SYSTEM OF COMMUNICATION AND CONTROL BASED ON THE TROUGHT

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ABSTRACT

The present work is oriented to offer a communication via to the many people who undergo of a severe loss of function motorboat as a result of different accidents and/or diseases, so that they can control and interact better with his environment, for which an brain-computer interface has been implemented through the acquisition of EEG signals by electrodes, implementation of algorithms to extract characteristics and to execute a method of classification of such way to interpret these signals and to execute corresponding actions.

The first objective to design and to construct to a System of Communication and Control Based on the Thought able to catch and to measures EEG signals.

The second objective is to implement the system of data acquisition including a digital filter in real time that allows us to eliminate the noise.

The third objective is to analyze the variation of the EEG signals in front of the different tasks under study and of implementing an algorithm of extraction of characteristics.

The fourth objective is to work on the base of the characteristics of the EEG signals, to implement a classification system that allows to discriminate the 2 tasks under study and on the basis of it of conducting the corresponding battles.

1. INTRODUCTION

There is a significant quantity of people who have incapacities severe by diverse causes, high cervical injuries, cerebral paralyses, multiple sclerosis or muscular dystrophies, in these cases the system of communication based on electroencephalogram (EEG) provide a new form with communication, or to increase integration in the society or to provide with means of control without permanent attendance in the surroundings in which they develop.

Diverse techniques and paradigms in the implementation of Brain Computer Interfaces (BCI) exist. Generally, the BCI are based on detecting signals of EEG associated to certain mental states.

An brain computer interface is a communication system that allows to generate a control signal to divide signals cerebral, such as electroencephalogram and the evoked potentials. The communication between the two essential parts that conform the BCI (brain and computer), is governed because the brain generates the commando and the computer must interpret it.

The development of BCI is a line of recent investigation, although already encouraging result were obtained that they make think about the possibility of developing a BCI with a performance of around 70 % of effectiveness.

2. THEORETICAL FRAME

The Electroencephalogram (EEG).- It is a study of the cerebral function that picks up the electrical activity of the brain, to pick up the cerebral electrical signal are used electrodes placed in the hairy leather, to which it is added grazes conductive to make possible that the cerebral electrical signal, that is of a magnitude of microvolts, can be registered and be analyzed.

The electroencephalography signals have different rates within the frequency band with the following characteristics:

Rhythm Alfa or Mu: It is a characteristic of the state of watch and physical and mental rest with the closed eyes.

- Low voltage (20-60 µv / 3-4mm) with variable morphology.
- High Frequency (8-13 Hz).
- Zones of origin: later.
- Visual blockade before palpebral opening and stimuli (reactivity).
- No differentiable childhood, after the 8 years 10 hertz, totally established after the 12 years.

Rhythm Beta: It is characteristics of the state of watch in states of cortical activation (reemplazamiento of α).

- Low voltage (10-15 µv / 1-1.5 mm) with variable morphology.
- High Frequency (13-25 ó + Hz) to grater predominant frequency in anxious subjects, anxious and unstable.
- Zones of origin: central frontals.

Rhythm Theta: It is characteristic of the state of deep and normal dream in the childhood (10 years), abnormal during the watch.

- Preponderant before the 2 years (emotional situations).
- Appearance in specific physiological conditions (hyperventilation and states of deep dream).
- High voltage (50 µv / 7mm).
- Low Frequency (4-8 Hz).
- Zones of origin: talamicas zones, parietotemporal location.

Rhythm Delta: It is characteristic of indicative pathological states of neuronal suffering (comma) and occasional during states of deep dream.

- High Voltage (70 –100 µv / 9 -14 mm) with variable morphology.
- Low Frequency (4 ó - Hz).
- Subcortical origin (not defined).

International System of Position of Electrodes 10/20.- The inactive or common electrode is placed remote of the skull (lobe of the ear, nose or chin).
It is counted on datum points such as: nasion and inion.
Ten percent over the datum points are the planes pre frontal and occipital.
The rest is divided in four equal parts of 20 % each.
Five cross-sectional planes exist:

- Prefrontal: Fpz
- Frontal: Fz
- Rolandico o vertex: Cz
- Parietal: Pz
- Occipital: Oz

Horizontal plane: 10-20% towards the right and left.

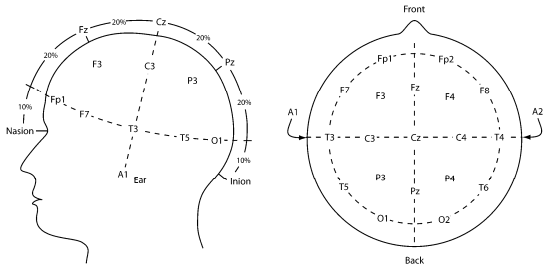

Fig. 1 Positioning of the Electrodes

3. DEVELOPMENT OF THE WORK

Block Diagram:

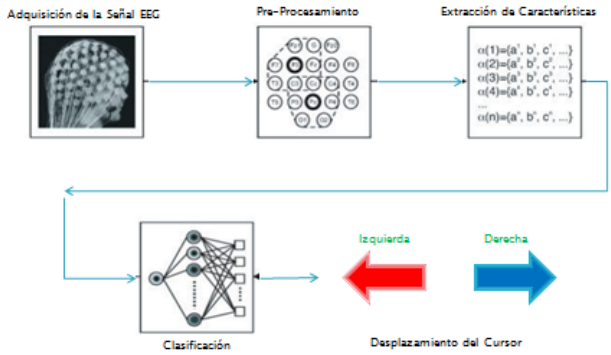

Fig.2 Block Diagram

Data Acquisition.- For the data acquisition it was used electrodes of 8mm of Ag/AgCl fixed on the position C3 and C4 of the international system of positioning 10/20. The signal has amplified with an amplifier EEG of 8 channels model Procomp Infinity. The sampling frequency is of 256 Hz.
A digital band pass filter has been implemented between 0.5 and 30 Hz in real time to especially eliminate the originating noise of different sources and of the mains.

Fig.3 Electrodes

Fig.4 Amplifier Procomp Infinity

Extraction of Characteristics.- The stage of extraction of characteristics is probably the most critical step in the processing of signal EEG, with a view to maximizing the potential success of the classification stage and as well the global yield of the system. A second objective of the stage of extraction of characteristics is to compress the data without loss of excellent information, in the phase of classification so that it can operate in real time.
The rhythm μ, which corresponds to an oscillation of signal EEG between the 8 and 13 Hz, is caught in the sensmotor zone located in the central region of the hairy leather.
This rhythm, present in majority of adults, has particularity to present attenuation in its amplitude when carries out some type of movement, or what is more important when the intention is had to realize some movement, or simply imagining movements of the extremities, as it in in figures 5, 6, 7 and 8.

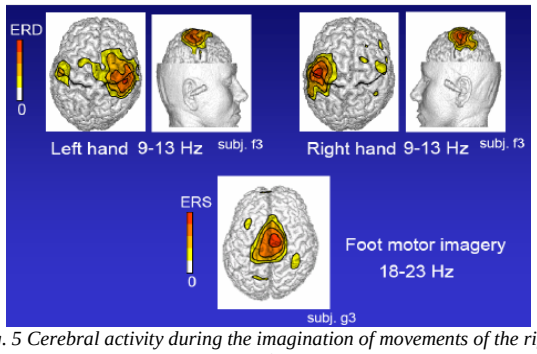

Fig. 5 Cerebral activity during the imagination of movements of the right and left hand

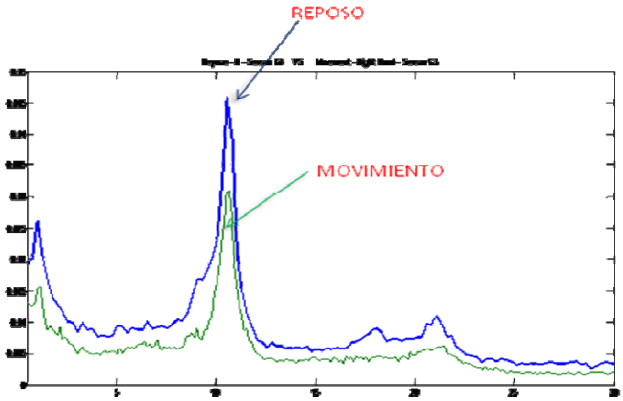

Fig. 6 Difference in the frequency band alpha between movement and rest

It is possible to stress that movements of the right hand produce a variation in the activity of the left part of the brain and vice versa.

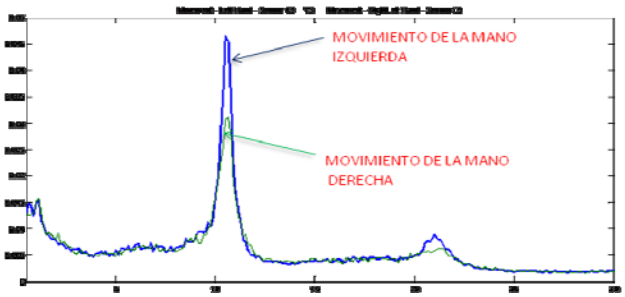

Fig. 7 Difference in the frequency band alpha between movement of the right and left hand in the electrode of the position C3

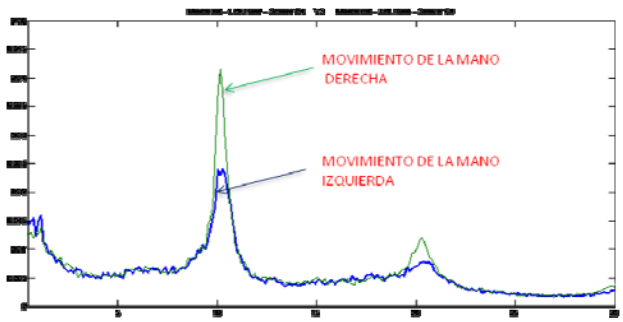

Fig. 8 Difference in the frequency band alpha between movement of the right and left hand in the electrode of the position C4

Autoregressive Adaptive Parameters (AAR).- In order to represent the characteristics previously described in numbers that allow us to implement a sort algorithm, because we used autoregressive adaptive parameters that allows us to represent the frequency response of the signal as it is in figure 9.

A model AAR of order *p* is written of the following way:

$$y(t) = a_1(t) * y(t-1) + \ldots + a_p(t) * y(t-p) + x(t)$$
$$= a(t)^T * Y(t-1) + x(t)$$

The difference with the stationary molding autoregressive (AR) is that parameters AAR vary with them, the prediction of the error calculates of the following way:

$$e(t) = y(t) - \hat{a}(t-1)^T * Y(t-1)$$

Fort he calculation of the parameters enough methods exist, in this opportunity we used the method of Last–Mean–Squares (LMS) whose it formulates this given by:

$$\hat{a}(t) = \hat{a}(t-1) + (UC / MSY) * e(t) * Y(t-1)$$

Where:

$$UC \rightarrow \quad Update \;\; Coeficient = 0.0055$$

$$MSY \rightarrow \quad Variace \; of \;\; the \; Signal = \frac{1}{N}\sum_{t=1}^{N} Y_t^2$$

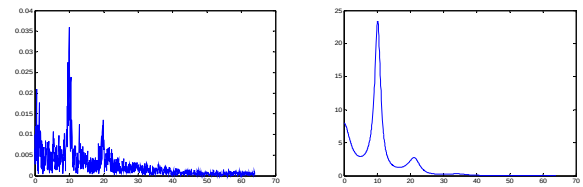

Fig. 9 Comparison of Frequency response with the FFT and Parameters AAR

In work with 6 parameters AAR by each joint electrode, that is to say 12 characteristics.

Classification.- The phase of classification is the final task of the processing. The entrance to the sort algorithm is the set of characteristics extracted in the previous stage and the exist is an indication of the mental state of the user. In this case we are working with two states: Left and Right.

Fort he present work it has been developed two methods of classification: Linear Discriminating Analysis and Neuronal Network, both methods give like result a vector of weights but a constant, this way the activation function would come given by:

$$AC = \sum x_i * w_i + cte$$
$$AC = X * W + cte$$

4. TEST CERTIFICATE

Fixation of the Electrodes.- Bipolar electrodes are used reason why each electrode is placed to 2.5 centimeters advanced back and of the positions C3 and C4 as it shows them figures 10 and 11.

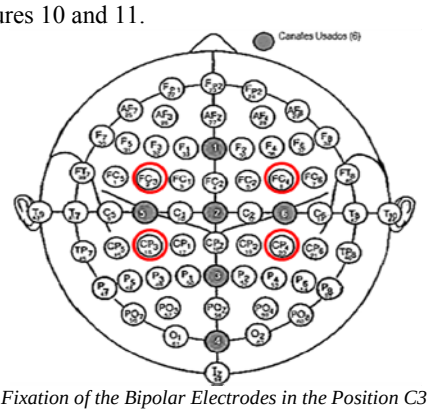

Fig. 10 Fixation of the Bipolar Electrodes in the Position C3 and C4

Fig. 11 Photographs with the Fixed Electrodes

Fort o fix the electrodes, gel is used and grazed conductive.

Fig. 12 Gel and Grazes Conductive

Acquisition of the Signal and Training.- Each of the tests lasts only 9 second and during the training process we can have 80 tests.

The test begins in rest and to the 3 seconds the system randomly chooses a value to send to the signal of right or left, reason why the person will have the 6 second rest to imagine the movement specified, to understand better we can observe figure 13.

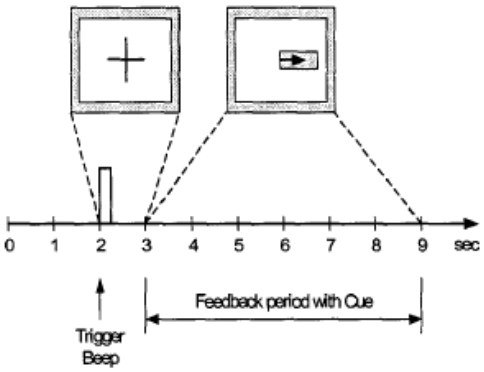

Fig. 13 Composition of the 9 seconds of the test

Fig. 14 Photographies during the process of acquisition of signals EEG

Fort he training 2 stage were realized, a first training OFFLINE in which there is no feedback and it serves to register and to keep the data son to analyze them of way offline; second it is a training ONLINE where exist feedback in function to the preliminary results of analysis offline, this training online serves so that the user can learn to control of better way the cerebral activity. In figures 15 and 16 we can observe the forms implemented for each one of the training.

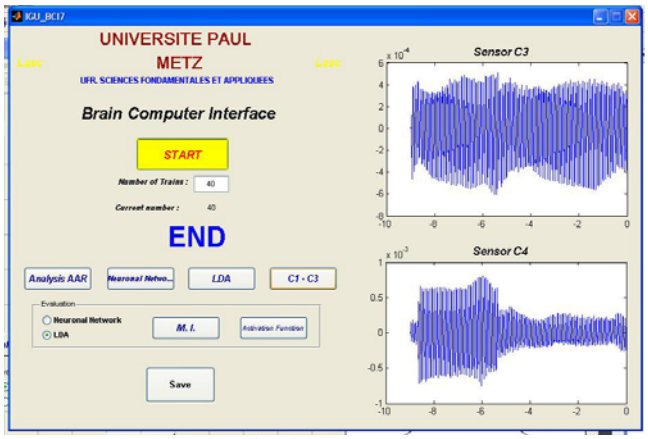

Fig. 15 Interface for Training OFFLINE

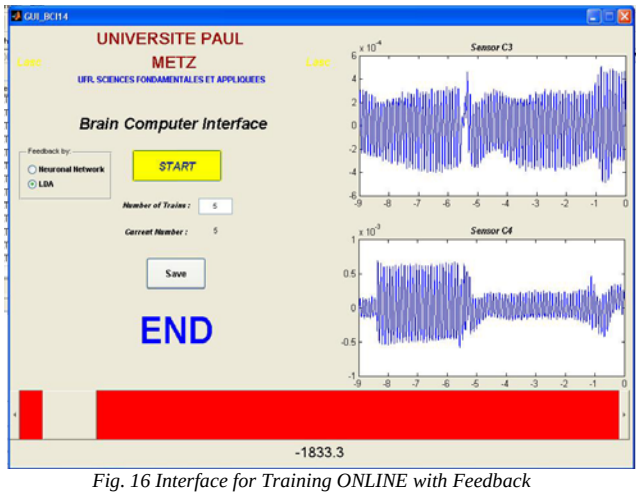

Fig. 16 Interface for Training ONLINE with Feedback

5. RESULTS

Fort o be able to evaluate the obtained results it was taken into account two methods:

Error Rate.- It is the error that takes place when trying to classify the produced signals both enters types of tasks under study (movement of the right hand and movement of the left hand).

Mutual Information.- It is the amount of information that can be recovered through the classification and the extracted characteristics.

As the analysis was realized of continuous way because the evaluation was realized in every moment of time with each simple of collected data reason why in figures 17, 18, 19 and 20 we can observe the values of the error and mutual information base don the time.

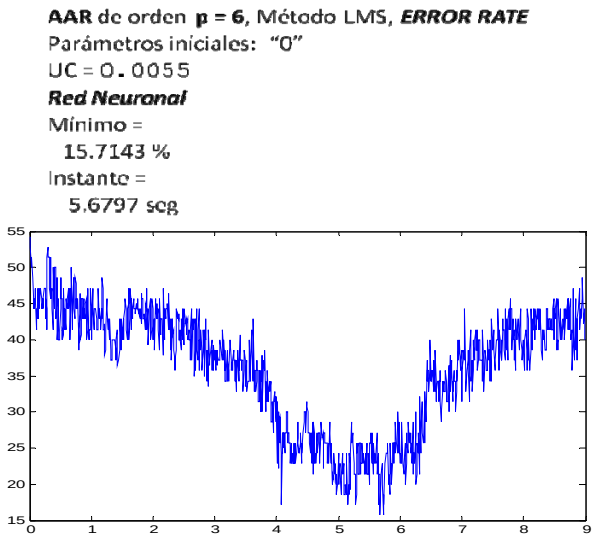

Fig. 17 Graphic of the Error with Neuronal Networks base on the Time

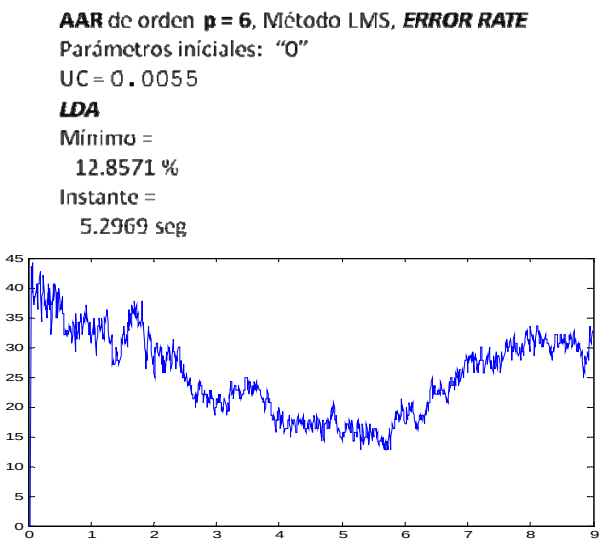

Fig. 18 Graphic of the Error with LDA in Function of the Time

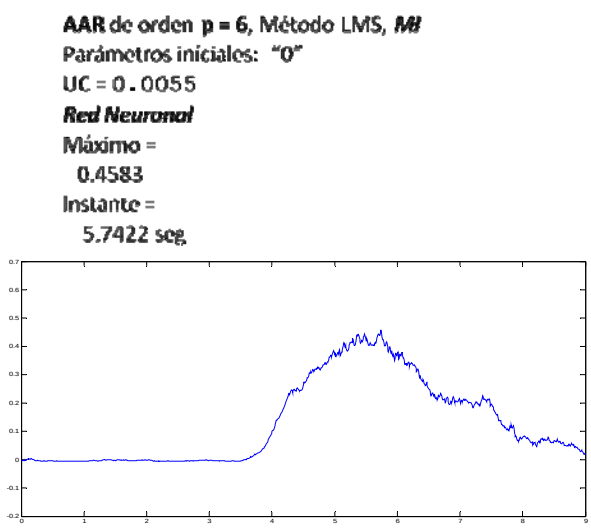

Fig. 19 Graphic of the Mutual Information with Neuronal Networks in Function of the Time

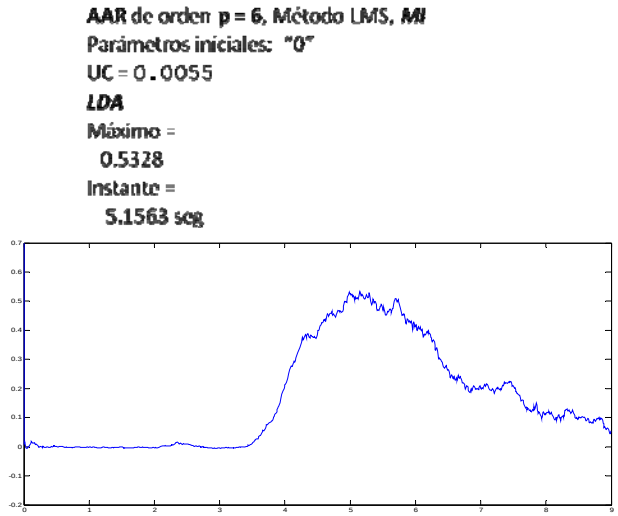

Fig. 20 Graphic of the Mutual Information with LDA in Function of the Time

The difference between the spectral energy of the band can be graphical alpha (8 – 13 Hz) of C3 and C4 when types of movement take place both. Also we can graphical the function of resulting activation of the classification method that is obtained when the movements is left or right. Both graphs are based on the time due to the continuous analysis that I am realized in every moment of time, as it is in figures 12 and 22.

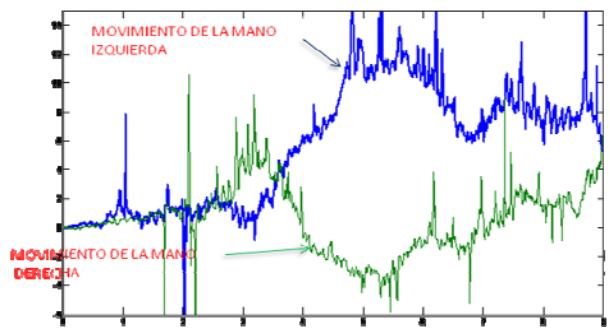

Fig. 21 Difference of spectral Energy between the electrodes C3 and C4

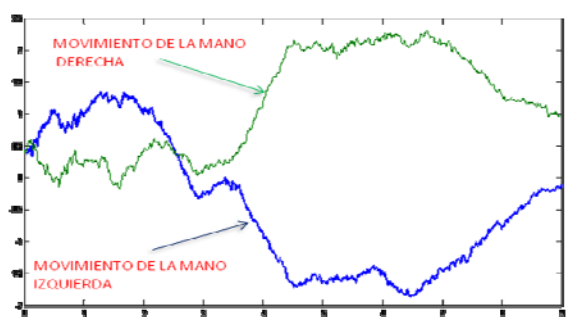

Fig. 22 Graphic of the Function of the Activation for movements of the right and left hand

By means of these graphics ones we can observe that the classes under study are separable.

CONCLUSIONS

- Profit the construction of a communication system and control base don the thought able to move a cursor on the screen of a computer from the cerebral activity al the time of imagining movements of the right and left hand.
- The fixation of the electrodes must be realized of the best way possible to be able to measure a good signal and not to commit errors, for which it is always recommended to make a verification of the impedance of the electrodes.
- Each individual is different and the way to control its cerebral activity also is different, is for that reason that stops each different user always is necessary to realized a previous training..
- Fort o be able to obtain a good training it is a necessary to at least realize 60 tests by each individual or user.
- The analysis has been realized of continuous way during the 9 seconds of each test and the best results as much of the minimum error as the maximum value of mutual information is between the fifth and sixth second.
- The errors found with the methods of classification LDA and Neuronal Networks are of 12.86 % and 15.71 % respectively.
- The values for Mutual Information found with the methods of classification LDA and Neuronal Networks are of 0.5328 and 0.4583 respectively.
- The different values found as much for the error can seem high, but they are comparable values with the results obtained by other groups of investigation.

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