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Brain Computer Interface to operate domotic environment

F. Aloise[1,2,#], E. Morabito[1,3], A.Riccio[1], M. Risetti[1], D. Mattia[1], M. Mecella[3], T. Catarci[3], F. Babiloni[4], S. Salinari[3], F. Cincotti[1]

[1] *Neurofisiopatologia Clinica, Fondazione Santa Lucia, IRCCS, Rome, Italy*
[2] *Dipartimento di Ingegneria Elettronica, Università Tor Vergata, Rome, Italy*
[2] *Dipartimento di Informatica e Sistemistica, Università Sapienza di Rome, Italy*
[3] *Dipartimento di Fisiologia e Farmacologia umana, Università Sapienza di Rome, Italy*

ABSTRACT

The brain computer interface (BCI) technology allows a direct connection between brain and computer without any muscular activity required, and thus it offers a unique opportunity to enhance and/or to restore communication and actions into external word in people with severe motor disability. Here we present a set of findings that confirm the feasibility of a real domotic environmental control operated via P300-based BCI. Furthermore, the relevant issue of a low bit rate of command execution is addressed by the implementation of a dynamical BCI interface whose upgrade is based on a continuous real-time collection of information from the environment.

Keywords
Brain Computer Interface, Domotic appliance, Assistive Technology

1. INTRODUCTION

The Brain-computer interfaces (BCI) are a direct connection between the brain and a computer, without using any of the brain's natural output pathways [1].

The P300 event-related brain potential is a positive endogenous potential which occurs over the parietal scalp region when infrequent or particularly significant stimuli are interspersed with frequent or routine stimuli [2]. Because of its stability and reproducibility, the P300 has been proposed as a control signal for BCI systems.

Preliminary findings indicated that a domotic environment can be operated by a P300-based BCI [3]. Here, we present findings that confirm the feasibility of a real domotic environment control via P300-based BCI. One of the main open issues relevant to this BCI application, concerns the low bit rate of command execution. In this study, we also addressed this issue by proposing a control modality in which the number of possible commands is dynamically optimized according to the environment actual status (for example if the light is on the subject is presented only with the off option and viceversa); this, in turn will allow a bit rate improvement for the user's final choice achievement. To this purpose, we implemented a dynamical interface whose upgrade is based on a continuous real-time collection of information from the environment.

Corresponding author: f.aloise@hsantalucia.it

2. MATERIAL AND METHOD

The figure 1 depicts a user who controls home appliances using a BCI (BCI2000; [4]). A portable 8-channel EEG amplifier (g.Mobilab, g.Tec GmbH, Austria) collects brain potentials from an array of electrodes mounted on the user's head by means of an elastic cap, which are processed by a PC (not shown). The visual interface shows an icon based cascading menu. When a certain icon is flashing and a P300 potential is recognized, that means the user is concentrating on it. After the command is recognized by the BCI, a command is sent to the target switch to enable/disable specific domotics features, (light, fan, DVD Player, mobile phone, webcam, motorized door, etc), through a unidirectional standard protocol X-10. In this interface version the possible user's choices were preloaded in the system by using a configuration file ("static interface").

Figure 1. Prototype setup in which a P300-BCI control signal is utilized to control domotic appliances.

3. RESULT AND DISCUSSION

Eleven volunteers (mean age 25 years; 1 female, 10 males) were challenged with the prototype to "mentally" control a real domotic environment. As illustrated in figure 2, the experimental design was as follows: subjects were asked to "mentally" perform 4 consecutive actions (turn on a webcam, open a door, turn on a light and a fan).

In order to successfully complete the 4 actions, all the subjects should make a number of choices fixed within a range of 9 (minimum required by the system) up to 36 (maximum arbitrarily fixed) to navigate within the cascading menu of the "static interface".

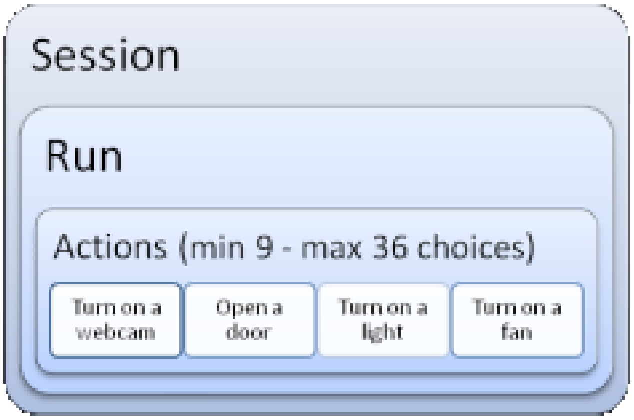

Figure 2. ***Schematic representation of the experimental design. Subjects performed two sessions each in two different days, and each sessions was composed by 6 runs. Each run consisted of 4 consecutive actions.***

Under these experimental conditions, 9 out of 11 subjects were able to control the 4 domotic appliances (actions) via P300-based BCI, with a mean choice number of 16 (12 run). The overall results are showed in the histogram below.

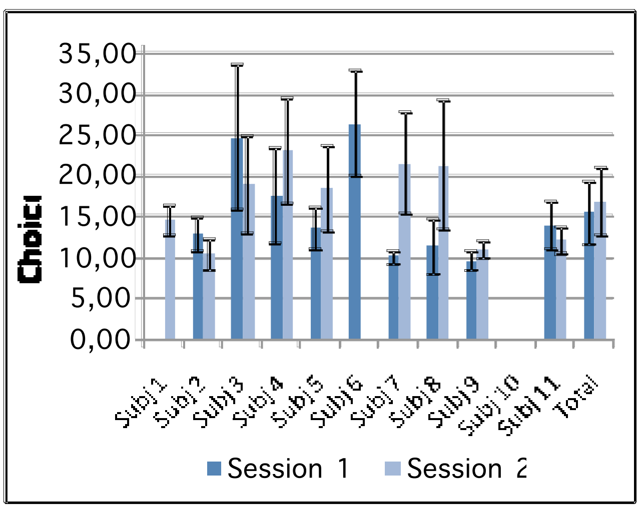

Figure 3. ***The histogram displays the mean number and standard deviation of choices relative to each subject performing the two sessions. The subject 1, 6 and 10 did not completed the tasks within 36 choices***

In the newly implemented version of the BCI2000 software, the choices are "dynamically" loaded: the information is received by means a TCP/IP protocol from a server and it is then exchanged with a XML file. This latter file codes for all the various appliances and their possible available configurations.

The server collects the information from the domotic platform (e.g. Konnex), and stores this information in a Concurrent Versions System (CVS).

When the BCI system indicates the user's choice, the server processes the relevant information. Finally, the processing module extracts the most probable actions, and returns the list of actions to the BCI that presents to the user the icons corresponding to the most probable commands (according to the home status and user preferences).

This architecture provides for a decrement in the number of choices presented to the subject and, in turn allows for the improvements in the bit rate communication. The testing and validation on a sample of users is presently in progress.

4. ACKNOWLEDGMENTS

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5. REFERENCES

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