Trainning profiles in motion sensor, facial expression, and mental commands for Emotiv Epoc+ in indicator LEDs interface

Perfil de entrenamiento para sensor de movimiento, expresión facial y comandos mentales de Emotiv Epoc+ en interfaz de leds indicadores

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Abstract

The study of the gyroscope method, facial expressions and mental commands using the Emotiv Epoc+ headset for driving indicator led is presented. The analog electrical signal provided by the inertial gyroscope located in the Emotiv headset, with the XY angular displacement and PITCH and JAW rotation, as well as the electrical pulses of cranial nerve VII associated with facial expressions and finally the extraction of the EEG signal acquired from the user's brain, are used to activate the output of indicator leds by developing a control program using Xavier Control Panel, Xavier Emokey and Visual Studio software. The electrical activation by means of the Emotiv Epoc+ headset favors several applications that can be explained with the leds and Arduino nano board interface.

Emotiv Epoc+ headset, Facial expressions, Mental commands, Gyroscope

Resumen

Se presenta el estudio del método Giroscopio, expresiones faciales y comandos mentales empleando la diadema Emotiv Epoc+ para el accionamiento de leds indicadores. La señal eléctrica análoga proporcionada por el giroscopio inercial ubicada en la diadema Emotiv, con el desplazamiento angular XY y de rotación PITCH y JAW, así como los pulsos eléctricos del nervio craneal VII asociado a las expresiones faciales y por último la extracción de la señal EEG adquiridas del cerebro del usuario, son empleadas para activar la salidad de unos leds indicadores desarrollando un programa de control empleando el software Xavier Control Panel, Xavier Emokey y Visual Studio. La activación eléctrica mediante la diadema Emotiv Epoc+ favorece diversas aplicaciones que pueden ser explicadas con la interfaz de leds y la tarjeta arduino nano.

Diadema Emotiv Epoc+, Expresiones faciales, Comandos mentales, Giroscopio

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Introduction

Currently there are several control applications related to the Epoc headset, an interface that converts the movement in the movement axes (X, Y) coming from the headset into musical notes for the control of virtual musical instruments has been developed [1]. On the other hand, a BCI system was developed to control a Mitsubishi RV-2AJ manipulator using facial pattern extraction systems and direct and inverse kinematic analysis of the manipulator used [2]. A robotic arm has been controlled by recorded eye-wink activity using two EEG electrodes [3], and a two-wheeled robot was controlled by human thought through robot motion training [4]. In this way, the Emotiv Epoc+ headset provides 3 working options: inertial gyroscope analysis, facial expressions and mental commands.

Inertial gyroscope. A graphical display of the 2D inertial motion captured by the inertial gyroscope is provided. The interface consists of a silver circle with an orange dot in its centre P, which represents the origin position of the rotation axes with the angular displacement XY of the rotation axis PITCH and JAW. At the bottom of the interface are two control bars that regulate the sensitivity of the sensor, increasing the angle required to move the PITCH and JAW point.

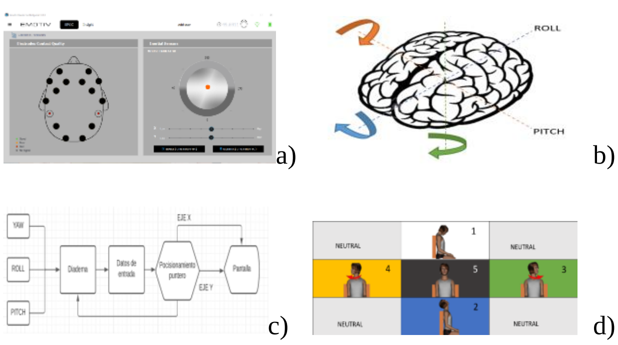

Figure 1 Visual representation of the inertial gyroscope method: (a) Emotiv interface, (b) physical plane, (c) block diagram, (d) working area.

Facial expressions. The brain-computer interface (BCI) is a real-time interface to monitor the interaction of brain signals. Facial expressions extracted from cranial nerve VII are processed in Xavier Control Panel using an AI programmed by Emotiv to identify whether the user is performing a gesture as shown in Fig. 2.

In this method, the acquired facial pattern is preprocessed to compare it with the neutral expression and thus associates the acquired gesture for subsequent sending to an external control device [5]. The signal is converted to a machine learning algorithm to capture muscle gesture patterns. [6].

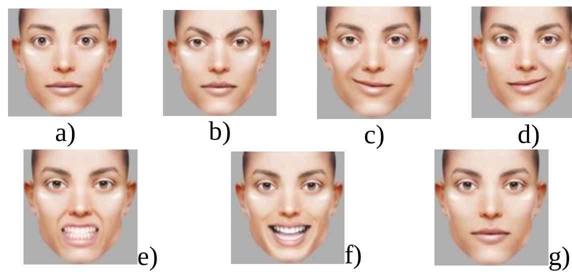

Figura 2 Representación de las expresiones faciales: a) Raise brow, b) Furrow Brow, c) Left smirk, d) Right smirk, e) Clench, f) Smile y g) Neutral

The user must perform training sessions where the program reads the voltage emitted by the electrodes over a period of time measured in seconds and stores it. The gesture to be trained is used as a reference point from which the AI can recognize the expected gesture. As the number of trainings increases, the recognition error in facial expressions is reduced and the AI generates the particular to the person's facial gesture. Fig. 3. shows the interface working with the face of an AI representation and a panel where the sensitivity is varied.

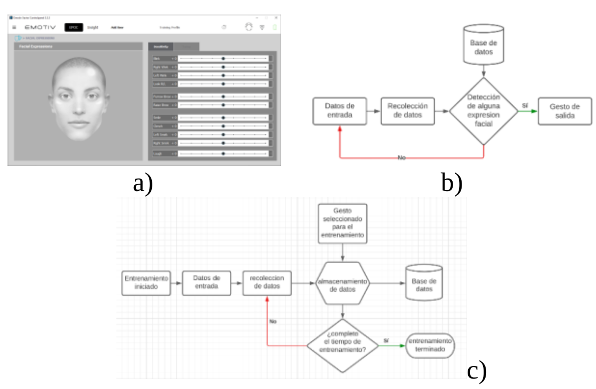

Figure 3 Visual representation of the facial expressions method: a) Emotiv interface, b) real-time diagram, c) training diagram

Mental commands. In a BCI system, neurons communicate with brain waves through electrical impulses smaller than one volt unit, having different types of frequencies: delta (0.2 - 3Hz), Theta (3 - 8 Hz), Alpha (8 - 12 Hz), Beta (12 - 27 Hz), Gamma (+27 Hz). The Emotiv Epoc+ headset captures the electrical signal in key regions of the brain, the Brodmann areas.

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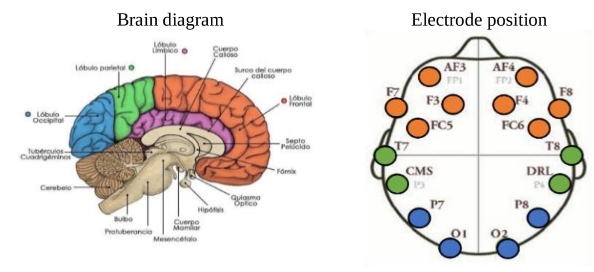
The electroencephalogram (EEG) signals are detected by sensors placed on the user's scalp that allow these electrical potentials to be seen as a waveform [7], see Fig. 4.



Lobe
Frontal: Cognitive functions processing
Parietal: Reception of stimuli
Occipital: Visual processing

Terminal partners
LEFT: AF3, F7, F3, FC5
RIGHT: AF4, F4, F8, FC6
LEFT: T7, CMS
RIGHT: T8, DRL
LEFT: P7, O1
RIGHT: P8, O2

Figure 4 Brain lobes associated with the positioning of the electrodes

The interface detects the level of connectivity of each electrode and reflects its status by changing the colour of the terminals present in Fig. 5.

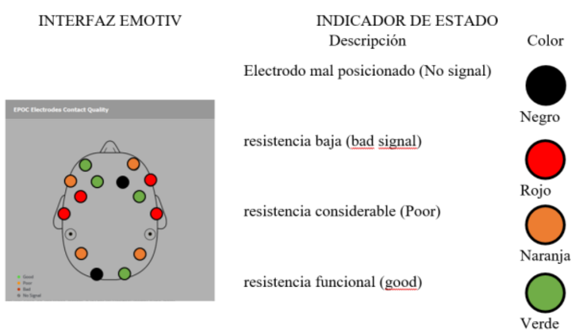


Figure 5 Representative state of the electrodes.

The Xavier Control Panel enables all control options once an optimal connection with all electrodes is detected, while the headband collects for each electrode in real time the EEG signal emitted by the cerebral cortex with amplitude between 10 and 100 µV [8].

Fig. 6. shows the BCI system that delivers as output a recognition algorithm associated to the mental commands.

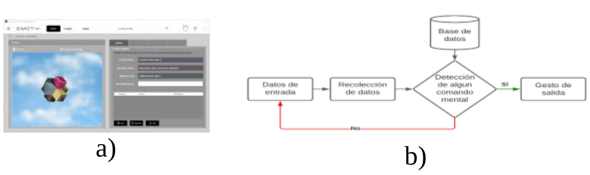


Figure 6 Representation of mental commands: a) software visualisation and b) block diagram.

The pattern recognition system is similar to that of facial expressions. Using as a reference point the associated mental command as neutral, the AI has the ability to learn to perform recognition of mental actions formulated by the user. The BCI system works with a 3D cube-based interface that links the mental movement of the cube acquired by the Emotiv headset. Fig. 7 shows the movements of the cube such as: push, pull, left right, up, down, rotate, disappear, which can be used for training actions of external devices.

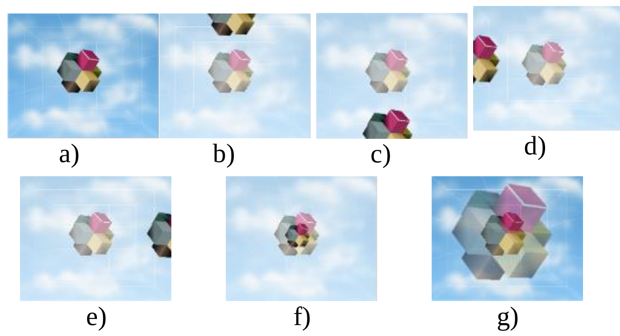


Figure 7 Representation of the 3D cube movement: a) neutral, b) lift, c) Drop, d) Left, e) Right, f) Push, g) Pull

This work proposes an alternative Led control using the 3 control techniques of the BCI interface.

Material and methodology

The Emotiv Epoc+ headset, the Arduino Nano board, different coloured LEDs, Xavier Control Panel and Xavier Emokey are used. The Visual Studio 2022 IDE was used to create an application that connects the microcontroller of the board and the LED actuators. Each option sends a logic value 0/1 output for the action programmed in a led. The test subject was a 14-year-old female to whom the Emotiv Epoc+ headset was attached to verify the correct connection of the system.

The circuit in Fig. 8a comprises the electronic diagram and Fig. 8b the electronic arrangement of the 4 LED indicators with colours: top white, bottom blue, left yellow and right green (red box); and the Arduino nano board. Fig. 8c represents the block diagram of the BCI and the LEDs. The activation is linked to Emokey and Visual Studio, where a digital value 0/1 associated to Table 1 is sent for each led and the method used. The identifier is a numeric value stored in a character.

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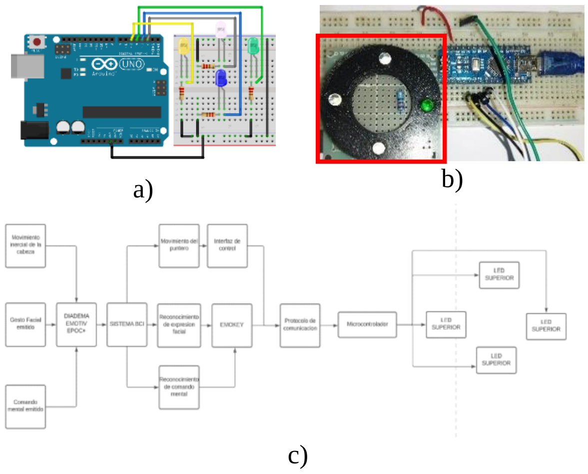

Figure 8 a) electronic diagram, (b) electronic circuit and (c) block diagram of the system.

ON/OFF command	Identificator	LED device colour	Inertial gyroscope	Associated gesture	Associated mental command
0 led	'0'	NA	central	R. Brow	Lift
upper led	'1'	White	upper	F. Brow	Drop
lower led	'2'	Blue	bottom	S. Left	Left
left led	'3'	Yellow	left	S. Right	Right
right led	'4'	Verde	right	Clench	Push
1 led	'5'	NA	outside	Smile	Pull

Table 1 Value of the character associated with the selected interface method and output leds

The control interface of Fig. 9, the inertial movement must have the same activation command configured as the Xavier Emokey program, Visual Studio associates the position of the pointer with an established region within a work zone which triggers the associated identifier as output. The Xavier Emokey plug-in uses the output data provided by Xavier Control Panel and associates facial expressions and/or mental commands with their respective alphanumeric keyboard value. The detection is triggered if the intensity value of the expression and/or mental command is greater than 0.2 ua.

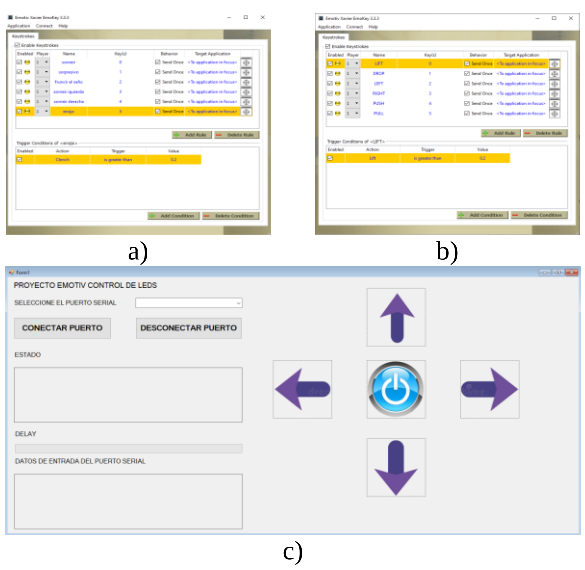

Figure 9 Programming of the outputs: a) VisualStudio (inertial movement), b) Emokey (facial expressions) and c) Emokey (mental commands).

Inertial gyroscope. The working area is divided into 5 positions of the user's head, the Visual Studio program detects the current position of the pointer to send the digital value 0/1 output associated with the corresponding position, and the "STATUS" command is displayed. The user turns the head to the required area to trigger the LED.

Facial expressions. When defining and characterising facial expressions, a total of 25 trainings are performed for each facial expression. This optimises the parameters necessary for Emokey to detect a facial expression and change the status of the LEDs. Emotiv Xavier shows in real time the expressions made and displays a message confirming that the command has been sent in the "STATUS" panel.

Mental commands. A total of 25 trainings are performed for each mental command to be used including the neutral state. The program displays the state of the cube in real time in the Emotiv Xavier software, in the Emokey program it displays a visual confirmation of the led and the mental command. In the Emokey software it sends the confirmation with the message in the "STATUS" panel.

Results

Inertial gyroscope. Fig. 10 shows the test where the user performs a downward movement of the head activating the identifier '2' and the activation of 1 for the lower led (blue colour). Continuing with off 0 by moving the head slightly upwards and activating the identifier '0', the user moves the head slightly upwards and activates the identifier '0'.

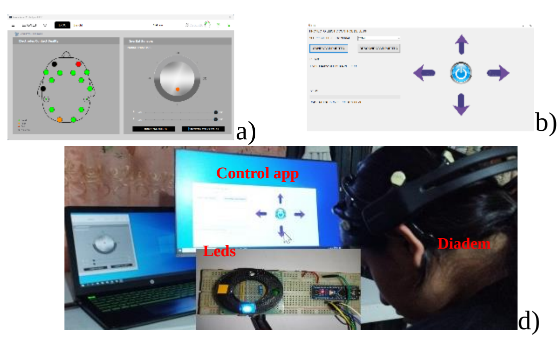

Figure 10 Inertial gyroscope method: (a) Xavier Control Panel software BCI interface, (b) motion control application and (c) head down

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Facial expressions. Fig. 11 shows the BCI system for facial expression recognition and the 25 trainings. The test was performed with the mental command Furrow Brow for the user which triggers the identifier '1' turning on 1 for the top white LED.

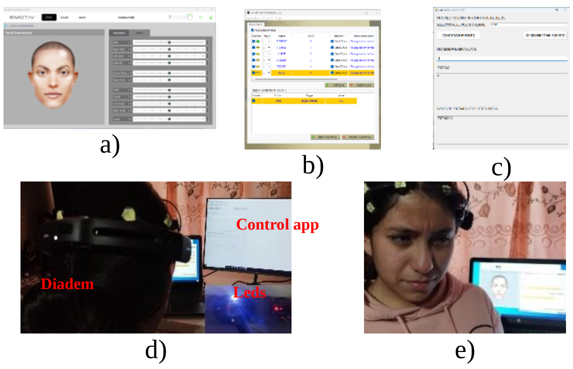

Figure 11 Facial expression method: a) BCI interface Xavier Control Panel software, b) Xavier Emokey programme, c) Control and user application, d) system view and e) expression wrinkle forehead and eyebrows.

Mental commands. Fig. 12 shows the test where the user executes the mental command "push" in which Emokey associates it with the identifier '4' to corroborate the correct functioning of the BCI interface.

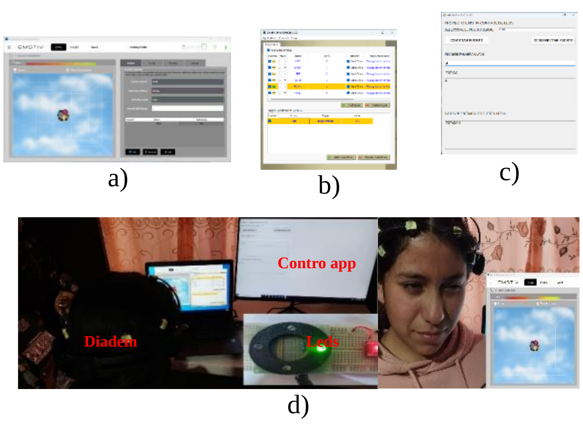

Figure 12 Mental command method: a) BCI interface Xavier Control Panel software, b) Xavier Emokey program, c) Control application and d) push command

Conclusions

The BCI system communicating via the Emotiv Epoc+ headset with an external LED array device demonstrates that it is possible to interact with the human brain, facial gestures and head movements. The methods of inertial gyroscope, cranial nerve VII signal and EEG signal from the brain extend the applications with the unification of Xavier Control Panel, Xavier Emokey and Visual Studio software for improved control of external electronic or robotic elements.

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