

Framework for Brain Computer Interface implemented to control devices in the context of home automation

Jorge Ierache^{1,2}, Gustavo Pereira¹, Enrique Calot², Juan Iribarren¹

Instituto de Sistemas Inteligentes y Enseñanza Experimental de la Robótica (ISIER)¹
Laboratorio de Sistemas de Información Avanzados Facultad de Ingeniería Universidad de Buenos Aires²

ISIER, Facultad de Informática Ciencias de la Comunicación y Técnicas Especiales
Universidad de Morón, Cabildo 134, (B1708JPD) Morón, Buenos Aires, Argentina
54 11 5627 200 int 189
jierache@yahoo.com.ar

Abstract. This paper presents the device controlling using brain machine interface (BMI), through the development of a Framework implemented for the acquisition, configuration and control in the context of home automation.

Key words. Domotic, Brain Machine Interface, Bio-Electrical Signal, Human Machine Interfaces, Neuroengineering

1. Introduction

In the field of emerging interfaces presents Brain Computer Interface (BMI, also known as BCI for its acronym in English), it facilitates communication between mental or cognitive functions created from the brain of a person, capturing the electrical signals to be processed, classified, and communicated with specific devices or applications. It is very interesting how applications employing BMI interfaces have increased during the last two decades [1], from controlling the lights on and off, using wheelchairs, computer control [2], movements in space [3], to video games [4]. In science the initial interest in using BMI presented since 1973 [1], among the first publication in the field of research in BMI were conducted in the nineties 1990 [5] and 1991 [6]. The application of controlling by bio-signals systems, robots, applications, games and other devices, presents a new approach to open the doors for interaction between humans and computers in a new dimension, which specifically exploit electrical biopotential registered user through: the electro-myogram, the EEG and electro-oculogram, which are electrical biosignal patterns generated by muscle activity, the welcome and the user's eyes.

Researching of BMI interfaces is developed in a multidisciplinary scientific field due to their medical, electrical and electronic signal processing components, neuroscience and applications like computing, home automation to robotics and Entertainment [7]. Several papers were presented: first, they used intracranial electrodes implanted in the motor cortex of primates [8], [9]. The noninvasive's human works used electroencephalography signals (EEG) applied to mental exercises commands, such as moving a computer cursor [10], [11] based on the use of Brain-Machine Interface (BMI). Millan et. al. [12] demonstrates how two people can move a robot using a simple electroencephalogram based on three recognizing mental states, which are associated with the robot command. The work Saulnier et. al. [13] focused on controlling the speed of a robot to extend its application to infer the user's stress level, and from this influence the social behavior of domestic robots, in this case a robot vacuum cleaner. The seminal work of Millan et. al. [12], used as an unique biosignal the EEG, based on two people working to give support in robot navigation, unlike the latter, our paper presents the preliminary result using a BMI of low cost, used in works like Saulnier et. al. [13] which includes the biosignals for the electroencephalogram, electro-oculogram and electromyogram. Unlike Saulnier's et. al. [13] work, which

implements a speed control based on electromyogram and infers the state of stress of the user through the electroencephalogram, our initial work focused on executing commands using a NIA BMI [14] to navigate of a robot [15] and is currently in the control of artifacts in the context of home automation. [16]. Control devices, moving robots or facilitate the implementation of devices for disabled without applying manual controls and gain control only through mental activity fascinated researchers, while achieving a plasticity with a BMI of time required by the user, on our experiences to facilitate employment to a user with minimal training was developed for auto focus control [15] in order that the Lego NXT robot [17] is guided by the use of a BMI-NIA, to accomplish a navigation pattern, improving mental control times, slightly surpassing the manual control, in performance tests of the same navigation pattern [18], [19]. In 2011 researchs we experience the remote controlling of a Lego NXT robot [20] via the Internet with the implementation of biosignals with NIA BMI [14]. In subsequent works [21], [22] navigation control using Emotiv's BMI navigation was developed. [23], which is detailed in the next section.

2. Non-invasive brain machine interface

On biosignals, EEG is the registry of the electrical activity generated by the neurons within the brain which is obtained through the skull by the use of electrodes placed on the surface of the head. Neuronal electrical activity is composed of slow waves which originate in synaptic activity of cortical neurons. Obtaining bioelectric signals is performed on the scalp using surface electrodes, which give the name of electroencephalogram (EEG). As to the surface electrode types are distinguished the ones attached, that consist of small metal discs which are fixed with a conductive paste giving very low contact resistance. Contact also exists, consisting of small tubes of chloridized silver threaded plastic holder containing at its end a pad wetted with saline is attached to the skull with elastic bands which are connected via alligator clips. Finally we have a mesh helmet composed by electrodes attached to a elastic helmet which are more comfortable for use and have a high positioning accuracy. The Emotiv Epoc's electrodes [23] are subject to a malleable plastic arms that ensure the proper location and have a pad soaked in a salt solution into each contact to allow conduction.

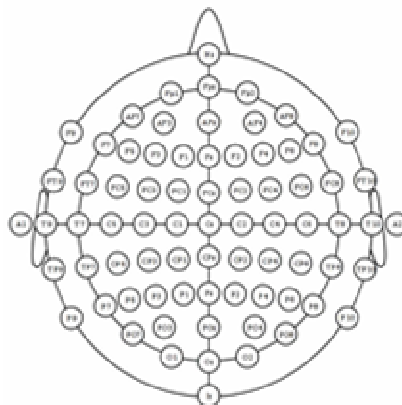


Figure N° 1 "Electrode system 10-20"

The international 10-20 electrode arrangement (Figure N ° 1) is the most used and developed one in order to ensure standardization for an individual studies. The system consists of letters and numbers to identify contact points. The letters identify the lobe and the number, the location within the hemisphere. The letters F, T, C, P and O stand for frontal, temporal, central, parietal and occipital respectively, (the letter C is used to identify the central horizontal line does not refer to any lobe). Even numbers correspond to the electrodes of the right hemisphere and left odd. Z subscripts are used to identify the vertical center line of electrodes. The arrangement of the electrodes on the Emotiv EPOC helmet, fit the 10-20 system, but only fourteen contact positions are used (Figure N ° 2a) plus a pair of reference (Common Mode Sense-CMS-and Driven Right Leg-DRL-) on each side, behind the ear or above it. In addition to the electrodes, the Emotiv EPOC helmet (Figure N ° 2b) contains a gyroscope consisting of two accelerometers that provide information on the movements that user performs with his head and a wireless transmitter by which links with the USB receiver connected to the computer, all powered by a rechargeable battery via USB.

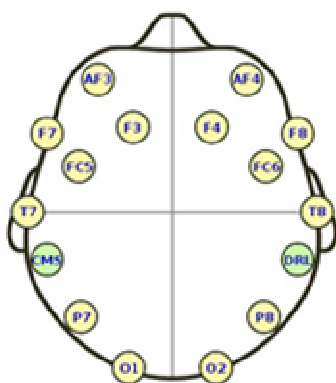


Figure N° 2a. “EMOTIV EPOC helmet electrodes”



Figure N° 2b. “EMOTIV EPOC helmet”

From the API and the software included in the development kit, the level of contact of the electrodes, the motion of the gyroscope, the wireless signal strength and battery charge can be monitored. Emotiv Development Kit has a set of libraries that allow communication with the helmet, the API for developers and the Emotiv engine. The Emotiv engine is the base component for the detection and interpretation of the signals from the electrodes that are located in the helmet and information captured by the EEG. It is also responsible for monitoring the battery state, the intensity of the wireless signal, the record of the connection time and to train recognition algorithms for expressive and cognitive modes, subsequently applying optimizations to each of them.

The Emotiv EPOC BMI (Brain Machine Interface), articulated with its SDK (Figure N° 3) consists of a control panel to create the user and log the profile, it also helps to visualize the connection status of the sensors and represents different record patterns (expressive, affective and cognitive). The expressive pattern can be viewed through an avatar in which signs of facial expression (blink, wink left, wink right, look left, look right, brows move up, move eyebrows down, smile, grit your teeth) can be trained. The affective pattern verifies different moods that are happening in a certain time (concentration, instant arousal, excitement among others). The cognitive pattern allows the training of an action on the basis of a thought, on which you can train up to thirteen actions, six of which are directional movements (push, pull forward, left, right, up and down), six rotational (rotation in the direction of clockwise, counter-rotating in the direction of clockwise, rotate left, rotate right, forward, backward) and an imaginary one that is disappearing. Other tool on the SDK is the Emokey (figure N° 4), which allows Emotiv to link an action with any key and thus to function as an interface to any application.

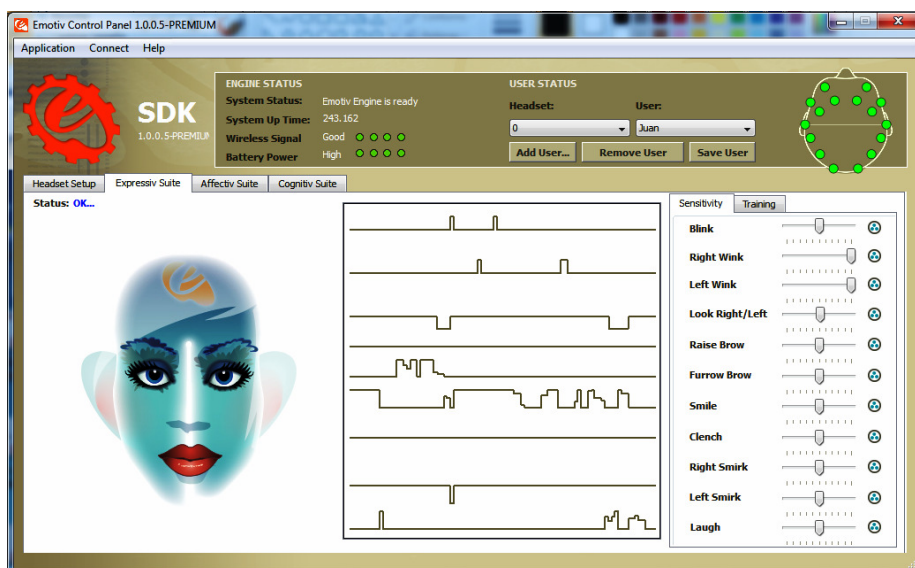


Figure N° 3 SDK-Emotiv

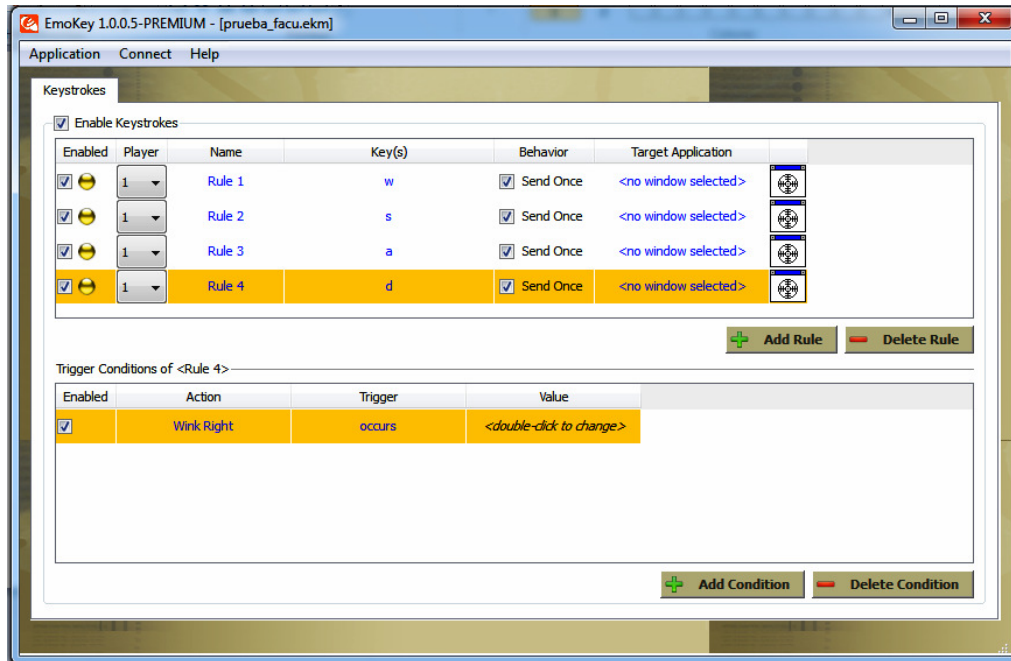


Figure N° 4 “Emokey”

3. Framework to control artifacts in the context of home automation

The framework to control artifacts was implemented to allow control of devices through BMI-Emotiv [23]. Functional restrictions were raised as to implement the control with the least amount of commands to facilitate learning and control by users, in this order only two commands are used to control devices, one is dedicated to action selection (change the tv channel, change the volume, turn on or off, change the temperature, mode of air conditioning, etc.) and another is dedicated to their execution. For the integration of communications to replace the IR remote control USB-UIRT IR transceiver is used [24], which was also applied to capture the command to be incorporated into the Framework that will execute the using the BMI. In sum, through the transceiver commands will be captured from any IR home device remote control (TV, DVD player, air conditioning, etc.) then the UI allows distribution of the buttons in a more comfortable way for the user and using a friendly interface and iconography to simplify identification. Figure No. 5 shows conceptually the control application in the context of the automation.

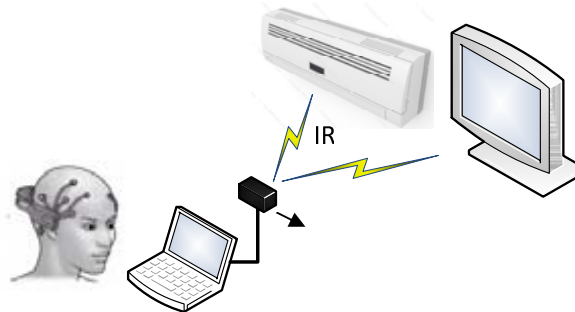


Figure N ° 5 “Application automation with Emotiv/USB-UIRT”

Developed Framework will facilitate disabled persons to control devices, as well as the interaction and control of such users with remote devices on site. Over these facilities a simple profile is determined for managing a device, and in first place characterize and associates the control to selecting a command based on the detection of muscle signals, in this case through a slight movement of the eyelids. Second, executing high level commands to a device, in this case worked using alpha brainwaves. The framework was developed in C#. Class diagram is presented in Figure No. 6, it consists of two sections, the first one is configuring the layout of commands where you learn (catcher) and set the IR codes of the remote control device chosen (Class Configuration) and the second one where the user interacts with the devices (Class MainForm) by USB-UIRT API Managed Wrapper [25].

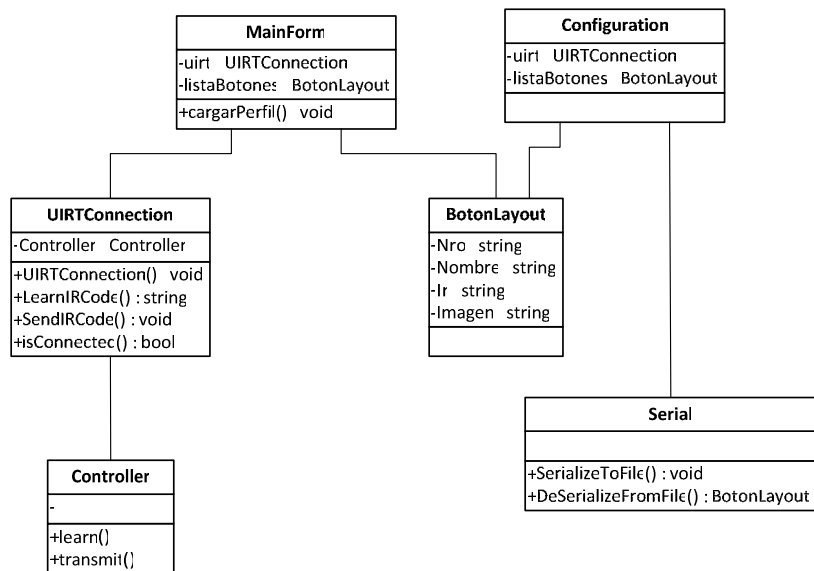


Figure N ° 6 “Framework class diagram”

Figure N° 7 shows the diagram of components that make the application of the Framework, interaction with USB-UIRT interface is observed, through the MainForm class

with which it develops control devices and their interaction with the Emotiv transparently controlling through biosignals. using Emokey. Finally, Serial Class converts into a plain text acquired through its Serialize method using the command to control a device that corresponds to a hexadecimal value. To execute the command applies the Deserialize method that allows recovering from the plaintext in hexadecimal command to the USB-UIRT IR transmitted via the device.

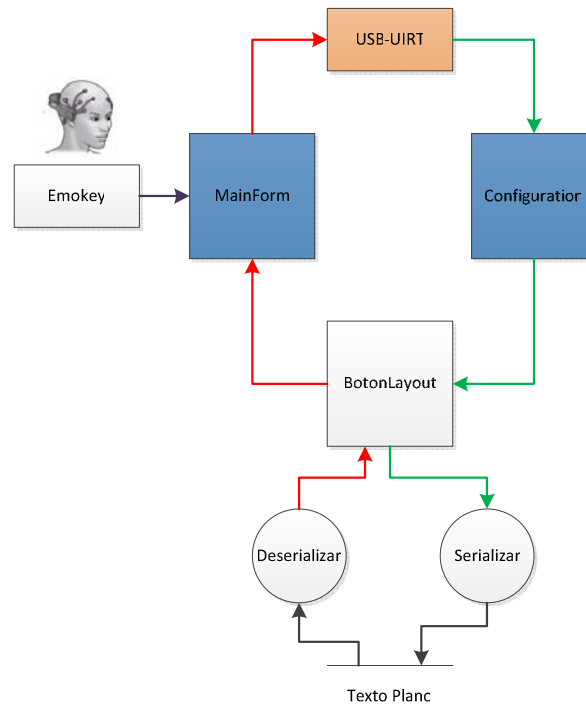


Figure N ° 7 “Component diagram”

In the Configuration section the user selects the button that performs the action with the possibility of building an specific layout distribution, places the button name, choose an icon that matches and then copies the hex value of the command on the remote control using the Learn button and with USB-UIRT device connected. Once finished the layout configuration, it is stored in a disk file to be recovered in future runs of the application (Figure N ° 8).



Figure N° 8 “Mapping controls configuration”

The second section (MainForm) is the simplified layout display was configured in the above mentioned section and it interacts with the end user of the application. By two command executions assigned in the Emokey (move right and run) the user will select the controls and runs according to your needs (Figure N° 9), the layout are presents only the configurated buttons, also allowing to visually distribute commands for user comfort.



Figure N° 9 “Command Execution”

4. Conclusions and future lines of research

Framework development, on the initial basis of robot control and its extension to control devices, with the ability to facilitate the capture and configuration of commands on the

devices demonstrated during tests [22] a stable behavior in the devices integrated control over Emotiv BMI.

Future lines of research will be implemented over extended control features as artifacts both robots infrared remote control (air conditioning, TV, and other devices), targeting both local devices and those located in remote sites by an unique cross-platform framework that integrates libraries for a lot of known devices, command profiles import and export and an assistant for training and familiarization with the Emotiv user.

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