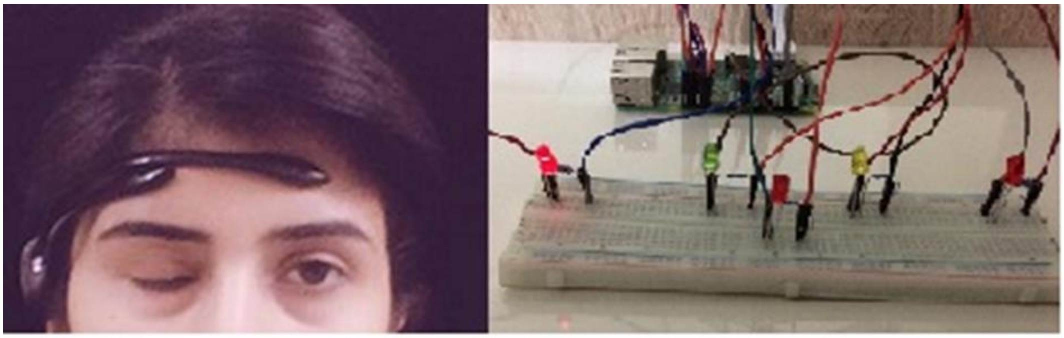

Figure 9. The effect of wink right.

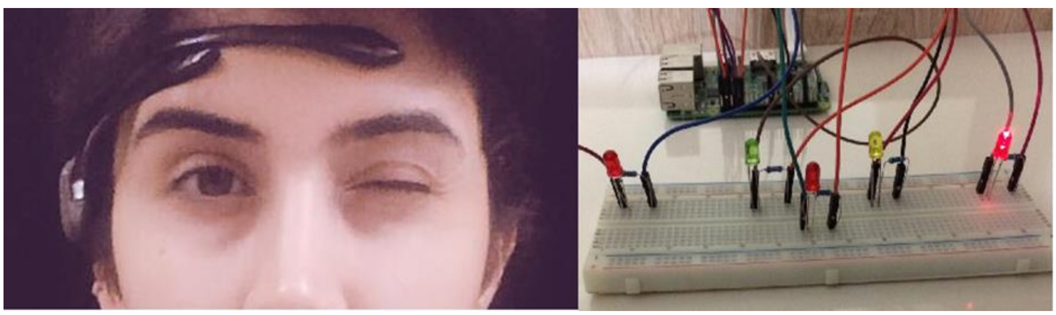

Figure 10. The effect of wink left.

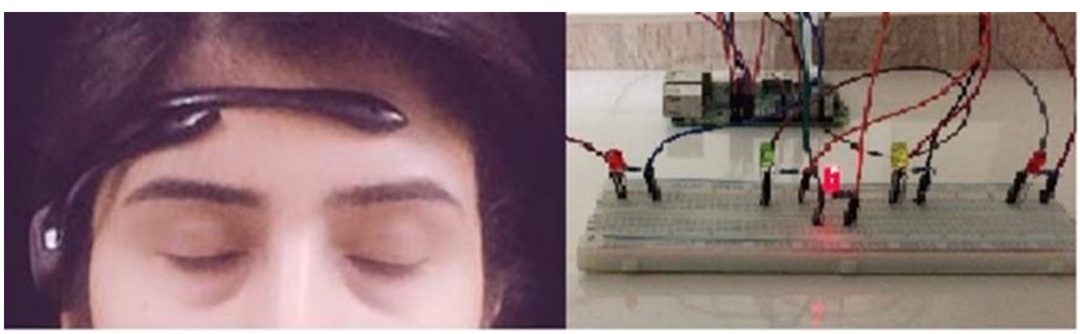

Figure 11. The effect of blinking.

When the user winks his/her right eye, the red LED (right turn action) on the right of the whiteboard would lit, as expressed in Fig. 9. The same is happened when the user winks left eye, as shown in Fig. 10 foe left turn action. As mentioned above, the blink action is used for activating/deactivating the proposed control system. The user has to blink five times within five seconds in order to turn on the red LED (ON/OFF the system) that is located in the center of the board, as shown in Fig. 11.

Considering the accuracy of the headset, and the fact that its sensors pick the electricity from the environment, it has the capacity to pick up very tiny signals. Those signals tend to interfere with the original signals, therefore the obtained signals need to be filtered before moving to the next step.

The obtained signals after processing are acceptable at some level. The user has to be trained to sit relax, clear his mind and focus on his/her facial expressions movement. If we planned to go further with the project, the system can be used in many applications. One of them is controlling a quadriplegia persons wheelchair. This could be very useful for paralyzed persons and can help them to depend on themselves. Finally, the results were accurate under some conditions, so that LED ON/OFF turning can be managed with pulse signals extracted from an EEG signal obtained from the motor cortex of a volunteer when the person moves his/he face muscles.

5. CONCLUSION

A directional control system is presented as a prototype using the EEG signals. These signals were used for controlling the movement directions: forward, backward, right turn and left turn. They were considered in synchronization with face reactions, such as rising brows, furrow brows, right wink, left wink, and the blink. Emotiv headset was adopted as an electronic device to measure the EEG signals using five sensors allocated in different positions. The collected signals were sent to Raspberry Pi III for analyzing them and performing the direction controlling. The directional movement actions were represented in this prototype using LEDs with different colors. Different experiments were implemented to test the proposed system. The obtained results showed the accepted performance of the proposed system in terms of accuracy up to 80% ratio. This work should open a gate for many future applications that would come with benefit for disabled peoples, for example, wheelchair control system, moving cursor on a screen, etc.

REFERENCES

[1] Sergio Machado, Fernanda Araiijo, Flavia Paes, Bruna Velasques, Mario Cunha, Henning Budde, et al., " EEG-based brain-computer interfaces: an overview of basic concepts and clinical applications in neurorehabilitation", Reviews in the Neurosciences, Vol.21, No.6, p.p.451-468, 2010

[2] Tadashi Isa, Eberhard E. Fetz and Klaus-Robert Muller, "Recent advances in brain–machine interfaces", Neural networks: the official journal of the International Neural Network Society, Vol.22, No.9, p.p.1201, 2009

[3] SG Mason, Bashashati A, Fatourechi M, Navarro KF and Birch GE, "A comprehensive survey of brain interface technology designs", Annals of biomedical engineering, Vol.35, No.2, p.p. 137-169, 2007

[4] Ravikumar K. Tiwari and S.D.Giripunje, "Design approach for EEG-based human computer interaction driver monitoring system", Int J Latest Trends Eng Technol IJLTET, Vol.3, No.4, p.p.250-255, 2014

[5] Somer M. Nacy, Sadeem N. Kbah, Hind A. Jafer and Ibraheem Al-Shaalan, "Controlling a servo motor using EEG signals from the primary motor cortex", American Journal of Biomedical Engineering, Vol.6, No.5, p.p.139-146, 2016

[6] Xiaomu Song, Kyle Mann, Eric Allison, Suk-Chung Yoon, Henri Hila, Albert Muller and Christine Gieder, "A quadcopter controlled by brain concentration and eye blink", IEEE Signal Processing in Medicine and Biology Symposium (SPMB), p.p.4, 2016

[7] Jangho Kwon, Da-Hye Kim, Wanjoo Park and Laehyun Kim. " A wearable device for emotional recognition using facial expression and physiological response". Engineering in Medicine and Biology Society (EMBC). Pp. 5765-5768. 2016

[8] Constanza Levicán, Andrés Aparicio, Vernon Belaunde and Rodrigo F. Cádiz "Insight2OSC: using the brain and the body as a musical instrument with the Emotiv Insigh", p.p.15, 2017

[9]"Spatial resolution – whole brain sensing", https://www.emotiv.com/the-science/, 8:30 PM, 23/3/2018

[10]"Facial expression detections", https://emotiv.zendesk.com/hc/en-us/articles/201216295-Facial-Expression-Detections, 3:45, 21/3/2018

[11] Jason Scotts, "Raspberry Pi programming genius", Create Space Independent Publishing Platform, April 19, 2013

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