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Facial Expression Recognition with Emotiv

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Abstract: The project objective is to distinguish some facial expressions using color "Emotiv EEG neuroheadset" device capable of receiving and controlling the bio-electric activity of the brain through Electro Encephalo Graphy (EEG) and 16 channels with the continued receipt of brainwaves accurately and fast as this device has a friendly and easy to use platform allowing people without any experience manage to handle it. MATLAB platform took it as a system for filtering waves and through serial communication Arduino board which receives each logical data sent by the sensor and is shown by means of leds used. Differentiation of three expressions is obtained: wink, blink and smile each differentiated by different colored led.

Key words: Emotiv, EEG, BCI, facial expressions, Arduino, brainwaves

INTRODUCTION

This project is based in recognize facial expressions using Emotiv sensor (Emotiv, 2012) which consists in a headset with 16 electrodes distributed in a specific way over the head surface to achieve a right measure of electric potential generated on the neurons when this one's process the information (Oussama *et al*., 2015).

The Emotiv is connected wireless to a BCI (Brain Computer Interface) platform which makes easy the processing and analysis of the information captured from the electrodes on the headset. The electroence phalography is the basic principle of the Emotiv Epoc this uses the electric impulses generated by the neurons when this ones receive or sent information from "outside". This phenomenal gives neuronal plasticity, property of the brain cells for establish and modulate stimulus perception which are on the environment (Khandpur, 2015).

It made tests to find out the voltages according to expressions and it allowed the analysis of data. Facial expression vary according the person of study it was an important fact which was taken into account for such reason it establish a series of ranges in the data acquisition according to the gestures made.

Based on previous projects as Matlovic *et al*. (2016) and Kubacki *et al*. (2016) it was found a voltage pitch according the facial expression made it facilitated data analysis in the computer.

Literature review: Emotiv Epoc device has allowed the advance and development of the wireless control technology through the brain waves giving easy a way to get better its process to the different field of the engineer. The medicine is a field where the engineer has realized important advances. Some advances are registered coming up: In 2015, Macquarie University in Australia used Emotiv to recollect signals in patients with normal and low hearing. Previously, the register had been done with patients with greater ages (60 years old forward) and in a range in 6-12 years old and the results were similar con a notorious activity in specific points of the sensor (Badcock *et al*., 2015).

In Dayton University in United States, it was achieve in manipulation of a robotic arm of 7 DOF using emotions which were acquired with Emotiv EPOC with the operation to open and close the gripper (Ouyang *et al*., 2013).

In 2010 in the SASTRA College in India, it was developed a platform to for cellular controlled by Emotiv with specific activities (emotions and facial gesture), allowing make call to specific contacts through the reception of the signals (Mukerjee, 2010).

A video game for Android was development in England in 2016. This project used Emotiv to recollect EEG signals. It used facial gestures to control the position of mouse and the gyroscope was in charge of click (Raju *et al*., 2016).

Also, it was implemented an emergency brake for a car. This project compares the response time with different devices like EEG, EMG, gas pedal and a regular brake. The results determined that the faster response time was the EEG and EMG which was 500 msec compared whit mechanical brake. The study was made in August of 2014 at England (Kim *et al*., 2015).

A flight simulator was made using a BCI where it was trained 10 test subjects with ages between 22-26 years old

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to pilot an airplane with Emotiv. Even the results showed that BCI performance decreased from 83-63% while the assisted to additional tasks of alerts and surveillance is possible realize various task at the same time with a BCI device (Beyrouthy *et al*., 2016).

BCI: A BCI (Brain-Computer-Interface) is a communication method which is based on the neuronal activity generated by the brain which one is independent of periphery nervous and muscles outputs. Those signals are acquired, processed and interpreted by a machine or computer. The neuronal activity used in BCI could be acquired through invasive and non-invasive techniques (Bin, 2005). There are three BCI sub-types.

Active BCI: It drifts its outputs from brain activity controlled consciously by the user and it is independent of external events.

Reactive BCI: It drifts its outputs from brain activity from an external stimulation which is indirectly modulated by the user to control the application.

Passive BCI: It drifts its outputs from involuntary with no specific purpose for give information explicit on the interface (Jonathan and Wolpaw, 2012). To implement a BCI (Fig. 1) is necessary.

Signal acquisition: The signal acquisition is necessary to capture the electrical brain signals. Usually, this required pass by an amplification process to be read by a translator to be processed digitally.

Signal processing: In this step, the signal is filtered to be analyzed. Then is select the specific characteristics of the EEG signal and finally, the signal is classified in frequency and form.

Signal manipulation: Once the signal is processed is can be manipulated according to the application wished (Hassanien and Azar, 2014).

Emotiv: In this project was used the Emotiv Epoc EEG to measure the brain activity because is a BCI device that permits to measurement electrical signals produced by the neurons to communicate between them.

Position: The electrodes position is given by mount-ing, this is a symmetric pattern of electrode in the head. This electrodes are distributed on the head according to a standard system called 10/20 system (Anonymous, 2016) (Fig. 2). The electrodes are ordered according to their head position, shown at Table 1.

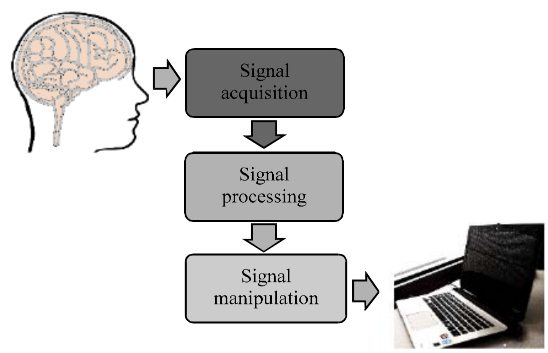

Fig. 1: Structure BCI to implementation

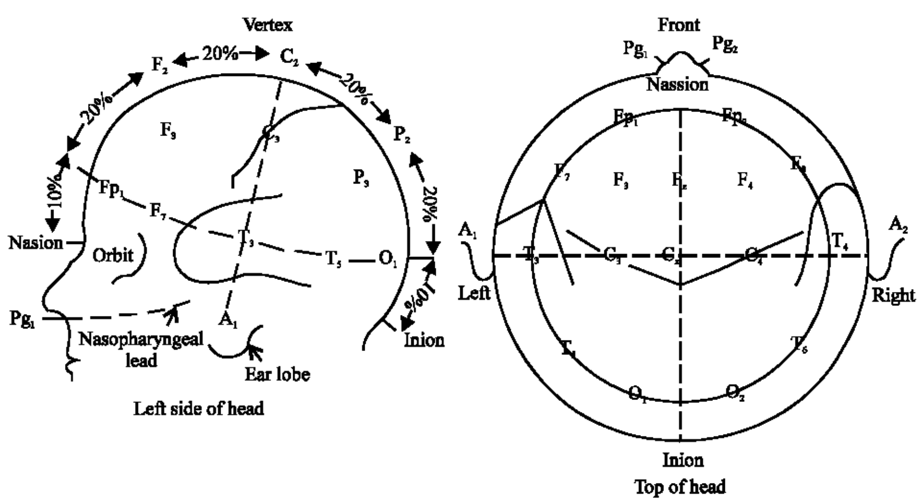

Fig. 2: Electrode position system

Table 1: Nomenclature used for electrodes position

Abbreviation	Position
Fp	Pre-frontal
F	Frontal
C	Central
P	Parietal
T	Temporary
O	Occipital

MATERIALS AND METHODS

For the development of this project, it was implemented the next activity list in Fig. 3.

Signal acquisition: The signal acquisition of different gestures was made through Emotiv Epoc. The electrodes required for smile, wink and blink are AF_3, F_7 and F_8. Figure 4 shows the position of electrodes in Emotiv Headset.

One of the advantages of the Emotiv is the wireless communication with the computer because it generates order in the physic work space 5 and the noise decrease by the signal conditioning (Fig. 5).

Then, the acquired data was sent to the computer using the Epoc Bluetooth in the computer was realized the signal processing.

Signal processing: MATLAB was used to get the data sent by the Emotiv Epoc. To make it possible was necessary the implementation of the according libraries. Also, it was implemented an algorithm for the reading of each sensor. Figure 6 shows signal processing methodology.

Experiment setup: To establish the sensor range operation, it realized 3 tests where every subject made some time the same gestures. The test are in Fig. 7-9.

Gesture analysis: To realize the gesture analysis it made an algorithm to compare the sensor input signals if the signals were on the established operation range it will be counting as one gesture. Of this way each sensor would have a counter (Fig. 10):

$$\text{Smile} = AF_3\{220 \sim 240\ \mu V$$
$$\text{Wink} = F_7\{220 \sim 230\ \mu V$$
$$\text{Blink} = AF_3\{170 \sim 190\ \mu V$$

Embedded system communication: Through serial communication it sent the according data. Every gesture belongs to a letter when the character comes to the counter would be activated and MATLAB send the according letter to the embedded system:

Fig. 3: Methodology

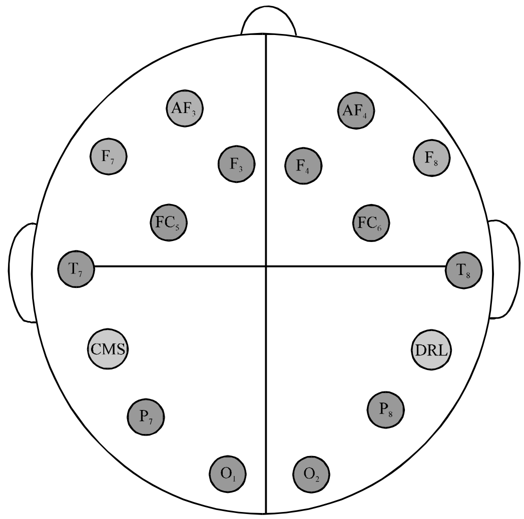

Fig. 4: Electrodes location on emotiv EEG

Fig. 5: Emotiv-computer communication

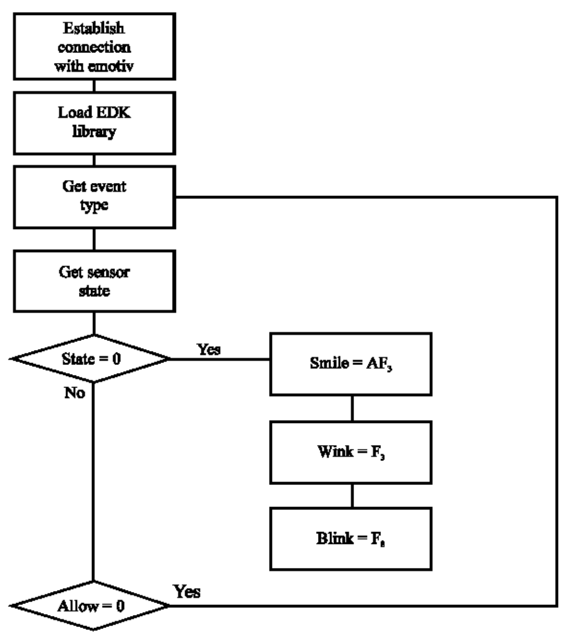

Fig. 6: Signal processing methodology

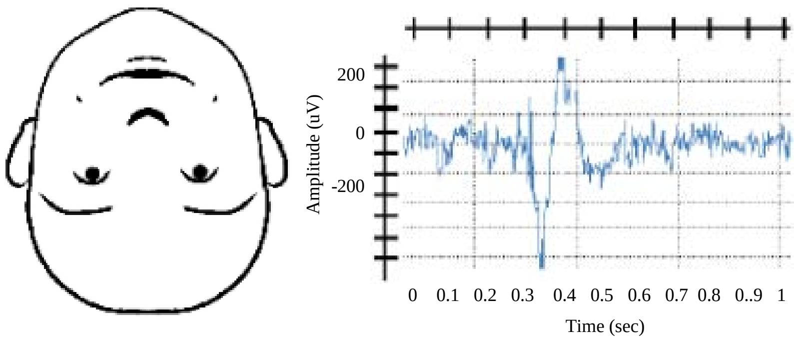

Fig. 7: Smile test

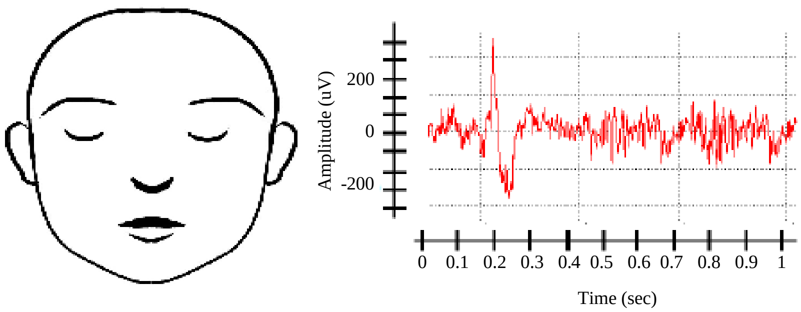

Fig. 8: Blink test

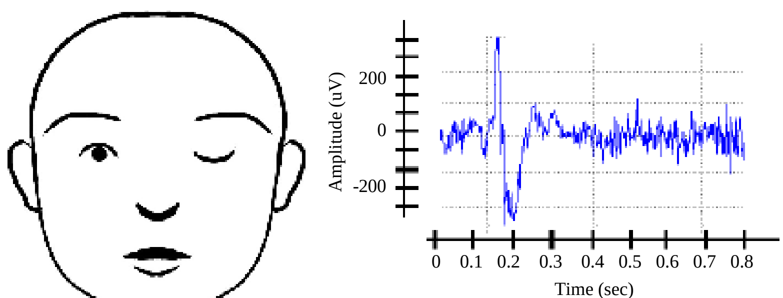

Fig. 9: Wink test

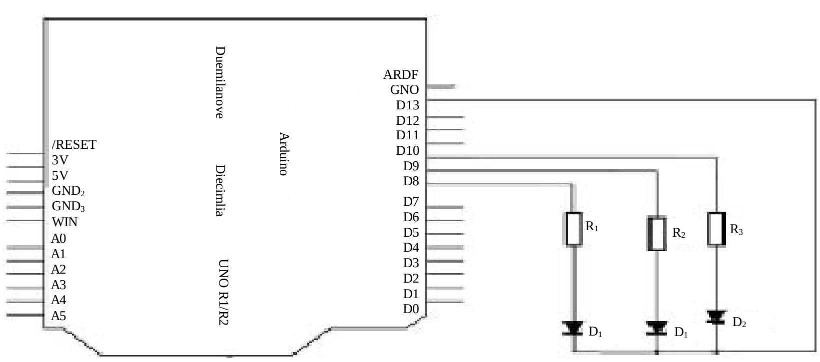

Fig. 10: Gesture disply montage

$$\text{Dn}(\text{serial}) = \begin{cases} D_1 \text{ if serial} = \text{'C'} \\ D_2 \text{ if serial} = \text{'S'} \\ D_3 \text{ if serial} = \text{'B'} \end{cases} \quad (1)$$

Display: Arduino was used to make the display system. When a letter is received through serial communication, the algorithm compares the data incoming and turn on the according led. Every led indicates a different expression, red to wink white to blink and yellow to smile. Figure 10 shows gesture display montage.

RESULTS AND DISCUSSION

It realized the measurement of each electrodes in charge of the facial gestures with Emotiv EEG. The measurement obtained of the AF_3 electrode generated a peak of 230 µV when the subject blinks (Fig. 11).

When it made a sequence of 3 blinks (Fig. 12) it observes that the sensor detects the sequence with no problem but the values peaks vary for that reason it calculated the average value and this is 220 µV and an error of 4.34%.

On the F_7 electrode signal measurement in charge of monitoring wink, it observes a peak of 180 µV (Fig. 13). When it made a 4 winks sequence(Fig. 14) it presents an average value of 190 µV and a error of 5%. It realized the F_8 electrode measurement when the subject smiles it generated a peak of 190 µV (Fig. 15). To smile twice (Fig. 16) it observes an average value of 174 µV and an error of 8.4%.

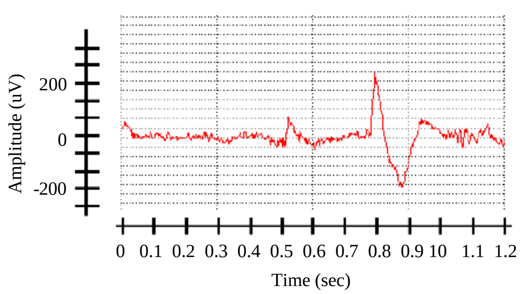

Fig. 11: AF_3 electrode, blink signal

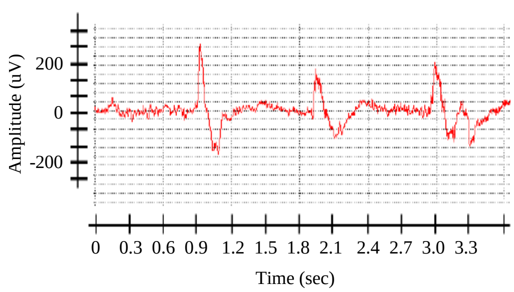

Fig. 12: AF3 electrode, 3 blinks signal

It made tests with 3 subjects measuring the different facial expressions. Each subject made a determinate sequences of gestures to measure the effectiveness of uptake with 3 gestures: blink, wink and smile.The results are shown on Table 2. Later it calculates the percentage of hits (Table 3). It realized the average with the success of the test and the obtained results were:

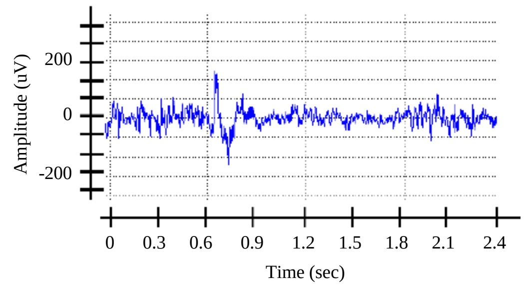

Fig. 13: F_7 electrode, wink signal

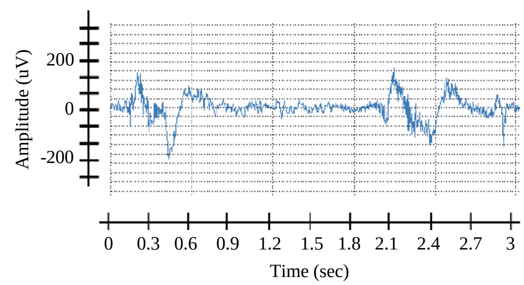

Fig. 14: F_7 electrode, 4 winks signal

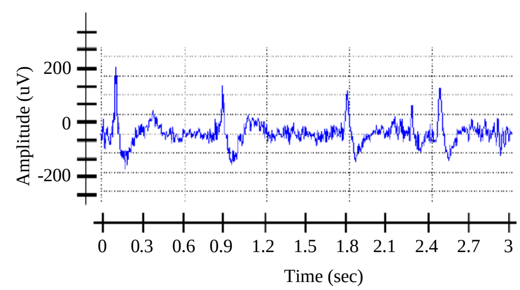

Fig. 15: F_8 electrode, smile signal

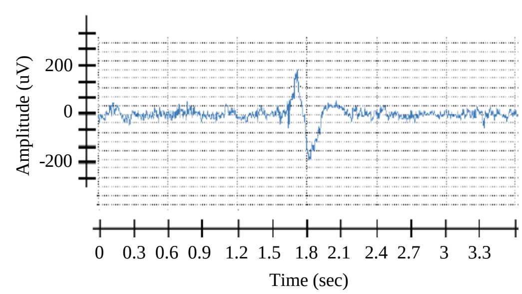

Fig. 16: F_8 electrode, 2 smiles signal

Table 2: Quantity of success for each gesture

	Gesture					
	Blink		Wink		Smile	
Subjects	Success	Attempt	Success	Attempt	Success	Attempt
1	12	12	10	11	12	12
2	10	12	11	11	10	12
3	11	12	8	11	12	12

Table 3: Percentage of hits according to gestures

	Attempt		
Subjects	Blink (%)	Wink (%)	Smile (%)
1	100.0	90.9	100.0
2	83.3	100.0	83.3
3	91.7	72.7	100.0

- Blink 91.6%
- Wink 87.87%
- Smile 94.4%

CONCLUSION

The use of Emotiv EPOC allows easy communication with different systems based on the interpretation of brain signals, giving a large space for medical applications and domotics in general.

The sensor set (F_7, AF_3 and F_8) captured the electrical impulses presented of wink, blink and smile which allowed the recognition of the expression with out previous training of the user. With the compiled signals, the facial gesture detected is shown through a display.

SUGGESTIONS

As a future research, this process gives the implementation to facial recognition be used as a model of a robotic arm controlled with Emotiv, Also, this one open the action field for medical and domotic applications.

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